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FOLLY BEACH, SOUTH CAROLINA. SURVEY REPORT ON BEACH EROSION CON--ETC(U)
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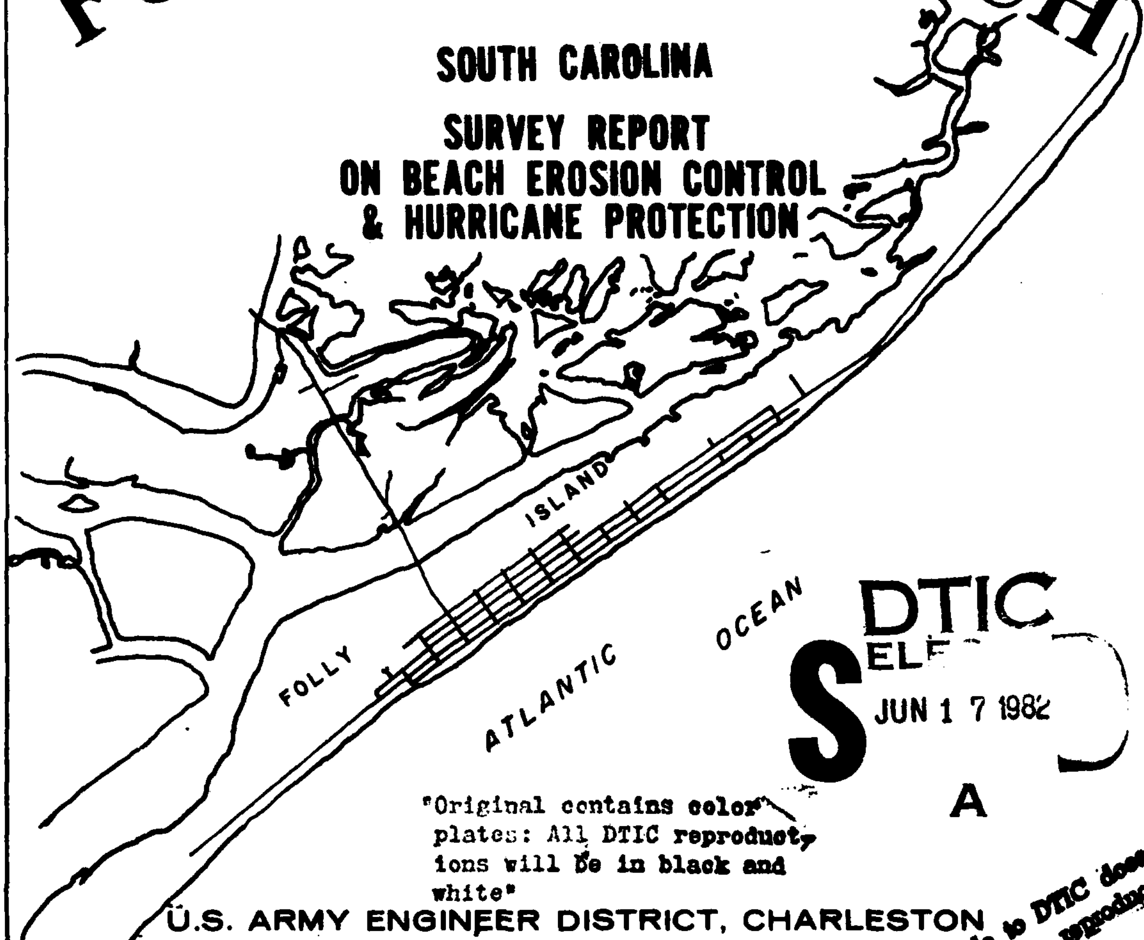
Appendixes

FOLLY BEACH

SOUTH CAROLINA

SURVEY REPORT ON BEACH EROSION CONTROL & HURRICANE PROTECTION



U.S. ARMY ENGINEER DISTRICT, CHARLESTON

CORPS OF ENGINEERS

Charleston, South Carolina

SUBMITTED:

AUGUST 1979

DISCLAIMER NOTICE

APPENDIXES

Folly Beach
South Carolina

Feasibility Report

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SOUTH CAROLINA

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PREPARED BY THE
CHARLESTON DISTRICT, CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY

SECTION A

THE STUDY AND REPORT

THE STUDY AND REPORT

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SECTION A

THE STUDY AND REPORT

1. An understanding of the background and other characteristics of the study and the report provides a useful introduction to the presentation of the study and its results.

Purpose and Authority

2. The purpose of this study, the results of which are presented in this technical appendix, was to investigate the beach erosion, hurricane protection and related problems at Folly Beach, Charleston County, South Carolina. Inherent in the investigation was the development of the most suitable plan for alleviating these problems. Recommendations are presented in the main report.

3. The study and report are in compliance with the following resolution adopted 15 June 1972 by the Committee on Public Works of the United States Senate which reads:

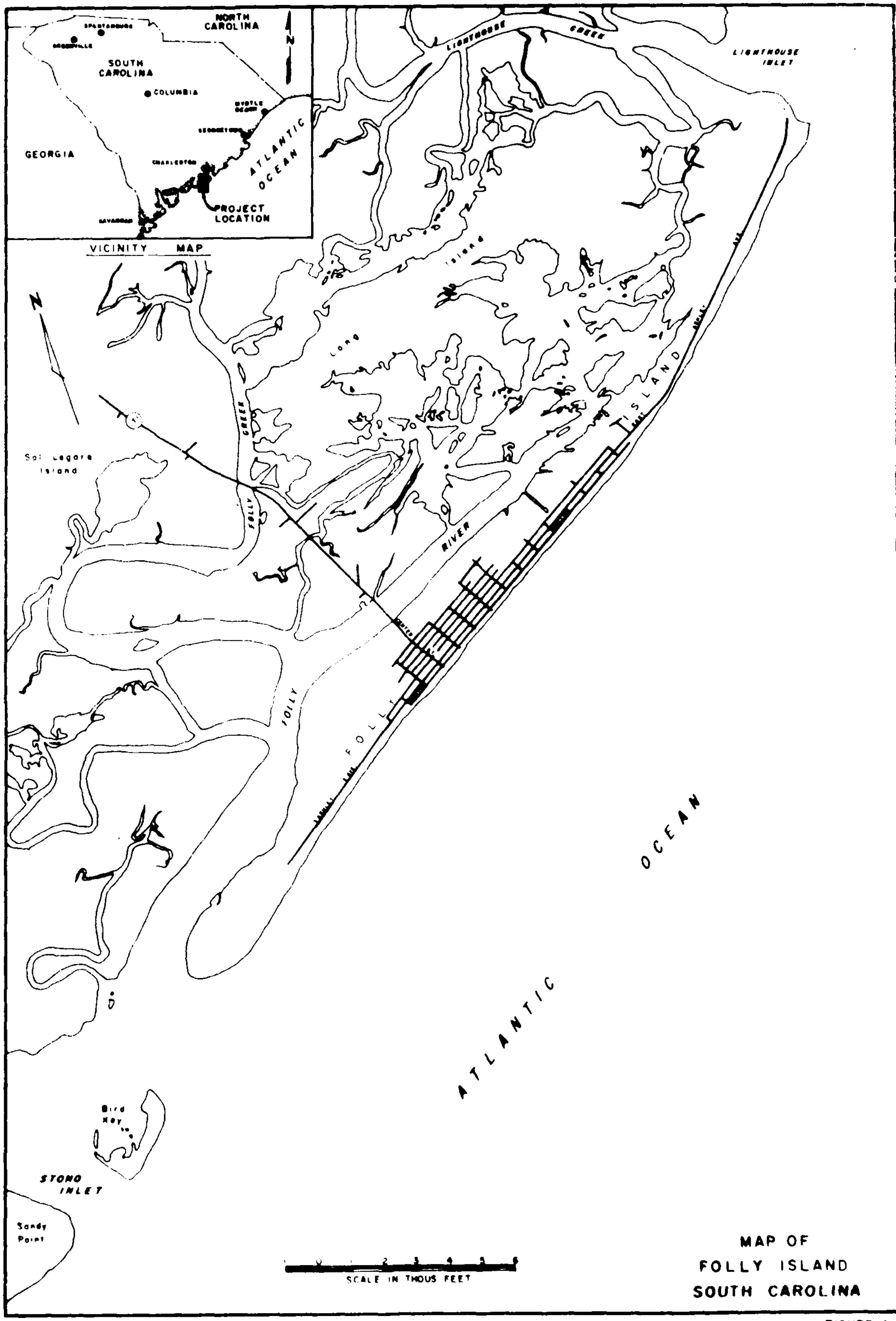
"That in accordance with Section 110 of the Rivers and Harbors Act of 1962, the Secretary of the Army be, and is hereby, requested to cause to be made under the direction of the Chief of Engineers, a survey of the shores of the State of South Carolina at and in the vicinity of Folly Beach, Charleston County, South Carolina, and such adjacent shores as may be necessary, in the interest of beach erosion control, hurricane protection, and related purposes."

Scope of the Study

4. The studies in this report focus on the water and related land resource needs in the vicinity of Folly Island in Charleston County, South Carolina as shown on Figure A-1.

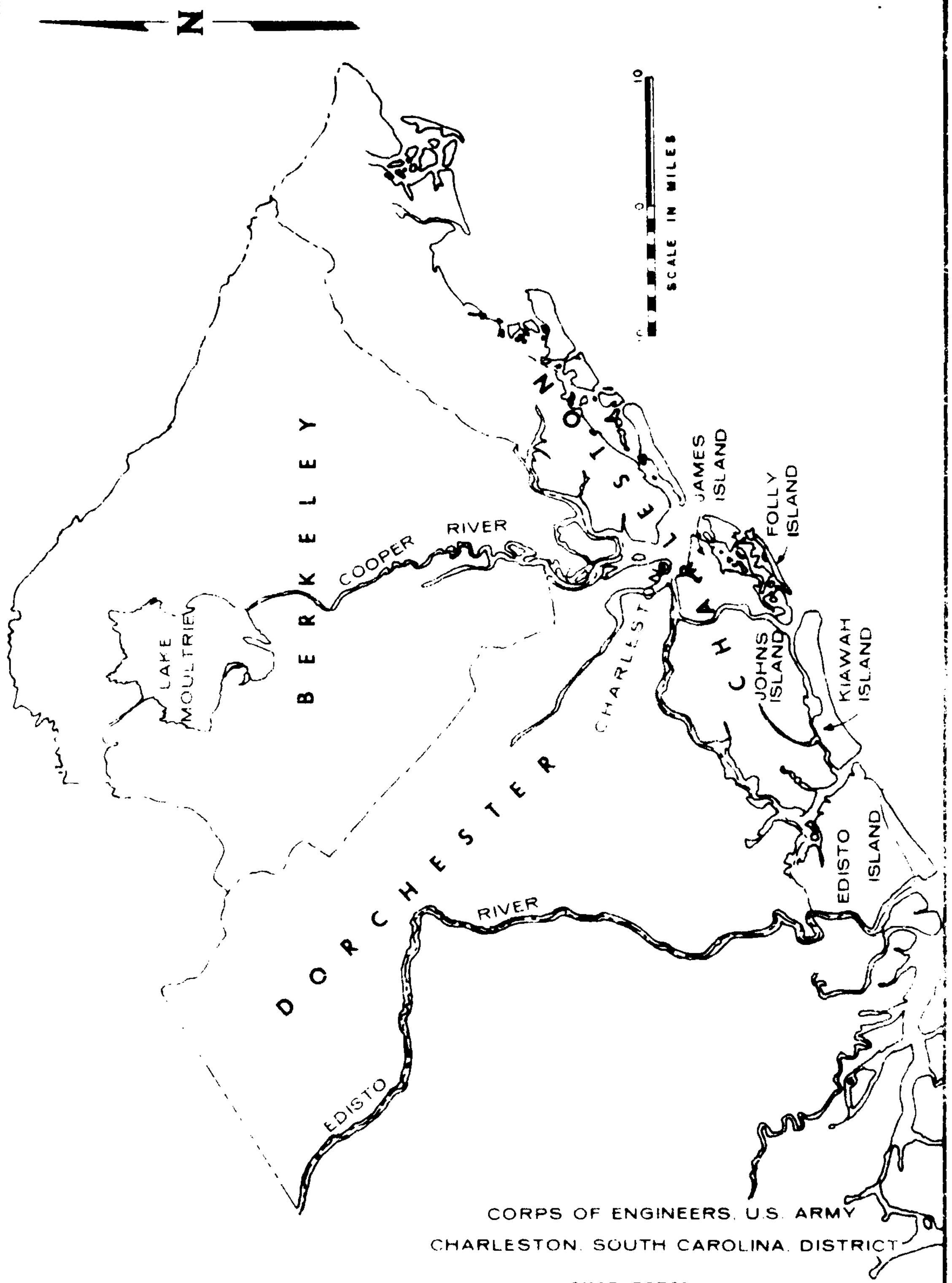
5. As is the case with many water resource studies, the boundaries of the immediate planning area are different from the political boundaries in the vicinity. Therefore, to characterize the setting in which the planning area lies, Figure A-2 gives the geographical locations and boundaries of the broader political and user areas. The Berkeley-Dorchester-Charleston planning area is congruent with those of the Charleston Standard Metropolitan Statistical Area (SMSA).

6. The immediate planning area encompasses the six miles of coastline on Folly Island. Investigations were made of the area to determine damages, either by erosion of the coastline or by storm tides and



MAP OF
FOLLY ISLAND
SOUTH CAROLINA

FIGURE A-1



CHARLESTON SMSA (INCLUDES ALL OF TRI-COUNTY AREA)

FIGURE A-2

waves; measures for protecting the area or preventing the damages; the accompanying costs and benefits; the selection of the most feasible plan; and related matters, including coordination with concerned agencies and the public. The studies were made in the depth and detail needed to permit the development of an economically feasible, environmentally compatible and socially acceptable plan of improvement.

Study Participants and Coordination

7. Charleston District was assigned the responsibility for the conduct and coordination of this study, consolidation of information from other agencies and local interest, formulation of a plan and preparation of the report. A multi-disciplinary team was used to accomplish these tasks. This team was composed of a project engineer, biologist, coastal engineer, economist, cost estimator, and a foundations and material specialist. Additional assistance was provided by geologists, hydrologists, real estate appraisers, surveyors, and others as specific data and analysis were required.

8. The studies and investigations were coordinated with various Federal, State and local agencies. Comments concerning problem identification and possible solutions were received from such agencies as the U. S. Bureau of Sport Fisheries and Wildlife; National

Park Service; U. S. Coast Guard; U. S. Environmental Protection Agency; U. S. Public Health Service; National Oceanic and Atmospheric Administration; South Carolina Wildlife and Marine Resources Department; S. C. Highway Department; S. C. Department of Parks, Recreation, and Tourism; and Charleston County Park, Recreation and Tourist Commission. Several local environmental groups also participated in the study. A total of three public meetings were held during the course of the study to afford interested parties and the general public an opportunity to express their views concerning the improvements desired and the need and advisibility of their execution. Dates of these meetings were 8 April 1976, 29 November 1977, and 7 December 1978.

The Report

9. The organization and format of this report is in compliance with instructions contained in ER 1105-2-402 and ER 1105-2-403. This report has been arranged into a main report and four appendixes.

10. The main report is a non-technical presentation, with recommendations, concerning the need for and advisability of providing beach erosion control and hurricane protection works at Folly Beach. It presents a broad view of the overall study for the benefit of both general and technical readers. Included are a description of the study area; the problems and needs for protective measures; formulation of a

plan for meeting these needs, a summary of project economics indicating the benefits, costs, and justification; the division of project responsibility between Federal and non-Federal interests; a summary of environmental, social, and economic effect assessment; and recommendations for implementing the selected plan. The main report is a summary document where brevity and ease of comprehension are emphasized.

11. Appendix One is a technical report having the same general outline as the main report but in greater detail. It is the key document for the technical reviewer. Here, more emphasis is placed on methods of analysis and supporting detail so the reader will be able to evaluate the validity of the decisions made in selecting the measures included in the recommended plan of improvement.

12. Appendix Two contains the Environmental Impact Statement.

13. Appendix Three contains pertinent correspondence.

14. Appendix Four contains the Section 404(b) Evaluation for the recommended project plan.

Prior Studies and Reports

15. In 1935, a beach erosion report on Folly Beach was submitted by the Beach Erosion Board (renamed Coastal Engineering Research Center) in cooperation with the Sanitary and Drainage Commission of Charleston

County. In this report the Board identified three methods of protection but refrained from making any recommendation as to the adoption of any specific one of the methods given, as it was considered that the selection must necessarily be made by local interests. The problem area at that time was on the southwestern portion of Folly Island where storms of September 1933 and May 1934 destroyed the first row of houses.

The plans presented were:

Plan A - Restoration of eroding beaches;
Plan B - Construction of bulkheads and groins; and
Plan C - Beach restoration with groin construction.

All of the cost of these improvements would be paid by local interests.

16. A study of Charleston Harbor Jetties, 1935, was done by the Charleston District, U.S. Army Corps of Engineers, to become a part of the Shore Protection Board, OCE report entitled "Report on Jetties". The study was made to determine the effect of the Charleston Harbor Jetties on adjacent shorelines. The report that was completed in 1938 found some erosion down drift of the south jetty, on Morris Island, with some accretion at the north end of Morris Island where the jetty approaches the shore. The report also concluded, from a number of jetties studied,that the extent of erosion that might be expected beyond the down drift jetty was only about one mile.

17. An appraisal report, Investigation on Hurricanes and Associated Problems Along the South Carolina Coast, was prepared by the U. S. Army Corps of Engineers, Office of the District Engineer, Charleston, S. C. It was submitted in January 1957 and approved July 1957. The investigation indicated the need for further study and report with a view

toward effecting protective measures for minimizing loss of human life, damage to property and health hazards, and for improving hurricane forecast and warning services.

18. A hurricane survey interim report on Folly Beach was printed as House Document No. 302, 89th Congress, 1st Session, on 7 October 1965. It was concluded in this report that protective works to prevent hurricane damage were not economically justified.

19. In 1968, the U. S. Army Corps of Engineers, Charleston District, completed the Folly Beach Detail Project Report on Beach Erosion Control. This report evaluated the erosion problem on the northeastern portion of Folly Beach. A reach of beach, extending about one-half mile downcoast from the United States Coast Guard Loran Station, was recommended for beach nourishment using sands deposited in Lighthouse Creek. The recommended project called for initial placement of a 5-year supply of sand or about 45,500 cubic yards at an estimated first cost (1967 dollars) of $52,000. Cost apportionment was to be 55 percent local to 45 percent Federal. The project was economically feasible; however, the local sponsor (Folly Beach Township Commission) was unable to provide the allocated items of local cooperation. For this reason, it was recommended that no Federal project be authorized.

SECTION B

RESOURCES AND ECONOMY

OF STUDY AREA

RESOURCES AND ECONOMY OF THE STUDY AREA

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SECTION B

RESOURCES AND ECONOMY OF STUDY AREA

1. A general understanding of the resources and development trends of the study area is helpful in identifying its problems and needs and formulating the various solutions thereto. The following pages discuss the environmental, natural, and human resources of the area as well as its development and economy.

2. Charleston County which contains Folly Island and the Town of Folly Beach has a well diversified economy. The principal economic activities of the area can be related to the availability of several natural resources. A temperate climate, along with favorable topography and soil conditions are conducive to both agriculture and silviculture, which are engaged heavily in the county and account for the greatest land use. A coastal location with several navigable rivers makes Charleston a favorable place for import/export shipping and related port and terminal activities. The South Carolina Ports Authority is presently planning additional port facilities with a view towards improving the economic development of the county and the state.

3. Also, attributable to the geographical and geological situation of Charleston County are several military and government installations, including Air Force and Navy Bases, which employ a large segment (approximately one-third) of the work force in the area. The coastal location also affords opportunities for area residents to engage in several fishery related activities, including shrimping, fin-fishing, oystering, clamming and crabbing. The historical background and fine architecture of Charleston, in addition to the beauty and aesthetic appeal of the Lowcountry's beaches, marshes and rivers, combine to make Charleston extremely popular with tourists from the entire eastern seaboard. Tourism, recreation, and associated services provide 12,000 jobs and 45 million dollars per year in personal income to residents of the area. In fact, tourism-related employment is second only to Government employment within the county. In the immediate vicinity of Folly Island which is located about 10 miles south of the City of Charleston, recreation, tourism and fisheries are of primary importance, both in terms of income and local employment.

Environmental Setting and Natural Resources of the Study Area

GEOGRAPHY AND TOPOGRAPHY

4. Charleston County is at the center of what is known locally as the Carolina Lowcountry. The name fits, elevations are typically

less than twenty feet above mean sea level and relief is extremely limited. The study area lies within the lower coastal plain bordering the Atlantic Ocean which was once a submerged portion of the Continental Shelf. The coastline in this region is composed of a chain of barrier islands, which are usually between two and ten miles long and often less than one mile wide. They are fronted by gently sloped sandy beaches on the seaward side and backed by vast expanses of extremely productive saltmarsh. Folly Island is one of more than a dozen such islands in Charleston County. Separating these islands from each other are broad tidal rivers (such as the Stono River) which drains the interior. Tributary to these major rivers, flowing laterally between the islands and the mainland, are series of dendritic tidal creeks which alternately flood and drain the marshes. Folly River is the main artery for such a system of creeks located behind Folly Island and Lighthouse Creek is a smaller tidal stream at the northeastern end of the island. As one proceeds inland, the larger estuaries taper into meandering brackish rivers penetrating into low wooded lots and farm land. Continuing further upstream, relief increases gradually. At some locations in the interior of the county there are small series of rolling hills, which are relics of beach dunes from previous stands of the sea.

GEOMORPHOLOGY AND SEDIMENTOLOGY

5. The geologic formations of the Coastal Plain Provinces are comprised of layers of unconsolidated sands and gravels underlain by layers of loams, clays and marls of different ages, all lying nearly

horizontal. This stratification of inorganic and organic materials is a result of the alternating predominance of physical and biological factors over recent geological time. As various climactic conditions have changed, the ocean shoreline has alternately receded and advanced as have the other features associated with it such as, the dune system, saltmarsh and tidal rivers which back the barrier islands. Changes in the littoral environment have also caused Stono Inlet and Lighthouse Inlet to migrate up and down the coast. Sub-surface investigation in the inlet areas have produced fine sand with occasional layers of organic material which are remnants of this inlet migration. Soil boring in Folly River behind Bird Key and Folly Island produced fine silty sand to a depth of twenty feet below mean low water. Grain size analysis demonstrates that this material is similar to native beach sand, which indicates that it was derived from the littoral environment. Soil borings were also taken in Stono and Lighthouse Inlet shoals. The grain size analysis of this material revealed the existence of fine sand to a depth of about 20 feet below mean low water. There is considerable amounts of littoral material deposited in the two inlet shoals: approximately 135,000 cubic yards of sand lies above the low water level and another 720,000 cubic yards of sand is incorporated in subtidal shoals of Stono Inlet; the shoals of Lighthouse Inlet contain about 315,000 cubic yards above mean low water and at least 800,000 cubic yards in the subtidal shoals. A review of hydrographic maps and aerial photographs, covering the period from the years 1854 to 1973, indicates that although the orientation of Stono Inlet has oscillated considerably over time, the general location has remained fairly constant. Over the same period, Lighthouse Inlet has had a gradual southerly migration and the ocean shoreline of Folly Island has generally been unstable with erosion prevailing.

CLIMATE

6. Climate of the "Lowcountry's" barrier islands is classified as marine subtropical. The mean average annual temperature near Folly Island is 66°F with an average high temperature in July of 81°F and an average low of 49°F in February. Relative humidity in the area is around 75 percent, but the discomforting effect of this high humidity is moderated by an afternoon sea breeze. Precipitation occurs chiefly as rainfall, averages about 50 inches per year, and is fairly well distributed throughout the year. Between morning and evening twilight, the sun shines an average of 65 percent of the time in Charleston during the year. May and September are the sunniest months; with the sun being visible as much as 90 percent of the time during daylight periods. These conditions provide Charleston County with a relatively long growing season of 295 days per year. These conditions further allow human comfort the year round and provide a situation that is well suited for outdoor recreation and tourism.

BIOLOGICAL RESOURCES

7. There are some 4,000 acres of saltmarsh in the immediate planning area. These wetland areas play a very important role in the ecology

of the area; providing habitat for waterfowl, nursery area for juvenile stages of many important species of fish and shellfish, water quality improvement and primary biological production which supports a host of marine life in adjacent coastal waters.

8. There are public oyster grounds and private leases for oysters and clams in the planning area. Crabbers also fish Folly and Stono Rivers extensively. Shrimp are taken recreationally. The area is a favorite one for local fishermen who catch numerous different species of fish in and around the estuary.

ARCHEOLOGICAL RESOURCES

9. The National Register of Historic Places lists no structures, places or items of historical significance in the area of proposed work or in areas immediately adjoining the work area. It appears likely that the Stono and Folly Rivers were used by aborigines prior to settlement in the area by Europeans. Due to the proximity of Charleston and the reliance on water-based transportation from colonial times to the 20th century, the two rivers were probably used extensively during this period.

10. Wrecks or abandonments of vessels have probably occurred in the planning area; however, due to the shifting nature of the channels involved, it is highly unlikely that dredging to a depth adequate for use as a borrow area - ten to twelve feet below MLW - would cause the loss of significant archeological resources. The migration of the

natural channel has scoured, redeposited and rescoured the area numerous times to a depth greater than that which would be accomplished by dredging a borrow area in Folly River, Stono Inlet, or Lighthouse Inlet. This scouring action has probably eroded any wooden structures away and metal objects would have settled to the bottom of the channel and been reburied.

11. In spite of the small chance of any cultural resources being located in the shifting sands of the project area and the sanitary facility sites, a documentary search and a magnetometer survey will be performed for the area prior to construction. If the search and survey provides evidence that historically significant resources are present in areas which would be affected by construction, work in these areas would be delayed so that any significant resources or data may be recovered.

SUMMARY OF NATURAL RESOURCES

12. In short, the major natural resources of the study area are: a temperate climate; topography and soil conducive to agriculture and silviculture (which are important to the County but of little significance within the immediate planning area); geologic features such as, a coastal location with sheltered highground areas having access to the ocean via navigable rivers; the ocean itself harboring abundant biological and mineral resources; long stretches of gently sloped sandy beaches for walking and bathing; and vast expanses of extremely productive saltmarshes which serve as nursery areas for a variety of marine

organisms and in turn supports large commercial and recreational fisheries.

Human Resources

POPULATION

13. Historically, Charleston County has been the most populous county in the state. However, in the past decade both Richland and Spartanburg Counties in the upcountry have come to be about equal in population to that of Charleston County.

14. The population in Charleston County has grown from 216,382 in 1960 to 247,650 in 1970 and 260,400 in 1975. This population is expected to reach 271,000 by 1980. At the same time, the James Island Division has grown from 13,872 in 1960 to 24,197 in 1970, 25,525 in 1975 and is expected to reach 28,090 in 1980. The population of Folly Island has been more stable. In 1960, there were 1,137 permanent residents of Folly Beach; in 1970, there were 1,157 persons and in 1975, the population was 1,500.[1/]

15. It is estimated that Folly Island's resident population increases to about 4,500 persons during the summer months and on peak weekend days, visitors to this island may exceed 30,000. The beaches of the entire Charleston area receive about 3,000,000 visits each year.

1/ Provided by Berkeley-Dorchester-Charleston Council of Governments.

EDUCATION

16. Based on 1970 census, the median school year completed by the 25-year and older segment of the study area was 11.8. This was slightly better than the state average. There are numerous institutions offering post secondary education in the area. The Medical University of South Carolina is located in Charleston and besides offering technical education and health services, the Medical University complex is the third largest employer in the County. The College of Charleston offers liberal arts education and some graduate programs. Liberal arts programs are also offered at the Baptist College at Charleston. The Military College of South Carolina, The Citadel, offers liberal arts plus an excellent Engineering curriculum. Trident Technical College offers associate degrees in many technical disciplines.

Development and Economy

17. The Federal Government is the largest employer in the area. Other economic activities are recreation and tourism, shipping and trade related activities, education, fisheries, silviculture and agriculture. Recreation, tourism and fisheries activities provide the majority of employment opportunities in the immediate planning area.

18. Unemployment in Charleston County was on the increase during the early 1970's due in part to a general recession and reduced Military and Govern-

ment spending in the area. However, in recent years the percentage of Charleston County residents who are employed has been increasing. It is locally hoped that increased activity in the tourism, trade and educational areas will replace the reduced military generated employment and continue this downward trend in unemployment. Increased recreational use of the beach area would provide more secure employment for those already employed in this sector, and there would be some potential for increased employment due to the improvement of Folly's shoreline.

PROJECTED POPULATION, EMPLOYMENT, AND INCOME

19. An indication of historical and projected future growth in population, per capita income, and employment in the study area is given in Table B-1. It should be noted that the immediate planning area is extremely small in comparison to the entire Charleston Metropolitan Area and is much more heavily dependent on recreation, tourism and fisheries than the larger demographic area covered in Table B-1.

ECONOMY OF THE IMMEDIATE PLANNING AREA

20. The Town of Folly Beach's economy is based on the sea, shore and surrounding estuary natural resources. As a summer resort, it caters to modest income vacationers and day visitors who come, mostly from nearby, to enjoy the water based recreation and entertainment available there. Typical diversions are: swimming and surfing along the island's 6-mile shore; fishing and boating in the

TABLE B-1

POPULATION, INCOME, AND EMPLOYMENT
FOR CHARLESTON SMSA[1]

Item	Year							
	1959	1970	1980	1990	2000	2010	2020	2030
Population	[illegible]	[illegible]	[illegible]	421,0[illegible]	[illegible]	477,500	497,500	515,200
Total Personal Income (Thousands of 1967 Dollars)	[illegible]	[illegible]	1,497,[illegible]	[illegible],121,400	[illegible]	4,358,100	[illegible]	7,475,500
Per Capita Income (1967 Dollars)	1,641	2,700	3,[illegible]	5,039	[illegible]	9,127	11,600	14,510
Total Employment	94,533	127,950	161,800	175,500	196,900	210,900	213,500	221,500
Employment To Population Ratio	0.34	0.38	0.42	0.42	0.43	0.44	0.43	0.43
Total Earnings:	388,437	744,13[illegible]	1,252,400	1,745,900	2,518,900	3,485,600	4,586,700	5,30[illegible]
Government	159,244	247,346	[illegible]	720,600	1,012,600	1,390,300	1,839,300	2,362,200
Manufacturing	59,229	121,892	205,400	284,600	395,500	526,300	644,[illegible]	767,700
Wholesale and Retail Trade	57,343	1[illegible],107	161,500	218,200	306,600	414,800	527,[illegible]	649,600
Services	41,924	[illegible],284	170,300	263,600	418,6[illegible]	637,900	892,[illegible]	1,240,176

[1] Charleston SMSA consists of Berkeley, Charleston, and Dorchester Counties. The data is generally from Summary of Projections of Economic Activity in the Southeastern States (Series E Population), October 1976, U.S. Army Corps of Engineers, South Atlantic Division.

surrounding waters; and dining on local seafood available at the numerous restaurants in the vicinity. Nearly all local employment and income is derived from these visitors, who may number as many as 30,000 on a peak summer day.

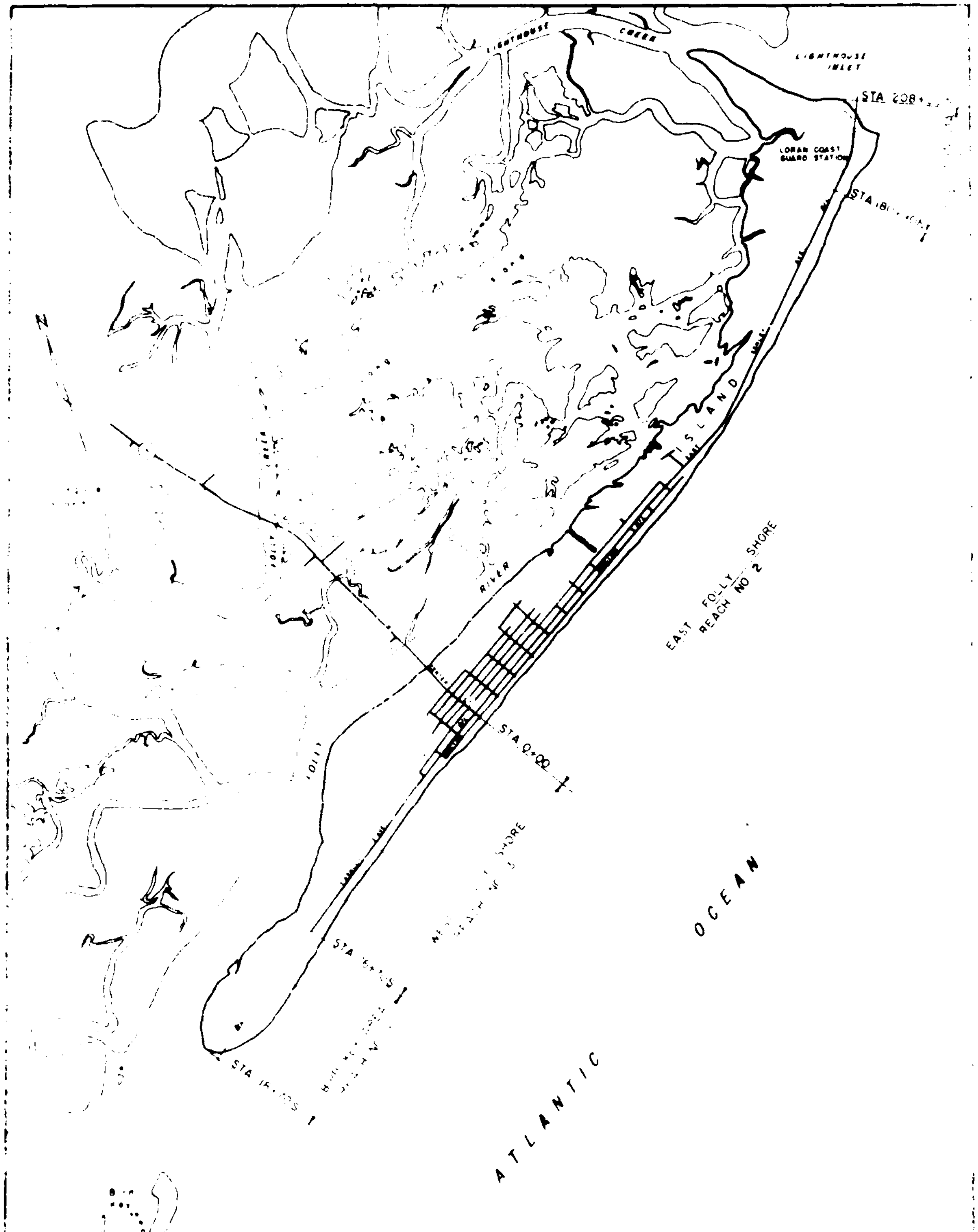
21. Folly Beach's amusement area, about 8 acres in the center of the island, was purchased in February 1978 by a church group intent on changing the character of recreation offered to the public at this facility. They plan to restore the storm damaged fishing pier to its original 600-foot length. The pavilion and boardwalk will be repaired and the dance pier, which recently burned, will be redecked. Tennis and basketball courts, a swimming pool, and a waterslide will be added to the attractions. Local leaders believe that the redirection of recreational opportunities at the central amusement area will increase and refine its clientele to the benefit of the entire community.

LAND USE ANALYSIS

22. Within the Town of Folly Beach, there are approximately 1500 acres of land, half of which is marshland. Of the 750 acres of high ground within the corporate town limits, 327 acres remain undeveloped leaving about 420 acres of developed land. Residential usage is made of 204 acres or about half of the presently developed land. Of the 1,329 housing units, most (80%) are single family cottages. Only one third of these units are occupied on a year-round basis. This bears witness to the resort nature of this shore community.

23. The second largest category of land use on Folly Island is transportation rights-of-way. The town has a roadnet that occupies 120 acres of land. Commercial properties occupy only about 20 acres and consist mostly of retail establishments, such as grocery stores, filling stations, restaurants and arcades, located in the central portion of the island.

24. On the northeast end of the island, the U. S. Coast Guard occupies 32 acres from which it operates electronic aids to navigation (Loran Station). The southwest end of the island is presently undeveloped. This 190 acre parcel is a narrow recurved spit which consists of a mile long primary and secondary dune system backed by maritime thicket, salt marsh and the Folly River. Only 55 acres of this land lies above mean high water. Southwest of this end of Folly Island, across a series of sand flats, lies an extremely small sand island, Bird Key, which serves as a rookery for several species of shore birds.



GENERAL MAP
FOLLY ISLAND
SOUTH CAROLINA

REV 28 MAR '80 FIGURE B

SECTION C

PROBLEMS AND NEEDS

PROBLEMS AND NEEDS

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SECTION C

PROBLEMS AND NEEDS

1. This section of Appendix 1 discusses the problems and needs to which this study addresses itself. It discusses natural forces, such as winds, waves, and tides, and their influences over the movements of sand along the beach. Storms are also discussed and storm damage information is given. The beach problems are then discussed, both in terms of physical damage and recreational needs. Lastly, improvements desired by local interests are discussed.

Natural Forces

WINDS

2. A study of recorded and possible wind speeds, duration and direction was made to determine their effects on the wave characteristics in the Folly Beach area. Wind generated waves are the

primary cause of material losses from the beaches. The height and force of waves likely to be experienced are factors critical to the design of shore protection structures.

3. Wind data recorded at the National Weather Service at Charleston, South Carolina, have been compiled for the 58-year period 1918-1974 (see Table C-1). The coastline in the study area is exposed to onshore and alongshore winds from northeast through east, southeast, and south to southwest. Winds from the northeast through east to southeast move over practically unlimited fetches of the Atlantic Ocean. Fetches to the south and southwest are limited but that to the south still is extensive. The wind data indicate that the stronger winds have a northerly component. Considerable transport of sand takes place during periods of high wind causing dunes to form and at times sand to be deposited in streets where it must be removed. The following table shows the average velocity and percent of the time winds occur from the eight points of the rose.

Table C-1
AVERAGE WIND SPEED AND DIRECTION

Direction	Speed in Miles Per Hour	Percent Occurrence
N	9.9	15.9
NE	10.8	13.0
E	10.3	9.5
SE	9.1	8.0
S	9.4	16.3
SW	9.8	17.0
W	9.4	12.0
NW	9.3	7.4
Calm	0	0.9

WAVES AND LITTORAL PROCESSES

4. Waves and currents are important considerations in the planning of shore protection methods and ways by which shore erosion might be controlled. Waves and currents supply the necessary forces to move littoral materials. The mechanics of littoral transport are not precisely known, but it may be generally stated that littoral material is moved by one of three basic modes of transport:

a. Material known as "littoral drift", moved along the foreshore in a saw toothed or zig-zag path due to uprush and back-wash of obliquely approaching waves.

b. Material moved principally in suspension in the surf zone by long shore currents and the turbulence of breaking waves.

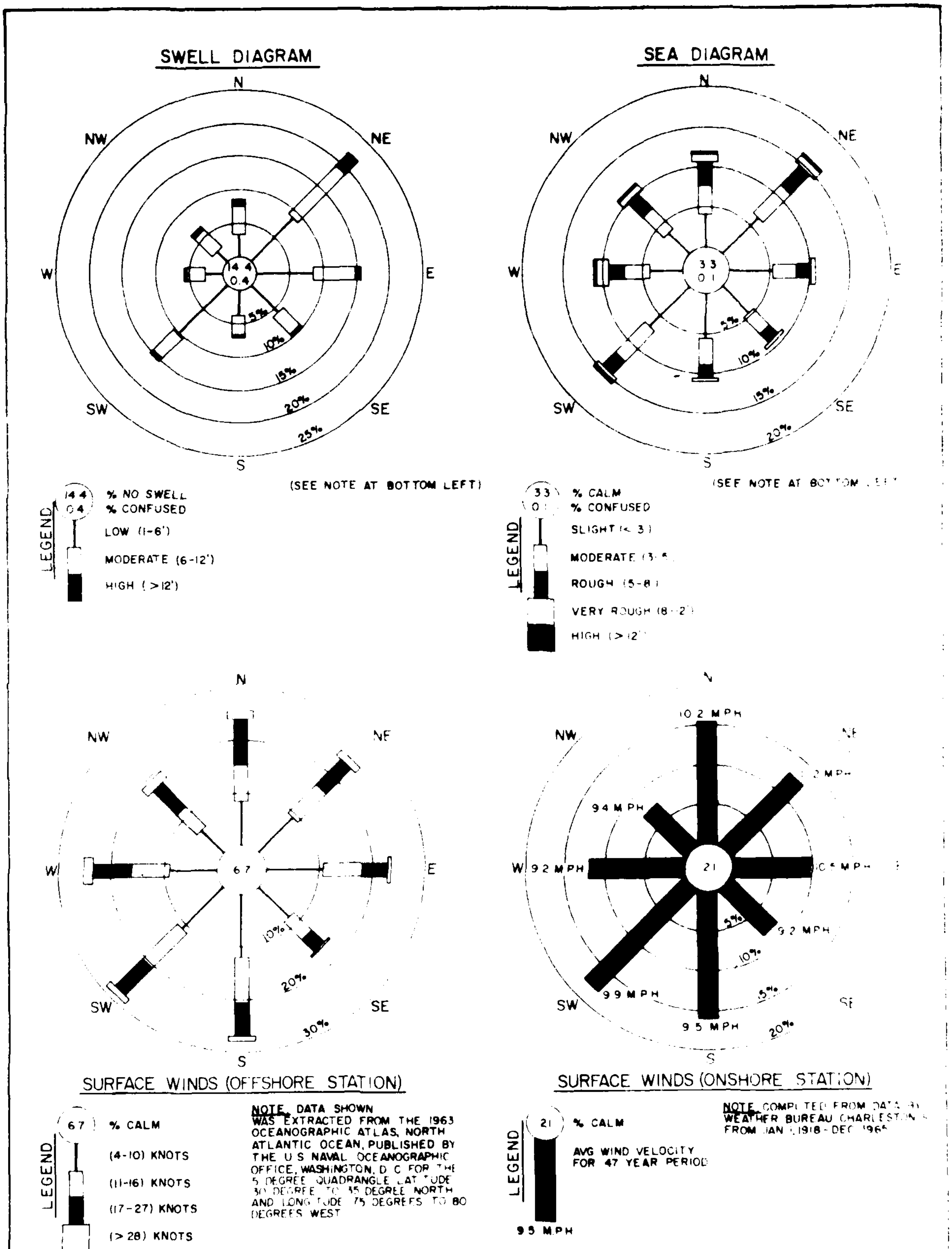
c. Material, known as bedload, which is moved close to the bottom by sliding, rolling, and saltation, within and seaward of the surf zone by the oscillating currents of passing waves.

Regardless of the mode of transport, the direction and rate of littoral transport depend primarily upon the direction and energy of waves approaching the shore. Exceptions exist on short stretches of shore adjoining tidal inlets where the tidal currents may be dominant.

5. While within the area in which they are generated, waves are referred to as "wind waves" or "sea". As they pass out of the stormy area in which they are generated, the "sea" becomes known as "swell", and such waves gradually diminish in height and steepness (ratio of wave height to wave length). As swells, waves may traverse great stretches of open ocean without much loss of energy. When they reach the shoal waters of the continental shelf, the wave fronts are bent until they almost parallel the shoreline. The irregular waves of deep water are organized by the effect of the bottom into regular lines of crests moving in the same direction at similar velocities. The depth continues to decrease until finally in very shallow water it becomes impossible for the oscillating water particles to complete their orbits. When the wave breaks the momentum carries the broken water onward until the waves' remaining energy is expended on the sandy beach face.

6. Wave data. Sea, swell and wind diagrams for the area offshore of Folly Island extracted from charts prepared by the U. S. Navy Oceanographic Office (Oceanographic Atlas of the North Atlantic Ocean, Section IV Sea and Swell, 1963), are shown on Figure C-1. The sea and swell diagrams indicate that waves of all magnitudes approach more frequently from the northeast quadrant. Wave period and breaker height data were taken from the Coastal Engineering Research Center (CERC) wave gauge at Savannah Light Tower.

7. Littoral transport. Under a contract with the Corps of Engineers, the South Carolina coastline surrounding Folly Beach was



SEA, SWELL AND WIND DIAGRAMS

FIGURE

modeled using the computer program WAVNERG to determine rates of littoral transport. The report prepared by Dr. Frank W. Stapor, Jr. of the Marine Resources Institute is presented as Attachment C-1. Model-predicted areas of erosion and deposition generally agree with annual rates determined from other methods. The following conclusions were derived from the model results.

a. Littoral transport is northeasterly along all of Folly Island from Stono Inlet region to Lighthouse Inlet with annual amounts varying between 5,000 cubic yards to 20,000 cubic yards.

b. No net littoral transport is taking place in the Stono Inlet region between Folly and Kiawah Islands.

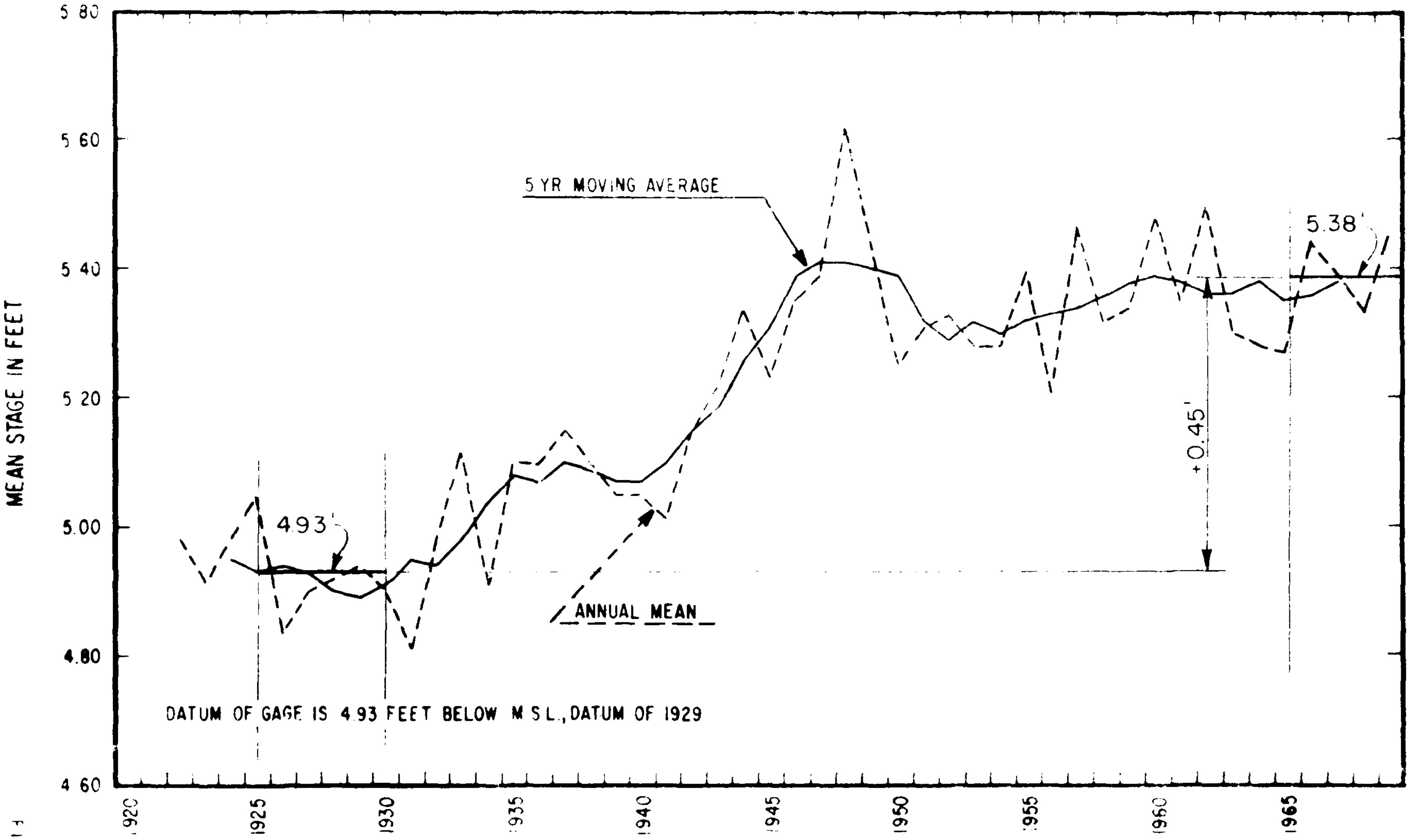
c. The southernmost Folly Island beach is experiencing net erosion at a maximum rate of 14,000 cubic yards per year. Nearly half of this amount is deposited on the beaches lying northward up to 12th Street East, or at the "bend" in the shoreline. Net erosion begins again from that point to the United States Coast Guard Station with a maximum rate of 20,000 cubic yards per year. Deposition begins again at the Coast Guard Station and continues north to the southwestern border of Morris Island, across Lighthouse Inlet with a maximum deposition rate of 14,000 cubic yards per year. Sand is also moving in the inlet region from the northeast with Folly Island suffering a net loss of 5,000 cubic yards per year to Morris Island.

d. Lighthouse Inlet can be seen to be a major deposition site receiving sand moving both to the northeast and southwest. This may help account for the permanence of this shoal system in the fact of significant landward retreat of the adjacent part of Morris Island.

e. The Charleston Harbor jetties do influence littoral processes on the northern half of Morris Island but probably do not affect Folly Island.

8. Proposed works for the reduction of shoaling in Charleston Harbor, in which waters entering Cooper River from the Santee River will again be channeled through the lower reaches of the Santee River, should have an insignificant effect on the quality and quantity of materials moving within the littoral zone. Likewise, future engineering works provided for the purpose of stabilizing shorelines to the north and possible future deepening of channels in Charleston Harbor should have little effect on the littoral regimen off Folly Island.

9. Sea level rise. In connection with the tidal action in the vicinity of the problem area, possible erosion of the shoreline as a result of the gradual rise of mean sea level elevation should be recognized. At Charleston, South Carolina, the average sea level elevation was 4.93 feet gage datum for the five-year period 1925-1930 (see Figure C-2). The average sea level now is about 5.38 feet



CHANGES IN SEA LEVEL
CHARLESTON, S. C.
(CUSTOM HOUSE DOCK)

FIGURE

gage datum, an increase of 0.45 feet. This rise in sea level is a contributing factor to the recession of shoreline at Folly Beach with about 10 to 15 feet of erosion occuring as a result of this rise. This factor is contained in the observed shoreline changes which were used to compute design erosion rates.

10. There have been numerous technical reports on sea level rise published in recent years documenting the fact that the sea level is rising slowly and irregularly. Among these are:

a. Per Brunn, W.H.M., (1962), Sea-Level Rise as a Cause of Shore Erosion: Engineering Progress at the University of Florida, Leaflet No. 152, Gainesville, FL., (Also published as ASCE paper 3065, February, 1962, 117-130)

b. U. S. National Ocean Survey, (1973), Trends and Variability of Yearly Mean Sea Level (1893-1971), NOAA Technical Memorandum Nos. 12, Rockville, MD.

c. King, C.A.M., Beaches and Coasts, (1972), 2 Ed., St. Martin's Press, New York.

TIDES AND TIDAL CURRENTS

11. Tides. Tides in the vicinity of Folly Beach are semi-diurnal; that is, there are two highs and two lows in a tidal (or lunar) day. National Ocean Survey Tide Tables give the following Mean and Spring Ranges of Tide:

	Mean Range (ft)	Spring Range (ft)
Folly Beach, outer coast	5.2	6.1
Folly River (behind Folly Beach)	5.4	6.4

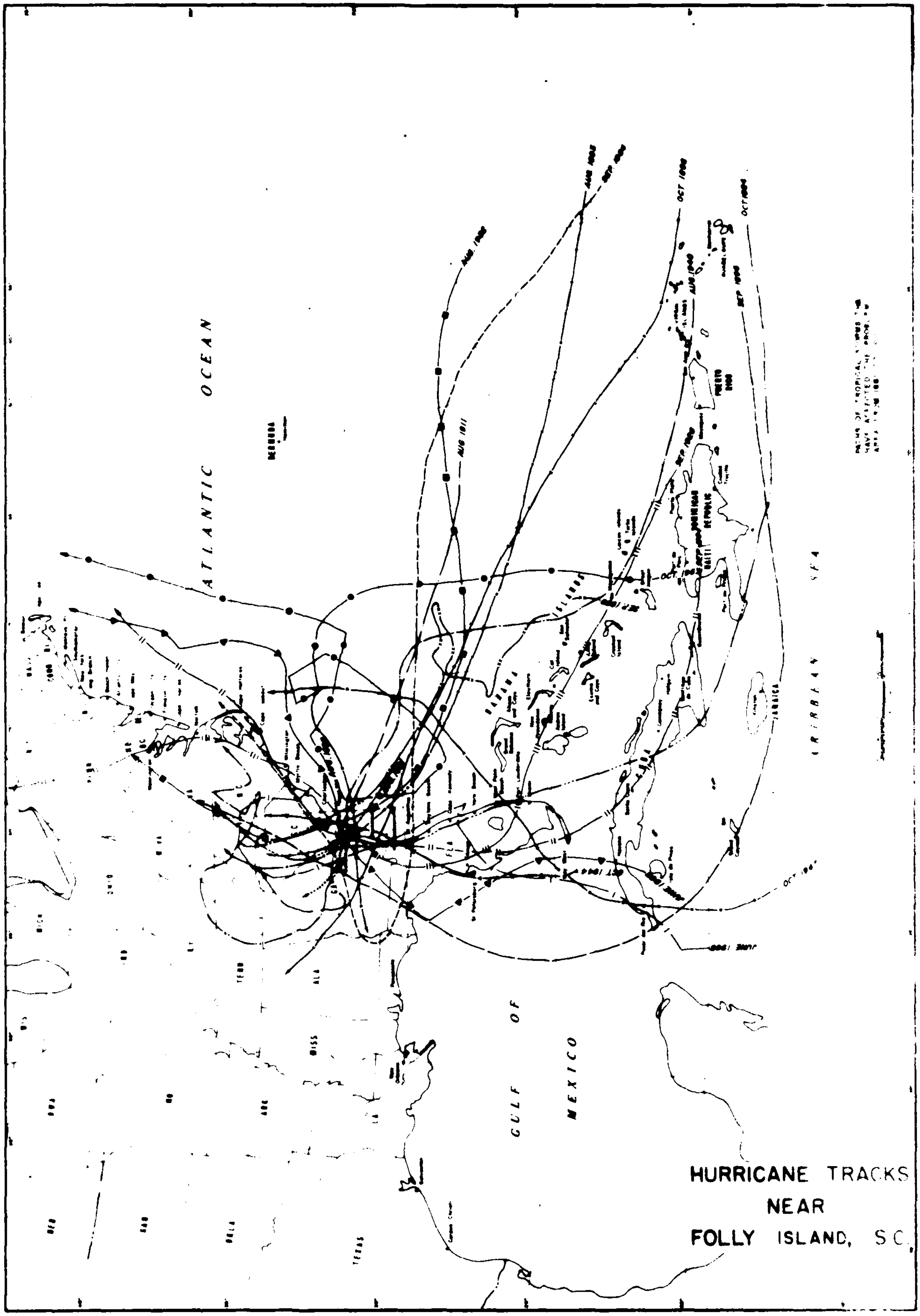
12. Tidal currents. Tidal Current Tables of the National Ocean Survey give tidal current velocities in knots for a number of nearby locations. These velocities can be altered considerably by local winds. Several of these are in the vicinity of the Charleston Harbor Jetties just north of Folly Beach. In the entrance channel between the jetties maximum flood and ebb velocities are 1.8 knots; at the break in the south jetty the maximum flood current velocity is 1.2 knots directed towards true north, while the maximum ebb current velocity is 2.8 knots, directed S 15° W. These tidal currents in the vicinity of Charleston Harbor are also shown graphically in the Coast and Geodetic Survey publication entitled "Tidal Current Charts, Charleston Harbor, S. C.", first published in 1967. To the south of Folly Beach, in Stono Inlet, the maximum flood and ebb velocities are 1.9 and 2.7 knots, respectively. The offshore tidal currents are rotary, ranging from 0.1 to 0.3 knots, and are given for (1) Whistle Buoy 2C at the harbor entrance, (2) 2 miles east of Folly Beach, and (3) 3.5 miles east of Folly Beach.

STORMS AND STORM FREQUENCY

13. A hurricane is a well-developed cyclonic storm, usually of tropical origin. Hurricane characteristics are violent, counter-clockwise winds, producing tremendous waves and surges and torrential rainfall. Size and duration vary with each hurricane. They generally extend over thousands of square miles, reach a height of 30,000 feet or more, and last about 9 to 12 days from origin to dissipation.

14. Origins and tracks. Hurricanes originate exclusively in the shifting zone of equatorial calms called the "doldrums" which lies between the two trade wind systems. Early in the hurricane season, June to July, there is a tendency for the storms to develop in the western Caribbean Sea, while late in the season, September and October, storms are more likely to develop in the Atlantic Ocean. While still in the initial stages of development, the storms are affected by the trade winds and begin to move toward the west or northwest. In the vicinity of 30^{o} N. latitude, they recurve and begin to move in a northeasterly direction at an accelerated speed. This is only a very general path that hurricanes follow and actually there are many deviations. Hurricanes have been known to circle back and cross over their paths. See Figure C-3 for hurricane tracks near Folly Island, S. C.

15. Barometric pressure and winds. Normal barometric pressures in the tropics are about 30 inches of mercury, whereas the pressures recorded in hurricane centers range between 27 and 29 inches or sometimes even lower. The wind system of a hurricane follows a counterclockwise circular pattern with the wind direction deflecting about 30^{o} inward toward the center of the storm. At the outer limits of the storm, the winds are light to moderate; at about 35 miles from the center, they reach a maximum 5-minute average velocity of about 100 m.p.h. although higher averages have occurred. Gusts as high as 190 m.p.h. have been reported. At the center, winds are relatively calm. This calm area, called the "eye" of the storm, ranges between 7 and 20 miles in diameter. The point of lowest barometric pressure is located in the vicinity of or within the eye. The lowest recorded



HURRICANE TRACKS
NEAR
FOLLY ISLAND, S.C.

FIGURE C 3

barometric pressure for hurricanes occurring along the Atlantic Coast is 26.35 inches. This measurement was recorded at 33^{o} N. latitude in 1935.

16. Hurricane surge. The hurricane surge or storm tide which inundates low coastal lands is the most destructive of the hurricane characteristics. It alone accounts for three-fourths of the lives lost from hurricanes. It is the product of meteorological and beach, shore and inland topographic conditions. All other factors being equal, a higher surge will be produced if the hurricane path is perpendicular to shore, the velocity of forward movement is fast, or the diameter of the storm is very large. Along the Atlantic Coast, a major component affecting the height of the hurricane surge is the timing of the storm's landfall and the predicted astronomical tide. At Folly Beach, a storm arriving at the time of the predicted high tide can produce a surge more than five feet higher than if it arrives at low tide. (See paragraph 11 of Section C of this Appendix, Tides.) Maximum surge heights experienced along the Atlantic Coast range between 10 and 20 feet.

17. Hurricane waves. The waves generated by hurricane winds cause extensive damage to shore structures and the adjacent beaches. At sea, the waves are high and turbulent, particularly in the right front quadrant and near the eye of the storm. Near shore, wave heights which have diminished some since origin begin to increase again because of the shoaling effect of the shallow water. Further, breaking waves can run up and overtop shore structures whose crowns are higher than the wave heights. The force expended when waves break causes the most damage to shore structures. Methods for estimating the height

of hurricane waves will be discussed in subsequent paragraphs.

18. Rainfall. Rainfall accompanying a hurricane usually is heavy and sometimes torrential. However, its distribution during the passage of a hurricane is not uniform. The rain may begin long before the arrival of the storm. Prior to the passage of the eye, rainfall generally reaches its maximum rate, and after the eye has passed it ceases almost entirely. Rainfall is particularly heavy in the right front quadrant. Some hurricanes, however, are accompanied by little or no rainfall over considerable lengths of their paths.

The Storm Problem

19. Most hurricanes that affect the South Carolina coast form west of the Antilles, while some form in the Caribbean. In most cases, as these hurricanes approach the Florida and Georgia coasts, they turn northeastward and remain over the ocean before landfall in South Carolina. Others make a limited penetration of the Florida and Georgia mainlands and then move parallel to the southeastern seaboard. The majority of hurricanes pass well offshore of South Carolina and inflict little damage. Figure C-3 shows the paths of some of the hurricanes that have affected the Folly Beach area.

EARLY HURRICANES

20. The earliest recorded hurricane along the South Carolina coast is that of 16 September 1700. It was reported that the streets of Charleston were flooded and a number of settlers perished when their vessels sank in the harbor. The storms of September 1713, September 1728, September 1752, and September 1804, were reported to have caused considerable loss of life and property damage. The hurricane which occurred on 27 August 1813 was described by the Charleston Courier as "one of the most tremendous gales of wind ever felt on our coast and a night of horrors." Torrents of rain accompanied this hurricane, and the tide rose 18 inches higher than in 1804. Extensive damages were reported to have occurred on Sullivans Island, and as many as 15 lives were reported lost.

RECENT HURRICANES

21. Some of the more recent hurricanes that have inflicted damage on the study area are those of 25 August 1885, 27 August 1893, 28 August 1911, 14 July 1916, 18 September 1928, 11 August 1940, 30 August 1952, and 29 September 1959. The 1885 storm cost 21 lives in the Charleston area and inflicted damages estimated at $1,690,000. The 1893 storm cost 1,000 lives and caused property damages of $10,000,000 in South Carolina. Charleston experienced gusts of 120 miles per hour, and a maximum 5-minute velocity of 96 miles per hour. The 1911 storm made landfall between Savannah and Charleston, where wind velocities of 106 miles per hour were recorded. It is reported to have cost 17 lives,

and to have caused damages totaling $1,000,000 in the state. The 1916 storm was of small diameter, and caused little property damage and no loss of life; however, it caused heavy rains and flooding, and there was an estimated $10-$11 million lost in crop damage. The 1928 storm was also notable for its rain, which caused about $2 million damage through flooding, of a total of about $4 million damage to the state.

HURRICANE OF 1940

22. The center of the storm was first observed in the Virgin Islands on the morning of 5 August. During the next 5 days it moved in a generally northwesterly direction over the Atlantic Ocean. It struck the South Atlantic seaboard near Savannah, Georgia, about 4:00 p.m., on 11 August. The lowest barometric reading occurred at Savannah (28.78 inches), while a low of 29.64 inches occurred at Charleston. Maximum 5-minute wind velocities of 73 and 66 miles per hour were recorded at Savannah and Charleston, respectively. Tides ran about 6 feet above normal in the Charleston area. Damage in Charleston was estimated at $1,500,000, mainly due to inundation of the waterfront perimeter. Damage on Sullivans Island was estimated at $116,000, and was caused mostly by wind. Only minor damage was experienced on Isle of Palms.

HURRICANE OF 1959

23. This hurricane, Gracie, the most intense tropical cyclone to enter the southeastern United States since 1954, passed inland near

Beaufort, South Carolina, during the morning of 29 September. The lowest observed pressure in the area was 28.05 inches. A maximum 5-minute wind speed of 97 miles per hour, and wind gusts of 138 miles per hour were recorded. The highest tide at Charleston was about 6.0 feet above mean sea level. This represented something in excess of an 8-foot surge, and it is fortunate that it occurred within an hour of the predicted low tide. Damages from wind were extremely heavy. Many roofs were blown off, or damaged by trees broken and blown down by the wind. Damages were estimated at $73 million in South Carolina and $7 million of this amount was estimated for Charleston County, within which the study area lies.

SYNTHETIC STORMS

24. Parameters for certain synthetic storms and methods for derivations of others are contained in Report No. 33, Meteorological Considerations Pertinent to Standard Project Hurricane, Atlantic and Gulf Coasts of the United States and Memorandum HUR7-120, Revised Standard Project Hurricane Criteria for the Atlantic and Gulf Coasts of the United States. A Standard Project Hurricane (SPH) is one that may be expected from the most severe combination of meteorological conditions that are considered reasonably characteristic of the region. The general SPH that is considered characteristic of the South Carolina coast corresponds to one having a frequency of once in 100 years for a zone having north and south boundaries at approximate latitudes 33° N. and 27° S., respectively and west and east boundary paralleling the Atlantic coastline 50 miles inland and 150 miles offshore. The specific SPH used in

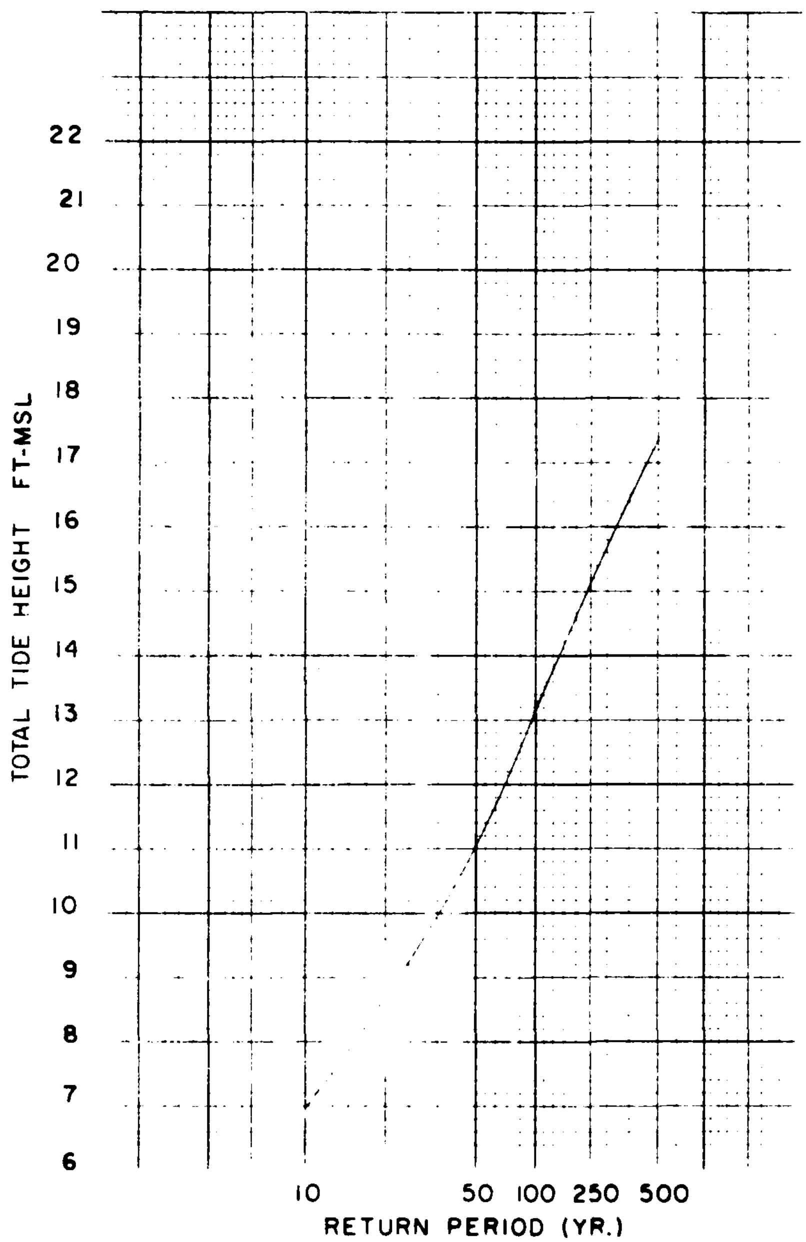
this study has a central [illegible] of 27.46 inches of mercury, a maximum over water wind [illegible] m.p.h., at a radius to maximum winds of 30 nautical miles and a forward speed of 11 knots. The parameters for SPH as well as [illegible] for other synthetic storms having different frequencies were used to estimate hurricane waves at Folly Beach. The method is discussed in paragraph 26.

STORM TIDE FREQUENCIES

25. The National [illegible] Administration (NOAA) has at the request of the [illegible] Administration (FIA) developed estimates of storm tide [illegible] the South Carolina coast. Figure [illegible], which was [illegible] NOAA Technical Report NWS-16 entitled "Storm [illegible] South Carolina Coast", June 1975, show the tidal [illegible] applicable to the Folly Beach Study. As can be [illegible] 100-year storm surge at Folly Beach is 13.2 feet [illegible]. This stage along with the 50-year frequency storm surge were [illegible] the proposed hurricane protection plans for Folly Beach.

DESIGN WAVES

26. Techniques for predicting the deepwater significant wave height and period for various synthetic storms are outlined in Paragraph 3.73, Volume I of the Shore Protection Manual, 1977. In applying the technique, various storm parameters including CPI, radius to maximum wind, and the forward speed are required. The parameter for storms approaching



NOTE: CURVE REPRODUCED FROM NOAA TECHNICAL REPORT MWS-16 "STORM TIDE FREQUENCIES ON THE SOUTH CAROLINA COAST" JUNE 1975

TIDAL STAGE-FREQUENCY
FOLLY BEACH, S.C.

FIGURE C-4

the South Carolina coast were obtained by methods discussed in Paragraph 24, Synthetic Storms. At sea, the waves in a hurricane are high and turbulent. As these waves propagate shoreward their heights and period are modified by the effects of shoaling and refraction. Tables C-2 and C-3 show the computed deepwater wave heights and period for the SPH and the 50 year frequency hurricane. In applying the method, offshore depths were taken from Coast and Geodetic Survey Chart number 1239. For each Synthetic Storm, the total depth along the range was obtained by converting the mean low water depths to mean sea level and to this depth adding the incremental storm surge. For each of the Synthetic hurricanes, stage frequencies were taken from the stage frequency curve shown on Figure C-4. The source of this curve was discussed in Paragraph 25. It should be noted that the 100 year stage at Folly Beach, S. C. (13.2 Ft. MSL) was used in conjunction with the (SPH) storm parameters to compute the design waves for the 18-foot high dune plan.

WAVE RUN UP

27. General wave runup on a protective structure depends on the characteristics of the structure (i.e., shape and roughness), the depth of water at the structure, and the wave characteristics. The vertical height to which water from a breaking wave will run up on a given protective structure determines the top elevation to which the structure must be built to prevent wave overtopping and resultant flooding of the area to be protected. Wave runup is considered to be the ultimate height to

Table C-2

COMPUTATIONS FOR WIND WAVES OVER THE CONTINENTAL SHELF
FOLLY BEACH, S. C.
50 Year Hurricane Surge

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
X	d_x MLW	d_1	d_2	$\bar{d}_T$	F_e	H_o	T_o	$\frac{T_o^2}{\bar{d}_T}$	K_s	A	K_f	H_o'	F_e'	T_o'	$\frac{T_o'^2}{d_2}$	K_{s2}	H	N	H_{max}
65	420	777	423	600	74.59	39.39	13.4	.297	.998	.033	1.00	39.38	74.59	13.4	.422	.987	38.9	734	70.6
60	270	423	273	348	74.59	39.4	13.4	.513	.973	.096	.999	39.34	74.44	13.4	.653	.949	37.3	735	67.8
55	222	273	225	249	74.59	39.4	13.4	.717	.939	.181	.993	39.1	73.5	13.3	.79	.931	36.4	737	66.1
50	186	225	189	207	74.59	39.4	13.4	.863	.925	.260	.986	38.8	72.5	13.3	.93	.921	35.8	740	65.0
45	114	189	117	153	74.59	39.4	13.4	1.17	.913	.470	.965	38.0	69.5	13.2	1.47	.916	34.8	747	63.3
40	96	117	100	108	69.5	38.0	13.1	1.60	.920	.911	.90	34.2	56.3	12.5	1.55	.918	31.4	788	57.3
35	90	100	95	97	56.3	34.2	12.5	1.60	.920	1.020	.89	30.4	44.6	11.7	1.45	.916	27.8	835	51.1
30	78	95	84	89	44.6	30.4	11.7	1.55	.918	1.070	.89	27.1	35.3	11.1	1.46	.916	24.8	885	45.7
25	60	84	67	75	35.3	27.1	11.1	1.64	.920	1.350	.855	23.2	25.8	10.2	1.57	.919	21.3	958	39.4
20	45	67	54	60	25.8	23.2	10.2	1.75	.925	1.810	.80	18.5	16.5	9.2	1.56	.919	17.0	1070	31.8
15	43	54	53	53	16.5	18.5	9.2	1.58	.919	1.840	.81	15.0	10.8	8.2	1.28	.913	13.7	1190	25.8
10	41	53	53	53	10.8	15.0	8.2	1.28	.913	1.480	.87	13.0	8.2	7.7	1.12	.914	11.9	1276	22.5
5	32	53	45	49	8.2	13.1	7.7	1.21	.913	1.510	.875	11.4	6.3	7.2	1.15	.913	10.4	1363	19.8
0	0	45	14	29	6.3	11.4	7.2	1.79	.926	3.830	.65	7.43	2.7	5.8	2.41	.953	7.0	1690	13.7

Explanation of symbols: (See next page)

Explanation of symbols:

Column No.	Symbol	Definition
1	x	Distance from shoreline in nautical miles
2	d_x	Depth at shoreward end in feet, MLW
3	d_1	Depth at the beginning of section
4	d_2	Water depth at shoreward end of section
5	$\overline{d}_T$	Average of d_1 and d_2
6	F_e	Effective fetch in nautical miles
7	H_o	Deepwater significant wave height in feet
8	T_o	Deepwater significant wave period
10	K_s	Shoaling coeficient
11	A	Friction loss parameter
12	K_f	Friction factor
13	H_o'	Equivalent deepwater wave height
14	F_e'	Equivalent effective fetch length
15	T_o'	Deepwater significant wave period corresponding to H_o'
17	K_{s2}	Friction factor at location 2
18	H	Wave height in feet
19	N	Total number of waves applicable to significant wave
20	H_{max}	Maximum wave height in feet

Table C-3

COMPUTATION FOR WIND WAVES OVER THE CONTINENTAL SHELF
FOLLY BEACH, S. C.

100 Year Hurricane Surge

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
X	d_x MLW	d_1	d_2	$\bar{d}_T$	F_e	H_o	T_o	$\frac{T_o^2}{d_T}$	K_s	A	K_f	H_o'	F_e'	T_o'	$\frac{T_o'^2}{d_2}$	K_{s2}	H	N	H_{max}
65	420	777	423	600	76.3	42.2	13.84	.319	.997	.035	1.000	42.2	76.3	13.84	.452	.982	41.4	709	75.1
60	270	423	273	348	76.3	42.2	13.84	.55	.965	.102	.998	42.1	76.0	13.82	.70	.942	39.7	710	71.8
55	222	273	225	249	76.3	42.2	13.84	.77	.934	.193	.992	41.8	75.0	13.80	.84	.927	38.8	712	70.3
50	186	225	189	207	76.3	42.2	13.84	.92	.921	.275	.983	41.5	73.7	13.72	.995	.917	38.0	715	68.9
45	114	189	118	153	76.3	42.2	13.84	1.25	.913	.500	.955	40.3	69.6	13.5	1.55	.918	37.0	726	67.1
40	96	118	101	109	69.6	40.3	13.5	1.68	.922	.950	.890	36.2	56.2	12.8	1.63	.920	33.3	767	60.7
35	90	101	96	98	56.2	36.2	12.8	1.68	.922	1.060	.880	31.9	43.5	12.0	1.51	.917	29.2	816	53.5
30	78	96	85	90	43.5	31.9	12.0	1.60	.920	1.100	.885	28.2	34.1	11.3	1.50	.917	25.9	868	47.5
25	60	85	68	76	34.1	28.2	11.3	1.68	.922	1.340	.850	24.0	24.6	10.4	1.60	.920	22.0	941	40.8
20	45	68	55	61	24.6	24.0	10.4	1.78	.926	1.810	.800	19.2	15.7	9.3	1.58	.919	17.6	1052	32.8
15	43	55	55	55	15.7	19.1	9.3	1.58	.919	1.770	.810	15.5	10.3	8.4	1.30	.913	14.2	1171	26.6
10	41	55	54	54	10.3	15.5	8.4	1.30	.913	1.480	.870	13.5	7.8	7.8	1.13	.914	12.3	1255	23.4
5	32	54	47	55	7.8	13.5	7.8	1.11	.914	1.240	.905	12.2	6.4	7.4	1.18	.913	11.1	1319	21.1
0	0	47	16	31	6.4	12.2	7.4	1.79	.926	3.570	.670	8.2	2.9	6.1	2.32	.949	7.8	1611	14.9

Explanation of symbols: (See previous page).

which water in a wave ascends on the proposed slope of a protective structure. This condition usually occurs when the surge is at the maximum elevation.

28. In order to compute wave runup on a protective structure, the significant wave height (H_S) and wave period (T) in the vicinity of the structure must be known. They were determined as described in paragraph 26.

29. Wave runup was calculated by use of model study data developed by Savelle and others which relates relative runup (R/H_0'), wave steepness (H_0'/T^2), and relative depth d/H_0'. The method employed is explained in paragraph 7.21 volume II of the Shore Protective Manual. Once the significant wave height (H_S) and wave period (T) are known, the deep water wave length (L_0) can be computed from the following equation:

$$L_0 = 5.12\ T^2$$

The equivalent deepwater wave height (H_0') can then be determined from Table C-1, volume III of the Shore Protection Manual. Table C-1 relates d/L_0 to H/H_0'. Table C-4 lists the wave characteristics used to compute runup for two Hurricane Protection plans considered at Folly Beach.

30. With the terms d/H_0' and H_0'/T^2 known, runup on a protective structure can be computed if the slope of the structure is known. The dune configurations used for the Folly Beach study, see Figure C-5, are comprised of a composite of slopes. In order to use the runup charts in the Shore Protection Manual, the composite slopes must be replaced by

Table C-4

WAVE CHARACTERISTICS - FOLLY BEACH, S. C.

Symbol	Characteristics	50 Yr. Hurricane	100 Yr. Hurricane
H_s	Significant Wave Height (FT)	7.0	7.8
T	Wave Period (SEC)	5.8	6.1
L_o	Deepwater Wave Length (FT)	172	184
d/L_o	Relative Depth	.1686	0.1685
H_s/H_o'	Shoaling Coefficient	.9133	0.9133
H_o'	Deepwater Wave Height (FT)	7.7	8.5
H_o'/T^2	Wave Steepness (FT/SEC^2)	.2288	0.2372

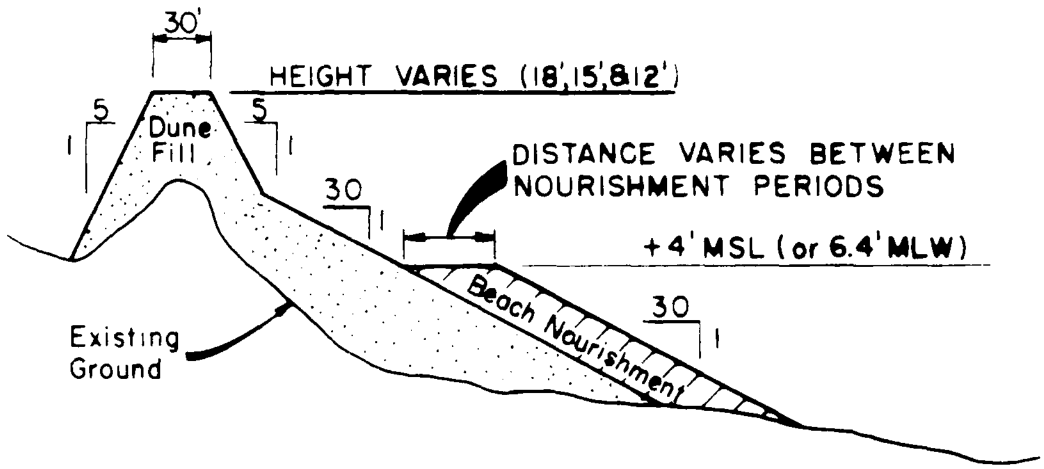
a single hypothetical constant slope. This hypothetical slope is computed by estimating a value of wave runup and then determining the slope of a line from the point where the wave breaks to the estimated point of runup. The breaking point may be located by subtracting the breaking depth d_b from the still water level elevation and extending the elevation horizontally to its intersects with the composite slope. The breaking depth is determined from the following equation:

$$d_b = \frac{0.667\ H_0'}{(H_0'/T^2)1/3}$$

Using the slope of this line, which is the hypothetical slope, a value of runup is determined. If the runup determined is different from the estimated runup, the process must be repeated using a new estimate runup. This process is repeated until the estimated value and the computed value agree. Slopes for the plan 1 and plan 2 beach dunes are designed to prevent overtopping by the significant waves for each of their respective design storms. The equivalent deepwater wave height for smaller breaking waves was also tested to insure that waves smaller than the significant waves would not overtop the design dunes.

HURRICANE PROTECTION PROFILE

31. The hurricane protection profile, shown in Figure C-5, was determined from an estimate of the quantity of material likely to be eroded during the occurrence of the design storms and from estimates of heights of wave runup for different dune and berm dimensions which would prevent wave



**HURRICANE
WAVE RUN UP
BEACH PROFILE MODEL
FOLLY BEACH, S.C.**

FIGURE C-5

overtopping of the dune through the period of maximum design storm tide elevation. The most desirable dimensions are those which provide the lowest practicable dune grade and the widest beach berm fronting the dune. The breaking point of the significant wave was placed approximately 200 feet oceanward of the dune centerline for both dune heights (18 ft. and 15 ft.), so that most of the wave energy will dissipate before reaching the dune. A 12-foot dune project was also analyzed. The artificially created hurricane protection dune, for the most part, will straddle the existing dunes along the present shoreline.

The Beach Erosion Problem

32. Another significant and related problem involves the instability and recession of the beach due to erosion. Stabilization of the shore is needed to protect existing and future development against damage from erosion and to insure the availability of adequate beach for recreational use. Encroachment of the ocean has destroyed both private and public works along most of the ocean shoreline. Homes, roads, erosion control structures, and valuable beach-front lands have suffered severely. Much of the dry beach area also has been lost in recent years.

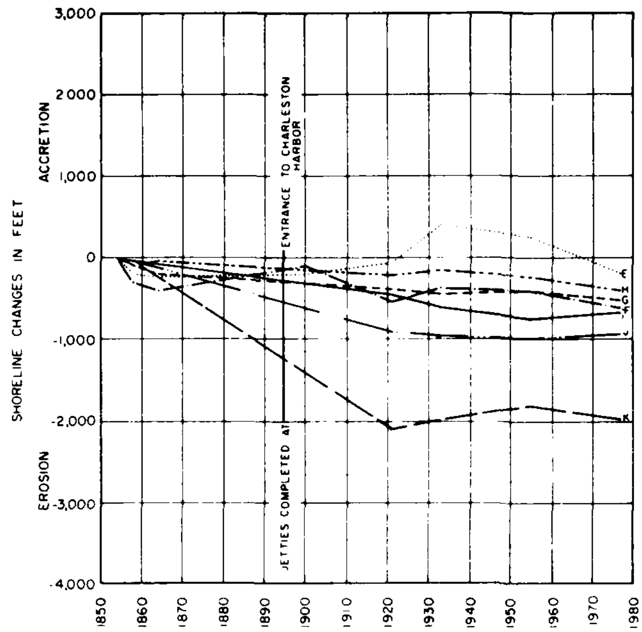
SHORE HISTORY

33. Available Data. Data on shoreline location, land topography and ocean and inlet bathymetry are available from coastal charts of the

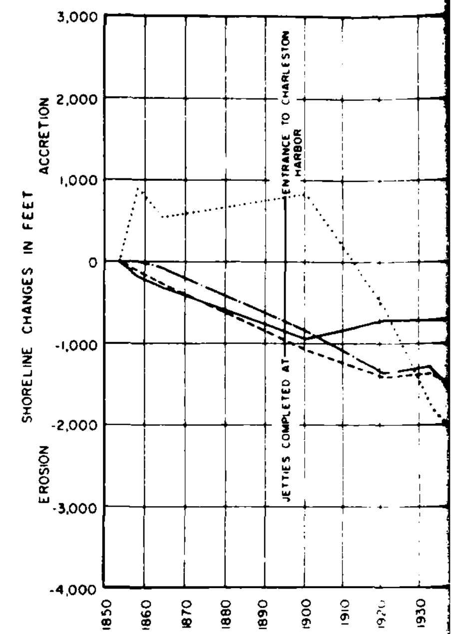
U. S. Coast and Geodetic Survey (now the National Ocean Survey). Comparative analyses of land and bathyometric features, made by the Coastal Engineering Research Center of the Corps of Engineers, were used in the Folly Island analysis. This information was supplemented with data contained in aerial photographs flown in January 1977 by Continental Aerial Surveys, Incorporated, Alcoa, Tennessee for the Charleston District; in the "Beach Erosion Inventory of Charleston County, South Carolina" (S. C. Sea Grant Technical Report No. 4, 1975); and in a letter report prepared by the Charleston District in 1935 entitled "Report on Jetties, Charleston, S. C."

34. Comparative highwater shoreline locations displayed in Figure C-6 allow independent review and analysis of the erosion history of Folly Island. A graphical display is included (mass curves) which facilitates the quantification of erosion rates at four points along the shore of Morris Island and seven points along Folly Island. These same analysis points are used later in predicting future shoreline positions of Folly Island. To facilitate understanding of the erosion problem, the two islands have been divided in reaches. All of Morris Island is considered as a single reach and Folly Island is divided into four reaches of unequal length.

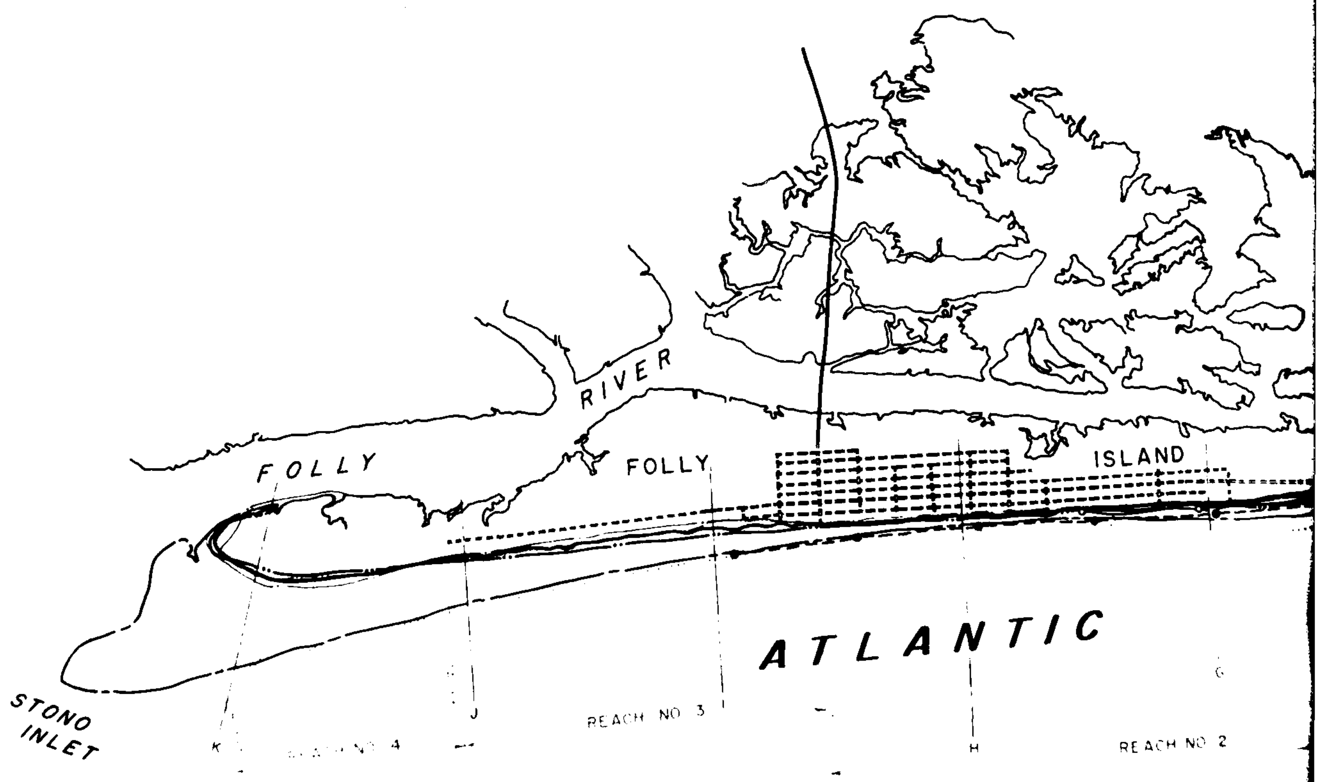
35. Morris Island. An abrupt change in the trend at Morris Island appears to have taken place after jetties protecting the entrance to Charleston Harbor were completed. Before the construction, the mean-high-water shoreline was receding along the northern three-quarters of



SHORELINE CHANGES AT FOLLY ISLAND



SHORELINE CHANGES AT MORRIS I



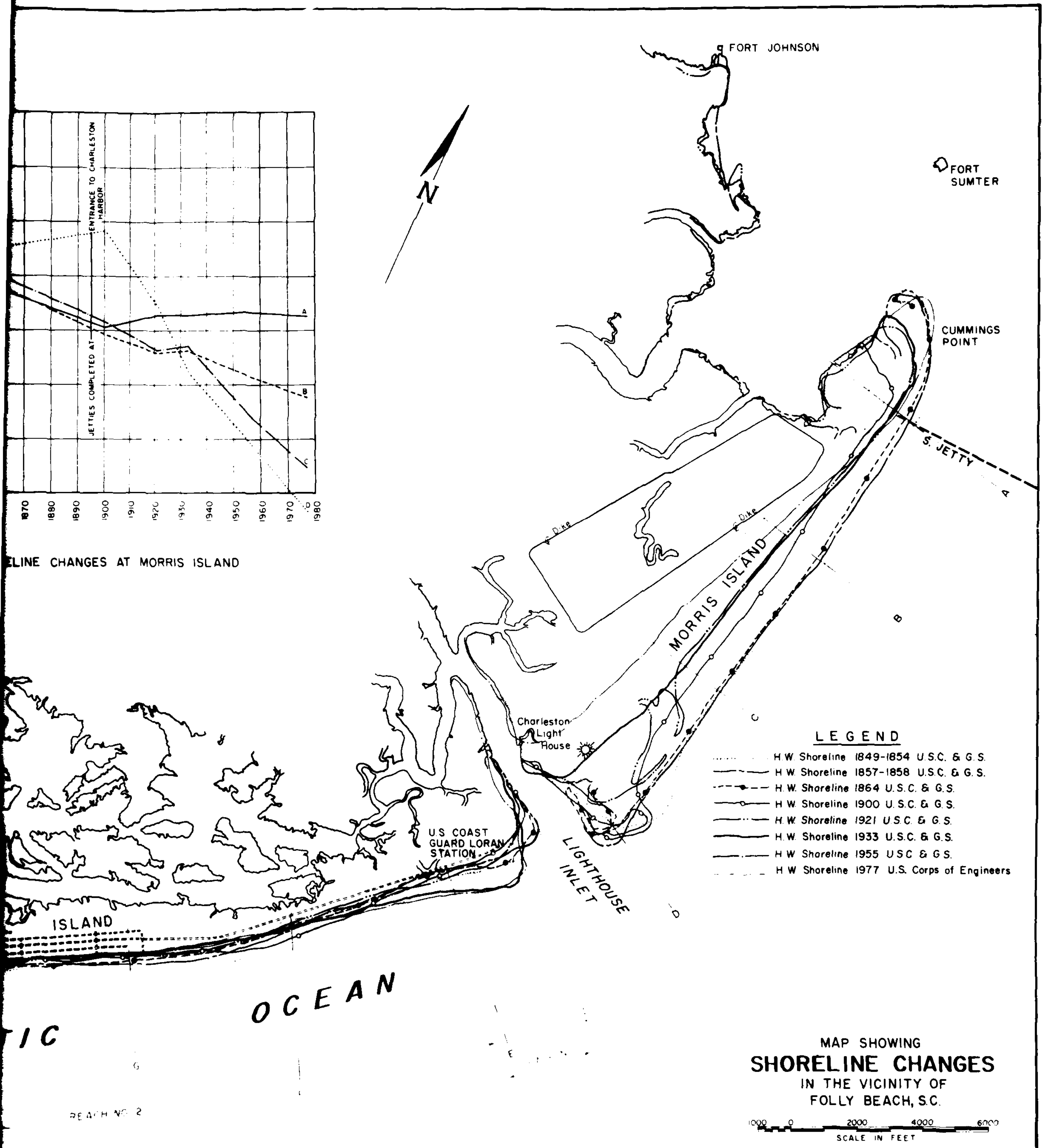

FORT JOHNSON
FORT SUMTER
N
CUMMINGS POINT
S. JETTY
MORRIS ISLAND
Dike
Charleston Light House
U.S. COAST GUARD LORAN STATION
LIGHTHOUSE INLET
ISLAND
OCEAN
TIC
BEACH NO. 2
ENTRANCE TO CHARLESTON HARBOR
JETTIES COMPLETED AT
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
A
B
C
D
ELINE CHANGES AT MORRIS ISLAND
LEGEND
H.W. Shoreline 1849-1854 U.S.C. & G.S.
H.W. Shoreline 1857-1858 U.S.C. & G.S.
H.W. Shoreline 1864 U.S.C. & G.S.
H.W. Shoreline 1900 U.S.C. & G.S.
H.W. Shoreline 1921 U.S.C. & G.S.
H.W. Shoreline 1933 U.S.C. & G.S.
H.W. Shoreline 1955 USC & GS.
H.W. Shoreline 1977 U.S. Corps of Engineers
MAP SHOWING
SHORELINE CHANGES
IN THE VICINITY OF
FOLLY BEACH, S.C.
1000
0
2000
4000
6000
SCALE IN FEET

FIGURE C-6

Morris Island at a fairly uniform rate and at the southern quarter the shoreline was moving oceanward. After the jetties were completed, the direction of shoreline change was reversed. The subsequent trend is one of erosion from the southern end with a decreasing rate to the north until near stability is encountered at the shoreward end of the submerged portion of the south jetty.

36. U. S. Coast Guard Loran Station (Folly Island Reach No. 1). The Inlet side of this reach has had very significant erosion as a result of southwesterly migration of Lighthouse Inlet. The remainder of the reach eroded a couple hundred feet during the period 1849 to 1858, then fluctuated only short distances from this position until about the turn of the century when accretion began. By 1933, the shoreline was 400 feet or more seaward of the 1849 position. This position held until 1955. Between the years 1955 and 1977 (Referred to in Table C-5 as "Recent") all of this reach experienced erosion at such a high rate that facilities at the Loran Station were jeopardized. In 1962, the Coast Guard began constructing groins and seawalls. This work by the Coast Guard is described in Attachment C-2. Since 1977, this reach has been accreting to a point where many of the groin compartments are filled to capacity and this shoreline appears to be stablilized.

37. East Folly Shore (Folly Island Reach No. 2). This reach, which extends 18,080 feet from Center Street to the Coast Guard Station, is currently eroding over most of its length. A segment of about 3,000 feet nearest to the Coast Guard Station appears to have stabilized recently. Severe erosion has taken place along this segment since 1955 with two streets, which ran parallel to the coast, being lost

Table C-5

HISTORICAL SHORELINE CHANGE RATES BY REACHES

Reach No.	Period 1/	Location of Erosion or Accretion: From	Location of Erosion or Accretion: To	Reach Length (ft)	Annual Rate of Erosion(-) or Accretion(+): Average Width (ft)	Annual Rate of Erosion(-) or Accretion(+): Total Volume 2/ (cu. yds)
1	Long term	180+80 N	203+00 N	2,220	+ 1.0	+ 1,300
Loran Station	Recent	203+00 N	208+00 N	500	-13.0	- 3,900
		180+80 N	208+00 N	2,720	-23.2	-37,900
2	Long term	0+00	180+80 N	18,000	- 3.8	-41,200
East Shores	Recent	0+00	180+80 N	18,080	- 7.0	-76,000
3	Long term	76+70 S	0+00	7,670	- 7.4	-34,100
West Shores	Recent	76+70 S	20+00 S	5,670	+ 8.5	+28,900
		20+00 S	0+00	2,000	- 6.3	- 7,200
4	Long term	118+70 S	76+70 S	4,200	-20.0	-50,400
Bird Key Area	Recent	118+70 S	83+00 S	3,570	- 7.1	-15,200
		83+00 S	76+70 S	630	+ 7.0	+ 2,600

1/ Long term: 1849-1977; recent: 1955-1977.

2/ Using a conversion approach where one square foot of surface area eroded equals six-tenths of a cubic yard of volumetric change.

to the ocean. The remaining 15,000 feet of the reach has a serious problem with about 25 feet of erosion having occurred in the last five years according to local residents.

38. West Folly Shore (Folly Island Reach No. 3). Locals report that this reach, which extends from Center Street southwest to the end of the developed coastline, a distance of 7,670 feet, has eroded an average of about 15 feet between 1972 and 1977. The high water shoreline is very near the front street edge at the popular day-use area extending from Center Street to a point about 2,000 feet southwest of this point. Two houses located along this segment of beach no longer have any land above the mean high water level beneath them. Erosion along the remaining 5,670 feet of this segment is not considered critical to improvements at this time since beachfront houses are protected by a well developed dune system.

39. Bird Key Area (Folly Island Reach No. 4). This undeveloped reach at the southwest end of the island has had the greatest recession of shoreline since 1849, about 1,500 feet or about 20 feet per year. The erosion rate over the last five years, though, is estimated by the locals at only about five feet per year with some areas at the island's southwest end having experienced accretion.

40. Erosion Rates. Since the year 1849, approximately 560 acres (0.875 square miles) of beachfront has been lost from Folly Island. This is equivalent to an average annual erosion rate of 5.9 feet

over the entire length of the ocean shoreline. In reality, the erosion has not been uniform as implied by the computation of the average figure. It varies greatly with both location and time. Pictorial and graphical displays of the erosion contained in Figure C-6 have been discussed previously. This information has also been reduced in tabular form and is presented in Table C-5. Two time periods are evaluated to demonstrate the wide variation in the erosion problem relative to the sampling period selected as typifying historical conditions. The long term record period is for the 128 year period 1849 to 1977, and the recent record is for the 22 year period 1955 to 1977. Values displayed in the table were derived by planimetering the area of beach lost in each reach over a given period of time. The values generated were then divided by their respective reach lengths to calculate the average annual erosion rate.

PRIOR CORRECTIVE ACTION AND EXISTING STRUCTURES

41. On the northeast end of Folly Island, at the Loran Station, the U. S. Coast Guard has constructed a combination groin-retaining wall structure which apparently has significantly reduced erosion at that site. The timber wall and much of the six timber and rock groins have been covered with sand, and vegetation is migrating oceanward beyond the wall along most of this reach. Coast Guard stabilization structures consist of a timber sea wall around the east end of the island from which six groins spring oceanward, and a combination training breakwater structure composed of segments of stone and of fabric sand bags on the

inlet side. Attachment C-2 gives an account of the Coast Guard efforts to [illegible] erosion on the east end of Folly Island. Photographs of these structures and of others described later are displayed in the main body of this feasibility report.

42. The S. C. Highway Department has constructed and is maintaining [illegible] timber and rock groins along the developed coastline of Folly Beach from the Loran Station to the northeast to within about 4,000 feet of the southwest end of the island. Locations are shown on Figure C-7 and pertinent data tabulated in Table C-6. A rock revetment approximately 1,200 feet long has also been constructed between Groins [illegible] and 15 where erosion narrowed the island to the point that a breakthrough might occur, severing the northeast end from the remainder of the island.

43. Beachfront property owners are using many different type structures to protect their property. These include: concrete sheet-pile, asbestos corrugated sheet pile, timber seawalls, rock revetment, rubber tire walls, sand-fencing, and one property owner is experimenting with concrete block breakwaters constructed just oceanward of the mean high water line. Type, lengths and ownership of these erosion control works are given in Table C-7. Property owners have had varying degrees of success with their erosion control efforts. One problem stems from the piecemeal way in which these structures were constructed. Some property owners are unable or unwilling to attempt to control the erosion of their property while others cannot agree with their neighbors on a

Table C-6

GROINS AT FOLLY BEACH, SOUTH CAROLINA

(All Constructed by S. C. Highway Department Except Nos. 1 through 5A by U. S. Coast Guard)

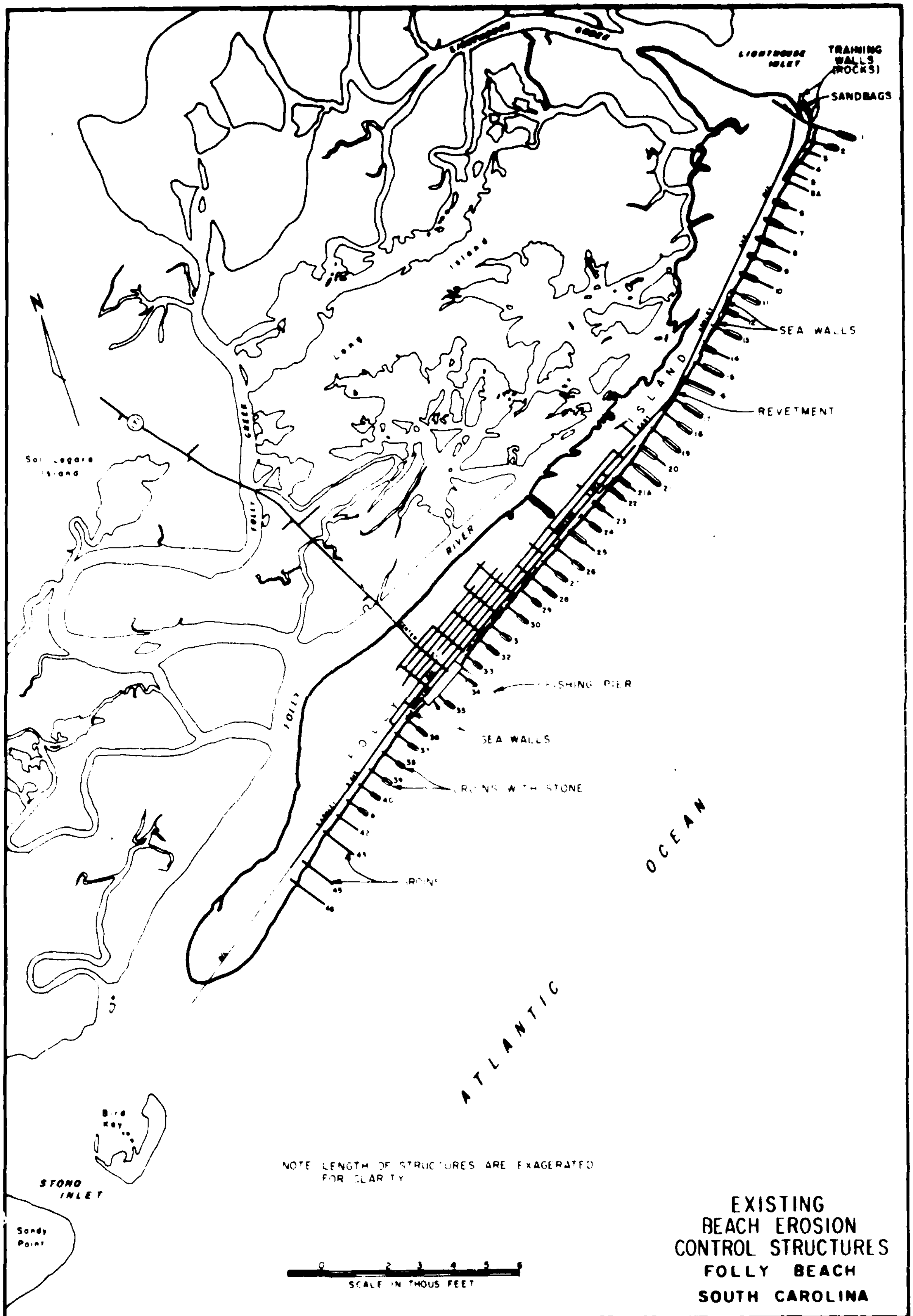
No. (Hwy. Dept.)	Location (Baseline Station)	Length (feet)	Distance to next groin(Feet)	Type Rock (R) or Timber (T)	Year Constructed	Year Repaired	Present Condition (Jul 77)		
							Good	Slightly Damaged	Badly Damaged
1	201 + 30 N	900	630	T + R	1962	1963 & 1974	X		
2	195 + 00 N	300	330	T + R	1962	1963	X		
3	191 + 70 N	200	400	T	1064		X		
4	187 + 70 N	200	350	T	1970	-	X		
5	184 + 20 N	200	320	T	1970	-	X		
5A	181 + 00 N	250	710	T	1970	-	X		
6	173 + 90 N	250	600	R + T	1970	-		X	
7	167 + 90 N	350	610	R + T	1970				X
8	161 + 80 N	350	590	R + T	1968				X
9	155 + 90 N	350	590	R + T + R	1963	1972		X	
10	150 + 00 N	350	610	R + T	1968				X
11	143 + 90 N	300	570	T + R	1963	1972	X		
12	138 + 20 N	300	620	R + T	1968	(1977)1/			X
13	132 + 00 N	350	730	T + R	1963	1972	X		
14	124 + 70 N	300	510	R + T	1967	(1977)1/			X
15	119 + 60 N	300	560	T + R	1963	1972	X		
16	114 + 00 N	300	570	R	1967	1975	X		
17	108 + 30 N	300	550	T + R	1964	1975	X		
18	102 + 80 N	350	690	T + R	1966	1975	X		
19	95 + 90 N	350	620	T + R	1966	1975		X	
20	89 + 70 N	300	600	R + T	1970	-	X		
21	83 + 70 N	300	510	R	1949	-			X
21A	78 + 60 N	300	470	R + T	1970	-	X		
22	73 + 90 N	250	630	R + T	1949	1968			X
23	67 + 60 N	250	570	R + T	1970	-	X		
24	61 + 90 N	250	550	T + R	1952	1973			X
25	56 + 40 N	300	680	R + T	1970	-	X		
26	49 + 60 N	350	550	T + R	1952	1968 & 1973	X		
27	44 + 10 N	300	590	T + R	1954	1973		X	
28	38 + 20 N	300	600	T + R	1953	1973		X	
29	32 + 20 N	250	540	T + R	1954	1973		X	
30	26 + 80 N	250	770	T + R	1953	1973	X		
31	19 + 10 N	250	570	T + R	1954	1973	X		
32	13 + 40 N	250	600	T + R	1953	1973	X		
33	7 + 40 N	200	600	T + R	1955	1975	X		
34	1 + 40 N	200	920	T + R	1955	1975	X		
35	7 + 80 S	200	1,130	T + R	1955	1975	X		
36	19 + 10 S	250	560	T + R	1958	1975	X		
37	24 + 70 S	250	610	T + R	1961	1975	X		
38	30 + 80 S	250	690	T + R	1958	1975	X		
39	37 + 70 S	250	550	T	1961	-			X
40	43 + 20 S	250	590	T	1958	-			X
41	49 + 10 S	250	550	T	1961	-			X
42	54 + 60 S	250	610	T	1958	-			X
43	60 + 70 S	350	1,160	T	1958	-			X
45	72 + 30 S	350	640	T	1959	-			X
46	78 + 70 S	400	-	T	1959	-			X
Total Number of Groins = 47							26	6	15

1/ Planned for repair during the year 1977.

Table C-7

EROSION CONTROL STRUCTURES (OTHER THAN GROINS) AT FOLLY BEACH, SOUTH CAROLINA

Type of Structure	Linear Feet of Structure by: Local Property Owner	S.C. Highway Department	U.S. Coast Guard
Concrete seawalls	4,160	-	-
Rock revetment	600	1,230	-
Timber seawalls	920	-	2,200
Rubber tire seawalls	160	-	-
Asbestos seawalls	100	-	-
Rock training walls	-	-	600
Fabric sand bags	-	-	700
Timber sand fencing	200	-	500
Concrete block off-shore breakwater	140	-	-
TOTAL LENGTH	6,280	1,230	4,000



LIGHTHOUSE INLET
TRAINING WALLS (ROCKS)
SANDBAGS
SEA WALLS
REVETMENT
FISHING PIER
SEA WALLS
GROINS WITH STONE
GROINS
ATLANTIC OCEAN
FOLLY ISLAND
FOLLY RIVER
STONO INLET
Sandy Point
NOTE LENGTH OF STRUCTURES ARE EXAGERATED FOR CLARITY
SCALE IN THOUS FEET
EXISTING
BEACH EROSION
CONTROL STRUCTURES
FOLLY BEACH
SOUTH CAROLINA

FIGURE C-7

best "solution." The City of Folly Beach is attempting to organize beachfront property owners so that an integrated erosion control system can be constructed. Currently, they are seeking State and County help in constructing a continuous seawall and placing approximately 700,000 cubic yards of sand on 22,000 linear feet of ocean shoreline. The city plans to use the same borrow areas that are considered for use in the Federal project. Such a project would only serve as a stop-gap measure for the preservation of high ground until such time as a more permanent solution is effected through Federal programs.

THE CONTINUING PROBLEM

44. Future Shoreline Positions. To gain insight into the future, historical shoreline change rates measured at the seven selected locations on Folly Island were used to predict future positions of the shoreline. Possibilities were plotted on the January 1977 aerial photographs so that the hazards to development, existing at that time, could be reasonably determined. Both the long term rates and the short term rates are displayed. A display of the predictions is presented in the main body of this feasibility report.

45. Beach Problems. Had there been no efforts to control the erosion at Folly Beach, the condition of the beach in the future

would be essentially the same as it has been in the past. Man, in his attempts to hold the high land, has placed artificial barriers to the erosive energy of incoming waves. These structures have at best resulted in a temporary solution to the problem they were meant to solve; however, the erosion of the beach strand and berm goes on, often at an accelerated rate because of the reflective nature of corrective structures. As the beach continues to erode, less and less area is available for recreational use while foundations supporting protective structures become more and more exposed to the forces of the ocean. For that matter, the whole structures' exposure increases as the erosion continues.

46. With the passage of time, many of the structures will fail from the piping of materials from behind. This process is visibly apparent at the Pavillion area sea wall. The beach fronting this wall has been lowered by erosion to such an extent that cracks in the construction joints, which are not sand tight, are now exposed to wetting and to pulsating hydraulic forces for a considerable portion of the normal tide cycle. Sand has piped out through these cracks and failures are apparent in the concrete slab walks which are supported on wall backfill.

47. Should this piping be allowed to continue, all of the backfill, which resists the overturning forces of the sea as well as serving as a base for walks and some of the buildings, will ultimately pipe away. When this happens, the wall will probably fail, leaving an

exposed headland. This will erode at an accelerated rate until that segment of shore better conforms to the alignment updrift and downdrift. Proof of this geomorphic phenomenon is shown in photographs of lesser structures at Folly Beach displayed in the main body of this report.

48. Existing structures which incorporated features to prevent piping failure (filters) may fail from foundation undermining or from the battering of the sea. When such situations occur, rapid adjustment of exposed steep embankments and/or headlands will take place unless adequate repairs are made in a timely fashion.

49. Failure of protective structures allows nature to create a higher and wider beach than that normally found fronting such structures before failure. This, of course, is achieved with a loss of high land and of the apertenances constructed thereon.

Improvements Desired

50. During the course of this study, individuals and groups were afforded many opportunities to express their desires concerning corrective works for hurricane surge and shore erosion problems. Viewpoints varied widely depending upon the hazard to one's property, pocketbook, and/or one's recreational opportunities.

51. Back Island Citizen's Viewpoint. It should be noted that not all of the permanent residents of the Town of Folly Beach are there because of the recreational beach opportunities. Many are living there because the island is separated from other communities and has in the past allowed individualism within the framework of a close-knit small and very personal community. These people are active in self improvement projects, community politics and activities, and may enjoy crabbing and fishing in nearby protected water more than they do surfing, swimming, sun bathing, etc. on the front beach.

52. These mostly back island citizens appreciate only to a limited extent the problem their neighbors are encountering on the front beach. They feel that the front beach owners were aware of the hazards of locating where they did. In spite of these hazards, they elected to invest their money to gain convenience, aesthetics, prestige, and/or income. Also, in spite of the wide publicity given the erosion problem, new construction is taking place along the front beach, possibly with the thought that nature will reverse itself or that the government (whatever level) will step in to correct the situation. With this background in mind, it is apparent, to the most casual observer, that a large segment of the town's population is only willing to go along with a level of involvement in erosion control works that does not result in a significant increase in their tax liability.

53. Town Consensus. As a feature of the Folly River small navigation project, the Charleston District proposed Federal participation in a

beach access/biological observation park at the presently undeveloped southwestern end of the island. This park was to be sponsored by the Charleston County Parks, Recreation and Tourism Commission; however, the Town of Folly Beach held a referendum to determine the townspeople's feelings towards the park. The vote was overwhelmingly against its creation. From the discussions which preceded the vote, it appears that the townspeople objected to the increased traffic that would accompany the development of the park and favored private residential development that would increase the town's tax base. Seldom were arguments heard expounding the benefits from increased sales and traffic fines associated with an increase in tourism.

54. Front Beach Owner Viewpoint. Front beach property owners are interested mainly in preserving their land and the appurtenances constructed thereon. As far as the beach strand is concerned, this special interest group would be satisfied with enough beach to meet their personal needs and the needs of those who rent their cottages and apartments. Recognizing that the opportunity for Federal assistance along private shores is contingent upon public use, this group is willing to encourage widespread public use of the beach. Merchants in the business district also support widespread usage of the beach as a means of stimulating business.

55. Visiting Day User Viewpoint. The majority of beach users during the season come from many areas of South Carolina and from other

states. A majority of these day users come from Berkeley, Charleston and Dorchester Counties. They are concerned primarily with problems of low quality and crowded beaches; hazards to bathers caused by groins, other protective works and root stubble; difficult access to the beach; lack of parking; and sanitary facilities for public use at strand segments apart from that adjacent to the central business district.

56. "Dynamite Hole" Viewpoint. The last identifiable group comes from no specific locality and/or special interest group. These are the people who are convinced that a dynamite hole was blown in the south jetty at the entrance to Charleston Harbor. Some even cite a specific date that this occurred; however, none has ever been able to show any proof concerning their claims nor have our own researchers been able to lend any evidence to the claims. This group has been referred to 19th century Annual Reports of the Chief of Engineers which record the design and purpose of the low sections incorporated in both of the jetties protecting the entrance to Charleston Harbor. The gaps were incorporated into the design to properly fill the estuary and to reduce ebb currents. This second feature was necessary to allow sailing ships to enter the harbor under favorable tide conditions. The low jetty sections in both jetties also were intended for a third purpose, that being to admit the littoral drift over the tidal weirs and then letting the sand be carried to sea by the ebb tides through the jetties and southward by the general movement of this drift. The design appears to be working and it is the Corps' position that the jetties are not affecting changes in the Folly Beach shoreline to any discernible degree. This evidence has had little, if any, effect on the thinking of the group.

They are very vocal in expounding the liability of the United States Government for eradicating erosion along Folly and Morris Islands at no cost to the local people as restitution for damages caused by the "dynamite hole" in the south jetty. This group contends that closure of the "dynamite hole" will immediately resolve the erosion problem of each island.

57. From the preceding discussions, it is apparent that the viewpoint as to what is a proper solution to the erosion problem is influenced mainly by individual point of perspective. Boiling all of these viewpoints down, it is concluded that the people want a cost and environmentally effective solution that will receive significant Federal funding. They also feel that the non-Federal cost should be supplied by the direct beneficiaries of the work with little or no additional tax burden or direct cost burden being placed on non-beneficiaries. As far as hurricane surge protection is concerned, most would consider approval of this type of protection only if the Federal Government picks up the tab, and if the protective structure doesn't block views and/or interfere with private land use and beach access.

ATTACHMENT C-1

LITTORAL MOVEMENT STUDY,

FOLLY BEACH

EROSION AND HURRICANE PROTECTION STUDY

CONTRACT DACW60-'76'-C-0028

FRANK W. STAPOR, JR.

MARINE RESOURCES RESEARCH INSTITUTE

APRIL 29, 1977

TABLE OF CONTENTS

LIST OF FIGURES

WAVNERG COMPUTER MODELING

Folly Beach and nearby coastal regions were modeled using USCGS chart 1245 on a scale of 1:80,000. The area comprises the region between Seabrook and Capers Islands, focusing on Folly Beach. Program WAVNERG (May, 1974) was used to compute the littoral component of wave power (P_L) at various points along the coastline, for given wave parameters and wave approach directions for the three tidal levels of low-, mid-, and high-tide. Input into the system includes depth values in a square matrix bathymetric grid, deep water wave height, wave period, and wave approach direction. With this data the program tracks coasting waves from a given point offshore to the shoreline. At the point of breaking, the program computes the littoral component of wave power. Noise in the system, attributable to many factors (May, 1974), was initially reduced by examining the printed output for bad values. This raw data was then used in the plotting program TWIST (Berquist and Murali, unpublished, FSU, 1974), which computes five point running median values of P_L, further reducing the noise in the system, and then plots P_L values against distance. These plots show changes in littoral component of wave power along the coast and also indicate the direction of drift. Positive values indicate littoral drift to the right (viewed from offshore) and negative values indicate littoral drift to the left. Positive and negative values strictly indicate drift directions. For details of program WAVNERG see May, 1974.

FOLLY BEACH STUDY DETAILS

Part of the South Carolina coastline surrounding Folly Beach was modeled using program WAVNERG. Bathymetric data was obtained from USCGS charts with a scale of 1:80,000. Wave period and breaker height data were taken from the CERC wave gauge at the Savannah Light Tower. Deep water wave height was estimated through repeated trials of WAVNERG for which various wave heights were checked against their resultant breaker height. That deep water height yielding the breaker height measured by the CERC wave gauge was chosen as the deep water wave height estimate.[1] The three wind directions used were south, southeast, and east; these directions were determined from observed

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1 Shipboard Marine Observations (SSMO) data for Area 10 (Charleston) furnished by T. Morgan (personal communication) were received after WAVNERG computer modeling was finished. These data indicate that waves having a period of less than 6 seconds occur about 52 percent of the time, and that these on the average, have a deep water height of about 3 feet. Thus the deep water wave parameters used in the WAVNERG computer modeling appear to be about the annual median as measured from SSMO data.

wind data presented in Corps of Engineers, U.S. Army, 1966. Tidal stages have a significant effect on the amount of wave power delivered to the shoreline. To determine the influence of the tidal stages on the waves and the resulting differences in drift systems, it was necessary to compute the littoral component values for the low-, mid-, and high-tides.

The following parameters were used for the Folly Beach Study:

Deep Water Wave Height:	1.00 Meters
Wave Period:	6.50 Seconds
Wave Approach Directions:	From South, Southeast and East
Tidal Stages:	High, Mid and Low

Using these conditions P_L plots were produced for each approach direction and each tidal stage. At every distance position or geographic point, for each approach direction, values of P_L for the three tidal stages were combined and averaged.

According to the Army Corps of Engineers Report on Folly Beach (Technical Report on Beach Erosion Control at Folly Beach, Charleston County, S.C.) frequency of wind waves in terms of sea and swell are as follows:

Direction	Sea	Swell
Northeast	12%	9%
East	11%	6%
Southeast	9.5%	6%
South	4%	4.2%

By assuming a sea to swell ratio of 2:1 the following frequencies were derived:

Direction	All waves - overall frequency
Northeast	11%
East	9.3%
Southeast	8.3%
South	4.1%
Total	32.7%

The values obtained for the frequencies are minimum (absolute) since storm conditions have been ignored. Also, it is seen from the above that no drift occurs during 67.3% (100 - 32.7%) of the year.

Weighting factors were obtained from the various directions using the overall frequency data. These factors represent the weighting to be given the P_L values for the various approach directions. The weighting factors are:

Direction	Weighting Factors
Northeast	2.7
East	2.3
Southeast	2.0
South	1.0

The P_L or littoral component of wave power values obtained after weighting are presented in Fig. 1 for south, southeast and east approach directions. These values indicate the instantaneous littoral power given to the coastline by coasting waves approaching from the south, southeast and east. This instantaneous power has to be converted into a yearly longshore transport rate (Q), using the dimensionless proportionality constant 'k'. Following Komar (1970), the breaker height (H_b) is assumed to be equal to significant wave height (H_s) which is equal to 1.416 times the root mean square of the wave height (H_{rms}). Using this relationship, the value of 'k' was computed as 0.299. It should be borne in mind that 'k' values differ based on whether one is considering longterm or instantaneous changes. For longterm changes a value for 'k' can be computed by map differencing techniques (Stapor, 1971); this value of 'k' is likely to be much less than the value obtained for instantaneous changes.

DISCUSSION OF WAVNERG RESULTS, EDISTO ISLAND TO CAPERS ISLAND

P_L values generated by waves approaching from the south indicate northeasterly drift or transport for this coast, except for 1) Edisto Beach State Park, 2) Seabrook Island and the southwestern half of Kiawah Island, 3) the Stono Inlet region, including northeastern Kiawah Island, and 4) northwestern Capers Island where southwesterly drift is indicated, see Fig. 2. Northeasterly littoral transport should result from the interaction of NE-SW coast and waves approaching from the south. The drift reversals to the SW are probably caused by refraction about the large shoals which flank major tidal inlets, i.e., the high magnitude SW drift in the vicinity of the North Edisto Inlet. The magnitude of P_L generally decreases to the NE, possibly a result of the shallow offshore bottom soaking up more and more wave energy as the wave travel path becomes longer and longer.

P_L values generated by waves approaching from the southeast indicate the existence of many longshore drift cells of variable lengths and magnitudes of transport, see Fig. 2. The two cells of greatest lengths (10.4 and 12.8 kilometers respectively) and magnitudes of transport are located between Edisto Beach State Park and the middle of Kiawah Island. The 12 remaining drift cells vary in length between approximately 3.0 and 10.0 kilometers. Given the complicated nature of the inshore bathymetry, large shoals flanking tidal inlets, and the essentially 'head-on' approach for southeast waves, many longshore drift cells of highly variable lengths and magnitudes of transport should be the expected result.

P_L values generated by waves approaching from the east indicate the existence of 3 longshore drift cells, one experiencing SW littoral transport and two NE transport. Southwesterly transport occurs from Kiawah Island to Edisto Beach State Park and northeasterly transport in two separate cells located 1) between Kiawah Island and Morris Island and 2) from Morris Island to Capers Island, see Fig. 2. The presence of projecting shoals and 'shorelines' greatly influences the magnitudes of these P_L values, i.e., the vicinity of the North Edisto Inlet and the Charleston Harbor jetties, respectively. For a NE-SW trending coastline to experience northeasterly littoral transport under the action of waves approaching from the east, significant wave refraction must occur in the offshore region. Offshore submarine features as well as the projecting shoals which flank the major tidal inlets probably effect this observed/model-predicted refraction.

Coasting waves approaching from the northeast probably do not affect the South Carolina coast, largely because of its NE-SW orientation. As a test of this hypothesis, a WAVNERG analysis was made using NE-approaching waves on a 1:450,000 bathymetric grid. No waves (1 meter, 6.5 second) reached the shoreline when they were started on a NE approach direction in waters sufficiently deep so that they didn't 'feel bottom' and immediately begin refracting. All waves, even those started so close inshore that they did immediately 'feel bottom' and begin refracting, exited the grid on its SW border without reaching the coast.

DISCUSSION OF WAVNERG RESULTS FOR FOLLY AND MORRIS ISLANDS

P_L values generated by waves approaching Folly Island from the south, southeast and east all indicate northeastward littoral transport. Furthermore, waves from all these three directions indicate net erosion for 1) the 800 to 1600 meter long portion of Folly Island adjacent to the Stono Inlet region and 2) the 800 to 2400 meter long portion of the island south of the United States Coast Guard Station, see Fig. 2. Erosion in this latter region is predicted to be more intense than that in the former. Material eroded on the beach adjacent to the Stono Inlet is deposited along the 800 to 2400 meters of beach lying immediately northward. The material eroded south of the Coast Guard Station is also deposited along 800 to 2400 meters of beach lying immediately to its north. Between these two erosion/deposition areas, sand is being transported northeastward and the island suffering very slight erosion. Thus, Folly Island has two major erosion/deposition areas on each end, connected by a stretch of beach simply transporting small amounts of sand northeastward.

The WAVNERG analysis of the Morris Island region is complicated by the presence of the Charleston Harbor jetties. As each bathymetric grid measured 800 meters by 800 meters, the jetties appeared as a narrow finger projecting straight out into the Atlantic Ocean. The shoreline is then continuous from Sullivan's Island, out along the jetties, and then back onto Morris Island. An admittedly artificial situation, but one, perhaps, not far removed from reality. These jetties are wave 'breaking' structures or 'shorelines', although no sand is moved down and/or up a 'beach'.

For waves approaching from the east, Morris Island completes the deposition region for material eroded south of the Coast Guard Station on Folly Island, see Fig. 2. For waves from the southeast, Morris Island comprises a longshore drift cell transporting material to the southwest. The northern 800 to 1600 meters of Morris Island are undergoing net erosion, the central 3200 meters are transporting this eroded material southwestward, and the southern 800 meters are acting as the deposition site. Waves from the south have a minor, rather variable, effect on Morris Island, see Fig. 2.

Lighthouse Inlet can be seen to be a major deposition site, receiving sand moving both to the NE and SW. This may help account for the permanence of this shoal system in the face of significant landward retreat of the adjacent part of Morris Island.

Plot 'Q' in Fig. 2 shows the combined, weighted average values of littoral transport in m^3/year moving past a given geographic point between Bay Point on Edisto Island the Price Inlet, separating Capers and Bull Islands. P_L values for south, southeast and east approach directions were averaged over three tidal positions, weighted according to wind/swell frequency, combined to yield an overall, grand P_L value which was converted to 'Q' using a 'k' factor of 0.299. Littoral transport is northeasterly along all of Folly Island, from the Stono Inlet region to Lighthouse Inlet. The southernmost Folly Island beach is experiencing net erosion at a maximum rate of 11,000 m^3/year. Nearly half of this amount is deposited on the beaches lying northward up to 12th Street, or the 'bend' or 'angle'. Net erosion begins again between 12th Street and the U. S. Coast Guard Station, with a maximum yearly rate of 15,000 m^3. Deposition begins at the Coast Guard Station and continues north to the southwestern border of Morris Island, across Lighthouse Inlet, with a maximum deposition rate of 11,000 m^3/year. Folly Island suffers a net sand loss of 4,000 m^3/year to Morris Island.

There is essentially no net littoral transport of sand in the Stono Inlet region between Folly and Kiawah Islands, see Plot 'Q' of Fig. 2. Furthermore, 'Q' values on Morris Island are either so small or so potentially complicated by the 'artificial' behavior of the Charleston Harbor jetties, that little meaningful interpretation can or should be made.

SUMMARY AND CONCLUSION

Using computer program WAVNERG developed by May (1974), a model of the littoral component of wave power was constructed for the Folly Island region, Charleston County, South Carolina. The bathymetric grid was constructed at a scale of 1:80,000 with each grid square measuring 800 meters x 800 meters. Coasting waves approaching from the south, southeast and east with deep water heights of 1 meter and periods of 6.5 seconds were modeled for low-, mid- and high-tide situations. The resulting P_L values for each approach direction were averaged over three tidal positions, weighted according to frequency, combined into a grand average, and then converted to 'Q' (m^3/year), using a 'k' factor of 0.299. P_L values for each approach direction, averaged over three tidal positions and weighted according to frequency, are presented in Fig. 2, along with final 'Q' values.

Given the limitations of this technique--no tidal effects considered, no onshore/offshore effects, and, of course, limited, sketchy wave climate data--a reasonable model of littoral transport was produced for the Folly Island region. Reasonable in that model-predicted areas of erosion/deposition, as well as magnitudes of transport, agree well with data determined from independent techniques.

Littoral transport is northeastward on Folly Island, with a rate varying between 4,000 m^3/year and 15,000 m^3/year. Folly Island suffers a net loss of 4,000 m^3/year to Morris Island. No net littoral transport is taking place in the Stono Inlet region between Folly and Kiawah Islands. The Charleston Harbor jetties do influence littoral processes on the northern half of Morris Island but probably do not affect Folly Island.

SAND BUDGETS

Estimates of material eroded and deposited in the Stono Inlet and the Morris Island regions were calculated by the method of bathymetric map differencing. U. S. Coast and Geodetic Survey boat sheets, surveyed at scales of 1:10,000 and 1:20,000, provided the bathymetric data. First-order triangulation points (common to the various boat sheets compared) provided the planimetric control. Differencing or comparison of two boat sheets was done by superimposing one over the other and marking all positions where isobaths crossed. These 'crossings' generate a number field consisting of positive (deposition) and negative (erosion) differences. This number field was then contoured and the resulting areas planimetered to calculate volumes of material eroded and/or deposited. After planimetering each specific area, an amount equal to 3 mm in the scale of the compared surveys was added and subtracted from the radius of each specific area to provide a first error estimate, incorporating the uncertainties as to isobath position as well as first-order triangulation point location.

MORRIS ISLAND REGION

The sand budget for the Morris Island region was calculated by comparing boat sheets H-254 (1851), H-2221 (1895), H-4181 (1921) and H-8781 (1963). The resultant volumes of material eroded and deposited during the intervals 1851 to 1895, 1895 to 1921, and 1921 to 1963 are presented in Figures 3A, 3B, and 3C respectively.

1851 to 1895 (see Figure 3A)

During this period, Morris Island proper eroded at an average rate of 96,000 m^3/year. The Civil War fortifications constructed in the early 1860's were all destroyed and the northern tip of Morris Island removed by coastal erosion. Offshore erosion and deposition were essentially balanced at a rate of approximately 60,000 m^3/year each. The Charleston Harbor jetties were constructed during the period of 1886 to 1896. Their effect on sand movement in the Morris Island region during this interval is unknown, but as the jetties were in existence during only 25% of this period (a liberal estimate) their effect may have been minimal.

The transport path of the material removed from Morris Island proper, approximately 96,000 m^3/year, is somewhat of a puzzle. This eroded material would make its way offshore to the main ebb channel, either directly or by transport to the northern tip of the island. Once in this ebb channel, sand would be transported south for deposition on the ebb delta in the vicinity of Lighthouse Inlet. Now, if the Lighthouse Inlet region had a net deposition rate of 96,000 m^3/year, a map differencing should have identified it and as it did not, then either 1) the material was thinly spread over a great area or 2) the material passed through this region to be redistributed elsewhere.

1895 to 1921 (see Figure 3B)

The effects of the Charleston Harbor jetties are very much in evidence during this interval. Offshore erosion and deposition were essentially balanced at a rate of approximately 120,000 m^3/year each, double that rate of 1851 to 1895 interval. The ebb tidal delta appears to have been experiencing net landward migration, a situation to be expected as a result of the jetties deflecting the bulk of the ebb tidal discharge away from the original ebb tidal channel.

Erosion on Morris Island proper greatly decreased, down to approximately 27,000 m^3/year, and much of this 'material' may not have been sand, but rather marsh silts and clays. Erosion during the 1851 to 1895 interval pushed the island back almost to the limit of the sand dune topography depicted on the 1950- and 1860- vintage topographic maps. Deposition took place on the island's northern tip (Cummings Point) at an average rate of 13,000 m^3/year. Much of this deposited sand could have come from local Morris Island erosion. Construction of the jetties had, in all probability, changed the basic tidal current transport along Morris Island from ebb-dominated to flood-dominated, by the partial sealing of the original ebb tide channel.

1921 to 1963 (see Figure 3C)

The offshore deposition rate was at least three times that of offshore erosion during this interval, 94,000 m^3/year versus 30,000 m^3/year respectively. The original ebb tidal channel had been largely filled by the landward migrating tidal delta. Furthermore, the sand deposited at the northern tip of Morris Island, 70,000 m^3/year, probably came from offshore rather than from local Morris Island erosion because erosion which occurred on Morris Island during this interval, 76,000 m^3/year, affected marsh clays and silts, the bulk of the sand having been removed previously. Of the 76,000 m^3/year eroded, perhaps 10% to 20% at most represents sand loss.

CHARLESTON ENTRANCE, CUMMINGS POINT AND SULLIVANS ISLAND REGION

A detailed sand budget for this area was calculated by comparing boat sheets H-5455 (1934) and H-8768 (1963), both of which were surveyed at a scale of 1:10,000. The resultant volumes of material eroded and deposited during this 29 year interval are presented in Figure 3D.

The Cummings Point region of Morris Island north of the south jetty experienced a minimum net deposition rate of 95,000 m^3/year. Most of this deposition occurred immediately adjacent to Cummings Point, allowing growth of the Point back to its mid-nineteenth century position relative to Ft. Sumter. Not all of this region northeast of Cummings Point experienced net deposition, the edge of this shoal adjacent to the Charleston Entrance Channel has undergone erosion.

The Sullivans Island coast and immediate offshore region lying west of the north jetty experienced a minimum net deposition rate of 30,000 m3/year. A small, although measureable, region adjacent to the Charleston Entrance Channel experienced net erosion.

These measured net deposition rates provide minimum estimates of the amount of sand delivered to Cummings Point and Sullivans Island by tidal and wave action. The combined value of 125,000 m^3/year is an order of magnitude higher than transport under coasting waves. Even allowing a 10% to 15% clay/silt content of the deposited material (to account for possible deposition of clay/silt material coming down the Santee-Cooper) does not alter this order of magnitude difference. Tidal currents are probably playing the major role in sand transport at both of these locations, not a startling conclusion given the size of the tidal prism flowing through this inlet. What is startling is the magnitude of sand involved given the general low level of deposition/erosion rates predicted for the open beach coasts of this region. Furthermore, this situation strongly suggests net <u>onshore</u> transport of sand.

The Morris Island/Cummings Point area may well <u>demand</u> net onshore transport as all of Morris Island except Cummings Point is an eroding <u>marsh</u> coast. It should be emphasized that these rates are <u>minimum</u> net values and thus the "real" transport is probably greater.

STONO INLET REGION

The sand budget for the Stono Inlet region was calculated by comparing boat sheets H-803 (1862), H-4181 (1921), and H-8879 (1964). The resultant volumes of material eroded and deposited during the intervals 1862 to 1921 and 1921 to 1964 are presented in Figures 4A and 4B.

<u>1862 to 1921</u> (see Figure 4A)

Erosion and deposition essentially balanced each other at the Stono Inlet during this interval at approximately 270,000 m^3/year each. The southwestern tip of Folly Island and the eastern portion of the ebb tidal delta experienced erosion; the eastern tip of Kiawah Island, the Bird Key region, and the southern portion of the ebb tidal delta experienced deposition; and the main Stono channel migrated to the west. There is no direct evidence to suggest that the Stono Inlet region received significant amounts of sand from external sources, or contributed significant amounts of sand to external areas. Rather, the evidence suggests a closed, independent system in which sand was locally reworked and redistributed.

1921 to 1964 (see Figure 4B)

Erosion and deposition cannot be demonstrated to be 'significantly' different, given the associated errors, and statistically 'balance' each other at 120,000 m^3/year and 205,000 m^3/year respectively. The average of these two values represents a 40% reduction in the rate of sand movement from the 1962 to 1921 interval. Once again the evidence suggests, although not as strongly as during the previous interval, that the Stono Inlet region acted as an independent system reworking local sand neither receiving nor losing significant net amounts from or to external sources.

FOLLY ISLAND REGION

Using boat sheets H-4181 (1921) and H-8870 (1965) no significant net changes could be measured in either the offshore bathymetry or shoreline position. Thus, map differencing cannot be employed to calculate a sand budget for this region. This apparent stability of the region lying immediately offshore of Folly Island is in marked contrast to the Morris Island and Stono Inlet regions.

SUMMARY AND CONCLUSIONS

Sand budgets have been calculated for the Morris Island and Stono Inlet regions for the 100 year period 1860 to 1960. The Charleston Harbor jetties have significantly effected the Morris Island region, changing it from ebb-dominated to flood-dominated, with the results that the original ebb tidal delta is migrating landward toward Morris Island.

This landward migration during the interval 1921 to 1964 took place at a minimum rate of 165,000 m^3/year. The Stono Inlet region has probably experienced no significant net exchange of sand with either Folly or Kiawah Islands. Erosion and deposition balance each other for this inlet at an average rate of 162,000 m^3/year each over the period 1921 to 1964. The Folly Island region has remained essentially stable or static with respect to measureable net erosion and/or deposition during the period 1921 to 1964.

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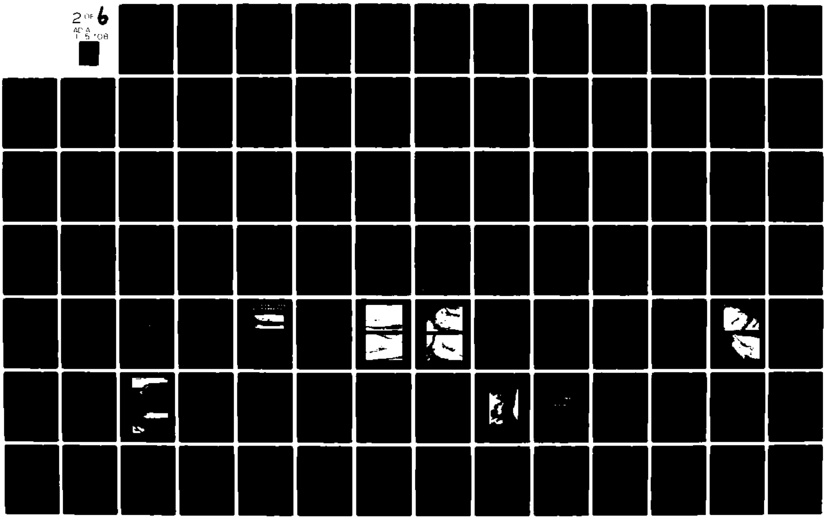

CURRENT METER STUDY

Bottom tidal currents in the lower Folly River/Stono Inlet region, the Charleston Harbor Entrance region between Sullivans Island and Lighthouse Inlet and the immediate offshore region between Lighthouse Inlet and Kiawah Island were measured using General Oceanics film recording current meters. These meters were deployed at each station for a minimum of 48 hours and were located as close to the bottom as possible, in order to measure velocities where sand actually moves. Forty three stations were monitored and all except six yielded meaningful results. Stations 5, 28, 29, 30, 38, and 42 (see Figures 5A, 5B and 5C for locations) suffered mooring malfunctions which so altered their recorded observations as to make them meaningless.

Average velocities for the ebb and flood portions of the tidal cycle as well as a net or resultant velocity for the entire tidal cycles monitored were calculated and are presented in Figures 5A, 5B, and 5C. Only those ebb and flood average velocities greater than or equal to 15 cm/sec were plotted. This velocity was chosen to represent the minimum critical velocity necessary to entrain the fine sand (1/2 to 1/8 mm diameter) present in the study region. This choice was made using the Hjulstrom-diagram as presented by Sundborg (1956). Now, the minimum critical velocity for fine sand entrainment covers a range from 15 to 25 cm/sec. The lower end of the range was taken in an attempt to account for the potentially greater erosive power of silt/clay laden sea water. No attempt was made to consider the effect of wave turbulence, either in the entrainment of sand or its subsequent transport. Thus, the current meter data has been interpreted as describing bottom tidal currents only.

CHARLESTON HARBOR ENTRANCE (see Figure 5A)

Of the 15 stations monitored about the Charleston Harbor Entrance 4 malfunctioned (27, 30, 38, 42) and two recorded no average minimum critical velocities (33, 43).

Station 41, located on the northside of the entrance, recorded average minimum critical velocities only during flood tide (17 cm/sec to the west).

In the Cummings Point region north of the south jetty, Stations 39 and 40 recorded average minimum critical velocities for both ebb and flood tides. Hence as sand is always entrained, the resultant indicates the sand transport rate and direction. At Station 39 the resultant of 12 cm/sec to the east indicates a transport toward the entrance channel as does the resultant at Station 40 (5 cm/sec to the east). These both indicate regions of erosion and are geographically positioned in the major erosion area north of Cummings Point defined by map differencing (see Figure 3D).

South of the south jetty, the bottom tidal current data indicates that flood tides are the only ones competent to entrain sand at Stations 34, 36, and 32 (see Figure 5A). Station 37, located immediately south of the south jetty, offshore of Morris Island recorded average minimum critical velocities during both ebb and flood tides with a resultant of 5 cm/sec to the east or offshore. Station 35, located in the deep channel immediately south of the south jetty, recorded average minimum critical velocities during both ebb and flood tides (25 cm/sec to the south and 15 cm/sec to the northwest respectively). The resultant of 3 cm/sec to the northeast indicates sand transport toward the jetties.

These results do not contradict the hypothesis developed from the sand budgets that the pre-1900 ebb tidal delta is migrating landward, serving as the source of sand depositing at Cummings Point. However, they do indicate a rather involved transport path, expecially in the area immediately adjacent to Cummings Point. The net offshore transport indicated at Station 37 is unexpected and emphasizes the "involved" nature of the actual transport path.

The southerly resultant at Station 31 may indicate a shift in position of the ebb channel from its 1964 location. The observation that only northerly flood currents are capable of entraining sand at Station 32 further supports this shift in position.

LIGHTHOUSE INLET TO KIAWAH ISLAND (see Figure 5B)

Of the eight stations monitored in the offshore waters from Lighthouse Inlet to Kiawah Island, three suffered mooring malfunctions which rendered the recorded data meaningless (9, 28, 29) and two yielded average velocities less than the minimum needed to entrain sand (25, 26). Station 27, located off the southwest tip of Folly Island, recorded an average minimum critical velocity only during flood tide (17 cm/sec in a due south direction). Apparently, water flooding into the Folly River near this point is located either on the surface or closer to Folly Island. Station 24, located on the seaward boundary of the Stono Inlet channel, recorded an average minimum critical velocity only during ebb tide (22 cm/sec in a due south direction). Station 10, located on the west side of the Stono ebb tidal shoal/delta complex recorded an average minimum critical velocity only during ebb tide (17 cm/sec in a due south direction). From this admittedly sketchy data it appears that flood currents operating in the waters seaward of both Folly Island and the Stono ebb tidal shoal/delta are not competent to transport sand.

Station 8 recorded an average minimum critical velocity only during flood tide (16 cm/sec to the north). Average minimum critical velocities were recorded during both flood and ebb tides at Station 7.

As sand is always in motion, the resultant velocity of 11 cm/sec in a northeasterly direction indicates the net sand transport. Both of these stations indicate the presence of flood tide-dominated transport in this section of the Stono ebb tidal shoal/delta (see Figure 5B for location).

Stations 5 and 23, located in the seaward end of the Stono Inlet, recorded average minimum critical velocities only during ebb tide (26 cm/sec to the south and 19 cm/sec to the southeast, respectively).

Station 6, located in the Stono Inlet throat, recorded minimum critical velocities during both flood and ebb tide (32 cm/sec to the northwest and 35 cm/sec to the southeast, respectively). Thus, sand should always be in motion and has a net transport path of northeast at 2 cm/sec. Now, this indicates transport across the throat section rather than up or down the channel. Divers from the Coastal Research Division, Department of Geology, University of South Carolina, report that in this portion of the throat channel the bottom is floored with phosphatic pebbles and cobbles (Denis Hubbard, personal communication). Hence, there may well be no fine sand present to be moved.

FOLLY RIVER/STONO INLET REGION (see Figure 5C)

The lower Folly River is divided into two main channels separated by a mid-river sand bar. The northern channel runs from the Stono River northeastward to the vicinity of Station 15 and was monitored by Stations 2, 21, 13, 17, 16 and 15. The southern channel runs from the southwestern tip of Folly Island northeastward to Station 16 and was monitored by Stations 3 and 16. The "mid-river" sand bar runs from the vicinity of Station 13 northeastward to Station 15, and was monitored by Stations 20 and 18 (see Figure 5C for these locations).

Northern Channel: The portion of this channel between Bird Key and Cole Island was monitored by Station 2. This station recorded an average minimum critical velocity only during ebb tide (27 cm/sec to the southwest). The next reach to the north was monitored by Station 21 which recorded average minimum critical velocities during both ebb and flood tides (34 cm/sec to the south and 36 cm/sec to the northeast respectively). Thus, as sand is always entrained and in motion the resultant velocity of 19 cm/sec to the southeast indicates the sand transport rate and direction. This suggests that this reach may be shifting seaward but is halted by sand moving landward over the adjacent shoal. The reach in the vicinity of Station 13 experiences average minimum critical velocities only during ebb tide (25 cm/sec to the southwest). Sand is constantly entrained during both ebb and flood tides at Station 19 (25 cm/sec to the southwest and 19 cm/sec to the northeast respectively) with a resultant transport due south at 2 cm/sec. This moves sand directly onto the "mid-river" bar. The same general pattern persists at Station 17 with a resultant transport southeast at 21 cm/sec onto the "mid-river" bar (flood of 32 cm/sec to the southeast and ebb of 25 cm/sec to the southwest). Station 15 recorded an average minimum critical velocity only during flood tide (29 cm/sec to the east) which again feeds sand onto the "mid-river" bar.

Mid-river Bar: The highest resultant velocity was recorded at Station 18, 33 cm/sec to the south. Sand is constantly entrained and moving during both ebb and flood (41 cm/sec to the south and 30 cm/sec to the southeast, respectively). Station 20 recorded an average minimum critical velocity only during ebb tide (29 cm/sec to the southwest).

Southern Channel: Station 3 recorded an average minimum critical velocity only during ebb tide (22 cm/sec to the west). Sand is constantly entrained during both ebb and flood tides at Station 16 with a resultant transport of 6 cm/sec to the east (ebb of 25 cm/sec to the south and flood of 33 cm/sec to the northeast).

Station 11, situated in a small channel in the shoal between Folly Island and Bird Key, recorded quite variable currents during its 3½ tidal cycle monitoring period. Only one flood tide was recorded, ebb flow occurred during the rest of the time. An average minimum critical velocity was reached, however, only during ebb tide (25 cm/sec to the south). This location may be serving as a significant ebb channel for water coming down the Folly River southern channel, and, consequently, sand then moves from the "mid-river" bar to this shoal area.

Station 12, located immediately offshore of the southwest tip of Folly Island, recorded average minimum critical velocities during both ebb and flood tides (34 cm/sec to the south and 43 cm/sec to the north respectively). Sand movement follows the resultant of 10 cm/sec to the northwest. This is the major flood channel at the southwest of Folly Island and may well serve to feed sand into the Folly River southern channel where it is moved to the shoal of Station 11.

Stations 14 and 4 are located at the landward and seaward ends respectively of the channel separating Bird Key from the shoal southwest of Folly Island. Sand is constantly entrained at both stations. The net resultant at Station 14 is 2 cm/sec to the northeast, indicating a shifting channel. That of Station 4 is 2 cm/sec to the southeast, indicating dominant ebb transport out to sea.

Station 22, located in the Stono River at the junction with the Folly River northern channel, recorded average minimum critical velocities during both ebb and flood tides (28 cm/sec to the south and 26 cm/sec to the north respectively). The net resultant of 2 cm/sec to the southeast indicates dominant seaward or ebb transport of sand. Hence, any sand coming down the Folly River northern channel between Cole Island and Bird Key would be transported seaward in the

Stono River.

Current meter data from Stations 21, 14, and 2 suggest that although the Folly River reach between Cole Island and Bird Key experiences only southerly sand transport, the sand actually moved probably can come from no further north than Station 14. Stations 21 and 14 both indicate net sand transport away from this Cole Island/Bird Key reach.

Stations 19, 20, 17, 18, 15, 16, 3, and 11 indicate a unidirectional sand transport among the northern channel, "mid-river" bar, southern channel, and the shoal between Folly Island and Bird Key. Sand moves from the northern channel to the "mid-river" bar and then down to the shoal. It is unknown at present if the shoal is the final resting place or if sand moves from it back into the northern channel.

CONCLUSIONS

1. Littoral transport is northeastward on Folly Island, with a rate varying between 4,000 and 15,000 m^3/year. Folly Island suffers a net loss of 4,000 m^3/year to Morris Island. No net littoral transport is taking place in the Stono Inlet region between Folly and Kiawah Islands. The Charleston Harbor jetties do influence littoral processes on the northern half of Morris Island but probably do not affect Folly Island.

2. Map differencing techniques were successful in producing sand budgets for the Charleston Harbor Entrance region, including Morris Island and for the Stono Inlet region, including the southwestern end of Folly Island. However, shoreline and isobath changes over the bulk of Folly Island have not been of a magnitude large enough to be measured. The Cummings Point region of Morris Island is experiencing a deposition rate of 70,000 to 95,000 m^3/year. The Stono Inlet region is essentially an independent system, reworking local materials at a rate of between 120,000 and 205,000 m^3/year.

3. Bottom tidal currents competent to entrain sand only during flood tide are predominant south of the south jetty at the Charleston Harbor Entrance. These currents are causing the pre-1900 (or jetty construction) ebb tidal delta/shoal to migrate toward Cummings Point on Morris Island.

4. Bottom tidal currents define a unidirectional sand transport system in the lower reaches of the Folly River, near the southwestern tip of Folly Island. Sand is transported south and east from the north side of the river to a "mid-river" bar and then southwest and south to a shoal adjacent to the southwest tip of Folly Island. This

pattern serves to maintain both the "mid-river" bar and the shoal. As the bar has been a long-term feature, and as the main river channel south of the bar is dominated by southwest moving currents, either the shoal may be supplying sand northwest to the northern channel, 2) sand is supplied from further northeast to nourish the bar, or some combination of both.

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DATA APPENDIX I

AVERAGE VELOCITY VECTORS FOR LUNAR TIDAL CYCLES AT EACH CURRENT METER STATION

The following tables contain average hourly (lunar) velocity vectors for a complete tidal cycle (12 lunar hours). Each vector is an average of all such lunar hours monitored at each station.

The station identification is the last <u>two</u> digits of the hand printed four digit number appearing in the upper left hand corner.

The column labeled "VALID POINTS" contains the number of observations used to determine the respective hourly average.

The columns labeled "VELOCITY*SIN OF DIRECTION" and "VELOCITY* COS OF DIRECTION" list both mean values and variances. The column labeled "COVARIANCE" lists the covariance between the previously mentioned values.

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VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC

***** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEAD LOW-3

FRAME COUNT = 8 GROUP COUNT = 46 INCREMENT= 12

32	-33.729	60.108	-15.568	517.324	1074.	37.145	245.224
32	-34.710	58.333	3.615	393.204	-236.4	34.698	275.945
32	-27.454	138.245	11.244	69.290	-655.6	29.667	292.273
32	-10.846	352.389	2.596	144.615	-257.3	11.152	283.460
32	16.201	326.797	-11.730	276.562	-580.1	20.001	125.905
32	15.821	906.315	-26.376	82.559	-444.6	30.757	149.043
32	13.202	382.984	-26.408	116.254	-626.5	29.526	153.438
32	13.701	151.083	-19.527	188.601	-415.8	23.554	144.945
32	4.248	137.820	-14.658	69.406	-126.4	15.261	163.837
32	-0.515	103.125	-12.243	60.249	-36.27	12.254	182.408
24	-11.582	214.284	-10.951	53.715	172.5	15.940	226.604
24	-32.039	201.120	-10.558	332.375	625.4	33.734	251.761

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302

***** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE READ HIGH+2

FRAME COUNT = 17 GROUP COUNT = 43 INCREMENT= 12

VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
68	-3.595	58.071	-18.580	50.572	168.4	18.925	190.951
68	-11.756	37.257	-28.809	16.540	701.5	31.115	202.199
68	-22.473	45.946	-33.888	7.757	1551.	40.663	213.551
68	-18.046	38.198	-32.106	7.627	1186.	36.830	209.340
68	-8.058	18.798	-24.189	17.728	407.4	25.496	198.423
68	-2.003	6.271	-17.547	87.303	80.51	17.661	186.514
68	-0.329	8.816	-12.669	16.959	7.344	12.674	181.487
51	-1.681	24.025	-9.705	11.260	42.07	9.850	189.828
51	1.365	2.555	-6.882	1.977	-20.47	7.016	168.779
51	2.246	6.022	-7.465	3.985	-36.95	7.796	163.253
51	3.574	14.082	-8.734	9.713	-66.96	9.437	157.746
51	3.084	17.811	-9.140	10.784	-63.69	9.646	161.355

0303

STATISTICS BASED ON NUMBER OF CYCLES CHOSEN .
VALUES REPRESENT EITHER LUNAR HOURS OF A
EBB AND FLOOD TIDE. CHECK CYCLES-PER HOUR

Average Values For A Lunar cycle Starting at surface Dead High

FRAME COUNT= 17 GROUP COUNT= 46 INCREMENT= 12

VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION Degrees Magnetic
68	-0.334	617.550	-6.141	192.094	224.5	6.170	183.103
65	-7.375	277.576	-1.950	153.945	97.49	7.628	255.193
67	-32.554	91.993	-8.158	223.921	637.9	33.568	255.881
68	-36.719	46.136	-7.090	295.410	627.1	37.397	259.072
68	-31.637	36.440	0.751	213.716	23.04	31.646	271.359
67	-17.249	61.553	10.105	163.778	-318.1	19.991	300.362
64	0.960	92.336	-0.315	161.435	-96.19	1.011	108.164
67	7.434	22.650	-15.017	17.152	-227.5	16.757	153.662
68	-0.483	107.058	-22.332	25.069	37.67	22.338	181.240
68	-4.872	276.708	-18.599	602.977	495.9	19.226	194.679
51	-6.908	414.917	-10.317	917.520	660.2	12.466	214.149
51	-9.326	443.156	-8.207	788.574	663.4	12.422	228.652

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0304

***** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEAD HIGH+1

FRAME COUNT = 17 GROUP COUNT = 44 INCREMENT= 12

VALID POINTS	VELOCITY * SIN OF DIRECTION		VELOCITY * COS OF DIRECTION		COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
	MEAN	VARIANCE	MEAN	VARIANCE			
68	5.574	183.032	-23.820	712.223	-411.6	24.464	166.830
68	15.140	60.320	-44.747	148.349	-1388.	47.239	161.306
68	20.491	34.751	-53.522	40.516	-2233.	57.310	159.051
68	16.144	40.980	-50.844	44.380	-1699.	53.350	162.386
68	6.884	85.663	-38.455	85.279	-608.7	39.067	169.851
68	-3.161	111.363	-4.586	1264.740	-278.0	5.570	214.578
68	-10.409	116.783	33.068	830.286	-944.0	34.668	342.528
68	-15.094	27.945	44.728	32.563	-1386.	47.206	341.352
51	-15.554	28.895	42.442	24.232	-1347.	45.203	339.873
51	-13.069	25.108	41.061	21.006	-1092.	43.091	342.345
51	-7.035	44.496	37.208	24.047	-535.2	37.867	349.292
51	-3.081	120.924	17.413	318.709	-135.4	17.683	349.967

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0305

VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
***** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEAD LOW+2							
FRAME COUNT =	17	GROUP COUNT =	65	INCREMENT=	12		
283	-3.441	711.906	-6.034	95.918	36.09	6.946	209.695
100	-18.686	297.813	5.194	269.644	-164.1	19.395	285.532
102	-15.663	250.857	8.623	208.487	-242.6	17.880	298.834
102	-5.175	439.923	8.811	244.852	-133.2	10.218	329.576
102	11.594	364.358	9.766	263.917	186.3	15.159	49.890
85	17.899	369.483	-1.900	246.798	-116.3	18.000	96.061
85	15.581	318.282	-12.563	220.116	-364.0	20.015	128.880
85	7.404	317.684	-24.223	195.290	-234.4	25.330	163.004
85	-2.925	240.935	-34.398	133.610	305.4	34.522	184.860
85	-13.970	90.278	-39.749	48.155	1118.	42.132	199.364
85	-18.023	37.319	-33.569	201.382	1227.	38.101	208.231
85	-16.383	95.949	-19.968	191.227	668.9	25.829	219.366

0306

STATISTICS BASED ON NUMBER OF CYCLES CHOSEN.
VALUES REPRESENT EITHER LUNAR HOURS OF A
EBB AND FLOOD TIDE. CHECK CYCLES PER HOUR

Average Values For A Lunar Cycle starting at Surface Dead Low

FRAME COUNT= 17 GROUP COUNT= 4° INCREMENT= 12

VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY cm/sec	RESULTANT DIRECTION Degrees magneti
85	-9.523	212.180	19.664	169.081	-468.4	21.849	334.159
68	-24.176	276.165	26.280	51.620	-1312.	35.709	317.388
68	-35.585	142.563	30.152	41.660	-2169.	46.641	310.275
68	-37.244	40.238	26.921	43.596	-2044.	45.996	305.931
68	-28.760	294.817	23.645	117.983	-1307.	37.232	309.425
68	-3.506	450.013	5.579	255.899	-92.03	6.588	327.854
68	16.162	418.332	-4.848	232.122	-110.2	16.873	106.699
67	45.797	296.241	-17.653	554.471	-1350.	49.082	111.080
68	45.783	312.109	-25.941	675.177	-2007.	52.622	119.536
68	37.525	273.682	-27.747	547.019	-1798.	46.669	126.480
68	17.450	78.052	-29.533	206.732	-1101.	34.303	149.422
68	5.632	67.193	-2.033	188.979	-124.3	5.989	109.894

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0307

***** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEAD LOW+1

FRAME COUNT = 17 GROUP COUNT = 48 INCREMENT= 12

VALID POINTS	VELOCITY * SIN OF DIRECTION		VELOCITY * COS OF DIRECTION		COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
	MEAN	VARIANCE	MEAN	VARIANCE			
68	11.417	115.388	23.085	499.146	538.0	25.754	26.315
68	31.427	175.604	43.483	96.898	2827.	53.651	35.857
68	39.832	166.317	46.048	197.437	3733.	60.885	40.860
67	36.759	247.298	47.078	350.350	3607.	59.729	37.983
68	24.940	451.282	31.820	395.374	1873.	40.429	38.088
67	2.111	389.200	6.153	587.822	313.5	6.505	18.932
67	1.494	214.526	-10.798	81.200	.7660	10.901	172.121
66	-14.928	283.755	-22.518	225.503	859.4	27.016	213.542
68	-27.439	287.477	-30.351	144.923	1737.	40.916	222.115
68	-21.576	142.174	-28.543	108.284	1314.	35.781	217.086
64	-4.030	168.864	-14.509	111.268	204.0	15.058	195.524
68	1.347	357.356	-5.010	356.531	79.50	5.188	164.949

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VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY CHASES	RESULTANT DIRECTION DEGREES MAGNETIC

0308

***** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEAD LOW+2

FRAME COUNT = 8 GROUP COUNT = 51 INCREMENT= 12

28	-1.678	154.966	-1.922	110.472	-19.06	2.477	222.644
30	-5.832	286.303	9.334	160.709	-99.11	10.172	326.019
33	-6.528	170.022	18.902	155.666	-147.8	19.998	340.947
28	-5.239	256.865	24.165	148.712	-141.6	24.727	347.768
32	-3.507	365.030	23.419	151.796	2.906	23.680	351.482
28	-4.631	334.646	17.672	210.028	-21.03	17.269	345.316
25	-6.930	324.733	-5.424	201.767	2.927	8.690	231.950
27	-9.882	155.874	-11.108	181.644	100.0	14.868	221.656
26	-4.117	214.789	-11.958	227.753	-10.96	12.647	199.000
32	2.737	167.051	-7.588	140.839	-50.05	8.067	160.166
30	-4.845	146.614	-4.731	107.286	63.24	6.772	225.681
32	-3.903	187.544	0.428	62.926	-34.37	3.927	276.258

0310

STATISTICS BASED ON NUMBER OF CYCLES CHOSEN.
VALUES REPRESENT EITHER LUNAR HOURS OF A
EBB AND FLOOD TIDE. CHECK CYCLES PER HOUR

Average Values For A Lunar Cycle Starting at Surface Dead Low

FRAME COUNT= 17 GROUP COUNT= 26 INCREMENT= 12

VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY cm/sec	RESULTANT DIRECTION Degrees magnet
41	-15.960	487.597	-1.999	640.707	199.4	16.085	262.860
51	-8.324	617.898	2.277	562.897	-89.12	8.617	284.979
34	-5.119	733.946	14.267	433.440	-298.0	15.157	340.265
34	8.113	534.966	8.216	547.959	131.7	11.547	44.639
34	12.990	350.760	-2.905	622.340	-161.0	13.311	102.607
34	15.779	286.576	-13.458	463.514	-498.8	20.738	130.462
34	19.735	254.509	-15.257	339.345	-627.0	24.945	127.708
34	11.399	389.907	-24.498	365.256	-626.6	27.011	155.038
34	3.575	367.330	-17.177	546.594	-99.62	17.565	167.923
34	-1.632	404.362	-15.817	461.590	38.78	15.901	185.891
34	-7.313	500.881	-16.945	438.258	278.8	18.456	203.344
34	-20.510	405.796	0.906	592.053	90.56	20.530	272.528

0311

STATISTICS BASED ON NUMBER OF CYCLES CHOSEN .
VALUES REPRESENT EITHER LUNAR HOURS OF A
EBB AND FLOOD TIDE. CHECK CYCLES PER HOUR

Average Values For a Lunar Cycle Starting at Surface Dead High

FRAME COUNT= 17 GROUP COUNT= 42 INCREMENT= 12

VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY cm/sec	RESULTANT DIRECTION Degrees magnet
68	-1.646	17.495	-27.994	56.538	109.9	28.042	183.365
68	-3.547	14.000	-33.779	11.987	247.9	33.956	185.997
68	-1.544	12.733	-33.646	12.760	107.4	33.682	182.628
68	0.968	4.008	-27.301	12.032	-50.94	27.318	177.969
68	-0.223	20.702	-14.197	215.073	17.25	14.108	180.907
68	-1.161	23.530	-6.020	524.667	86.63	6.131	190.914
51	0.039	26.679	-7.784	624.452	52.15	7.784	179.710
51	2.441	26.710	-6.925	793.631	-40.57	7.343	160.586
51	5.054	10.959	-7.796	803.328	-150.4	9.291	147.048
51	3.677	29.179	-7.197	841.234	-151.8	8.082	152.933
51	0.942	41.956	-1.924	671.920	-73.63	2.142	153.900
49	0.567	83.499	-1.153	318.773	-16.22	1.285	153.806

0312

STATISTICS BASED ON NUMBER OF CYCLES CHOSEN .
VALUES REPRESENT EITHER LUNAR HOURS OF A
EBB AND FLOOD TIDE. CHECK CYCLES PER HOUR

Average Values For a Lunar Cycle Starting AT Surface Dead High

FRAME COUNT= 17 GROUP COUNT= 42 INCREMENT= 12

VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY cm/sec	RESULTANT DIRECTION Degrees magnetic
53	-3.129	75.043	-28.902	410.582	196.1	29.071	186.179
66	-10.464	180.785	-44.792	93.353	907.6	45.998	193.149
68	-12.571	214.447	-45.508	69.732	1078.	47.212	195.442
67	-10.752	137.456	-35.853	62.769	718.8	37.430	196.693
45	-3.061	62.964	-18.262	195.008	137.6	18.517	189.514
44	9.802	1383.309	41.493	17723.477	5440.	42.635	13.291
48	0.929	235.452	31.437	203.022	-135.4	31.450	1.693
51	-10.111	72.003	46.333	86.965	-982.1	47.423	347.689
51	-11.373	95.817	46.728	236.627	-1145.	48.092	346.321
51	-13.420	65.437	48.431	93.571	-1347.	50.256	344.512
49	-11.952	116.510	40.046	132.036	-1055.	41.791	343.382
32	0.322	270.069	16.639	228.624	-139.6	16.641	1.109

0313

STATISTICS BASED ON NUMBER OF CYCLES CHOSEN.
VALUES REPRESENT EITHER LUNAR HOURS OF A
EBB AND FLOOD TIDE. CHECK CYCLES PER HOUR

AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEAD

FRAME COUNT= 17 GROUP COUNT= 42 INCREMENT= 12

VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
68	0.097	81.853	-11.359	27.073	7.579	11.359	179.509
68	-27.911	159.503	-10.852	176.126	612.9	29.952	248.723
65	-38.529	38.767	-14.095	100.877	1115.	41.022	249.919
68	-35.681	40.111	-14.916	54.869	1071.	38.673	247.314
65	-27.249	54.722	-13.841	93.365	796.6	30.561	243.071
68	-7.543	87.007	-5.373	108.012	66.03	9.261	234.537
51	1.666	9.934	-8.209	29.556	-27.73	3.377	169.529
51	6.947	37.554	-2.998	159.526	-109.7	7.567	113.340
49	13.832	94.175	0.147	148.616	-44.51	13.839	89.391
49	24.628	69.201	-1.699	220.819	-113.3	24.687	93.945
45	32.305	83.010	-1.494	147.690	-114.4	32.339	92.631
51	16.318	100.414	-7.076	36.143	-204.3	17.786	113.444

0314

●●●●● AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE [illegible]

EVALE COUNT = 17 [illegible] COUNT = 14 [illegible] = 12

VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
85	24.944	457.164	-26.347	[illegible]	-1076.	36.312	135.021
85	6.413	227.265	-57.115	202.321	-642.3	57.475	173.594
85	3.590	[illegible]	-71.965	[illegible]	-3300.	72.003	172.404
85	1.225	102.335	-50.56[illegible]	441.251	-253.1	50.585	178.532
85	-2.600	163.7[illegible]	-30.725	10101.407	443.2	30.842	184.986
85	0.232	65.165	8.533	635.[illegible]	-66.27	8.536	1.500
85	-2.500	31.337	28.573	1104.[illegible]	-293.7	28.683	354.999
85	-3.930	32.965	51.741	312.[illegible]	-3[illegible].2	51.890	355.653
85	-4.661	2[illegible].061	57.277	23.464	-532.0	57.466	355.358
85	-7.885	47.172	56.552	30.085	-941.1	57.095	352.093
85	-4.798	24.985	43.703	103.760	-434.7	43.965	353.735
68	5.027	29.100	12.346	504.[illegible]	-30.[illegible]	14.154	29.301

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VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC

0315

***** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEAD LOW

FRAME COUNT = 17 GROUP COUNT = 66 INCREMENT= 12

102	2.661	137.052	-3.266	35.476	-38.81	4.213	140.831
102	19.411	330.687	-8.239	29.656	-325.8	20.171	114.109
102	39.191	210.944	-8.644	33.308	-675.5	40.133	102.438
102	57.698	7935.951	-8.651	153.195	-21.83	58.342	98.527
102	43.515	126.397	-10.046	26.759	-852.1	44.659	103.000
102	12.833	775.582	-8.698	28.804	-240.4	15.503	124.129
85	-11.332	596.163	-5.817	65.126	228.5	12.738	242.826
85	-21.129	618.649	-5.608	144.645	490.5	21.861	255.135
85	-23.471	327.123	-9.351	73.891	544.7	25.265	248.278
85	-13.973	208.713	-6.666	67.403	257.5	15.482	244.495
85	-1.804	32.508	-7.104	61.448	31.08	7.387	194.134
85	-0.812	29.876	-5.741	59.457	10.51	5.799	188.049

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0316

***** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEAD LOW

FRAME COUNT = 17 GROUP COUNT = 66 INCREMENT= 12

VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
102	2.888	86.265	8.067	1011.491	216.0	8.569	19.099
102	10.067	194.250	23.919	1065.590	818.3	25.951	22.825
102	21.773	180.577	44.111	457.353	2174.	49.192	26.270
102	25.340	71.557	50.306	37.299	2595.	56.325	26.735
102	19.496	143.529	41.159	76.050	1665.	45.543	25.345
102	8.164	333.594	15.313	902.969	522.0	17.353	28.005
85	-3.065	125.010	-23.419	910.876	336.6	23.619	187.457
85	-6.787	62.737	-47.283	109.615	697.8	47.768	188.109
85	-5.939	46.189	-45.517	93.300	590.0	45.903	187.433
85	-8.846	147.454	-28.984	323.964	338.8	30.303	196.972
85	-2.793	103.285	-9.676	696.801	-52.94	10.071	196.099
85	4.028	47.410	1.198	660.739	51.23	4.202	73.436

P33010EA ********************************

0317

***** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEAD LOW

FRAME COUNT = 17 GROUP COUNT = 66 INCREMENT= 12

VALID POINTS	VELOCITY * SIN OF DIRECTION		VELOCITY * COS OF DIRECTION		COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
	MEAN	VARIANCE	MEAN	VARIANCE			
102	1.307	313.984	-20.492	57.458	-167.9	20.534	176.349
102	22.169	671.911	-22.700	285.542	-1119.	31.729	135.678
102	49.195	50.755	-15.755	663.226	-1517.	51.657	107.758
102	53.378	105.334	-9.892	766.760	-966.1	54.287	100.499
102	42.410	329.652	-8.866	728.498	-698.1	43.327	101.809
102	11.856	555.045	-15.936	356.530	-279.4	19.863	143.350
85	-16.167	376.517	-19.937	417.341	928.0	25.668	219.039
85	-27.073	55.482	-28.326	164.507	1594.	39.183	223.705
85	-20.564	34.661	-28.081	38.603	1165.	34.806	216.216
85	-13.349	25.812	-22.221	21.823	597.3	25.922	210.995
85	-10.990	19.840	-19.411	8.790	423.2	22.306	209.518
85	-11.209	21.891	-16.692	21.352	375.8	20.106	213.883

P33010FA ********************************

0318

***** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE HEAD ...

FRAME COUNT = 17 GROUP COUNT = 66 INCREMENT = 12

VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
102	-14.426	327.483	-22.947	137.087	659.5	27.105	212.155
102	-0.246	365.965	-31.970	35.586	-2.569	31.971	180.442
102	29.468	269.013	-30.491	35.777	-1751.	42.404	135.977
102	38.494	175.723	-28.557	51.304	-2151.	47.936	126.574
102	36.614	221.278	-24.672	63.408	-1745.	44.151	123.974
102	17.540	266.836	-30.450	65.926	-980.7	35.141	150.057
85	-1.156	567.882	-37.753	207.513	396.4	37.770	181.754
85	-26.219	43.646	-48.154	92.449	2580.	54.830	208.568
85	-29.[illegible]	42.995	-45.468	77.066	2761.	54.311	213.153
85	-26.645	31.636	-38.252	66.575	2091.	46.525	214.853
85	-22.220	11.846	-30.805	9.083	1381.	37.982	215.803
85	-21.931	9.479	-28.117	9.145	1239.	35.655	217.954

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0319

••••• AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEAD LOW

FRAME COUNT = 17 GROUP COUNT = 67 INCREMENT= 12

VALID POINTS	VELOCITY * SIN OF DIRECTION		VELOCITY * COS OF DIRECTION		COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
	MEAN	VARIANCE	MEAN	VARIANCE			
102	-5.304	525.473	-2.183	294.076	113.7	5.736	247.629
102	9.726	1693.053	-6.914	378.328	-5.296	11.933	125.408
102	36.144	490.563	11.280	944.807	533.4	37.867	72.669
102	34.962	403.480	27.734	398.815	1605.	44.626	51.577
102	26.549	224.374	30.172	283.059	1432.	40.189	41.345
102	12.874	107.196	13.699	299.263	465.3	18.799	43.222
102	-17.477	387.395	-18.031	361.016	606.9	25.111	224.107
85	-37.850	271.407	-23.185	338.356	1619.	44.387	238.511
85	-37.379	227.614	-21.954	269.967	1526.	43.349	239.572
85	-28.880	246.336	-14.191	174.250	743.2	32.179	243.832
85	-16.755	140.880	-7.549	172.403	259.0	18.377	245.746
85	-6.851	69.133	1.825	204.130	23.22	7.090	284.916

P3301DEA ********************************

0320

***** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEAD HIGH+1

FRAME COUNT = 17 GROUP COUNT = 60 INCREMENT= 12

VALID POINTS	VELOCITY * SIN OF DIRECTION		VELOCITY * COS OF DIRECTION		COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
	MEAN	VARIANCE	MEAN	VARIANCE			
74	0.757	194.471	1.724	538.671	223.5	1.883	23.710
80	-19.062	453.964	-26.618	683.486	1421.	32.739	215.607
77	-32.783	380.315	-42.944	303.562	3009.	54.027	217.358
82	-37.631	325.021	-39.520	76.373	3044.	54.570	223.597
85	-23.774	343.124	-37.095	126.276	1958.	44.059	212.655
83	-6.693	64.271	-26.587	56.339	412.0	27.417	194.130
85	2.154	24.961	-14.521	90.593	-17.68	14.680	171.561
81	7.284	72.624	-8.701	177.533	-93.52	11.347	140.068
82	2.677	316.111	-1.659	599.885	130.5	3.149	121.789
85	6.401	429.594	10.537	811.908	590.0	12.329	31.278
85	17.325	676.326	20.342	576.106	1273.	26.720	40.420
85	15.141	439.670	17.739	712.632	1041.	23.322	40.482

R3101OEA ********************************

0321.

***** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEAD LOW

FRAME COUNT = 17 GROUP COUNT = 66 INCREMENT= 12

VALID POINTS	*VELOCITY * SIN OF DIRECTION MEAN	VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VARIANCE	COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
102	14.924	313.590	17.954	473.629	778.3	23.346	39.735
102	40.978	448.363	25.907	473.591	1923.	48.428	57.798
102	48.232	482.840	30.557	879.211	2589.	57.097	57.644
102	43.531	269.625	28.138	762.770	2099.	51.834	57.122
102	41.670	356.299	17.419	566.706	1240.	45.164	67.314
102	14.206	260.495	5.588	321.552	171.7	15.266	68.528
85	-7.877	342.781	-17.913	336.959	353.0	19.568	203.738
85	-5.985	961.967	-48.151	257.454	443.9	48.522	187.065
85	-2.522	885.816	-58.658	215.075	308.5	58.712	182.462
85	-0.945	502.095	-50.513	315.821	-52.46	50.522	181.072
85	-2.069	175.329	-32.558	251.917	94.05	32.624	183.636
85	-2.504	110.144	-10.996	271.363	88.23	11.278	192.828

P33010FA

0322

***** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE HEAD HIGH+2

FRAME COUNT = 17 GROUP COUNT = 59 INCREMENT = 12

VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
85	-0.163	232.074	-17.489	645.176	205.0	17.490	180.535
85	4.421	290.561	-42.539	151.126	-304.4	42.768	174.067
85	13.477	75.070	-45.100	42.717	-1208.	47.071	163.363
85	9.620	36.103	-38.893	76.553	-773.5	40.065	166.106
85	4.306	42.600	-22.996	231.123	-243.9	23.396	169.394
85	0.730	41.364	-6.125	403.706	-8.842	6.168	173.206
85	0.422	161.254	17.713	619.869	100.7	17.718	1.365
85	7.068	365.533	41.385	175.494	457.3	41.975	9.611
85	2.825	596.573	42.790	285.694	444.0	42.883	3.777
85	-5.897	663.327	30.333	529.765	126.6	30.901	349.998
85	-8.124	454.893	26.876	525.159	-22.31	28.077	343.180
68	-5.240	414.383	6.922	230.755	130.3	8.682	322.875

17	-20.427	15.006	2.051	56.414	10.45	20.599	277.395

P33010FA ************************************

0323

VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC

***** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEAD HIGH+1

FRAME COUNT = 17 GROUP COUNT = 60 INCREMENT= 12

85	1.400	100.445	2.379	154.666	2.871	2.760	30.484
85	10.078	108.109	-12.064	197.188	-326.6	15.720	140.126
85	17.791	156.088	-25.138	125.415	-937.6	30.791	144.727
85	19.995	160.234	-26.815	164.572	-1084.	33.390	143.427
85	21.177	159.246	-24.327	208.632	-1131.	32.253	138.960
85	13.695	159.813	-16.630	176.065	-545.9	21.543	140.529
85	2.214	139.904	-1.339	286.845	-163.4	2.588	121.169
85	-13.371	184.243	18.796	207.904	-532.3	23.067	324.574
85	-25.135	255.054	21.263	262.911	-890.2	32.923	310.230
85	-13.150	205.853	22.303	210.271	-424.4	25.891	329.476
85	-7.046	192.994	19.657	156.895	-133.7	20.881	340.280
85	-5.216	151.688	10.574	159.086	-32.00	12.266	329.552

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0324

●●●●● AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEPTH

FRAME COUNT = 17 GROUP COUNT = 56 INCREMENT= 12

VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
136	-20.414	102.209	-3.277	767.648	224.6	20.676	260.661
136	-10.455	199.507	6.615	657.015	-26.59	12.372	302.323
119	0.260	190.600	9.113	535.459	4.550	9.117	1.656
119	7.526	270.761	-5.021	462.265	29.15	9.047	123.711
119	8.737	318.524	-11.693	583.168	-30.45	14.597	143.231
119	12.759	264.304	-17.860	614.680	-215.5	21.956	144.458
119	5.005	157.293	-31.374	141.773	-372.2	31.771	170.936
119	1.088	145.739	-28.010	239.250	-127.8	28.031	177.775
119	-9.584	143.759	-17.476	544.393	194.7	19.931	208.741
119	-16.225	126.179	-16.137	578.400	461.7	22.883	225.156
119	-21.021	80.918	-16.067	529.982	667.7	26.470	232.574
119	-23.159	67.351	-14.348	540.046	717.6	27.243	234.219

P33010FA ••••••••••••••••••••••••••••••••••

VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC

0325

••••• AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEAD LOW

FRAME COUNT = 17 GROUP COUNT = 36 INCREMENT= 12

136	-14.328	145.139	-10.376	406.092	227.8	17.690	234.088
136	-12.373	153.755	-8.070	257.416	136.2	14.772	236.885
119	-4.249	126.950	-4.661	198.904	-8.521	6.307	222.353
119	0.297	95.019	-1.185	170.355	14.64	1.222	165.928
119	0.930	136.937	-2.490	168.384	19.04	2.625	161.574
119	-1.851	311.243	2.719	255.013	114.3	3.289	325.765
119	-2.461	243.001	-2.907	245.106	135.4	3.809	220.252
119	-3.706	231.645	-2.590	248.346	75.07	4.521	235.052
119	-9.407	122.763	2.127	157.440	-65.20	9.645	282.742
119	-10.280	150.590	-4.152	234.854	-37.57	11.087	248.006
119	-13.259	237.077	-3.805	220.680	-22.38	13.794	253.988
119	-16.820	249.411	-4.358	325.720	102.5	17.376	255.474

P33010FA ********************************

03 27

***** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEAD LOW

FRAME COUNT = 17 GROUP COUNT = 87 INCREMENT = 12

VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
136	-1.810	48.400	-15.550	169.328	47.43	15.655	186.639
136	-2.306	59.528	-13.285	239.713	67.69	13.485	189.847
136	-1.252	79.011	-13.703	332.446	75.18	13.760	185.221
119	1.486	69.235	-10.622	233.186	-7.175	10.725	172.035
119	3.564	94.971	-3.492	352.114	52.71	4.990	134.420
119	4.070	84.628	3.943	342.429	94.76	5.702	45.550
119	4.423	112.126	3.840	294.837	105.6	5.858	49.038
119	3.845	112.484	-7.404	249.175	-45.56	8.343	152.553
119	1.983	82.570	-9.529	174.661	-20.86	9.733	168.246
119	-0.012	91.427	-10.070	177.940	15.53	10.070	180.070
119	-2.108	57.849	-14.740	110.656	56.51	14.890	188.140
119	-2.065	49.323	-16.611	118.232	72.69	16.739	187.085

P33010FA ***********************************

0331

***** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEAD LOW

FRAME COUNT = 17 GROUP COUNT = 88 INCREMENT= 12

VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
136	-7.877	165.307	15.315	495.049	-149.7	17.223	332.764
136	-4.806	193.830	18.143	435.791	-113.1	18.769	345.164
136	-3.667	217.685	18.157	386.382	-55.75	18.523	348.563
136	-2.358	191.332	10.010	526.799	-13.34	10.284	346.746
119	0.770	232.656	1.570	491.892	-8.278	1.749	26.124
119	1.437	263.499	-7.418	523.633	40.59	7.556	169.038
119	3.067	187.169	-19.750	329.011	-133.5	19.987	171.173
119	1.598	173.473	-29.587	325.637	-80.79	29.630	176.909
119	1.665	96.662	-37.244	114.887	-100.2	37.281	177.441
119	0.744	190.468	-26.275	380.203	-55.99	26.286	178.376
119	-4.743	199.577	-13.001	676.986	39.04	13.839	200.043
119	-6.802	245.317	5.341	705.282	-88.89	8.648	308.137

P4101DEA ******************************

VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC

0332

***** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE HEAD LOW

FRAME COUNT = 17 GROUP COUNT = 67 I-COUNT = [illegible]

136	-7.232	85.470	21.333	134.115	-312.2	22.542	341.323
136	-5.457	119.891	19.312	175.368	-235.1	20.066	344.220
136	-3.268	112.863	18.214	175.942	-101.5	18.505	349.827
119	1.181	136.009	9.170	317.333	.5905	9.245	7.339
119	3.862	106.145	1.137	457.101	25.22	4.026	73.596
119	8.482	150.253	-4.708	266.331	-34.27	9.701	119.031
119	8.563	198.275	-1.383	288.267	63.13	8.674	99.174
119	5.266	318.589	-8.324	369.335	-85.91	9.850	147.601
119	3.769	192.547	-5.621	511.727	-145.1	6.768	146.157
119	0.515	194.955	6.197	547.031	-178.3	6.219	4.753
119	-3.100	121.067	16.277	260.139	-198.2	16.570	349.217
119	-6.919	94.134	25.755	65.104	-376.6	26.669	344.963

P33010FA ********************************

**** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEAD LOW-2

FRAME COUNT = 17 GROUP COUNT = 89 INCREMENT= 12

VALID POINTS	VELOCITY * SIN OF DIRECTION		VELOCITY * COS OF DIRECTION		COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
0332	MEAN	VARIANCE	MEAN	VARIANCE			
136	-0.702	154.384	10.795	476.935	-199.9	10.818	356.279
136	-5.019	126.491	21.953	181.332	-285.1	22.520	347.122
136	-7.232	85.470	21.393	134.115	-312.2	22.582	341.323
136	-5.457	119.891	19.312	178.368	-235.1	20.068	344.220
136	-3.268	112.883	18.214	175.942	-101.5	18.505	349.827
119	1.181	136.809	9.170	317.339	.6905	9.245	7.339
119	3.862	106.145	1.137	357.101	25.22	4.026	73.596
119	8.482	150.253	-4.708	266.331	-34.27	9.701	119.031
119	8.563	198.275	-1.383	288.267	63.13	8.674	99.174
119	5.266	318.589	-8.324	389.335	-85.91	9.850	147.661
119	3.769	192.547	-5.621	511.787	-145.1	6.768	146.157
119	0.515	194.955	6.197	547.831	-178.3	6.218	4.753

P33010FA ********************************

0333

***** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEAD HIGH

FRAME COUNT = 17 GROUP COUNT = 62 INCREMENT= 12

VALID POINTS	VELOCITY * SIN OF DIRECTION		VELOCITY * COS OF DIRECTION		COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
	MEAN	VARIANCE	MEAN	VARIANCE			
102	2.173	131.815	-9.726	361.491	57.16	9.966	167.408
102	-1.583	196.785	-7.271	286.545	89.79	7.441	192.286
85	-3.641	162.600	-8.636	268.218	72.69	9.372	202.863
85	-7.348	182.267	4.368	305.789	-26.42	8.549	300.730
85	-9.229	91.572	1.961	479.068	37.83	9.435	281.994
85	-12.707	48.055	4.324	583.231	-70.75	13.423	288.792
85	-12.380	43.781	-2.957	621.793	79.06	12.728	256.568
85	-9.226	83.326	-3.443	606.010	193.9	9.847	249.537
85	-8.313	115.975	-5.678	529.320	220.5	10.067	235.668
85	-5.173	137.182	-9.425	431.223	192.1	10.751	208.761
85	1.566	211.677	-13.222	359.093	-57.24	13.315	173.244
85	5.952	132.639	-11.477	435.407	-75.16	12.928	152.590

P33010FA ••••••••••••••••••••••••••••••••••

0334

••••• AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEAD LOW

FRAME COUNT = 17 GROUP COUNT = 89 INCREMENT= 12

VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
131	7.777	57.912	19.172	344.164	353.8	20.669	22.081
123	6.915	47.173	28.853	158.446	413.6	29.570	13.477
128	7.208	64.733	26.214	401.756	316.0	27.167	15.374
125	4.399	73.741	25.938	157.591	214.9	26.309	9.626
135	0.795	97.175	19.120	244.745	81.30	19.133	2.112
119	2.095	84.034	5.803	406.615	77.74	6.170	19.851
119	3.574	87.034	-4.502	260.603	-54.93	5.746	141.556
119	-2.365	178.604	-5.991	159.141	-11.72	7.360	158.693
119	5.470	188.926	-4.150	204.710	-61.37	6.672	127.259
119	6.112	144.747	3.251	289.734	-33.50	6.923	61.990
119	6.394	65.144	6.278	474.966	67.64	8.961	45.523
119	6.753	48.334	10.723	423.906	134.1	12.672	32.203

0335

VALID POINTS	VELOCITY [illegible]	[illegible]	VELOCITY [illegible]	[illegible]	COVARIANCE	[illegible]	RESULTANT [illegible]

***** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT [illegible]

[illegible] COUNT = 17

VALID POINTS	VELOCITY [illegible]	[illegible]	VELOCITY [illegible]	[illegible]	COVARIANCE	[illegible]	RESULTANT [illegible]
132	[illegible]	112.[illegible]	[illegible]	[illegible]	-1[illegible]	[illegible]	[illegible]
126	[illegible]	11[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	34[illegible].512
132	[illegible]	10[illegible]	27.71[illegible]	12[illegible].111	-1[illegible]	27.[illegible]	[illegible].417
129	[illegible]	15[illegible].[illegible]7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible].741
115	[illegible]	[illegible]	11.4[illegible]	[illegible]	7[illegible]	11.[illegible]	[illegible]
116	[illegible]	31.7[illegible]	[illegible].7[illegible]	[illegible]	[illegible]	[illegible]	[illegible].1[illegible]
114	[illegible]	51.[illegible]	-1[illegible].7[illegible]	[illegible]7[illegible].[illegible]47	-1[illegible]	1[illegible]	1[illegible]
116	[illegible]	[illegible]	-2[illegible]	17[illegible]	-2[illegible]	[illegible]	1[illegible].572
116	11.[illegible]3	1[illegible]	-2[illegible]	[illegible]	-[illegible].3	[illegible]	1[illegible]
110	7.6[illegible]	[illegible]7.444	-17.57[illegible]	7[illegible].[illegible]21	-[illegible]11.[illegible]	1[illegible].1[illegible]1	15[illegible].[illegible]1
110	1.872	141.51[illegible]	-[illegible].[illegible]72	741.[illegible]	-17[illegible].1	1.[illegible]	10[illegible].738
116	-[illegible].338	15[illegible].3[illegible]	1[illegible]	[illegible]	-257.[illegible]	17.[illegible]	34[illegible].[illegible]

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0336

••••• AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEAD [illegible]

FRAME COUNT = 17 GROUP COUNT = 62 INCREMENT= 12

VALID POINTS	VELOCITY * SIN OF DIRECTION		VELOCITY * COS OF DIRECTION		COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
	MEAN	VARIANCE	MEAN	VARIANCE			
102	4.277	245.561	-0.119	286.186	56.38	4.279	91.600
102	1.576	288.426	-13.805	336.621	60.34	13.895	173.487
85	-2.042	154.427	-19.531	314.638	142.2	19.637	185.969
85	-5.717	246.880	-6.783	324.484	42.68	8.871	220.126
85	-8.046	217.555	4.998	317.546	-90.05	9.472	301.845
85	-2.335	190.963	12.801	308.938	-115.6	13.012	349.661
85	2.039	94.943	24.136	85.010	104.6	24.222	4.829
85	3.423	81.673	25.979	37.343	186.2	26.204	7.507
85	5.766	31.428	26.258	22.718	305.7	26.883	12.385
85	4.584	62.368	25.029	21.540	244.6	25.445	10.379
85	5.419	99.427	18.436	131.593	211.9	19.216	16.381
85	5.383	144.664	6.476	321.193	84.18	8.421	39.738

P33010FA *********************************

0337

***** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEAD LOW

FRAME COUNT = 17 GROUP COUNT = 89 INCREMENT= 12

VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
136	20.484	110.217	31.215	466.766	1240.	37.336	33.274
136	19.148	70.642	33.920	481.098	1320.	38.951	29.445
136	12.558	89.231	29.203	631.606	788.3	31.789	23.269
136	6.962	124.394	23.486	526.246	402.4	24.496	16.511
136	1.790	207.424	6.122	858.664	62.43	6.379	16.294
119	-2.596	158.680	-10.954	470.576	28.07	11.257	193.331
119	-5.392	50.357	-31.682	516.651	304.6	32.138	189.658
119	-3.905	22.572	-41.190	16.527	321.9	41.375	185.416
119	-3.718	18.836	-40.654	17.125	301.3	40.823	185.225
119	-1.922	117.644	-28.391	451.764	254.9	28.456	183.874
119	7.227	244.584	-1.755	421.097	333.3	7.437	103.649
119	15.073	237.786	18.637	716.345	617.6	23.969	38.966

P33010FA ************************************

0339

***** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEAD HIGH

FRAME COUNT = 17 GROUP COUNT = 59 INCREMENT= 12

VALID POINTS	VELOCITY * SIN OF DIRECTION		VELOCITY * COS OF DIRECTION		COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
	MEAN	VARIANCE	MEAN	VARIANCE			
85	25.800	166.181	-27.139	91.005	-1407.	37.446	136.449
85	34.054	125.628	-30.313	109.794	-2017.	45.591	131.674
85	31.590	131.311	-28.284	268.194	-1664.	42.402	131.840
85	27.513	8672.406	-21.586	1080.162	-3990.	34.970	128.118
85	2.291	131.772	-10.099	186.105	-96.61	10.356	167.219
85	-2.912	85.000	-6.758	570.529	36.38	7.358	203.312
85	-6.366	106.991	15.200	628.152	-78.60	16.487	337.209
85	-1.029	100.097	31.225	26.256	-58.06	31.242	358.112
85	-3.254	97.206	28.426	153.493	-112.7	28.612	353.470
85	1.292	94.182	22.671	126.999	93.92	22.707	3.262
85	10.857	200.523	7.019	301.540	94.85	12.928	57.115
68	21.644	152.328	-4.747	473.524	-265.2	22.159	102.371

[illegible]10EA

0340

***** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE [illegible] HIGH

FRAME COUNT = 17 GROUP COUNT = 63 [illegible] = 12

VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
102	3.954	40.563	-21.527	1[illegible].[illegible]34	-171.2	21.9[illegible]	169.040
102	3.745	46.737	-31.355	92.427	-543.4	32.552	164.417
102	9.435	223.012	-32.147	15[illegible].751	-492.9	33.543	163.715
85	5.708	153.632	-32.546	246.653	-443.9	33.055	169.699
85	4.445	30.855	-8.715	119.104	-77.10	9.801	152.779
85	6.206	65.257	10.525	177.444	232.5	13.345	37.934
85	12.914	145.655	26.354	87.529	739.1	29.344	26.105
85	5.436	175.468	32.576	122.197	373.4	33.027	9.474
85	-4.962	142.555	32.900	148.757	-325.6	33.273	351.423
85	-3.546	102.542	27.727	260.030	-90.30	27.960	352.609
85	-0.703	37.270	14.755	264.142	-8.122	14.775	357.271
85	5.029	32.705	-5.455	303.919	-60.89	7.420	137.326

P33010FA

ONE HALF LUNAR CYCLE (6 HOURS) AVERAGE VALUES STARTING AT SURFACE DEAD HIGH-1

METER LOCATION NUMBER	SPHERE NUMBER	NUMBER OF POINTS	FRAMES PER HOUR	FRAMES PER LUNAR HOUR	STARTING POINT	ENDING POINT
0341	M	1097	16.	99	80	1176

VALID POINTS	VELOCITY * SIN OF DIRECTION		VELOCITY * COS OF DIRECTION		COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC
	MEAN	VARIANCE	MEAN	VARIANCE			
99	6.981	74.499	-5.270	205.835	-61.65	8.747	127.047
99	-16.753	108.045	-3.451	188.682	49.11	17.105	258.361
99	11.031	160.838	-7.382	172.029	-83.25	13.273	123.791
99	-9.539	108.625	-3.998	167.156	50.51	10.343	247.260
99	13.492	184.887	-7.411	101.633	-69.69	15.394	118.780
99	-15.677	157.614	-2.543	223.060	85.77	15.882	260.787
99	-16.410	90.943	-1.457	58.580	40.54	16.474	264.927
99	-20.800	96.794	2.277	72.744	3.419	20.924	276.247
99	13.367	340.836	-6.030	86.350	-113.6	14.664	114.279
99	-16.455	227.635	-4.152	134.617	57.06	16.970	255.840
99	17.341	259.791	-5.638	83.036	-26.35	18.234	108.011

P33010FA ********************************

VALID POINTS	VELOCITY * SIN OF DIRECTION MEAN	VELOCITY * SIN OF DIRECTION VARIANCE	VELOCITY * COS OF DIRECTION MEAN	VELOCITY * COS OF DIRECTION VARIANCE	COVARIANCE	RESULTANT VELOCITY CM/SEC	RESULTANT DIRECTION DEGREES MAGNETIC

0343

***** AVERAGE VALUES FOR A LUNAR CYCLE STARTING AT SURFACE DEAD HIGH

FRAME COUNT = 17 GROUP COUNT = 62 INCREMENT= 12

102	8.051	98.965	2.906	105.041	80.35	8.500	70.157
102	6.419	94.742	5.040	63.795	68.50	8.161	51.854
85	5.368	98.469	4.334	58.998	53.41	6.899	51.066
65	1.951	83.264	-0.996	176.998	-2.565	2.191	117.040
85	-3.142	89.861	0.447	246.063	-28.09	3.174	278.100
85	-5.320	76.591	-0.317	249.830	9.900	5.330	266.594
85	-6.291	80.782	-2.434	311.057	-130.69	6.745	248.846
85	-6.566	68.752	1.368	322.087	-80.35	6.707	281.771
85	-6.374	47.619	7.731	230.037	-123.5	10.020	320.498
85	-1.815	53.268	5.528	191.033	-35.64	5.818	341.820
85	2.281	56.027	2.122	[illegible].732	-14.74	3.116	47.065
85	6.156	53.883	-3.610	286.153	-4.767	7.136	120.365

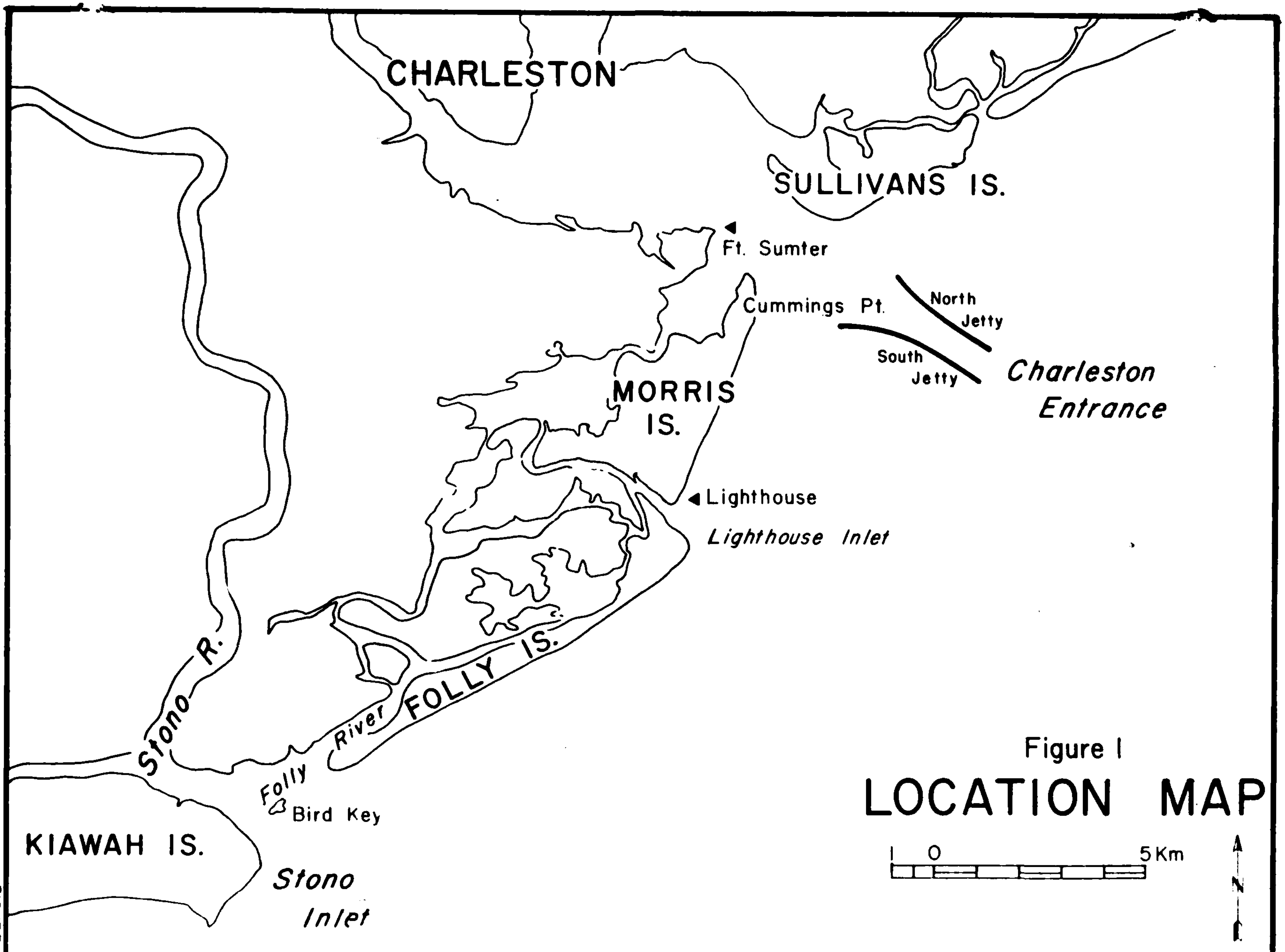
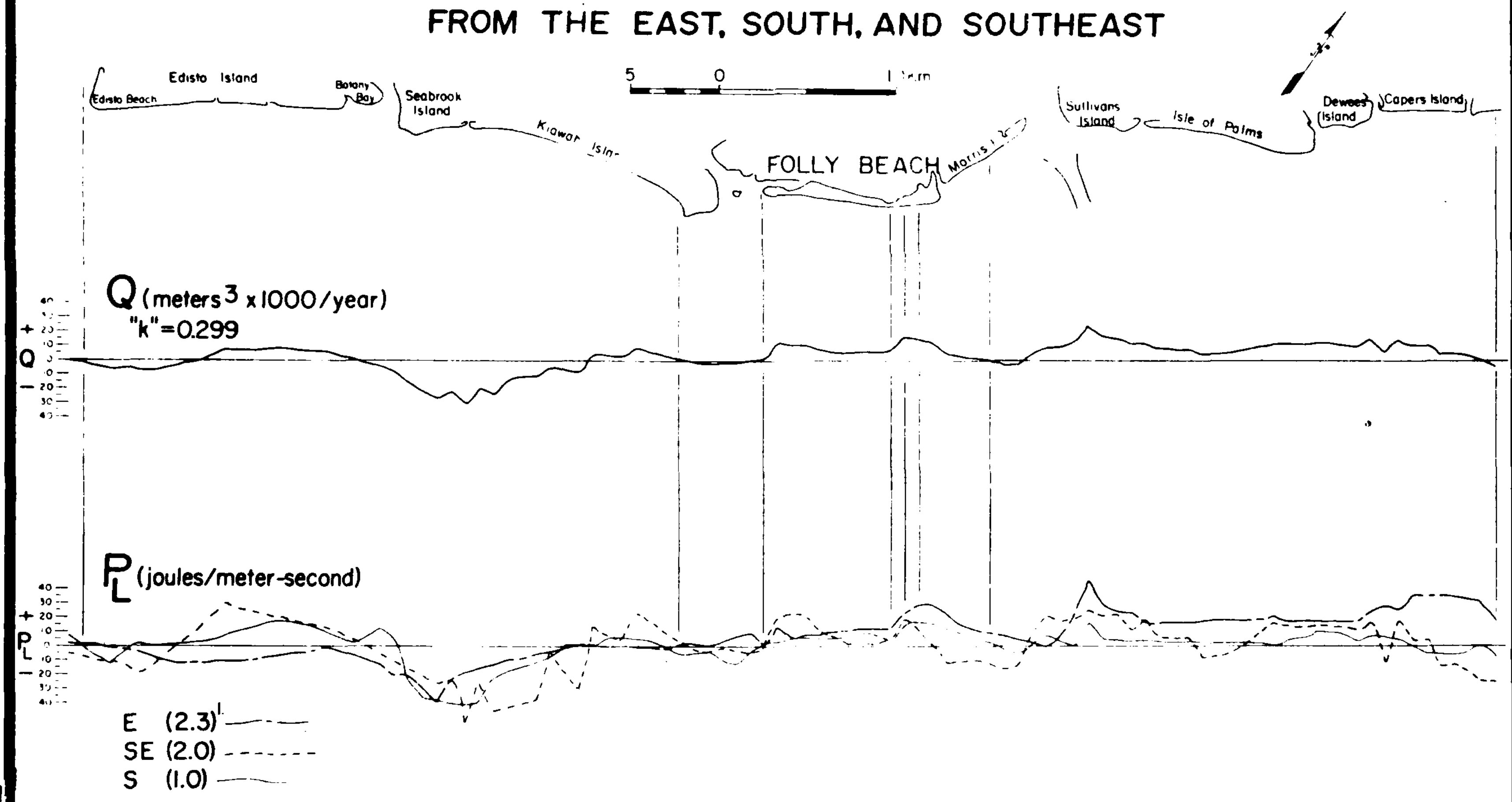


Figure I
LOCATION MAP

FIGURE I

P_L & Q DATA FOR FOLLY BEACH, SOUTH CAROLINA

ANALYSIS MADE USING 6.5 SECOND, 1.0 METER WAVES FROM THE EAST, SOUTH, AND SOUTHEAST



Positive values of Q and P_L indicate northeast transport, negative values southwest transport.

¹Weighting factor for wave frequency, calm conditions exist 67% of the time.

FIGURE

Figure 2

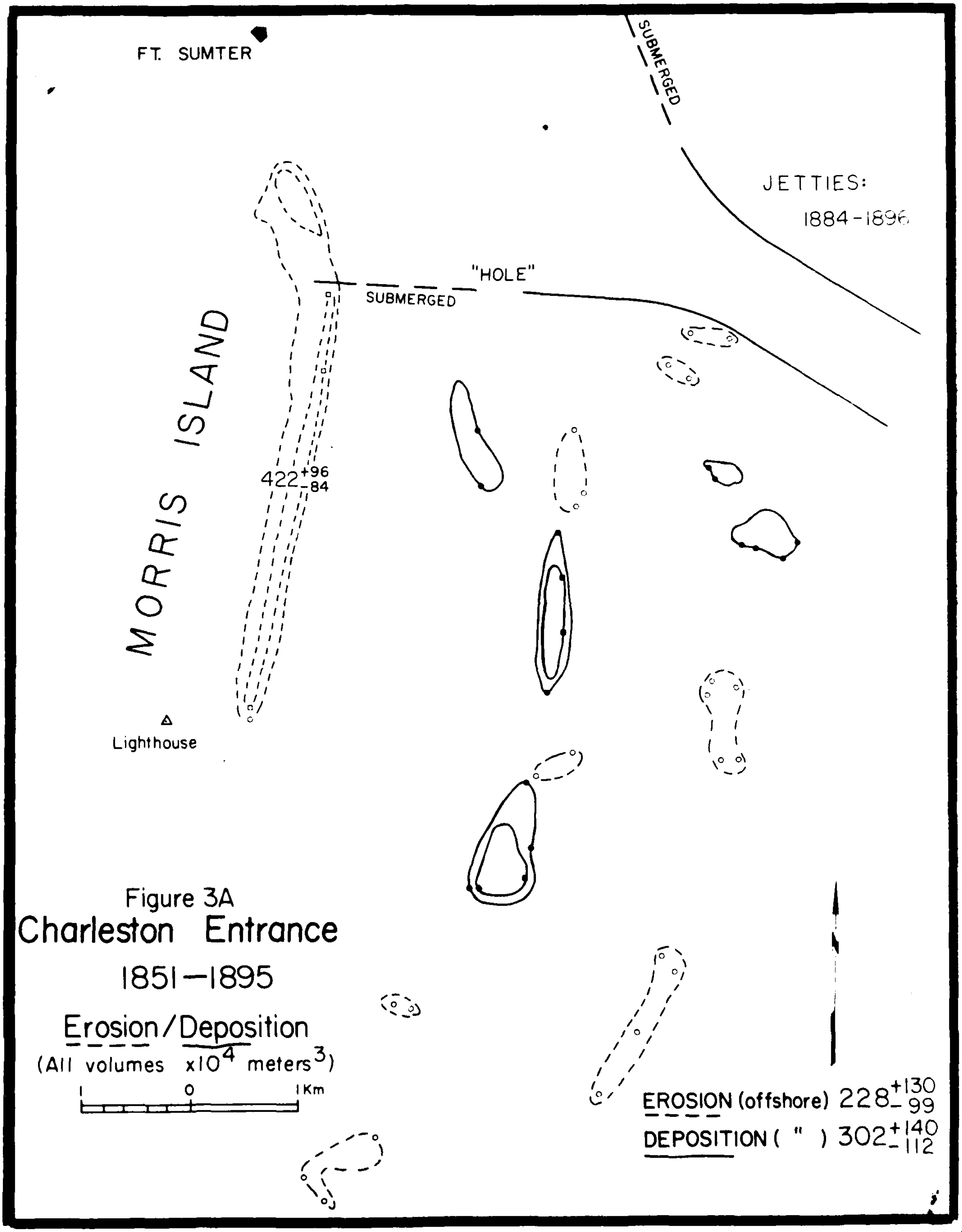


Figure 3A
Charleston Entrance
1851—1895
Erosion/Deposition
(All volumes x10^4 meters^3)

FIGURE 3A

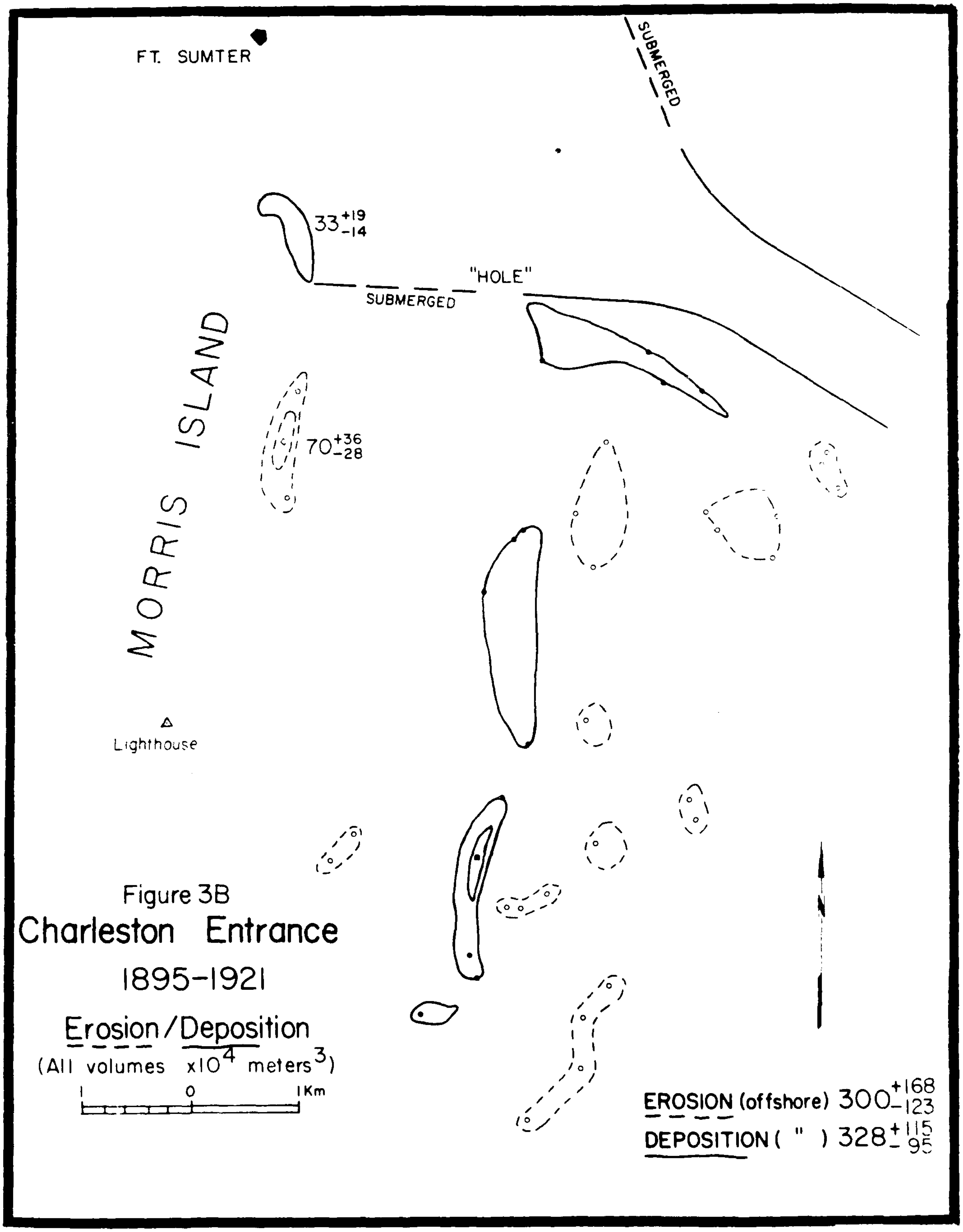


Figure 3B
Charleston Entrance
1895–1921
Erosion/Deposition
(All volumes x10^4 meters^3)

FIGURE 3B

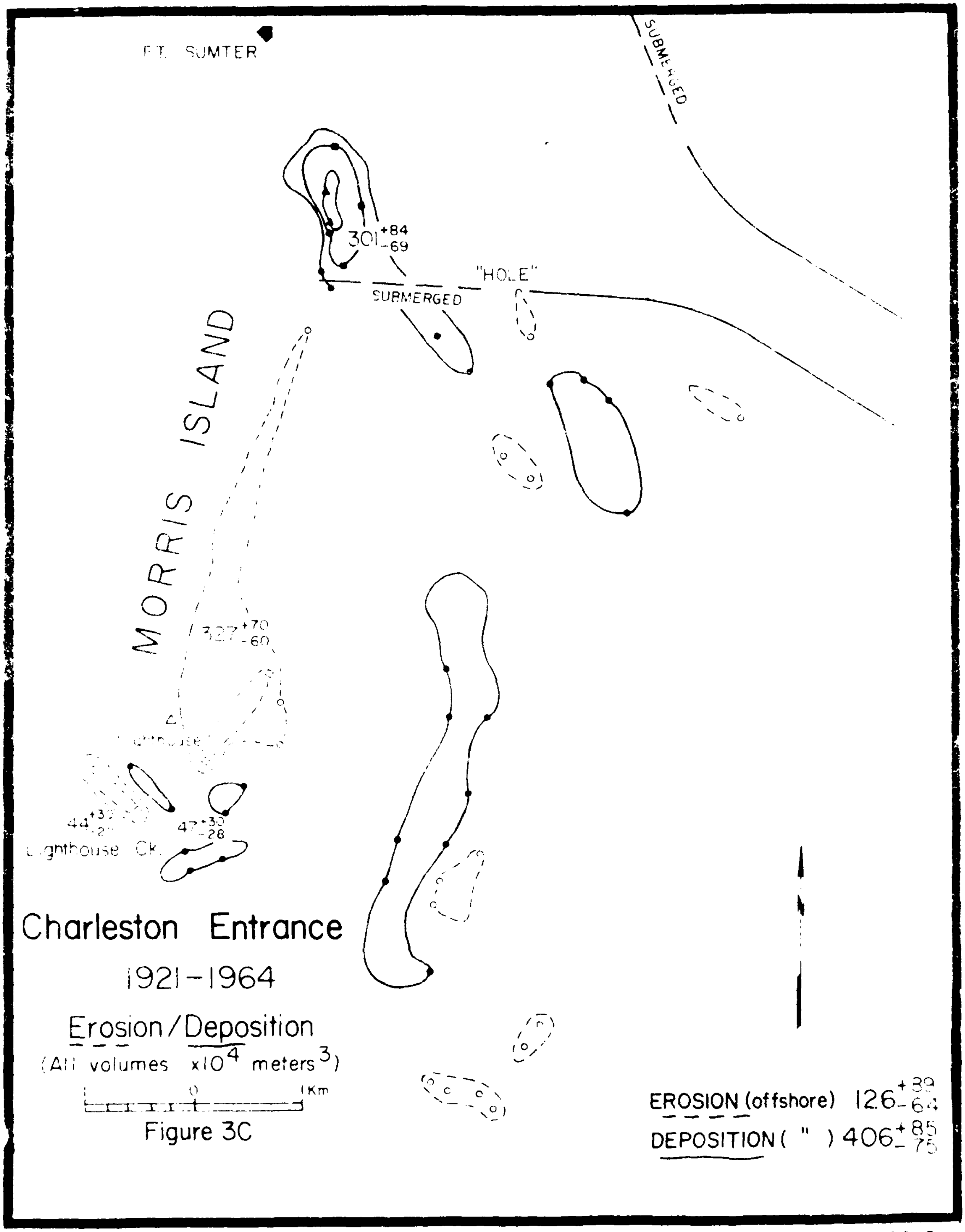


Figure 3C

FIGURE 3C

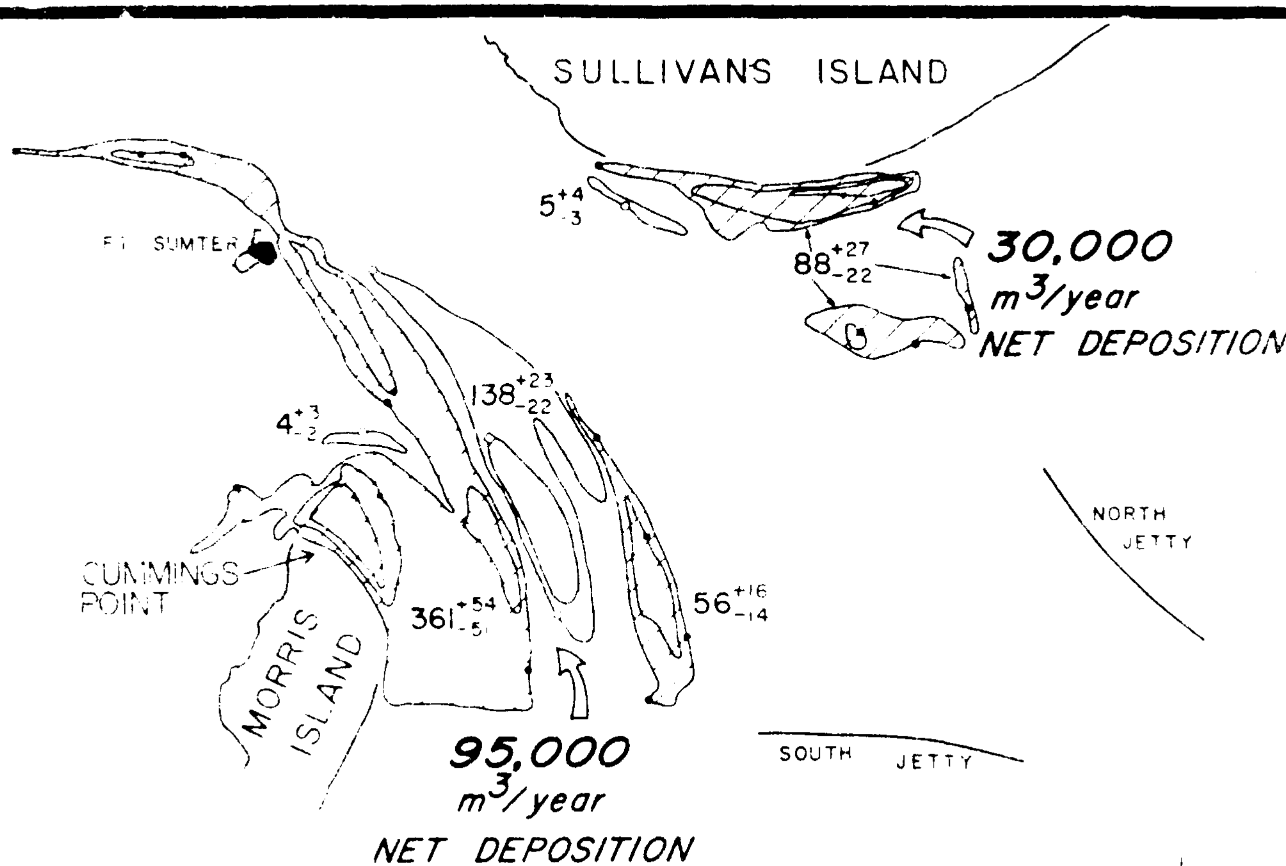


Figure 3D

CHARLESTON ENTRANCE 1934–1963

EROSION ( ) and DEPOSITION ( )
All volumes x10⁴ meters³

FIGURE 3D

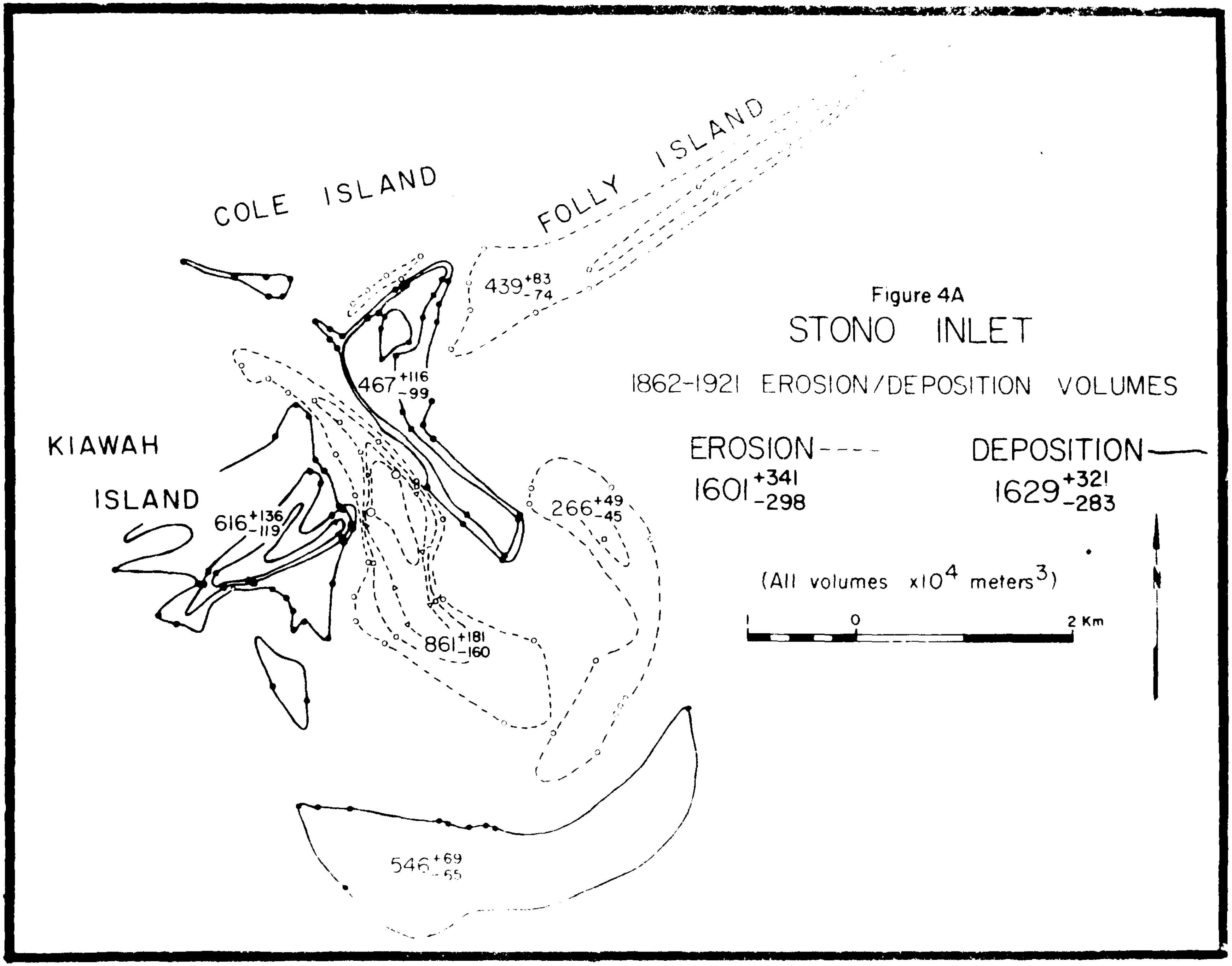


Figure 4A
STONO INLET
1862-1921 EROSION/DEPOSITION VOLUMES
EROSION ----
1601^{+341}_{-298}
DEPOSITION —
1629^{+321}_{-283}
(All volumes x10^4 meters^3)
0
2 Km
COLE ISLAND
FOLLY ISLAND
KIAWAH ISLAND
439^{+83}_{-74}
467^{+116}_{-99}
616^{+136}_{-119}
266^{+49}_{-45}
861^{+181}_{-160}
546^{+69}_{-65}

FIGURE 4A

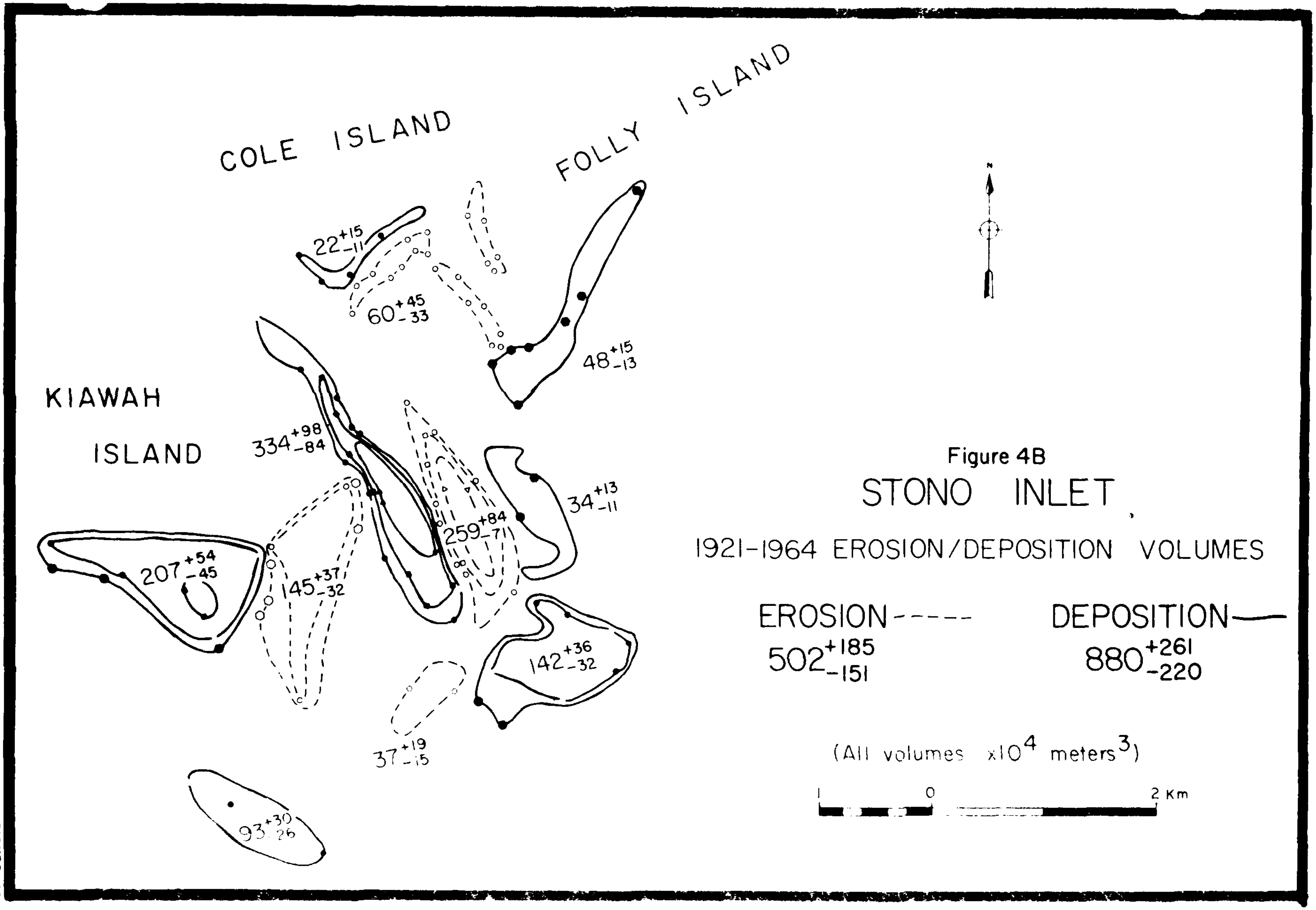


Figure 4B

STONO INLET

1921-1964 EROSION/DEPOSITION VOLUMES

FIGURE 4B

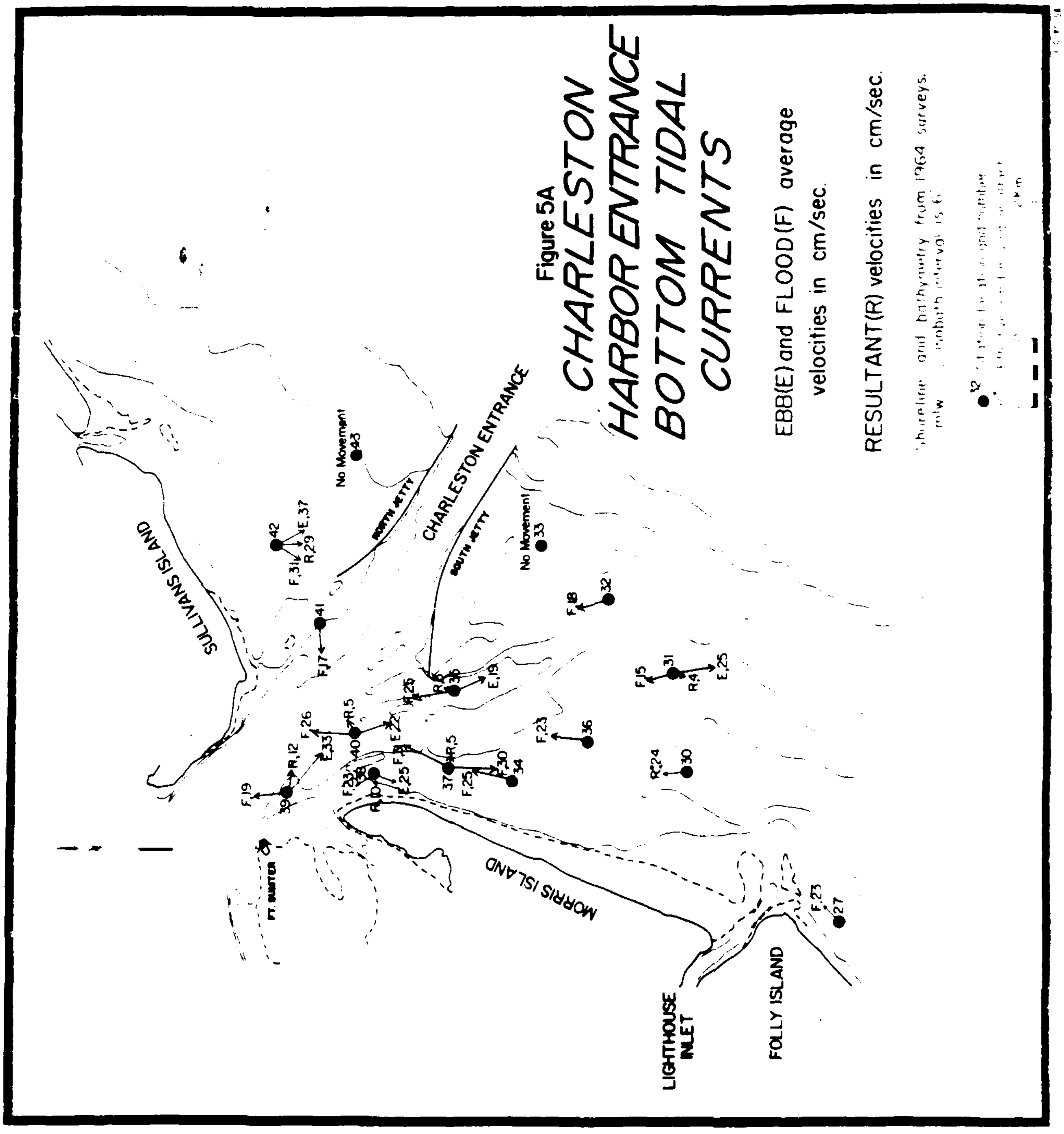


Figure 5A
CHARLESTON HARBOR ENTRANCE BOTTOM TIDAL CURRENTS
EBB(E) and FLOOD(F) average velocities in cm/sec.
RESULTANT(R) velocities in cm/sec.
Shoreline and bathymetry from 1964 surveys.
SULLIVANS ISLAND
MORRIS ISLAND
FOLLY ISLAND
LIGHTHOUSE INLET
CHARLESTON ENTRANCE
NORTH JETTY
SOUTH JETTY
FT. SUMTER
No Movement
No Movement

FIGURE 5A

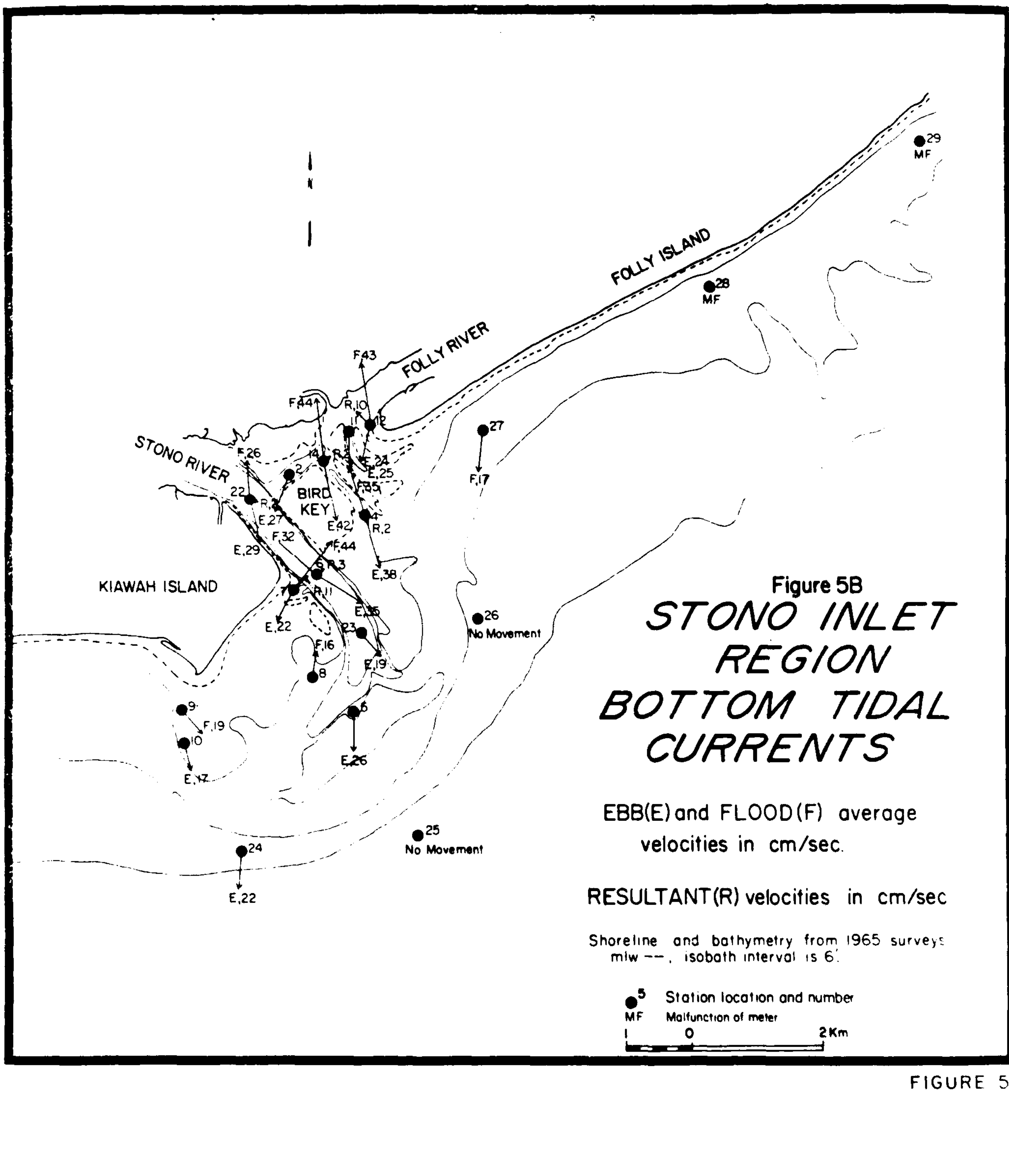

FOLLY ISLAND
FOLLY RIVER
STONO RIVER
BIRD KEY
KIAWAH ISLAND
N
F,43
F,44
R,10
E,26
E,27
E,29
F,32
E,42
F,44
R,3
R,11
E,22
E,38
E,35
F,16
E,19
F,19
E,17
E,26
E,22
F,17
No Movement
No Movement
MF
MF
Figure 5B
STONO INLET REGION BOTTOM TIDAL CURRENTS
EBB(E) and FLOOD(F) average velocities in cm/sec.
RESULTANT(R) velocities in cm/sec
Shoreline and bathymetry from 1965 surveys mlw --, isobath interval is 6'.
Station location and number
MF Malfunction of meter
0
2Km

FIGURE 5B

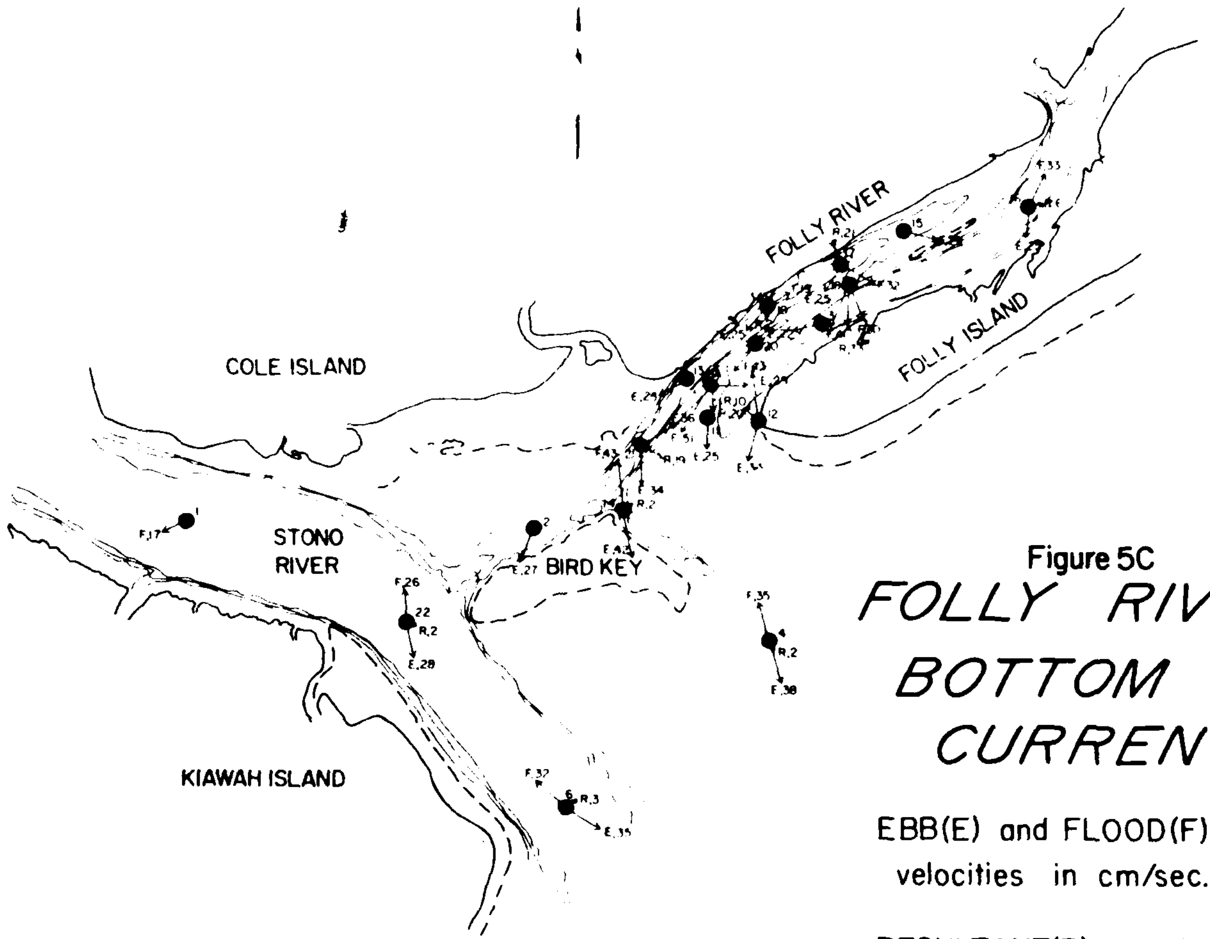


Figure 5C

FOLLY RIVER BOTTOM TIDAL CURRENTS

EBB(E) and FLOOD(F) average velocities in cm/sec.

RESULTANT(R) velocities in cm/sec.

Shoreline and bathymetry from 1934 surveys. mlw — —, isobath interval is 6'

0 1Km

● 12 Station location and number.

FIGURE 5C

ATTACHMENT C-2

Attachment C-2 is an account of the Coast Guard's beach erosion problems on the east end of Folly Island and that agency's efforts to control this erosion. Attachment C-2 includes an article entitled "Folly Island Loran Station Embattled" which was written by Mr. B. S. Brown, a civil engineer for the Seventh Coast Guard District in Miami, Florida. The article was published as part of the July-August-September 1974, Edition No. 184 of the Department of Transportation, Coast Guard Engineer's Digest (CG-133). Also included in Attachment C-2 is a follow-up letter dated 2 April 1976 giving an updated status report of the beach erosion problem at the Loran Station.

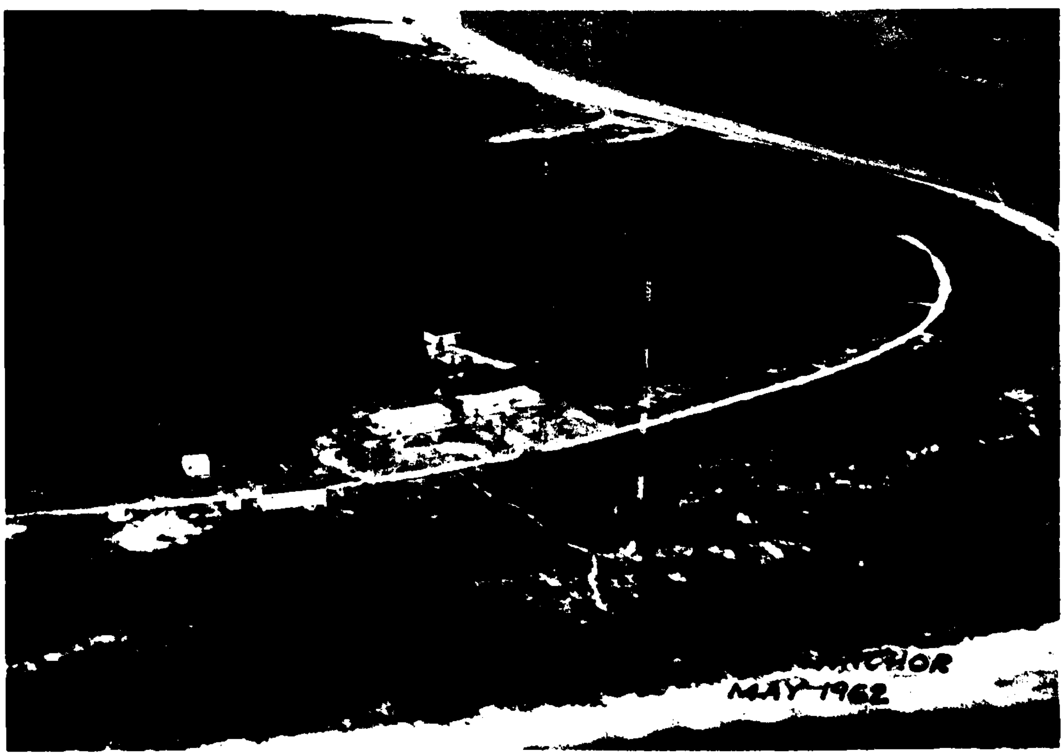
FOLLY ISLAND LORAN STATION EMBATTLED

MR. B. S. BROWN
Civil Engineering Branch
Seventh Coast Guard District

It would appear strange that a peaceful Coast Guard Station engaged in a mission to provide electronic navigational assistance to mariners, should be engaged in a battle for its life. Yet since 1962, this has been the case. Its adversary has been, is, and will continue to be tough, persistent, unpredictable "Mother Nature" herself, who appears determined to destroy the station. The principle weapon in her arsenal (her most potent being hurricane driven seas), is the winter northeast storm which usually produces massive beach erosion along an unprotected beach. Words such as usually, probably, possibly abound when describing beach erosion processes, as the various controlling forces and conditions are many and changing--such as current patterns and velocities, direction of sea and wind, intensity and direction of storms, shifting of offshore bars, etc. The best procedure in battling beach erosion is to formulate a general overall plan with a probable construction sequence, but to be ready to modify them when required to meet a particular assault of nature.

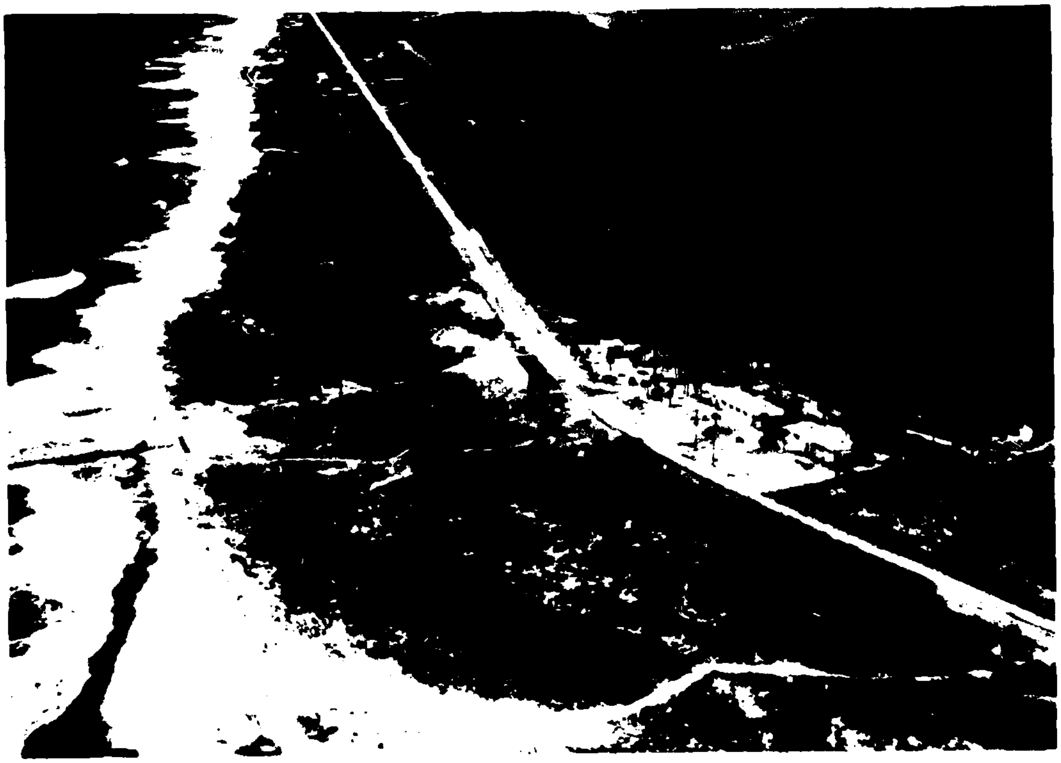
The battle was joined in the fall of 1962 when the high water line reached the easterly guy anchor threatening destruction of the main Loran Transmitting Tower (See Figures 1 and 2 showing the sea advancing toward the easterly guy anshor). To combat this threat, the first significant emergency measure, the construction of two creosoted timber groins (which straddled the threatened guy anchor) was begun in October, 1962. However, before the first groin was half completed, a northeast storm eroded the beach, and moved the high water line approximately 20 feet behind the guy anchor. The groin construction was halted, and the contractor was directed to drive a circular sheet steel cofferdam around the anchor block to prevent it from being undermined. He completed this in the nick of time. Shortly after its completion, a second northeast storm removed sand from around the sheet steel cofferdam so that at high tide, there was a water depth of 3 feet adjacent to the cofferdam. But the guy anchor was now safe. (See Figure 3 showing the high water line beyond the sheet steel encased guy anchor, and the half completed northerly groin.) The contractor then proceeded to complete the construction of the two groins, with the inboard terminal ends apparently well anchored into the sand dunes behind the high water line.

FEBRUARY 1959 FIGURE 1



MAY 1962 FIGURE 2

DECEMBER 1962 FIGURE 3



OCTOBER 1963 FIGURE 4

DETERMINATION OF COAST GUARD TENURE AT SITE

In April, 1962 (following a STRUCTALT which approved the first emergency measure to combat erosion described hereinabove but prior to the contract award), the District requested advice from the COMMANDANT concerning Coast Guard tenure at the site, having heard of long range plans to phase out Loran "A" Stations in favor of Loran "C." Obviously, a most significant planning factor for the erosion control project would be the length of time that protection would have to be provided. The COMMANDANT's reply was that the future of Loran "A" Stations appeared to be in the order of ten to fifteen years of additional service. The temporary protection in the approved STRUCTALT should be provided, and an AC&I project prepared for more permanent protection. This direction was followed with the first result being the construction of the above described first two groins at the station along with preparation of an AC&I project.

PROPOSAL TO RELOCATE SITE

During the development of the AC&I project, it became apparent that a considerable sum of money (estimated at $450,000 in 1962 dollars) would be required to provide the 10 to 15 years protection required. If a longer tenure became necessary, another substantial expenditure of funds would be required with the ultimate outcome far from certain. The principle reasons for such uncertainty are the combination of conditions tending to accelerate erosion along the east coast of the United States in general, and at Folly Island in particular, such as:

downdrift shore experiences an interlude of accretion. While this process would appear to neutralize itself, it has two detrimental effects. First, there is an overall net loss in the process, as much of the downdrift littoral material accumulated on the offshore bar is lost either in bays inland of the inlet or in deep water beyond the inlet from regular tidal flow occurring during this cyclic process. Second, during the part of the cycle that forces the ebb tidal channel closer to the downdrift shore, erosion control structures, such as groins, are in danger of being undermined as the shoreline recedes.

The District, therefore, recommended that a new site be selected and the station relocated. The COMMANDANT concurred with this recommendation, and a site survey for a new location was undertaken. It appeared that the battle to save the station would be abandoned due to the uncertain outcome and the high costs involved in resisting nature's relentless attacks.

CONTINUATION OF CONSTRUCTION OF EROSION CONTROL STRUCTURES

Meanwhile, while the site survey was underway, the assault on the shoreline continued. Both groins were flanked by the sea, which called for quick remedial action. Since time is of the essence in meeting such attacks, a negotiated contract was executed in the summer of 1963 to extend without delay the northeasterly groin 120 feet inland, and to construct a 43 foot wing wall at right angles to and centered on the southwesterly groin (Figure 4). This wing wall was an attempt to discourage flanking action of the southerly groin, while the extension of

a. The damming of rivers on the eastern side of the Appalachians.--Sand formerly transported to the ocean from regions in the interior is now deposited in the dam reservoirs. The silt picked up downstream of these dams in reduced in quantity and grain size and thus is less effective in building up the beaches.

b. The more rapid rate of erosion on beaches having small grain size alluvium.--These materials which are now deposited on the beaches under favorable conditions are of such small grain size, that when unfavorable conditions occur, such as winter northeast storms, or rough seas accompanied by unusually high tides, the shoreline erodes at a considerably faster rate than when the beaches were composed of coarser sands.

c. The construction of jetties and man made inlets.--Such types of construction, along with natural inlets, act as barriers to littoral drift causing erosion on the downdrift side of such barriers.

d. The alternate erosion and accretion of beaches near inlets associated with migration of the bar channel.--Littoral accumulation on the offshore bar forces the ebb tidal channel closer to the downdrift shore causing erosion and shore recession of the adjacent beach. As this bar continues its downdrift enlargement, a critical constriction of the bar channel occurs forcing a breakthrough on the updrift portion of the bar closer to the inlet, shifting the tidal channel through this breakthrough. The portion of the bar downdrift of the new channel is then free to move shoreward under the influence of wave action, and the

the north groin inland was for the obvious purpose of again blocking the flanking attack of the advancing sea. Both of the two items of this negotiated contract were very temporary in nature. The sea again flanked both groins following the first northeast storm of the 1963 winter season. It became apparent that in this situation, with little ground remaining to retreat, a line would have to be drawn beyond which the sea would not be permitted to advance. A marginal timber bulkhead interconnecting the groins and proceeding southerly was the method selected. With regard to the northerly groin, it would have to extend westerly as far as necessary to prevent flanking action of the sea. and to serve as the anchor structure of the remaining work to follow south of it. This anchor groin must be protected against undermining or flanking at whatever cost if the continuing project were to have any chance of success.

A contract was executed in October, 1963 to fulfill these concepts, and the contract was successfully completed. It consisted in the construction of a 644 foot long creosoted timber bulkhead interconnecting the two groins, a 300 foot more or less long southerly bulkhead extension tied to the southerly end of the wing wall, and a 200 foot long landward extension of the northerly anchor groin (Figure 5).

RESULTS OF SITE SURVEY

In March of 1964, the site survey to relocate the station was completed, and several substitute sites were recommended in a comprehensive report submitted to the COMMANDANT. Their review of the site survey, joined to an evaluation of the work already completed at the Loran Station,

MAY 1964 FIGURE 5

NOVEMBER 1969 FIGURE 6

resulted in the following decision: there was insufficient [illegible] for the purchase of a new site; the station was to remain at the [illegible] site until it was determined that its destruction was certain. The [illegible] was resumed.

FURTHER CONSTRUCTION

During the fall of 1964, the assault of nature was now directed again [illegible] the southern end of the existing system. The northerly anchor groin appeared to be holding firm, and the beach had stabilized between the groins. However, erosion south of the then southern terminus threatened flooding of the station. This threat had to be met at once. In December 1964, a contract was entered into to extend the existing bulkhead 100 feet southerly, and to construct a 200 foot groin a few feet from the new existing southern bulkhead terminus. This construction succeeded in its immediate aim, but made it painfully apparent (as was recognized in the beginning of the project in the development of the initial ACSI Report) that there would be a continuous danger of losing the lone Station access road unless the Coast Guard completed their system to the south AND the State of South Carolina would continue their groin field northerly to meet the Coast Guard's groins to form one unbroken system. Preliminary contacts with the State provided assurance that they were planning to do just that, but the time of construction would depend on priorities and availability of funds. The cooperative effort between Coast Guard and the State of South Carolina to join their groin fields had been initiated

Although the northerly anchor groin was holding at this time, it was fully expected that the forces unleashed by the winter northeast storms would compel additional work on this groin.

For the next few years, the erosion continued, but slowly, with no need for immediate action. However, this relatively placid condition evaporated in the late fall and early winter of 1969. On November 1. 1969 a strong northeast storm accompanied by unusually high tides caused extensive erosion all along the beach with a particularly large beach loss southerly of the then southerly terminus of the existing bulkhead. The ocean had advanced considerably closer to the access road, as well as undermining the southerly end of the marginal bulkhead. (See Figure 6.) While arrangements were made to fund the construction of the remaining southerly extension of the groin/bulkhead system, the State of South Carolina was again contacted at this critical juncture concerning their intentions to extend their groin construction up to the Coast Guard property line. They advised that they would complete their groins to meet the Coast Guard's planned southerly groins to form one unbroken groin field with the Coast Guard's system.

Fortunately, the Station weathered the remainder of the 1969-1970 winter season with only minor additional beach loss. In the summer of 1970, a contract was executed to complete the Loran Station's southerly groin/bulkhead system. The State, true to their assurances, completed their groins northerly to meet the Coast Guard system. With the arrival of the 1970-1971 winter season, a single unbroken groin field was in place. The immediate threat to destroy the lone access road has been removed.

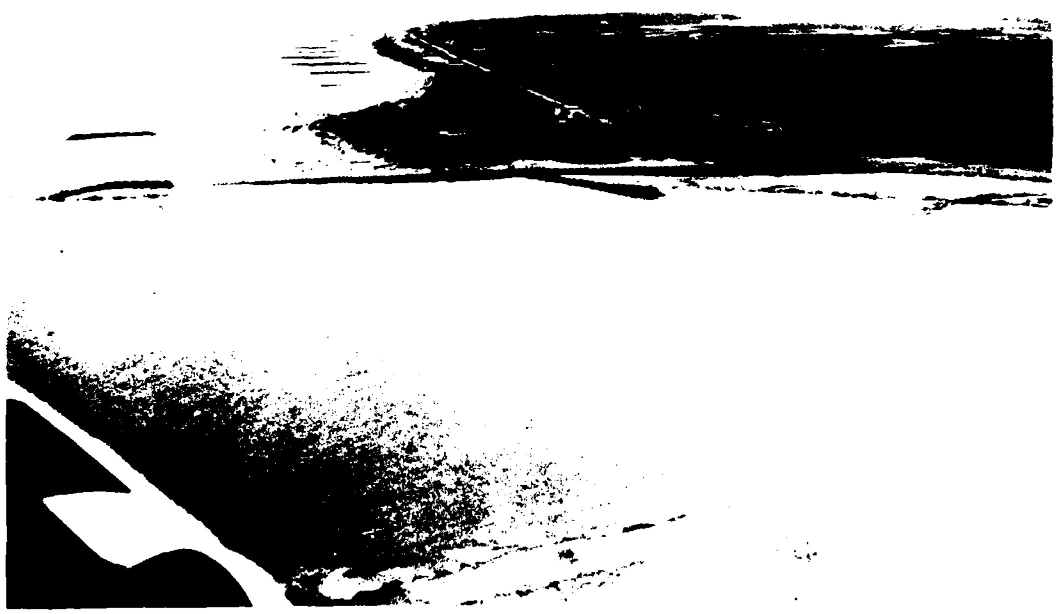
THE ATTACK SHIFTS NORTH

With the attack in the southerly portion of the Coast Guard beach blunted by the completed Coast Guard/State groin field, the expected assault began in earnest against the northerly anchor groin, beginning slowly in the 1970-1971 winter season, and increasing in intensity during the 1971-1972 winter season. As a stop-gap measure, PVC-coated sand filled nylon bags were installed using Coast Guard personnel in the fall of 1971 to extend the bulkhead/groin system northerly of the anchor groin. (The remnants of this work can be seen in Figure 7.) But this measure was insufficient to stop the erosion north of the anchor groin. Reports from the station during the 1972-1973 winter season, which was monitoring the beachside erosion, indicated that the winter northeast storms had once again flanked the northerly anchor groin along with extensive erosion north of and adjacent to the northerly side of this groin. Over 100 feet of beach depth had been lost in this location during the single 1972-1973 winter season leaving the station vulnerable to flooding should no corrective action be taken during the summer of 1973.

RECENTLY COMPLETED STRUCTURES

In view of the condition of the northerly anchor groin, and the beach northerly of it, it was considered imperative to extend the flanked groin landward, and to take measures to insure that the northerly anchor groin would not be undermined. Particularly dangerous was a channel of deep water that was approaching the groin following the extensive

MAY 1974 FIGURE 7



MAY 1974 FIGURE 8

1972-1973 winter season beachside erosion. This deep water had to be diverted away from the groin to prevent undermining of the anchor groin.

The last contract work begun in the summer of 1973 and completed in March 1974 consisted principally of the following items:

1. The flanked groin was extended back terminating at the low lying marsh land along the westerly edge of the station. This structure, it is believed, will end the flanking threat as long as it remains intact. Should wave action now follow the groin, it will flow back into the low lying marsh land, dissipating its energy there, and return back to sea through the many creek-like tributaries leading into ocean connected Lighthouse Inlet lying north of the Station.

2. The outboard end of the anchor groin which was damaged by marine borer action, and subject to scour was reinforced with stone. This reinforcement, by sealing the end of the timber groin, will greatly diminish further borer damage, and will additionally prevent scour by presenting a sloped surface to storm waves to dissipate their energy harmlessly and without scour. The outboard end of the groin adjacent to the south was similarly repaired, and for the same reasons.

3. A 150 foot long stone "Training Wall" was constructed approximately along the northerly extension of the interconnecting marginal bulkhead. This structure has been successful in "training" the ebb

tidal currents to flow further away from the anchor groin as well as to protect the portion of the groin inboard of it from wave action. To be more effective, it was originally planned to have this structure attain a length of 400 feet, but was constructed to its present length due to funding limitations. Observing the beneficial effects of this training wall, a second one was constructed along the berm line to protect the inboard portion of the groin should northeast storms again erode the beach north of the anchor groin.

4. The face of the groin seaward of the outboard training wall was armored with stone, in addition to protecting this exposed portion of the groin, the armor (in a manner similar to the reinforcement at the outer end of this groin) will diminish marine borer damage, and reduce scouring action adjacent to the groin.

5. Finally, sand from recently formed dunes southerly of the groin that formed following the construction of the interconnecting bulkhead was used to restore in part the eroded beach between the training walls. It is this area that will serve as a depository for sand nourishment when required.

SAND NOURISHMENT

Very early in the planning stages it was recognized that should the Coast Guard and the State complete their groins to form one unbroken system (a cooperative effort that was implemented successfully as described herein), the continued expected loss of beach and sand dunes northerly of the northerly anchor groin would still present a problem to be faced. Eventually, sand to replace the beach and dunes lost from northeast storms would undoubtedly be required if the Coast Guard Loran Station continued to remain at the present site over an extended period of time.

In a recent Beach Erosion control study (circa 1967) made by the Charleston District Corps of Engineers, it was determined that at the north end of Folly Island, there was a net rate of loss of beach sand requiring an annual replacement of approximately 9100 cubic yards. Their recommendation was that a five year supply of sand be deposited at the north end of Folly Island using the shoal area north of Lighthouse Inlet as a source of material. (This shoal area can be seen in Figure 8.) This recommendation was considered in a 1969 AC&I project (which also included the construction of the groin/bulkhead system at the southerly end of the Station and which was constructed as described herein), but was never accomplished due to the high cost of this item. Inquiries with local hydraulic dredging firms indicated the cost for such sand transfer across the inlet would approximate $100,000, about double the original estimate. A less costly method of nourishment was desired.

It is believed that the training walls, installed in the last construction, will trap some sand adjacent to the groin which will reduce the need of nourishment. However, periodic sand nourishment will undoubtedly be required. Since the construction of the interconnecting bulkheads as noted previously, a natural development of sand dunes has formed southerly of the northerly anchor groin, almost completely covering several Coast Guard groins. To augment this natural formation, a pilot project of sand fences was installed to induce further sand dune formation. (These fences can be seen in Figure 7.) When the need for nourishment arises, it would be relatively inexpensive to move these sand dune to the area between the training walls to serve as sand replacement and nourishment. Sand fences could then be reset to again produce sand dunes for further nourishment as required. Should Loran "A" Stations be phased out in the near future, it is hoped that this source of sand will be sufficient to meet requirements. In any event, the planned foregoing method of nourishment will be attempted before expending approximately $1[illegible],000 for sand transfer by hydraulic dredge.

CURRENT EVALUATION AND FUTURE OUTLOOK

At the start of the last contract work begun in the summer of 1973, the inboard end of the northerly anchor groin which was flanked by the sea was so seriously undermined that it was on the verge of collapse. There is no doubt that had this last contract work not been begun this summer, the inboard end of this anchor groin would have collapsed under the force of the winter northeasterly storm seas, and the Station would have experienced flooding. The current condition, though a vast improvement over its pre-1973 contract condition, will still require upgrading. To better induce ebb currents to flow away from the groin, and to improve its ability to protect the inboard end of the groin, the outboard training wall will need to be lengthened. The armor stone protecting the exposed portion of the groin will need to be maintained. Stone reinforcement of the outer end of the anchor groin will need to be extended to diminish marine borer damage. Stone armor will need to be placed on the northerly side of the anchor groin between the training walls should scouring occur in this area. The lengthening of the outboard training wall should, however, diminish this requirement. And finally, sand will undoubtedly be required for replacement and nourishment to be deposited on the north side of the anchor groin between the training walls.

In spite of the best of plans and prognostications, the unpredictable and potentially enormous forces of nature, such as those attending a hurricane passing close offshore, or crossing Folly Island, could change the entire outlook. Even with the more predictable storms, tidal flows, longshore currents, etc., vigilance and timely action will be required to continue the battle fought successfully thus far.

The story of embattled Folly Island Loran Station has not yet ended.

ABOUT THE AUTHOR

Mr. Brown graduated from the U. S. Coast Guard Academy in June 1944 and obtained his Bachelor's Degree in Civil Engineering from the University of Miami in June 1956. He served in both line and engineering duty while on active duty in the Coast Guard and subsequently worked for the Dade County, Florida, Engineers prior to joining the Seventh Coast Guard District Civil Engineering Branch in March of 1957, in which office he serves as a senior Civil Engineer. He is a Registered Professional Engineer and Land Surveyor in the State of Florida.

ENCLOSURE 1

SECTION D

MATERIALS INVESTIGATION

MATERIALS INVESTIGATION

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SECTION D

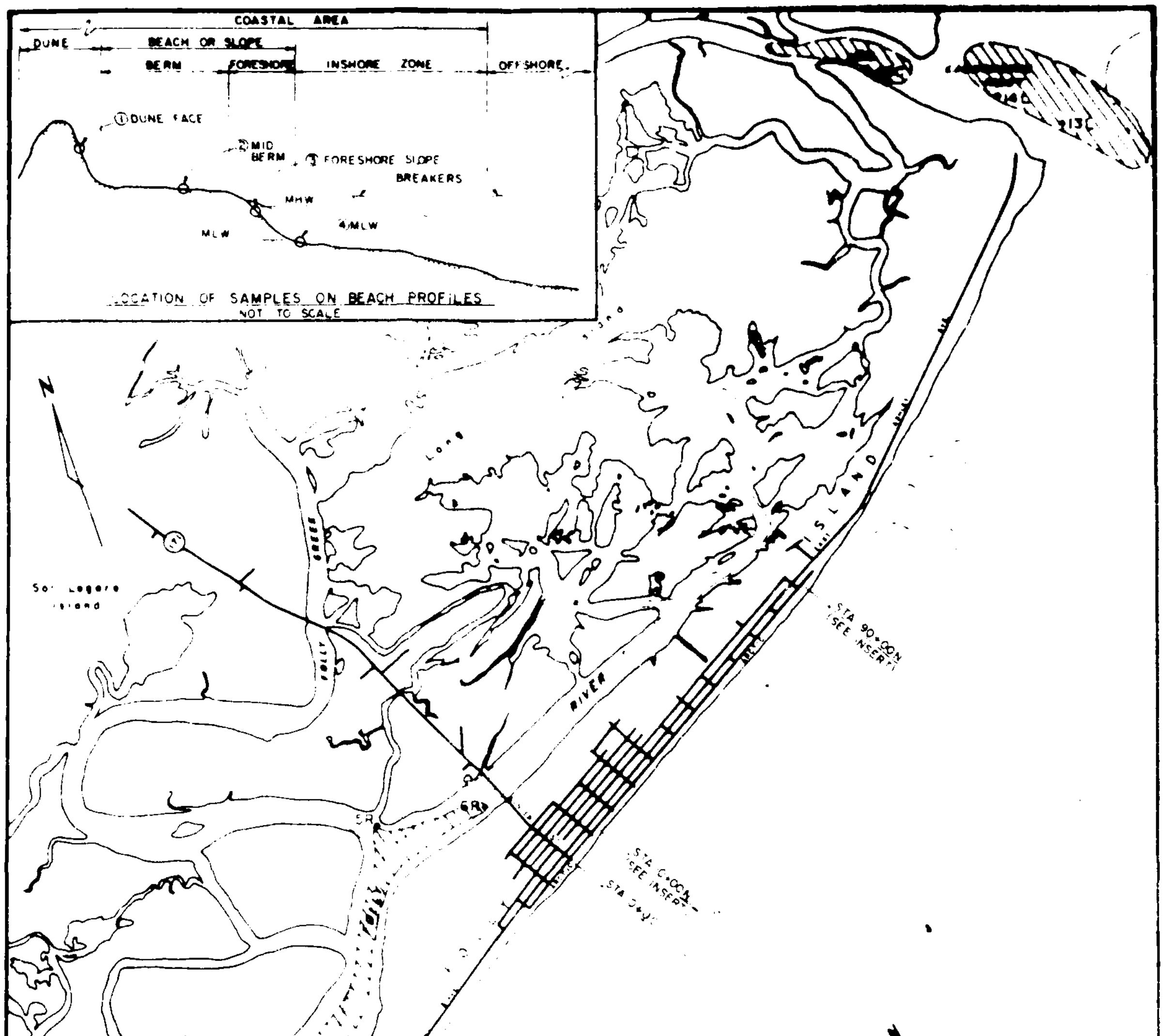
MATERIALS INVESTIGATION

1. Field sampling of insitu soils was made to determine the nature of the beach materials, and the suitability of borrow material for use as beach nourishment or dune construction. Location of sampling points are shown on Figure D-1. Samples were sent to the South Atlantic Division Laboratory at Marietta, Georgia, for analysis. Laboratory results are shown in the back of this Section, (Figure Nos. D-20 through D-60). Evaluations of compatability of sands allocated for beach nourishment or dune construction are based on grain size, expressed in equivalent phi values, of samples as obtained in the field without having first removed shell fragments.

Methodology

2. Using the procedure developed by James [1/], one can estimate the volume of borrow material required to produce one cubic yard of stable sand on the beach, after natural sorting and winnowing processess. In assessing the various borrow materials (sands) for use in nourishing Folly Beach it is useful to make matchings of various borrow samples with various native beach material (the sand found on the beach). Basically what is compared is the grain-sized histograms of the sand to find if the borrow material is generally coarser or finer than the native material. By matching these samples an estimate can be made of the "fill factor" and the "renourishment factor". The "fill factor" is the number of cubic yards required to satisfy the requirement for one cu. yd. of additional native beach material, in order to make allowance

1/ James, William R.,"Techniques in Evaluating Suitability of Borrow Material for Beach Nourishment", Tech. Memorandum No. 60, U. S. Army Coastal Engineering Research Center, Dec. 1975.



LOCATIONS OF BORINGS AND POSSIBLE BORROW AREAS NEAR FOLLY BEACH SOUTH CAROLINA

NOV 1976

FIGURE D-1

for the fact that the borrow material will lose some of its finer material during hydraulic placement and immediate reworking. The "renourishment factor" is the rate at which borrow material will erode relative to native beach material; it is used to determine how often the beach will have to be renourished if a certain borrow material is used. The location of the possible borrow sites are shown in Figure D-1.

3. Equivalent phi parameters. The criteria developed by James (1975) uses equivalent phi values of grain sizes which are computed as the negative logarithm to the base of 2 of the grain diameter in millimeters:

$$\phi = -\log_2 d \qquad (1)$$

When plotted on probability paper, the curve for most beach sands will approach a striaght line. Because of this characteristic, computations are made on the basis of a straight line drawn through the 16 and 84 percentile points on the phi plot as shown on Figure D-2. Phi parameters evaluated were computed as follows:

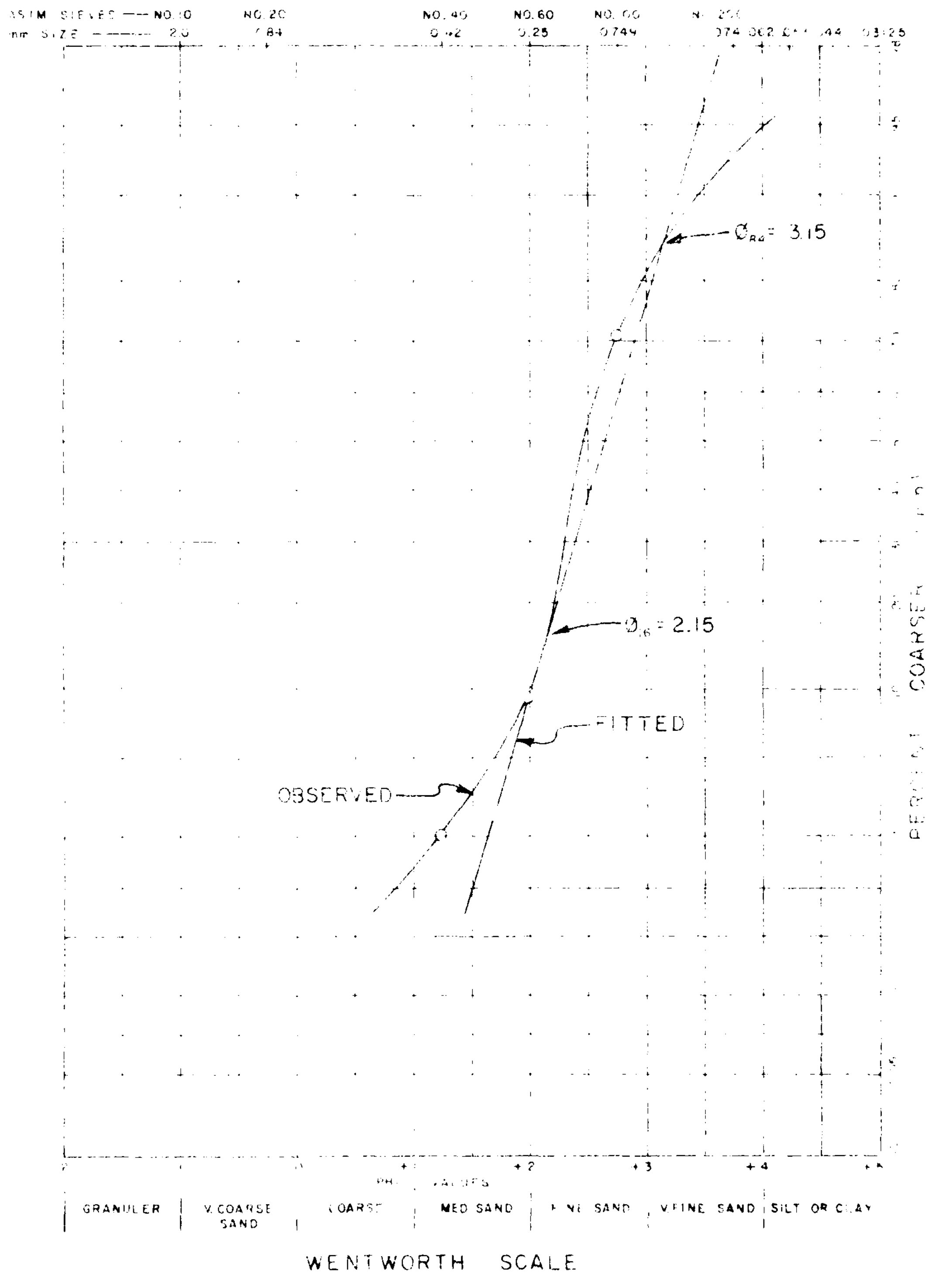
a. Mean diameter. The phi mean diameter of grain-size distribution where:

$$M_\phi = \frac{\phi_{84} + \phi_{16}}{2}$$

b. Standard deviation. Phi standard deviation is used as a measure of grain size sorting in the sample and is computed using the formula:

$$\sigma_\phi = (\phi_{84} - \phi_{16})/2$$

In the case of perfect sorting, the phi standard deviation is zero.



OBSERVED CURVE AND FITTED PHI—NORMAL CURVE
BORING NO. 4 COMPOSITE OF SAMPLES 1, 2, & 3

FIGURE D—2

Native Beach Material

4. Samples were taken at three stations, shown on Figure D-1, to establish the composition of existing or native beach material. Sample points on the beach profile were at the dune face, mid-berm, foreshore slope, and mean low water. A representative beach sample was selected at each station for the purpose of comparing native beach material with material from several possible borrow areas. All the beach samples were well-sorted medium and fine grained sands having median grain sizes of from 0.14 to 0.19 millimeters (2.80 to 2.40 phi units). For the sand samples co-lected along beach profiles, the median grain sizes in millimeters and equivalent phi values are shown in Table D-1.

TABLE D-1

Median Grain Size of Surface Sand Samples

Collected on Beach Profiles

Beach Profile Station	Dune Face		Mid Berm		Foreshore Slope		Mean Low Water		Average	
	mm	Ø	mm	Ø	mm	Ø	mm	Ø	mm	Ø
50+00 S	0.15	2.75	0.18	2.50	0.16	2.60	0.15	2.72	0.16	2.64
10+00 N	0.16	2.62	0.15	2.70	0.19	2.40	0.15	2.75	0.16	2.62
90+00 N	0.14	2.80	0.15	2.70	0.14	2.80	0.16	2.65	0.15	2.74
All Stations	0.15	2.72	0.16	2.63	0.16	2.60	0.15	2.71	0.16	2.67

Borrow Material

5. Borings and samples tested are listed in Table D-2.

a. Folly River. Seven holes, Nos. 1R to 7R in Figure D-1, were drilled in Folly River to obtain soil samples for comparison with native beach material to determine compatibility. Samples were obtained with a splitspoon sampler. Drilling logs for holes made in Folly River are presented in Figures D-3 through D-9.. Samples were tested and were classified as fine sands, of the type that would be suitable for beach nourishment purposes.

b. Lighthouse Creek. Two holes, 8C and 9C, were drilled in Lighthouse Creek. Boring logs for the holes are displayed in D-) and D-11. Materials encountered were classified as organic, silty, clayey, and very fine sand. These would not be suitable for nourishment of the beach.

c. Stono Inlet. Holes numbered 10S, 11S, and 12S were drilled in the shoal adjacent to Stono Inlet channel just offshore from Bird Key Island. Drilling logs were displayed in Figures D-12, D-13, and D-14. Materials in this shoal would be suitable for beach nourishment purposes.

d. Lighthouse Inlet. Two holes 13L and 14L, were drilled in Lighthouse Inlet. Drilling logs are displayed in Figures D- 5, and D-16. Materials tested from these holes indicates that the site contains materials satisfactory for beach nourishment and/or dune construction.

e. Maintenance dredging of Charleston Harbor Entrance Channel. More than one million cubic yards of sandy material is taken from the entrance channel to Charleston Harbor via hopper dredge each year. Surface scoop sample taken in the vicinity of the entrance channel indicate that this material is suitable for beach nourishment.

Hopper dredges with pumpout capability have been used to nourish beaches at other east coast projects in recent years. However, due to long pumping distances at Folly Beach such an operation would not be economical at this time. This source of material option will be evaluated

TABLE D-2

BORINGS AND COMPOSITED SAND SAMPLES
COMPRISING EACH SIEVE ANALYSIS OF
FOLLY BEACH BORROW SITES

Analysis No.		Soil Combinations for Analysis	
		Hole No.	Composite of Samples Numbered 1/
1	Folly River	4R	1, 2, & 3
2		1R	1, 2, 3, & 4
3		2R	1 & 2
4		2R	3 & 4
5		1R & 2R	#5 from each
6		3R	1 & 2
7		3R	3
8		3R & 4R	#4 from each
9		5R	1 & 2
10		5R	3
11		5R	4 & 5
12		6R	3
13		6R	1 & 2
14		6R	4 & 5
15	Lighthouse Creek	8C	1 & 2
16		9C	1, 2, 3, & 4
17	Stono Inlet	10S	1 & 2
18		10S	3
19		11S	1 & 2
20		11S	3 & 4
21		11S	5
22		11S	6
23		12S	1 thru 6, incl.
24	Lighthouse Inlet	13L	1, 2, & 3
25		13L	4
26		13L	5
27		13L	6
28		14L	1, 2, 3, & 4
29		14L	5

1/ For description of samples see following drilling logs.

TABLE D-3

TEXTURE AND SEDIMENTARY PARAMETERS
OF CHARLESTON OFFSHORE APPROACHES

Sample No.	Depth in Ft.	Md in mm	Ø50 Md	Q_{25} mm	Q_{75} mm	So Sorting Coeff	Sk. Skewness	Max. Quartz (mm)	Shell 1/	%Fines <0.05 mm
CH 1	12	0.12	3.05	0.10	0.15	1.23	1.04	1.5	M	0.2
CH 2	20	0.13	2.94	0.11	0.17	1.24	1.10	2.2	M	7.8
CH 3	28	0.15	2.73	0.11	0.17	1.24	0.83	1.0	S	0.1
CH 4	12	0.15	2.73	0.14	0.17	1.10	1.06	1.6	S	0.2
CH 5	15	0.10	3.32	0.07	0.12	1.28	0.84	1.1	S	6.3
CH 6	22	0.12	3.05	0.10	0.14	1.18	0.97	1.1	S	3.3
CH 7	24	0.13	2.94	0.10	0.14	1.18	0.83	0.6	A	0.1
CH 8	28	0.18	2.47	0.15	0.19	1.12	0.88	1.2	S	0.1
CH 9	20	0.50	1.00	0.28	1.08	1.96	0.83	1.3	M	0.5
CH 10	21	0.17	2.55	0.13	0.20	1.24	0.90	1.3	S	0.1
CH 11	27	0.30	1.73	0.25	0.65	1.62	3.88	1.8	A	0.1
CH 12	16	0.09	3.47	0.03	0.13	1.29	3.22	1.1	S	30.6
CH 13	15	0.15	2.73	0.13	0.17	1.14	0.98	2.1	S	0.5
CH 14	21	0.18	2.47	0.16	0.22	1.18	1.08	2.2	M	0.1
CH 15	27	0.15	2.73	0.13	0.19	1.21	1.10	1.6	M	0.8
CH 16	31	0.90	0.14	0.40	1.05	1.63	0.52	1.8	A	0.1
CH 17	15	0.15	2.73	0.13	0.18	1.18	1.04	1.4	S	0.1
CH 18	12	0.15	2.73	0.09	0.16	1.16	0.60	1.2	M	6.5
CH 19	21	0.19	2.40	0.15	0.25	1.29	1.03	1.7	A	0.1
CH 20	29	0.09	3.47	0.08	0.13	1.28	1.28	2.0	M	2.0

1/ Shell content by column: S<5%, M=5% to 30%, A>30%

TABLE D-2

MATCHING OF BORROW MATERIAL WITH NATIVE BEACH SANDS TO DERIVE
ADJUSTED FILL FACTOR (R_A) AND RENOURISHMENT FACTOR (R_J)

BORROW MATERIAL					BORROW MATERIAL COMPARED WITH AVERAGE NATIVE BEACH SAND (FROM TABLE D-1)			
Location	Analysis No	Hole No.	$M_{\phi b}$	$\sigma_{\phi b}$	$\frac{M_{\phi L} - M_{\phi n}}{\sigma_{\phi n}}$	$\frac{\sigma_{\phi b}}{\sigma_{\phi n}}$	Ra 1/ (Quadrant)	Rj 2/
Folly Beach	1	4	2.65	0.50	-0.0312	1.5625	1.20 (2)	0.50
	6	3	2.47	0.72	-0.5937	2.2500	1.25 (2)	0.07
	7	3	2.25	0.55	-1.2812	1.7188	1.03 (2)	0.12
	10	5	2.72	1.02	+0.1875	3.1375	1.60 (1)	0.02
	12	6	2.60	0.50	-0.1875	1.5625	1.15 (2)	0.50
	14	7	2.32	0.37	-1.0625	1.1563	1.00 (2)	0.33
Stono Inlet	19	11	2.72	0.42	+0.1875	1.3125	1.26 (1)	1.00
	23	12	2.77	0.52	+0.3437	1.6250	1.40 (1)	0.67
	24	13	2.50	0.30	-0.5000	0.9315	1.00 (3)	0.67
Lighthouse Inlet	25	13	1.30	1.90	-4.2500	5.9375	1.20 (2)	0.02
	26	13	2.65	0.55	-0.0312	1.7188	1.25 (2)	0.50
	27	13	4.10	2.00	+4.5000	6.2500	3.60 (2)	0.02
	28	14	2.40	0.40	-0.8125	1.2500	1.00 (2)	0.33
	29	14	2.35	0.35	-0.9687	1.0938	1.00 (2)	0.33

1/ Comparisons are shown for only the most promising 14 samples analyzed of the 29 samples taken from 14 bore holes shown on Figure D-1.
2/ Using a "R_A" value of 1.20, one cubic yard of sand subject to sorting will require 1.20 cubic yards removal from the borrow area.

3/ Using a "R_J" value of 0.50, the rate at which one cubic yard of borrow material will erode is one-half the rate at which the natural beach materail will erode; thus using this R_J only 0.50 cu. yds. would be required for renourishment for each cu. yd. of native beach sand lost.

Hole No. #1

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Folly Beach, S.C.	SHEET 1 OF 1 SHEETS

1. PROJECT Nourishment	10. SIZE AND TYPE OF BIT 1 3/8" ID Splitspoon
2. LOCATION (Coordinates or Station) West Bank Folly River, Near Day Mark "15"	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW
3. DRILLING AGENCY Savannah District	12. MANUFACTURER'S DESIGNATION OF DRILL CD-2, Skid Rig
4. HOLE NO. (As shown on drawing title and file number) #1 P	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 5; UNDISTURBED 0
5. NAME OF DRILLER P. Rountree	14. TOTAL NUMBER CORE BOXES 0
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER MLW
	16. DATE HOLE: STARTED 9 Nov. 1976; COMPLETED 9 Nov. 1976
7. THICKNESS OF OVERBURDEN 18.0'	17. ELEVATION TOP OF HOLE MLW -2.0'
8. DEPTH DRILLED INTO ROCK 0.0'	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 18.0'	19. SIGNATURE OF INSPECTOR Belville

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. JAR f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g	BLOWS
-2.0	0		SM-Blue green, soft, wet, fine, silty sand w/shell fragments & Heavy minerals		1	No Casing Set	13
							16
-5.0	3		dense			Begin drilling 0845 End drilling 0949	48
	5				2	Jet To Top of Drives	57
							50
							55
	10				3		31
							35
							24
-15.5	13.5		clayey, increasing plasticity		4		21
	15						18
					5		39
-20.0	18		BOTTOM OF HOLE 18.0' NOTE: Soils field classified in accordance with the Unified Soil Classification System.			BLOWS PER FOOT: Number required to drive 1 3/8" ID splitspoon w/ 140 lb. hammer falling 30". Folly River Drilling Log No. 1	

FIGURE D-3

Hole No. #2

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Folly Beach, S.C.	SHEET 1 OF 1 SHEETS

1. PROJECT: [illegible]
2. LOCATION (Coordinates or Station): West Bank Folly River, Near Day Mark "15"
3. DRILLING AGENCY: Savannah District
4. HOLE NO. (As shown on drawing title and file number): #2 R
5. NAME OF DRILLER: [illegible]
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 16.5'
8. DEPTH DRILLED INTO ROCK: 0.0'
9. TOTAL DEPTH OF HOLE: 16.5'
10. SIZE AND TYPE OF BIT: 1 3/8" ID Splitspoon
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MLW
12. MANUFACTURER'S DESIGNATION OF DRILL: Skid Rig CD-2
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 5; UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES: 0
15. ELEVATION GROUND WATER: MLW
16. DATE HOLE: STARTED 9 Nov. 1976; COMPLETED 9 Nov. 1976
17. ELEVATION TOP OF HOLE: MLW -4.3
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: Belville

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. (JAR) f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g	BLOWS
-4.3	0		SM-Blue green, soft, wet, fine, silty sand w/shell fragments & heavy minerals		1	No Casing Set	12
						Begin drilling 10:20	15
-7.3	3		Dense			End drilling 11:20	[illegible]
	5				2	Jet to top of drives	46
							56
							57
	10				3		41
							50
							54
	15				4		57
[illegible]	16.5				5		61
			BOTTOM OF HOLE 16.5' NOTE: Soils field classified in accordance with the Unified Soil Classification System.			BLOWS PER FOOT: Number required to drive 1 3/8" ID Splitspoon w/ 140 lb. hammer falling 30".	

Folly River Drilling Log No. 2

FIGURE D-4

Hole No. #3

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Folly Beach, S.C.	SHEET 1 OF 1 SHEETS

1. PROJECT Nourishment	10. SIZE AND TYPE OF BIT 1 3/8" ID Splitspoon
2. LOCATION (Coordinates or station) Behind Bird Key, Near Day Mark "R-10"	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW
3. DRILLING AGENCY Savannah District	12. MANUFACTURER'S DESIGNATION OF DRILL CD-2, Skid Rig
4. HOLE NO. (As shown on drawing title and file number) #3 R	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 4; UNDISTURBED 0
5. NAME OF DRILLER P. Rountree	14. TOTAL NUMBER CORE BOXES 0
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER MLW
	16. DATE HOLE: STARTED 9 Nov. 1976; COMPLETED 9 Nov. 1976
7. THICKNESS OF OVERBURDEN 13.5'	17. ELEVATION TOP OF HOLE MLW -7.0'
8. DEPTH DRILLED INTO ROCK 0.0'	18. TOTAL CORE RECOVERY FOR BORING
9. TOTAL DEPTH OF HOLE 13.5'	19. SIGNATURE OF INSPECTOR Belville

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. JAR	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g	BLOWS
-7.0	0		SM-Blue green, soft, wet, fine, silty sand with shell fragments & heavy minerals		1	No Casing Set	15
						Begin drilling 12:55	22
					2	End drilling 13:43	15
	5					Jet to top of drives	16
-13.0	6		Clayey, increasing plasticity				17
							19
	10						1?
					3		17
					4		1?
-20.5	13.5		BOTTOM OF HOLE 13.5' NOTE: Soils field classified in accordance with the Unified Soil Classification System.			BLOWS PER FOOT: Number required to drive 1 3/8" ID splitspoon with 140 lb. hammer falling 30".	

Folly River Drilling Log No. 3

FIGURE D-5

Hole No. #4

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Folly Beach, S.C.	SHEET 1 OF 1 SHEETS

1. PROJECT: Nourishment	10. SIZE AND TYPE OF BIT: 1 3/8" ID Splitspoon
2. LOCATION (Coordinates or Station): Behind Bird Key, Near Day Mark "R-10"	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): M L W
3. DRILLING AGENCY:	12. MANUFACTURER'S DESIGNATION OF DRILL: CD-2
4. HOLE NO. (As shown on drawing title and file number): #4 R	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 4; UNDISTURBED 0
5. NAME OF DRILLER: P. Roundtree	14. TOTAL NUMBER CORE BOXES: 0
6. DIRECTION OF HOLE: [x] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER: MLW
7. THICKNESS OF OVERBURDEN: 15.0'	16. DATE HOLE: STARTED 9 NOV 1976; COMPLETED 9 NOV 1976
8. DEPTH DRILLED INTO ROCK: 0.0'	17. ELEVATION TOP OF HOLE: MLW -6.8
9. TOTAL DEPTH OF HOLE: 15.0'	18. TOTAL CORE RECOVERY FOR BORING: %
	19. SIGNATURE OF INSPECTOR: Belville

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g	BLOWS:
-6.8	0		SM - Blue-green, dense, wet, fine, silty sand, w/ shell fragments and heavy minerals		JAR 1	No casing set	23
							25
	5				2	Begin Drilling 1415	19
							21
						End drilling 1510	15
							17
	10				3	Jet to top of drives	14
							14
							23
-21.8'	15				4		25
			BOTTOM OF HOLE 15.0'				
			NOTE: Soils field classified in accordance with the Unifed Soil Classification System.			BLOWS PER FOOT: Number required to drive 1 3/8" ID split-spoon w/140 lb. hammer falling 30".	

Folly River Drilling Log No. 4

FIGURE D-6

Hole No. #5

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Folly Beach, S.C.	SHEET 1 OF 1 SHEETS

1. PROJECT Nourishment	10. SIZE AND TYPE OF BIT 1 3/8" ID Splitspoon
2. LOCATION (Coordinates or Station) Mouth of Folly Creek, North bank of marsh	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) M L W
3. DRILLING AGENCY Savannah District	12. MANUFACTURER'S DESIGNATION OF DRILL CD-2
4. HOLE NO. (As shown on drawing title and file number) #5 R	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 5; UNDISTURBED 0
5. NAME OF DRILLER P. Roundtree	14. TOTAL NUMBER CORE BOXES 0
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER MLW
	16. DATE HOLE: STARTED 10 NOV 1976; COMPLETED 10 NOV 1976
7. THICKNESS OF OVERBURDEN 18.0'	17. ELEVATION TOP OF HOLE M L W -1.8
8. DEPTH DRILLED INTO ROCK 0.0'	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 18.0'	19. SIGNATURE OF INSPECTOR Belville

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO. JAR	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)	BLOWS
-1.8	0		SC - Blue-green, very soft, wet, silty, clayey, fine sand w/ shell fragments		1	No casing set	0
						Begin drilling 0820	0
	3.0		SM - Very soft, wet, silty, fine sand w/shell fragments and heavy minerals.		2	End drilling 0917	2
	5						1
							17
-10.8	9.0						18
	10		Dense, lense MH @ 9.0' to 9.3		3		24
							26
							34
	15				4		35
							27
-19.8	18.0				5		29
			BOTTOM OF HOLE 18.0'			BLOWS PER FOOT:	
			NOTE: Soils field classified in accordance with the Unified Soil Classification System.			Number required to drive 1 3/8" ID splitspoon w/140 lb. hammer falling 30".	

Folly River Drilling Log No. 5

Figure D-7

Hole No. #6

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Folly Beach, S.C.	SHEET 1 OF 1 SHEETS

1. PROJECT Nourishment	10. SIZE AND TYPE OF BIT 1 3/8" ID Splitspoon
2. LOCATION (Coordinates or Station) 500' D.S. Hwy 700 Bridge, East bank Folly River	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) M L W
3. DRILLING AGENCY Savannah District	12. MANUFACTURER'S DESIGNATION OF DRILL CD-2
4. HOLE NO. (As shown on drawing title and file number) #6 R	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED 5 — UNDISTURBED 0
5. NAME OF DRILLER P. Roundtree	14. TOTAL NUMBER CORE BOXES 0
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER M L W
	16. DATE HOLE — STARTED 10 NOV 1976 — COMPLETED 10 NOV 1976
7. THICKNESS OF OVERBURDEN 15.0'	17. ELEVATION TOP OF HOLE MLW -4.9
8. DEPTH DRILLED INTO ROCK 0.0'	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 15.0'	19. SIGNATURE OF INSPECTOR Belville

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. JAR	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g	BLOWS
-4.9			MH - Gray, very soft, wet, fat silt		1	No casing set	0
						Begin drilling 0845	0
	5				2	End drilling 0954	0
-10.9	6.0				3		0
			SM - Firm, wet fine silty sand w/ shell fragments and heavy minerals, Gray-green				17
-13.9	9.0						25
	10						33
			Dense		4		47
							76
-19.9	15				5		63

BOTTOM OF HOLE 15.0'

NOTE: Soils field classified in accordance with the Unified Soil Classification System.

BLOWS PER FOOT:

Number required to drive 1 3/8" ID split-spoon w/140 lb. hammer falling 30".

Folly River Drilling Log No. 6

Figure D-8

Hole No. #7

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Folly Beach, S.C.	SHEET 1 OF 1 SHEETS

1. PROJECT Nourishment	10. SIZE AND TYPE OF BIT 1 3/8" ID Splitspoon
2. LOCATION (Coordinates or Station) West bank Folly River, Near Day mark "15"	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW
3. DRILLING AGENCY Savannah District	12. MANUFACTURER'S DESIGNATION OF DRILL CD-2
4. HOLE NO. (As shown on drawing title and file number) #7 R	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED 12 — UNDISTURBED 0
5. NAME OF DRILLER P. Roundtree	14. TOTAL NUMBER CORE BOXES 0
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN 18.0'	16. DATE HOLE — STARTED 10 NOV 1976 — COMPLETED 10 NOV 1976
8. DEPTH DRILLED INTO ROCK 0.0'	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE 18.0'	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR Belville

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO. JAR	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) BLOWS
-3.3	0		SM - Bluegreen, loose, wet, fine silty sand, w/ shell fragments and heavy minerals		1	No casing set
					2	10
-6.3	3.0				3	17
					4	Begin drilling 1300
	5		Dense		5	End drilling 1410 23
					6	27
					7	39
					8	37
	10				9	33
			Thin lenses of MH 12.0 to 13.5		10	39
						25
					11	29
	15					27
-21.3'	18				12	27
			BOTTOM OF HOLE 18.0'			

NOTE: Soils field classified in accordance with the Unified Soil Classification System.

BLOWS PER FOOT:

Number required to drive 1 3/8" ID splitspoon w/140 lb. hammer falling 30".

Folly River Drilling Log No. 7

Figure D-9

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Hole No. #8

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Folly Beach, S.C.	SHEET 1 OF 1 SHEETS

1. PROJECT: Nourishment	10. SIZE AND TYPE OF BIT: 1 3/8" ID Splitspoon
2. LOCATION (Coordinates or Station): Upstream of light house in light house Ck.	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): M L W
3. DRILLING AGENCY: Savannah District	12. MANUFACTURER'S DESIGNATION OF DRILL: CD-2
4. HOLE NO. (As shown on drawing title and file number): #8 C	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 2; UNDISTURBED 0
5. NAME OF DRILLER: P. Roundtree	14. TOTAL NUMBER CORE BOXES: 0
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER: M L W
	16. DATE HOLE: STARTED 11 NOV 1976; COMPLETED 11 NOV 1976
7. THICKNESS OF OVERBURDEN: 13.5'	17. ELEVATION TOP OF HOLE: M L W -19.8
8. DEPTH DRILLED INTO ROCK: 0.0'	18. TOTAL CORE RECOVERY FOR BORING: %
9. TOTAL DEPTH OF HOLE: 13.5'	19. SIGNATURE OF INSPECTOR: Belville

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. JAR	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g	BLOWS:
			SC - Gray, wet soft organic, silty, clayey, very fine sand w/shell fragments and oder of rotten eggs.			No casing set	0
						Begin drilling 1009	0
	5					End drilling 11.02	0
					1		1
							2
							1
	10				2		3
							3
-19.8	13.5						5
			BOTTOM OF HOLE 13.5'			BLOWS PER FOOT:	
			NOTE: Soils field classified in accordance with the Unified Soils Classification System.			Number required to drive 1 3/8" ID split-spoon w/140 lb. hammer falling 30".	

Lighthouse Creek
Drilling Log 8

Figure D-10

Hole No. #9

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Folly Beach, S.C.	SHEET 1 OF 1 SHEETS

1. PROJECT: Nourishment	10. SIZE AND TYPE OF BIT: 1 3/8 ID Splitspoon
2. LOCATION (Coordinates or Station): Upstream of light house in light house Ck.	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): M L W
3. DRILLING AGENCY: Savannah District	12. MANUFACTURER'S DESIGNATION OF DRILL: CD2
4. HOLE NO. (As shown on drawing title and file number): #9 C	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 4; UNDISTURBED 0
5. NAME OF DRILLER: P. Roundtree	14. TOTAL NUMBER CORE BOXES: 0
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER: M L W
	16. DATE HOLE: STARTED 11 Nov 1976; COMPLETED 11 NOV 1976
7. THICKNESS OF OVERBURDEN: 12.0'	17. ELEVATION TOP OF HOLE: M L W 8.0
8. DEPTH DRILLED INTO ROCK: 0.0'	18. TOTAL CORE RECOVERY FOR BORING: %
9. TOTAL DEPTH OF HOLE: 12.0'	19. SIGNATURE OF INSPECTOR: Belville

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. JAR f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g	BLOWS:
-8.0	0		CH - Gray, very soft, wet, silty, fat clay, w/ some very fine sand, oder of rotten eggs			No casing set begin drilling 1319 end drilling 1405	0 0
	5					No recovery 0.0-6.0	0
					1		0
					2		2
	10				3	Weight of hammer drives to 6.0	1 2
-20.0	12.0				4		1
			BOTTOM OF HOLE 12.0'				
			NOTE: Soils field classified in accordanced with the Unified Soil Classification System.			BLOWS PER FOOT: Number required to drive 1 3/8" ID splitspoon w/140 lb. hammer falling 30".	

Lighthouse Creek
Log No. 9

FIGURE D-11

Hole No. 10

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Folly Beach, S.C.	SHEET 1 OF 1 SHEETS

1. PROJECT Nourishment	10. SIZE AND TYPE OF BIT 1 3/8" ID Splitspoon
2. LOCATION (Coordinates or Station) Shoal near bird key	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) M. L. W.
3. DRILLING AGENCY Savannah District	12. MANUFACTURER'S DESIGNATION OF DRILL CD-6
4. HOLE NO. (As shown on drawing title and file number) #10 S	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 3; UNDISTURBED 0
5. NAME OF DRILLER P. Roundtree	14. TOTAL NUMBER CORE BOXES 0
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER MLW
	16. DATE HOLE: STARTED 16 NOV 1976; COMPLETED 16 NOV 1976
7. THICKNESS OF OVERBURDEN 9.0'	17. ELEVATION TOP OF HOLE 0.0' MLW
8. DEPTH DRILLED INTO ROCK 0.0'	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 9.0'	19. SIGNATURE OF INSPECTOR Belville

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g	BLOWS:
0.0'	0		JAR				
			SM - Green gray, wet, soft, very fine, silty sand, w/ shell fragments and heavy minerals		1		11
-3.0'	3.0					Begin drilling 0900	16
	5		Dense		2	End drilling 0959	29
						No casing set	39
						Hole not completed	35
-9.0'	9.0'				3	to -20.0' due to incoming tide.	38
			BOTTOM OF HOLE 9.0'			BLOWS PER FOOT:	
			NOTE: Soils field classified in accordance with the Unified Soil Classification System.			Number required to drive 1 3/8" ID splitspoon w/140 lb. hammer falling 30".	

Stono Inlet Drilling Log No. 10

FIGURE D-12

Hole No. 11

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Folly Beach, S.C.	SHEET 1 OF 1 SHEETS

1. PROJECT Nourishment	10. SIZE AND TYPE OF BIT 1 3/8" ID Splitspoon
2. LOCATION (Coordinates or Station) North side of Bird Key	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) M. L. W.
3. DRILLING AGENCY Savannah District	12. MANUFACTURER'S DESIGNATION OF DRILL CD-6
4. HOLE NO. (As shown on drawing title and file number) #11 S	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED 6 — UNDISTURBED 0
5. NAME OF DRILLER P. Roundtree	14. TOTAL NUMBER CORE BOXES 0
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER MLW
	16. DATE HOLE — STARTED 16 NOV 1976 — COMPLETED 16 NOV 1976
7. THICKNESS OF OVERBURDEN 22.5'	17. ELEVATION TOP OF HOLE + 3.0 MLW
8. DEPTH DRILLED INTO ROCK 0.0'	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 22.5'	19. SIGNATURE OF INSPECTOR Belville

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. JAR	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g	BLOWS
+3.0'	0		SM - Green gray, wet, dense, fine silty sand w/shell fragments and heavy minerals.		1		21
						Begin drilling 1015	27
	5				2	End drilling 1055	57
							65
						No casing set	66
					3		68
	10						65
							64
							61
	15				4		63
							64
							67
-16.5'	19.5						66
	20		SC - Wet, dense, fine, silty, clayey fine sand, w/shell fragments and heavy minerals.		5		68
-19.5'	22.5				6		62
			BOTTOM OF HOLE 22.5'				

NOTE: Soils field classified in accordance with the Unified Soil Classification System.

BLOWS PER FOOT:
Number required to drive 1 3/8" ID Splitspoon w/140 lb. hammer falling 30".

Stono Inlet
Drilling Log No.11

FIGURE D-13

Hole No. 12

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Folly Beach, S.C.	SHEET 1 OF 1 SHEETS

1. PROJECT: Nourishment	10. SIZE AND TYPE OF BIT: 1 3/8" ID Splitspoon
2. LOCATION (Coordinates or Station): Bird Key 2000' off shore, South Tip	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): M. L. W.
3. DRILLING AGENCY: Savannah District	12. MANUFACTURER'S DESIGNATION OF DRILL: CD-6
4. HOLE NO. (As shown on drawing title and file number): 12 S	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 6; UNDISTURBED 0
5. NAME OF DRILLER: P. Roundtree	14. TOTAL NUMBER CORE BOXES: 0
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER: MLW
	16. DATE HOLE: STARTED 17 NOV 1976; COMPLETED 17 NOV 1976
7. THICKNESS OF OVERBURDEN: 21.0'	17. ELEVATION TOP OF HOLE: 0.0MLW
8. DEPTH DRILLED INTO ROCK: 0.0'	18. TOTAL CORE RECOVERY FOR BORING: %
9. TOTAL DEPTH OF HOLE: 21.0'	19. SIGNATURE OF INSPECTOR: Belville

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. JAR	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g	BLOWS:
-0.0'	0		SM - Gray green, soft wet, fine silty sand w/ shell fragments and heavy minerals		1		10
						Begin drilling 0935	14
	4.5					End drilling 1034	19
	5		Dense		2	No casing set	37
							45
					3		33
	10						20
							24
					4		36
	15		Small clumps black ch 16.5' to 17.0'				47
-17.0'	17.0						59
			Black and gray green		5		62
	20						64
	20.1				6		69
			BOTTOM OF HOLE 21.0'				

NOTE: Soils field classified in accordance with the Unified Soil Classification System.

BLOWS PER FOOT:

Number required to drive 1 3/8" ID splitspoon w/140 lb. hammer falling 30".

Stono Inlet Drilling Log No. 12

FIGURE D-14

Hole No. 13

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Folly Beach, S.C.	SHEET 1 OF 1 SHEETS

1. PROJECT Nourishment	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station) Near light house on shoal in light house Creek	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) M. L. W.
3. DRILLING AGENCY Savannah District	12. MANUFACTURER'S DESIGNATION OF DRILL CD-6
4. HOLE NO. (As shown on drawing title and file number) #13 L	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED 0 — UNDISTURBED 0
5. NAME OF DRILLER P. Roundtree	14. TOTAL NUMBER CORE BOXES 0
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER MLW
	16. DATE HOLE — STARTED 18 NOV 1976 — COMPLETED 18 NOV 1976
7. THICKNESS OF OVERBURDEN 21.0'	17. ELEVATION TOP OF HOLE 0.0' MLW
8. DEPTH DRILLED INTO ROCK 0.0'	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 21.0'	19. SIGNATURE OF INSPECTOR Melville

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g	BLOWS
0.0'			SM - Green gray, wet, firm, fine, silty sand w/shell fragments and heavy minerals		1		12
						Begin drilling 0935	17
-4.5'	4.5' / 5				2	End drilling 1034	22
			Dense				31
						No casing set	39
					3		46
	10						52
							57
	15				4		53
			Thin layers, gray and black CH - 17.5' to 18.0'				49
-17.5'	17.5'						
-18.0'	18.0'						54
			SC - Blue gray, wet, dense, fine, silty, clayey sand w/shell fragments and heavy minerals		5		52
	20						
-21.0'	21.0'				6		54
			BOTTOM OF HOLE 21.0'			BLOWS PER FOOT:	
			NOTE: Soils field classified in accordance with the Unified Soil Classification System.			Number required to drive 1 3/8" ID splitspoon w/ 140 lb. hammer falling 30".	

Lighthouse Inlet
Drilling No. 13

FIGURE NO. D-15

Hole No.

DRILLING LOG		INSTALLATION	SHEET 1 OF 1 SHEETS

1. PROJECT
2. LOCATION
Near ... in light ... Creek
3. DRILLING AGENCY
Savannah
4. HOLE NO. 14
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): M.L.W.
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 5, UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES 0
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED ... NOV 1976, COMPLETED 18 NOV 1976
17. ELEVATION TOP OF HOLE +4.5 MLW
18. TOTAL CORE RECOVERY FOR BORING
19. SIGNATURE OF INSPECTOR

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
+4.5'			SP - ... gray, ... fine, silty, sand w/ ... and heavy minerals		1	6
	2.5'				2	Begin drilling 1105 / End drilling 1202 / No casing set; 14, 28
	5		... gray, wet, dense			
	6.0'					32
			... gray, wet, dense w/thin discontinuous clay lenses ... to 11.5'		3	36, 55
	10					62
	11.5'		... dense, fine ... and heavy minerals			68, 62
	15				4	54, 61
	20				5	63, 59, 73, 65
	24.0'				6	66

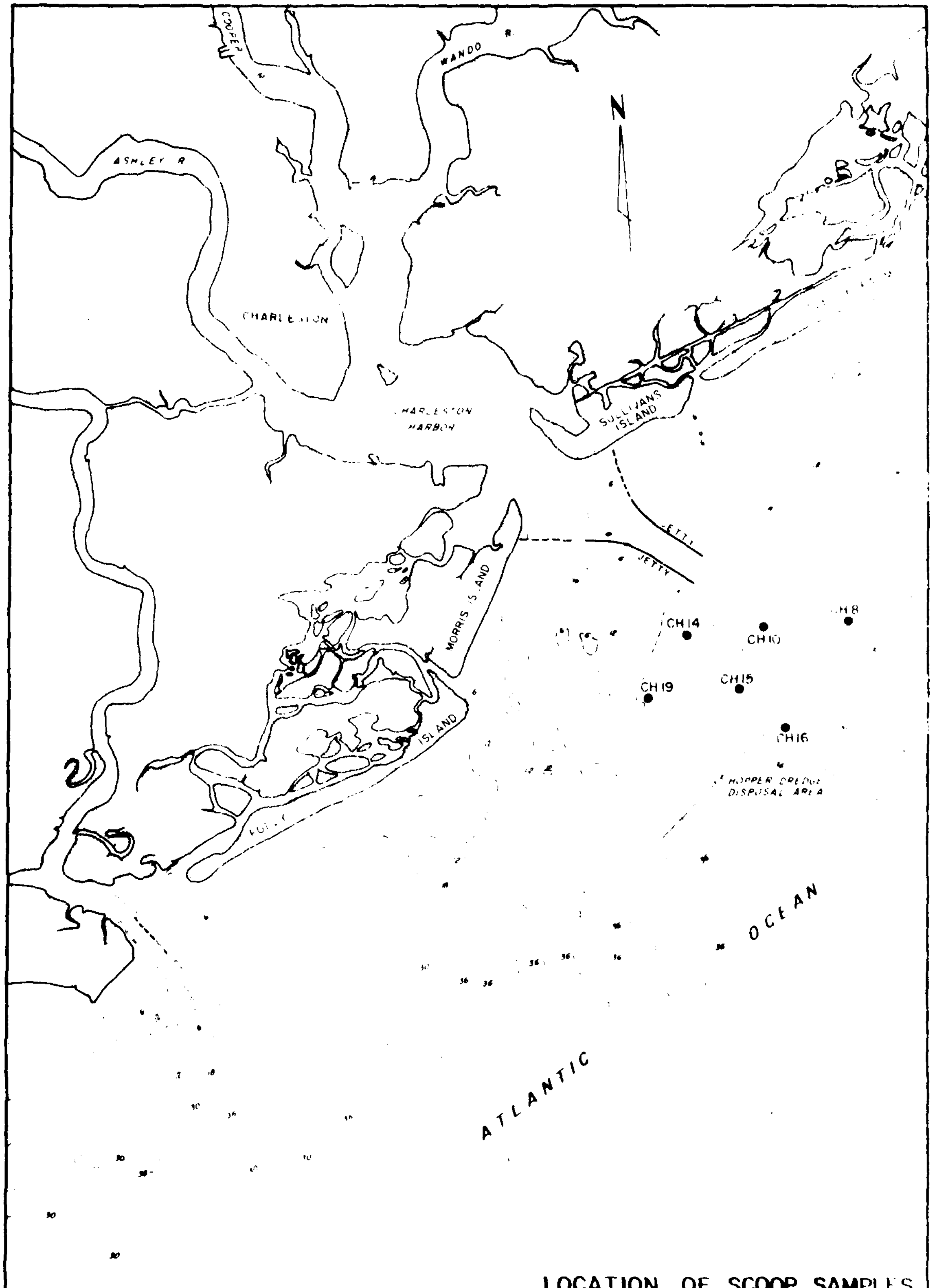
BOTTOM OF HOLE 24.0'

NOTE:
Soils field classified in accordance with the Unified Soil Classification System.

BLOWS PER FOOT:
Number required to drive 1 3/8"ID Splitspoon w/ 140 lb. hammer falling 30".

Lighthouse Inlet
Drilling No. 14

FIGURE No. D-16



LOCATION OF SCOOP SAMPLES TAKEN IN CHARLESTON HARBOR AND APPROACHES (1964)

FIGURE D-17

further during the pre-construction planning period. Location of samples are shown on Figure D-17 and descriptive parameters are listed in Table D-3.

ADJUSTED FILL FACTORS AND RENOURISHMENT FACTORS OF BORROW MATERIAL

6. Matchings of the various borrow materials with a composite representative sample of native beach sands are shown in Table D-4. The locations of the various borrow areas cited in this table are shown in Figure D-1. It will be noted that in addition to showing the fill factors (Ra), and the renourishment factors (Rj) (see Shore Protection Manual, 1977, Figures 5-3 and 5-4), that the quadrant of each matching is shown, and this relates to the Quadrantal information in Table 5-1, Shore Protection Manual, 1977. Matchings falling in quadrants 1 and 4 indicate borrow material finer than native beach sand, and those falling in quadrants 2 and 3 indicate borrow material coarser than native material.

7. Adjusted fill factors (R_A) and renourishment factors (R_J) of suitable borrow material in the Folly Island area are summarized in the following paragraphs.

a. Folly River. For all samples analyzed from Folly River the average R_A equals 1.20. The material from Boring Hole No. 5 at the mouth of Folly Creek (shown on Figure D-1) was found to be the least promising with a R_A value of 1.60 and Hole No. 7 was the most suited for beach fill borrow material with a R_A equal to unity. The overall average of 1.20 appears to be a good representation of borrow material in Folly River.

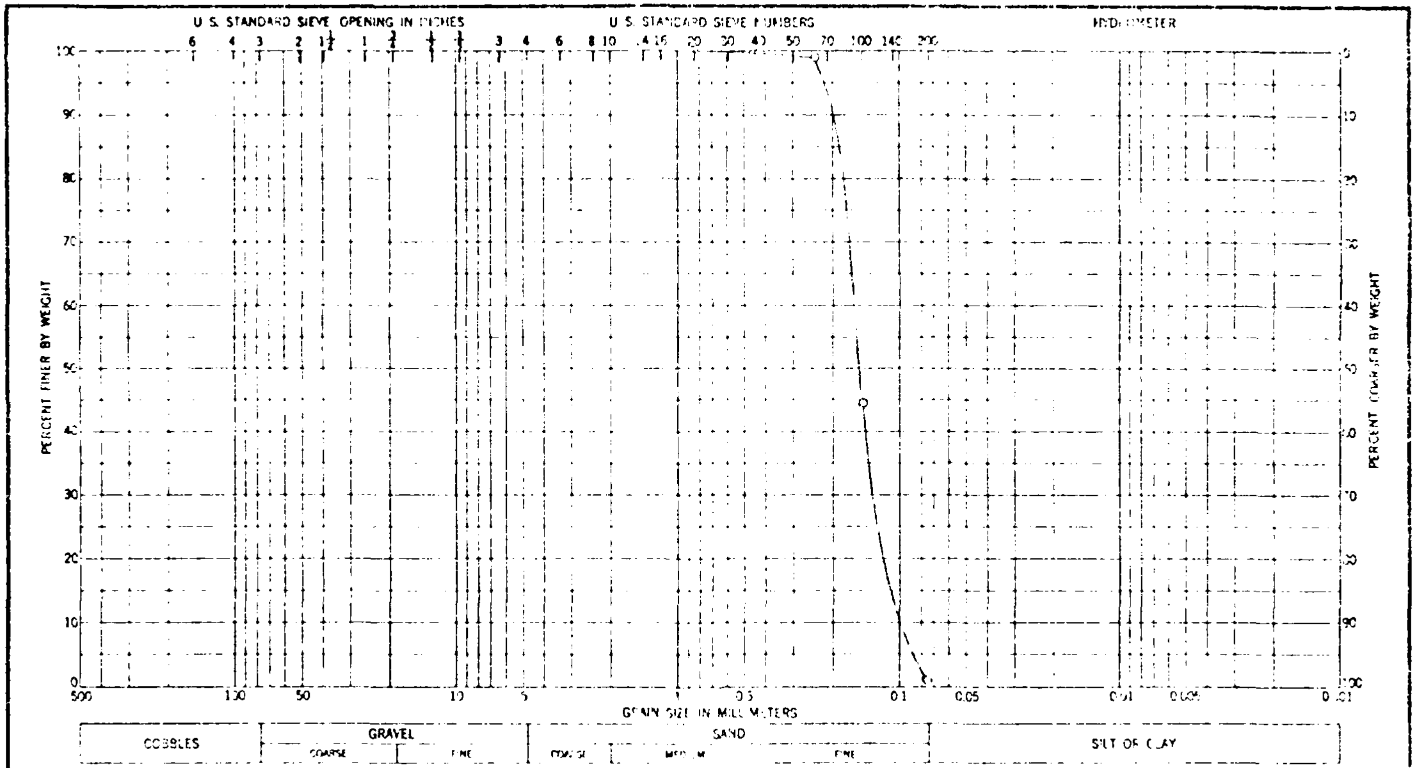
The R_J values average from 0.26 for all Folly River Holes. From the computed R_J values it appears that the borrow material after sorting action has occurred, will erode at a lower rate than the native beach sand but the average values is considered excessively low; therefore, a larger value is considered appropriate. The procedure for calculation and application of the renourishment factor presented in the Shore Protection Manual, 3rd edition (1977) was discussed with a consultant with the Coastal Engineering Research Center (CERC). This consultant recommended, contrary to the example shown in SPM, that a minimum R_J value of unity be used due to the unknown natural forces involved in erosion such as winds, waves, storms, and tides.

b. Stono Inlet. Only two sand samples were analyzed from this borrow area. The average R_A equals 1.33 and the average R_J equals 0.84. Since the number of samples taken from Stono Inlet shoals are small, the R_A value to be used is rounded upward to 1.40. The R_J value of 1.00 was used.

c. Lighthouse Inlet. The average R_A is 1.51 for the six samples analyzed from Lighthouse Inlet shoals and the average R_J is 0.31. Four of the six samples were taken from Hole No. 13 (for location see Figure D-1) and two were taken from Hole No. 14. Using an average R_A value for each of these two holes, the weighted average R_A equals 1.38 (rounded to 1.40). This value is considered to be appropriate for use when computing overfill amounts of this material. The computed values of R_J give evidence that this borrow material, after sorting action, would erode slower than the native beach sand. However, the more conservative 1.00 was applied as the R_J factor.

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0712
Req. No. SACSO-77-58



Sample No	Elev or Depth	Classification	Nat w%	LL	PL	PI
1	--	Gray poorly graded sand(SP)	-	-	-	-

Project: CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C.
Lab. No. 74/2366

Area: --

Boring Sta. No. 59 C... Sample No. 1

Date: 3 August 1977

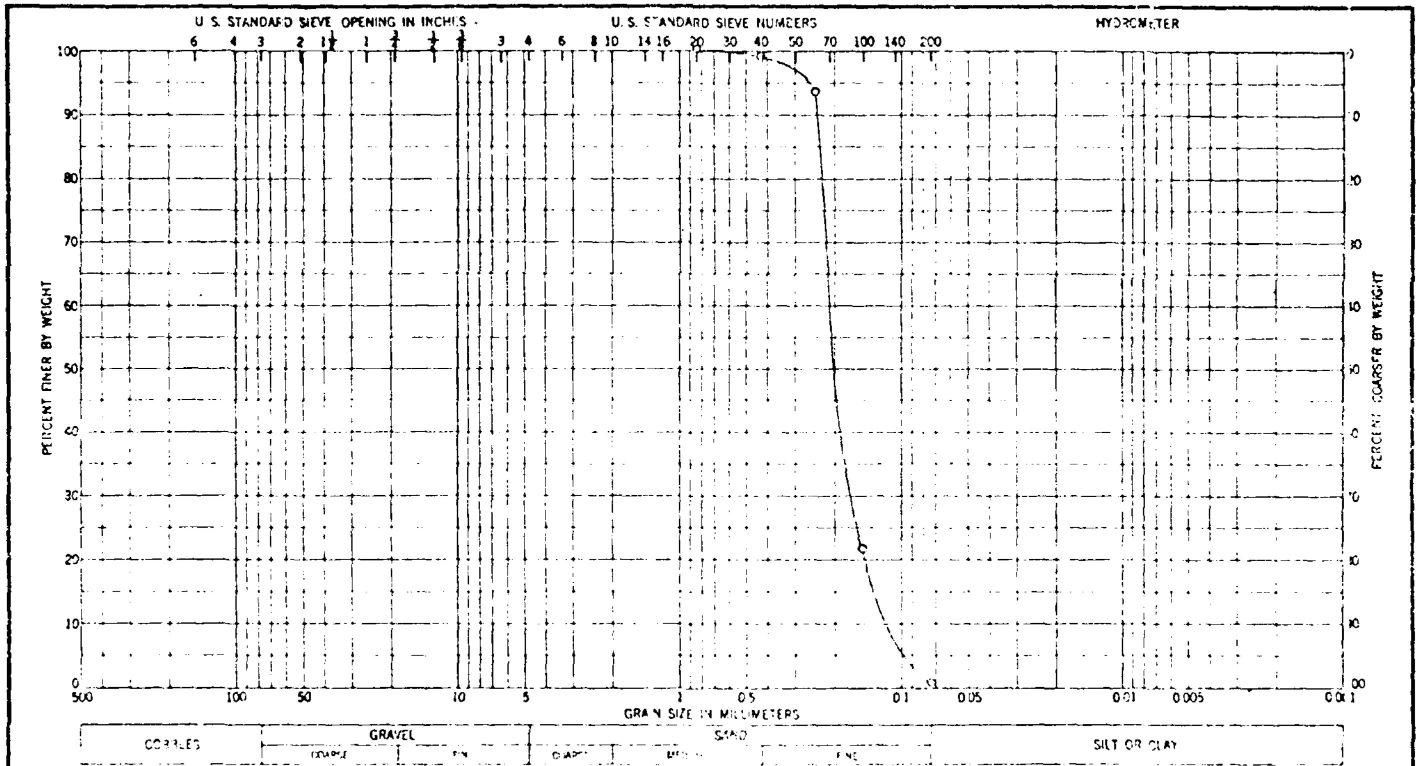
GRADATION CURVES

ENG FORM 2087

FIGURE D-18

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0712
Req. No. SACEC-77-53



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
2	--	Gray poorly graded sand(SP)	-	-	-	-

Project Survey Report, Folly Beach, S.C.

Lab. No. 74/2357

Area --

Boring Sta. No. 50+00S, Sample No. 2

3 August 1977

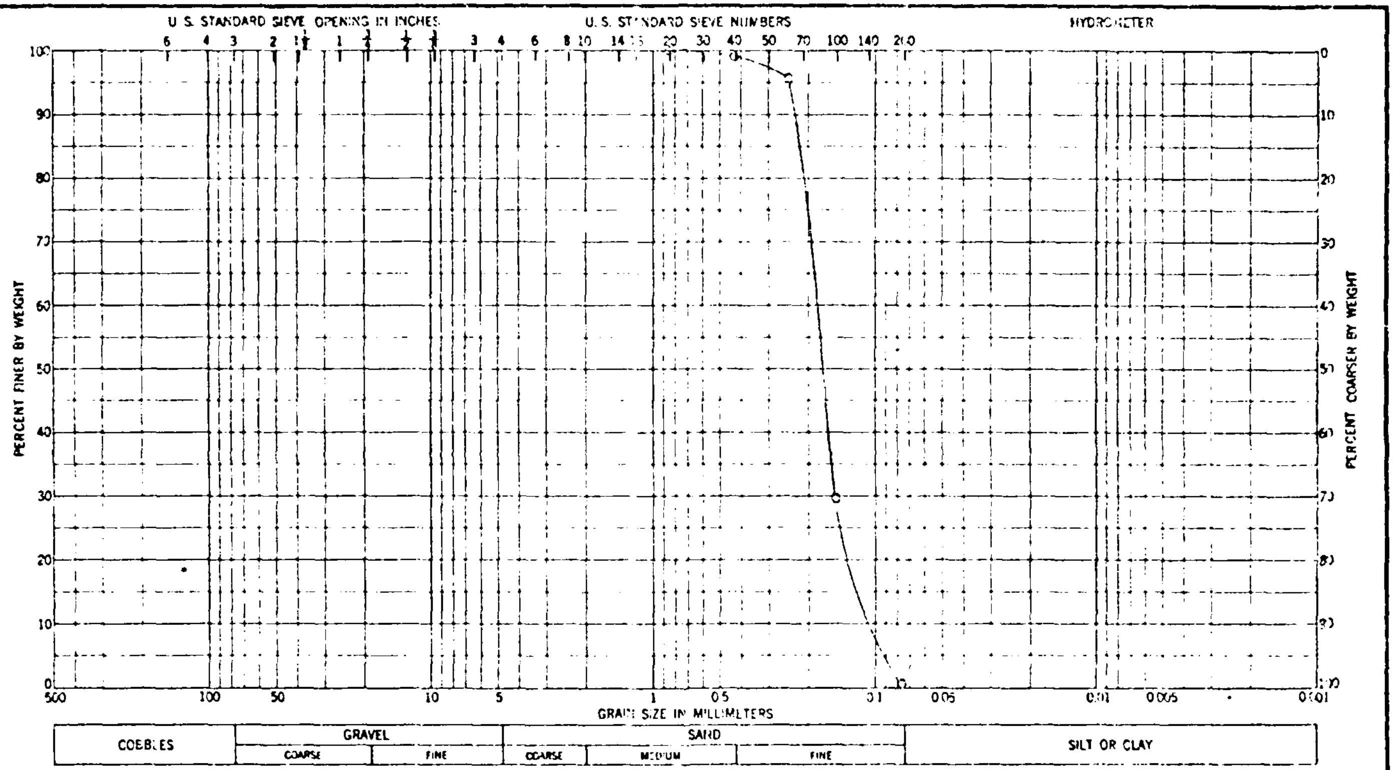
GRADATION CURVES

ENG FORM 2087

FIGURE D-19

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0712
Req. No. SACEC-77-53



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
3	--	Gray poorly graded sand (SP)	-	-	-	-

Project: CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C.
Lab. No. 74/2369
Area --
Sta. No. 50+00 S., Sample No. 3
Date 3 August 1977

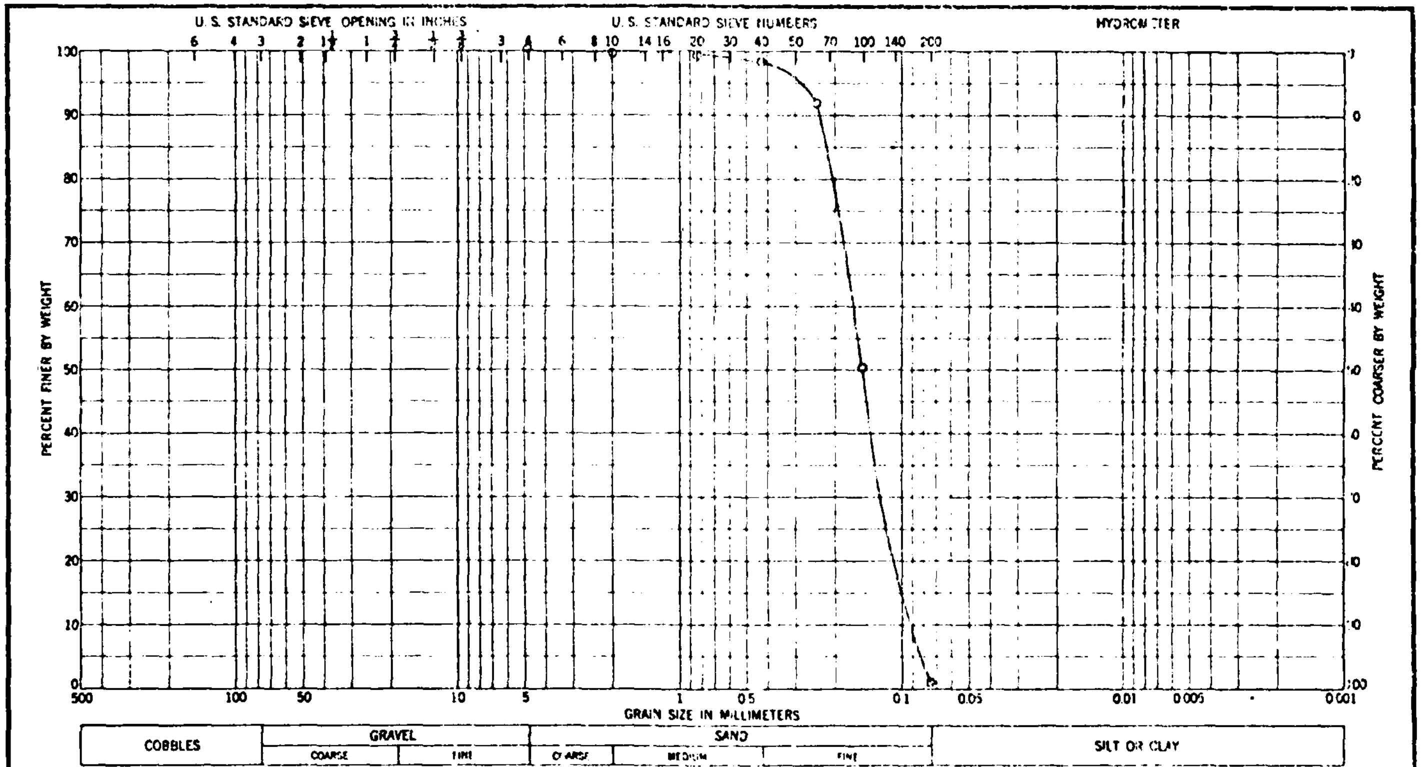
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-20

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0712
Req. No. SACEC-77-53



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
4	--	Gray poorly graded sand(SP)	-	-	-	-

CHARLESTON DISTRICT, Folly Beach
Project Survey Report, Folly Beach, S.C.
Lab. No.74/2369
Area --
Boring Sta.No. 50 00S, Sample No. 4
Date August 1977

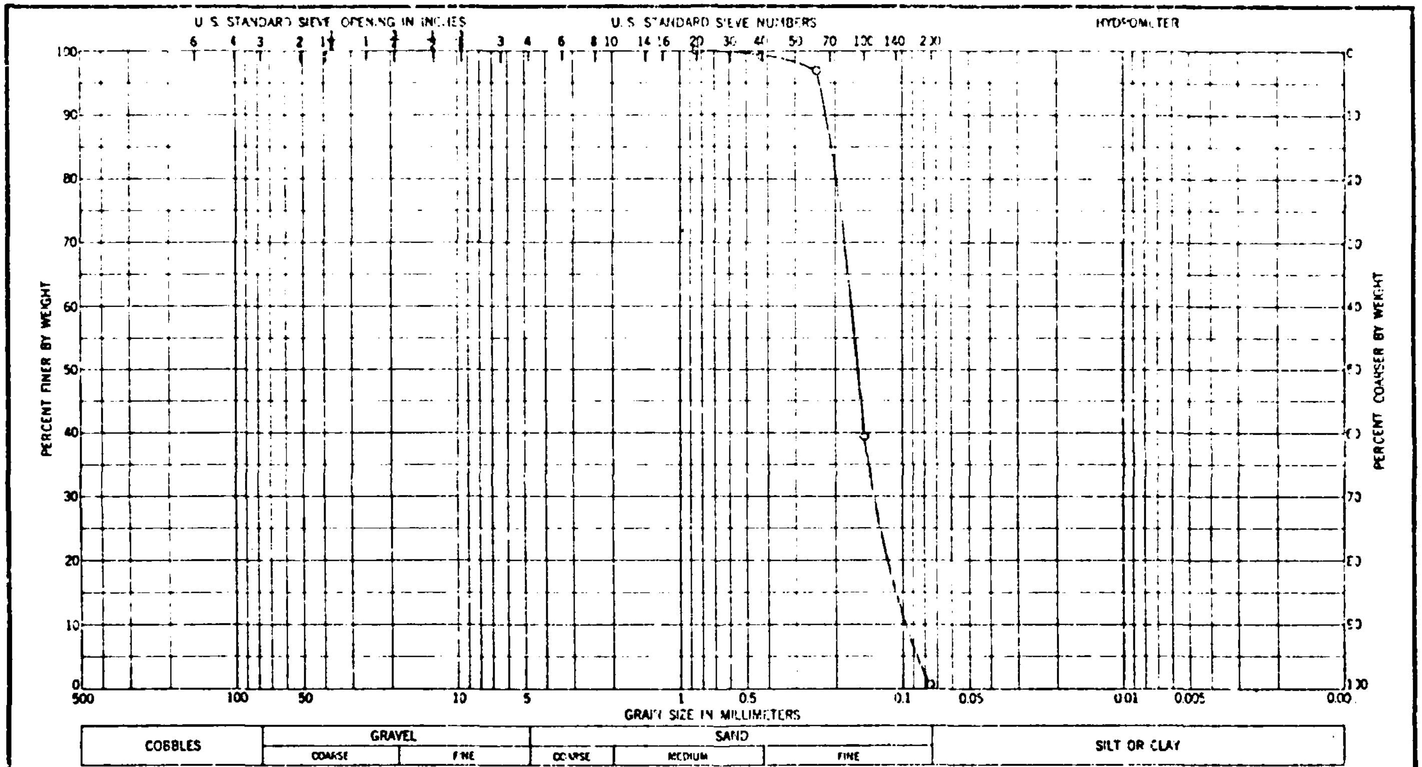
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-21

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0712
Req. No. SACEC 77-58



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
1	--	Gray poorly graded sand (SP)	-	-	-	-

CHARLESTON DISTRICT, Folly Beach
Project Survey Report, Folly Beach, S.C.
Lab. No. 74/2370
Area -
Boring Sta. No. 10+00 N, Sample No. 1
Date 3 August 1977

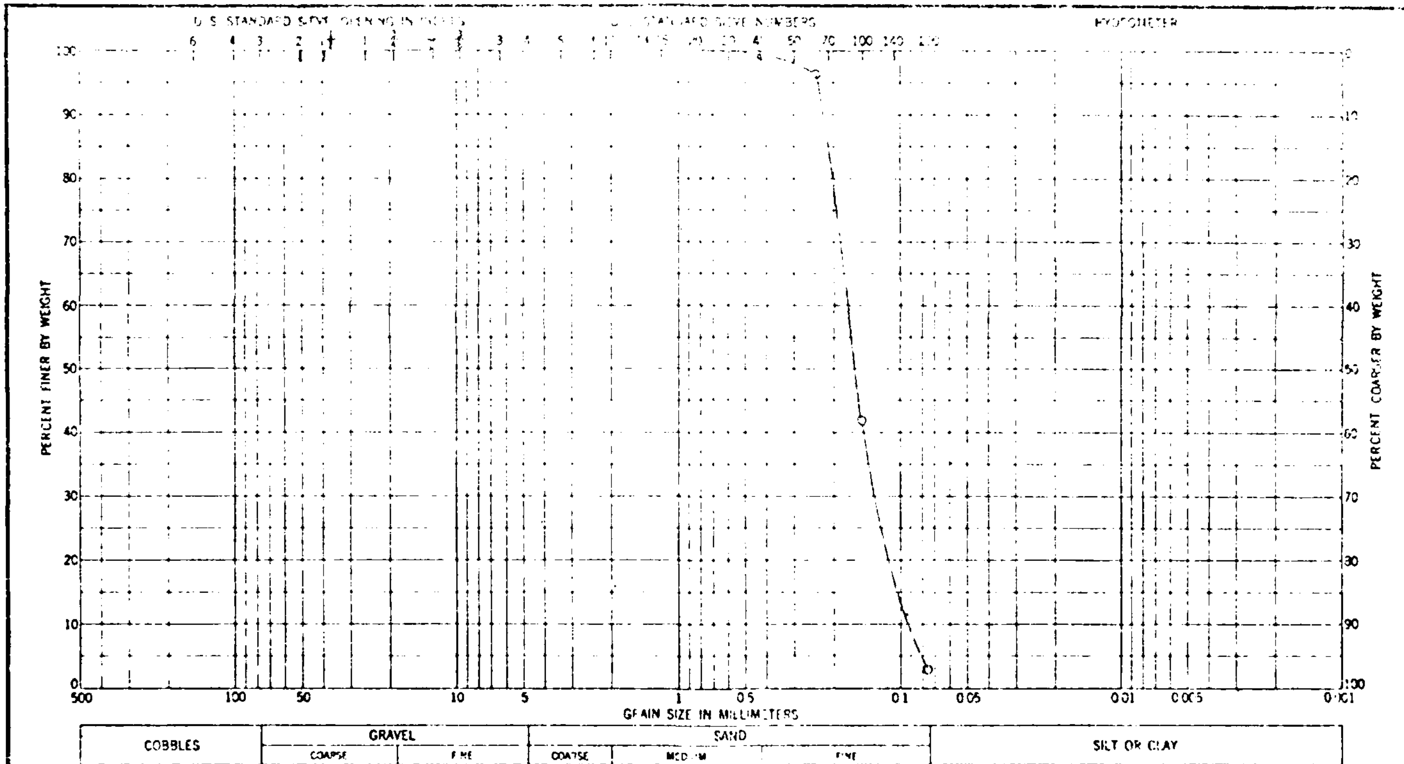
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-22

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA 30061

WORK ORDER NO. 0712
Req. No. SACEC 77-58



Sample No	Elev or Depth	Classification	Nat w%	LL	PL	PI
2	--	Gray poorly graded sand (SP)	-	-	-	-

Project: CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C. Lab. No. 74/2371

Area: --

Boring No.: Sta. , 10 + 00 N, Sample No. 2

Date: 3 August 1977

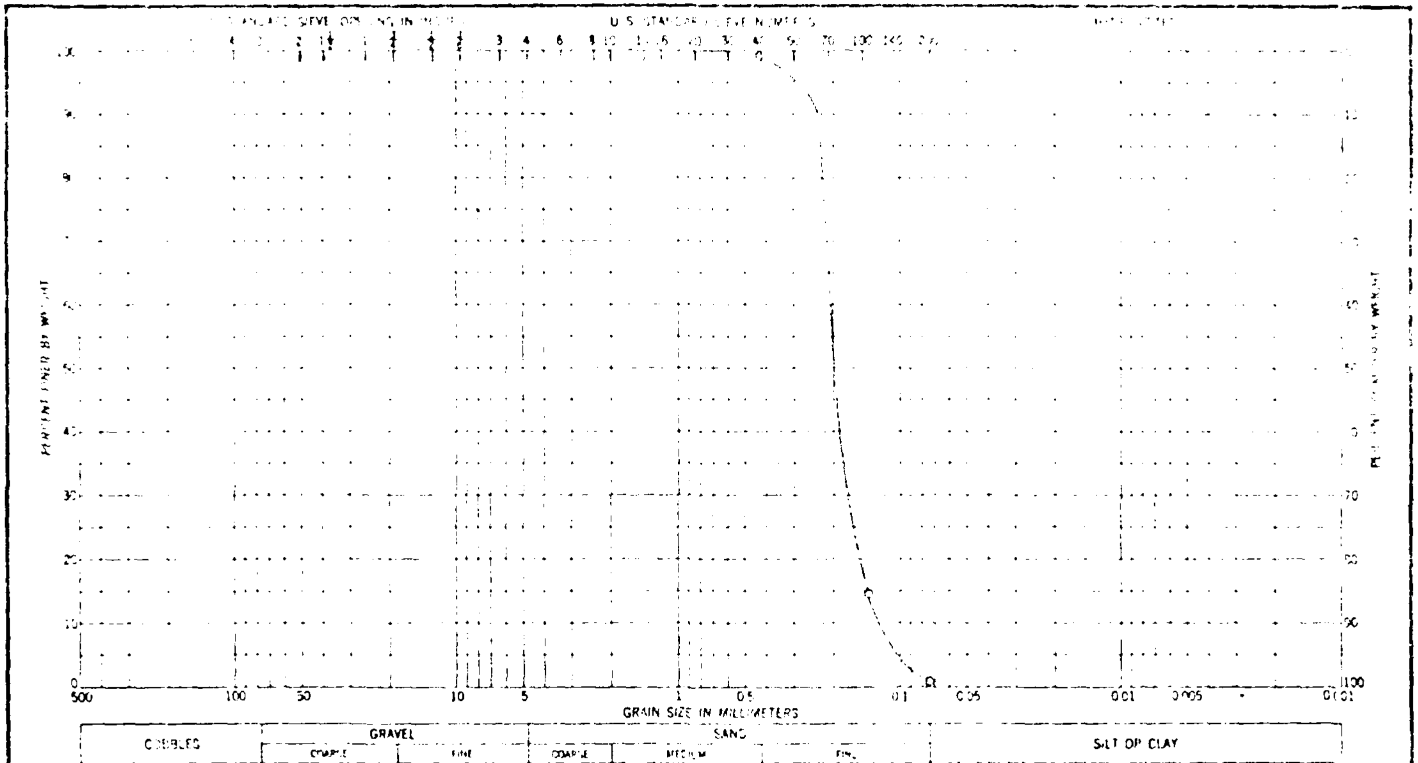
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-23

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0712
Re. No. SA SEC 77-30



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
3	--	Gray poorly graded sand (SP)	-	-	-	-

Project CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C.

Lab. No. 74/2372

Area -

Sta. No. 10+00 N, Sample No. 3

Date 3 August 1977

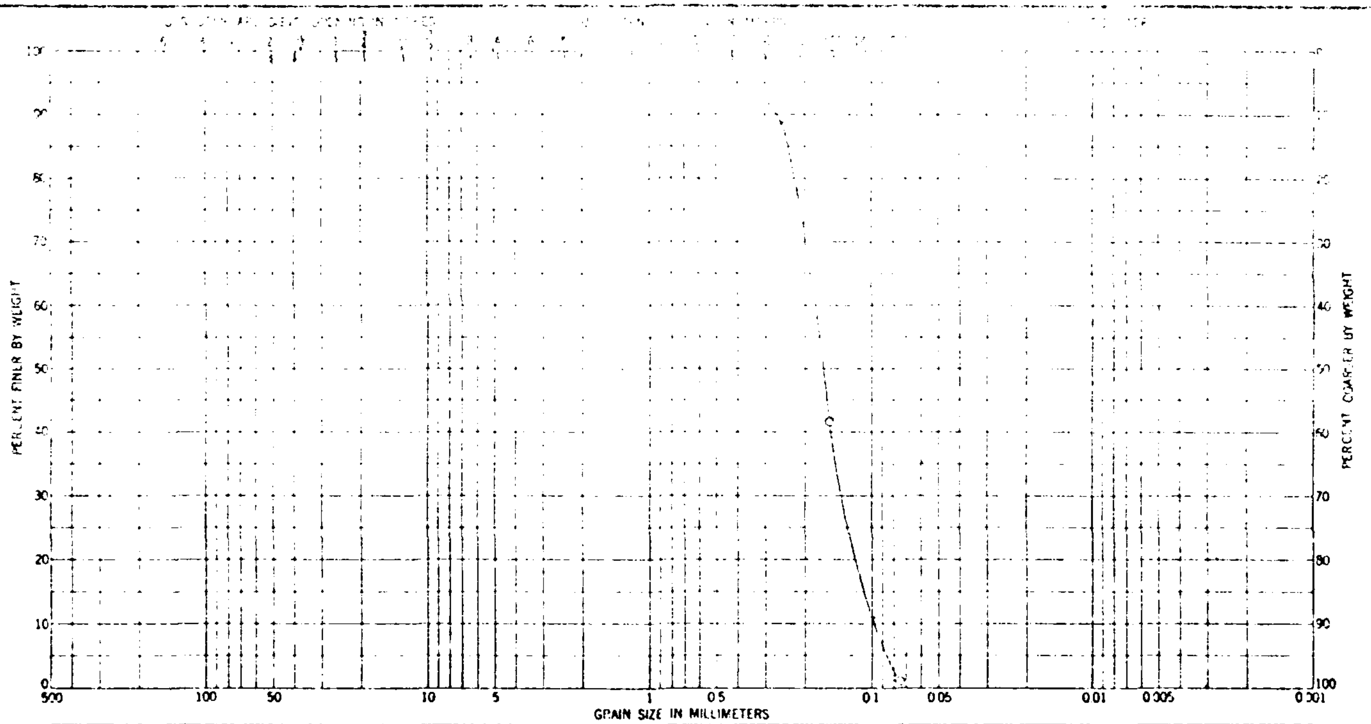
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-24

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA

WORK ORDER NO. 0712



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	P
4	--	Gray poorly graded sand(SP)	-	-	-	-

CHARLESTON DISTRICT, Folly Beach
Project Survey Report, Folly Beach, S.C.
Lab. No. 74/2373
Area -
Sta. No. 10 + 00 N, Sample No. 4
Date 3 August 1977

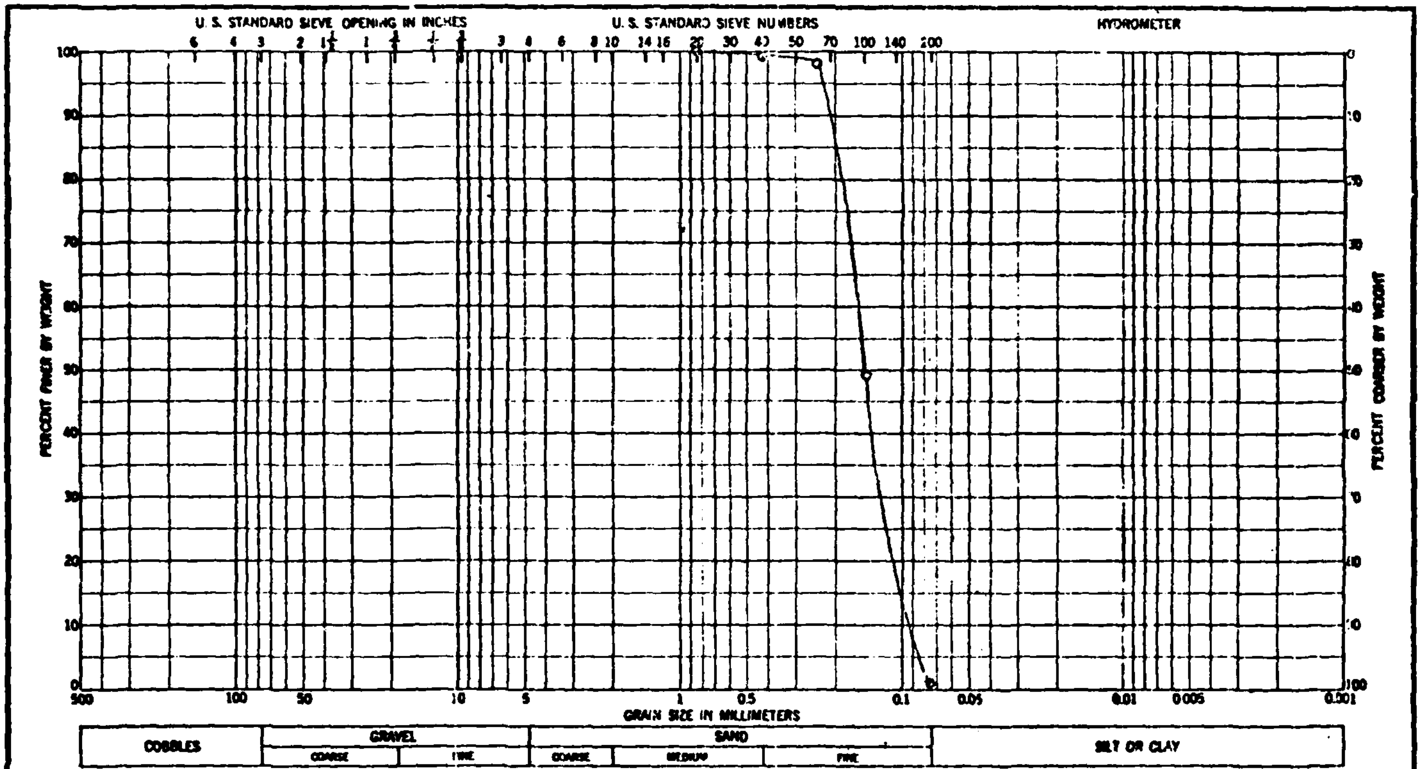
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-25

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0712
Req. No. SACEC 77-58



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
1	--	Gray poorly graded sand(SP)	-	-	-	-

Project: CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C.
Lab. No. 74/2374

Area: -

~~Boring~~ Sta. No. 90 + 00 N, Sample No. 1

Date: 3 August 1977

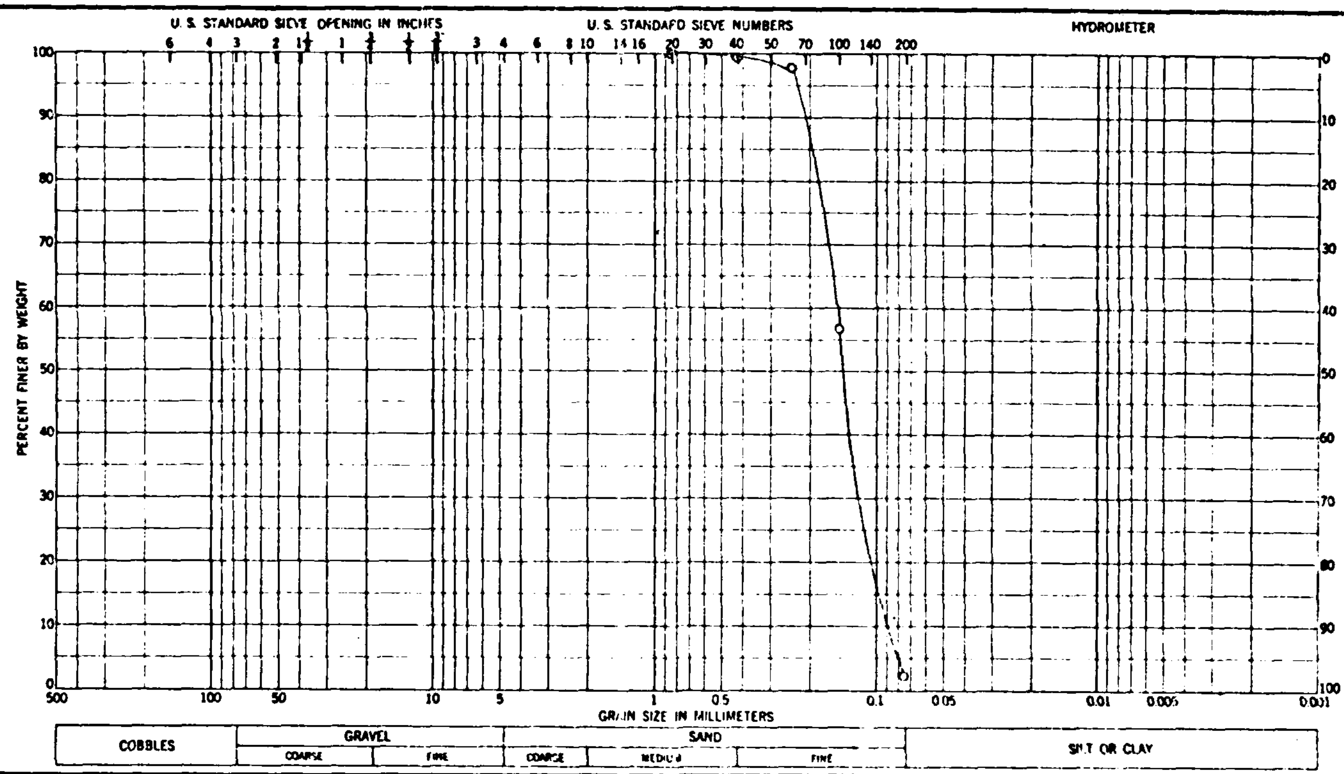
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-26

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0712
Req. No. SACEC 77-58



Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
2	--	Gray poorly graded sand(SP)	-	-	-	-

Project: CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C.
Lab. No. 74/2375

Area: --

Sta. No. 90+00 N, Sample No. 2

Date: 3 August 1977

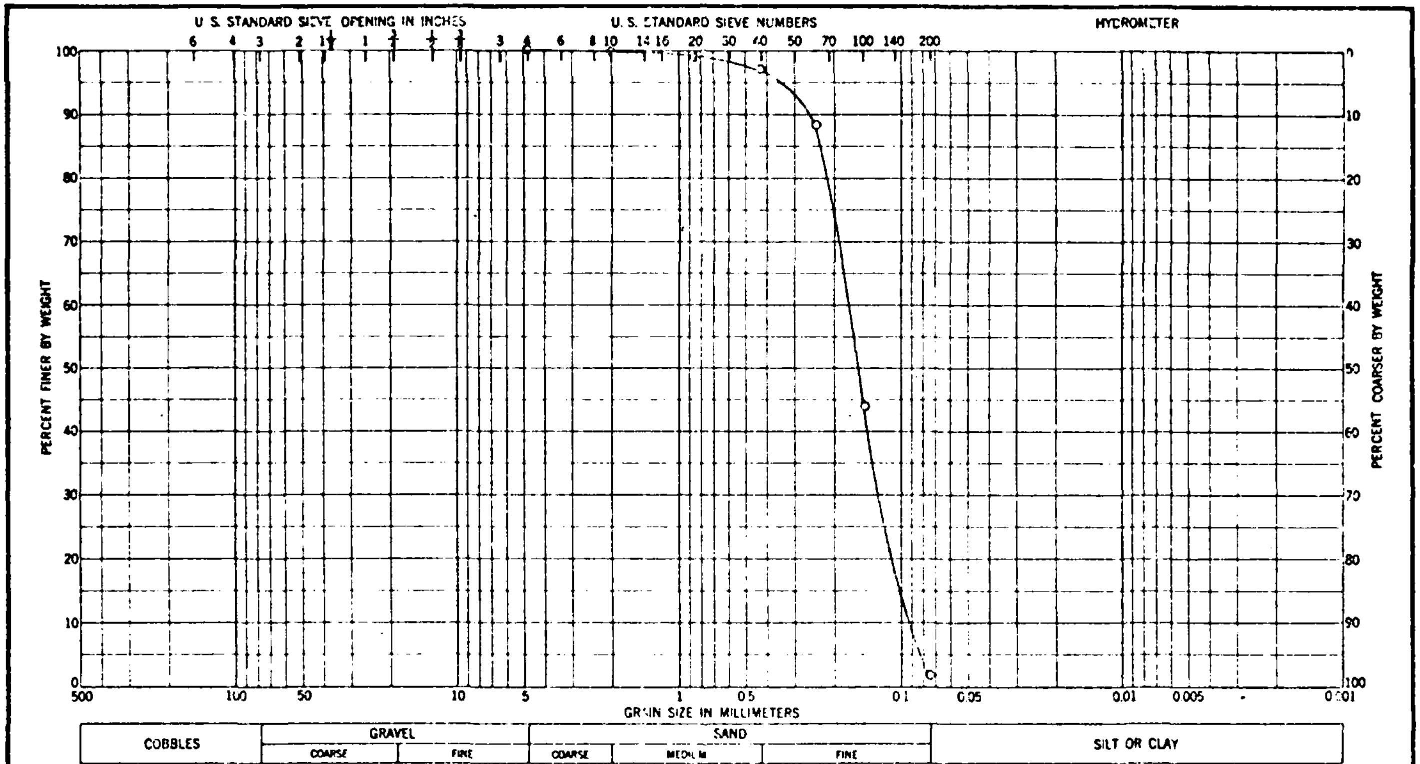
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-27

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0712
Req. No. SACEC 77-58



Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
3	--	Gray poorly graded sand (SP)	-	-	-	-

CHARLESTON DISTRICT, Folly Beach
Project Survey Report, Folly Beach, S.C.
Lab. No. 74/2376
Area S-
Sta. No. 90+00 N, Sample No. 3
Date 3 August 1977

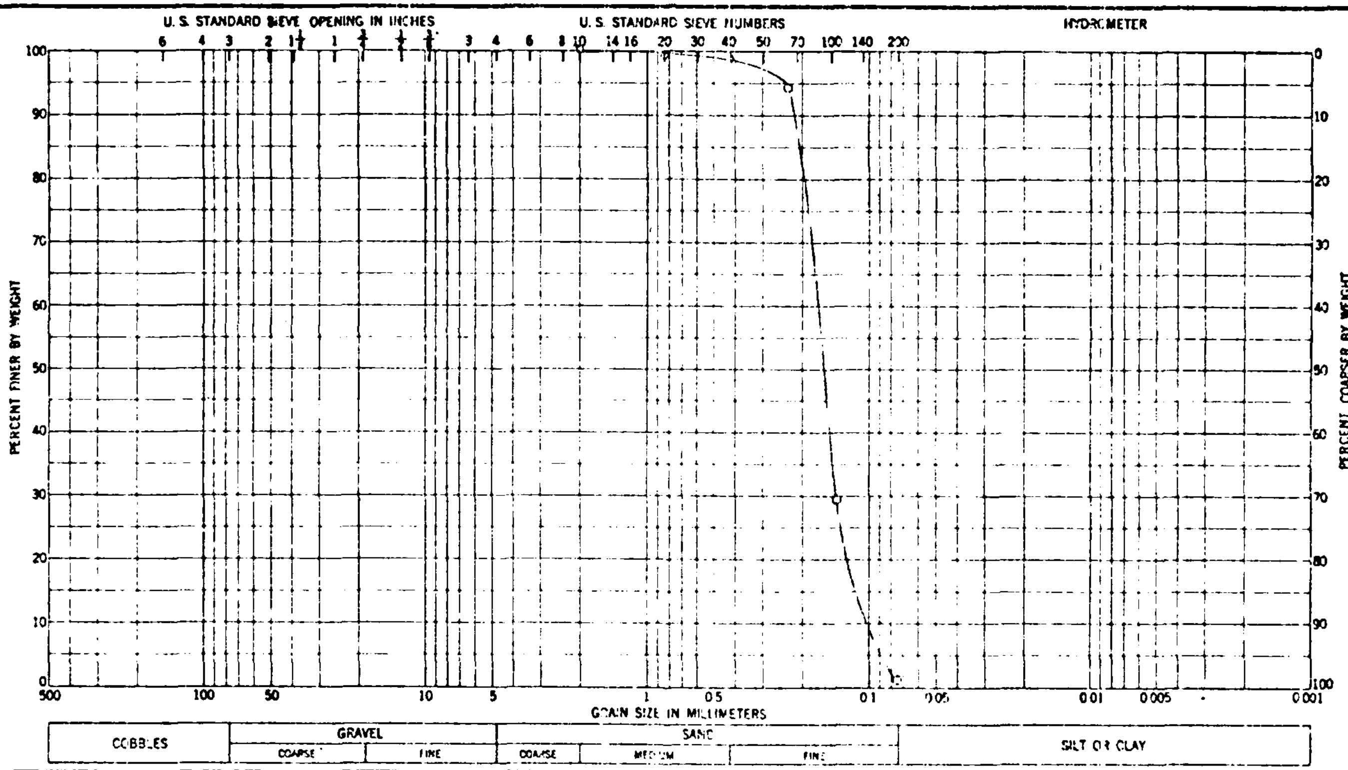
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-28

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0712
Req. No. SACEC 77-58



Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
4	--	Gray poorly graded sand (SP)	-	-	-	-

Project: CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C.
Lab. No. 74/2377

Area: --

Sta. No. 90+00 N., Sample No. 4

Date: 3 August 1977

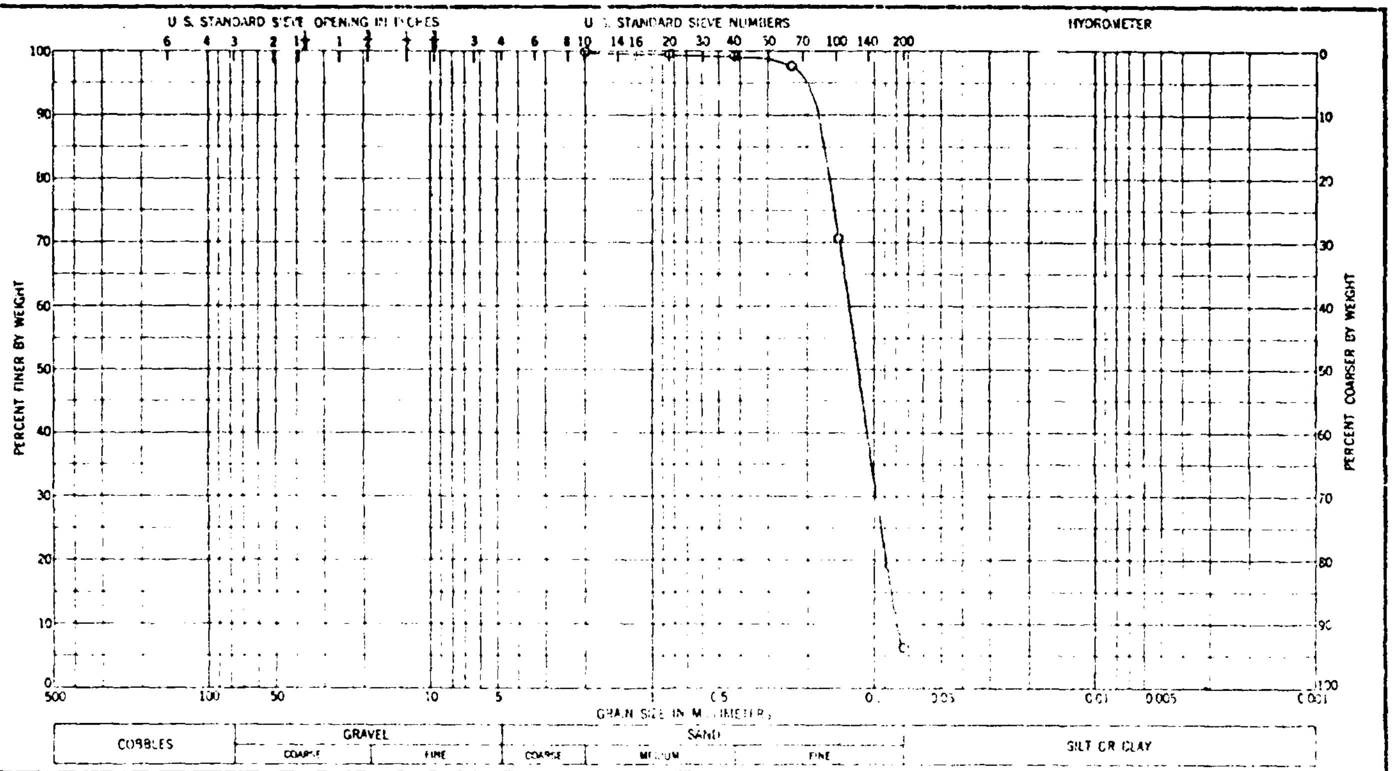
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-29

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0449
Req. No. SACEC-77-20



Sample No.	Elev or Depth	Visual Classification	Nat w %	LL	PL	PI
1, 2, 3, and 4	--	Greenish gray poorly graded silty sand (SP-SM)	-	-	-	-

[illegible] Folly Beach
Project Survey Report, Folly Beach, S.C.
Lab. No. 74,2306,2307,2308,2309
Area --
Boring No. 1, Samples 1, 2, 3, & 4
Date 2 March 1977

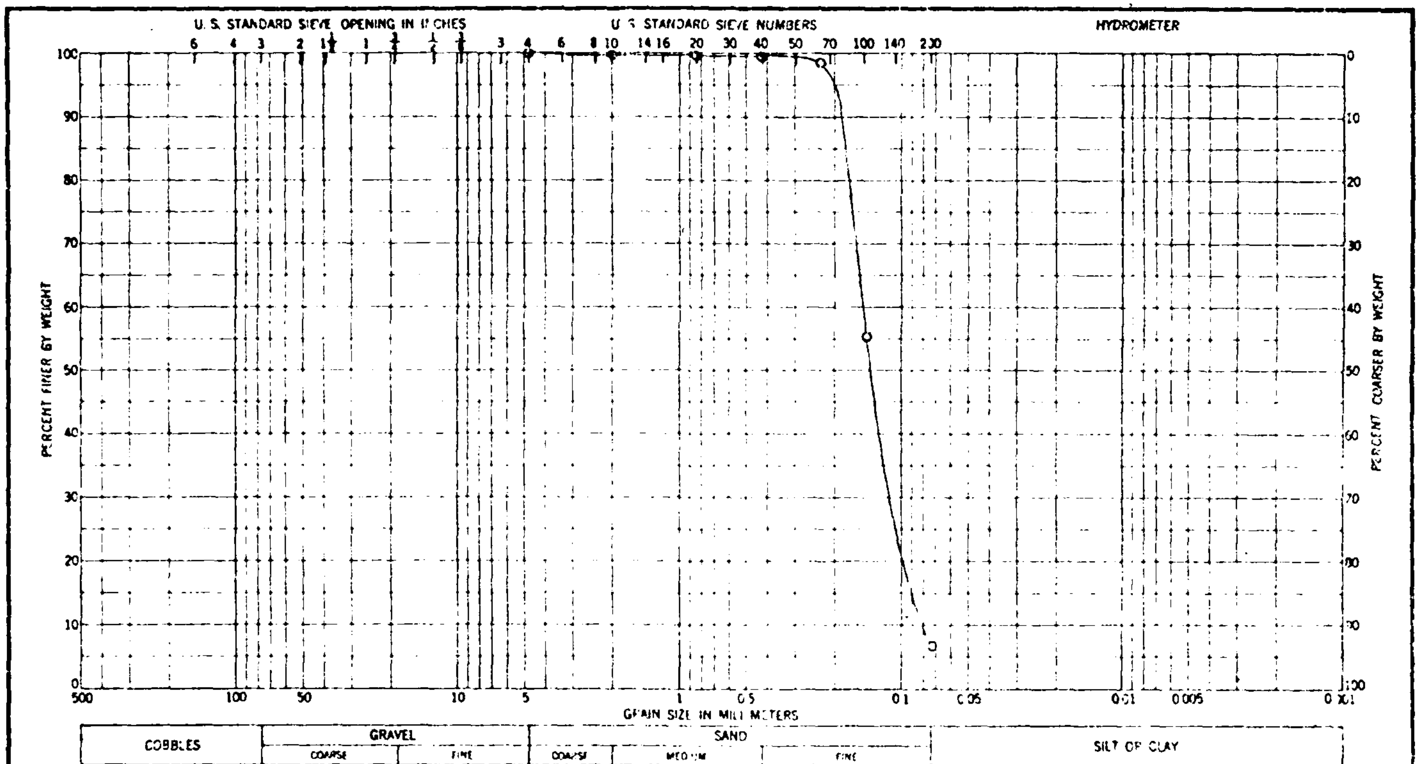
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-30

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0449
Req. No. SACEC-77-20



Sample No	Elev or Depth	Visual Classification	Nat w %	LL	PL	PI
1, 2	--	Gray poorly graded silty sand (SP-SM)	-	-	-	-

Project Survey Report, Folly Beach, S.C.
Lab. No. 74/2311, 2312
Area --
Boring No. 2, Samples 1 & 2
Date 2 March 1977

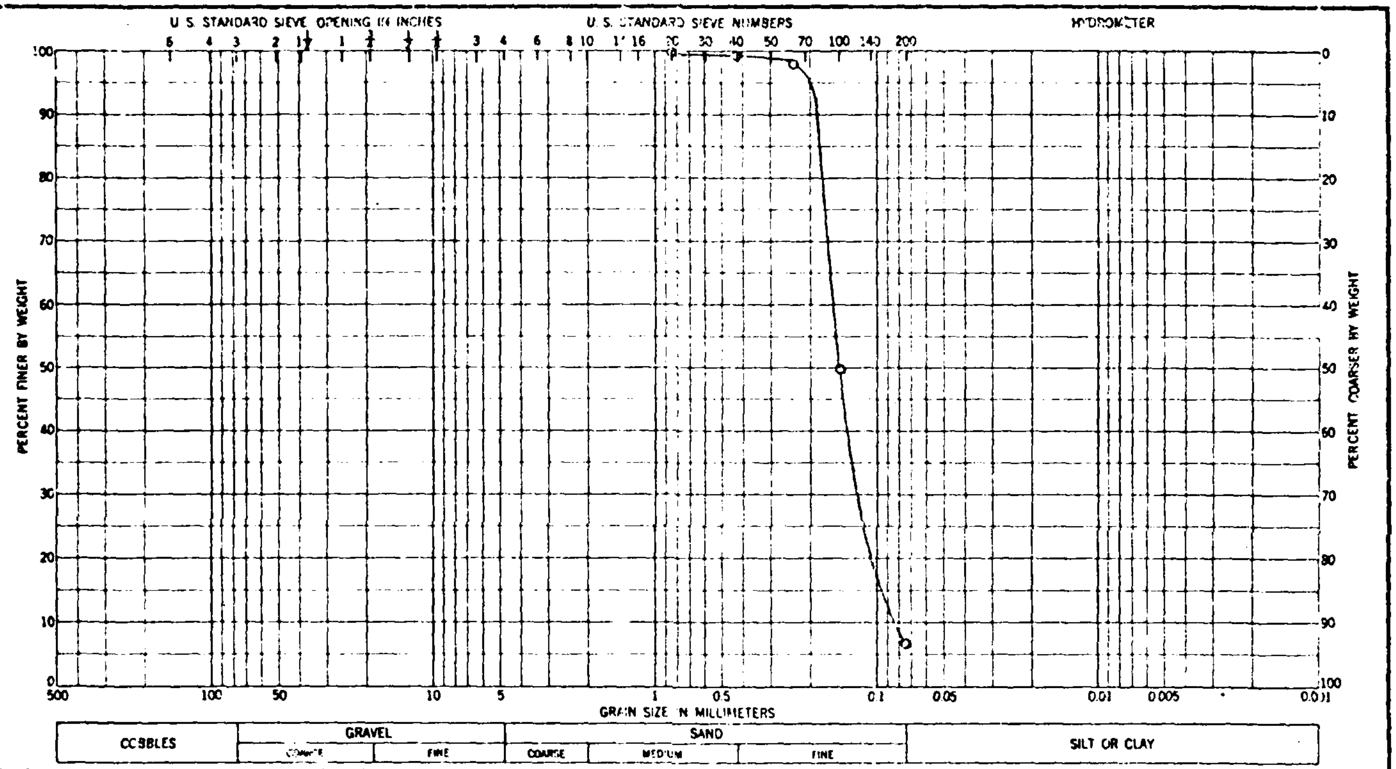
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-31

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0149
Req. No. SACEC-77-20



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
3, 4	--	Visual Gray poorly graded silty sand (SP-SM)	-	-	-	-

Project CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C.
Lab. No. 74/2313, 2314
Area --
Boring No. 2, Samples 3 & 4
Date 2 March 1977

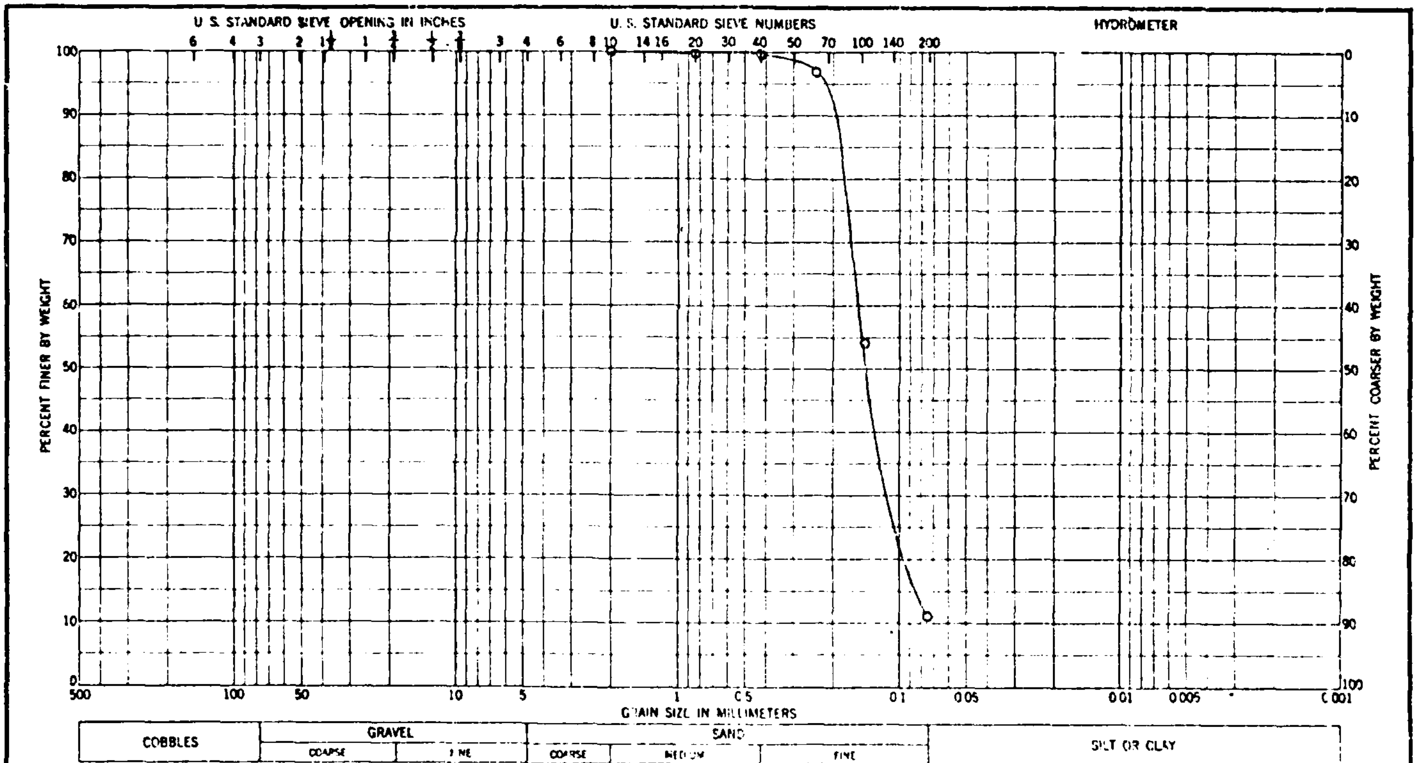
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-32

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0449
Req. No. SACEC-77-20



Sample No.	Elev or Depth	Visual Classification	Nat w %	LL	PL	PI
5 & 5	--	Gray poorly graded silty sand (SP-SM)	-	-	--	-

Project: CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C.
Lab. No. 74/2310, 2315
Area: --
Boring No: Hole 1, Sample #5; Hole 2, Sample #5
Date: 2 March 1977

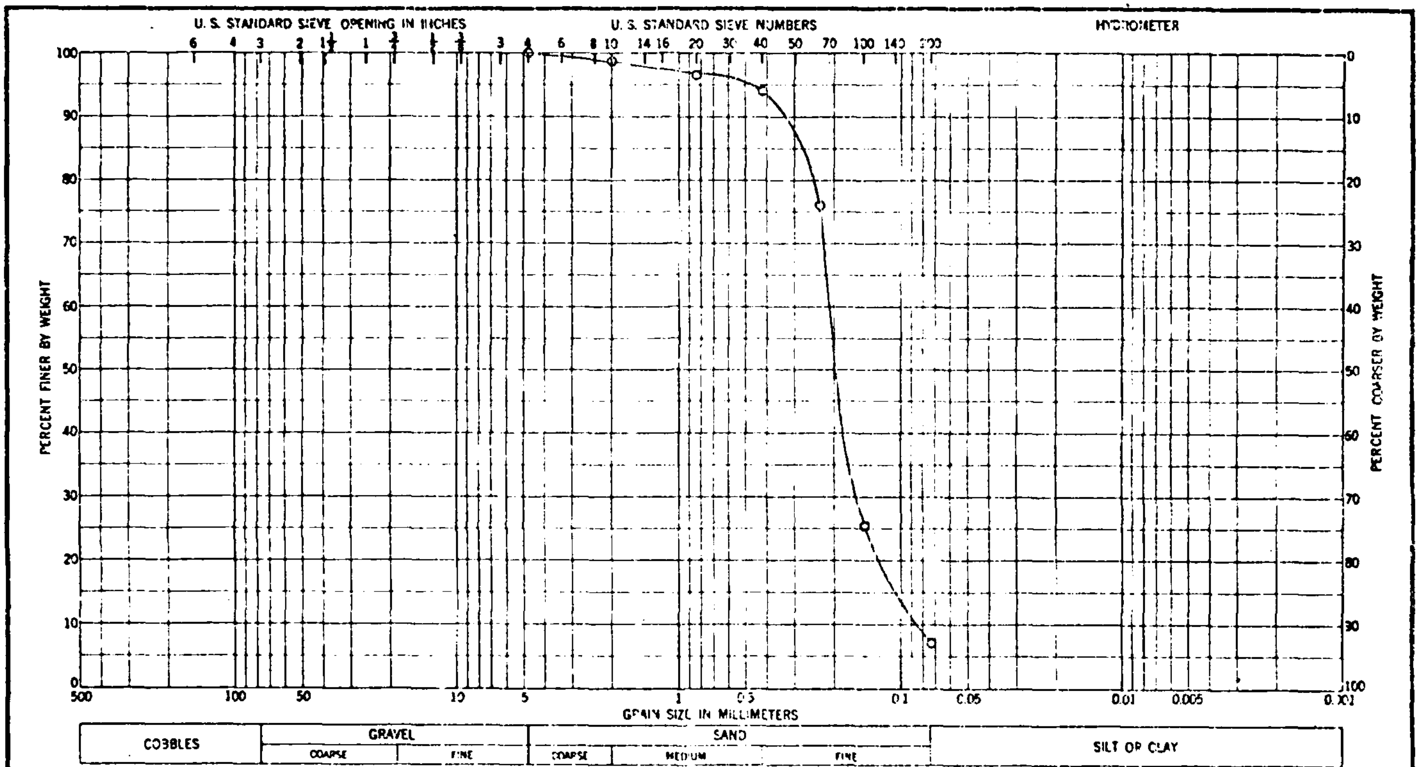
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-33

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611-SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0449
Req. No. SACEC-77-20



Sample No	Elev or Depth	Visual Classification	Nat w %	LL	PL	PI
1, 2	--	Gray poorly graded silty sand (SP-SM) with a trace of coarse-medium sand size shell fragments. Shell approximately 5%	-	-	-	-

Project: CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C.
Lab. No. 74/2316, 2317

Area: --

Boring No. 3, Samples 1 & 2

Date: 2 March 1977

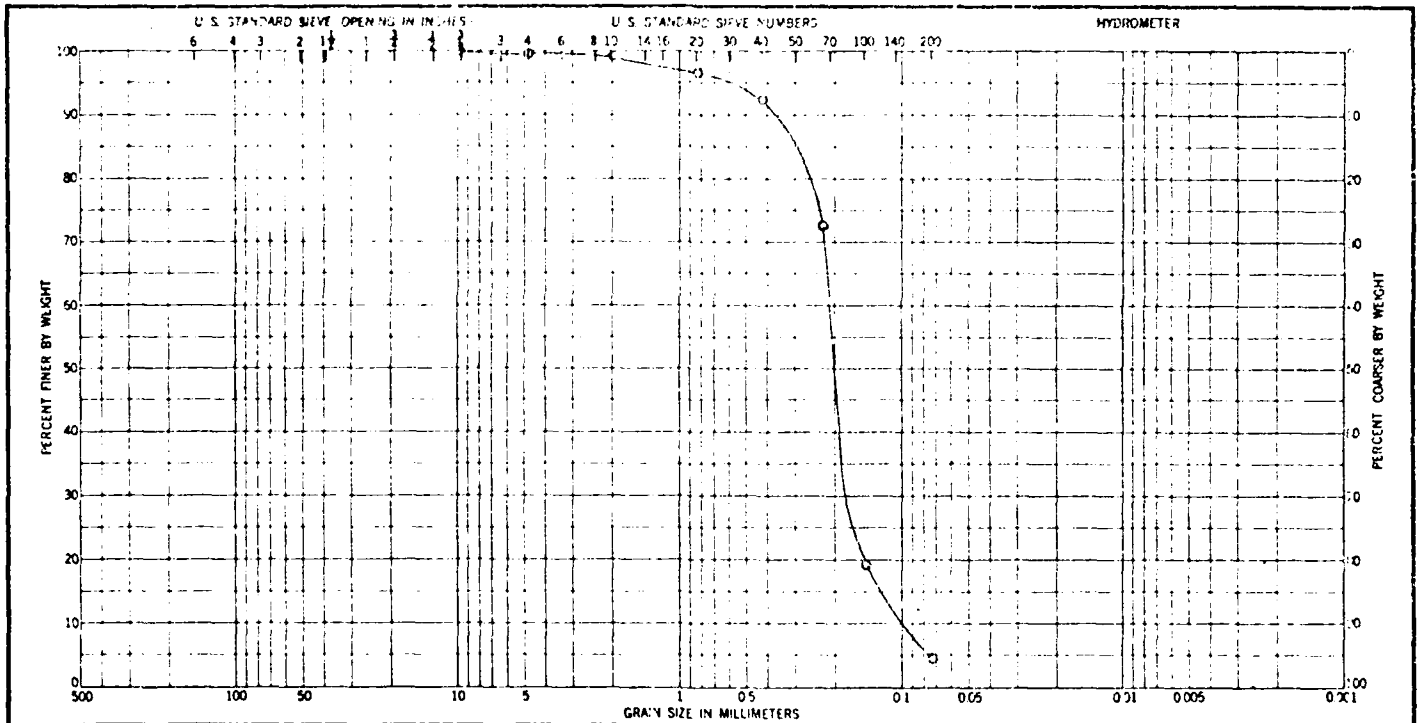
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-34

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. [illegible]49
Req. No. [illegible]-77-20



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
3	--	[illegible] poorly graded sand (SP) with a trace of gravel size and coarse-medium sand size shell fragments [illegible] shell [illegible] 4[illegible]	-	-	-	-

Project [illegible], Folly Beach [illegible] Survey Report, Folly Beach, S.C.
Lab. No. 74/2315
Area --
Boring No. 3, Sample No. 3
Date [illegible] 1977

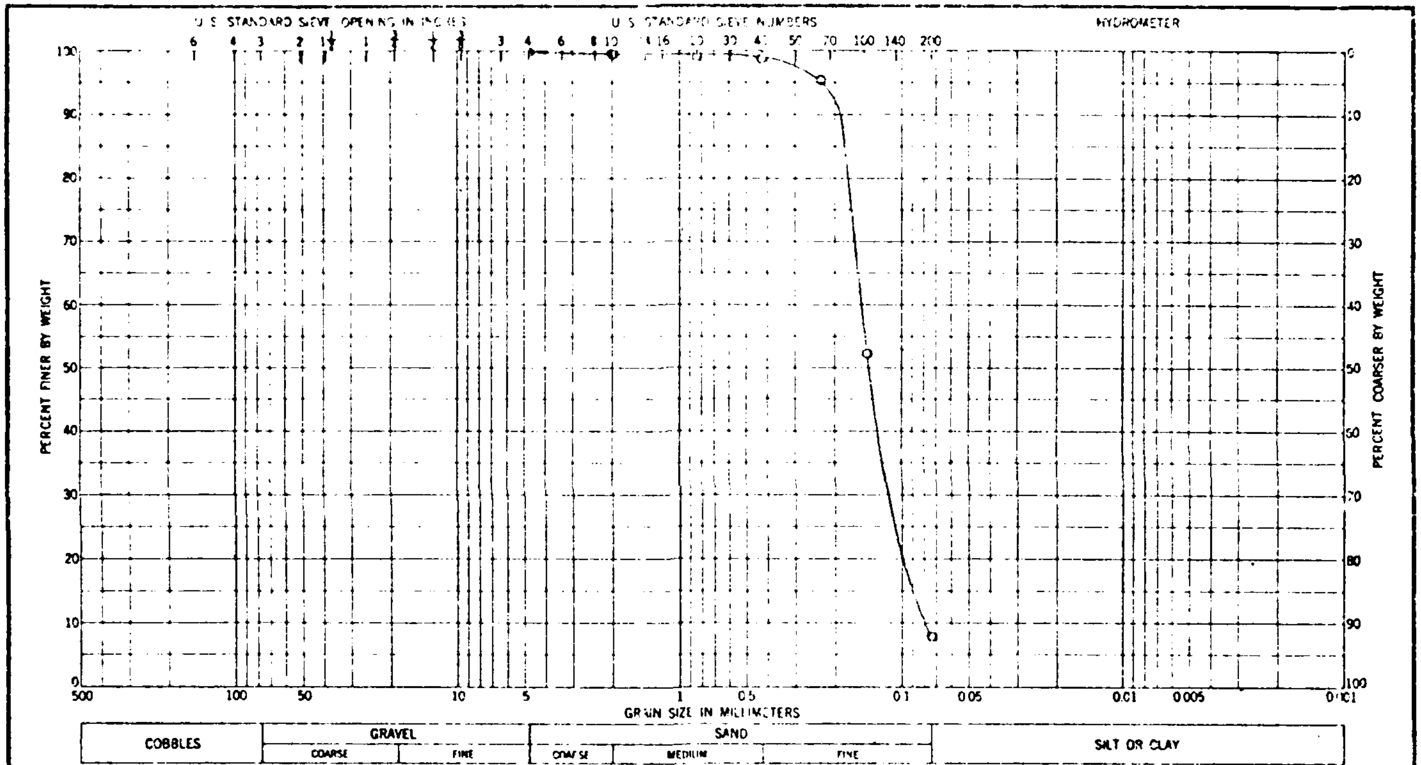
GRADATION CURVES

ENG FORM MAY 63 2087

FIGURE D-35

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA 30061

WORK ORDER NO. [illegible]
Req. No. [illegible]



Sample No	Elev or Depth	Visual Classification	Nat w %	LL	PL	PI
4 & 4	--	Greenish gray poorly graded silty sand (SP-SM) with a trace of coarse-medium sand size shell fragments. Shell approximately 1%	-	-	-	-

Project: Charleston District, Folly Beach Survey Report, Folly Beach, S.C.
Lab. No. 74/2319, 2323
Area: --
Boring No. Hole No. 3, Sample No. 4; Hole No. 4, Sample No. 4
Date: 2 March 1977

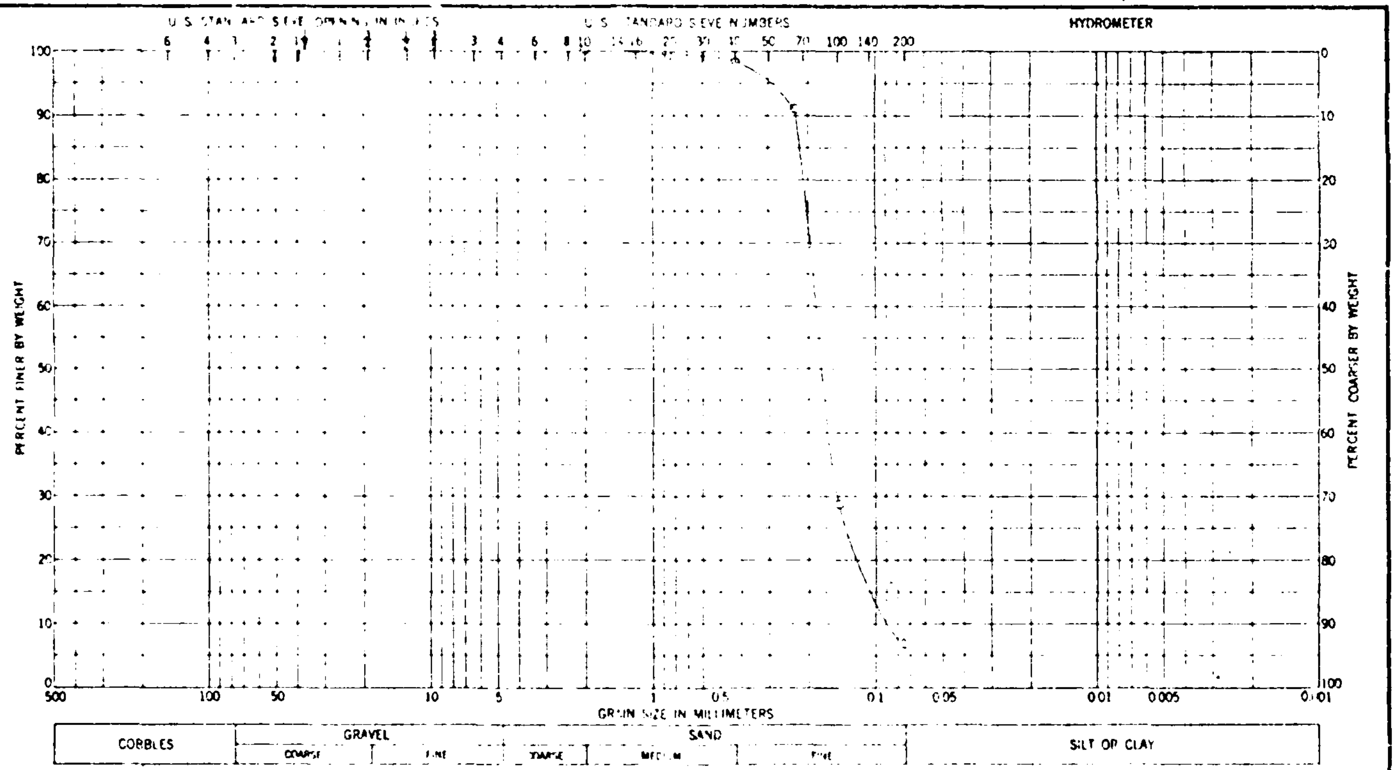
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-36

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0449
Req. No. SACEC-77-20



Sample No.	Elev or Depth	Classification	Nat w%	LL	PL	PI
1, 2, 3	--	[illegible] silty sand [illegible]	-	-	-	-

Project: [illegible] Survey Report, Folly Beach, S.C.
Lab. No. 74/2020, 2121, 2222
Area --
Boring No. [illegible], Sample Nos. 1, 2, 3

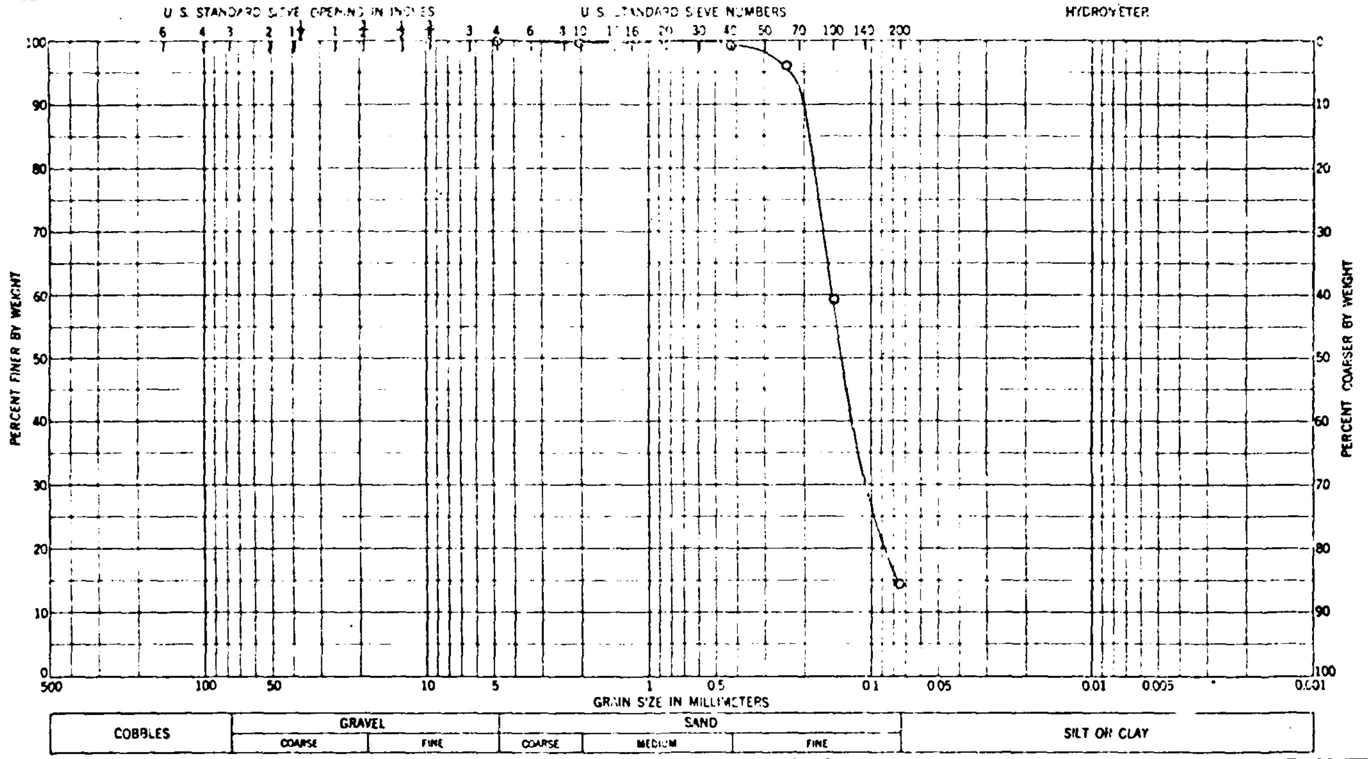
GRADATION CURVES

ENG FORM 2087

FIGURE D-37

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA 30061

WORK ORDER NO. 0449
Req. No. [illegible]-77-20



Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
1 & 2	--	Visual Gray silty sand (SM) with a trace of medium sand size shell fragments Shell approximately 1%	-	-	-	-

Project: CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C.
Lab. No. 74/2324, 2325
Area: --
Boring No. 5, Samples 1 & 2
Date: 2 March 1977

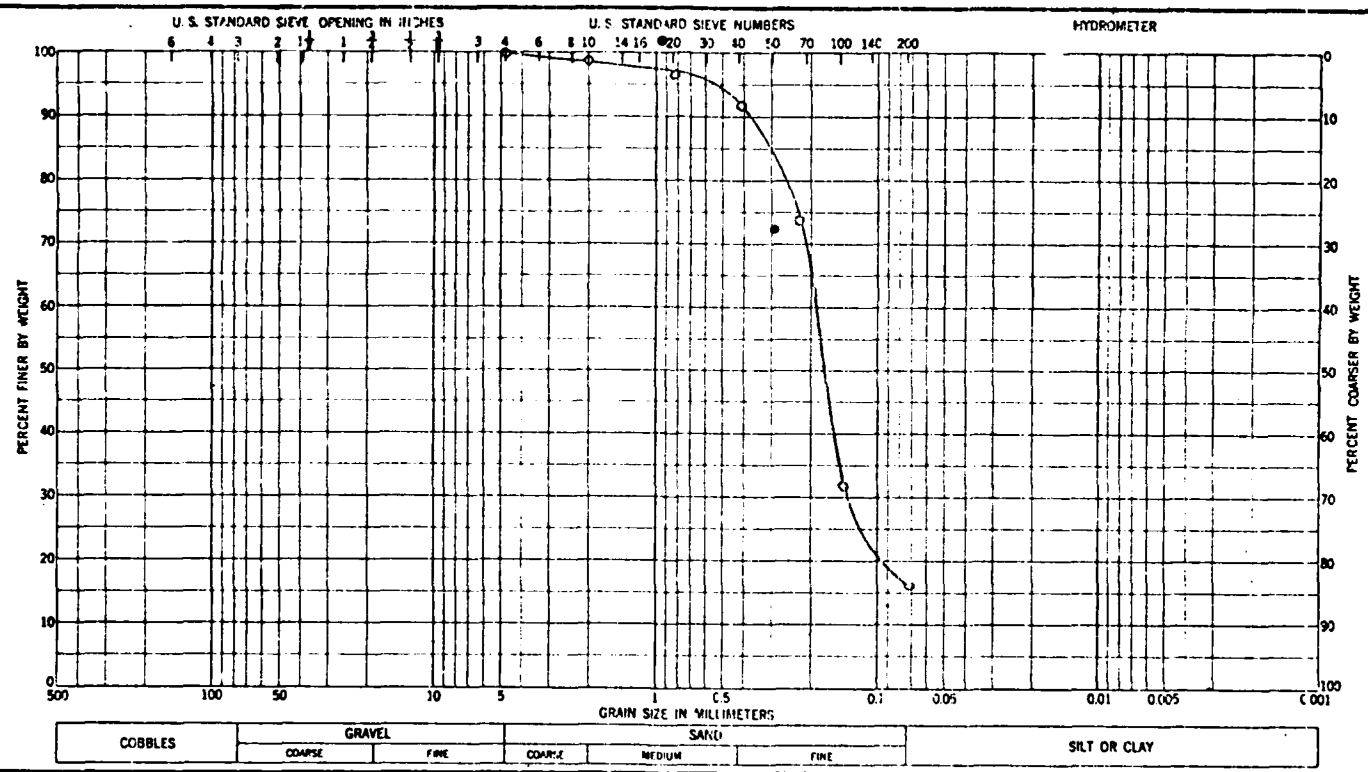
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-38

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0449
Req. No. SACEC-77-20



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
3	--	Visual Gray silty clayey sand (SM-SC) with a trace of coarse-medium sand size shell fragments Shell approximately 4%	-	--	-	-

CHARLESTON DISTRICT, Folly Beach
Project Survey Report, Folly Beach, S.C.
Lab. No. 74/2326
Area --
Boring No. 5, Sample No. 3
Date 2 March 1977

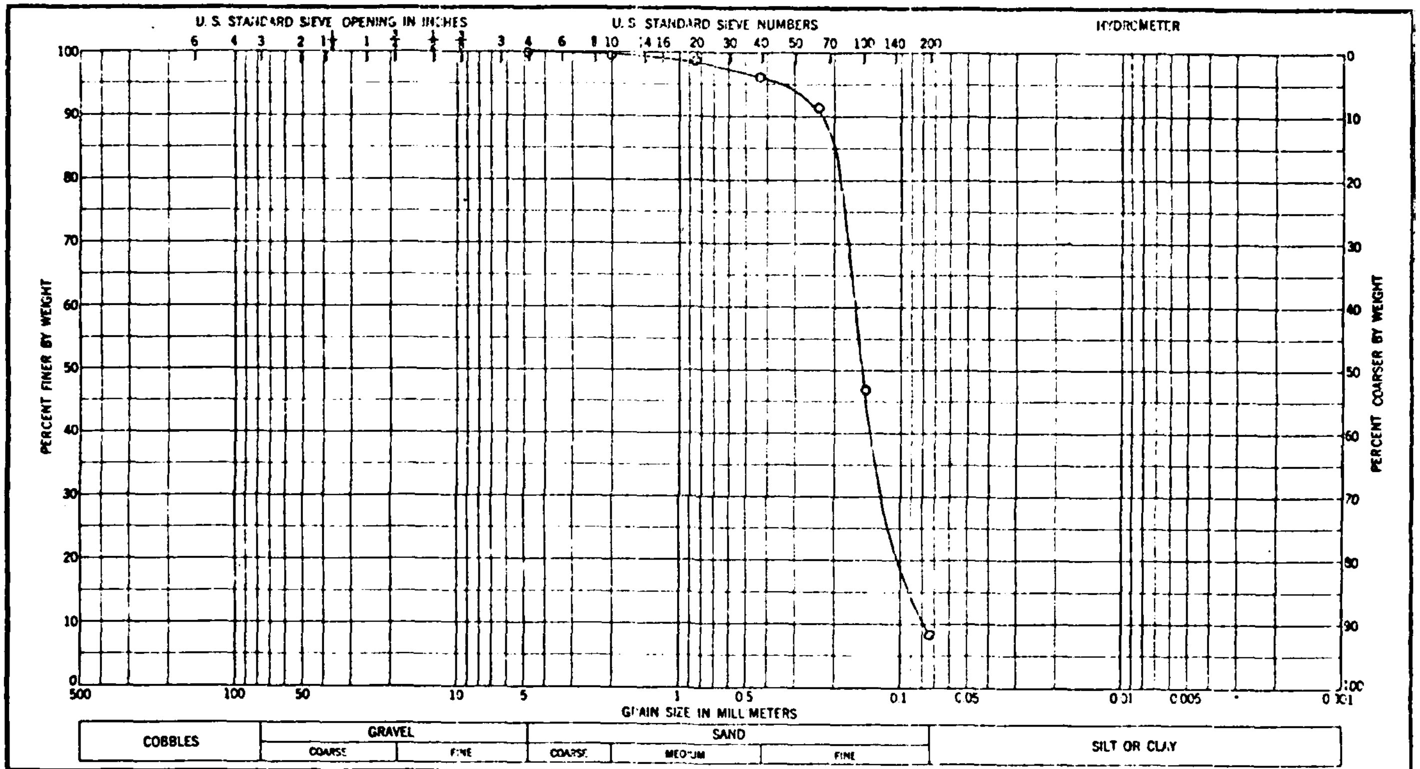
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-39

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0449
Req. No. SACEC-77-20



Sample No.	Elev or Depth	Visual Classification	Nat w %	LL	PL	PI
4 & 5	--	Gray poorly graded silty sand (SP-SM) with a trace of coarse-medium sand size shell fragments. Shell approximately 2%	-	-	-	-

Project: CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C.

Lab. No. 74/2327, 2328

Area: --

Boring No. Hole No. 5, Samples 4 & 5

Date: 2 March 1977

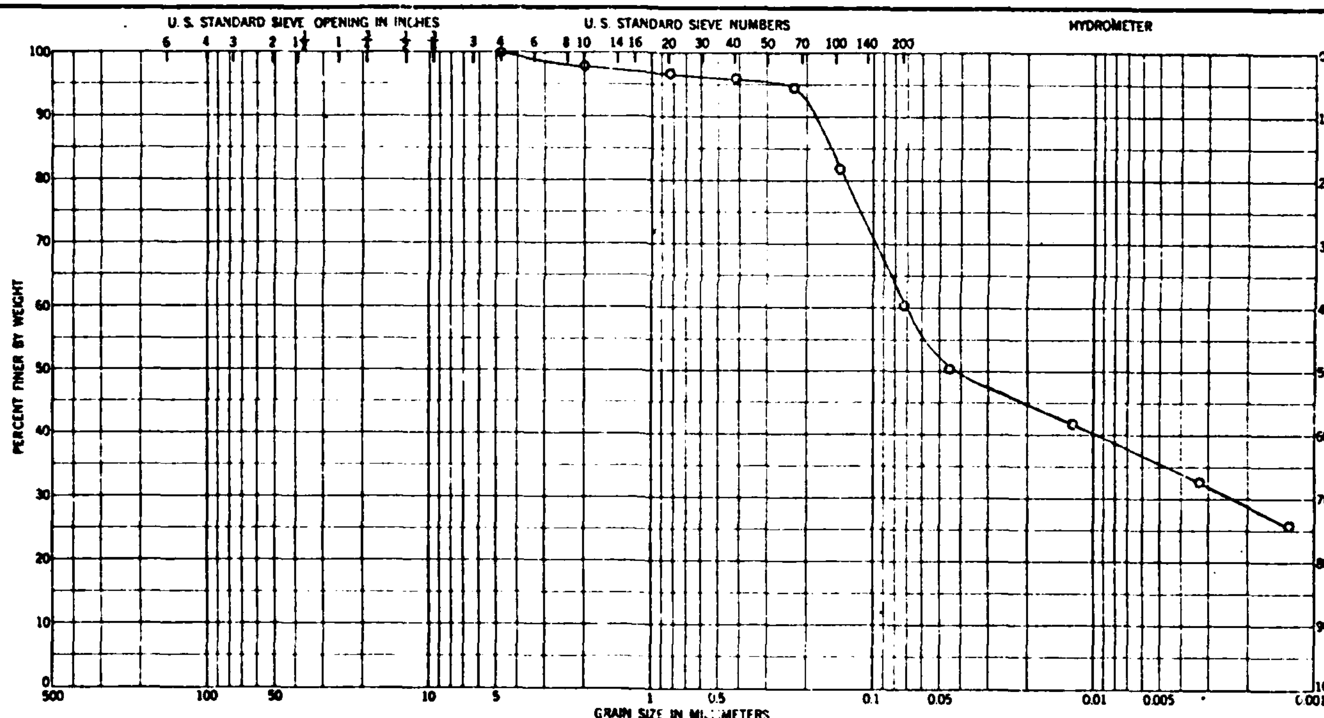
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-40

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0449
Req. No. SACEC-77-20



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
1 & 2	--	Visual: Gray clayey sandy inorganic silt, high LL(MH) with a trace of coarse-medium sand size shell fragments & a trace of root. Shell approximately 7	60.8	-	-	-

Project: CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C.
Lab. No. 74/2329, 2330
Area: --
Boring No. 6. Samples 1 & 2
Date: 2 March 1977

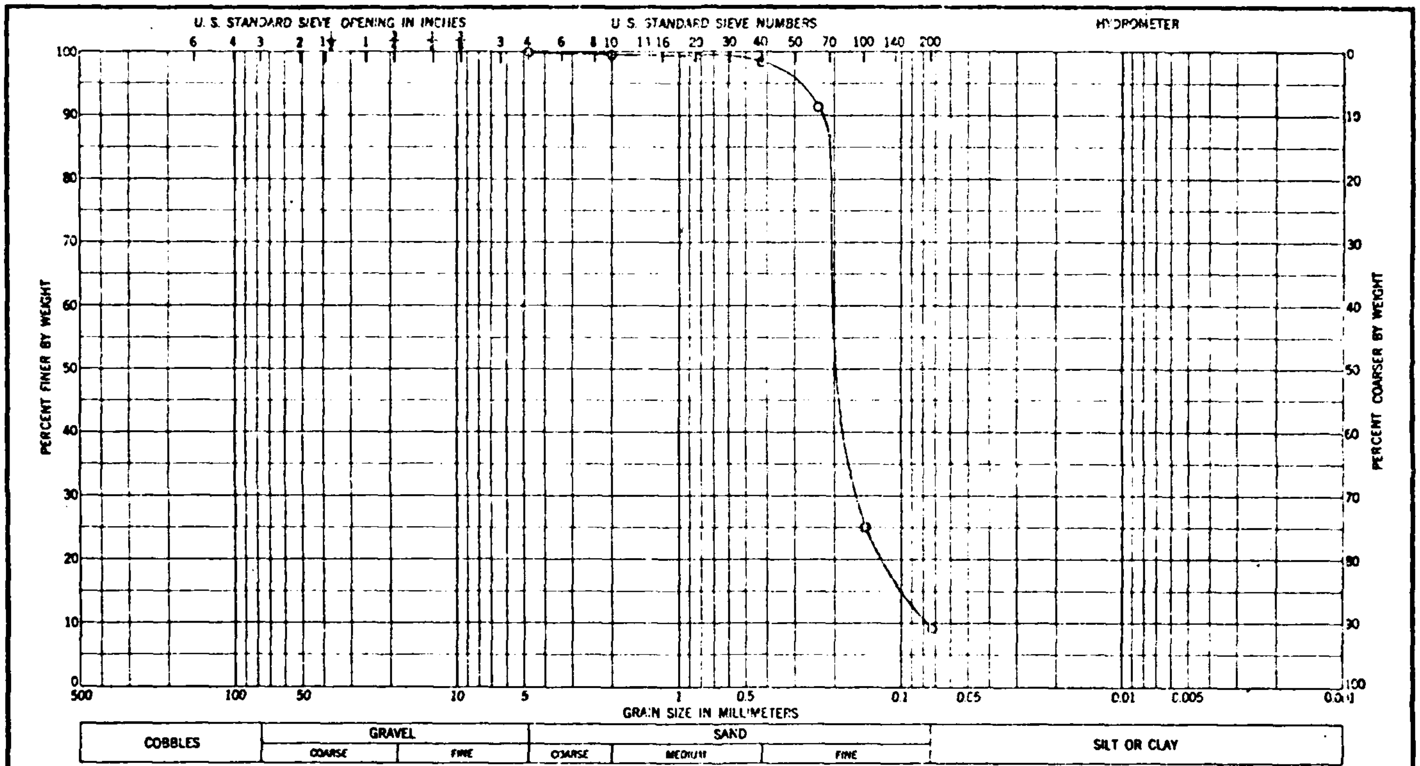
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-41

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0449
Req. No. SACEC-77-20



Sample No.	Elev or Depth	Visual Classification	Nat w %	LL	PL	PI
3	--	Grey poorly graded silty sand (SP-SM) with a trace of coarse-medium sand size shell fragments. Shell approximately 1%	-	-	-	-

Project: Charleston District, Folly Beach Survey Report, Folly Beach, S.C.
Lab. No. 74/2731
Area: --
Boring No. 6, Sample No. 3
Date: 2 March 1977

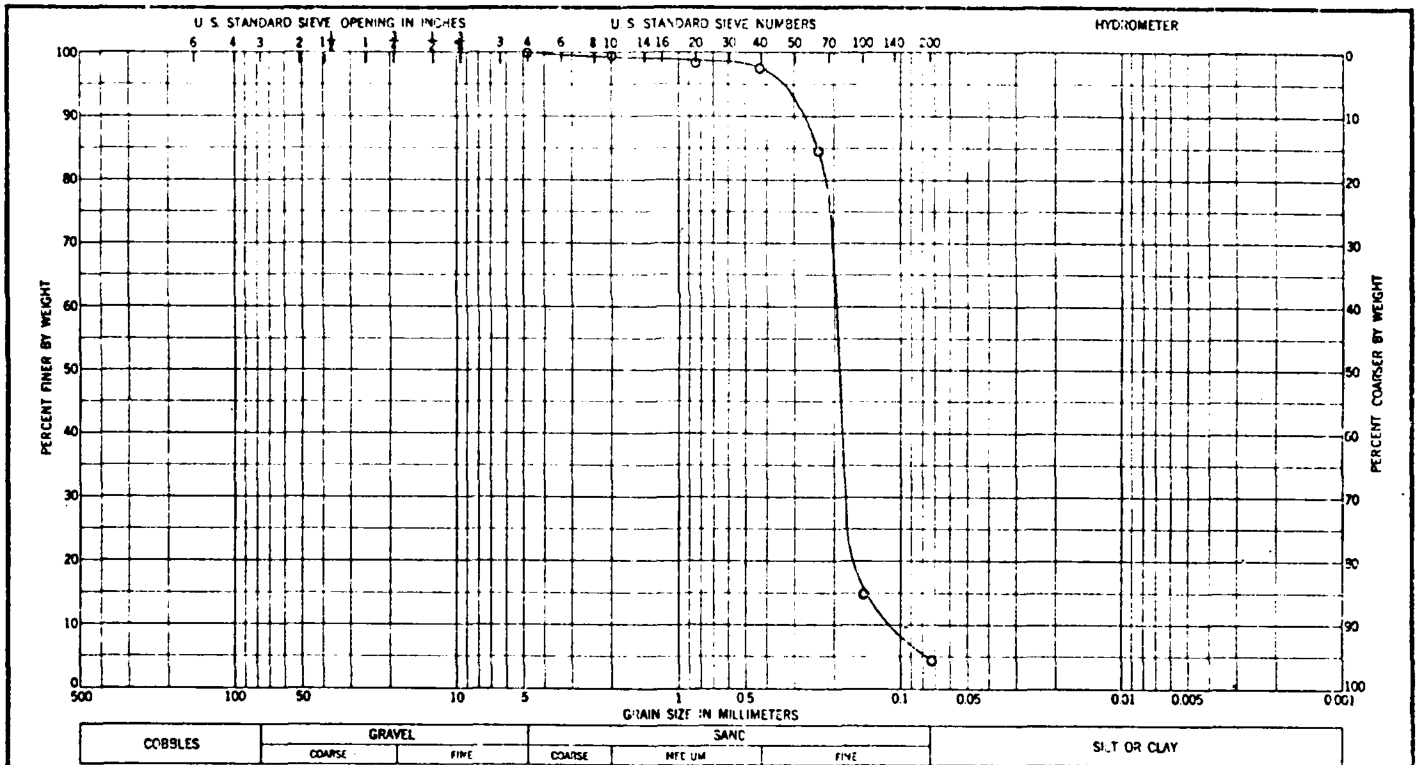
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-42

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. [illegible]49
Req. No. [illegible]-77-20



Sample No.	Elev or Depth	Visual Classification	Nat w %	LL	PL	PI
4 & 5	--	Gray poorly graded sand (SP) with a trace of coarse-medium sand size shell fragments	-	-	-	-
		Shell approximately 3%				

GRADATION CURVES

Project: CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C.
Lab. No. 74/2332, 2333

Area: --

Boring No. 6, Samples 4 & 5

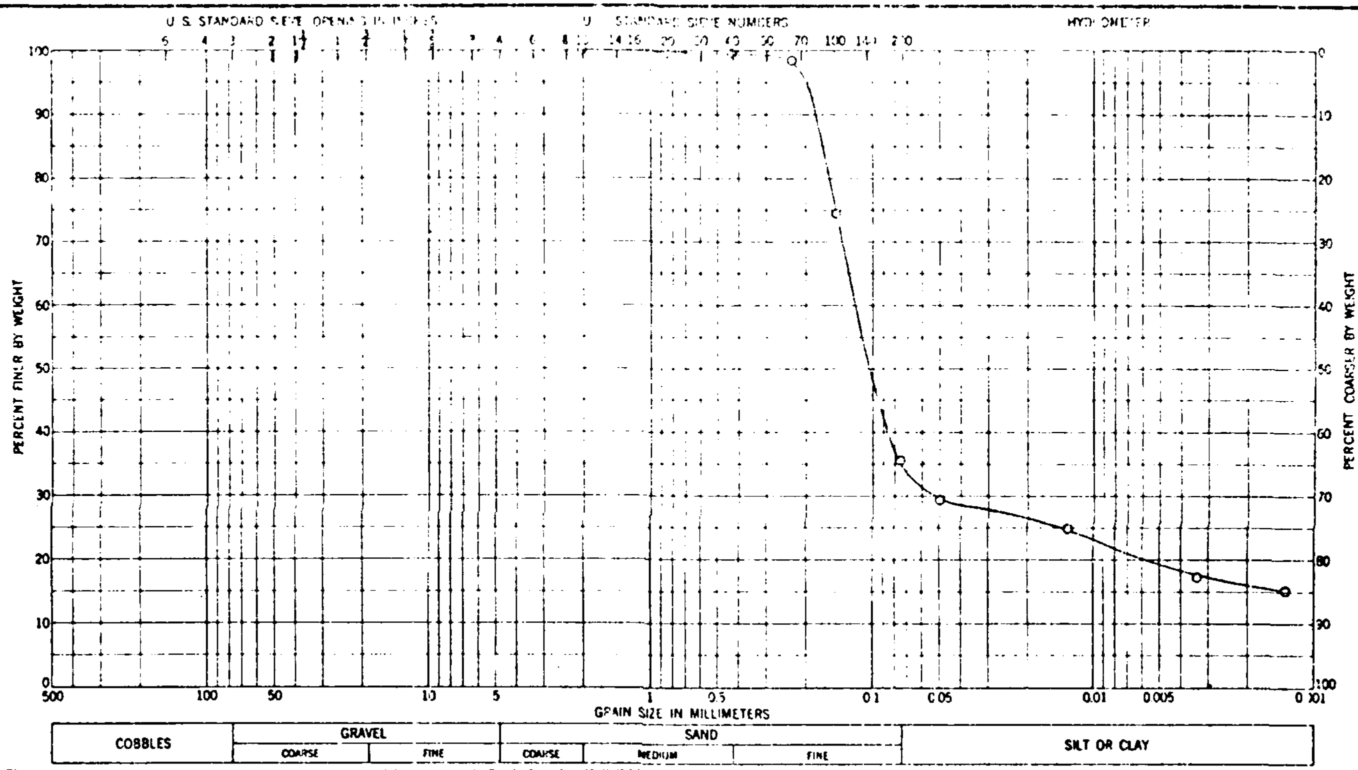
Date: 2 March 1977

ENG FORM 1 MAY 63 2087

FIGURE D-43

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. [illegible]
Req. No. [illegible]



Sample No	Elev or Depth	Visual Classification	Nat w %	LL	PL	PI
1 & 2	--	Dark gray clayey sand (SC)	[illegible]	-	-	-

Project: CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C.
Lab. No. 74/2334, 2335

Area: --

Boring No. 3, Samples 1 & 2

Date: 2 March 1977

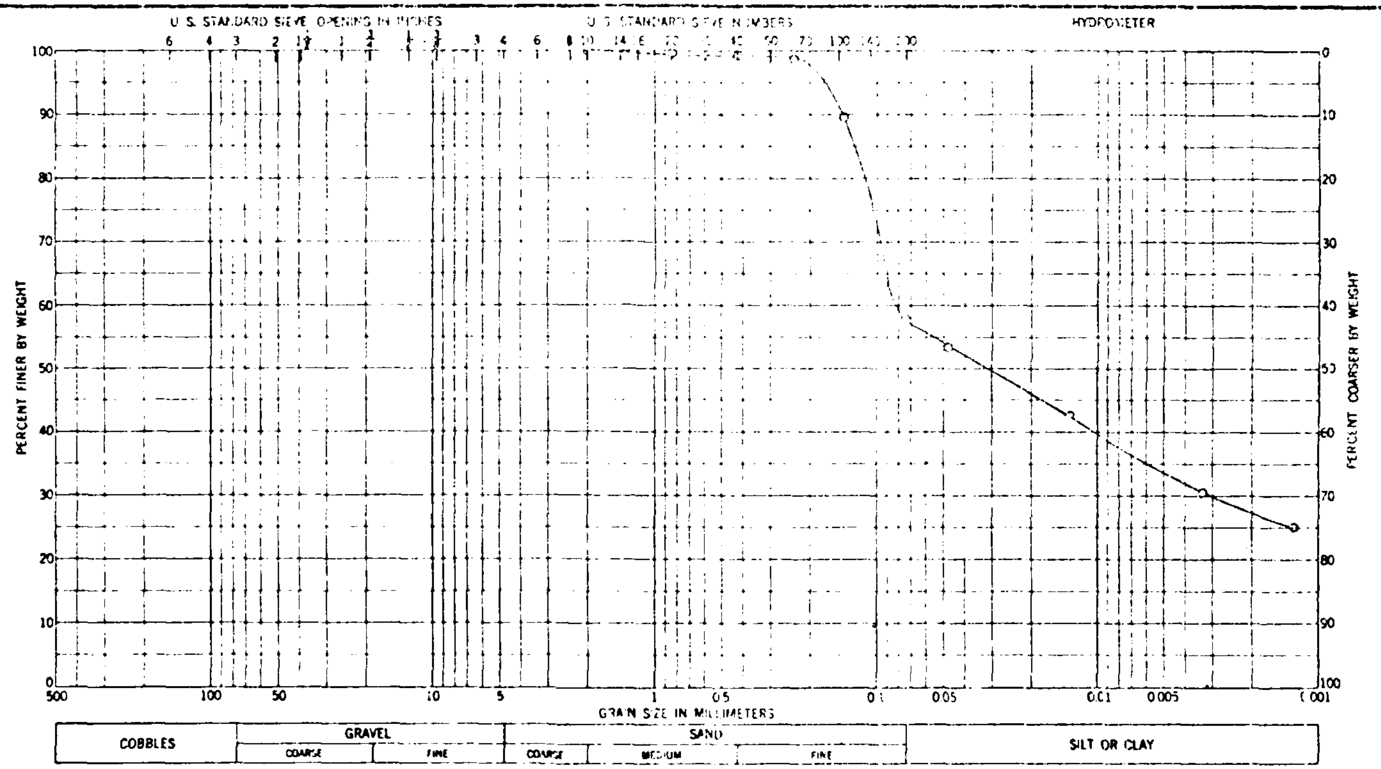
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-44

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0449
Req. No. [illegible]



Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
1, 2, 3, & 4	--	Gray sandy [illegible] clay [illegible]	[illegible]	--	--	--

Project: [illegible], Folly Beach Survey Report, Folly Beach, S.C.
Lab. No. [illegible] 2336, 2337, 2338, 2339
Area: --
Boring No. 9, Samples 1, 2, 3 & 4
Date: 2 March 1977

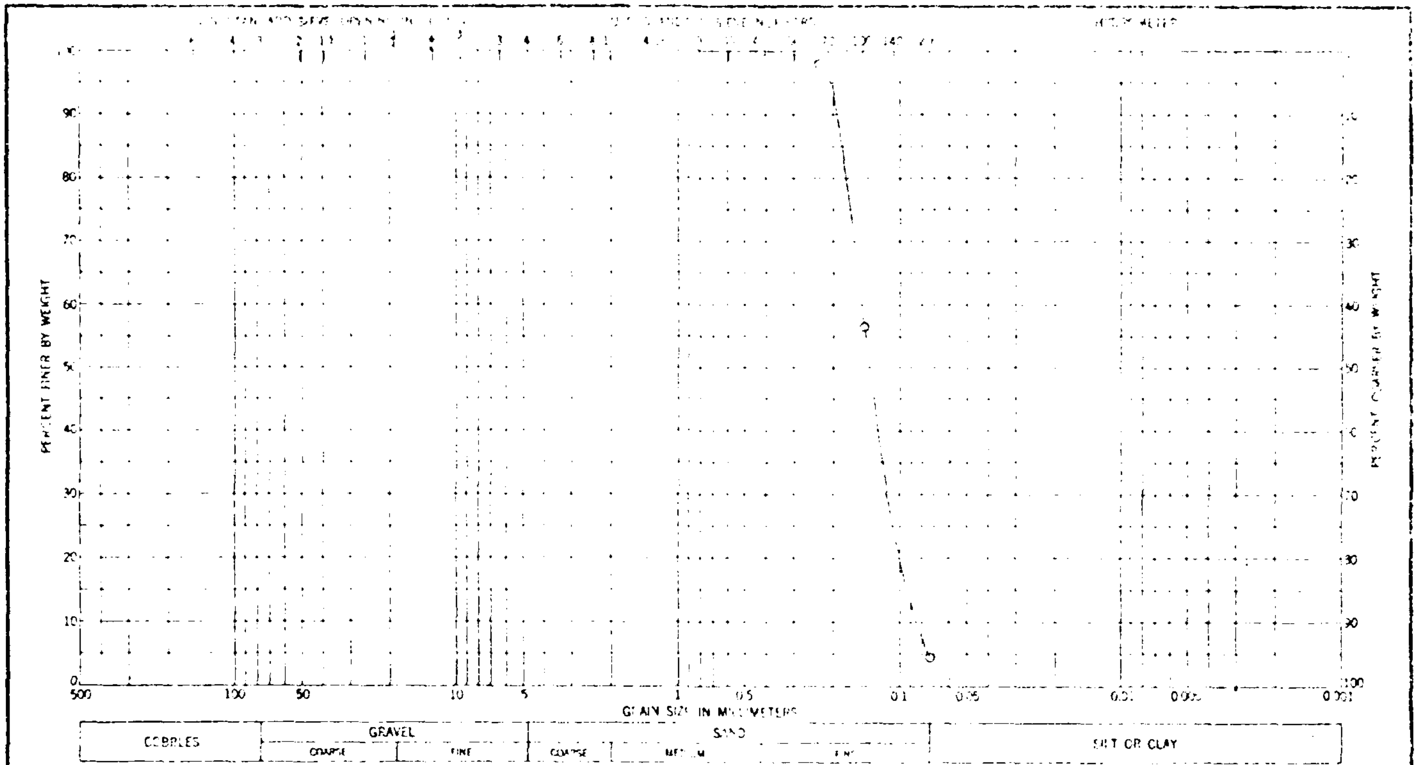
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-45

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, [illegible] 30061

WORK ORDER NO. [illegible]
Rec. No. [illegible]



Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
1 & 2	--	Gray and tan poorly graded sand (SP)	--	--	--	--

Project: [illegible] Folly Beach Survey Report, Folly Beach, S.C.
Lab. No. [illegible]/2340, 2341

Area: --

Boring No: 10, Samples 1 & 2

Date: 2 March 197[illegible]

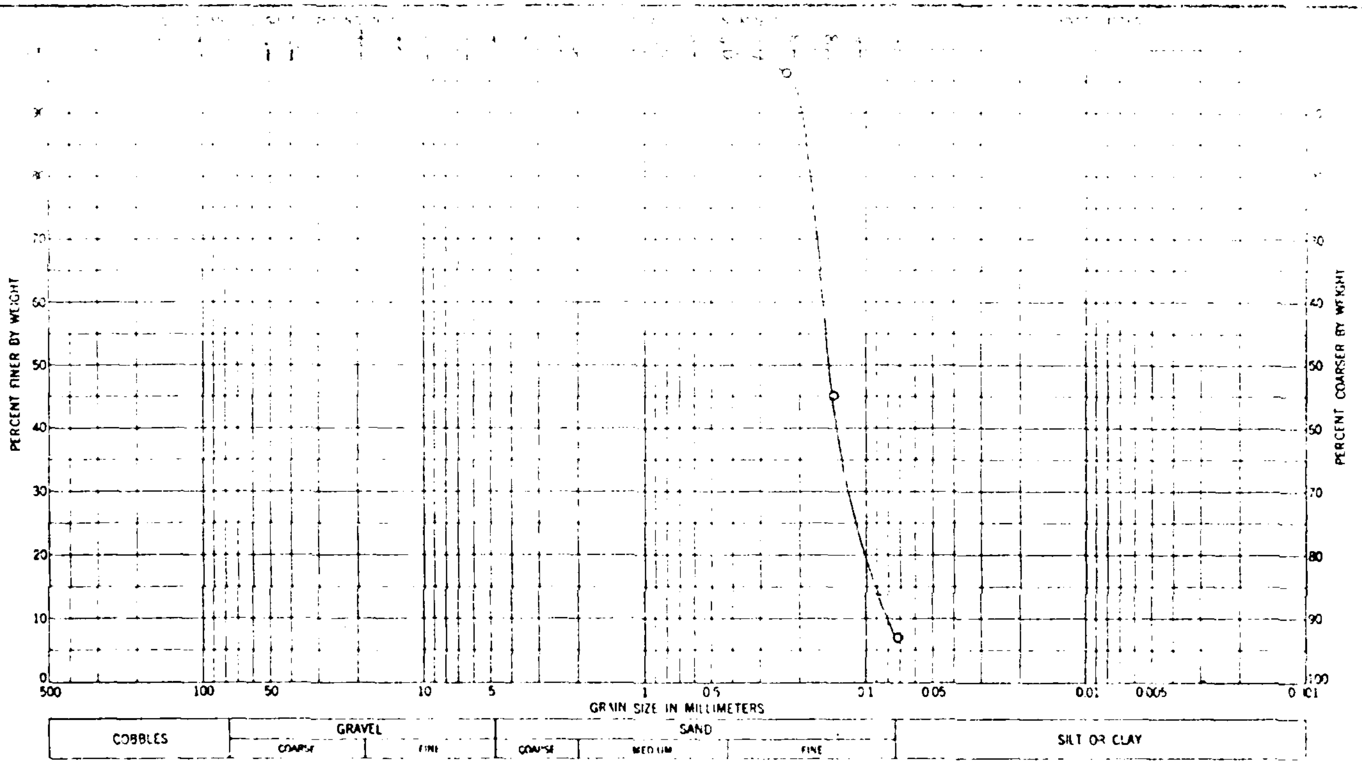
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-46

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER NO.
RPT. NO



Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
3	--	Gray poorly graded silty sand ([illegible])	--	--	--	--

Project: CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C. Lab. No. [illegible]2342

Area: --

Boring No: 10, Sample No. 3

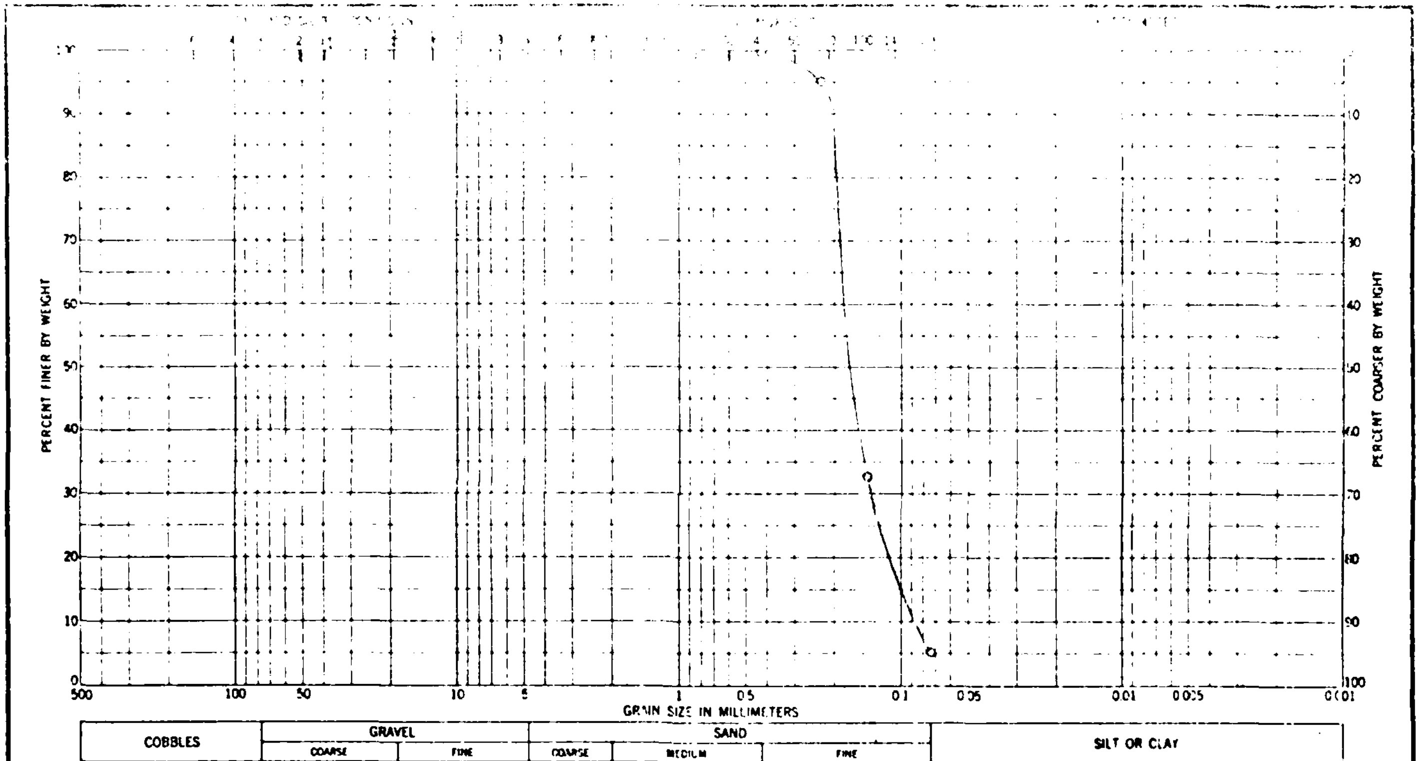
Date: [illegible]

GRADATION CURVES

ENG FORM 2087

FIGURE D-47

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA



Sample No.	Elev or Depth	Visual Classification	Nat w %	LL	PL	PI
1 & 2	--	Gray poorly graded silty sand (SP-SM) with a trace of medium sand size shell fragments	--	--	--	--
		Shell approximately [illegible]%				

Project: CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C.
Lab. No. 74/2343, 2344

Area: --

Boring No. 11, Samples 1 & 2

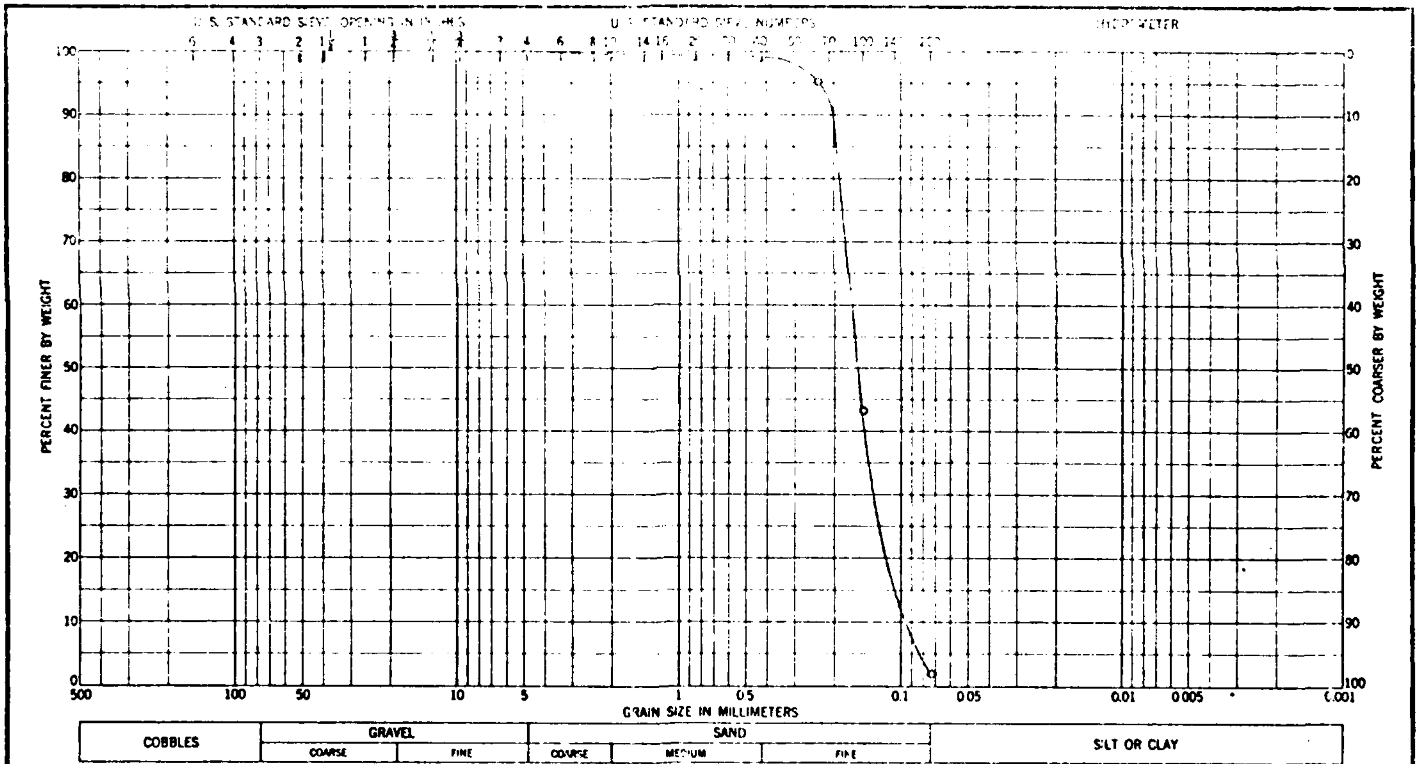
Date: 2 March 1977

GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-48

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY   WORK ORDER NO. [illegible]
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA 30061   Req. No. [illegible]



Sample No.	Elev or Depth	Visual Classification	Nat w %	LL	PL	PI
3 & 4	--	Gray poorly graded sand (SP) with a trace of sand size shell fragments	--	--	--	--

Project: CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C. Lab. No. 74/2345, 2346

Area: --

Boring No. 11, Samples 3 & 4

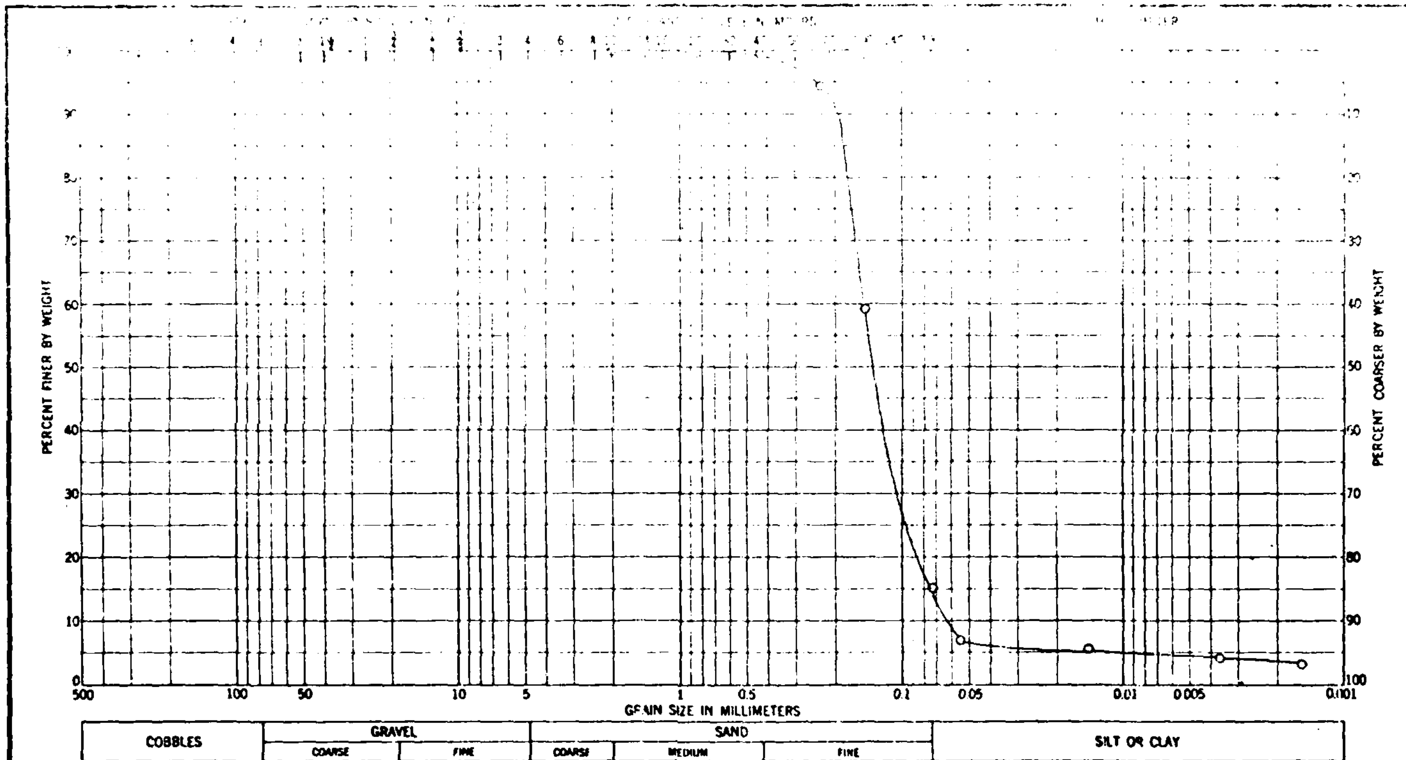
Date: 2 March 1977

GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-49

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS ... MARIETTA, ... 30061



Sample No.	Elev or Depth	Visual Classification	Nat w %	LL	PL	PI
5	--	Gray silty sand (SM)	--	--	--	--

Project: CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C.
Lab. No. 74/2347

Area: --

Boring No. 11, Sample No. 5

Date: 2 March 1977

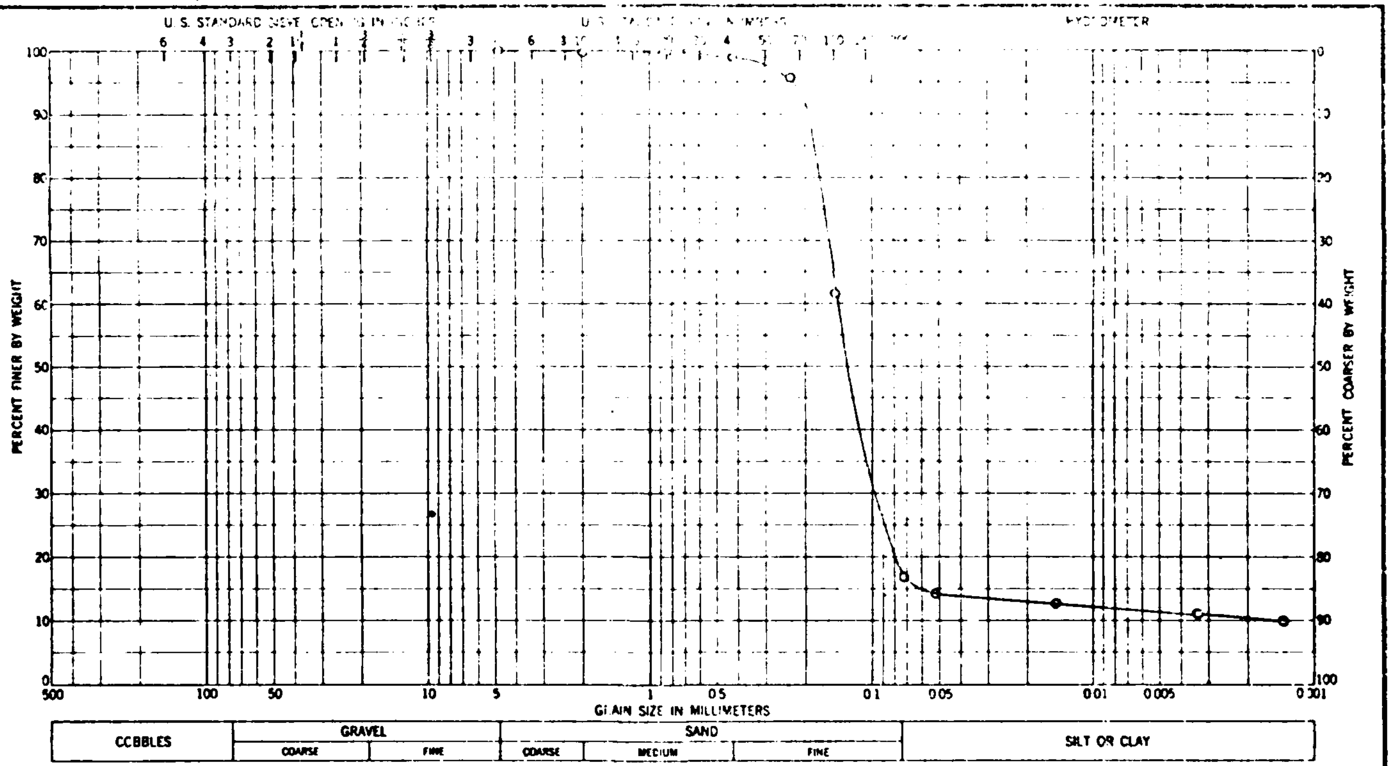
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-50

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA 30061

WORK ORDER NO.
Rpt. No.



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
6	--	Visual: Gray clayey sand (SC) with a trace of wood	--	--	--	--

Project: CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C. Lab. No. 74/2348

Area: --

Boring No. 11 Sample No. 6

Date: 2 March 1977

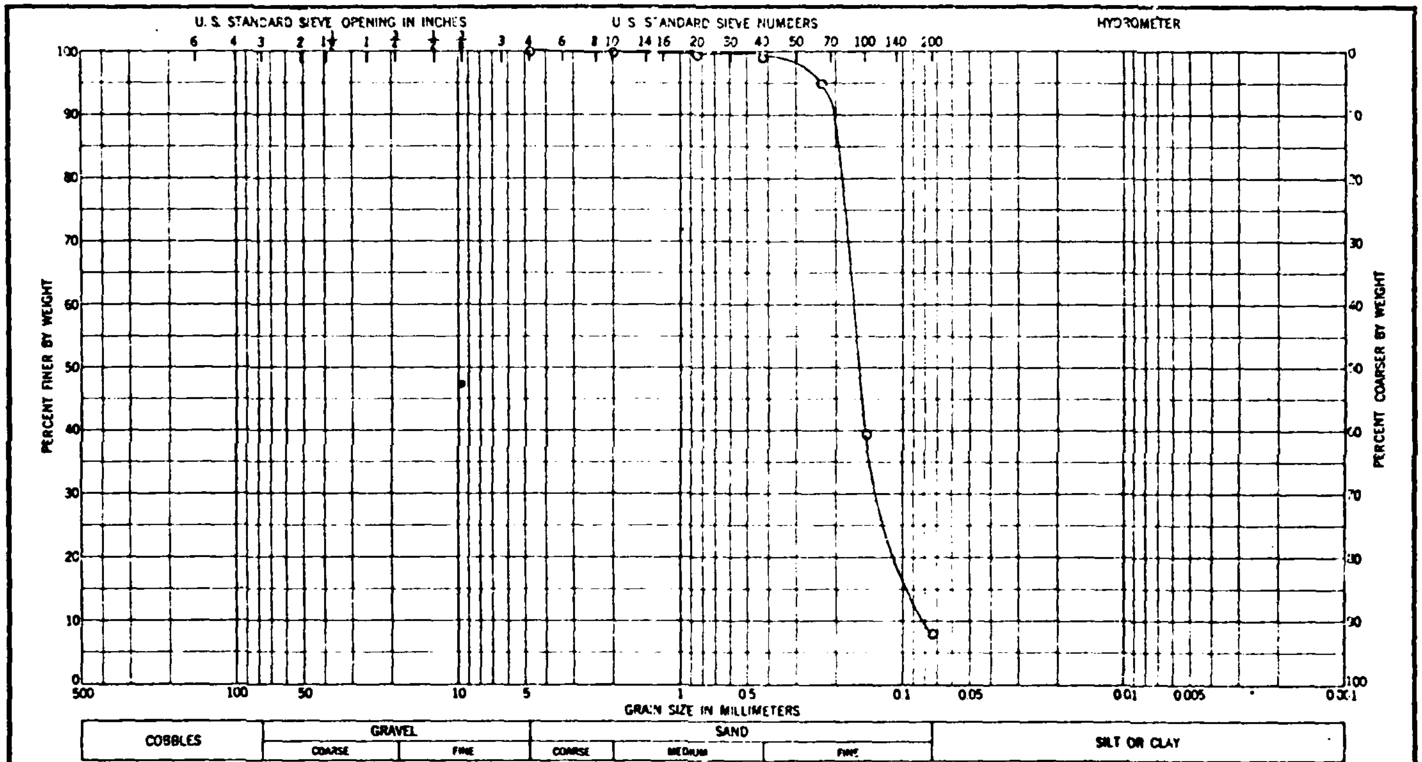
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-51

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0449
Req. No. SACEC-77-20



Sample No.	Elev or Depth	Visual Classification	Nat w %	LL	PL	PI
1, 2, 3, 4, 5 & 6	--	Gray poorly graded silty sand (SP-SM) with a trace of sand size shell fragments	--	--	--	--
		Shell approximately 1%				

Project: CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C.
Lab. No. 74723.9, 2350, 2351, 2352, 2353, 2354
Area: --
Boring No. 12, Samples 1, 2, 3, 4, 5 & 6
Date: 2 March 1977

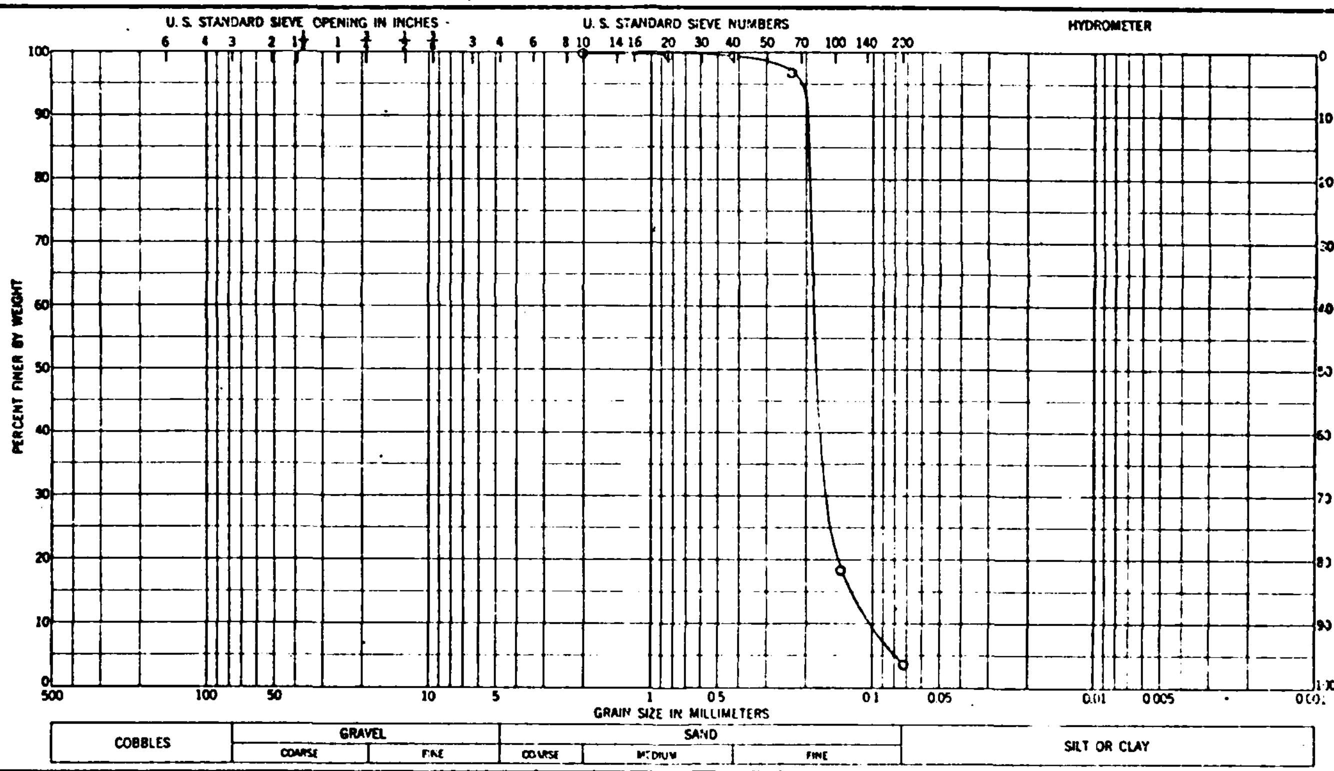
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-52

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0449
Req. No. SACEC-77-20



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
1, 2, 3	--	Visual Gray and tan poorly graded sand (SP) with a trace of sand size shell fragments Shell < 1%	-	-	-	-

Project: CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C.
Lab. No. 74/2355, 2356, 2357
Area: --
Boring No: 13, Samples 1, 2, & 3
Date: 2 March 1977

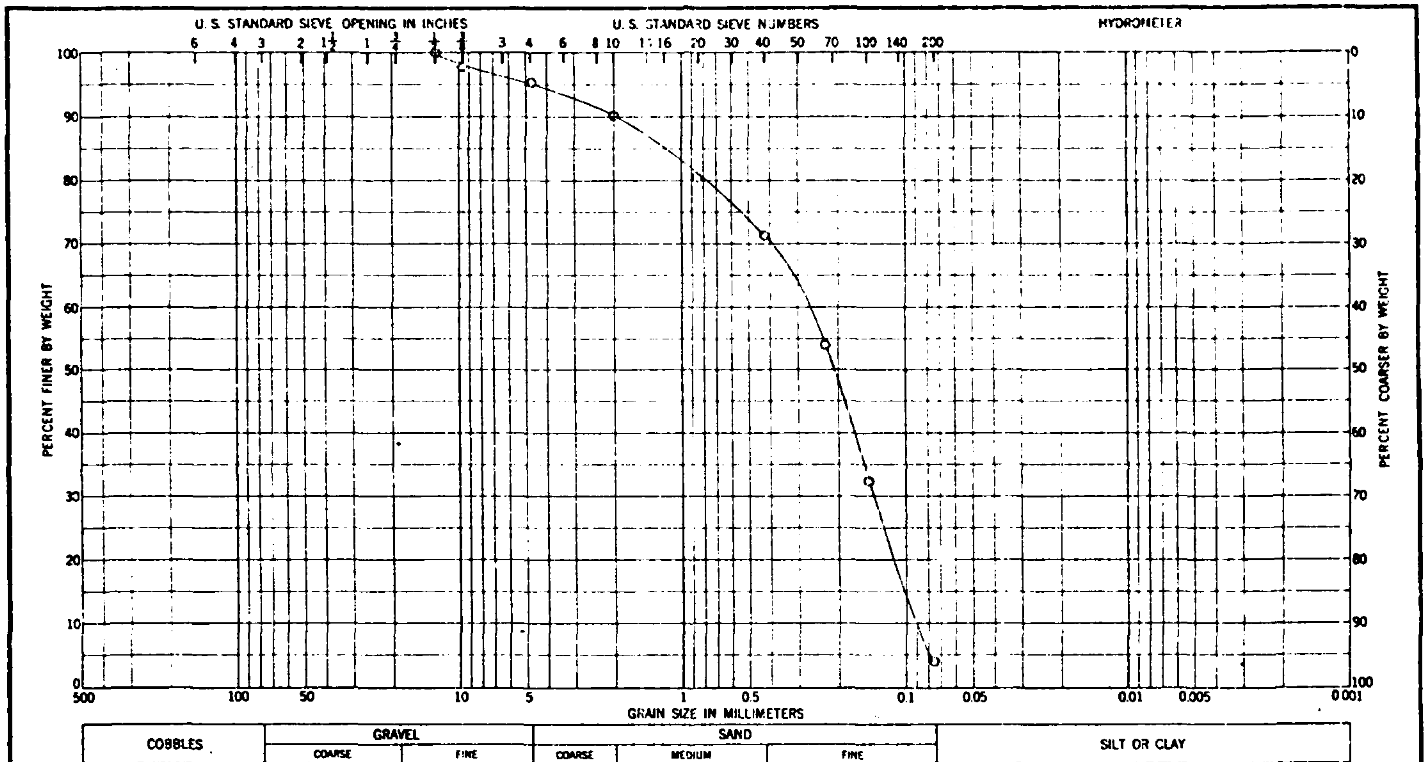
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-53

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY,
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 2449
REQ. NO. SACEC-77-20



Sample No.	Elev or Depth	Visual Classification	Nat w %	LL	PL	PI
4	--	Gray poorly graded sand (SP) with some gravel size and coarse-medium sand size shell fragments Shell approximately 25%	-	-	-	-

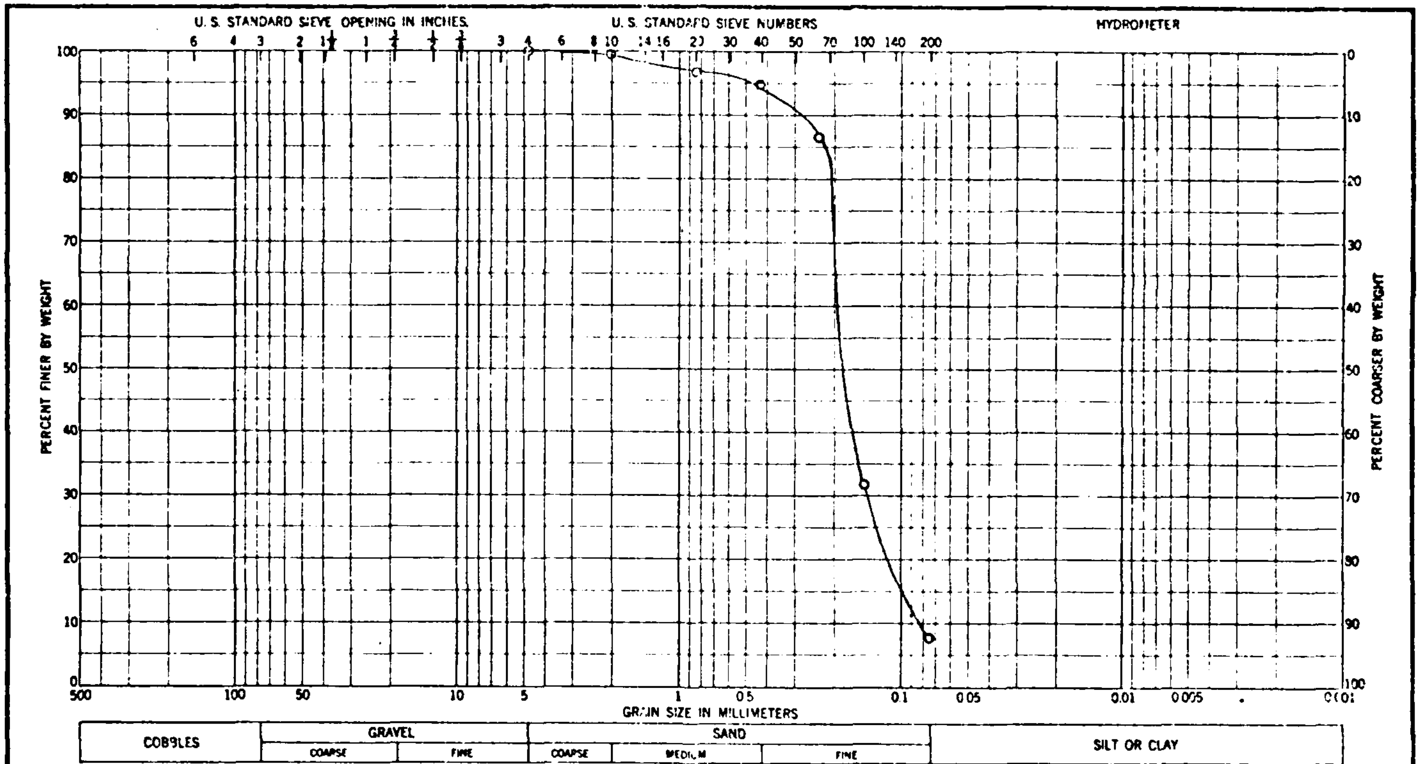
GRADATION CURVES

Project CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C.
Lab. No. 74/2358
Area --
Boring No. 13, Sample No. 4
Date 2 March 1977

ENG FORM 1 MAY 63 2087

FIGURE D-54

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY **WORK ORDER NO.** 0449
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061 **Req. No.** SACEC-77-20



Sample No.	Elev or Depth	Visual Classification	Nat w %	LL	PL	PI
5	--	Gray poorly graded silty sand (SP-SM) with a trace of shell fragments	-	-	-	-
		Shell approximately 2%				

Project: CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach S.C.
Lab. No. 74/2159
Area --
Boring No. 13, Sample No. 5
Date 2 March 1977

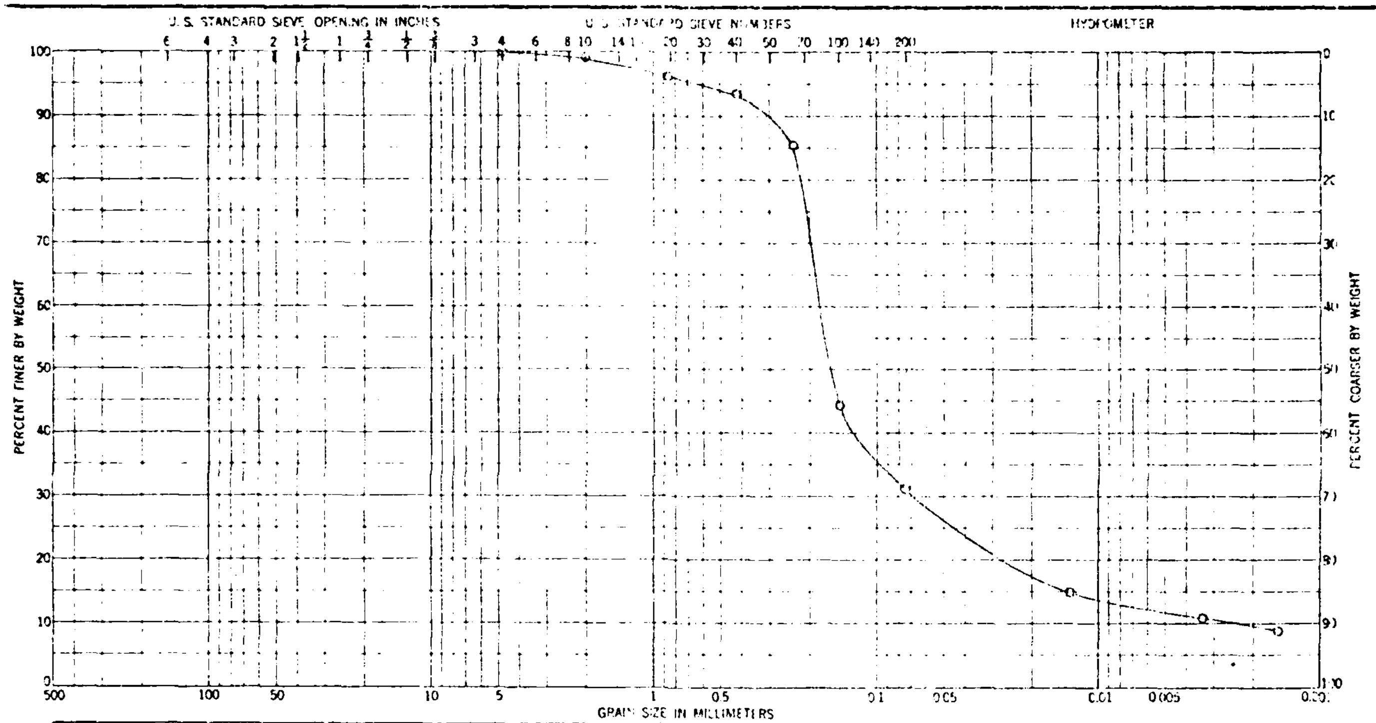
GRADATION CURVES

ENG FORM 1 MAY 63 2037

FIGURE D-55

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY,
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. 0449
REQ. NO. SACEC-77-20



Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
6	--	Visual Gray clayey sand (SC) with a trace of coarse-to-fine sand size shell fragments Shell approximately 4%	[illegible]	-	-	-

Project CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C.
Lab. No. 74/2563
Area --
Boring No 13, Sample No. 6
Date 2 March 1977

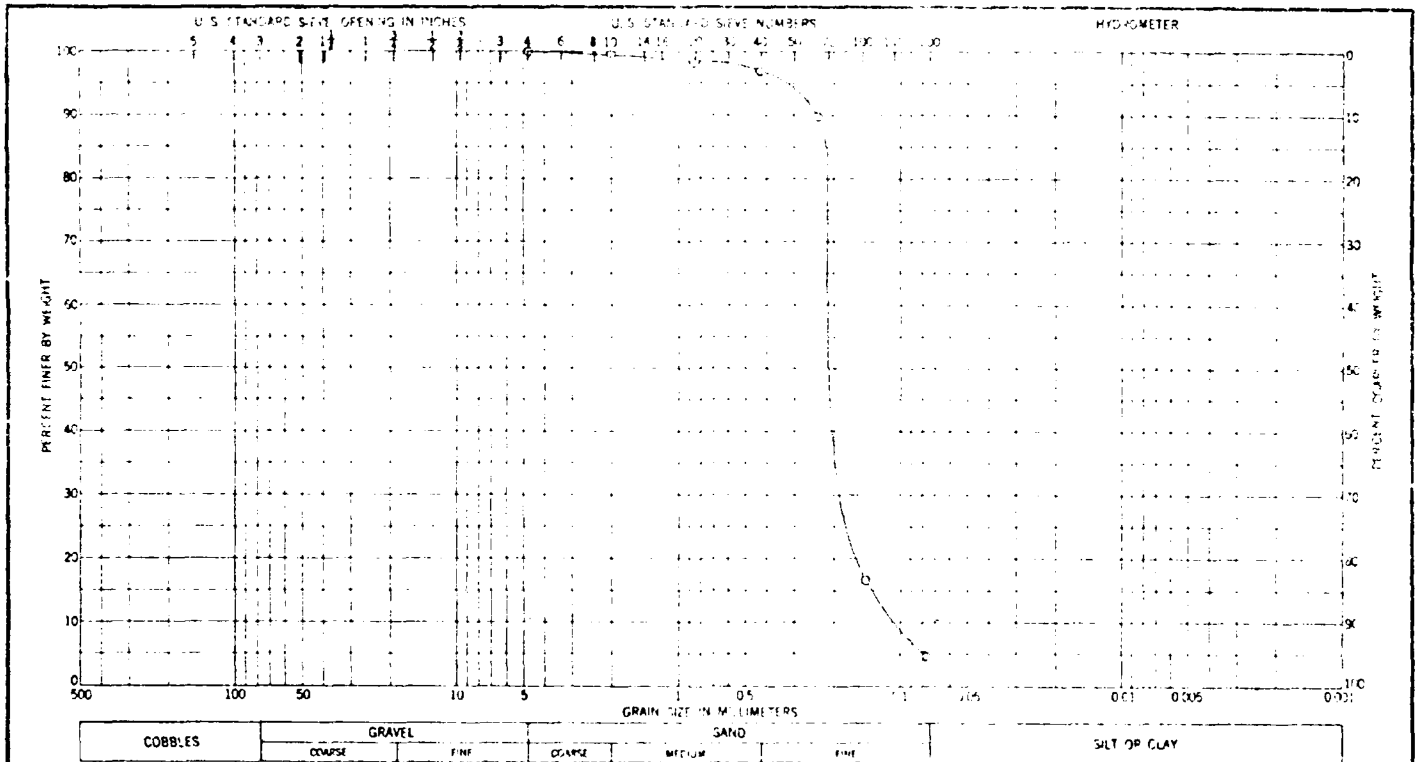
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-56

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061

WORK ORDER NO. [illegible]
Req. No. [illegible]-20



Sample No.	Elev or Depth	Visual Classification	Nat w %	LL	PL	PI
1, 2, 3, & 4	--	Gray poorly graded sand (SP) with a trace of shell frag[illegible]	-	-	-	-
		Shell approximately [illegible]				

Project Survey Report, Folly Beach, S.C.
[illegible] 2361, 2362, 2363, 2364
Area --
Boring No. 14, Samples 1, 2, 3, & 4
Date 2 March 197[illegible]

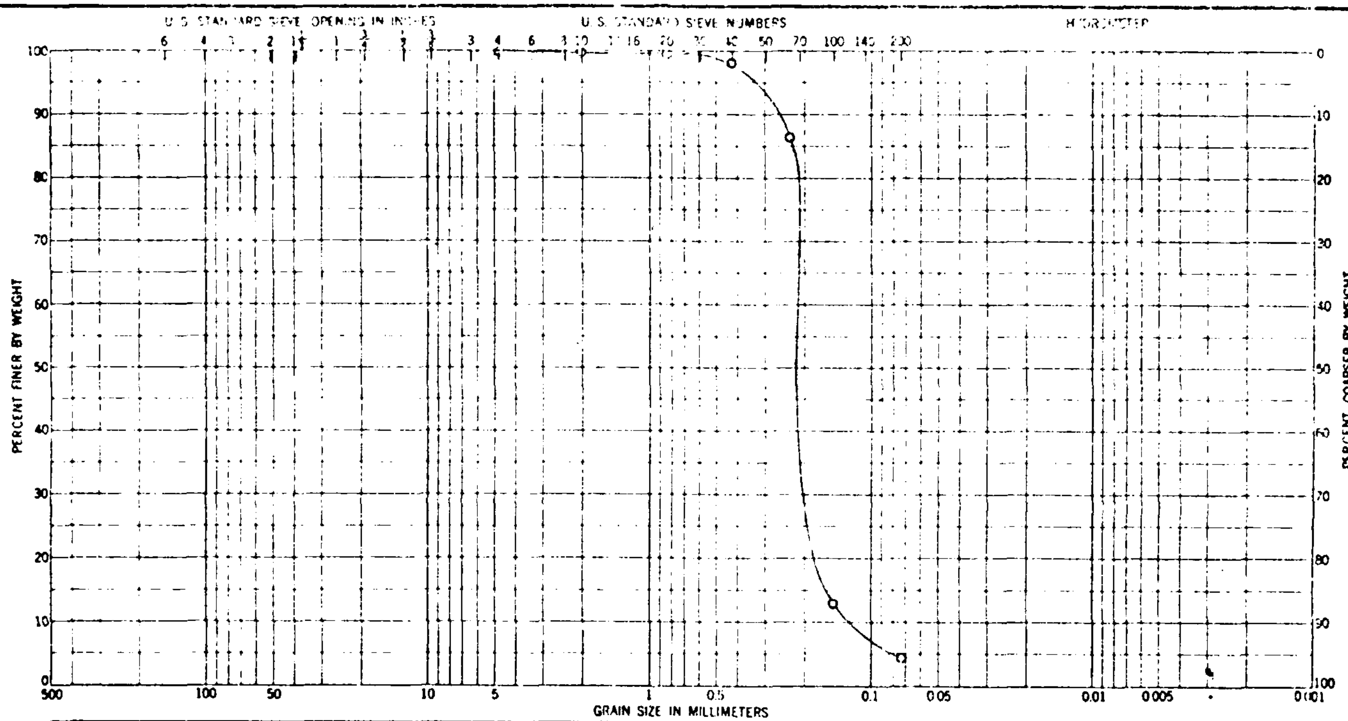
GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-57

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA 30061

WORK ORDER NO.
Req. No. SASDG-77-20



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
5	--	Visual Gray poorly graded sand (SP) with a trace of sand size shell fragments Shell approximately 2%	-	-	-	-

Project: CHARLESTON DISTRICT, Folly Beach Survey Report, Folly Beach, S.C.
Lab. No. 74/2365
Area --
Boring No. 14, Sample No. 5
Date 2 March 1977

GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE D-58

SECTION E

ESTIMATED BENEFITS

ESTIMATED BENEFITS

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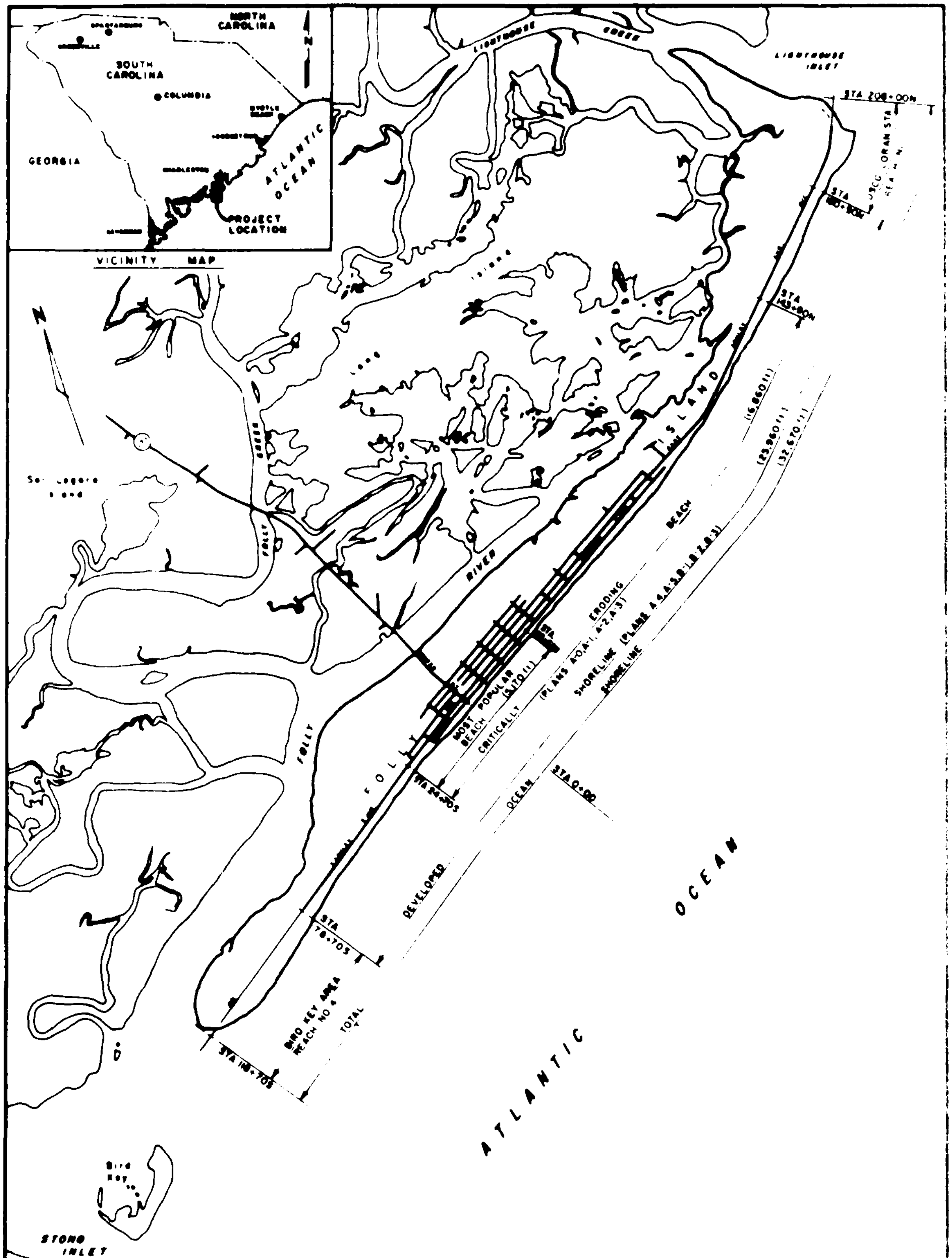
SECTION E

ESTIMATED BENEFITS

1. The purpose of this section of the report is to estimate the benefits which would result from various plans of improvement for comparison with associated costs. This will allow a determination of the economic feasibility of the various plans of improvement and aid both in identifying those measures which will economically contribute to planning objectives and in sizing them to maximize their output.

Alternative Plans

2. Derivation of benefits for the six "Beach Development" plans and the three "Beach and Dune Development" plans which best meet the planning objectives are presented in this section. The Beach Development plans are designated as A-0 through A-5 and the Beach and Dune Development plans as B-1 through B-3. Figure E-1 shows the locations of these plans of improvement. These lengths and the average recreational beach widths, between 5-year nourishment periods, are given in Table E-1. Figure C-5 in Section C of this appendix is a typical



LENGTHS OF ALTERNATIVE PLANS OF IMPROVEMENTS
FOLLY BEACH
SOUTH CAROLINA

FIGURE E-1

section of the combined beach and dune development plans. Three different dune heights were evaluated: +12 feet, +15 feet and +18 feet, measured from mean sea level. The beach development, only, plans would have the same beach slope, 30 to one, as the beach and dune plans. Berm elevation of the beach would be set at +4 feet MSL. Beach widths (measured from the back edge of berm to mean high water on the beach slope) were analyzed in 50-foot increments up to 150 feet in order to optimize designs. The most promising alternative plans are described below and discussed in greater detail in Section G, "Project Formulation".

Table E-1

PERTINENT DATA ON ALTERNATIVE PLANS

Plan	Dune Height (feet, MSL)	Average Width of Recreational Beach (in feet) Provided for Different Reaches.1/			Total Project Length (feet)
		Recreational (5,200 ft.)	Critically Eroding (11,700 ft.)	Less Serious Erosion (9,100 ft.)	
BEACH DEVELOPMENT					
A-0	--	50	50	0	16,900
A-1	--	100	50	0	16,900
A-2	--	150	50	0	16,900
A-3	--	150	100	0	16,900
A-4	--	100	50	50	26,000
A-5	--	150	100	50	26,000
BEACH AND DUNE DEVELOPMENT					
B-1	12	123	123	123	26,000
B-2	15	125	125	125	26,000
B-3	18	128	128	128	26,000

1/See Figure E-1 for reach locations.

3. There are two types of benefits to be derived from the solutions considered. The first category stems from prevention of the loss of real property. Houses, land, public utilities, etc., are, in the case of a beach development project, saved from destruction by ordinary erosive forces or in the case of a combination beach and dune project, from destruction by direct wave attack during a storm. The second category of benefits, recreation benefits, result from increasing the carrying capacity and recreational quality of the beach.

4. Recreation benefits usually account for the majority of benefits attributable to beach restoration and nourishment projects; consequently, the economic justification of any plan will be largely dependent on them. For this reason, the economic analysis of the various plans will begin with an examination of recreational benefits. Following this, the benefits resulting from protection of real properties will be examined.

Recreational Benefits

5. Improved quality and increased capacity are two objectives of a beach protection project (restoration and nourishment). The benefits derived from meeting these objectives are heightened enjoyment and increased recreational use of the improved beach. To determine the economic benefits which would be derived from increasing the

carrying capacity of a particular beach, it is necessary to determine the amount of increased beach usage which will result from the improvement. This is a function of the physical capacity and value of the beach with and without the improvement, the demand for beach use in the area and the availability of competing beach resources in the vicinity. The first quantity which must be determined is the demand for beach use in the area both present and projected. Next, the supply available can be evaluated and compared with the demand to determine the need for additional beach. If area needs for this type of recreation are met, there would be little justification for increasing the supply. On the other hand, if there is a deficiency of supply, some expenditure to improve the supply might be justified. The difference in the projected demand and supply would also give some indication of the amount of improvement needed. There are reports available which examine the supply and demand situation for beach use in South Carolina. This study will begin with an examination of those reports.

BEACH USE

6. There are two readily available sources from which the demand for beach recreation in the Charleston area can be estimated. These are (1) The South Carolina State Comprehensive Outdoor Recreation Plan (SCORP) and (2) a consultant study Beach Access and Recreation in South Carolina, conducted by the firm of Hartzog, Lader and Richards for various state and Federal Resource Management agencies hereafter referred to as the "HLR Study".

7. <u>SCORP Report</u>. In the SCORP report, existing demand for 10 different types of activities in 14 subregions were estimated: participation rates were determined from resident and non-resident surveys, user occasions were calculated by multiplying participation rates by resident population and non-resident visitation respectively. Demand forecasts for South Carolina residents are based solely on population projections; disregarding shifts in income distribution, increases in leisure time, etc. Beach activity demand for Subregion II (Charleston County Beaches) is shown in Table E-2. Location of Subregion II is shown in Figure E-2.

TABLE E-2

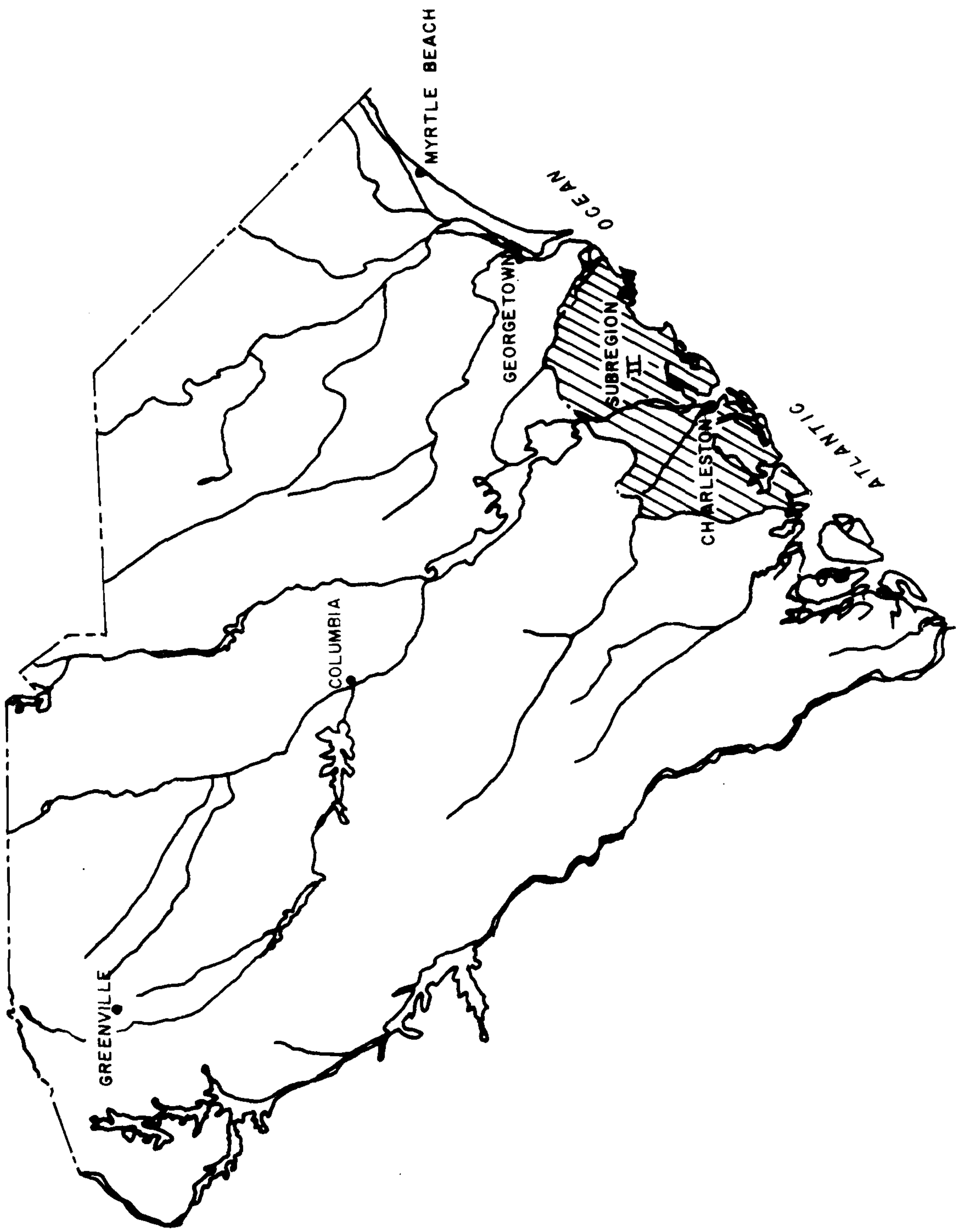
TOTAL RESIDENT AND NON-RESIDENT
DEMAND FOR BEACH USER OCCASIONS--SUBREGION II (CHARLESTON COUNTY BRANCHES)
(As given in SCORP Report, 1974)

YEAR	AVG. DAILY	PEAK DAY	AVG. DAILY PEAK SEASON	YEARLY TOTAL	YEARLY RESIDENT	YEARLY NON-RESIDENT
1972	8,731	68,129	14,617	3,186,716	1,650,759	1,535,957
1975	9,136	71,294	15,297	3,334,776	1,653,347	1,681,429
1980	9,504	74,161	15,912	3,468,875	1,698,755	1,770,120
1985	9,869	77,009	16,523	3,602,068	1,741,675	1,860,393
			(With necessary revisions to SCORP Report)[1]			
1972	8,866	69,184	14,843	3,236,074	1,700,117[2]	1,535,957
1975	9,244	72,139	15,478	3,374,291	1,692,862[2]	1,681,429
1980	9,656	75,345	16,166	3,524,254	1,754,134[2]	1,770,120
1985	9,900	77,250	16,575	3,613,389	1,752,996[2]	1,860,393
			(Projections beyond SCORP Report)			
1990	10,603[3]	82,738[4]	17,753[5]	3,870,114	1,921,794[6]	1,948,320[7]
2000	11,374[3]	88,751[4]	19,043[5]	4,151,351	2,062,055[6]	2,089,296[7]
2010	12,056[3]	94,072[4]	20,184[5]	4,400,232	2,170,544[6]	2,228,688[7]
2020	12,619[3]	98,467[4]	21,127[5]	4,605,832	2,252,800[6]	2,353,032[7]
2030	14,677[3]	114,530[4]	24,574[5]	5,357,156	2,883,740[6]	2,473,416[7]

1. For the years 1972, 1975, 1980, and 1985, the "average daily", "peak day", and "average daily for the peak season" have been increased (revised) in the ratio of the annual user occasions (revised) to the annual user occasions, SCORP.
2. The SCORP estimates of S.C. Population are at variance with Census Bureau estimates appearing in the 1977 "City-County Data Book". Hence "Residential User Occasions" have been increased in accordance with the following factors.

YEAR	SCORP POP.	CENSUS BUR. POP.	FACTOR	
1972	2,590,516	2,668,000	1.0299	
1975	2,750,000	2,815,800	1.0239	
1980	2,914,000	3,009,000[a]	1.0326	a-From "Summary of
1985	3,129,200	3,149,500[a]	1.0065	Projections..."

3. Annual User-Occasions x 0.0027398, which is the ratio: 9,900/3,613,389.
4. Annual User-Occasions x 0.0213788, which is the ratio: 77,250/3,613,289.
5. Annual User-Occasions x 0.0045871, which is the ratio: 16,575/3,613,289.
6. South Carolina Population x 0.58296, which is (for the year 1980) the ratio of the Resident User-Occasions to the South Carolina Population.
7. The United States Population (in millions) x 7,920, which is (for the year 1980) the ratio of the Non-Resident User-Occasions to the U.S. Population (in millions).



Hatched area shows limits of Subregion II.

SOUTH CAROLINA
STATE COMPREHENSIVE
OUTDOOR RECREATION PLAN

SUBREGION II CHARLESTON ARE

FIGURE E-

8. Demand for Beach Use at Folly Beach. A study of the relative popularity and demand for various South Carolina beaches entitled "Public Beach Access and Recreation in South Carolina" was completed in 1976 by the firm of Hartzog, Lader and Richards for the South Carolina Department of Parks, Recreation, and Tourism, et. al. This (hereinafter "HLR") report employed a gravity model to determine market demand for beach recreation in South Carolina, and to distribute this demand to the various beaches.

9. The HLR report estimated the day use demand for Charleston County beaches in 1975 to be 2,805,400; the resident vacation user demand to be 103,300 user occasions per year; and the non-resident vacation beach user demand to be 621,700 user occasions per year. Or a total 1975 demand for beach use in Charleston County of 3,530,400 user occasions, comparing rather closely with the SCORP estimate of 3,334,778 user occasions for the same year (Table E-2).

10. The HLR report gave the following estimates of 1980 beach user occasions for the following Charleston County beaches (all figures are in thousands of beach-user occasions):

TABLE E-3

HLR ESTIMATES OF 1980 BEACH USE IN CHARLESTON COUNTY
(in 1,000's)

BEACH	VACATION USE RESIDENTS	 NON-RESIDENTS	DAY USE	TOTAL	%
Isle of Palms	14.6	83.6	911.7	1,009.9	27.5
Sullivans Island	13.4	83.6	1,298.1	1,395.1	38.0
Folly Beach	71.2	417.8	563.7	1,052.7	28.7
Kiawah	12.3	69.6	130.7	212.6	5.8
TOTALS	111.5	654.6	2,904.2	3,670.3	100.0

The above figures are from Pages 132, 140, and 146 of the HLR report. They show a total number of beach user occasions of 3,670,300 for Charleston County in 1980, and may be compared with the figure of 3,468,875 given on Page 3-97 of the S.C. SCORP Report, or with the figure 3,524,254 shown in Table E-2.

SEASONAL VARIATIONS IN BEACH USE

11. The South Carolina SCORP report was based on 1972 survey. It gave the seasonal distribution of beach use for non-residents of South Carolina using South Carolina beaches, but for residents it noted only whether such occasions were in one of the following categories: Vacations, weekend trips, or outings. Thus it is necessary to estimate the seasonal distribution of resident beach use. For this purpose the year has been characterized as: Peak season--98 days, between and including Memorial Day and Labor Day, and basically the summer months of June, July, and August; within the peaks season there is a peak day (4th of July), and two lesser peak days (Memorial Day and Labor Day), 24 peak season weekend days, and 71 peak season weekdays. Transition season-55 days; that is 30 days of May and 25 days of September, which includes, on the average, 16 weekend days and 39 weekdays. Off season--October through April, has 212 days. The latter season is one of low beach use, and while weekend day use may be somewhat greater than weekday, only the average daily for this off season has been used.

12. It will be noted (Table E-2) that in 1972 the South Carolina SCORP report gives an average daily beach use of 14,617 during the peak season. This, however, cannot be reconciled with similar data in the SCORP report. For instance, on p. 3-46 the number of summer beach use occasions for Region II beach is given as 1,201,249 for 1972 (see also Table E-4, line 1); but this when divided by 98 gives an average daily number of user occasions of 12,257. This, it should be noted is for

non-residents alone, and they account for 48 percent of the total number of user-occasions (see Table E-4). Thus we would expect the average daily beach use for Region II for 1972 to be on the order of 24,000 rather than the 14,617 figure given. Thus the SCORP report data is not only erroneous; it lacks internal consistency. Table E-4 attempts (in the absence of reliable SCORP data) to derive a reasonable seasonal distribution of total Region II beach use for 1972. It will be noted that Table E-4 ultimately derives a summer (peak season) use of 2,174,642 beach user occasions for 1972, which is 67.2 percent of the annual total, and which if divided by 98 gives an average daily peak season usage of 22,190 user occasions.

13. We are now in a position to estimate number of user-occasions associated with each type of day described in paragraph 11; and the results are shown in Table E-5. In line 1 of this table, the figure 8,866 will be found in Table E-2, and 3,236,074 will be found in that table as well as E-4. The average for the peak season (22,190) is derived as stated above; the peak day (69,184) will be seen to have come from Table E-2 (that is, from the SCORP report). For the other types of days data was generally scant; data on weekly beach use at Hunting Island Beach State Park was generally available. The lesser peak day (of which there are two) is assumed to have 75% of the user-occasions of the peak day, or 51,888. Each of the 24 peak season weekend days is about 70% of the peak day, or 48,428. This accounts for 1,335,232 of the 2,174,742 summer user occasions, leaving 839,410 for the remaining 71 weekdays, or an average of 11,822 user occasions for each such day. Assuming the daily average use in May is about 80 percent of the daily average for the peak season, there are 532,560 users; and assuming the daily average in September is about 50 percent of the peak season average,

there are 277,375 uses; or a total of 809,935 for the 55-day transition period, which is a daily average of 14,726. This leaves 251,497 for the 212-day off season, or a daily average of 1,186. In the transition period there are 16 weekend days. If these are assumed to be about 50 percent of the summer weekend days, each represents 24,214 uses, or a total of 387,424, leaving 422,543 uses for the remaining 39 days, or a use of 10,834 for each of such days. The results of these estimates and assumptions appears in Table E-5.

PROJECTIONS OF FUTURE DEMAND

14. The projected future demand for beach use in Charleston County and Folly Beach is shown in Table E-6. The derivation of the projections for Charleston County are explained in Table E-2, and its footnotes. The projections for Folly Beach's share of the total will continue to be the 28.7 percent estimated in the HLR report (Table E-3). In terms of daily beach use occasions, the projections for Folly Beach are as given in Table E-7.

TABLE E-4

REGION II, BEACH USE OCCASIONS (BY SEASON) 1972

USER TYPE	SPRING	SUMMER	FALL	WINTER	TOTAL
NON RESIDENTS OF STATE[1]	244,420	1,201,249	29,928	60,360	1,535,957
RESIDENTS:					
Vacation Beach Use Occasions[2]	18,039	234,508	6,193	10,500	269,240
Week-End Trips[3], User Occasions[3]	92,118	106,291	81,489	74,403	354,301
Outings (1 day), User Occasions[4]	221,879	599,895	168,464	36,980	1,027,218
TOTAL[5]	576,456	2,141,943	286,074	182,243	3,186,716[5]
SEASONAL PERCENTAGES	18.1	[illegible]	9.0	5.7	100.0
TOTAL[6]	585,729	[illegible]	291,247	184,456	3,236,074

NOTES:

1. From SC SCORP Report, p. 3-46 (which gives the seasonal beach user occasions for non-residents).
2. Total resident vacation beach use is given in Table 3-36 (SCORP); it has been assumed that seasonally the number of beach user occasions is proportional to the number of resident vacations for each season. (p. 44).
3. The total (354,301) is from SCORP, Table 3-36; it has been assumed that seasonally the number of such beach user occasions is proportional to occupancy figures for hotels, motels, etc., as given in SCORP, Table 3-14.
4. The total (1,027,218) is from the SCORP report, Table 3-36; seasonal allocation has been made on the assumption that the number of user occasions associated with one-day outings is proportional to seasonal camping figures as shown in p. 3-16 and p. 3-15, SCORP
5. The total (3,186,716) is the 1972 figure as used in the SC SCORP Report of 1974.
6. The total (3,236,074) is the figure that must be used to reconcile the SC SCORP Report of 1974 (which used 1972 population figures that were later revised by the Census Bureau) with the true population figures (see Table E-2, third column from right). This line should be considered the final result of this table. The figures for each season are derived from the total via the seasonal percentages shown in the line above, which were derived as indicated.

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TABLE E-5

AVERAGE AND PEAK BEACH USE OCCASIONS, 1972, REGION II BEACHES
(CHARLESTON COUNTY, S.C.)

TYPE OF DAY	AVG. NO. USES PER DAY	FACTOR[1/]	NO. OF SUCH DAYS	TOTAL BEACH USE FROM SUCH DAYS	PERCENT OF ANNUAL USE
Each day of the year	8,866	1.0	365	3,236,074	100
Peak Season:	22,190	2.5	98	2,174,642	67.2
Peak Day	69,184	7.8	1	69,184	2.1
Lesser Peak Day	51,888	5.8	2	103,776	3.2
Weekend Day	48,428	5.5	24	1,162,272	35.9
Weekday	11,822	1.3	71	839,410	26.0
Transition Season:	14,726	1.7	55	809,935	25.0
Weekend Day	24,212	2.7	16	387,392	12.0
Weekday	10,834	1.2	39	422,543	13.0
Off Season	1,186	0.13	212	251,497	7.8

[1/] The average number of beach use occasions for the type of day indicated divided by the average (annual) daily number of beach uses (8,866).

TABLE E-6

PROJECTED AVERAGE ANNUAL BEACH DEMAND
(VISITS PER YEAR)

YEAR	CHARLESTON COUNTY	FOLLY BEACH
1975	3,374,291	968,421
1980	3,524,254	1,011,460
1990	3,870,114	1,110,722
2000	4,151,351	1,191,437
2010	4,400,232	1,262,866
2020	4,605,832	1,321,873
2030	5,357,156	1,537,503

TABLE E-7

FOLLY BEACH DEMAND FOR EACH TYPE OF BEACH USE DAY

DAY TYPE	1980	1990	2000	2010	2020	2030
Total Annual Visits1/	1,011,460	1,110,722	1,191,437	1,262,866	1,321,873	1,537,503
Peak Day2/	21,624	23,745	25,471	26,998	28,260	32,870
(1) Such Day	21,624	23,745	25,471	26,998	28,260	32,870
Lesser Peak Day	16,218	17,808	19,103	20,248	21,195	24,652
(2) Such Days	32,436	35,616	38.206	40,496	42,390	49,305
Peak Season Weekend Day	15,136	16,621	17,829	18,898	19,782	23,009
(24) Such Days	363,264	398,904	427,896	453,552	474,768	552,216
Peak Season Weekday	3,919	4,304	4,616	4,893	5,122	5,958
(71) Such Days	278,249	305,584	327,736	347,403	363,662	423,019
Transition Season Weekend Day	7,856	8,310	8,914	9,449	9,890	11,504
(16) Such Days	125,696	132,960	142,624	151,184	158,240	184,066
Transition Season Weekday	3,386	3,718	3,988	4,227	4,425	5,147
(39) Such Days	132,054	145,002	155,532	164,853	172,575	200,750
Off Season Day	274	325	349	370	387	449
(212) Such Days	58,137	68,911	73,972	78,380	81,978	95,277

1/Table E-6

2/28.7 percent times peak days Charleston County beaches, Table E-2.

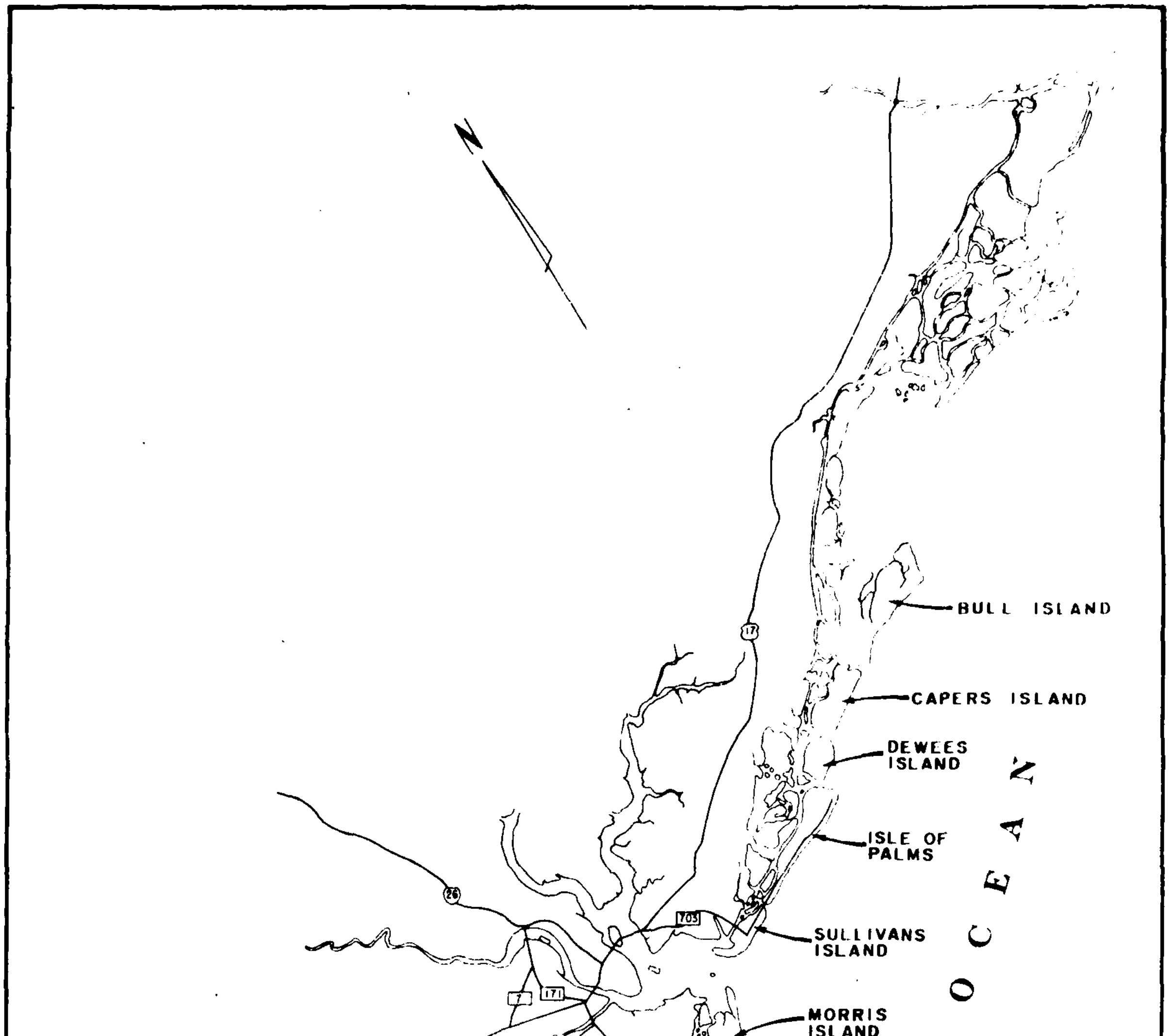
AVAILABILITY OF BEACH RECREATION IN THE VICINITY OF CHARLESTON, SOUTH CAROLINA

15. There are five barrier islands in the Charleston vicinity which are accessible by road (see Figure E-3). Three of these islands: Sullivans Island, Isle of Palms and Folly Island serve as the primary day-use destinations for Charleston area residents. Kiawah Island and Seabrook Island are primarily resort areas which serve mostly non-resident vacationers and are used little as day-use destinations.

16. Isle of Palms, located approximately 11 miles northeast of Charleston, has about 7 miles of ocean front beaches and is open to the public. Parking is available to commercial areas, while on-street parking near the beach is restricted. Isle of Plams is mostly residential with 1,000 of the 1,800 homes on the island occupied year-round.

17. Sullivans Island, located adjacent to Charleston Harbor on the north side, is mostly residential. Beach access is available all along the 4 mile ocean front but is restricted by the lack of availability of parking.

18. Folly Island, 12 miles south of Charleston, has about 6 miles of ocean front beaches. Folly Beach is a shore town with a small (1,200) permanent population and a large number of modest summer cottages. Only 32 percent of Folly's 1,329 housing units are occupied year-round. The influx of summer residents brings the peak season population of Folly Beach to about 4,500 persons. On the 4th of July 1973, the Folly Beach Police Department reported 20,000 persons on the beach by 3 p.m.



CHARLESTON
AREA BEACHES

FIGURE E-3

"with more to come", as published in the Charleston News and Courier on 5 July 1973. Perhaps as many as 30,000 visitors come to Folly Beach on a peak summer day. Folly Island's beaches are the most easily accessible of all the Charleston area beaches. On-street parking is allowed along the beach front and back roads. Conspicuously marked public beach access points are located every couple hundred yards along the entire beach front. Although the beach is accessible, it is in poor condition for recreation use due to erosion. At high tide, there is little or no dry beach area. As a result of this condition, many area residents travel to other more distant beaches or stay home. A survey of beach goers at Edisto Beach State Park revealed that 64% of the vistors were from the Charleston area. The presence of so many Charlestonians at a beach 60 miles away indicates that there is, for one reason or another, a large surplus of demand for suitable recreational beaches in the Charleston area.

BENEFITS FROM INCREASED RECREATIONAL USE

19. The benefits attributable to recreational use of an improved beach are the differences between the recreational values to be realized by the improved beach less those to be realized by the beach as it will exist without improvement. Annual values of each of these have been estimated, and examples are given in Tables E-9 and E-10. This analysis is for "Beach Protection" Plan A-1.

20. The unit recreational values (values per user occasion) without a project (existing conditions) have been taken as $0.60 for the amusement

center frontage (the 5,170 feet between Stations 27 + 00N and 24 + 70S) which is, in effect, dedicated to public usage, and $0.40 for the remainder of the beach frontage, the usable beach, in total, is 28,600 feet. The "with" project conditions involve the improvement of two reaches of 16,860 and 25,960 feet, the former (from Station 143 + 90N to 24 + 70S) being included in the latter (Station 180 + 90N to 78 + 70S). To the 25,960 feet is added 1,320 feet (one-fourth mile) on each end of the beach, assumed to be within walking distance from access points, yielding the total beach length of 28,600 feet. The unit recreational value with project conditions has been assumed as follows: For the amusement center area, $1.00 per user occasion, as it will be well developed with regard to facilities and amenities, essentially dedicated to public use, and enhanced by widening. For the remainder of the improved beach (11,690 or 20,790 feet, depending on the project), $0.80 per user occasion, because of improvements in effective public access, particularly through parking improvements to be required of the locality, and amenities improvements. This beach, with frontage technically in private ownership, has always been available for public use, and with nourishment, the increment of dry beach area will, under the laws of South Carolina, belong to the state. The remainder of the unimproved beach, which will be either 2,640 or 11,740 feet, depending on the project, is assumed to have a value of $0.40 per user occasion, as in the "without" project condition.

21. The procedure was as follows. Projections of daily demand were made, as in Table E-7. Estimates of daily carrying capacity were made, as in Table E-8. Footnotes generally explain the assumptions. Estimates of the realizable recreational values with a project were

TABLE E-8

DAILY FOLLY BEACH CARRYING CAPACITY
(visits)

Alternative Structural Plans	1980	1990	2000	2010	2020	2030
Without Project:	6,248	1,780	1,627	1,627	1,627	1,627
With Project:						
A-0	19,736	17,713	17,713	17,713	17,713	17,713
A-1	24,886	22,963	22,963	22,963	22,963	22,963
A-2	30,036	28,113	28,113	28,113	28,113	28,113
A-3	41,746	39,823	39,823	39,823	39,823	39,823
A-4	32,166	31,460	31,460	31,460	31,460	31,460
A-5	49,020	48,320	48,320	48,320	48,320	48,320
B-1	64,714	64,008	64,008	64,008	64,008	64,008
B-2	66,150	65,444	65,444	65,444	65,444	65,444
B-3	67,636	66,986	66,986	66,986	66,986	66,986

REMARKS:

Carrying capacity is for all of the beach, whether improved or not. It is the dry beach area divided by 100 sq. ft. per use, times 2 uses per day (turnover rate).

Along the reaches not protected by project improvements, it is assumed that erosion will continue but the dry beach area will not completely disappear. As the beach erodes lands, homes, and other structures may be lost but some constant width of dry beach area will remain after the year 1990. It is assumed that without bulkheads, seawalls, or revetments, this width of dry beach will be reduced to and remain at about 5 feet; and with these bulkheads, etc., the width of dry beach will be only about 2 feet.

TABLE E-9

BEACH USE RECREATIONAL VALUES, WITH PROJECT (Plan A-1)1/

DAY TYPE (NO. OF DAYS)	1980	1990	2000	2010	2020	2030
Carrying Capacity	24,886	22,963	22,963	22,963	22,963	22,963
Peak Day (1)	21,624	22,963	22,963	22,963	22,963	22,963
Lesser Peak Day (2)	16,218	17,808	19,103	20,248	21,195	22,963
Weekend Day, Peak Season (24)	15,136	16,621	17,829	18,898	19,782	22,963
Weekday, Peak Season (71)	3,919	4,304	4,616	4,893	5,122	5,958
Weekend Day, Trans. Season (16)	7,856	8,310	8,914	9,449	9,890	11,504
Weekday, Trans. Season (39)	3,386	3,718	3,988	4,227	4,425	5,147
Day, Off Season (212)	274	325	349	370	387	449
Annual Uses:	1,011,411	1,103,929	1,188,945	1,258,891	1,316,642	1,523,004
Recreational Values: ($) @ $0.84 2/	849,585	932,340	998,713	1,057,468	1,105,979	1,279,323

1/ Beach use limited by demand.

2/ This is an area-weighted figure for each user occasion for the 28,600 ft. of usable beach, including the unimproved beach, 11,740 feet of beach lying on both sides of the 16,860 feet to be protected.

TABLE E-10

BEACH USE RECREATIONAL VALUES WITHOUT PROJECT

DAY TYPE (NO. OF DAYS)	1980	1990	2000	2010	2020	2030
Carrying Capacity	6,248	1,775	1,627	1,627	1,627	1,627
USE:						
Peak Day (1)	6,248	1,775	1,627	1,627	1,627	1,627
Lesser Peak Day (2)	6,248	1,775	1,627	1,627	1,627	1,627
Weekend Day, Peak Season (24)	6,248	1,775	1,627	1,627	1,627	1,627
Weekday, Peak Season (71)	3,919	1,775	1,627	1,627	1,627	1,627
Weekend Day, Trans. Season (16)	6,248	1,775	1,627	1,627	1,627	1,627
Weekday, Trans. Season (39)	3,386	1,775	1,627	1,627	1,627	1,627
Day, Off Season (212)	274	325	349	370	387	449
Annual Uses:	737,055	340,475	322,919	327,371	330,975	344,119
Recreation Values (@$0.43)1/	316,933	146,404	138,855	140,769	142,319	147,971

1/ This is an area-weighted figure for each user occasion for the 28,600 ft. of usable beach, and assumes a value of $0.60 per user occasion for the 3,170 ft. fronting the amusement center, and $0.40 for the remaining frontage.

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made as in Table E-9; and those without a project as in Table E-10; the differences being the recreational benefits for each of the decennial years. The equivalent average annual recreational benefits were computed by a computer program that interpolated benefits for each year between those shown, giving, by summation, the total present worth of benefits for all years; then multiplied this by the capital recovery factor to give the equivalent annual benefits. The interest rate used was 6-7/8%, and the period of analysis was 50 years. A summary table (Table E-11) gives these annual benefits for all project configurations analyzed. This analysis assumes development of adequate associated facilities such as parking, bath houses, etc.

Erosion Control Benefits

GENERAL

22. These benefits consist of the value of the land loss prevented by beach stabilization, of the value of the various structural improvements that might be expected to be lost in the absence of a project, and land enhancement. The land referred to is privately owned land, presently landward of the mean high water shoreline. Counting the prevention of its loss as a benefit does not amount to a double-counting of recreational benefits previously estimated, as the latter are predicted on values yielded by land oceanward of the present mean high water line. These benefits are limited (cannot be greater) than the cost of their prevention by means other than the shore protection project, and the most economical alternative means. This has been assumed to be by means of a seawall, which presumably the property owners would construct if it were cheaper than suffering the losses.

TABLE E-11

RECREATIONAL BENEFITS RESULTING FROM
VARIOUS ALTERNATIVE PLANS OF IMPROVEMENTS

PLAN	AVERAGE ANNUAL RECREATIONAL BENEFITS
BEACH DEVELOPMENT	
A-0	$681,500
A-1	$746,060
A-2	$771,820
A-3	$760,640
A-4	$760,630
A-5	$760,640
BEACH AND DUNE DEVELOPMENT	
B-1	$738,130
B-2	$738,130
B-3	$738,130

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LAND LOSS PREVENTED

23. Tables E-12 and E-13 give estimates of the value of the land that would be lost along the two applicable reaches of oceanfront in the absence of protection, and this is equal to the loss prevented by a properly maintained project. These generally show the assumptions made, and indicate that the annual value of land loss prevented along the 16,860 foot project shore would be $119,200 and that along the 25,960 foot project shore would be $177,200.

TABLE E-12

ESTIMATES OF VALUES OF LAND AND BUILDINGS
TO BE LOST WITHOUT SHORE STABILIZATION IN THE
16,860 FOOT REACH INTENDED FOR PROTECTION UNDER
PLANS A-0 THROUGH A-3

ITEM	ANNUAL LOSS ($/yr.)
LAND: Frontage (within project area) not presently protected by structures is 9,350 ft. Land loss at 5 ft/yr is 46,750 square feet, and at $2.55 per square foot this amounts to...	$119,200
BUILDINGS: The present value of structures along the 9,350 ft. not protected by a seawall is $2,332,100.[1] Erosion of some 250 ft. in 50 years would destroy all these first row structures, at the rate of about $46,640/year, and this times the growth factor (1.109) is...[2]	$ 51,700

[1] See Table E-14.

[2] See Table E-15.

TABLE E-13

ESTIMATES OF VALUES OF LAND AND BUILDINGS
TO BE LOST WITHOUT SHORE STABILIZATION IN
THE 25,960 FOOT REACH INTENDED FOR PROTECTION
UNDER PLANS A-4 & A-5 AND B-1 THROUGH B-3

ITEM	ANNUAL LOSS ($/yr)
LAND: For the 9,350 feet of shore previously mentioned...	$ 119,200
For the 9,100 feet beyond the limits of Plans A-0 through A-3, the land loss at 2.5 ft/yr is 22,750 square feet, and at $2.55 per square foot this amounts to...	58,000
TOTAL VALUE OF LAND LOSS:	$ 177,200
BUILDINGS: For the 9,350 feet of shore previously mentioned...	$ 51,700
For th 9,100 feet beyond (as above), at a rate of 2.5 ft/yr (125 ft. in 50 yrs) is assumed that about ½ the value of the present structures, valued at $2,269,700 will be destroyed,[1/] an amount of $1,134,850 at $22,697 per year, which, times the growth factor (1.109) amounts to...[2/]	$ 25,200
TOTAL VALUE OF STRUCTURES LOST:	$ 76,900

[1/] See Table E-14.

[2/] See Table E-15.

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BUILDING DAMAGE PREVENTED

24. There are 259 structures along the developed 25,960 feet of beach along which erosion is to be controlled. Counting only the value of the building itself, these have an average value of $25,000, or a total of $6,475,000 or $249 per linear foot of beach. Table E-14 shows these building values by reaches. Tables E-12 and E-13 give estimates of the values of buildings that would be lost along the applicable reaches of oceanfront in the absence of protection, and this is equal to the building loss prevented by a properly maintained project, It should be noted that the economic life of a project is assumed to be 50 years, and that losses have been estimated on this basis.

25. Growth and Development Factor. The value of damageable property in constant dollars is expected to increase during the project life. It is desired to have a factor by which we may multiply annual damages estimated on the basis of present values by which to obtain the annual damages on the basis of the value of such property over the life of the project. The assumed values of damageable property for certain years is shown in Table E-14. The growth and development factors have been derived as illustrated in Table E-15.

26. Limitation on Erosion Control Benefits. The total of the benefits shown in Table E-12 and E-13 are limited by the cost of the most economical protective means to prevent them. This has been assumed to be a seawall, and the estimates of annual costs of protection by means of such a seawall are given in Table E-16. This shows the annual cost of seawall protection

for the 16,860 foot frontage to be about $218,900, which exceeds the potential land and building loss of $170,900 and it shows the annual cost of seawall protection for the 25,960 foot frontage to be about $400,000, which exceeds the potential land and building loss of $254,100 for this frontage; and thus the appropriate benefit values are those shown in Table E-12 and E-13. Consideration was given to a possibly less expensive back-filled rubble-mound structure that would function as a revetment. However, the annual costs of this (because of the greater maintenance costs) were estimated to be higher than the concrete seawall. Also, seawalls have been the major structural controls used by beach front property owners at Folly Beach.

TABLE E-14

ASSUMED VALUE OF OCEANFRONT PROPERTY, FOLLY BEACH

Reach	Length (ft)	Value of Structures in $1979			Number of Structures:	
		1980 1/	1990	1990 (upgraded)	1980	1990
A	7,510	1,873,200	2,148,000	2,276,900 2/	75	86
B	9,350	2,332,100	2,674,300	2,674,300	93	107
C	9,100	2,269,700	2,602,700	2,602,700	91	104
Total	25,960	6,475,000	7,425,000	7,553,900 2/	259	297

Remarks:

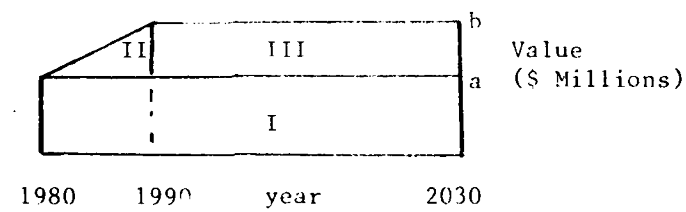
1/ There are 259 oceanfront structures at an average value of $25,000 each ($6,475,000, or $249.42/LF). By 1990 it is estimated that there will be 38 more at the same value; that is $7,425,000, or $286,017/LF.

2/ Assumes that in the period 1980-1990 ten percent of the structures in Reach A (protected) will be upgraded to an average value of $40,000 per structure. As the ratio of $40,000/$25,000 = 1.6; then the factor is (0.90 + 0.10(1.6)) = 1.06. For Reach A this makes the value/LF = $303.18; and for all reaches, it is $290.98.

General: Reach A is the shoreline presently protected by bulkheads, seawalls, or revetment; all of which is within the 16,860-foot reach of critically eroding shoreline (Figure E-1). Reach B is the remainder of the 16,860-foot reach, or 9,350 ft. Reach C is the remainder of the developed shoreline, or 25,960 - 16,860 = 9,100 ft.

TABLE E-15

ESTIMATION OF GROWTH AND DEVELOPMENT FACTOR



Reach	Value of Structures ($Million) b	a	(b - a)	(factor)[1/] Future Increment	of Present Structures[2/] ($)	Growth and Development Factor[3/]
B	2.6743	2.3321	0.3422	3.5789	36.2781	1.109
C	2.6027	2.2697	0.3573	3.4827	35.3083	1.109
B + C	5.2770	4.6018	0.6752	7.0616	71.5877	1.124
25,960 ft	7.5539	6.4750	1.0789	11.3836	102.0757	1.109

All factors use discount rate of 6-7/8%

1/ (b - a) x PW factor, which is 10.458463. That is, sum of PW factors for II and III.
PWF (II) = 3.500715 (10-yr, uniformly increasing annuity factor)
PWF (III) = 13.527 x 0.51436 = 6.95775. In which the 1st factor is the EPS PW factor, 40 yrs; and the 2nd factor is the SP-PW factor for 10 yrs.

2/ (a) x (14.021947). In which 14.021947 is the EPS PW factor, 50 yrs. (Part I, PW).

3/ Growth and Development Factor = PW of future structures/PW of present structure, which is equal to 1 + PW of future increment/PW of Present structures.

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TABLE E-16

ESTIMATE OF ANNUAL COST OF SEAWALL PROTECTION
AT FOLLY BEACH AS AN ALTERNATIVE MEANS OF
PREVENTING LOSS OF PRIVATE LAND AND STRUCTURES

ITEM	ANNUAL COST
FOR THE 16,860 FOOT FRONTAGE: (Plans A-0 through A-3)	
Additional 9,350 ft. of seawall:	
First Cost: 9,350 x $218/ft. = $2,038,300	
Interest and amortization on above (6-7/8%; 50 yrs.)	$ 145.365
Maintenance (at 2% of first cost/yr.) ($4.36/ft.)	40,766
Maintenance of existing 7,510 ft. seawall (@ $4.36/ft.)	32,744
Total annual costs for the frontage:	$ 218,875
FOR THE 25,960 FOOT FRONTAGE: (Plans A-4 through B-3)	
Additional 18,450 ft. of seawall:	
First Cost: 18,450 x $218/ft. = $4,022,100	
Interest and amortization on above	$ 286,844
Maintenance on the above (@ $4.36/ft.)	80,442
Maintenance of existing 7,510 ft. seawall	32,744
Total annual costs for the frontage:	$ 400,030

LAND ENHANCEMENT

27. In some cases in the initial restoration of the beaches, sand will be added on private property and landward of the property holding line. Strictly speaking, legal opinions of the law of South Carolina hold that the riparian owner owns naturally accreted land (above the Mean High Water Line, but it has been held that the state owns artificial accretions. Here, however, it is assumed that private property owners benefit from sand placed landward of the property holding line, and that this benefit is the value of the acreage added measured along the Mean High Water Line. For the projects embracing 16,860 feet of beach, it is estimated that 4.4 acres will be so added; and for the projects embracing 25,960 feet of beach, it is estimated that 5.8 acres will be added. This results in estimated enhancement values, annually, in the amounts of $34,800 and $45,900, respectively; that is 4.4(43,560) x $2.55 x 0.071317 = $34,800, and 5.8 (43,560) x $2.55 x 0.071317 = $45,900. In these figures, the value of the land is taken as $2.55 per square foot, as before, and 0.071317 is the capital recovery factor, 6 7/8%, 50 years, which assumes that the enhancement is provided once and for all initially, and is hence amortized over the life of the project.

Hurricane Wave Damage Prevention Benefits

28. The following analysis is a method of calculating the benefits that would accrue to the establishment of a dune capable of providing structures at Folly Beach protection from wave damage due to hurricane storm surge. Hurricane storm surge is the increase in water level from the norm due to the action of the storm.

29. Flood protection, it must be stressed, is not afforded by the presence of a dune. Thus, flood damages are not a consideration in this analysis.

30. Four conditions are analyzed: (1) existing conditions, present dune configuration; (2) post construction of 12-foot msl dune; (3) post construction of a 15-foot msl dune; (4) and post construction of an 18-foot msl dune. Each dune provides protection from storms of increasing severity to one whose severity corresponds to a certain return period.

31. The method of analysis consisted of: (1) finding the number of structures on the ocean front (259); (2) classifying the structures according to foundation type; (3) calculation of damages accruing to each foundation type, combining them at hurricane tide stages (elevations above mean sea level); (4) from graphs of damage versus hurricane tide stage and frequency/return period versus hurricane tide stage finding total damages for each condition in each reach; and (5) calculation of benefits (or the difference in damages between existing conditions and the various proposed dunes).

ASSUMPTIONS

32. Certain key assumptions must be made at this level of stüdy before proceeding with computation of wave protection benefits.

33. Hurricane wave damages are generally believed to occur only to those structures on the ocean front. For the purposes of this analysis, these are the only structures considered. Groins, bulkheads, and paved areas were omitted. Also, the commercial structures (Arcade) and the fishing pier located between Station 3+70 North and Station 11+55 South were omitted from the analysis.

34. From a representative sample of structures on the ocean front, it was assumed that foundations could be grouped in three classifications. Structures had either slab foundations, were constructed on piles less than 8 feet in height, or were constructed on piles 8 feet and greater.

35. All structures above their foundations were treated as having the same capacity for resistance to wave damage. Some damage to piles, in the uppermost 2 feet, was assumed to occur. Complete destruction of structures, 5 feet above the foundation, and damages in the first 5 feet of building height (above the foundation) increasing non-linearly was also assumed.

36. Finally, while an average dune elevation is given, dunes at Folly Beach are not at all regular and are not existent in a large portion of the northeastern most reach analyzed (Referred to as Reach No. 2 on Fig. E-1).

GENERATION OF STAGE DAMAGE CURVES

37. Stage damage curves relate stillwater elevation (hurricane tide stage) to damage due to wave action. Their generation is the first step toward finding possible annual damages due to existing conditions and annual benefits due to the establishment of a dune.

38. The three dune heights under study: 12, 15 and 18 feet msl; will provide protection against storms with return periods of 25, 50, and 100 years, respectively.

39. Upon classification of the various foundation types, it is necessary to compute each's percent of the total, the percent contribution of each type to total damages at specific elevation intervals, and the total damages at these same intervals. (Tables E-17 and E-18).

40. These damages (total damages at various elevation intervals) are then plotted on a graph (stage damage) versus their elevation plus the average building elevation (relative to mean sea level - average building elevation is the existing condition) and/or the elevation plus the stillwater elevations corresponding to the various hurricane return periods. (Figures E-4 and E-5).

ANNUAL DAMAGES AND BENEFITS

41. Tables E-19 through E-26 present the total average annual damages for each condition in Reaches 2 and 3 (see Figure E-1). These

Table E-17

PHYSICAL DAMAGES EXPRESSED IN PERCENT

Foundation Classification	% of Total	WAVE ELEVATION ABOVE FOUNDATION 1' A	1' B	2' A	2' B	4' A	4' B	8' A	8' B	10' A	10' B	12' A	12' B	13' A	13' B
Slab	56.23	0.15	.0843	0.35	.1968	0.65	.3655	1.00	.5623	1.00	.5623	1.00	.5675	1.00	.5623
Piles (Less than 8')	17.24	0.00	.0000	0.00	.0000	0.10	.1720	0.20	.0395	0.40	.0690	0.80	.1379	1.00	.1724
Piles (8' or greater)	26.43	0.00	.0000	0.00	.0000	0.00	.0000	0.10	.0264	0.20	.6232	0.40	.1058	0.80	.2099
			.0893		.1968		.3827		.6232		.6842		.8060		.9496

Notes:

A. Fraction of individual structural damages per classification.

B. Fraction of structural damages per classification.

Table F-18

DAMAGES IN DOLLARS[1/]

	WAVE ELEVATION ABOVE FOUNDATION						
REACH NUMBER	1'	2'	4'	8'	10'	12'	13'
1	$145,000	$340,000	$660,000	$1,075,000	$1,180,000	$1,390,000	$1,630,000
2	400,000	930,000	1,800,000	2,940,000	3,230,000	3,800,000	4,460,000

1/ Average value of structure taken to be 25,000 dollars (Sample size of 87 structures - Total Number of structures - 259).

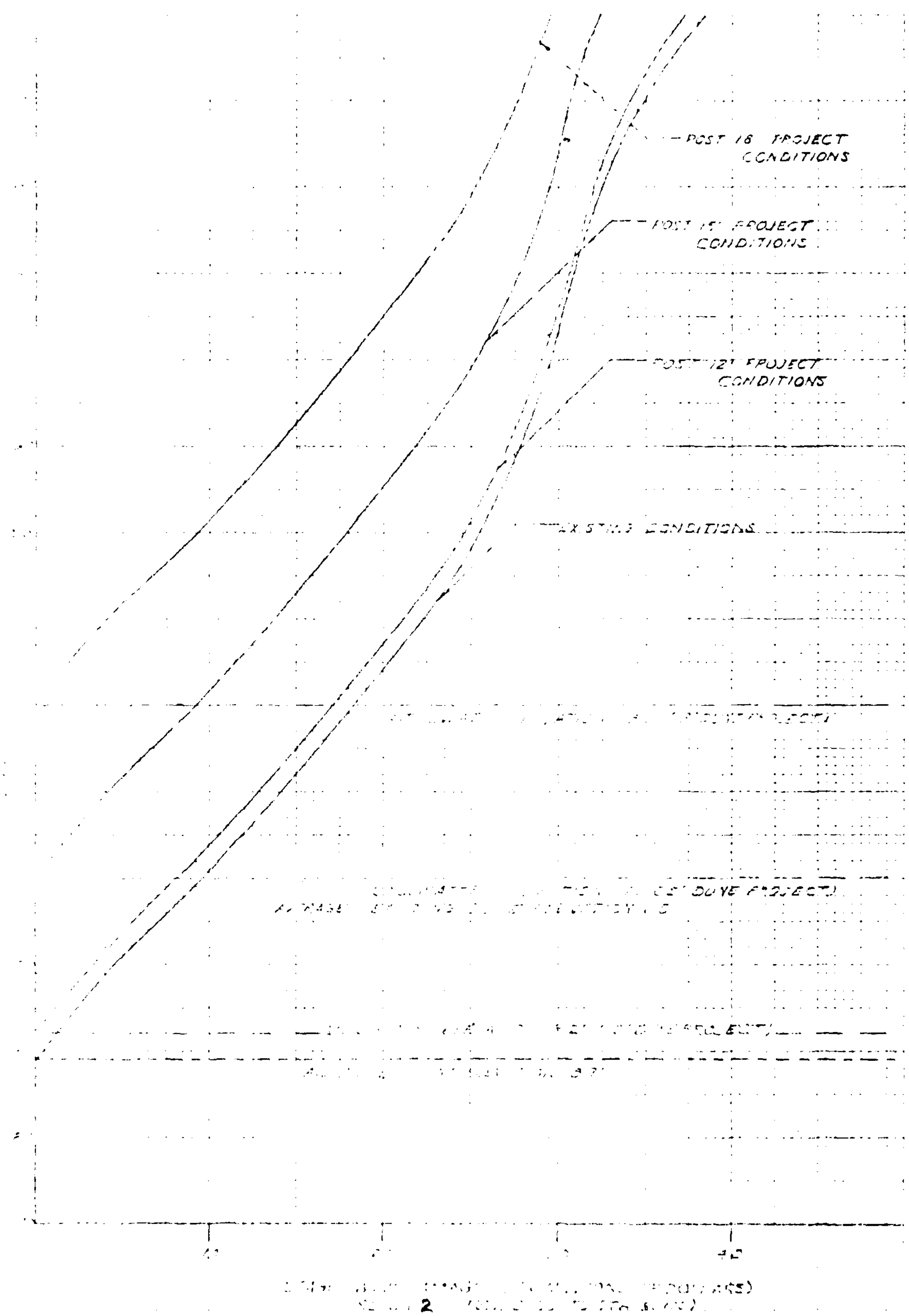
POST 16 PROJECT CONDITIONS
POST 15 PROJECT CONDITIONS
POST 12 PROJECT CONDITIONS
EXISTING CONDITIONS

Figure E-

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FOLLY BEACH, SOUTH CAROLINA. SURVEY REPORT ON BEACH EROSION CON--ETC(U)
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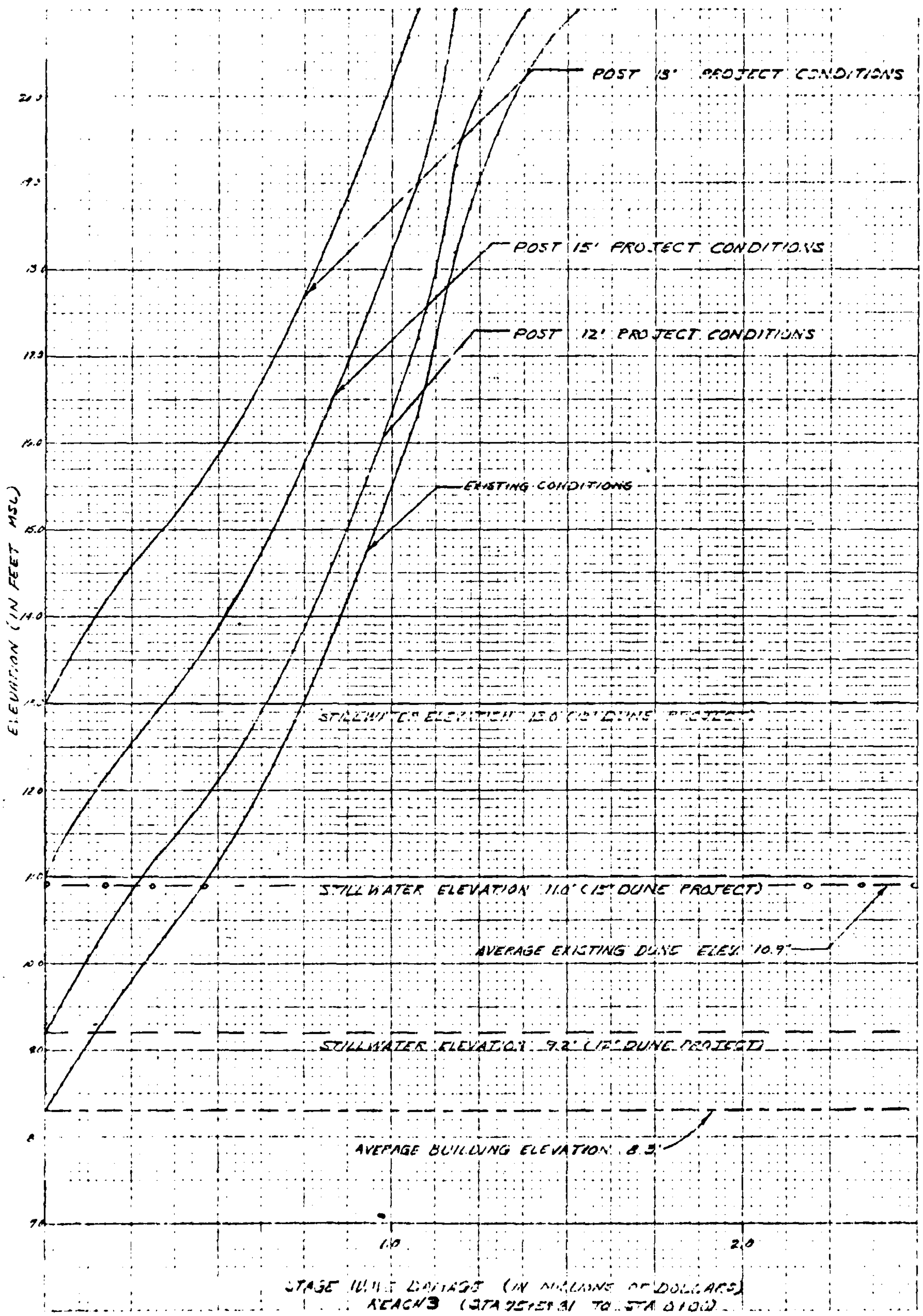
POST 18' PROJECT CONDITIONS
POST 15' PROJECT CONDITIONS
POST 12' PROJECT CONDITIONS
EXISTING CONDITIONS
STILLWATER ELEVATION 11.0' (15' DUNE PROJECT)
AVERAGE EXISTING DUNE ELEV. 10.9'
STILLWATER ELEVATION 9.2' (12' DUNE PROJECT)
AVERAGE BUILDING ELEVATION 8.5'
ELEVATION (IN FEET MSL)
1.0
2.0
STAGE DAMAGE (IN MILLIONS OF DOLLARS)
REACH 3

Figure E-5

totals represent the area under a damage-frequency curve (not shown). The computations within the tables represent a numerical method for summing the area under a damage frequency curve.

42. Table E-27 is a summation of average annual damages and annual benefits when each dune project under study is compared to existing conditions.

43. Summary of Hurricane Wave Damage Prevention Benefits. Equivalent annual damage under existing conditions amounts of $73,400. The analysis shows the relative inefficiency of an established 12-foot dune at Folly Beach. The dune will yield only $11,300 in equivalent annual benefits. Considerating future development, this would be increased to $12,900.

44. The 15-foot dune affords greater protection than the 12-foot dune with an annual benefit of $42,400 for existing development and $48,400 including future development.

45. Finally, the 18-foot dune affords the greatest protection, yielding an annual benefit of $58,800, increased to $67,100 with future development included.

Table E-19

AVERAGE ANNUAL DAMAGE COMPUTATION

Type of Damage HURRICANE WAVE Damage Stage 8.9' MSL

Reach Number 2 ~~Gage~~ Location FOLLY BEACH

Condition WITHOUT PROJECT

Frequency in years	Probable Occurrence	Incremental Probability	Elevation of WS (msl)	Damages in $1,000	Average	Damage Increment
		0.0020			5000	
500	0.0020		17.9	3000		
		0.0005			2968	[illegible]
400	0.0025		16.9	2935		
		0.0008			2883	[illegible]
300	0.0033		16.3	2830		
		0.0017			2700	[illegible]
200	0.0050		15.1	2570		
		[illegible]			2198	[illegible]
100	0.0100		13.0	1825		
		[illegible]			1705	[illegible]
80	0.0125		12.4	1585		
		[illegible]			1388	[illegible]
60	0.0167		11.5	1190		
		[illegible]			1070	
50	0.0200		11.0	950		
		[illegible]			855	[illegible]
40	0.0250		10.6	760		
		[illegible]			580	[illegible]
30	0.0333		9.8	400		
		[illegible]			265	[illegible]
20	[illegible]		9.2	120		
		[illegible]			105	[illegible]
[illegible]	[illegible]		9.1	80		
		0.0028			40	[illegible]
[illegible]	[illegible]		8.9	0		
		0.0031				
[illegible]	[illegible]					

TOTAL $ [illegible]

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Table E-20

AVERAGE ANNUAL DAMAGE COMPUTATION

Type of Damage HURRICANE WAVE Damage Stage 9.2' MSL

Reach Number 2 ~~Gage~~ Location FOLLY BEACH, S.C.

Condition WITH PROJECT (12' DUNE)

Frequency in years	Probable Occurrence	Incremental Probability	Elevation of WS (msl)	Damages in $1,000	- Average	Damage Increment $
		0.0020			2975	5950
[illegible]	[illegible]		17.9	2975		
		0.0005			2928	1464
[illegible]	0.0025		16.9	2880		
		0.0008			2820	2256
[illegible]	0.0033		16.3	2760		
		0.0017			2620	4454
200	0.0050		15.1	2480		
		0.0050			2090	10450
100	0.0100		13.0	1700		
		0.0025			1580	3950
[illegible]	0.0125		12.4	1460		
		0.0042			1258	5283
[illegible]	0.0167		11.5	1055		
		0.0033			928	3062
[illegible]	0.0200		11.0	800		
		0.0050			708	3540
[illegible]	0.0250		10.6	615		
		0.0083			500	4150
[illegible]	0.0333		9.8	385		
		0.0067			193	1290
[illegible]	0.0400		9.2	0		
		0.0041				
[illegible]	0.0441		9.1			
		0.0028				
[illegible]	0.0469		8.9			
		0.0031				
20	0.0500					

TOTAL $45,849

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Table E-21

AVERAGE ANNUAL DAMAGE COMPUTATION

Type of Damage HURRICANE WAVE Damage Stage 11.0' MSL

Reach Number 2 ~~Gage~~ Location FOLLY BEACH, S.C.

Condition WITH PROJECT, (15' DUNE)

Frequency in years	Probable Occurrence	Incremental Probability	Elevation of WS (msl)	Damages in $1,000	Average	Damage Increment $
		0.0020			2635	5270
500	0.0020		17.4	2635		
		0.0005			2563	1282
400	0.0025		16.9	2490		
		0.0008			2380	1904
300	0.0033		16.3	2280		
		0.0017			2050	3485
200	0.0050		15.1	1820		
		0.0050			1370	6850
100	0.0100		13.0	920		
		0.0025			775	1938
80	0.0125		12.4	630		
		0.0042			415	1743
60	0.0167		11.5	200		
		0.0033			100	330
50	0.0200		11.0	0		
		0.0050				
40	0.0250		10.6			
		0.0083				
30	0.0333		9.8			
		0.0067				
25	0.0400		9.2			
		0.0041				
22.7	0.0441		9.1			
		0.0028				
21.3	0.0469		8.9			
		0.0031				
20.0	0.0500					

TOTAL $22,802

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Table E-22

AVERAGE ANNUAL DAMAGE COMPUTATION

Type of Damage HURRICANE WAVE Damage Stage 13.0' MSL

Reach Number 2 ~~Gage~~ Location FOLLY BEACH, S.C.

Condition WITH PROJECT (18 FOOT DUNE)

Frequency in years	Probable Occurrence	Incremental Probability	Elevation of WS (msl)	Damages in $1,000	- Average	Damage Increment $
		0.0020			1950	3900
500	0.0020		17.4	1950		
		0.0005			1853	927
400	0.0025		16.9	1755		
		0.0008			1628	1302
300	0.0033		16.3	1500		
		0.0017			1238	2105
200	0.0050		15.1	975		
		0.0050			488	2440
100	0.0100		13.0	0		
		0.0025				
80	0.0125		12.4			
		0.0042				
60	0.0167		11.5			
		0.0033				
50	0.0200		11.0			
		0.0050				
40	0.0250		10.6			
		0.0083				
30	0.0333		9.8			
		0.0067				
25	0.0400		9.2			
		0.0041				
22.7	0.0441		9.1			
		0.0028				
21.3	0.0469		8.9			
		0.0031				
20.0	0.0500					

TOTAL $10,674

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Table E-23

AVERAGE ANNUAL DAMAGE COMPUTATION

Type of Damage HURRICANE WAVE Damage Stage 8.3' MSL

Reach Number 3 ~~Cage~~ Location FOLLY BEACH, S.C.

Condition WITHOUT PROJECT

Frequency in years	Probable Occurrence	Incremental Probability	Elevation of WS (msl)	Damages in $1,000	- Average	Damage Increment
		0.0020			1135	2270
500	0.0020		17.4	1135		
		0.0005			1123	562
400	0.0025		16.9	1110		
		0.0008			1090	872
300	0.0033		16.3	1070		
		0.0017			1015	1726
200	0.0050		15.1	960		
		0.0050			853	4265
100	0.0100		13.0	745		
		0.0025			695	1737
80	0.0125		12.4	645		
		0.0042			598	2512
60	0.0167		11.5	550		
		0.0033			513	1693
50	0.0200		11.0	475		
		0.0050			438	2190
40	0.0250		10.6	400		
		0.0083			325	2698
30	0.0333		9.8	250		
		0.0067			198	1327
25	0.0400		9.2	145		
		0.0100			95	950
20	0.0500		8.6	45		
		0.0075			23	173
17.4	0.0575		8.3	0		
		0.0092				
15	0.0667					

TOTAL $22,975

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Table E-24

AVERAGE ANNUAL DAMAGE COMPUTATION

Type of Damage HURRICANE WAVE Damage Stage 9.2' MSL

Reach Number 3 ~~Gage~~ Location FOLLY BEACH, S.C.

Condition WITH PROJECT (12' DUNE)

Frequency in years	Probable Occurrence	Incremental Probability	Elevation of WS (msl)	Damages in $1,000	- Average	Damage Increment $
		0.0020			1085	2170
500	0.0020		17.4	1085		
		0.0005			1065	533
400	0.0025		16.9	1045		
		0.0008			1020	816
300	0.0033		16.3	995		
		0.0017			937	1593
200	0.0050		15.1	880		
		0.0050			758	3790
100	0.0100		13.0	635		
		0.0025			593	1483
[illegible]	0.0125		12.4	550		
		0.0042			465	1953
60	0.0167		11.5	380		
		0.0033			333	1099
50	0.0200		11.0	285		
		0.0050			248	1240
40	0.0250		10.6	210		
		0.0083			148	1228
30	0.0330		9.8	85		
		0.0067			43	288
25	0.0400		9.2	0		
		0.0100				
20	0.0500		8.6			
		0.0075				
17.4	0.0575		8.3			
		0.0092				
15	0.0667					

TOTAL $ 16,193

SAN 120, 4/26/65

Table E-25

AVERAGE ANNUAL DAMAGE COMPUTATION

Type of Damage HURRICANE WAVE **Damage Stage** 11.0' MSL

Reach Number 3 ~~Gage~~ **Location** FOLLY BEACH, S.C.

Condition WITH PROJECT (15 FOOT DUNE)

Frequency in years	Probable Occurrence	Incremental Probability	Elevation of WS (msl)	Damages in $1,000	Average	Damage Increment $
		0.0020			920	1840
500	0.0020		17.4	920		
		0.0005			895	448
400	0.0025		16.9	870		
		0.0008			840	672
300	0.0033		16.3	810		
		0.0017			740	1258
200	0.0050		15.1	670		
		0.0050			505	2525
100	0.0100		13.0	340		
		0.0025			280	700
80	0.0125		12.4	220		
		0.0042			140	588
60	0.0167		11.5	60		
		0.0033			30	99
50	0.0200		11.0	0		
		0.0050				
40	0.0250		10.6			
		0.0083				
30	0.0333		9.8			
		0.0067				
25	0.0400		9.2			
		0.0100				
20	0.0500		8.6			
		0.0075				
17.4	0.0575		8.3			
		0.0092				
15	0.0667					

TOTAL $8,130

SAN 120, 4/26/65

Table E-26

AVERAGE ANNUAL DAMAGE COMPUTATION

Type of Damage *HURRICANE WAVE* Damage Stage *13.0' MSL*

Reach Number *3* ~~Gage~~ Location *FOLLY BEACH, S.C.*

Condition *WITH PROJECT (15 FOOT LINE)*

Frequency in years	Probable Occurrence	Incremental Probability	Elevation of WS (msl)	Damages in $1,000	Average	Damage Increment $
		0.0020			715	1430
500	0.0020		17.9	715		
		0.0005			683	342
400	0.0025		16.9	650		
		0.0008			608	486
300	0.0033		16.3	565		
		0.0017			450	765
200	0.0050		15.1	335		
		0.0050			168	840
100	0.0100		13.0	0		
		0.0025				
80	0.0125		12.4			
		0.0042				
60	0.0167		11.5			
		0.0033				
50	0.0200		11.0			
		0.0050				
40	0.0250		10.6			
		0.0083				
30	0.0330		9.8			
		0.0067				
25	0.0400		9.2			
		0.0100				
20	0.0500		8.6			
		0.0075				
17.4	0.575		8.2			
		0.0072				
15	0.167					

TOTAL *$3863*

SAN 120, 4/26/65

Table E-27

SUMMARY OF HURRICANE WAVE DAMAGE PREVENTION BENEFITS

		Average Annual Damage		Annual Benefits	
Reach	Location	Without Project	With Project	Existing Development	Future Development[1/]
	12-foot Dune				
2	Sta 75+54.81 - Sta 0+00	$22,975	$16,193	$ 6,782	
3	Sta 0+00 - Sta 180+00	50,402	45,849	4,553	
	TOTAL	$73,377	$62,042	$11,335	$12,922
	15-foot Dune				
2	Sta 75+54.81 - Sta 0+00	$22,975	$ 8,130	$14,845	
3	Sta 0+00 - Sta 180+00	50,402	22,802	27,600	
	TOTAL	$73,377	$30,932	$42,445	$48,387
	18-foot Dune				
2	Sta 75+54.81 - Sta 0+00	$22,975	$ 3,863	$19,112	
3	Sta 0+00 - Sta 180+00	50,402	10,674	39,728	
	TOTAL	$73,377	$14,537	$58,840	$67,078

[1/] Future development was computed by multiplying benefits to existing development by the factor 1.14. Derivation of the future development factor is discussed in Paragraph 25 of this Section.

Summary of Benefits

46. A summary of total annual benefits which would result from the various plans of improvements is shown in Table E-28.

TABLE E-28

SUMMARY OF TOTAL ANNUAL BENEFITS

PLAN	TYPE OF BENEFIT					
	RECREATIONAL	LAND-LOSS PREVENTION	BUILDING DAMAGE PREVENTION	LAND ENHANCEMENT	HURRICANE WAVE-DAMAGE PROTECTION	TOTAL ANNUAL BENEFITS
A-0	$ 681,500	$ 119,200	$ 51,700	$ 34,800	$ 0	$ 887,200
A-1	748,000	119,200	51,700	34,800	0	953,700
A-2	771,800	119,200	51,700	34,800	0	977,500
A-3	760,600	119,200	51,700	34,800	0	966,300
A-4	760,600	177,200	76,900	45,900	0	1,060,600
A-5	760,600	177,200	76,900	45,900	0	1,060,600
B-1	738,100	177,200	76,900	45,900	12,900	1,051,000
B-2	738,100	177,200	76,900	45,900	48,400	1,086,500
B-3	738,100	177,200	76,900	45,900	67,100	1,105,200

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SECTION F

DESIGN AND COST ESTIMATES

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DESIGN AND COST ESTIMATES

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SECTION F

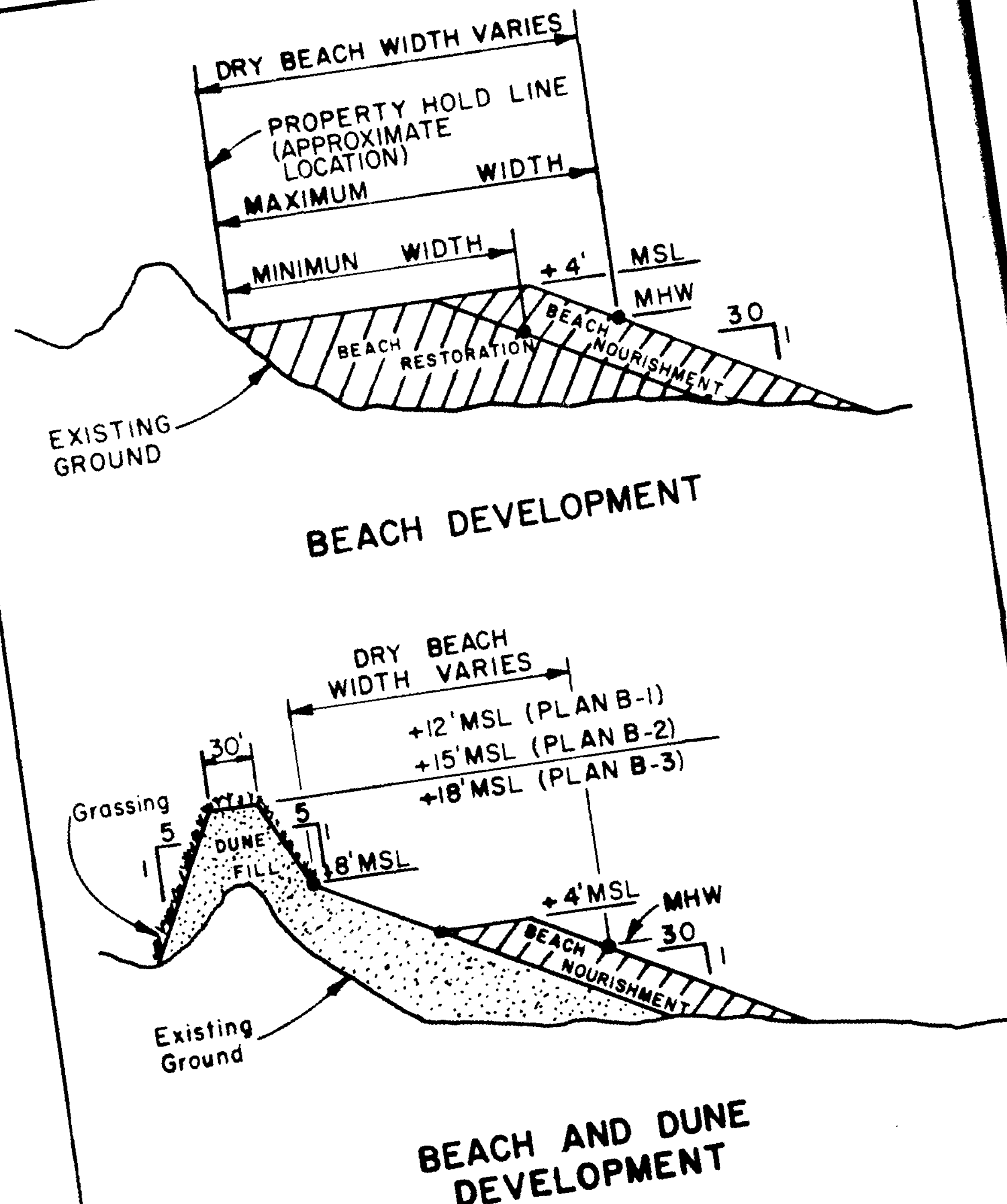
DESIGN AND COST ESTIMATES

Introduction to Alternative Plans

1. This section of the report discusses the details of design and the estimated cost of alternative structural plans of improvement which were considered in Phase 3 of the evaluation process. These plans include six "Beach Development" plans and three "Beach and Dune Development" plans. Plans are described in Sections E and G and economic benefits are evaluated in Section E. Typical cross-sections of the two types of beach-fill structures are shown in Figure F-1 and a map displaying project lengths is provided in Figure F-2. Detailed discussions of the problems are contained in Section C, "Problems and Needs."

2. Beach Development Plans. These plans consist of a beach berm which would serve as a wearing surface against erosive forces while maintaining varying amounts of dry beach area for recreational use. A program of periodic renourishment would be used to maintain design beach dimensions.

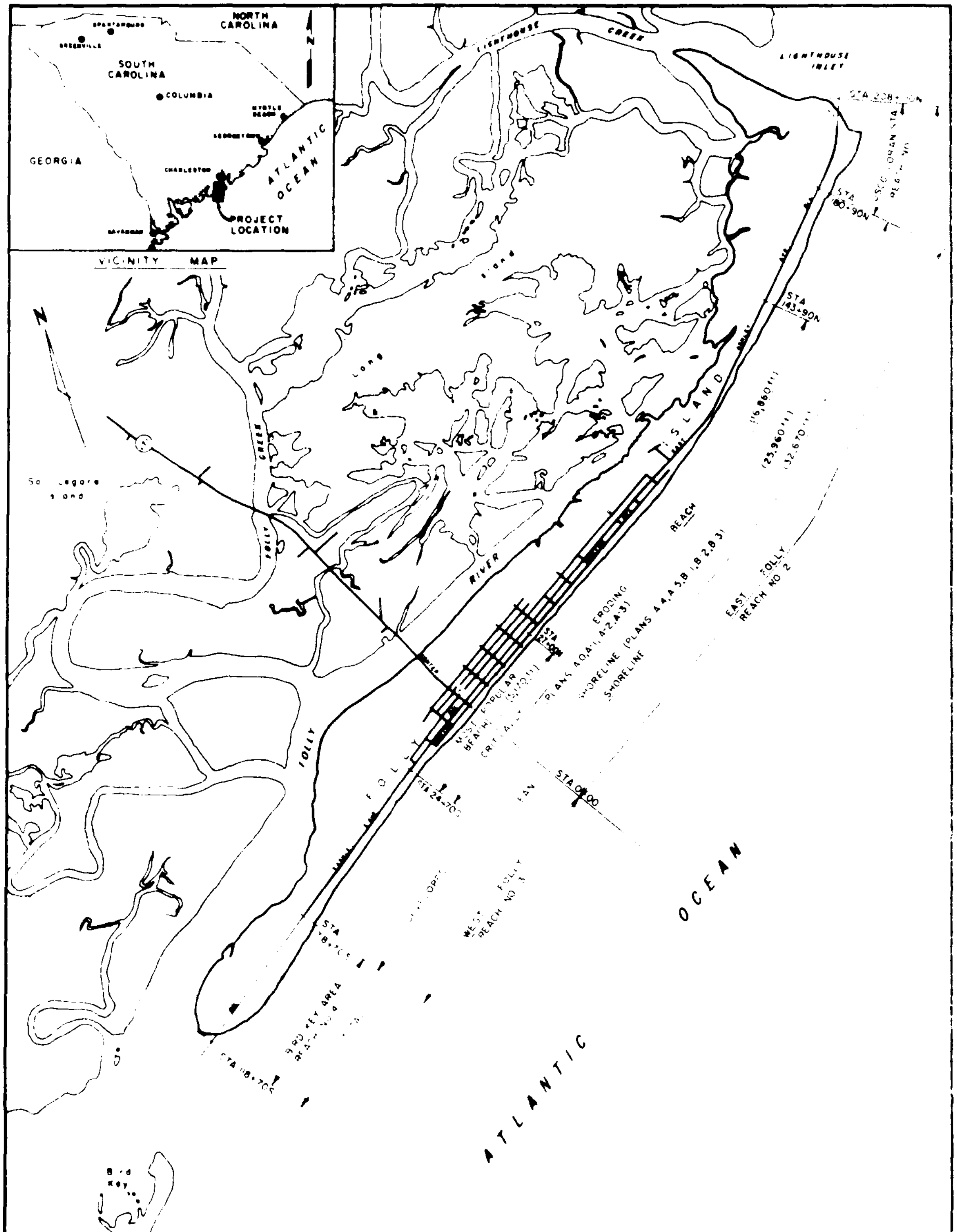
3. Beach and Dune Development Plans. These plans provide for a continuous beach and dune restoration fill to provide protection from storm waves, and a sacrificial beach for erosion protection. The dune would have a vegetative cover to prevent wind and water runoff erosion. Dune maintenance and periodic beach renourishment would be required for each of these alternative plans.



TYPICAL SECTIONS OF CONSIDERED PLANS AT FOLLY BEACH, S.C.

NOTE:
0' MSL = 2.4' MLW

REV. 28 MAR. '80 FIGURE F-1



LOCATION OF CONSIDERED PLANS OF IMPROVEMENTS
FOLLY BEACH
SOUTH CAROLINA

FIGURE F-2

Design

DESIGN EROSION RATES

4. Two different erosion rates were developed for use in the design of the artificial fill. These are based on historical erosion rates and an analysis of the effects of existing protective structures.

5. Along that reach of shore lying between stations 24+70S and 143+90N (16,860 feet), erosion of about seven feet per year occurred during the 22 year period 1955 to 1977. Most of the groins now found along the beach were constructed during this period (See Section C for a record of construction). Based on a comparison of historical erosion rates experienced during the 22 year period with those that occurred prior to 1949, it was determined that the groins along the beach are about 50% effective at reducing erosion. Had the groins not been constructed during the analysis period, the average erosion rate along this reach probably would have been ten feet a year. Likewise, had the system been complete, the rate would have been about five feet per year. This is about the same average annual rate of erosion as the historical rate since the earliest available shoreline record in the year 1849. This rate was used in the computations of the volumes of fill needed for the various alternative corrective works considered for the reach of shoreline in question.

6. In some of the alternative plans, contiguous beach nourishment was considered for an additional 9,100 feet of shoreline. Of this 5,400 feet lies southwest and 3,700 feet lies northeast of the previously discussed reach. Again, taking into account the effectiveness of the groin system, the design erosion rate for these shore segments is estimated at 2.5 feet per year.

BEACH DIMENSIONS

7. Reaches of improvements. The reaches of shoreline requiring restoration and nourishment were determined on the basis of hazards to real property and the need for recreational space. The reach having the greatest risk to real property is that 16,860 foot reach now eroding at a rate of 5 feet per year. Plans A-0 through A-3 provide for the protection and improvement of this reach. A sub-reach at the southwestern end of this, 5,170 feet long, is considered separately because of the concentration of beach use demand on this segment. This high demand stems from the closeness to the beach of off street parking and the availability of sanitary facilities, amusements, and other public facilities.

8. The remainder of the developed shoreline, 9,100 feet, is included in the other plans evaluated. The shoreline has experienced a high rate of erosion in the past, but, the recent trend appears to be less serious erosion with expected future rates being estimated at 2-1/2 feet per year.

9. It was determined from earlier planning phases that protection of the ocean shoreline at the U. S. Coast Guard Loran Station (Reach 1) and along the undeveloped southwest end (Reach 4) is not economically justified. It was also determined that considered hurricane dune protection should be continuous along all of the developed shoreline (25,960 feet).

10. Shore protection profiles. Shore protection profiles are designed to conform to the natural shore profile. A typical profile is shown in Figure F-1. The berm elevation of 4 feet above m.s.l. is slightly higher than the normal berm and the average high spring tides to preclude frequent overtopping. The natural berm width is increased to provide sufficient width for recreational demand, and

sacrificial sands (nourishment strand). The foreshore beach slope is designed at 30 horizontal to one vertical. Beach widths (measured from the landward end of the berm to the mean low water level on the beach slope) are considered in 50-foot increments up to 150 feet. Wider widths are evaluated for reaches where projected use is greatest. Where existing shore profiles equal or exceed design dimensions, addition of fill is not required.

11. Beach and dune protection profile. Three other optional profiles considered provide dunes to protect against hurricane wave action, one with an elevation of 12 feet, MSL (Plan B-1), one with an elevation of 15 feet, MSL (Plan B-2), and the last with an elevation of 18 feet, MSL (Plan B-3). Dune crest width for each of these options is 30 feet. Each of these options is considered as an increment to Plan A-5. Dune side slopes are designed at 5 horizontal to one vertial on the landward side, and to elevation 8 feet, MSL on the seaward side, and 30 horizontal to one vertical from elevation 8 feet msl to the natural or artificial berm level.

12. The dune crest elevation of 18 feet, MSL (Plan B-3), is designed to protect against a 100-year frequency hurricane tide which would have a still-water surface elevation of about 13.2 feet, MSL. The dune elevation in Plan B-2 of 15 feet, MSL, is designed for a 50-year hurricane tide with a still-water surface elevation of 11.0 feet, MSL, and the 12-foot dune (Plan B-1) would give hurricane wave protection for approximately the 25 year storm. Storm surge computations are included in Section C of this appendix. Existing dune remnants in the project area are incorporated in the design sections.

13. A summary of "Beach Development" and "Beach and Dune Development" plans is given in Table F-1.

TABLE F-1

SUMMARY OF BEACH DEVELOPMENT AND DUNE DEVELOPMENT PLANS

Plan	STA 24+70S to 27+00N Avg. Berm Width (Ft.)	STA 27+00N to 143+90N Avg. Berm Width (Ft.)	STA 143+90N to 180+90N Avg. Berm Width (Ft.)	STA 24+70S to 78+70S Avg. Berm Width (Ft.)	STA 78+70S to 180+90N Dune Elevation (Ft. msl)
A-0	50	50	---	---	---
A-1	100	50	---	---	---
A-2	150 1/	50	---	---	---
A-3	150 1/	100	---	---	---
A-4	100	50	50	50	---
A 5	150 1/	100	50	50	---
B-1 2/	---	---	---	---	+12
B-2 2/	---	---	---	---	+15
B-3 2/	---	---	---	---	+18

1/ Plan will require lengthening each of six existing groins 100 ft. seaward.
2/ Plan will require lengthening each of fifteen groins.

VOLUME OF FILL

14. The amount of beach fill required for initial construction is based on profiles surveyed in April 1977. These are shown in Section H of Appendix 1. Materials placed will satisfy one of four purposes. These are restoration, nourishment, private fill and dune construction. As the material is being placed, it is subjected to the natural sorting of waves, tides and currents. Borrow material will be taken from shoal areas in Lighthouse Inlet to the northeast of Folly Island and in Stono Inlet to the southwest. The material in Folly River was found to be suitable for these purposes but this site was considered less desirable since it would cause more damage to the environment and the amount of suitable material is less plentiful than in the ocean borrow area. Assumptions concerning the effects of sorting on quantities of material required by class are discussed below and displayed in Table F-2.

15. In Place Volumes. This volume was computed using the average end area method. End areas were developed by superimposing the design sections on the April 1977 beach profiles. Typical sections were spaced about 1,500 feet apart.

16. Adjusted Fill Volumes. Using procedures developed by James 1975, the number of yards of borrow material necessary to produce one cubic yard of stable sand on the beach after the natural sorting and winnowing processes have taken place was computed. This procedure was also used to predict the rate of erosion of the borrow material when compared with the rate of erosion of the native beach sand in order to determine the renourishment amounts required. Details concerning application of these methods are given in Section D.

17. Laboratory analyses of soil samples taken from holes drilled in potential borrow sites indicated that adjusted fill factors vary from 1.2 for material in Folly River to 1.4 for borrow sand from offshore areas at each end of Folly Island. Renourishment factors were determined to be less than the one for both Folly River borrow material and for material from offshore inlet shoals, thus 1.00 was used. Due to the uncertainties of natural forces which affect beach erosion, CERC has recommended using the more conservative 1.00 R_J value. This is discussed in paragraph 7a of Section D of this Appendix.

18. Folly River Navigation Project Potential. If the Folly River borrow area was used, some of the material needed for nourishment of Folly Beach may be provided through the maintenance efforts performed on channel shoals of the Folly River small navigation project. Maintenance on this element of the navigation project is expected to be performed at a five year interval using a pipeline hydraulic dredge. With renourishment of the beach also being required at a five year interval, contract requirements for both could be incorporated into a single contract thereby effecting beneficial useage of material removed from shoal hazards. Quantities available from the navigation project for use as beach nourishment are in the neighborhood of about 16,000 cubic yards every five years.

19. Volume of fill required for initial placement includes beach restoration, fill on private land, advance nourishment, and dune construction. These components of beach fill would be subjected to the sorting action of the waves to different degrees depending on their location along the beach profile. Material used for private fill would not be subjected to wave action, beach nourishment material would be 100 percent subjected to sorting, and restoration and dune contruction sands are assumed to be 50 percent sorted. A sample computation of adjusted fill requirements is shown on Page F-7 and a summary of these computations is presented in Table F-2.

TABLE F-2

VOLUME OF FILL
(1,000 cubic yards)

Plan	Class	In Place Requirement	Overfill Requirement	Total Borrow
A-0	Restoration (R)	233	47	280
	Private Fill (P)	50	0	50
	Nourishment (N)	253	101	354
	Total	536	148	684
A-1	R	319	64	383
	P	50	0	50
	N	253	101	354
	Total	622	165	787
A-2	R	384	77	461
	P	50	0	50
	N	253	101	354
	Total	687	178	865
A-3	R	613	123	736
	P	50	0	50
	N	253	101	354
	Total	916	224	1140
A-4	R	410	82	492
	P	60	0	60
	N	321	128	449
	Total	791	210	1001
A-5	R	690	138	828
	P	60	0	60
	N	321	128	449
	Total	1071	266	1337
B-1	Dune Construction (D)	998	200	1198
	R	690	138	828
	P	60	0	60
	N	321	128	449
	Total	2069	466	2535
B-2	D	1735	347	2082
	R	690	138	828
	P	60	0	828
	N	321	128	449
	Total	2806	613	3419
B-3	D	2607	521	3128
	R	690	138	828
	P	60	0	60
	N	321	128	449
	Total	3678	787	4465

FOLLY BEACH BORROW VOLUME NEEDS

PLAN A-O (THOUSANDS CU. YD.)

	1	2	3		4	5
	Total native sand reqd	Not Subject to Sorting (Native Borrow)	Subject to sorting (Native)	X	Subject to sorting (Borrow Volume)	Total borrow volume reqd (2)+(4)
INITIAL SAND PLACEMENTS:						
1. RESTORATION (subject to sorting 50%)	233	116.5	116.5	(R_A=1.40)	163.1	279.6
2 FILL ON PRIVATE LAND (none subject to sorting)	50	50	0		0	50.0
3. ADVANCED NOURISHMENT, sufficient for 5 years (all subject to sorting)	253	0	253	(R_A 1/ 1.40)=354.2		354.2
4. Total Initial Requirements:	536	·				683.8
TOTAL 50-YEAR PERIODIC NOURISHMENT REQUIREMENTS:						
5. At 5 year intervals (years 0, 5, 10, ...45) of the 50 year project life the volumes shown on line 3 will be required; and for the whole project life, 10 times the amounts on line 3, which amounts to..........	2,530					3.542
TOTAL 50-YEAR SAND PLACEMENT						
6. For the total project life the total sand requirements will be: (1) + (2) + (5)	2,813					3,872

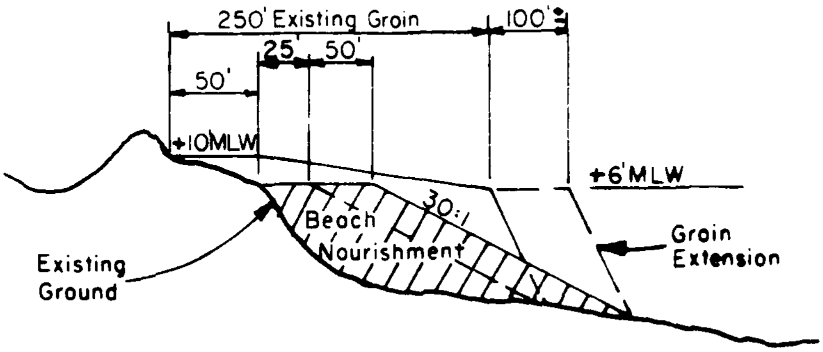
.....FOR THE SPECIFIED BORROW MATERIAL

1/ Assuming a R_J value of 1.00

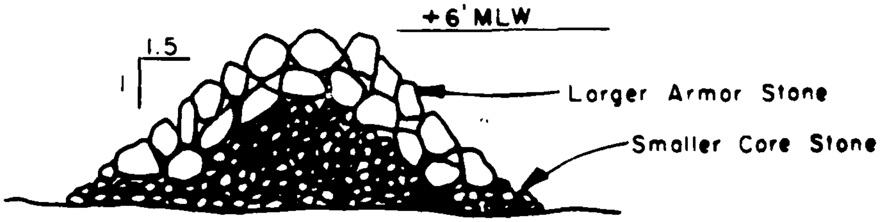
20. Beach Renourishment. That volume of fill classified as nourishment in Table F-2 will serve as a sacrificial strand which will require periodic replacement. Volumes shown are those representing five years of exposure assuming average annual erosion rates previously discussed. The same fill factors are applied in the computations of renourishment requirements as those applied in the computation of the original nourishment requirement. From the computed renourishment factor it appears that the borrow material, after sorting action, may erode at a lower rate than the native beach sand but due to the unknowns of natural forces such as winds, waves, storms, and tides, a more conservative 1.00 renourishment factor was considered appropriate and was recommended by CERC. Fill factors and renourishment values are discussed in Section D of this Appendix.

GROINS

21. Groin construction would consist of extending existing South Carolina Highway Department groins oceanward to protect nourishment which extends beyond their present terminal uses. Figure F-3 shows a typical section for groin extention. Alternatives A-2, 3 and 5 and B-1, 2 and 3 would require some extentions. Lengths are recorded in the Estimated First Cost table which follows this discussion on Design.



BEACH PROFILE



TYPICAL SECTION

not to scale

GROIN CONSTRUCTION

FIGURE F-3

DUNE VEGETATION

22. Purpose and selection. Included in dune design was vegetation for the prevention of erosion by wind and water runoff. Vegetation also creates a trap for materials blown onto the dune from other sources and thereby provides the means for natural renewal and growth. All of the dunes would be grassed down to existing ground on the landward side and to elevation +8 feet msl on the seaward side. The most satisfactory plants are long-lived perennials with extensive root systems. These spread rapidly, either vegetatively or by seed, and maintain surface growth even though sand accumulates around them. Plants of this type, recommended for South Carolina, are shown in the following table.

TABLE F-3

DUNE STABILIZATION PLANTS

Common Name	Scientific Name
American beach grass	Ammorphila breviligulata
Sea oats	Uniola paniculata
Running beach grass or bitter panicum	Panicum amarum
Silver beach grass	Panicum amarulum

23. Berm and dune maintenance. For feasibility and formulation purposes, the quantity of sand lost annually from the dune and berm is estimated to be 0.4 cubic yards per linear foot for the 12-foot msl dune, 0.5 cubic yards for the 15-foot dune, and 0.6 cubic yards for the 18-foot dune. Rates vary due to differences in volume of the structures and their exposure to destructive forces. Dune and berm maintenance is expected to be accomplished by land-based earthmoving equipment. Maintenance would be done every five years with the beach renourishment operation and would be about 52,000 cubic yards, 65,000 cubic yards and 78,000 cubic yards respectively for 12-foot, 15-foot and 18-foot dunes.

BEACH MONITORING PROGRAM

24. To insure timely renourishment and to evaluate the performance of artificially placed materials, a routine monitoring program will be laid out and implemented. The program will include the collection and analysis of data on beach profiles, soil composition, and volumetric changes with respect to time. Profiles will extend seaward to the -6 ft. MLW depth and sand samples will be taken at: Mid berm, foreshore slope (above MLW), and -6 ft. MLW. Established profiles which will be monitored (shown on Figure H-1, Section H of Appendix 1) include:

(1)	STA 95+555	(7)	STA 60+87 N
(2)	STA 76+925	(8)	STA 91+29 N
(3)	STA 45+455	(9)	STA 120+68 N
(4)	STA 15+275	(10)	STA 140+90 N
(5)	STA 0+00	(11)	STA 158+26 N
(6)	STA 30+52 N	(12)	STA 195+03 N

25. These profiles should be surveyed and initial sand samples taken prior to placement of any beach fill material. Following placement of the recommended fill, surveys and sand sampling will be done once per year for the first 5 years, once during year 7 and 10 and every 5 years thereafter until the end of the 50-year project life.

First Costs

26. First cost estimates for the alternative plans of improvement which are considered for detailed analysis are shown in Table F-5 Price level is April 1979.

COST ESTIMATES OF FILL MATERIAL

27. Cost estimates of fill material. Estimates of beach fill material costs are based on hydraulically dredging about one-half the fill from Stono Inlet and the other half from Lighthouse Inlet. Use of Stono Inlet or Folly River as a source of materials for the northeastern reaches would be impractical due to long pumping distances. Likewise taking all the material from Lighthouse Inlet would involve long pumping distances. It has been determined that the best method that can be employed is to use two source areas and that the Folly River source should not be used, as previously discussed. Average unit cost of using this scheme would be about $2.40 per cubic yard. Mobilization and demobilization cost would be $120,000. These same costs were used for computations of periodic nourishment costs since the quantity of borrow material would be large if done every five years. Listed below are the estimated costs using the various schemes for obtaining borrow material.

Scheme for Comparing Borrow Areas	Average Pumping Distance (feet)	Unit Cost of Borrow Material ($ per cu. yd.)	Mobilization and Demobilization Cost ($)
All from Stono Inlet	20,500	3.20	160,000
All from Folly River	15,500	2.45	130,000
All from Lighthouse Inlet	16,500	3.00	150,000
Lighthouse Inlet & Stono Inlet	15,000	2.40	120,000
Lighthouse Inlet & Folly River	12,000	2.10	110,000

COST OF GROINS

28. Cost of extending groins at South Carolina beaches is currently running at $400 per linear foot. This figure is used as the unit cost for estimates contained herein.

COST OF DUNE VEGETATION

29. Cost of providing vegetation on artificial dunes is based on Charleston District experience with similar plantings on the dikes at Morris Island, S. C., and Wilmington District experience on dunes at Wrightville and Carolina Beaches, N. C. Costs are based on machine-planting. Initial cost of planting and fertilizing is approximately $1,500 per acre. Average annual maintenance cost is estimated at $50 per acre.

COST OF BEACH MONITORING PROGRAM

30. The initial cost of the monitoring program is estimated to be $7,000 and the annual cost is estimated at $3,700. These costs are summarized in Table F-4.

TABLE F-4

BEACH MONITORING PROGRAM COST

ITEM	AMOUNT
FIRST COST	
Profile surveys and collection of sand samples	$2,000
Sand sample analysis (36 @ $50)	1,800
Report preparation	2,000
SUBTOTAL	$5,800
Contingencies (20%)	1,200
TOTAL COST	$7,000

AVERAGE ANNUAL COST

$7,000 x ($\Sigma$ present value factors) x (capital recovery factor) =

$7,000 x 7.46904 x 0.071317 = $3,700

SUBTOTAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Contingencies	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Engineering and Design	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Supervision and Administration	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SUBTOTAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Beach Monitoring Program	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL FEDERAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NON-FEDERAL										
Beach Fill	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Contingencies	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total Construction Cost	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Engineering and Design	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Supervision and Administration	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Subtotal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Land Costs	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL NON-FEDERAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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Renourishment and Dune Maintenance Costs

30. Periodic renourishment and/or dune maintenance is anticipated to be required about every five years. Estimated cost of each operation for alternative plans is shown in Table F-6.

TABLE F-6

ESTIMATED RENOURISHMENT AND DUNE MAINTENANCE COSTS (5-Year Periods)

(April 1979 Price Level)

ITEM	PLAN A-0 Total Length = 16,860' Length (A) = 5,170' BW=50' Length (B) = 11,690' BW=50' Length (C) = 0 BW=0		PLAN A-1 Total Length = 16,860' L(A) = 5,170 BW=100' L(B) = 11,690' BW=50' L(C) = 0 BW = 0		PLAN A-2 Total Length = 16,860' L(A) = 5,170' BW = 150' L(B) = 11,690' BW = 50' L(C) = 0 BW = 0		PLAN A-3 Total Length = 16,860' L(A) = 5,170' BW = 150' L(B) = 11,690' BW = 100' L(C) = 0 BW = 0	
	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
FEDERALLY SHARED								
Mobilization & Demobilization		$ 120,000		$ 120,000		$ 120,000		$ 120,000
Beach Nourishment @ $2.40 per cu. yd.	354,000cy	850,000	354,000cy	850,000	354,000cy	850,000	354,000cy	850,000
Subtotal		970,000		970,000		970,000		970,000
Contingencies @ 20%		194,000		194,000		194,000		194,000
Total Fed. Shared Construction Cost		$1,164,000		$1,164,000		$1,164,000		$1,164,000
Engineering & Design @ 5%		58,000		58,000		58,000		58,000
Supervision & Administration @ 6%		70,000		70,000		70,000		70,000
TOTAL FEDERALLY SHARED 5-YR COST		$1,292,000		$1,292,000		$1,292,000		$1,292,000
NON-FEDERAL (NO COST SHARING)								
Dune Maintenance Soil @ $2.40 per cu. yd., Vegetation & Fertilization @ $250 per acre								
Subtotal								
Contingencies @ 20%								
Total Non-Federal Construction Cost								
Engineering & Design @ 5%								
Supervision & Administration @ 6%								
TOTAL NON-FEDERAL ONLY 5 YR COST								
TOTAL 5-YEAR COST		$1,292,000		$1,292,000		$1,292,000		$1,292,000

ITEM	PLAN A-[illegible] Total Length = 25,960' L(A) = [illegible] BW = 150' L(B) = 11,690' BW = [illegible] L(C) = [illegible]1/ BW = [illegible]		PLAN A-5 Total Length = 25,960' L(A) = 5,170' BW = 150' L(B) = 11,690' BW = 100' L(C) = 9,100'1/ BW = 50'		PLAN B-1 Total Length = 25,960' Dune Height = 12'MSL		PLAN B-2 Total Length = 25,960' Dune Height = 15'MSL		PLAN B-3 Total Length = 25,960 Dune Height = 18'msl	
	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
FEDERALLY SHARED										
Mobilization & Demobilization		$ 120,000		$ 120,000		$ 120,000		$ 120,000		$ 120,000
Beach Nourishment @ $2.40 per cu. yd.	449,000 cy	1,078,000	449,000 cy	1,078,000	449,000 cy	1,078,000	449,000 cy	1,078,000	449,000cy	1,078,000
Subtotal		1,198,000		1,198,000		1,198,000		1,198,000		1,198,000
Contingencies @ 20%		240,000		240,000		240,000		240,000		240,000
Total Fed. Shared Construction Cost		$1,438,000		$1,438,000		$1,438,000		$1,438,000		$1,438,000
Engineering & Design @ 5%		72,000		72,000		72,000		72,000		72,000
Supervision & Administration @ 6%		86,000		86,000		86,000		86,000		86,000
TOTAL FEDERALLY SHARED 5-YR COST		$1,596,000		$1,596,000		$1,596,000		$1,596,000		$1,596,000
NON-FEDERAL (NO COST SHARING)										
Dune Maintenance Soil @ $2.40 per cu. yd., Vegetation & Fertilization @ $250 per acre					52,000cy 48 acres	$125,000 12,000	65,000 cy 60 acres	$156,000 15,000	78,000 cy 78 acres	$187,000 20,000
Subtotal						$ 137,000		$ 171,000		$ 207,000
Contingencies @ 20%						27,000		34,000		41,000
Total Non-Federal Construction Cost						$ 164,000		$ 205,000		$ 248,000
Engineering & Design @ 5%						8,000		10,000		12,000
Supervision & Administration @ 6%						10,000		12,000		15,000
TOTAL NON-FEDERAL ONLY 5 YR COST						182,000		227,000		275,000
TOTAL 5-YEAR COST		$1,596,000		$1,596,000		$1,778,000		$1,821,000		$1,871,000

1/This is the 3,700 feet northeast of the 16,860-foot projects and 5,400 feet southwest of the 16,860-foot projects.

Annual Costs

31. Average annual cost computed for alternative plans are given in Table F-7. Analyses are based on a project life of 50 years and an interest rate of 6-7/8 percent.

TABLE F-7

ESTIMATED AVERAGE ANNUAL COST

(April 1979 Price Level, Interest Rate = 6-7/8 $, Project Life = 50 Years)

Item	PLAN A-0 First Cost or 5-yr Cost	PLAN A-0 Average Annual Cost	PLAN A-1 First Cost or 5-yr Cost	PLAN A-1 Average Annual Cost	PLAN A-2 First Cost or 5-yr Cost	PLAN A-2 Average Annual Cost	PLAN A-3 First Cost or 5-yr Cost	PLAN A-3 Average Annual Cost	PLAN A-4 First Cost or 5-yr Cost	PLAN A-4 Average Annual Cost	PLAN A-5 First Cost or 5-yr Cost	PLAN A-5 Average Annual Cost	PLAN B-1 First Cost or 5-yr Cost	PLAN B-1 Average Annual Cost	PLAN B-2 First Cost or 5-yr Cost	PLAN B-2 Average Annual Cost	PLAN B-3 First Cost or 5-yr Cost	PLAN B-3 Average Annual Cost
FEDERALLY SHARED																		
Interest and Amortization (0.071317 x Fed. Shared First Cost)	$[illegible],193,000	[illegible]	$2,[illegible],000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	$[illegible]	[illegible]	$4,[illegible],000	$325,900	$8,975,000	$640,000	$12,623,000	$900,200	$17,069,000	$1,217,300
Beach Nourishment (0.071317 x 2.40838[1] x 5-yr Fed. Shared Cost)	[illegible],292,000	[illegible]	1,292,000	221,900	1,292,[illegible]	[illegible]	[illegible],292,000	[illegible]	1,596,000	[illegible]	[illegible]	274,100	1,596,000	274,100	1,596,000	274,100	1,596,000	274,100
Beach Monitoring Program Cost[2]		3,700		[illegible]		3,700		[illegible]		3,700		3,700		3,700		3,700		3,700
TOTAL FEDERALLY SHARED ANNUAL COST		$382,[illegible]		$40[illegible]		[illegible]		[illegible]		$5[illegible],200		$603,700		$917,800		$1,178,000		$1,495,100
NON-FEDERAL (NO COST SHARING)																		
Interest and Amortization (0.071317 x Non-Federal Only First Cost)	200,000	[illegible]	200,000	14,300	[illegible]	[illegible]	200,000	[illegible]	[illegible]	[illegible]	[illegible]	16,800	660,000	47,100	660,000	47,100	660,000	47,100
Dune Maintenance (0.071317 x 2.40838[1] x 5-yr Non-Federal Only Cost)	[illegible]	[illegible]	[illegible]	0	[illegible]	[illegible]	0	[illegible]	0	[illegible]	0	[illegible]	182,000	31,300	222,000	39,000	275,000	47,200
TOTAL NON-FEDERAL (NO COST SHARING) ANNUAL COST		$14,[illegible]		$14,300		$14,[illegible]		$14,300		[illegible]		$16,800		$78,400		$86,100		$94,300
TOTAL AVERAGE ANNUAL COST		$396,30[illegible]		$419,800		[illegible]		[illegible]		[illegible]		[illegible]		$996,200		$1,264,100		$1,589,400

1/ Present worth of 9 maintenance operations at 5-year intervals = (present worth, equal payment series, 6-7/8 - 45 years) / (compound amount, equal payment series, 6-7/8 - 5 years) = (13,815,9[illegible]) / (5.736412) = 2.40838

2/ Figures from Table F-[illegible]

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SECTION G

FORMULATING A PLAN

FORMULATING A PLAN

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SECTION G

FORMULATING A PLAN

1. This section discusses the step by step development of detailed plans to meet the study objectives laid out in Section A and to resolve the problems and needs defined in Section C.

Formulating a plan that will satisfy the needs for beach erosion control, hurricane protection, and solutions to related problems at Folly Beach involves the consideration of several alternative measures. Each potential solution was considered on the basis of its economic, environmental, and social impacts. To facilitate in logically selecting the best plan, each plan and its associated effects were displayed side by side in a system of accounts.

Formulation and Evaluation Criteria

2. Federal policy on multiobjective planning, derived from both legislative and executive authorities, established and defines the national objective for water resource planning, specifies the range of impact that must be assessed, and sets forth the conditions and criteria which must be applied when evaluating plans. Plans must be

formulated with due regard to benefits and costs, both tangible and intangible, and effects on the environmental and social well-being of the region; and the plans must be institutionally feasible.

3. The planning criteria uses a framework established in the Water Resource Council's "Principles and Standards for Planning Water and Related Land Resources," which requires the systematic preparation and evaluation of alternative solutions to problems, under the objectives of National Economic Development (NED) and Environmental Quality (EQ). The process also requires that the impacts of a proposed action be measured and the results displayed or accounted for in terms of contributions to four accounts: NED, EQ, Regional Development (RD), and Social Well-Being (SWB). The formulation process must be conducted without bias as to structural and non-structural measures.

TECHNICAL CRITERIA

4. Within the planning framework the following technical criteria were adopted:

a. Federal participation in the cost for restoration of beaches shall be limited to areas landward of the limits of the historical shoreline of record; and

b. Restored beach profiles shall be based on natural berms and foreshore beach slopes, tide levels, and historical erosion rates.

ECONOMIC CRITERIA

5. The following economic criteria were established to insure that the selected plan would be the most economical method of meeting the planning objectives. This assures that there are not more economical ways, evaluated on a comparable basis, of accomplishing the same purposes that would be precluded if the selected plan were undertaken.

a. Tangible benefits should exceed project economic costs;

b. Each separable unit of improvement or purpose should provide benefits at least equal to its cost unless justifiable on a non-economic basis;

c. Each plan, as ultimately formulated, should provide the maximum net benefits possible within the formulation framework;

d. The costs for alternative plans of development would be based on preliminary layouts, estimates of quantities, and 1979 unit prices;

e. The benefits and costs should be in comparable economic terms to the fullest extent possible;

f. Annual costs and benefits are based on a 50-year amortization period and a discount rate of 6-7/8 percent;

g. The annual charges should include the cost of operation and maintenance of the selected plan;

h. Interest during construction should be charged to any portion of the project that exceeds two years to construct;

i. Plans should consider the effects of:

Employment in the area

Tax base of the area

Property values of the area

Regional growth potentials of the area; and

j. Plans should examine the possible adverse impact of displacement of businesses.

SOCIOECONOMIC AND ENVIRONMENTAL CRITERIA

6. The criteria for socioeconomic and evironmental consideration in water resource planning is prescribed by the National Environmental Policy Act of 1969 (PL 91-190) and Section 122 of the River and Harbor and Flood Control Act of 1970, (PL 91-611). The criteria prescribe that all significant adverse and beneficial economic, social and environmental effects of planned developments be considered and evaluated during formulation.

7. The following criteria were selected for the formulation and evaluation of plans relative to their contributions to EQ:

a. Plans should incorporate beneficial features and minimize adverse features in relation to potential impacts on:

Manmade resources,

Natural resources,

Air pollution,

Water pollution,

Land pollution,

Esthetics effects;

b. Plans should avoid detrimental effects to the extent feasible; and

c. Unavoidable adverse environmental impacts should be fully noted, analyzed quantitatively when possible and qualitatively when not, so that knowledgeable decision making would be possible.

8. SWB is concerned with the direct and indirect effects of an action on man and his life style. Criteria used to direct plan formulation, so that effects of proposals contained in this study would be minimal, are:

a. Plans should minimize and, if possible, avoid:

Destruction or disruption of community cohesion,

Injurious displacement of people, and

Disruption of desirable community growth;

b. Consideration should be given to protection of historical, archeological and other public interest areas;

c. Plans should not significantly increase noise pollution during construction or create conditions that will tend to raise the overall noise level of the area over the project life; and

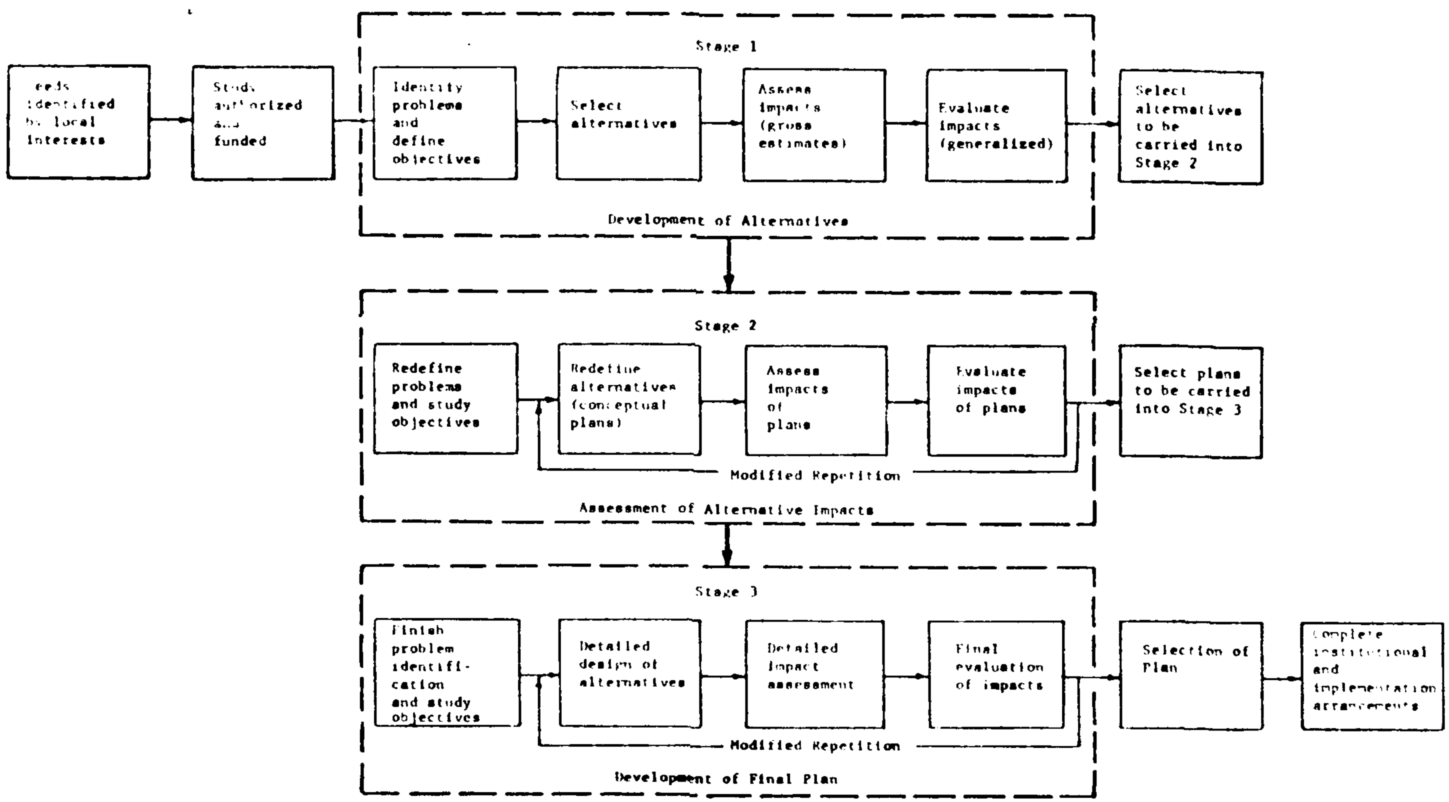
d. Provisions should be made during project formulation to afford interested segments of the public an opportunity to participate in plan selection.

INSTITUTIONAL CRITERIA

9. Institutional feasibility involves the ability and willingness of existing political and social institutions to fulfill the necessary requirements to transform the various plans into realities. Local assurances must be obtainable, so must the necessary permits, approvals and endorsements.

Formulation Methodology

10. Formulation of plans was through an iterative three stage process. An abbreviated work sequence diagram graphically illustrating the process is shown in Figure G-1. The stages were (1)



GENERALIZED WORK SEQUENCE DIAGRAM OF PROJECT FORMULATION

FIGURE G-1

Identification of Possible Solutions, (2) Development of Intermediate Plans, and (3) Development of Detailed Plans. Utilization of the three stage process allows for a logical sequence to develop and assess those plans addressing study objectives using as a judgment basis the NED, EQ and/or a mix of the two accounts. Those plans identified as best meeting the planning objectives are subsequently reevaluated in increasing detail as the planning process progresses.

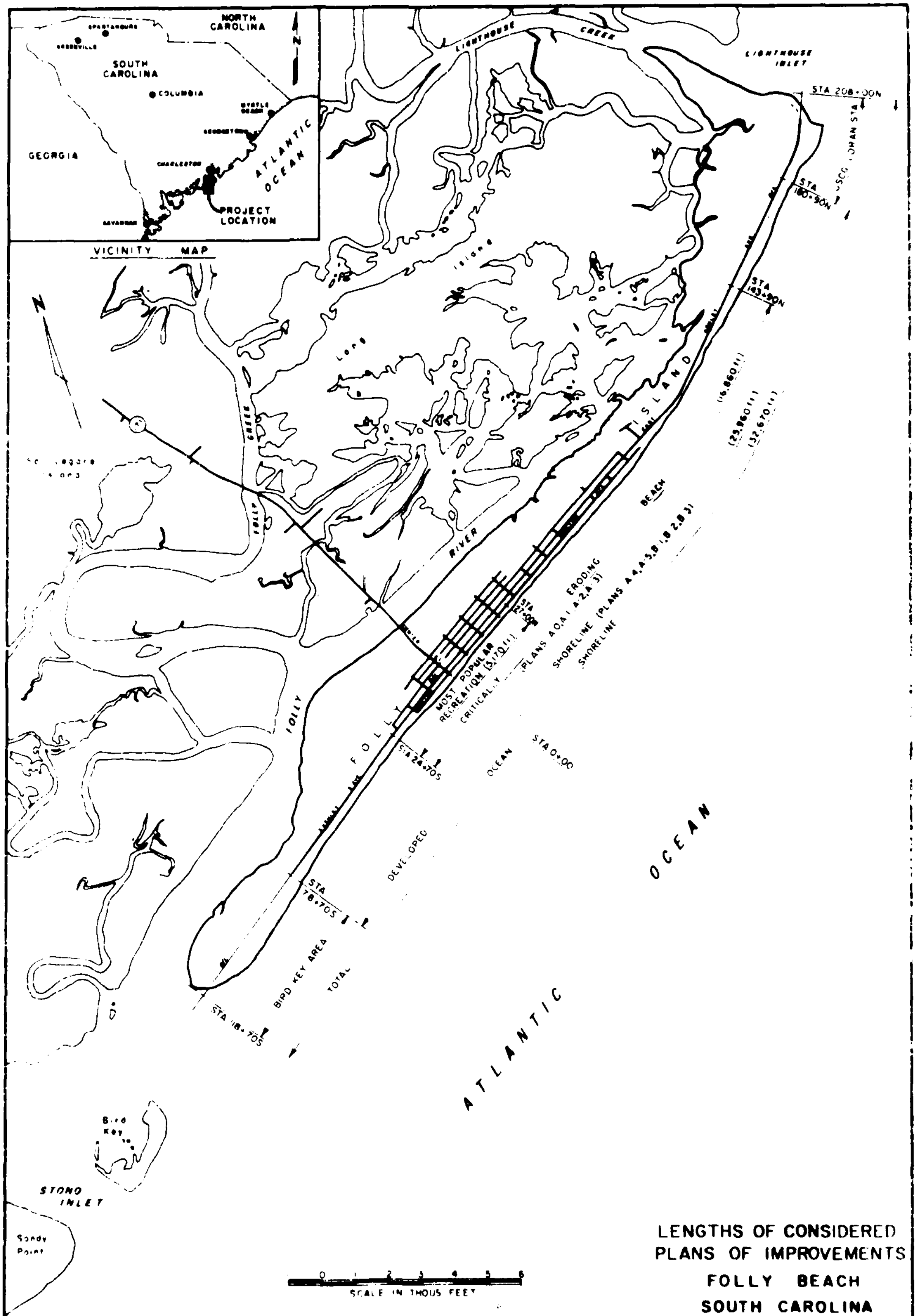
Profile of Existing Conditions

11. A profile outlining existing physical, economic, social and environmental conditions in the study area was presented in Section C, Problems and Needs. The discussion of the future shoreline positions and beach problems presented in the text and Section C serves as the scenario for the "do nothing" alternative. Table G-1 summarizes the non-structural and structural alternatives considered in each stage of the planning process.

TABLE G-1
SUMMARY OF ALTERNATIVES

	ALTERNATIVE	STAGE 1	STAGE 2	STAGE 3
NON-STRUCTURAL	Relocation of Structures	X	X	X
	Evacuation Planning	X		
	Flood Insurance	X		
	Zoning & Mod. of Bldg. Codes	X	X	
	Regulation of Flood Plain	X		
	Floodproof Structures	X		
	Grass Existing Beach	X		
	No Growth	X		
	Do Nothing (No Action)	X	X	X
STRUCTURAL	Beach Development	X	X	X
	Beach Revetment	X		
	Seawall	X		
	Offshore Breakwater	X	X	
	Beach & Dune Development	X	X	X
	"Dynamite Hole" Closure	X		

12. Historically, Folly Island's entire ocean shoreline, about six miles, has suffered from beach erosion. On the northeast end of the island at the Loran Station (See Figure G-2), the U. S. Coast Guard has constructed erosion control structures which have apparently stabilized that section of the study area, thus the Coast Guard Property was not included for further consideration after the initial elimination step. Likewise, the southwest reach, called "Bird Key Area" was not considered past the first study iteration of alternative solutions since the area is undeveloped and is inaccessible, except by foot. The Bird Key Area has recently experienced some degree of stability with some evidence of local accretion. Of the five miles of developed shoreline, there are about three miles where erosion is considered critical to improvements. Another subdivision of the developed shoreline is effected through development classification. This is the approximately one mile reach of popular recreational beach near the center of the island which has offstreet parking, sanitary facilities, and concessions.



LENGTHS OF CONSIDERED PLANS OF IMPROVEMENTS
FOLLY BEACH
SOUTH CAROLINA

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FIGURE G-2

IDENTIFICATION OF POSSIBLE SOLUTIONS (STAGE 1)

13. General. Table G-1 referred to previously, lists the alternatives developed in the Stage 1 formulation process. The list was developed in consultation with local interests. Many of these initial alternatives were not retained for further analysis in Stage 2 because they do not effectively address the planning objectives or were unacceptable to local interests. Table G-2 displays the relative outputs of the initial list of alternatives in terms of the planning objectives and their contribution to the four accounts designated in the Principle and Standards.

14. Non-structural measures. Section 73 of the Water Resources Development Act of 1974 requires that in any study involving flood protection, consideration be given to non-structural alternatives. Such alternatives cover a wide variety of techniques whose effective application depend upon local condition and

TABLE G-2

STAGE 1 ALTERNATIVES AND RELATION TO PLANNING OBJECTIVES AND PRINCIPLE AND STANDARDS ACCOUNTS

Alternatives	Local Planning Objectives 1/				Principles & Standards 2/			
	RB	HP	EC	TBE	NED	EQ	SWB	RD
Non-structural								
1. Relocation of Structures	P 3/	F 3/	-	P	-	P	P	P
2. Evacuation Planning	-	P	-	-	-	-	P	-
3. Flood Insurance	-	P	-	-	-	P	P	-
4. Zoning & Mod. of Bldg. Codes	-	-	-	-	-	-	-	-
5. Regulation of Flood Plain	-	P	-	-	P	-	P	P
6. Flood Proof Structures	-	P	-	-	P	-	P	-
7. Grass Existing Beach	-	-	-	-	-	P	-	-
8. No Growth	-	-	-	-	-	P	-	-
9. Do Nothing (No Action)	-	-	-	-	-	P	-	-
Structural								
1. Beach Development	F	P	P	F	F	P	F	F
2. Beach Revetment	-	P	F	P	P	P	P	P
3. Seawall	-	P	F	P	P	P	P	P
4. Offshore Breakwater	P	P	P	P	P	P	P	P
5. Beach and Dune Development	F	F	P	F	F	P	P	P
6. "Dynamite Hole" Closure	-	-	-	-	-	P	-	-

1/ RB = Provision of recreation beach
HP = Protection from hurricane wave damage
EC = Beach erosion control
TBE = Protection of tourist base economy

2/ NED = National economic development
EQ = Environmental quality
SWB = Social well being
RD = Regional development

3/ F = Meet fully
P = Meet partially
Blank spaces indicate not meeting objective

characteristics of the flood plain. Flood plain regulation, relocation of flood plain development, floodproofing, building regulations and evacuation are some of the considered non-structural measures.

15. Other non-structural measures such as a well-executed evacuation plan, flood insurance and zoning and building regulations and regulation of the flood plain were not regarded as overall solutions but could be advantageous in reducing future damages and individual losses. Zoning would not protect existing development but is a valuable measure for reducing the flood damages potential for new development. Efficient evacuation plans will reduce future losses, particularly bodily injuries and loss of life, but will not substantially reduce structural damages. Flood insurance does not prevent damages but in effect distributes monetary loss of the individual property to the general public.

16. Further investigation of the local ordinances and emergency programs indicated that these non-structural measures have been implemented to a large degree already. The City of Folly Beach is participating in the Federal Flood Insurance Program and with the insurance program comes mandatory flood plain regulatory

zoning and reasonable building codes. The Charleston County Disaster Preparedness Agency has established evacuation plans setting forth evacuation routes, storm shelters and instructions for evacuees.

17. Island development, particularly those structures along the front beach, are subject to wave attack in addition to flooding from surge tides. Flood proofing of structures is considered effective only in still water flood areas. Accordingly, flood-proofing is regarded as having limited application in the study area and is disregarded as an effective protection measure as it inadequately addresses planning objectives.

18. Grassing the existing beaches would limit the use of the beaches for recreational purposes and would not be very effective in controlling erosion, assuming grass could be established on the beach. However, grassing is considered in conjunction with artificial dune development as a dune stabilization measure.

19. "No growth" like many of the preceeding non-structural alternatives would prevent damages to structures erected sometime into the future, but does not address the problems of erosion losses and inadequate recreational opportunities. Additionally, "no growth" is considered counter productive to the community desire to enlarge its tax base.

20. In addition to the positive action courses considered, a course of "No Action" (Do Nothing Plan) was also considered. This alternative is developed to facilitate the prediction of the area's future without corrective actions and for comparison with expected future conditions generated by alternative action plans. A scenario of the future situation if nothing is done to check the erosion is presented in Section C. Effects of the do nothing alternative and the relocation of structures alternatives are displayed in the System Accounts along with structural measures carried through the third iterative stage.

21. Structural measures. Of the structural alternatives considered, those referred to as beach development, offshore breakwater, and beach and dune development best address the planning objectives. Consequently, these alternatives were carried forward in the planning process for further consideration in Stage 2.

22. The beach revetment and seawall alternatives are capable of meeting various aspects of the planning objectives. Their effectiveness and contributions were judged to vary significantly. Neither addresses the RB planning objective. Therefore, both were eliminated from further consideration in Stage 2.

23. Some local people contend that the low section, referred to as the "dynamite hole", which is in the southernmost Charleston Harbor jetty has caused the Folly Beach erosion and that the problem will be solved by closure of this hole. This gap was never dynamited, according to available records, but was a design feature of the jetties protecting the entrance to Charleston Harbor. This is discussed in paragraph 56, Section C of Appendix 1. A contracted littoral movement study (Attachment C-1) concluded that the jetties probably do not

affect erosion on Folly Island. Corps studies also have concluded the jetties don't affect erosion on Folly Island, therefore, closure of the "dynamite hole" was not considered further.

24. Development of a beach access/biological observation park was suggested during the Folly River Navigation Study (1977) for the undeveloped 196-acre tract occupying the southwestern end of Folly Island. Features of the proposed park included a short access road, parking lot, comfort station, walkway to the front beach, fishing dock, and nature trails with interpretive signs pointing out the occurrence of natural processes in the area. Such a park would preserve this natural area for public enjoyment as well as provide a controlled beach access area on Folly Island. Incorporation of the proposed park in an EQ plan would provide for greater environmental enhancement.

25. Initial response to the park proposal was general opposition by citizens of Folly Beach. They favored residential development of the subject area so that the City of Folly Beach would derive greater tax benefits than from a park. The Charleston County Department of Parks, Recreation, and Tourism (CCPRT) has shown continued interest in development of the park despite local opposition and problems related to purchase of the 196-acre tract. Should CCPRT be able to purchase the area for park development, this could be included as an additional feature of the recommended plan for erosion control and hurricane protection for Folly Beach.

26. Continued lack of support for the park plan has resulted in dropping the park feature. Therefore, this plan was not considered further in this study.

27. Alternatives surviving the initial evaluation process were given more detailed analytical analysis in Stage 2 of the Formulation Process.

DEVELOPMENT OF INTERMEDIATE PLANS (STAGE 2)

28. General. Of the initial (Stage 1) 15 alternatives identified and evaluated 6 were selected for further consideration in the Stage 2 Fromulation Process. The alternatives considered in the Stage 2 phase are listed as follows:

Non-Structural

1. Relocation of Structures
2. Modification of Building Codes
3. Do Nothing (No Action)

Structural

1. Beach Development
2. Offshore Breakwater
3. Beach and Dune Development

Table G-3, Effects Assessment, displays the positive and negative effects of the non-structural and structural alternatives considered in terms of their environmental and social effects.

29. Non-structural measures. Relocation of Structures, Modification of Building Codes, and Do

affect erosion on Folly Island. Corps studies also have concluded the jetties don't affect erosion on Folly Island, therefore, closure of the "dynamite hole" was not considered further.

24. Development of a beach access/biological observation park was suggested during the Folly River Navigation Study (1977) for the undeveloped 196-acre tract occupying the southwestern end of Folly Island. Features of the proposed park included a short access road, parking lot, comfort station, walkway to the front beach, fishing dock, and nature trails with interpretive signs pointing out the occurrence of natural processes in the area. Such a park would preserve this natural area for public enjoyment as well as provide a controlled beach access area on Folly Island. Incorporation of the proposed park in an EQ plan would provide for greater environmental enhancement.

25. Initial response to the park proposal was general opposition by citizens of Folly Beach. They favored residential development of the subject area so that the City of Folly Beach would derive greater tax benefits than from a park. The Charleston County Department of Parks, Recreation, and Tourism (CCPRT) has shown continued interest in development of the park despite local opposition and problems related to purchase of the 196-acre tract. Should CCPRT be able to purchase the area for park development, this could be included as an additional feature of the recommended plan for erosion control and hurricane protection for Folly Beach.

26. Continued lack of support for the park plan has resulted in dropping the park feature. Therefore, this plan was not considered further in this study.

27. Alternatives surviving the initial evaluation process were given more detailed analytical analysis in Stage 2 of the Formulation Process.

DEVELOPMENT OF INTERMEDIATE PLANS (STAGE 2)

28. General. Of the initial (Stage 1) 15 alternatives identified and evaluated 6 were selected for further consideration in the Stage 2 Fromulation Process. The alternatives considered in the Stage 2 phase are listed as follows:

Non-Structural

1. Relocation of Structures
2. Modification of Building Codes
3. Do Nothing (No Action)

Structural

1. Beach Development
2. Offshore Breakwater
3. Beach and Dune Development

Table G-3, Effects Assessment, displays the positive and negative effects of the non-structural and structural alternatives considered in terms of their environmental and social effects.

29. Non-structural measures. Relocation of Structures, Modification of Building Codes, and Do

TABLE G-3

STAGE 2

Effects Assessment

Effect
(+) Beneficial
(-) Negative

Magnatude
(0) None to Negligible
(1) Minor
(2) Moderate
(3) Major

	Economic Accounts										Environmental Accounts							SWB Account		
	Tax Revenues	Property Values	Public Facilities	Public Services	Regional Growth	Employment/Labor Force	Business Activity	Displacement of Farms	Benefit Cost Ratio	Excess Benefits to Cost	Man Made Resources	Natural Resources	Air Pollution	Water Pollution	Noise	Esthetic Values	Land Pollution	Displacement of People	Community Cohesion	Community Growth
Non-Structural																				
Relocation of STRS	-2							NA			-3	+2	+1	0	+1	+2	+1	-2	-2	-2
Mod. of Bldg. Codes	+1	+1						NA			-1	0	0	0	0	0	0	0	0	-1
Do Nothing (No Action)	-2	-2						NA			-2	0	+1	0	-1	-1	+1	-1	-1	-2
Structural																				
Beach Development	+2	+2	+2			+2		NA	1.7		+1	+2	-1	-1	-1	+2	-1	+1	+1	+2
Offshore Breakwater	+2	+2	+2			+2		NA	.7		+1	+2	-1	-1	-1	+1	-1	+1	+1	+2
Beach and Dune Development	+2	+2	+2			+2		NA			+2	+3	-1	-1	-1	+3	-1	+2	+1	+3

Nothing (No Action) were further evaluated during this stage of the planning process. Modification of building codes would provide minor benefits, economically , by increasing tax revenues and property values since more expensive houses would be constructed. Relocation of structures would decrease these revenues and property values. A preliminary real estate evaluation was made of the shoreline properties. From this it was determined that ocean front lots with improvements cost approximately $500 per front foot. Not only would a purchase relocation plan be costly it would only be effective until the eroding shoreline touches second row lots or public highways. Thus, at sometime in the future relocation would again be required when the shoreline again reaches a critical position. However, of the non-structural plans considered, the relocation of structures alternative was determined to be the best plan to minimize the potential negative effects on the flood-plain. therefore, this alternative was taken to Stage 3 planning. Evaluation of these effects and selection of the best flood-plain plan is in compliance with Flood-Plain Management Executive Order No. 11988.

30. Structural measures. Beach restoration and nourishment, offshore breakwaters, and sand dune development and stabilization were considered in more detail in this stage. Preliminary estimates of cost and benefits were developed for these alternatives to determine their cost effectiveness and to gain insight into their relative cost. Pertinent data so developed is presented in Table G-4. The reach of beach being considered is shown on Figure G-2. Preliminary estimates were for the total ocean shoreline (Sta 118 + 70S to Sta 208 + 00N), and the currently critically eroding reach (Sta 24 + 70S to Sta 143 + 90N).

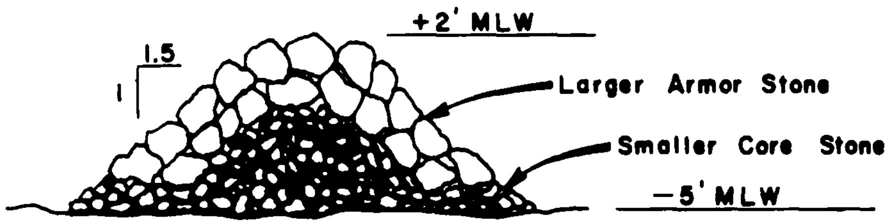
TABLE G-4

PRELIMINARY ESTIMATES OF BENEFITS AND COSTS

Type of Improvement		Total Ocean Shoreline	Currently Eroding Portion
Beach Development	Total Investment	$ 2,200,000	$ 1,110,000
	Benefits	990,000	830,000
	Annual Cost	650,000	340,000
	B/C Ratio	1.5	2.4
Offshore Breakwater	Total Investment	16,000,000	9,610,000
	Benefits	990,000	830,000
	Annual Cost	1,460,000	770,000
	B/C Ratio	0.7	1.07
Beach and Dune Development	Total Investment	15,400,000	8,310,000
	Benefits	1,590,000	1,530,000
	Annual Cost	2,600,000	770,000
	B/C Ratio	0.6	1.9

31. Analysis of the data indicates the beach development plan has the best potential for meeting planning objectives. The offshore breakwater had marginal economic value at best. Drawbacks of this type of structural control include excessive costs and undesirable environmental effects, i. e., heavy downdrift erosion would require mitigation and/or sand bypass. Also, the effectiveness of the offshore breakwater would be difficult to evaluate. It may be necessary to initially place the desired beach fill in order to be assured of adequate dry beach area for recreational use. In exposed locations such as offshore of Folly Beach, breakwaters are generally some variations of a rubble-mound structures, such as the one shown in Figure G-3.

32. The beach and dune development alternative appeared to be economically justifiable for the developed reach, Sta 78+70S to Sta 180+90N. The large initial investment, particularly the non-federal share required of the local sponsor, could ultimately determine the selection or rejection of this alternative. It was decided tc carry this alternative along with the beach development alternative into Stage 3 for further analysis.



CONSIDERED RUBBLE - MOUND
OFFSHORE BREAKWATER

FIGURE G - 3

DEVELOPMENT OF DETAILED PLANS (STAGE 3)

33. General. Analysis of the possible solutions presented in the Stage 2 Formulation Process indicates that the beach development and beach and dune development are the most promising structural alternatives and relocation of structures is the best non-structural plan. Accordingly, along with the "No Action" plan these three plans are selected for consideration in greater detail in the Stage 3 Formulation Process.

34. Relocation of structures. The best non structural plan was found to be relocation of beach front buildings and allowing the shoreline to continue to erode. Based on the predicted long-term future shoreline shown on the aerial mosaic plates 2 through 6 in the main report, 184 buildings would be destroyed within 50 years if they were not relocated. But it will be noted that there are 259 buildings along the project shore, some 75 of which are assumed to be capable of surviving with maintenance of present protective structures. If relocation of beach front structures is to be proposed, it would seem unrealistic not to consider the

relocation of these apparently protected structures, as these owners would probably feel entitled to the same assistance given their neighbors, and they would be left to bear, without assistance, the cost of maintaining their protective works. Thus the relocation alternative assumes the necessity of relocating 259 buildings. The present (April 1979) value of the relocation costs and the cost of purchasing new lots is estimated at $3,529,000 and the total value of these buildings that would be lost to erosion over the project life, without relocation, is estimated at $6,475,000. The estimate annual cost of relocating these 259 buildings is $73,310. Comparing this annual cost with the resulting average annual losses of buildings without relocation ($79,080), the benefit to cost ratio for the relocation plan is 1.08 and therefore, the relocation plan is economically feasible. Benefit computations are shown on Table G-5, and cost estimates are given in Tables G-6 and G-7.

TABLE G-5

ESTIMATED BENEFITS FROM THE ELIMINATION OF EXPECTED STRUCTURAL LOSSES

ITEM	AMOUNT					
Period of Erosion (yrs)	0-10	10-20	20-30	30-40	40-50	Total
Number of Structures Lost 1/	32	36	97	53	41	259
Value at $25,000 each ($1,000)	800	900	2,435	1,325	1,025	6,475
Present Worth Factor	0.514	0.265	0.136	0.070	0.036	-
Present Worth ($1,000)	411	238	330	93	37	1,109
Average Annual Benefits ($1,109,000 x 0.071317)						$79,080

1/ Building is assumed to be 100% destroyed when erosion of the mean highwater shoreline reaches landward limit of structure.

TABLE G-6

ESTIMATED COSTS TO REMOVE STRUCTURE AND

CONTENTS TO AN EROSION-FREE SITE 1/
(Per House)

ITEM	ESTIMATED COST
New Site Purchase and Preparation 2/	$ 9,960
Moving Structure to New Site 3/	2,670
Moving and Related Expenses 4/	600
Cost to Convey Property to Government	400
Total First Cost	$13,630
Value of Structure	$25,000
Percentage of Structural Value	54.5%

1/ Estimated for a $25,000, 1,300 square foot structure. Computations based on data presented in Physical and Economic Feasibility of Non-structural Flood Plain Management Measures" by William K. Johnson of the Hydrological Engineering Center, Institute for Water Resources U. S. Army Corps of Engineers, March 1978.

2/ Land values of new site was assumed to be $5,000. Other costs include clearing and grading lot. constructing foundations, driveways, and walks, installing sewer and water lines, and landscaping.

3/ Costs include 25 percent for contractor's bonds overhead, profit, and engineering.

4/ Cost for moving building contracts, electricity, and telephone hookup, etc.

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TABLE G-7

ESTIMATED ANNUAL COST TO REMOVE 259

STRUCTURES AND CONTENTS TO AN EROSION-FREE SITE

ITEM	AMOUNT					
Period of Erosion (in years)	0-10	10-20	20-30	30-40	40-50	Total
Number of Structures Moved 2/	84	84	56	35	0	259
Value at $25.000 each (in $1,000)	2,100	2,100	1,400	875	0	6,475
Cost of Moving Structure 2/	1 144	1,144	763	477	0	-
Present Worth Factor 3/	0.514	0.265	0.136	0.070	0.036	-
Present Worth (in $1,000)	588	303	104	33	0	1,028
Average Annual Cost ($1,028,000 x 0.071317)						$73,310

1/ Building will be relocated when erosion of the mean high water shoreline reaches ocean side of structure. Relocation would be limited to structures which would be expected to be lost without erosion control measures.

2/ Percentage of structural value is 54.5% (from Table G-6).

3/ Interest rate is 6 7/8 percent and evalutaion period is 50 years.

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35. Do Nothing (No Action) Plan. The "No Action" alternative perceives the continuation of existing conditions and no new solution for existing problems. This option, although not favored by local study sponsors, avoids both the monetary investment and potential adverse impacts associated with structural improvements. Effects of the "No Action" plan provides a basis for evaluating impacts of alternative plans.

36. The value of real estate and buildings that would be lost in the absence of a project depends on the expected rate of erosion and control measures that r. · exist or that might be installed in the absence of a project. The developed shoreline at Folly Beach is about 25,960 feet, and there are within it some 259 "front row" structures. Approximately 16,860 feet of this are critically eroding, with the remaining 9,100 feet of lesser erosion consisting of a segment of 3,700 feet north of the critically eroding segment, and a 5,400 foot segment to its south. As explained in Appendix 1, Section F, the long-term rate of erosion is projected to be 5 feet per year for the critically eroding 16,860 foot frontage, and 2.5 feet per year for the remaining 9,100 foot frontage. Within the critically eroding frontage, some 7,510 feet (Reach A) are presently protected by bulkheads, seawalls and revetments spaced intermittently along the 16,860 feet. Some 75 structures having an average value of $25,000 (structure only) are sited behind these protective works. It is assumed that 10 percent of these protected structures will be increased to an average value of $40,000 per structure by additions and upgrading, during the period 1980 to 1990. It is assumed that this

7,510 feet of protective structures will be properly maintained, and that there will be no further loss of structures or land landward of the protection.

Reach B is the remaining 9,350 feet of critically eroding shoreline developed with some 93 front-row structures with an average value of about $25,000 each. It is assumed that without a project this frontage will remain unprotected, and that the shore recession of some 250 feet over the next 50 years will result in the loss of all its front row structures.

Reach C identifies the remaining 9,100 feet of developed beach, consisting of two segments described above. Some 91 structures, unit value as above, lie along this frontage, which is projected to recede some 125 feet in the next 50 years with the destruction of about half the value of these structures.

As there are vacant lots permitting the construction of an additional 38 structures along the 25,960 feet of developed shore, and as new homes are being built along the beach, it is assumed that 38 additional structures will be constructed between 1980 and 1990. This will increase the total number of structures at that time to 297; that is, 86 in Reach A, 107 in Reach B, and 104 in Reach C. This future development is assumed to have an average value of $25,000 per structure.

It is also assumed that a number of the front row structures would be lost during any hurricane. Past experience, however, indicates these would socn be rebuilt or replaced. The present policies of the Federal

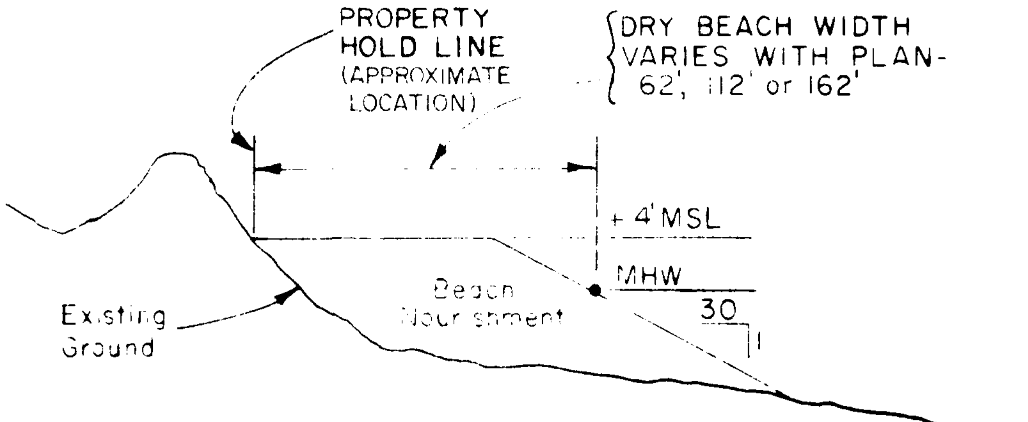
Emergency Management agency, Insurance and Mitigation Division (formerly Federal Insurance Administration) does not prohibit rebuilding, but does require that first floor elevations be at or above the 100-year flood elevation.

Based on the above assumptions, the potential for damage in average annual terms would be $177,200 for land and $76,900 for buildings.

37. Beach Development Alternatives. The best development alternatives were evaluated through analysis of six different options which differ only in scale. These optional plans are designated as plans A-0 through A-5. The location of beach protected by each plan is shown on Figure G-2 and pertinent physical dimensions are summarized in Table G-8. Figure G-4 displays typical sections for Stage 3 structural alternatives.

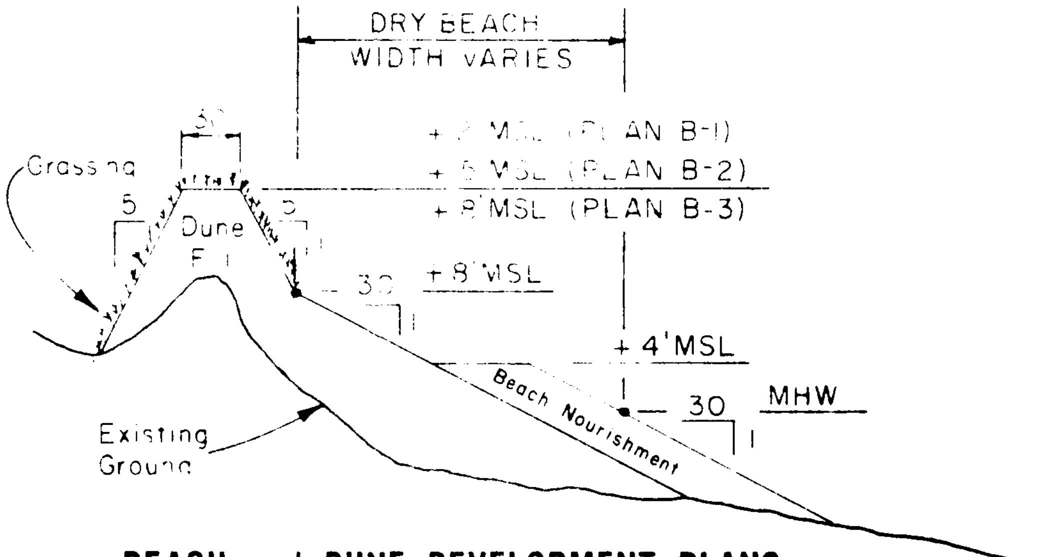
38. The Beach Development Plans would involve borrowing sand from offshore or inlet shoals and restoring the beach to a fuller, wider section. Since natural erosion would continue, the beach would require periodic nourishment by pumping in more sand. A minimal beach berm elevation of 4 feet above mean sea level and a minimal dry-beach width of 36 feet was determined through stage frequency and design analysis as that necessary to effectively resist attack by normal wave action and the effects of frequent storms. The usable dry-beach was considered to be the expanse between the hold line and mean high water. The length of shoreline improved by Plan A-0 (16,860 feet) is taken as the minimal project length since that reach is currently experiencing critical erosion.

39. Beach recreational needs were developed from demands presented in the 1974 "South Carolina State Comprehensive Outdoor Recreation Plan", (SCORP) prepared by the South Carolina Department of Parks, Recreation, and Tourism; and the 1976 contract study "Beach Access and Recreation in South Carolina", conducted by the firm of



BEACH DEVELOPMENT PLANS

(A-O through A-5)



BEACH and DUNE DEVELOPMENT PLANS

(B-1 through B-3)

NOTE

0' MSL=2.4 MLW

not to scale

TYPICAL SECTIONS
OF CONSIDERED PLANS
AT FOLLY BEACH, S.C.

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FIGURE G-4

Hartzog, Lader, and Richards for various state and Federal agencies. Estimated annual equivalent benefits and charges are developed in Sections E and F, respectively.

40. <u>Beach and Dune Development Alternative</u>. Three beach and dune development plans, designated as B-1 thru B-3, were analyzed in Stage 3. Each plan encompasses the same reach of beach, STA 78+70S to 180+90N, as shown on Figure G-2. This would provide continuous protection throughout the developed shoreline. It was determined in Stage 2 planning that longer sections are less economical and shorter sections are not considered appropriate since all this shoreline is similarily developed and would be subjected to about the same storm wave forces. The three beach and dune development plans analyzed differ essentially only in the degree of protection provided against storm wave attack, as shown in Table G-8.

41. The main difference between the beach and dune development plans and the beach development plans is the provision of an artificial dune system. Where a dune is incorporated in the protective scheme, the dry beach area, usable for recreation, would be the expanse between the oceanward toe of the dune and the beach face at mean high water. (See typical section on Figure G-4.) Derivation of the minimal widths of dune and beach berms necessary for storm protection was based on an analysis of design storm parameters and estimated corresponding erosion rates. Dune shore and seaward slopes of 1-vertical on 5-horizontal, and storm berm and beach nourishment fill slopes of 1-vertical to 30-horizontal were selected for stability.

TABLE G-8

SUMMARY OF BEACH DEVELOPMENT AND BEACH AND DUNE DEVELOPMENT PLANS

Plan	STA 24+70S to 27+00N Avg. Berm Width (ft)	STA 27+00N to 143+90N Avg. Berm Width (ft)	STA 143+90N to 180+90N Avg. Berm Width (ft)	STA 24+70S to 78+70S Avg. Berm Width (ft)	STA 78+70S to 180+90N Dune Elev. (ft. msl)
A-0	50	50	-	-	-
A-1	100	50	-	-	-
A-2 1/	150	50	-	-	-
A-3 1/	150	100	-	-	-
A-4	100	50	50	50	-
A-5 1/	150	100	50	50	-
B-1 1/	-	-	-	-	12
B-2 1/	-	-	-	-	15
B 3 1/	-	-	-	-	18

1/ Plan will require lengthening existing groins seaward for berm widths greater than 100 feet.

42. After establishing horizontal dimensions on the basis of design analysis, vertical requirements were evaluated. Determination of the optimum dune elevation required a comparison of estimated costs for varying storm protection levels with benefits for each level of improvement. Dune heights of 12 feet,MSL, 15 feet MSL, and 18 feet MSL were analyzed. These would provide wave damage protection from storms with frequencies of occurrences of 25, 50 and 100 years, respectively.

43. Economic Comparison of Structural Alternatives. The estimated annual equivalent benefits, annual charges, benefits to cost ratio, and excess benefits to cost for the structural plans are given in Table G-9. It can be seen here than Plan A-4 of the beach development plans and B-1 of the beach and dune development plans are the most economical.

44. The optimum beach development plan (Plan A-4) would provide an average dry beach width of 100 feet along the one-mile, most popular recreation beach near the center of the island, Station 25+70S to Station 27+00N, and a dry beach width of 50 feet for the remaining four miles of critically eroding beach from the standpoint of jeopardy to improvements. This plan would require initially filling from the existing 4-foot MSL contour with 1,001,000 cubic yards of sand at an estimated first cost of $3,410,000. Beach renourishment will be required at five-year intervals and is estimated at $1,596,000 per effort. A beach

TABLE G-9

COMPARISON OF COSTS AND BENEFITS

Plan	Annual Benefit	Avg. Annual Cost	Benefit to Cost Ratio	Excess Benefits to Cost
Beach Development Plans				
A-0	$ 887,200	$ 396,300	2.2	$ 490,900
A-1	953,700	419,800	2.3	533,900
A-2	977,500	460,400	2.1	517,100
A-3	966,300	523,100	1.8	443,200
A-4	1,060,600	521,000	2.0	539,600
A-5	1,060,600	620,500	1.7	440,100
Beach and Dune Development Plans				
B-1	$1,051,000	$ 996,200	1.06	$ 54,800
B-2	1,086,500	1,264,100	0.9	0
B-3	1,105,200	1,589,400	0.7	0

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monitoring program will be implemented to insure timely renourishment. The average annual cost of this monitoring program is $3,700. In addition to paying a portion of the cost of the beach development project, local interests would be required to furnish facilities for public use such as parking and bath houses, along access routes to the beach. The project would provide 36 additional acres of beach for recreational use, and would provide protection against normal erosion. The excess of annual benefits over annual cost are estimated at $539,600 and the benefit to cost ratio is 2.0.

45. The minimal plan of improvement is the beach development plan described in Table G-9 as A-0. This plan provides for a recreational beach 50 feet wide for all the critically eroding developed shoreline, 16,860 feet. The minimal plan with a benefit-to-cost ratio of 2.2 has one of the two highest benefit-to-cost ratios and is about the average in excess benefits over cost of all the structural plans considered in Stage 3 planning. The range in excess benefits to cost for all of the structural beach development plans is $440,100 to $539,600. The A-0 plan has the lowest initial investment of the other structural plans.

46. The minimal plan would include the filling from the existing 4-foot, m.s.l. contour with about 684,000 cubic yards of sand initially at a first cost of about $2,393,000 including local project costs. Periodic renourishment and beach monitoring are estimated to cost an annual equivalent of $221,900 and $3,700, respectively. Local interest would be required to furnish adequate public facilities such as parking, bath houses, and access routes to the beach. This project is considered to be the minimum acceptable effort that will

reasonably satisfy planning objectives. This minimal project would provide protection against normal erosion and would add 19 more acres of recreational beach area. The annual equivalant tangible benefits are estimated at $887,200 and the benefits to cost ratio is 2.2.

47. The optimum "Beach and Dune Development" plan would provide a dune with a 30-foot wide top at elevation 12 feet, m.s.l. stabilized with a vegetative cover. Fronting the dune would be a beach face on a 30:1 slope. Construction would require dredging an estimated 2,535,000 cubic yards of sand from the inlet bars at either end of Folly Island. In order to stabilize the fill material which would extend beyond the existing groins, it is estimated that 15 of these structures would have to be extended seaward by 15 feet each. Renourishment with 449,000 cubic yards and dune maintenance with 52,000 cubic yards would be required about every five years. A beach monitoring program will also be included in this plan. Initial cost is estimated at $9,634,000 with total equivalent annual charges of $996,200 including $309,100 for nourishment, maintenance and the beach monitoring program. The plan would provide estimated annual benefits of $1,051,000 and the benefits-to-cost ratio is 1.1. In addition to sharing in the project cost, local interests would also be required to provide dune walkways and public use facilities similar to those stipulated for the "Beach Development" plan.

EFFECT ASSESSMENT

48. In planning for any action, care must be taken to see that all known and possible or probable effects are taken into consideration. Effect assessment is carried out in terms of economic, social and environmental factors which could be associated with any of the alternatives considered for implementation.

RELOCATION OF STRUCTURES

49. ECONOMIC. The best non-structural plan, economically, is the "Relocation of Structures" alternative. This plan would prevent erosion from destroying 259 existing beachfront houses valued at $6,475,000 This computes to be an annual equivalent benefit of about $79,000. Comparing this with the average annual cost of relocating these endangered structures ($73,000) the benefits to cost ratio is 1.08. This plan, however, would slow down the rate of beachfront development, allow the loss of valuable land to continue unchecked, and would not help relieve the shortage of recreational beach area.

50. <u>Socio-Economic</u>. The "Relocation of Strutures" alternative would involve displacement of people and personal property. Temporary community disruption would occur. Erosional trends would continue. Bulkheads and other erosion control structures that have been constructed will be subjected to frequent wave damage and periodic destruction. Recession of the shoreline will occurr. The loss or reduction of recreation beach would diminish the attraction the area has for tourists and for local residents. The effects of erosion and storm damage would eventually depress the rate of growth of the area and the attendant tourist industry. Subsequent adverse impact upon development, employment, local earnings and the tax base represented by the existing development would occur.

51. <u>Environmental</u>. Implementation of the "Relocation" Plan would have little effect on the environment. Relocation would not involve dredging and its adverse impacts on marine life. This alternative would have little impact on the existing flora and fauna in the area since they would be left undisturbed until natural erosion eventually destroys the beach.

52. Esthetics will be impacted by the eventual loss of beach and dunes. Pilings and foundations left from relocated structures may be unsightly. A decline in visitation rate may reduce litter and traffic congestion problems.

Reduction in tourist visitation would reduce traffic and people noise. Air quality would be improved with lessened auto emissions.

NO ACTION

53. The base condition for evaluation of other alternative impacts is represented by the "No Action" alternative. Analysis of this alternative reflects perpetuation of existing trends and develops the no project impact and effects upon the study area.

54. Economic. If steps are not taken to counteract erosion, the usable beach will be adversely affected. Bulkheads and other erosion control structures that have been constructed will be subjected to frequent wave damage and periodic destruction. Where there are no protective structures further erosion and recession of the shoreline will occur, resulting in the loss of valuable property. Loss of or reduction in the recreation beach would diminish the attraction the area has for tourists and for local residents. Exposure to storms would periodically damage houses and other structures in exposed areas. Erosion and storm damage would eventually depress the rate of growth of the area and the attendant tourist industry.

54. The "No Action" alternative would forgo the monetary expenditure of resources required for the structural plans.

55. Socio-Economic. The effect of erosion and storm damage with the "No Action" plan would adversely impact upon development, employment, regional earnings, and the tax base represented by the existing development.

56. Environmental. No action would not involve dredging and its adverse impacts on marine life. This alternative would also have the least impact on the existing flora and fauna in the area since they would be left undisturbed until natural erosion eventually destroys the beach or pushes it back consuming real estate and the natural and man-made resources thereon. Reduction in tourist visitation would reduce traffic noise, auto emissions, and litter. However, the "No Action" alternative contributes negatively to the four planning accounts.

BEACH DEVELOPMENT

57. Economic . The optimum "Beach Development" plan (Plan A-4) would provide for most of the projected recreational use demand and would provide beach erosion control benefits including real estate loss prevention, building damage prevention and land enhancement. Estimated first cost is $3,410,000 and total equivalent annual charges are estimated at $521,000. A total recreation and beach erosion control benefits are estimated at $1,060,600 annually. Provision of present and projected beach recreational needs would permit a steady rate of development and economic growth in the study area.

58. The minimal plan (plan A-0) would provide for about the same beach erosion benefits but would satisfy less of the projected recreational use demand. Total recreation and beach erosion control benefits are estimated at $887,200. Comparing these benefits with total equivalent annual charges of $396,300 for this plan gives a benefit to cost ratio of 2.2. The relatively low cost of the minimal plan, $2,393,000 is a positive factor in view of the local financial requirements.

59. Socio-Economic. The optimum "Beach Development" plan would provide 25 acres of additional recreation beach area while the "Minimal" plan would provide 19 acres. This, coupled with existing beach area, would assure continuation of beach recreation and associated development and land use patterns. Continued development would increase employment and sustain good earnings along with projected increases in local population. As development and employment increase along the beach front, the area will assume an increasingly important role in the county and the general area's economic makeup.

60. Growth in that area will also increase the localized need for service facilities such as transportation, housing, health, and education. Regulatory functions will be necessary to preserve aesthetic qualities and to prevent excess noise and air pollution problems. With proper regulatory guides the considered plan would contribute favorably to desired regional and community growth. Generally, present water and land use trends existing in the area would continue.

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61. <u>Environmental</u> - Completion of the considered plan would produce a more favorable environmental condition than exists at present, although some long-term minor impacts may occur due to socioeconomic trends and some temporary adverse effects can be expected during construction and periodic nourishment. The plan would be esthetically pleasing and would contribute to beach recreation and related leisure time activities.

62. There would be temporary adverse effects caused by turbidity during dredging operations. The turbidity created should be no worse than that caused by severe storms. Turbid conditions would also occur in localized waters during periodic maintenance dredging. Long-term negative aspects of this plan include increased traffic, auto emissions, and litter associated with higher visitation rates to the improved and expanded beach.

63. The animal life which would be most affected by the project would be the benthic invertebrates associated with the borrow and beachfill areas. The less motile members of the benthic community in the borrow areas would be destroyed by the dredging operation. Organisms similar to those destroyed would probably re-establish within 6 to 18 months following the operation. Placement of fill material on the beach and intertidal areas would also result in the destruction of many invertebrate inhabitants. Ghost crabs and beach fleas of the berm; coquinas,

mole crabs, and burrowing worms of the intertidal area; and blue crabs, sand dollars, and many small mollusks of the subtidal area would sustain the greatest adverse effects from placement of fill. Restoration of the severely eroded beaches would restore habitat which was once available for those invertebrates associated with the beach life zone.

64. Fishes would tend to be less affected by the project than benthic organisms and seaside invertebrates. The overall impact on fishes would be minor since they are capable of avoiding areas of dredging activity and/or turbidity and these adverse factors would be of relatively short duration.

65. The area bird population should escape most of the adverse effects resulting from dredging operations. Construction activities may initially frighten some bird species, but some species would be attracted to the area to feed upon organisms dislodged from the borrow areas during dredging operations and subsequently deposited on the beach.

66. No rare or endangered species are expected to be adversely affected by the project.

67. According to the National Register of Historic Places, there are no known objects of archeological or historical significance located within the proposed borrow sites or beach nourishment area, although local history suggests that historic artifacts

may be present in the general area. Prior to construction, a magnetometer survey of the proposed borrow area and sanitary facilities sites would be conducted to determine possible historic shipwreck sites or other areas of historical interest.

68. Project implementation would not cause any irreversible commitment of natural resources. If, in the future, renourishment was stopped, the continuing erosion of the shoreline would move the beach sand by littoral transport to the inlet areas and eventually fill the borrow areas and restore the natural contours of the inlet shoals.

BEACH AND DUNE DEVELOPMENT

69. Economic - The optimum "Beach and Dune Development" plan (Plan B-1) would provide maximum beach recreation benefits, prevent erosion damages, and protect from the 25-year storm surge. Estimated first cost of the optimum plan is $9,826,000 and the total equivalent annual charges are estimated at $1,009,400. Total equivalent annual benefits are estimated at $1,055,000. Most direct benefits will be realized by immediate beach front property owners; however, benefits will also be realized by beach users in the local tributary area and the day-users, mainly from Charleston County.

70. <u>Socio-Economic</u> - Again, socio-economic effects of the "Beach and Dune Development" plan would generally equal or exceed those of the "Beach Development" plan. The plan would fully meet future recreation demands and provide adequate erosion control, but would only provide a low level of flood protection. Demographic effects, the impacts on earnings, the area's economic role, the need for health and service facilities, would be similar to those noted for the "Beach Development" plan. The considered "Beach and Dune Development" plan would not conflict with existing or proposed land use plans and is compatible with the goals of local interests and for management of the coastal zone resources. The high cost of this plan is a negative factor in view of the local financial requirements.

71. Substantial benefits accrue to the local economy as a result of expenditures made by tourists within the study area who patronize the rental homes, apartment houses, restaurants, and other commercial establishments. The plan, by preserving and enlarging the beach area, insures continued visitations. Expenditures made by recreationists and tourists contribute to the creation of jobs, the generation of incomes, and the stimulation of public and private investment within the study area.

72. Potentially unfavorable social aspect of the improvement would be slight blocking of the view from beach front houses that are lower than the proposed top-of-dune elevation, and some

diminished esthetic values (litter, traffic congestion, etc.) associated with higher visitation rates. Some minor drainage problems may also result at these locations. However, this is considered a minor tradeoff for the protection provided.

73. Environmental. The "Beach and Dune Development" plan even more than the "Beach Development" plan contributes to the Environmental Quality objective. Its features were formulated not only to provide the degree of protection necessary for the area's commercial and residential interests, but also to improve or maintain existing and future environmental conditions on the beach front and surrounding area. Construction and maintenance of the proposed project would materially improve the recreational use of the beach front and surrounding area. Construction and maintenance of the proposed project would materially improve the recreational use of the beach by enlarging and preserving its surface. The artificial dune line, appropriately grassed, would be much more visually pleasing than the base concrete retaining walls and other erosion control structures exposed along much of the beach. In addition, local interests would be required to undertake certain measures along the shoreline that would promote damage reduction while preserving and enhancing the existing environmental qualities of the area. These measures include protection of the removal or relocation by man of fill from the beach and dunes, and restriction of beach access to predetermined routes where access ramps would be provided.

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74. There would be a need for 2,535,000 cubic yards of sand to construct the project and 510,000 cubic yards at 5-year intervals for sand replacement. It is proposed to obtain this sand by dredging off-shore from inlet shoals at either end of the Folly Island. Analysis of sand samples taken from core drilling to about 20 feet below mean low water indicates that suitable borrow areas exist in the general vicinity.

75. Other environmental effects would be essentially the same as those reported for the "Beach Development" plan in paragraphs 60 through 67. Recreational use of the beach will be restricted during fill placement but the inconvenience will be temporary with a more stable beach available for public use upon project completion. Construction is estimated to take about six months and could be accomplished during the winter months or slack season for beach recreation.

EFFECTS ON THE FLOOD PLAIN

76. In compliance with Flood Plain Management Executive Order No. 11988, the potential effects of considered plans of improvements on the flood plain have been evaluated. The potential flood plain development with beach-fill projects would be mostly related to growth in recreational facilities to serve the expected increase in bathers and it is assumed that the oceanfront development would be mostly affected by a beach-fill project, although some recreation-related building inland is likely. Currently, there are 259 front beach structures which are affected in the project reach. They have an estimated value of $25,000 each. About 38 additional structures are expected to be constructed on vacant lots by the year 1990 and during the same period about ten percent or eight of the 75 existing structures which are protected by bulkheads, seawalls, and revetments will be upgraded from a value of $25,000 to about $40,000 each. It is assumed that all of the 38 new structures would be constructed and about eight of the existing structures would be upgraded even if erosion continues unchecked.

77. The beach-fill projects described above would have an effect on both natural and beneficial resources. The effect on natural resources is that beach-fill operations would produce an initial adverse

effect on invertebrates located in the "beach community". Restoration and nourishment of the beach zone would involve desposition of sediments which would cause suffocation and mortality of many relatively immobile inhabitants of the beach-fill zone. However, the effect would be short-term and temporary as colonizers from adjacent areas would rapidly establish new and similar populations in the affected areas. The overall and long-term effect of beach-fill projects is that productivity of the "beach community" species would be enhanced through the creation or more dry-beach area. Additionally, the restored beach would provide more habitat for shorebirds.

78. Beneficial resources would be enhanced through beach-fill operations. Recreational facilities such as more dry beach area, parking, and bath houses would be improved. All the structural plans considered in the Stage 3 formulation Process involve beach filling which would alter the shoreline by different degrees. These plans include "Beach Development" only and "Beach and Dune Development". The minimal project would alter the shoreline less than the other structural plans considered. The best non-flood plain alternative, however, would be the relocation of structures and the "Do Nothing" alternatives. These options, although not favored by local sponsors, avoid potential adverse impacts associated with structural improvements. Either plan would discourage present, as well as, future beachfront property owners. Relocations would probably result if erosion is allowed to continue. These non-structural alternatives would decrease property values, public facilities and services, community cohesion, and recreational opportunities. Existing dune vegetation would suffer damage or destruction. "Relocations" and

and the "No Action" plans would be impractical, socially unacceptable, and unresponsive to the other planning objectives.

79. The economic benefits of beach fill projects, although they enter the economy mostly on the local level, affect the national economic development since the increase in dry beach area will increase the total recreational beach-use opportunities for the United States. The best non-structural plan, "Relocation of Structures", was found to be economically feasible but would do little to increase national economic development.

80. In order to minimize damage to both the natural values of the floodplain and the recreational value of the beach area, construction and maintenance of the project would be scheduled for the winter season. This would minimize inconvenience to recreational beach users. This cooler season also coincides with periods of lower biological activity and would minimize adverse effects on biota of the beach and nearshore ocean. Dredging during winter would involve greater costs due to adverse sea conditions but is justified in the interest of environmental preservation and enhancement.

SUMMARY DISPLAY OF EFFECTS

81. Effective assessment is carred out in terms of the considered plans contributions to the four accounts: NED, EQ, RD, and SWB. A summary of effects of the considered plans is displayed in the main report in terms of their contributions to the four accounts. Included is an enumeration of the 17 areas of concern specifically

defined by Section 122 of Public Law 91-611 as being of critical importance. Other areas of significant concern are dealt with as required. Generally the effects are dealt with as non-qualifiable because either (1) no substantial or reliable raw data was obtainable or (2) available data could not be numerically manipulated due to the inadequacy of analytical tools.

SELECTING A PLAN

82. The selection of the best plan(s) to resolve the problems and meet the needs of the study area involves the comparison of the various alternatives within the context of the formulation criteria outlined earlier and the assessment of alternative impacts. The screening process is simplified by the formulation criteria and the impact assessment. Selection further involves evaluation of the considered plans in terms of established criteria to test their responsiveness. These criteria are: acceptability, completeness, effectiveness, and efficiency.

83. The structural plans considered for implementation, "Beach Development" and "Beach and Dune Development" plans have a high degree of acceptablility with local interests. Plan A-4 has the most excess benefits to cost of the "Beach Development" plans; however, Plan A-0 is considered the more viable because of the

lower non-Federal investment required. Plan B-1 has the highest benefits to cost ratio of all the "Beach and Dune Development" plans but is marginally feasible, economically. All of these plans require a substantial increase in first cost and non-Federal participation when compared to the "Beach Development" plans. The "No Action" plan is deplored by those directly affected by erosion and the Relocation of Structures plan is also unpopular with local interest.

THE SELECTED PLAN

84. In view of the overall evaluation, design criteria and planning objectives, the plan previously designated "minimal plan", Plan A-0, is selected for implementation. This plan in combination with non-structural endeavors that have been established in the study area will provide for meeting the existing and future needs for erosion control and recreation. Details of the minimal plan are presented in Section H, which is entitled "The Selected Plan".

85. Based on planning objectives and foregoing evaluations, Plans A-4 and B-1 are designated as the NED and EQ plans, respectively. The best non-floodplain alternative is the "Relocation of Structures" plan.

SECTION H

THE SELECTED PLAN

THE SELECTED PLAN

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SECTION H

THE SELECTED PLAN

1. This section presents an overall view of the Selected Plan its effects. It also discusses the significant design, cons and operation and maintenance of the plan.

Beach Ownership

2. In the State of South Carolina, virtually all wetlands ly mean high water belong to the State and are held in trust for benefit of the general public. This is the case of the beach Folly Island. As State property, it is protected from possess others except when natural accretment occurs. In this case, t the accretion falls to the riparian landholder unless this ri been previously given up.

3. Ownership of artificially accreted lands belongs to the Sta according to recently enacted legislation which created the Sou Carolina Coastal Zone Commission. Such accretment, if accompli without the consent of the riparian owner, would in effect be of property (riparian right) without due compensation. Such wou held to be unconstitutional by the judiciary should an objecti raised even though the artificial accretment might stabilize and prevent further erosion lost to the riparian owner.

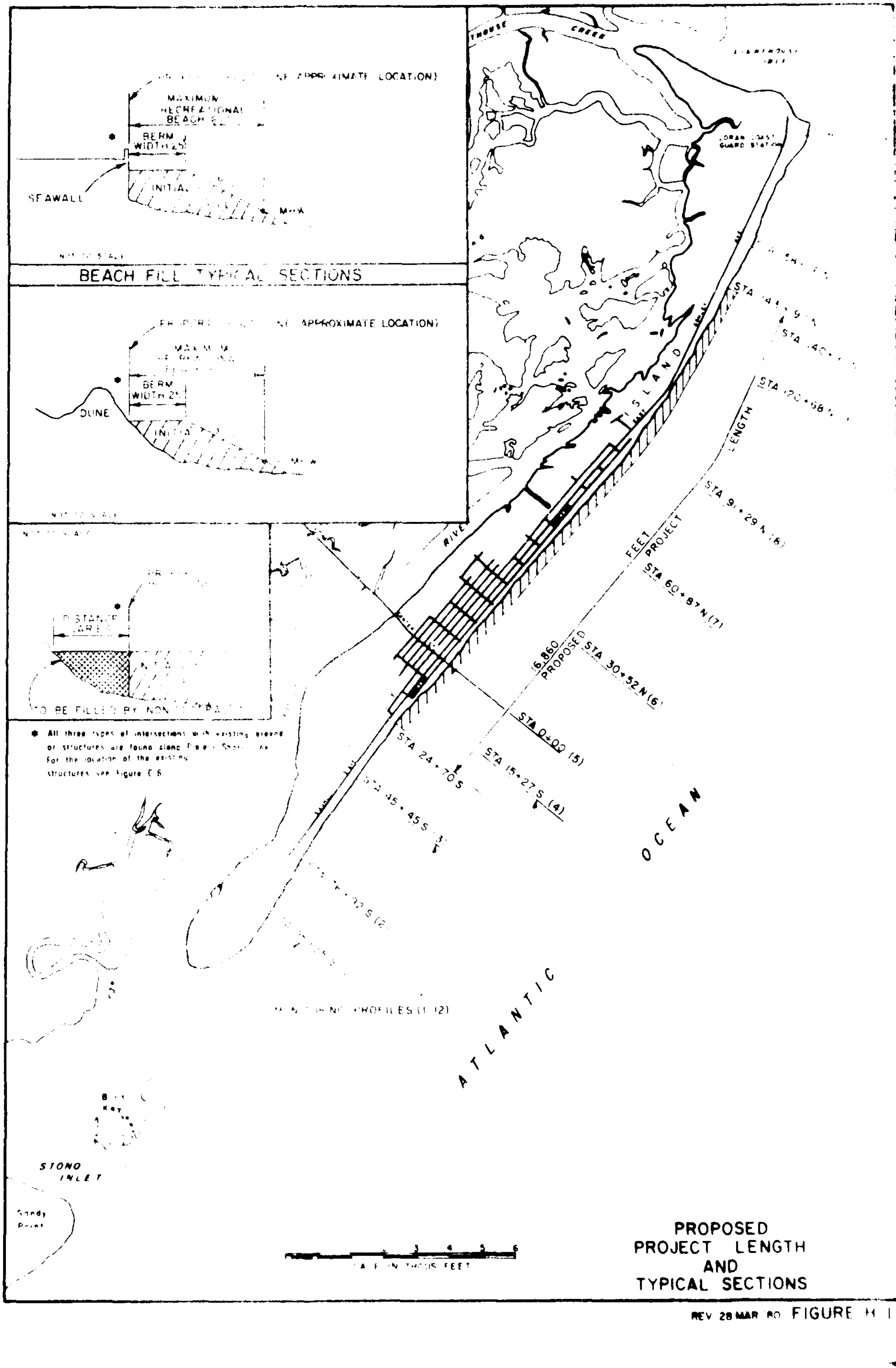
4. It is evident that when a Federal Project is constructed which calls for artificial beach nourishment, that it is in the best interest of all parties concerned to establish a boundary line or "hold line" between properties of the various claimants. This line would be surveyed and duly recorded. A quit-claim deed would be required for lots touched by the artificial accretment. Likewise, an instrument acceptable to both the Federal and State governments would be needed to legalize the filling of State owned wetlands and the borrow from them.

5. To avoid complicating the task of acquiring all the required lands, easements and rights-of-way, the "hold line" should correspond as nearly as possible to the existing mean high water line. Once such a line is established, all accretment seaward would be public property. Where filling is accomplished landward, the accretment would be privately owned. Cost of this latter type of accretment would be the responsibility of the non-Federal sponsor who more than likely would allocate the cost to the individual recipient landowner.

Plan Description

GENERAL

6. The Selected Plan, designated as Plan A-0 in Section G, Project Formulation, provides for beach restoration and periodic nourishment for that reach of Folly Beach lying between Station 24+70S and Station 43+90N as shown on Figure H-1. Existing groins at these stations, at each end of beach fill project, will function as a container to help stabilize the fill material. Typical sections reflecting existing conditions found along the beach are shown on Figure H-1.



PROPOSED PROJECT LENGTH AND TYPICAL SECTIONS

REV 28 MAR 80 FIGURE H 1

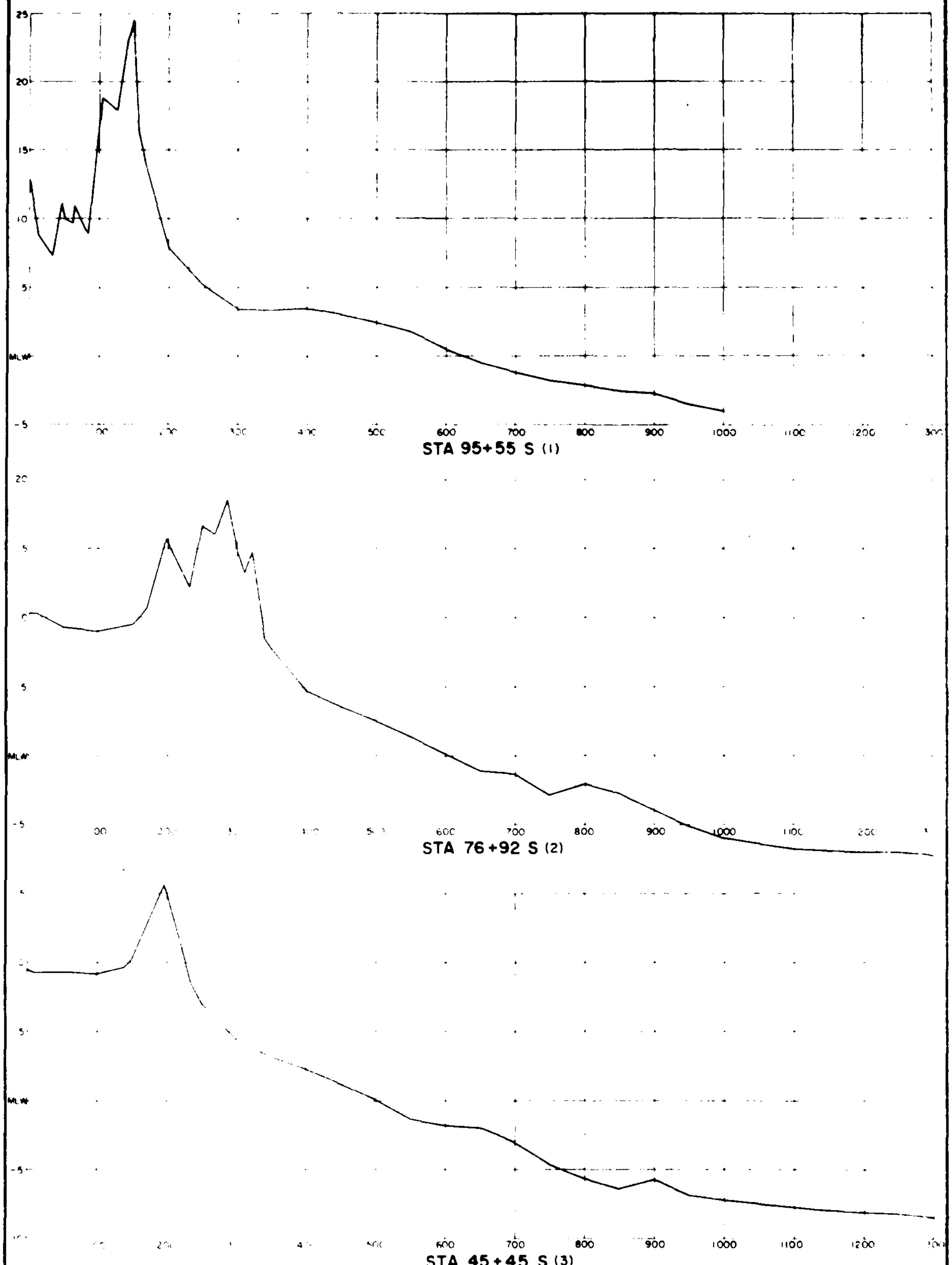
7. The beach berm would be constructed to an elevation of 4 feet above mean sea level and each would be fronted by a beach having a face slope of about 30 horizontal to one vertical. The project would provide an average useable width above mean high water line of 50 feet. The slope of the beach face will be formed by natural forces during and subsequent to material placement. Machines may be necessary to shape the berm depending upon the skill of contractors in placing the material.

8. In those areas where fill is to be placed landward of the "hold line," such placement would be made to effect proper drainage. Where possible runoff will be directed landward to avoid the erosive effect of sheet flow on the berm and beach face.

VOLUME OF FILL

9. Initial Construction. The amount of beach fill required for initial construction is based on the beach profiles survey of April 1977. Sections shown in Figures H-2 through H-5 are referenced to a baseline which is shown on Figure H-1. Volumes required at the time of construction may vary considerably from those used herein inasmuch as they will be based on the condition of the beach at that time and the positioning of the "hold line" established.

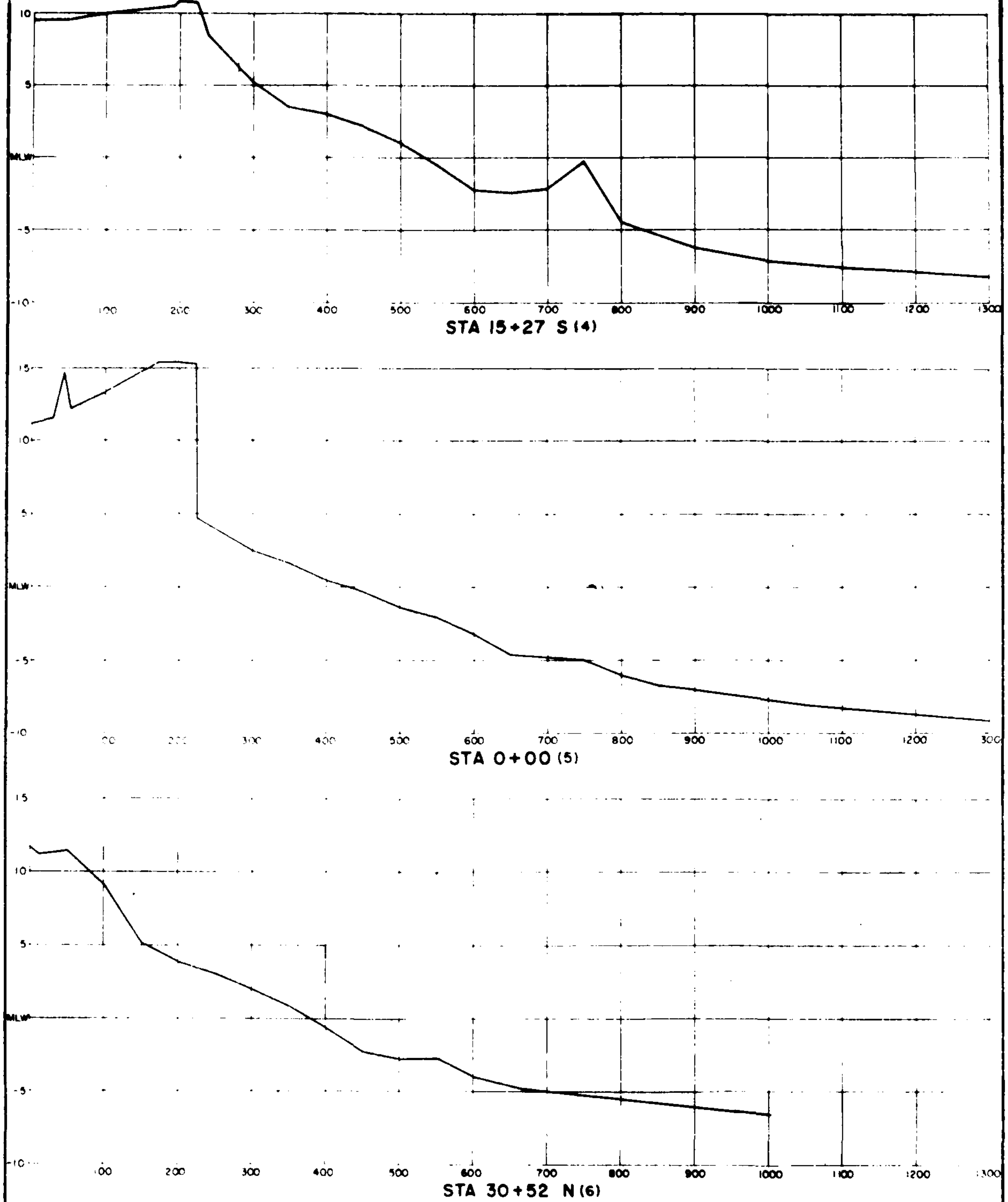
10. Materials placed will be classed as one of three categories. These are restoration, nourishment and private fill. As the material is being placed, it is subjected to the natural sorting of waves, tides and currents. Assumptions concerning the effects of sorting on the quantities of material required by class are displayed in Table H-1



TYPICAL SECTIONS

APRIL 1977 BEACH CROSS SECTIONS
AT FOLLY BEACH,
SOUTH CAROLINA

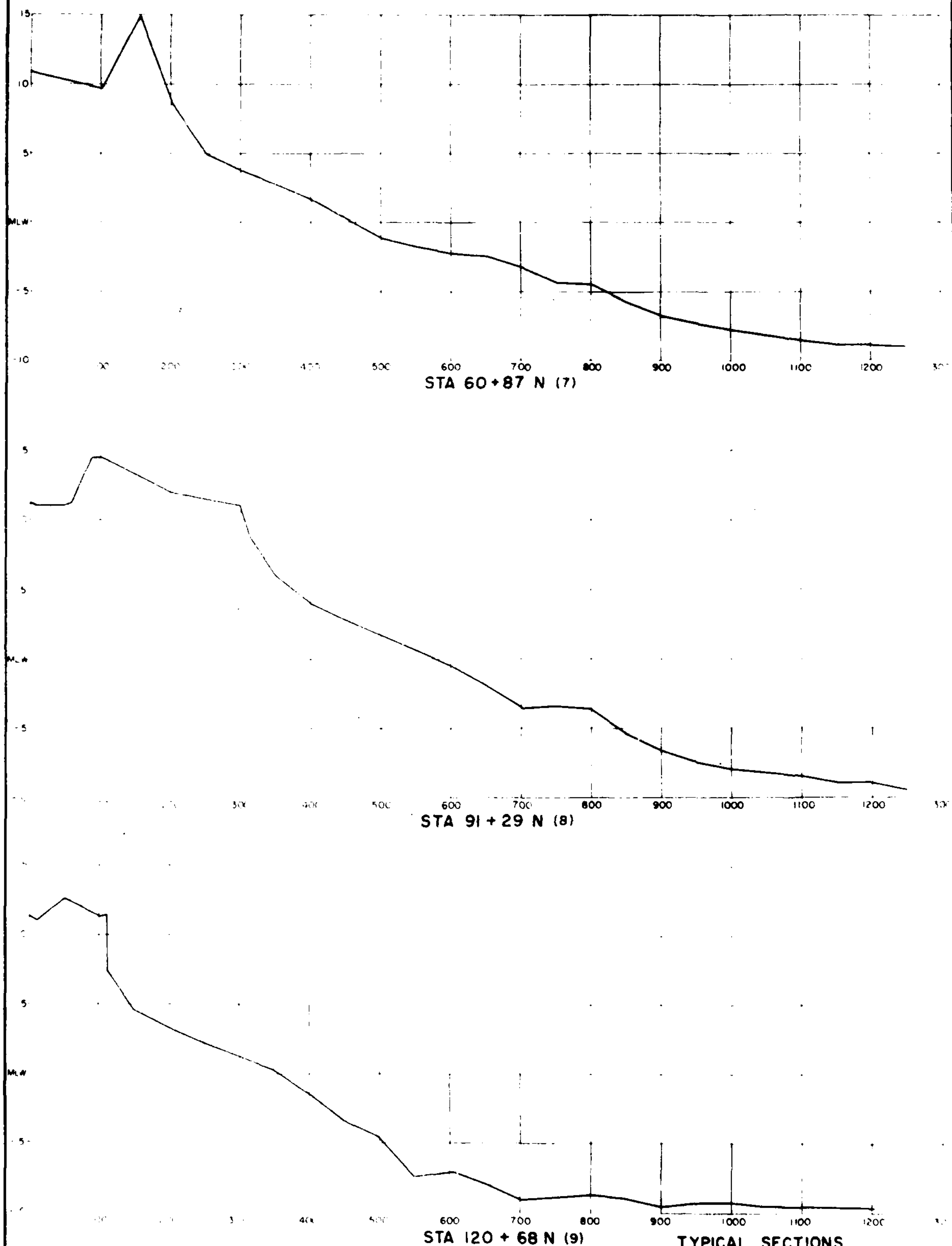
FIGURE H-2



TYPICAL SECTIONS

APRIL 1977 BEACH CROSS SECTIONS
AT FOLLY BEACH,
SOUTH CAROLINA

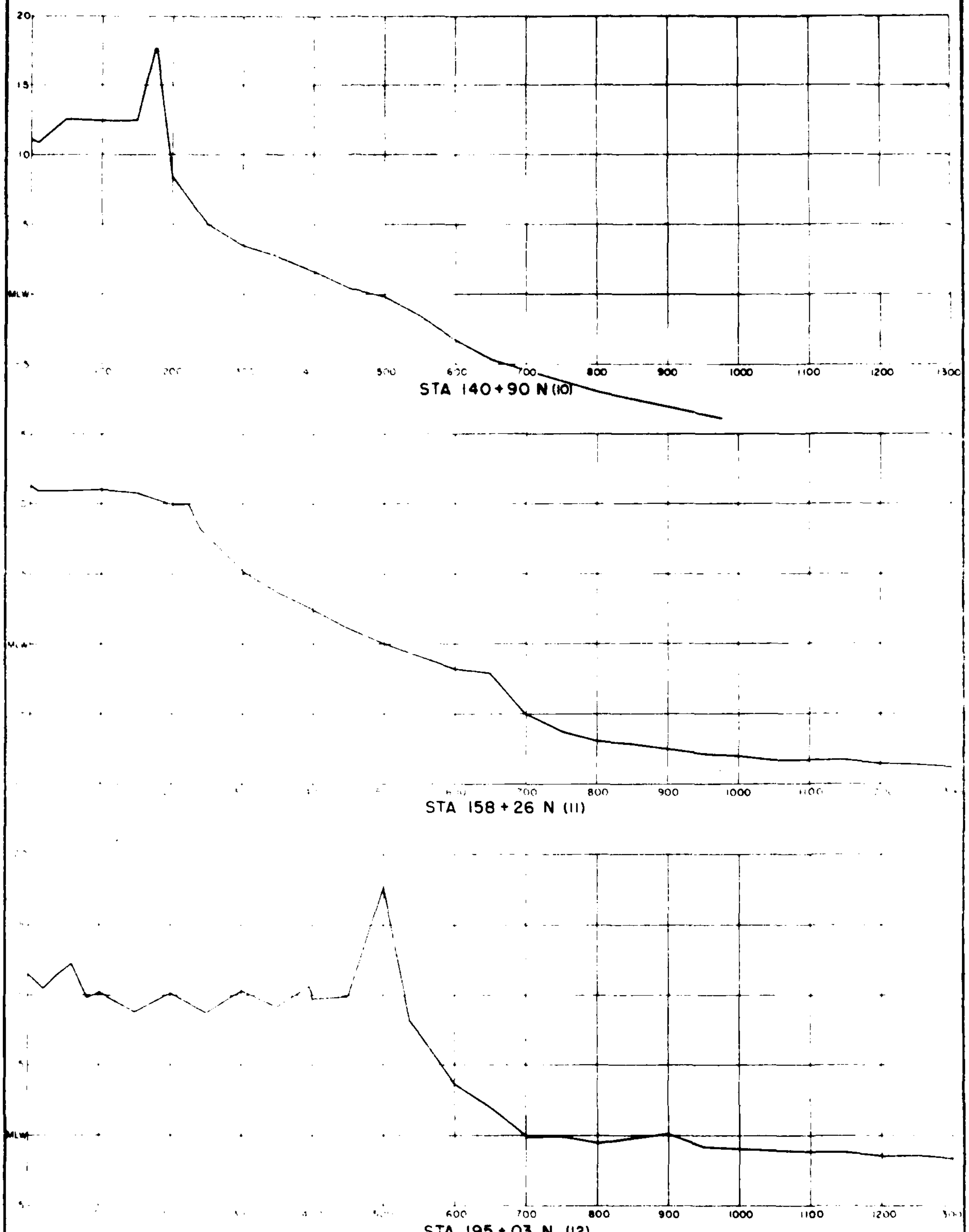
FIGURE H-3



TYPICAL SECTIONS

APRIL 1977 BEACH CROSS SECTIONS
AT FOLLY BEACH,
SOUTH CAROLINA

FIGURE H-4



TYPICAL SECTIONS

APRIL 1977 BEACH CROSS SECTIONS
AT FOLLY BEACH,
SOUTH CAROLINA

FIGURE H-5

which follows. A fill factor of 1.4 was used for computational purposes.

TABLE H-1

VOLUME OF INITIAL FILL

Class	In Place Requirement	Subject To Sorting	Volume of Overfill	Total Borrow
Restoration	233,000 yd^3	50%	47,000 yd^3	280,000 yd^3
Nourishment	253,000 yd^3	100%	101,000 yd^3	354,000 yd^3
Private Fill	50,000 yd^3	0%	0	50,000 yd^3
TOTAL	536,000 yd^3		148,000 yd^3	684,000 yd^3

11. Periodic Renourishment. Erosion of the artificial nourishment initially placed will be approximately 5 feet per year. In order to preserve the outputs of the project, it will be necessary to renourish the beach at about five year intervals. Using the profiles surveyed in 1977 as a guide, it is estimated that 253,000 cubic yards of material must be put in place. Taking into account the winnowing effect, another 101,000 cubic yards of material would be pumped to get the required placement assuming a fill factor of 1.4.

SOURCE OF MATERIAL

12. Section D gives the results of borings taken to locate potential sources of borrow material for use at Folly Beach. Laboratory analyses indicate that overfill ratios vary from about 1.0 to 3.6. It was determined that shoals found oceanward of each end of the island are the most feasible borrow areas with adequate quantities of suitable sands located within pumping distance of the project site. Use of these areas would minimize the adverse enviornmental effects and is recommended by other concerned agencies.

BEACH MONITORING PROGRAM

13. To insure timely renourishment and to evaluate the performance of artificially placed materials, a routine monitoring program will be laid out and implemented. The program will include the collection and analysis of data on beach profiles, soil composition, and volumetric changes with respect to time. Profiles will extend seaward to the -6 ft. MLW depth and sand samples will be taken at: Mid berm, foreshore slope (above MLW), and -6 ft. MLW. The location of stations which will be established and monitored are shown on Figure H-1 and cross sections of these 12 stations are shown on Figures H-2 through H-5.

14. These profiles should be surveyed and initial sand samples taken prior to placement of any beach fill. Following placement of the recommended fill, surveys and sand sampling will be done once per year for the first five years, once during year 7 and 10 and every five years thereafter until the end of the 50-year project life.

ASSOCIATED PUBLIC FACILITIES

15. There is an unsatisfied need for public facilities in the study area. Shortages exist in the supply of adequate parking spaces, bath houses and comfort stations, and/or public transportation for beach users. Costs of providing for these needs have not been included in the computation of project costs as these items are considered self-liquidating. In view of the recognized unsatisfied need, non-Federal interest would be required to provide facilities to satisfy unmet needs assiciated with the proposed public works.

16. Beach Access. Beach access is currently provided at street ends throughout most of the ocean shoreline. These access points, shown on Figure H-6, are considered to be adequate. Non-Federal interest would be required to insure that a sufficient number of these access points will remain open. This is to assure that potential users will not have to walk long distances, say about one-quarter of a mile, in order to get to the public beach.

17. Public Parking. There are presently about 325 off-street parking spaces, 750 private driveways, and 3,752 spaces on the city streets which are within easy walking distance of the proposed beach-fill project area. About 300 of the existing off-street public parking spaces are located in the recreational area in the center of the island. The developers of this area plan to increase this number by purchasing adjacent lands for conversion

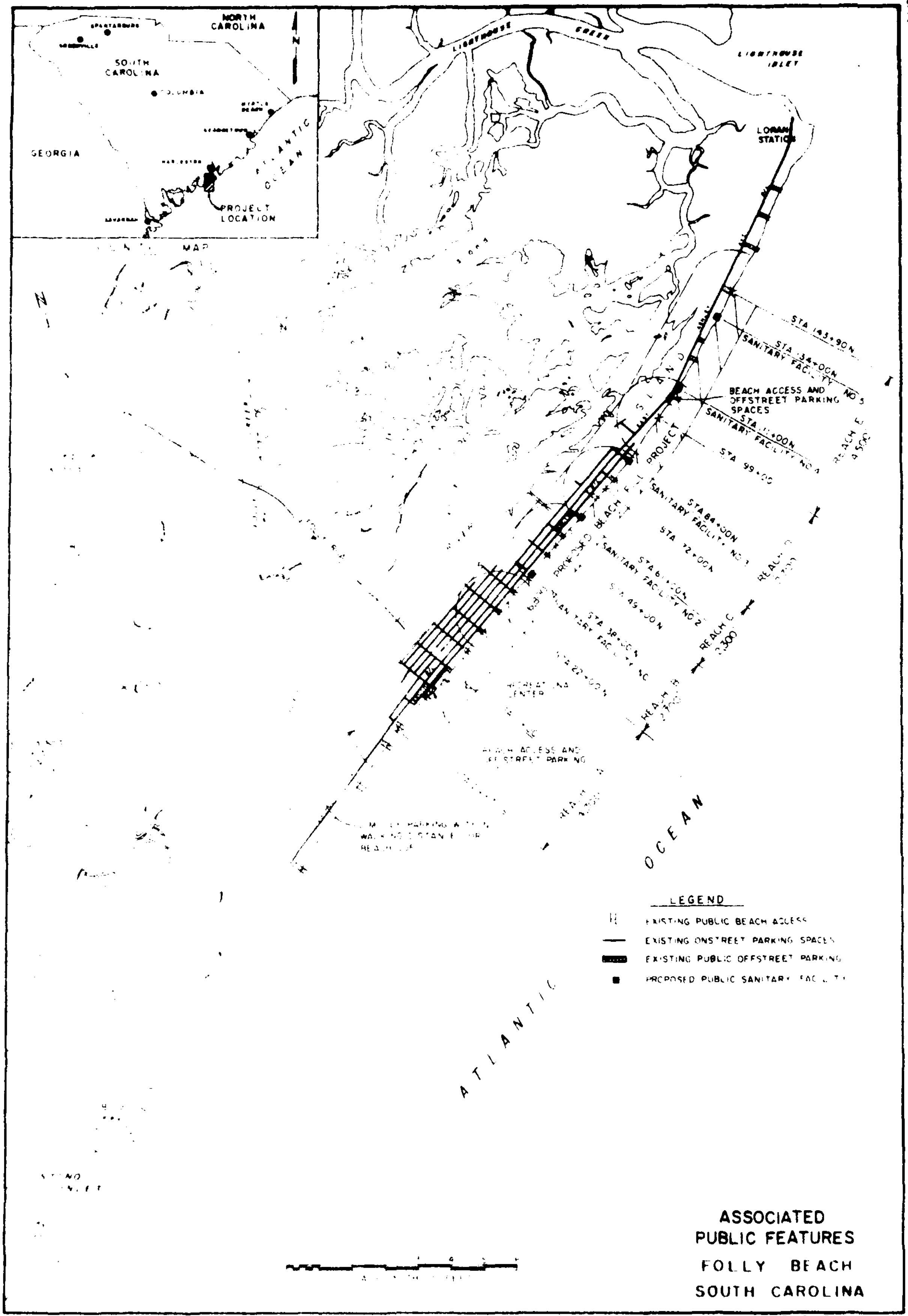

NORTH CAROLINA
SOUTH CAROLINA
COLUMBIA
GEORGIA
ATLANTIC OCEAN
PROJECT LOCATION
LIGHTHOUSE CREEK
LIGHTHOUSE INLET
LORAN STATION
STA 143+90N
STA 134+00N SANITARY FACILITY NO 5
BEACH ACCESS AND OFFSTREET PARKING SPACES
SANITARY FACILITY NO 4
STA 99+00
STA 84+00N SANITARY FACILITY NO 3
STA 72+00N
STA 61+00N SANITARY FACILITY NO 2
STA 49+00N
STA 38+00N
PROPOSED BEACH FILL PROJECT
OCEAN
ATLANTIC
LEGEND
EXISTING PUBLIC BEACH ACCESS
EXISTING ONSTREET PARKING SPACES
EXISTING PUBLIC OFFSTREET PARKING
PROPOSED PUBLIC SANITARY FACILITY
ASSOCIATED PUBLIC FEATURES
FOLLY BEACH
SOUTH CAROLINA

FIGURE H-6

to parking lots. The on-street spaces are considered to be 22 feet of usable and legal parking distance for each motor vehicle. The parking spaces needed with the recommended beach erosion control project was based on the design beach capacity with an average dry beach width of 50 feet for 16,900 feet of improved shore line. Assuming each beach user needs 100 square feet of dry beach area, the beach capacity created by the project is computed as 8,450 users. This is the number of bathers that could use the improved beach at one time without overcrowding. If it is assumed that all the beach users are transported to the project area by car and each car carried an average of three people, the number of parking spaces needed would be 8,450 divided by three, or 2,816 spaces. Thus it appears that there is an adequate number of existing parking spaces at Folly Beach. An analysis of the distribution of available parking spaces, however, reveals a deficiency of spaces in the northeastern portion of the project reach. This analysis is summarized in Table H-2.

18. The project shoreline was segmented to facilitate the evaluations. In the northeastern segment, designated as Reach E on Plate H-6, there is a deficiency of 92 parking spaces. Here the non-Federal sponsor of the beach nourishment project would be responsible for satisfying this deficiency. Added spaces would necessarily have to be added in Reach E or within easy walking distance of this reach. Parking could be added by either expanding the existing parking lot in this reach or by developing a new lot or lots.

19. The project sponsor, the City of Folly Beach, has been appraised of the parking deficiency and has plans to develop additional parking spaces

[illegible]	[illegible]	B	[illegible]	[illegible]	[illegible]	Total
Length of [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Onstreet Parking Spaces [illegible]						
Exclusive to the [illegible]	[illegible]	[illegible]	0	19	78	1,578
Spaces Within Walking [illegible] of Adjacent Northern [illegible]	[illegible]	[illegible]	288	136	0	1,211
Spaces Within Walking [illegible] of Adjacent Southeast [illegible]	[illegible]	[illegible]	206	224	71	963
Total Onstreet Parking Spaces	[illegible]	[illegible]	[illegible]	379	349	3,752
Offstreet Parking Spaces						
Public	[illegible]	[illegible]	0	0	25	325
Private Spaces Utilized While Improved Beach is at Capacity [illegible]	[illegible]	210	138	189	148	1,125
Total Offstreet Parking Spaces Utilized While Improved Beach is at Capacity	[illegible]	[illegible]	138	189	173	1,450
Total Parking Spaces Utilized While Improved Beach is at Capacity	[illegible]	1,021	632	568	522	5,202
Number of Spaces Needed 6/ While Improved Beach is at Capacity Use	783	450	383	450	750	2,816
Excess (+) or Deficiency (-)	+1,676	+571	+249	+118	-228	+2,386
Adjustment by Borrowing from Adjacent Reach	[illegible]	0	[illegible]	-118	+136	
Excess (+) or Deficiency (-) After Adjustment by Reach	+1,676	+571	+231	[illegible]	-92	

[illegible] Existing parking spaces are considered to be accessible to [illegible] if they are within easy walking distance (one-quarter of a mile).

[illegible] Based on 22 feet space length.

[illegible] These spaces are located [illegible] far (more than one-quarter mile) from adjacent reaches to share service.

[illegible] Spaces that are within [illegible] quarter mile of adjacent reach and could be shared between adjacent reaches.

5/ Assuming [illegible] cars [illegible] three people [illegible] car.

[illegible] Based on [illegible]

and introduce a shuttle bus system to relieve this deficiency. Lands would be purchased in the central portion of the island where there are vacant lots available, parking lots with restrooms would be constructed on this land, and buses or other modes of transportation would be used to shuttle people from this area, which has an excess of parking spaces, to the other portions of the project area where there is a shortage of spaces. Shuttle buses would only be required on peak days when the improved beach would be utilized to or near capacity.

20. Sanitary Facilities. Several automobile service stations, restaurants, arcades, and the boardwalk amusement park area in the central portion of the island have sanitary facilities which are currently being used by the public. Due to the increased recreational usage of Folly Beach resulting from construction of an erosion control project, it was determined that additional sanitary facilities would be required to serve users of the improved beach northeastward of the main business area. Although the city has no public sewer facilities at this time, everything being on septic tanks, it has taken the necessary steps toward correcting this situation with the development of a Section 201 (Public Law 92-500) sewer facilities plan, that includes sufficient capacity to handle the additional load attributable to the proposed beach project. This plan will include eight-inch forced mains parallel with Center Street and Folly Road to a sewage treatment plant located on James Island. The mains to Folly Island will have interceptor lines to serve both ends of Folly Island. The system's reserve capacity is adequate to accommodate the estimated 30,000 visitors

to Folly Beach on a peak summer day. The implementation of this facilities plan is expected within the next year which would make it available for use when additional sanitary facilities, needed for the beach erosion control project, are constructed.

21. The central portion of Folly Beach will have adequate sanitary facilities with the existing and proposed new works. Development plans by the owners of the boardwalk recreational area includes renovation and expansion of the two existing bath houses with four-stall rest rooms to a modern facility with a total of 20 stalls. Five additional comfort stations with outside showers will be required to service the remainder of the project area. The five new stations would be spaced at about one-half mile intervals in order to limit the walking distance to these facilities. Approximate locations of these comfort stations are shown on Figure H-6. The actual locations will depend to a great extent on the availability of suitable building sites at the time of project construction. Data on these facilities are shown in Table H-3.

TABLE H-3

DATA ON PROPOSED SANITARY FACILITIES

No.	Location	Service Reach (in Lin. Feet)	No. of Stalls 1/
1	38+00N	2,700	6
2	61+00N	2,500	6
3	84+00N	1,800	4
4	111+00N	2,500	6
5	134+00N	2,000	4

1/ Number of stalls is estimated at one per 200 people on peak day use for the 16,900 feet of shoreline protected. The capacity of the project dry-beach area at one time is estimated at 8,450.

Economics of Selected Plan

GENERAL

22. This part of the report discusses the economic aspects of the Selected Plan. It covers costs, benefits, and economic justification, and briefly describes the economic methodology. The analysis is based on a project life of 50 years and an interest rate of 6-7/8 percent.

METHODOLOGY

23. The tangible economic justification of the proposed improvements can be determined by comparing the equivalent average annual charges (i.e., interest, amortization, and maintenance costs), with an estimate of the equivalent average annual benefits which would be realized over the 50-year period of analysis selected. Appropriate values given to costs and benefits at their time of accrual are made comparable by conversion to an equivalent time basis using an appropriate interest rate. A rate of 6-7/8 percent applicable to public projects was used in this report. Interest during construction was not costed as the estimated construction period does not exceed 2 years. Recreational benefits are based on estimates of population and growth, beach use supply and demand, added opportunities created by the Selected Plan, and unit values of these opportunities.

ESTIMATED FIRST COSTS

24. Estimated first costs of fill material are based on the [illegible] previously discussed herein. For alternative comparison and fo[illegible] Selected Plan, materials placed on the beach were assumed to [illegible] taken in equal amounts from Stono Inlet and from Lighthouse [illegible] estimated unit cost of dredging, transporting and placing this [illegible] is $2.40 per cubic yard. Mobilization and demobilization costs [illegible] estiamted at $120,000. This unit cost would increase to $3.20[illegible] mob and demob costs about $160,000 should all of the material [illegible] from Stono Inlet. The unit cost would increase to $3.00/cy with [illegible] demob costs at $150,000 using only Stono Inlet. The initial cost [illegible] beach monitoring program is $7,000. Estimates of first costs of [illegible] Selected Plan are given in Table H-4

TABLE H-4

ESTIMATED FIRST COSTS
BEACH DEVELOPMENT PLAN

Item	Co[illegible]
FEDERALLY SHARED FIRST COST	
Mobilization & Demobilization	$ [illegible]
Beach Fill, 634,000 cy @ $2.40	1,[illegible]
Contingencies (20%)	[illegible]
Total Construction Cost	$ 1,[illegible]
Engineering and Design (5%)	
Supervision and Administration (6%)	[illegible]
Beach Monitoring Program Cost	
TOTAL FEDERALLY SHARED FIRST COST	$ [illegible]
NON-FEDERAL FIRST COST	
Beach Fill, 50,000 cy @ $2.40	[illegible]
Contingencies (20%)	
Total Construction Cost	$ [illegible]
Engineering and Design (5%)	[illegible]
Supervision and Administration (6%)	[illegible]
Easements and Acquisition Costs	[illegible]
TOTAL NON-FEDERAL FIRST COST	$ [illegible]
TOTAL PROJECT FIRST COST	$ [illegible]

PERIODIC RENOURISHMENT COSTS

25. Estimated costs of each renourishment effort made on an average of once every 5 years during the 50 year project life are shown in Table H-5 .

TABLE H-5

ESTIMATED RENOURISHMENT COSTS, FEDERALLY SHARED
(for 5-Year Beach Fill Amounts)

Item	Cost
Mobilization and Demobilization	$ 120,000
Beach Fill, 354,000 cy $2.40	850,000
Contingencies (20%)	194,000
Total Construction Cost	$1,164,000
Engineering and Design (5%)	58,000
Supervision and Administration (6%)	70,000
TOTAL 5-YR NOURISHMENT COST	$1,292,000

ANNUAL COST

26. An amortization period of 50 years was used with an interest rate of 6-7/8 percent for both the Federal and non-Federal contributions. No interest during construction has been included since construction should take less than 2 years. Estimated average annual charges are given in Table H-6.

TABLE H-6

ESTIMATED AVERAGE ANNUAL CHARGES

ITEM	COST
FEDERALLY SHARED	
Interest and Amortization (0.071317 X 2,193,000 1/)	$ 156,400
Periodic Renourishment (0.071317 X $1 292,000 2/ X 2.408384 3/)	221,900
Beach Monitoring Program Cost 4/	3,700
TOTAL FEDERALLY SHARED ANNUAL COST	$ 382,000
NON-FEDERAL (NO COST SHARING)	
Interest and Amortization (0.071317 X $200,000 1/)	$ 14,300
TOTAL ANNUAL COST	$ 396,300

1/ From Table H-4

2/ From Table H-5

3/ Present worth of 9 renourishment operations at 5 year intervals.

4/ Present worth of 16 monitoring program operations as described in Paragraphs 13 and 14 of this section of Appendix 1.

BENEFITS

27. Estimates for monetary benefits are based on April 1979 price levels. These are classed as (1) prevention of losses to real property and (2) enhancement of private lands, (3) preservation and supply of recreational opportunities. Losses to real property break out into two sub-classes: land losses prevented and building damage prevented including contents. Details on the methodology employed in quantifying benefits are given in Section E of Appendix I. A summary of the benefits quantified monetarily is given in Table H-7.

TABLE H-7

MONETARY BENEFITS

Class	Annual Benefit
Protection of Real Property:	
Land	$ 119,200
Buildings and Contents	51,700
Enhancement of Private Lands	34,800
Recreation	681,500
TOTAL	$ 887,200

BENEFIT-COST RATIO

28. In order to justify construction of the proposed project from an economic viewpoint, the average annual benefits for the plan should equal or exceed the average annual project cost. All monetary values are based on a common dollar value and are expressed in comparable terms to the fullest extent possible. A benefit-cost-ratio of was computed as follows:

$$\frac{\text{Benefit}}{\text{Cost}} = \frac{\$\,887,200}{\$\,396,300} = 2.2$$

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Impacts of Plan

29. Implementation of the recommended plan would produce several beneficial effects, including improved appearance of the beach, increased recreational dry beach area, and improved protection of shore structures against erosion.

30. Accompanying adverse impacts would be temporary and minor. Water quality would be degraded in the vicinity of the dredge cutterhead and adjacent to the nourishment site as localized increases in turbidity and reductions in dissolved oxygen occur. No significant biotic impacts should be generated by these conditions and water quality should return to normal within several days after project completion.

31. Mortality of benthic organisms and associated population reductions would also occur in borrow areas and beach nourishment sites, but colonizers of the same or similar species from nearby areas should reestablish viable populations in the affected areas within a period of several months.

32. Physical and biological effects of project maintenance would be similar to those of project construction but of a smaller magnitude. Project implementation would not significantly affect any rare or endangered species nor would it cause significant irreversible commitment of natural resources.

33. No archeological or historic resources of significance are known to occur in the project area. However, a magnetometer survey of potential borrow areas and sanitary facilities sites would be conducted prior to initiation of dredging activities. A detailed assessment of environmental impacts appears in the Environmental Impact Statement, Appendix 2.

Plan Accomplishment

34. The addition of sand to the present beach will provide a wider beachfront that can accommodate a larger number of visitors. This will act as an added attraction to the area, encouraging an increase in local and tourist visitation. It is estimated that the available dry beach area in 1980 without the proposed plan, would be only about 7 acres. With the proposed plan, the available dry beach area (from the landward end of the artifical berm to the mean high waterline) would be increased by approximately 19 acres. Estimated beach visitations and recreational activities with and without the selected plan are discussed in Section E.

35. Direct beneficiaries of the improvement would be the property owners and commercial interests along the shorefront who would receive protection from erosion, resident beach users, and tourists originating mainly from the State of South Carolina. Overall beneficiaries are numerous and widespread, being essentially the general public, although they are concentrated generally in the greater Charleston metropolitan area.

FOLLY BEACH

SOUTH CAROLINA

FINAL ENVIRONMENTAL IMPACT STATEMENT

APPENDIX

2

PREPARED BY THE

CHARLESTON DISTRICT, CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

SUMMARY

BEACH EROSION CONTROL AND HURRICANE PROTECTION FOLLY BEACH, SOUTH CAROLINA

( ) Draft Environmental Statement (X) Final Environmental Statement

Responsible Office: U. S. Army Engineer District, P.O. Box 919, Charleston, S. C. 29402 (AC 803-724-4229)

1. Name of Action: ( ) Administrative (X) Legislative

2. Description of Action: The recommended plan provides for beach restoration, erosion control and improvement of recreational beach along the ocean shoreline of Folly Beach, South Carolina. The plan of improvement provides for restoration and periodic renourishment of a continuous reach of beach in the center section of the Folly Island ocean shoreline for a total project length of 16,860 feet. The plan would require 684,000 cubic yards of sandy fill material. Borrow areas selected as a source of fill sand are shoal areas in Lighthouse and Stono Inlets.

3. a. Environmental Impacts: Beach nourishment and restoration would create and maintain a total of 23 acres of beach which would bring about an increase in recreational activity and reduce beach erosion which currently endangers oceanfront development. Minor and temporary impacts include the disruption of benthic populations, increase in water turbidity, reduction in aesthetic values during construction, possible improvement of the navigability of inlets due to the removal of shoal material and increase in auto emissions and noise levels during peak activity periods.

b. Adverse Environmental Effects: Temporary disruption of benthic populations, minor and temporary increase in water turbidity, and reduction in aesthetic values may occur during construction. Minor increases in auto emissions and noise levels may occur as a result of increased recreational activities.

4. Alternatives: Nonstructural alternatives include flood insurance, zoning and modification of building codes, evacuation planning, flood proofing

grassing existing beaches, relocation of structures, no growth and no action. Structural alternatives include seawalls, beach revetments, offshore breakwaters, beach development and beach and dune development.

5. Section 404 - Clean Water Act of 1977

a. Feasible alternatives to the proposed discharge have been considered and none that are practicable will have less adverse impact on the aquatic and semi-aquatic ecosystem.

b. There are no unacceptable environmental impacts on the aquatic and semi-aquatic ecosystem as a result of the discharge.

c. The discharge of the dredged (or fill) material will be accomplished under conditions which will minimize, to the extent practicable, adverse environmental effects on the aquatic and semi-aquatic ecosystem.

Findings: Based on the above evaluation and determinations, the proposed discharge site for the Folly Beach Project has been specified through the application of the Section 404(b) Guidelines.

6. Comments Received:

Department of Health, Education and Welfare
Federal Power Commission
United States Department of Interior
United States Environmental Protection Agency
United States Department of Commerce
South Carolina Coastal Council

7. Draft Statement to EPA 15 June 1979 ______.

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FINAL ENVIRONMENTAL IMPACT STATEMENT
BEACH EROSION CONTROL AND HURRICANE PROTECTION
FOLLY BEACH, SOUTH CAROLINA

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FOLLY BEACH, SOUTH CAROLINA

1. PROJECT DESCRIPTION.

1.1 Study Authorization. A survey to determine the need for beach erosion control, hurricane protection, and related improvements at Folly Beach, South Carolina, was authorized on 15 June 1972 by a resolution of the Committee on Public Works of the United States Senate in accordance with Section 110 of the Rivers and Harbors Act of 1962.

1.2 Project Purpose. The purposes of the project are to provide beach restoration, erosion control, and improvement of recreational beach along the ocean shoreline of Folly Beach, South Carolina. Accomplishment of these objectives would also contribute to the support of the tourist-based economy of the area.

1.3 Project Location. The project is to be constructed along a 16,860-foot reach of eroded beach in the town of Folly Beach, which is located on Folly Island about six miles south of the Charleston Harbor entrance channel (Figure 1). The island is six miles long, one-half mile wide, and is oriented northeast to southwest. The town of Folly Beach lies in the middle of the island between the U. S. Coast Guard Loran Station to the northeast and 190 acres of undeveloped land to the southwest. The extensive estuary and marshes behind the island drain to the Atlantic Ocean through Lighthouse and Stono Inlets to the north and south, respectively. South Carolina Route 171 crosses the marsh between James Island and Folly Island and provides the only highway access to Folly Beach.

1.4 Description of the Proposed Plan of Improvement. The proposed plan of improvement provides for restoration and periodic renourishment of a continuous reach of beach in the center section of the Folly Island ocean shoreline from Station 24+70 South to Station 143+90 North (Figure 1). Total project length would be 16,860 feet. This plan would require 684,000 cubic

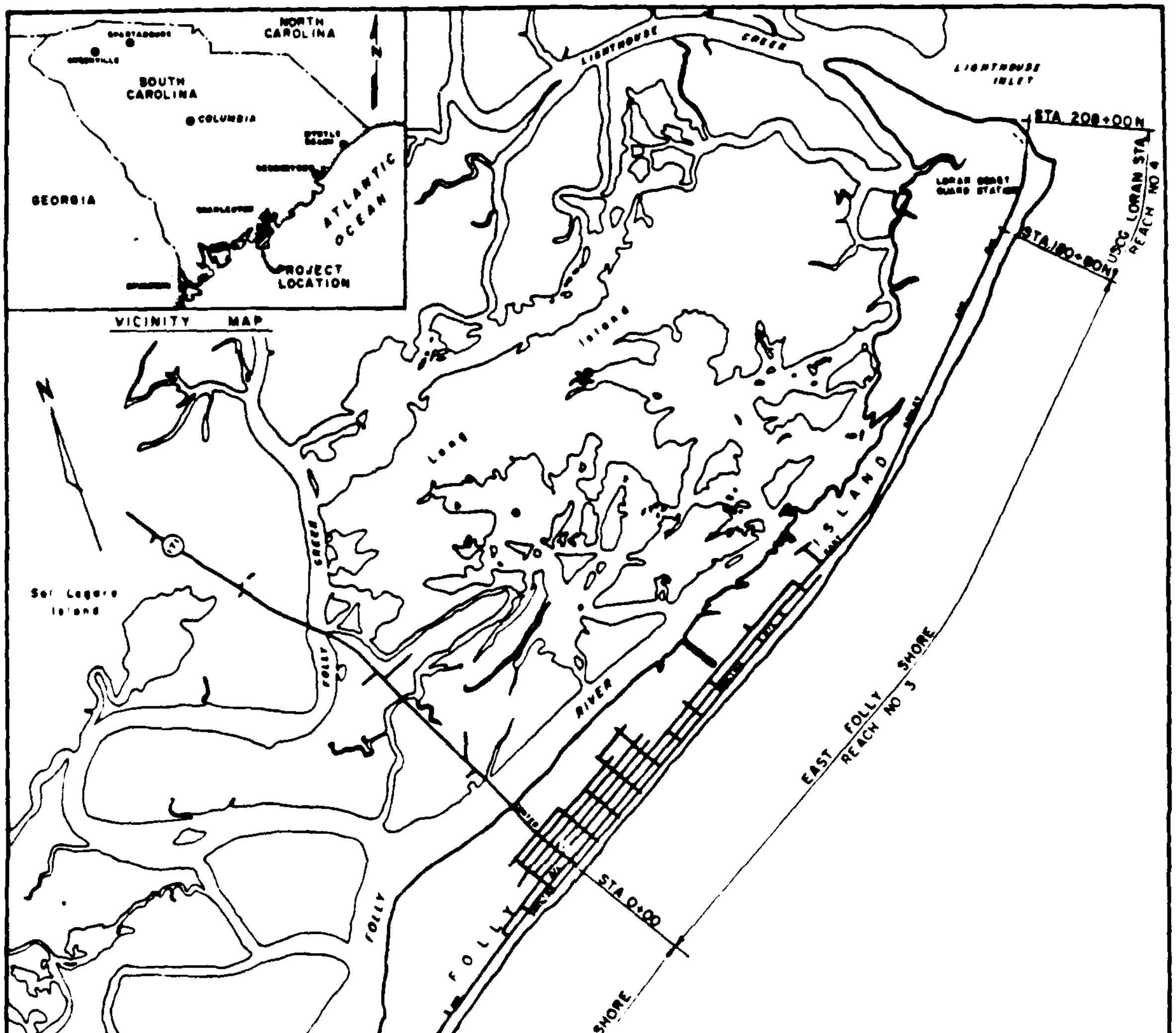
NORTH CAROLINA
SOUTH CAROLINA
COLUMBIA
GEORGIA
ATLANTIC OCEAN
PROJECT LOCATION
VICINITY MAP
LIGHTHOUSE CREEK
LIGHTHOUSE INLET
STA 208+00N
USCG LORAN STA REACH NO 4
STA 180+80N
FOLLY ISLAND
FOLLY RIVER
EAST FOLLY SHORE REACH NO 3
STA 0+00
WEST FOLLY SHORE REACH NO 2
STA 76+70S
BIRD KEY AREA REACH NO 1
STA 118+70S
ATLANTIC OCEAN
STONO INLET
SCALE IN THOUS FEET
GENERAL MAP
FOLLY BEACH
SOUTH CAROLINA

FIGURE 1

yards of fill material. Sandy sediment similar to native beach sand is available in adequate quantities from the sandy shoals of Stono Inlet and Lighthouse Inlet and would be moved by hydraulic pipeline. A berm 25 feet wide would be constructed from Station 24+70 South to Station 143+90 North. Features of the berm would include a crest height of four feet mean sea level (msl) and a front slope of 30 horizontal to 1 vertical. The berm plus the portion of the front slope above mean high water (2.8 feet msl) would provide a recreational beach 50 feet wide. Renourishment would require replacement of 354,000 cubic yards of fill at 5-year intervals. Available beach area by 1980 is estimated at 23 acres with the project versus seven acres without the project.

1.5 Sanitary Facilities. Current sanitary facilities are inadequate to meet the needs of the projected increase in beach users. Present public facilities include those found at several automobile service stations, restaurants, arcades, and the boardwalk amusement park area in the central portion of the island. The proposed plan calls for additional sanitary facilities to be evenly spaced along the entire project front.

The two existing four-stall rest rooms at the boardwalk recreational area will be expanded into a modern facility with a total of 20 stalls. Five additional comfort stations with outside showers will be required to service the remainder of the project area. The five new stations will be spaced at about one-half mile intervals along the beach in order to minimize the walking distance to the facilities.

2. ENVIRONMENTAL SETTING WITHOUT THE PROJECT.

2.1 General. The ocean shoreline of Folly Beach consists of approximately six miles of sandy beach. Long-term erosion has resulted in the loss of about 560 acres of beachfront lands since 1849. Although historic recession rates of up to 20 feet per year have been noted for some reaches, the recent trend has been a reduction in erosional rate, which is possibly related to the construction of rock and timber groins, seawalls, rock revetments, rubber tire walls, concrete block breakwaters, and sand fencing in various locations along the beach. The presence of these structures detracts from the general appearance of the beacn at low tide when they are exposed.

At high tide very little dry beach area exists along most of the shoreline, and two houses constructed on pilings are currently seaward of mean high water. These houses, as well as others along the beachfront, are experiencing a serious threat as the beach continues to recede and the ocean continues to advance. This problem is most severe along the 16,3[illegible]-foot central section of Folly Beach which is the most [illegible].

2.2 Climate. The climate in the study area is subtropical with long, hot summers and cool winters. The mean [illegible] annual temperature near Folly Island is 66° F. with an average [illegible] of 81° F. in July and an average low of 49° F. in January. Relative humidity in the area is around 75 percent. Precipitation [illegible] rainfall, averages about 50 inches per year, and is fairly well-[illegible] the year. (U. S. Department of Commerce, NOAA, 1973.

Air quality at Folly Beach is generally [illegible] surveillance data from James Island Fire Station, the closest air quality monitoring station, show no violations during 1976 (Table 1).

2.3 Topography. The Folly Beach study area lies on the lower coastal plain which was once a submerged portion of the continental shelf. The coast in this area is composed of a chain of barrier islands which are usually between two and ten miles long and often less than one mile wide. These islands are generally fronted by gently sloping beaches on the seaward side and backed by productive salt marshes. Folly Island is located about 10 miles south of Charleston and is one of more than a dozen such islands in Charleston County. Elevations of the developed section of the island range from 5 to 14 feet above mean sea level.

2.4 Geology and Soils. The coastal plain of South Carolina consists of sands, clays, marls, and limestones of various ages. Beach surface material is late Pleistocene and recent in age while layers underlying beaches south of Winyah Bay are mainly Cooper marl and Hawthorn formations of Eocene and Miocene age, respectively.

TABLE 1

Comparison of South Carolina Ambient Air Quality Standards and Recorded Air Pollutant Levels at James Island Fire Station for 1976[a]

Pollutant	Time Interval	Standard in Micrograms/m^3 [b]	James Island 1976 Mean	James Island 1976 High
Suspended Particulates	Annual geometric mean	60	50	-
	24-hour value	250	-	134
Sulfur Dioxide	Annual arithmetic mean	80	3	-
	24-hour value	365[c]	-	15
Nitrogen Oxides	Annual arithmetic mean	100	32	-
	24-hour value	NA[d]	-	69

[a]Source: South Carolina Department of Health and Environmental Control. 1977. 1976 air pollution measurements of the South Carolina air quality surveillance network.

[b]Measured at 25 C. and 760 mm Hg

[c]Not to be exceeded more than once per year

[d]Not applicable

2.5 Coastal beach soils comprising sandy shores and dunes are nearly white, medium- to fine-grained siliceous sands with some sea shells and shell fragments. Alkaline tendencies, as indicated by pH values of 6.6 to 8.7, and low fertility due to excessive nutrient leaching render these soils unsuitable for growth of most plant species. Beach sands are easily eroded by winds and water, particularly under storm conditions.

2.6 Tidal marsh-soft soils are dark gray to black or brown loams, clays, mucks, or peats which are flooded twice daily. They occur in the intertidal zone and are covered by a thick growth of salt-tolerant grasses, particularly smooth cordgrass. Sulfur content of these soils is high and their bearing capacity is low.

2.7 Tidal marsh-firm soils are slightly higher in elevation as they border the coastal beach. Their sand content is greater and organic content less than tidal marsh-soft soils. Flooding of these soils occurs daily to monthly or as a result of storm tides. Salt content of tidal marsh soils precludes the growth of all but salt-tolerant plant species.

2.8 Hydrology. Folly Island is bounded by waters of the Atlantic Ocean, Stono and Lighthouse Inlets, and the Folly River system. Characteristics of these waters are as follows:

a. Tides. Tide records for Folly Island indicated a mean tide level of 2.6 feet as measured on the seaward side of the island. The mean tide range is about 5.2 and the spring tide range is 6.1 feet.

b. Surface waters. Waters of Folly River, Stono River, other Coastal Waters of Charleston County, and the Atlantic Ocean in the vicinity of Folly Island are all classified by the State of South Carolina as SA or waters suitable for shellfishing for market purposes and other uses requiring waters of lesser quality. Salinity of these waters is nearly 35 parts per thousand, due to the lack of freshwater inflow in this area. No direct sources of urban or industrial pollution have been detected in the area, and chemical analyses of sediment collected from Folly River in November 1976 did not reveal significant quantities of any toxic or harmful substances.

2.9 Biotic Communities. Biological resources may be categorized into biotic communities, or distinct assemblages of plants and animals and associated physical environmental factors. Biotic communities are usually designated on the basis of their dominant plant species; in the absence of dominant vegetation, communities are identified by physiographic characteristics. Six biotic communities occur in the immediate study area. They are beach, dunes, shrub-thicket, tidal marsh, open water, and sand and/or mud flats.

2.10 Beaches. Beaches are gently sloping transitional areas between open water and upland terrestrial communities. They occur adjacent to the Atlantic Ocean along the southeastern coast of Folly Island, on Bird Key, and on the ocean side of other barrier islands nearby. These communities consist of a dry berm zone located beyond the high tide zone, an intertidal zone that is alternately covered and exposed by tidal action, and a subtidal zone that occurs below the low tide line and extends seaward.

2.11 The beach is a harsh environment characterized by extreme conditions. Rapid changes of physical factors such as temperature, moisture, and wave energy occur frequently. Vascular plants are usually absent from beach communities due to their inability to become established in such zones of sediment instability, high salinity, and extreme fluctuations of environmental conditions.

2.12 Relatively few species inhabit sandy beaches but those present frequently occur in large numbers. Consequently, high energy beaches are far from being biological deserts, and together with the associated fauna, they act as extensive food-filtering systems. Typical beach inhabitants are beach fleas and ghost crabs (scientific names of plants and animals appear in Appendices A, B and C) in the beach berm; coquinas, mole crabs and various burrowing worms in the beach intertidal zone; and blue crabs, horseshoe crabs, sand dollars and numerous clams and gastropod mollusks in the beach subtidal areas. In addition, several species of fish are commonly observed in the surf zone along the beach, many of which are of importance to the sport and commercial fisheries of the state. The Atlantic silverside, bay anchovy, Florida pompano, Gulf kingfish, striped mullet, rough silverside, striped killifish, striped anchovy, permit, bluefish, red drum, and planehead filefish are the most common. The beach zone is also utilized by many species of shorebirds for nesting and feeding. Species commonly observed are the American oystercatcher, plovers, willet, lesser and greater yellowlegs, gulls, and terns. Atlantic loggerhead sea turtles utilize South Carolina beaches for nesting purposes during the summer months.

2.13 Bird Key, located in Stono Inlet between Folly Island and Kiawah Island, is a sandy island which is utilized by large numbers of nesting and roosting shorebirds and wading birds. Between 300 and 700 pairs of birds, consisting of seven species, nest on the island each year. Of the seven species, black skimmers, gull-billed terns, and least terns are the most abundant. The other four species occur in scattered pairs and include common terns, Wilson's plovers, willets, and American oystercatchers. Bird Key also serves as a mass roosting area for migrating blue-winged teal.

2.14 <u>Dunes</u>. Dunes are sand ridges located landward of and parallel to the beach community. They consist of drifting sand and their height and direction of movement are determined by wind direction and intensity. Few plant species tolerate the harsh dune conditions of sediment instability, salt spray, and periodic saltwater overwash. Vegetative cover is usually sparse and consists primarily of perennial grasses such as bitter panic grass, sea oats, saltmeadow cordgrass, and broom sedges. Interspersed among these grasses are occasional specimens of Russian thistle, sea rocket, seaside elder, sandspur, seaside croton, beach spurge, purple sandgrass, seabeach orach, and evening primrose.

2.15 The lack of vegetative cover and an insufficient food supply limit the value of the dune community as wildlife habitat. Ghost crabs, tiger beetles, dragonflies, song sparrows, savannah sparrows, barn swallows, six-lined racerunners, eastern glass lizards, and eastern slender glass lizards are characteristic faunal inhabitants. Black skimmers and terns occasionally utilize the dune communities for nesting purposes during the spring and summer.

2.16 Shrub Thicket. Shrub thickets are typically found landward of the dune communities. These communities are characterized by a dense growth of low shrubs that are usually entangled with numerous vines. The community usually begins abruptly on the dune side. The first shrubs are commonly prostrate but they become progressively taller with increasing distance inland. The tops of the shrubs are often closely sheared by wind-borne salt spray and form a smooth, compact canopy surface. Salt spray shearing is most evident on the community's seaward side. Typical shrub inhabitants are wax myrtle, bayberry, silverling, seaside elder, winged sumac, yaupon, Carolina laurel-cherry, live oak, red cedar, and Hercules club. Shrub species distribution and density in specific areas vary according to substrate moisture and degree of salt spray influence. Common vine species in these communities are Virginia creeper, poison ivy, greenbriars, and wild grapes. Few herbaceous plants are present on the ground surface due to the shading effect created by the dense shrub growth. Shrub thickets do not provide a significant year-round food source for wildlife and hence, are not heavily utilized. Animal species which may be observed in this community include the ground dove, mockingbird, robin, blackbird, grackle, opossum, rabbit, raccoon, gray squirrel, and several species of reptiles and amphibians.

2.17 Tidal Marsh. Tidal marshes occur behind barrier islands all along the Carolina coast. Tidal marsh areas subject to semidiurnal tidal flooding are dominated by smooth cordgrass, usually the only emergent plant species of the intertidal zone. Salt marsh which does not experience daily flooding is characterized by salt grass and glasswort with some fimbristylis, sea lavender, and marsh aster also present. Shrubby plants such as marsh elder and sea ox-eye are scattered through a zone of saltmeadow cordgrass in the higher marsh areas. Between the low and high areas of salt marsh exists a band of black needlerush.

2.18 Tidal marsh communities are among the most productive lands on earth. The high primary productivity of marsh plants provides the basis of a complex food web involving an abundance and diversity of creatures. Detritus from dead and decaying plants is consumed by microbes. Both detritus and microbes are utilized by invertebrates common in the marsh. Invertebrates inhabiting these communities include a myriad of foraminiferans; nematodes; annelid worms; mollusks such as the marsh snail, marsh periwinkle, ribbed mussel, and eastern oyster; and crustaceans such as the penaeid shrimps, sand fiddler, mud fiddler, and blue crab. The marsh community provides a nursery ground for the principal commercial marine organisms of the state - namely white and brown shrimp and blue crabs. Marsh creeks serve as spawning and nursery grounds for many commercial and sport fishes and are valuable shellfish habitat. The dense plant growth in the marsh provides good cover for many species for birds and aquatic and semi-aquatic mammals.

2.19 Throughout these marsh communities numerous shorebirds, waterfowl, gulls, herons, and egrets will be found. Birds such as the clapper rail, plovers, dowitchers and sandpipers thrive on the benthic invertebrate population around the shoreline and on open flats. In the open water bordering these communities, waterfowl will be found feeding on vegetation or small marine fishes and free swimming invertebrates. The herons and egrets feed on fish, invertebrates, and small mammals in the marsh. They also are found nesting and roosting during the summer months. Many gulls occur the year around, resting and scavenging in these communities. Other birds such as the red-winged blackbird, common and boat-tailed grackles, and sparrows will be found nesting and feeding on insects and grains. Birds of prey such as the osprey and marsh hawk also utilize these areas to some degree. Mammals of the marshes typically include the raccoon, rice rat, opossum, and marsh rabbit.

2.20 Sand and/or Mud Flats. Sand and/or mud flats are found on both sides of Folly River. In most areas they lie below the mean high water line and are alternately covered and exposed by wind-driven or lunar tides and are typically devoid of vascular plants but are frequently inhabited by diatoms, bacteria, oysters, and infaunal invertebrates. These flats are usually fringed with open water, beach, or stands of vigorously growing and highly productive smooth cordgrass. Tidal action provides a constant influx of particulate organic matter to these habitats creating a rich nutrient supply for filter-feeding benthic invertebrates. When the tidal flats are covered by water, these animals and nutrients constitute an important food source for a variety of fish species. When the flats are exposed, the benthic animals are fed upon by numerous wading birds and shorebirds.

2.21 Open Water. The open water community in the vicinity of Folly Island consists of marine waters of the Atlantic Ocean, Stono Inlet, and Lighthouse Inlet; estuarine waters of the Folly River system; and underlying bottoms below the intertidal zone. Categories of biological inhabitants include plankton and nekton present in the water column and benthos living in or on the substrate.

2.22 The plankton group includes those organisms which lack sufficient motility to control their directional movements in the currents to which they are normally exposed. As a consequence of their weak motility, planktonic organisms are swept through the study area by tides and currents. Plankton includes unicellular algae, larval stages of many fish and invertebrate species, and adult stages of some invertebrate species such as jellyfish.

2.23 The nekton group consists of animals which are strong swimmers. Fish are the principal nekton, while some mollusks, such as the squid, and some crustaceans, such as penaeid shrimp and portunid crabs, spend at least part of their lives as nekton.

2.24 The benthos includes various plants and bottom-dwelling animals whose presence is correlated with substrate type. Unicellular and multicellular algae and occasional seaweeds are the primary producers of the photic zone of the benthic environment. Benthic decomposers consist of bacteria and protozoa. Most benthic animals such as crustaceans, bivalve and gastropod mollusks, and burrowing and tube-dwelling polychaete worms are filter or detritus feeders although crabs and some bottom-dwelling fishes obtain nourishment by predation. Benthic animals which feed on particulate matter play an important role in cycling organic and inorganic nutrients.

2.25 Near-Shore Ocean. The Atlantic Ocean delineates the southeastern edge of the study area and consists of a surf zone, a shallow inshore region, and a deeper offshore area. Phytoplankton accounts for most of the primary productivity in these waters since vascular plants are absent and few seaweeds are present. Zooplankton, tiny free-floating animals, feed mainly on phytoplankton and are, in turn, consumed by larger animals. Fish species common in ocean waters of the study area include spotted seatrout, weakfish, bluefish, red drum, black drum, spot, Atlantic croaker, sheepshead, killifish, Atlantic menhaden, gizzard shad, striped mullet, flounders, silversides, and sea catfish. Benthic organisms are low in diversity in the sandy substrate of this area and consist mostly of polychaete worms, mollusks, sea cucumbers, and sand dollars.

2.26 Inlets. Inlets provide an essential ecological link between ocean and inland waters. Semidiurnal flood tides push saline ocean waters through Stono and Lighthouse Inlets and mixing with fresh waters from terrestrial runoff occurs. The resulting estuarine environment exhibits intermediate salinity levels which are optimal for survival and growth of shellfish and various life stages of many other animal species. Inlets provide migrational routes for adult and juvenile finfish, crustaceans, and other organisms dependent on estuarine nursery and feeding grounds. Habitat value of inlets is very low for most creatures due to the continual forceful tidal flux and associated sediment shifting. Inlet inhabitants consist mostly of mollusks, amphipods, and polychaetes which are adapted to the dynamic situation.

2.27 Estuarine Areas. Folly River is a natural tidal river which serves as an outlet for an extensive marsh area. Several tidal streams flow into the river between its headwaters and the Stono River. The largest of these streams is Folly Creek. Folly River varies in width from about 500 feet behind Folly Island to about 1,500 feet at its confluence with the Stono River. Typical depths range from more than 30 feet at the mouth of Folly Creek and at the Stono River to less than four feet across the shoals near the Stono River. The controlling depth across the offshore bar in Stono Inlet is six feet. Folly Creek, the main tributary to Folly River, averages about 300 feet in width with typical depths ranging from 12 to 28 feet. The Folly River system, with its associated creeks, is a productive estuarine community which provides excellent conditions for supporting many life forms. Many commercially important finfish species, shrimp, oysters, clams, and crabs as well as other assorted invertebrates inhabit these waters and depend upon the estuary for completing part or all of their life cycles.

2.28 Fish and Wildlife Resources. Fish and wildlife resources of commercial and recreational importance occurring in the vicinity of Folly Island are as follows:

a. Commercial Fisheries. In 1976, commercial fishing activities in the study area were conducted by a fleet of 27 trawlers based in Folly River and Folly Creek. Catches from these and other vessels were landed at local docks. White and brown shrimp constituted the principal commercial landings: 160,000 pounds in 1976; 156,000 in 1975; 111,000 in 1974; and 95,000 in 1973. Other commercial species include spot, croaker, mullet, flounder, shark, blue crab, and oyster. Leased intertidal oyster bottoms of the area total about 800 acres.

b. Sport Fisheries. Estuarine and ocean waters of the Folly Island vicinity offer very good sport fishing opportunities and support thousands of man-hours of recreation annually. Principal sport fish species are spot, Atlantic croaker, southern flounder, summer flounder, black drum, red drum, weakfish, southern kingfish, black sea bass, sheepshead, and various species of sharks.

c. Wildlife Resources. Wildlife occurring in the study area includes shorebirds, wading birds, waterfowl, rabbits, squirrels, raccoons, opossums, and various rodents and reptiles. Diamondback terrapins are fairly common in the estuarine waters near Folly Island while pelagic turtles such as the green sea turtle and the loggerhead sea turtle are occasional visitors to the beaches. Hunting activity in the area is low, although the local marshes offer some opportunities for shooting marsh hens and waterfowl.

2.29 Endangered Wildlife. The Endangered Species Act of 1973 (PL 93-205) establishes two categories of endangerment:

Endangered Species. Those in danger of extinction throughout all or a significant portion of their range.

Threatened Species. Those likely to become endangered within the foreseeable future throughout all or a significant portion of their range (U. S. Department of Interior 1974).

The Federal endangered species list of 17 January 1979 includes the following species which may or do occur in the Folly Beach vicinity:

a. Reptiles.

Leatherback sea turtle -	Endangered	(E)
Atlantic Ridley sea turtle -		(E)
Green sea turtle -	Threatened	(T)
Loggerhead sea turtle -		(T)
American alligator -		(T)
Eastern indigo snake -		(T)

The green sea turtle and loggerhead sea turtle are occasional visitors to beaches of South Carolina. Neither has been observed at Folly Beach although the loggerhead nests on other less developed beaches in South Carolina. The Atlantic Ridley and leatherback sea turtles are not common in the study area but are occasional stragglers along the south Atlantic coast. The eastern indigo snake may exist in South Carolina, which is the northern limit of its historic range. However, it has not been recorded in the Folly Island area. There is no suitable habitat for the alligator on Folly Island or contiguous waters.

b. Birds.

Arctic peregrine falcon -	(E)
Bachman's warbler -	(E)
Brown pelican -	(E)
Eskimo curlew -	(E)
Kirtland's warbler -	(E)
Ivory-billed woodpecker -	(E)
Red-cockaded woodpecker -	(E)
Bald eagle -	(E)

The Arctic peregrine falcon is a winter migrant and is occasionally sighted in the area. The Bachman's warbler, Kirtland's warbler, and Eskimo curlew may occasionally occur as transients, but none have been sighted in the area in recent years. The red-cockaded and ivory-billed woodpeckers are unlikely to occur in the immediate area due to the absence of suitable habitat. The bald eagle is a permanent resident of South Carolina and nests in estuarine areas. None have been observed nesting in the Folly Beach vicinity, however. The brown pelican is commonly observed along the Carolina coast.

c. Mammals.

Eastern cougar - (E)
Florida manatee - (E)

The cougar has not been observed in the study area and suitable habitat is absent. The Florida manatee, or sea cow, resides in tropical waters, particularly in Florida, but occurs occasionally as a straggler along the South Carolina coast. In August 1977, two were seen at Beaufort, S. C., and in recent years some have been reported from the Cape Fear River estuary in North Carolina. None have been observed in the Folly Beach vicinity.

d. Fishes.

Shortnose sturgeon - (E)

Sturgeon regularly inhabit the Folly River as well as Stono and Lighthouse Inlets.

2.30 Recreational Values. The Folly Beach area, located only 10 miles from Charleston, is a valuable recreational resource due to its natural features and its availability and accessibility to large numbers of visitors. Recreational opportunities include not only swimming, beachcombing, and sunbathing on the beach itself, but also boating, water skiing, shrimping, crabbing, fishing, and oystering on nearby waters. A public oyster-gathering area is located just east of the Folly River bridge and a public boat ramp is located on the west side of the bridge.

2.31 Shortcomings for beach recreation in the area include limited surface area of exposed beach at high tide due to recent erosional trends and also a shortage of designated parking areas.

2.32 Cultural Resources. Waters of the study area may have been utilized by aboriginal inhabitants prior to European settlement and were of considerable importance in commercial and military navigation of the 18th and 19th centuries. The area was near the main route for transcontinental shipping in the 1700's due to its proximity to Charleston Harbor. Stono Inlet was the scene of battles during the War of 1812 and was utilized by the Union fleet during the Civil War. Folly Island was the major Union base during the siege of Charleston. During the 1800's, Folly and Stono Rivers were important for phosphate mining and for commercial navigation to coastal plantations.

2.33 Although local history suggests that shipwrecks or other artifacts may possibly occur in the vicinity of Folly Beach, the National Register of Historic Places lists no structures, places, or objects of historic significance in the immediate area.

2.34 Social and Economic Conditions. The population of Charleston County has increased from 216,382 in 1960 to 262,400 in 1975 and is expected to reach 276,000 by 1980. The population of Folly Beach has been more stable as it has increased from 1,137 in 1960 to 1,157 in 1970 and to 1,237 in 1975 (South Carolina Budget and Control Board 1977). During the summer months the number of people residing on Folly Beach swells to an estimated 4,500. Day visitors are common, and for 1975, visitor-days totalled 861,000. Visitation on peak weekends is estimated at 30,000.

2.35 Single-family dwellings comprise the majority of Folly Beach housing. Total housing units numbered 908 in 1970 and 973 in 1976. A 1977 survey indicated that 70 percent of all housing is 17 or more years of age and that 57 percent of all houses needed repair. The city's prohibition of trailers has restricted these units to one trailer park plus three other individual sites (Vismor, McGill and Bell, Incorporated 1977). High-density housing is absent due in part to dependency on septic tanks as no public sewerage facilities are available. Folly Beach is expected to have public sewerage by connection with the existing Plum Island Treatment Plant on James Island by 1981, and subsequent commercial growth is anticipated.

2.36 The city currently receives its water supply through a six-inch main from Charleston. The water distribution system is inadequate as it still employs two miles of four-inch lines in conjunction with its six-inch lines. Fire protection is also inadequate in some areas due to excessive distances to fire hydrants and because nine hydrants are still on four-inch water lines rather than six-inch lines as recommended. Several areas of Folly Beach are subject to small-scale flooding following heavy rainfall.

2.37 Tourism, the major industry of the city and the only industry other than commercial fishing, has been adversely affected by several local conditions. The pier and associated resort center burned in January 1977 and only recently has renovation begun. Buildings of the business district have received inadequate care and maintenance and 67 percent need repair. About 29 percent were considered substandard according to a 1977 survey by Vismor, McGill, and Bell, Incorporated. Available dry beach is extremely limited at high tide due to effects of severe erosion. Off-street public parking spaces are poorly marked and number only 450. (Public parking spaces on Isle of Palms and Sullivan's Island number 920 and 1,020, respectively.) Several high-volume streets lack sidewalks resulting in hazards to pedestrian traffic (Vismor, McGill, and Bell, Incorporated 1977).

2.38 The only highway access to the project area is via S. C. Highway 171. There is no scheduled air or rail service to Folly Beach although these services are available in nearby Charleston. Bus service to Folly Beach is provided by the Bee Line Bus Company of Charleston.

3. RELATIONSHIP OF THE PROPOSED ACTION TO LAND USE PLANS.

Implementation of the recommended plan would create no conflicts with any existing or proposed Federal, State, or local plans. Sources of suitable beach nourishment materials would include only sandy shoals located near Stono or Lighthouse Inlets as shown in Figure 2. Materials dredged from these shoals would be placed on existing beach areas and the adjacent nearshore ocean bottom.

4. PROBABLE IMPACT OF THE PROPOSED ACTION ON THE ENVIRONMENT.

The proposed plan of improvement would result in $681,500 net annual public recreation benefits through initial filling and renourishment of 19 total acres of beach. A beach capacity for 19,736 beach users per day would be created by the project. Additionally, $205,700 net annual benefits would be realized through private land-loss prevention, private building damage prevention, and private land enhancement. The dredging of borrow material from shoals in these two inlets might improve their navigability to recreational boaters.

Restoration and nourishment of the beach will create habitat for the beach community fauna. Open water community flora and fauna in the vicinity of the borrow and fill sites would be subject to temporary project impact.

4.1 Water Quality. Implementation of the proposed project would result in temporary, minor water quality degradation in the immediate project area. Although dredging activities typically contribute to localized turbidity increases in the vicinity of the operating dredge and adjacent to beach disposal sites, the sandy sediments which would be utilized for beach restoration and nourishment tend to settle rapidly, so turbidity increases should be minor and of short duration. Chemical analysis of sediments from potential borrow areas (previously discussed in paragraph 2.8.b) has revealed no significant concentration of toxic or harmful substances which could adversely affect water quality or biota of the area. The very low concentrations of organic matter in the sandy sediments should result in very little, if any, dissolved oxygen depression. Hence, water quality impacts from project construction should be insignificant. Periodic maintenance dredging and beach nourishment would produce similar effects but on an even smaller scale.

4.2 Biological Resources. Of the six biotic communities discussed in Section 2 above, there are three which may be affected by construction and maintenance of the proposed project. These are: (1) open water, (2) beach, and (3) tidal marsh. The following discussion addresses the potential impacts of the project on these communities.

4.3 Open-Water Community. All inhabitants of the water column and bottom sediments in the vicinity of borrow or fill sites would be subject to project impact.

4.4 Plankton. Some of the planktonic organisms entrained by hydraulic dredging operations would suffer injury or mortality. Also turbidity associated with dredging may reduce primary productivity by phytoplankton as light penetration into the water column is reduced. Both of these potential effects on plankton are expected to be minor and temporary as they would coincide in significance with the short duration of dredging, the small sizes of the borrow and deposition sites, and the extremely small percentage of fine particles in the affected sediments.

4.5 Benthic Invertebrates. Benthic invertebrates, because of their limited mobility, would likely experience greater adverse impacts from project implementation than would any other group of biota. Sandy sediments would be removed from borrow areas by hydraulic pipeline or hopper dredge and would be deposited on eroded beaches and adjacent ocean bottom. Some benthic invertebrates in the path of the dredge cutterhead would likely be physically injured or destroyed, while others dislodged from the substrate would become highly vulnerable to predation by fishes in the waters of the borrow areas and near beaches. Those invertebrates still alive when deposited on the beach area would experience significant mortality rates from predation by shorebirds as well as from possible isolation from sufficient moisture or exposure to extreme temperature changes.

4.6 Benthic populations occurring in sandy, nearshore ocean bottoms similar to those of the borrow and deposition areas are typically low in diversity and are adapted to dynamic, shifting-sand environments. Disruption or destruction of such communities would likely be a short-term impact since disturbed areas would be quickly recolonized through recruitment from adjacent undisturbed bottom. The length of time required for reestablishment of viable benthic populations in the affected areas would depend upon bottom topography, substrate composition, current patterns and water velocity, and future sediment distribution patterns, but would likely be less than 18 months. Since composition of bottom sediments is not expected to change appreciably and since recruitment is expected from similar bottom types, benthic populations which eventually become established would likely be similar to those presently existing in the area.

4.7 Fishes. Fish populations may sustain damage from dredging operations through mechanical action of the dredge cutterhead or as a result of associated water quality changes.

4.8 Action of the dredge cutterhead poses a threat of physical injury or mortality to any creature in its path. However, the mobility of fish populations enables them to avoid this danger, with the exception of weakly mobile embryonic or larval stages which are susceptible to adverse effects when they occur in the vicinity of dredging activity. Actual mortality of these early life forms in significant numbers is unlikely unless they occur in great density, however. Dredging during cooler months of the year coinciding with periods of lowered biological activity could effectively reduce the likelihood of such potential damages.

4.9 Minor water quality degradation in the form of increased turbidity may occur in the immediate vicinity of borrow and deposition. Sandy sediment, such as that of potential borrow areas, settles rapidly, exhibits minor dispersion tendencies, and the low silt content results in little turbidity. Adverse effects on most fishes would be insignificant although filter-feeding species such as menhaden, shad, and herring, and juveniles of all fish species would be more sensitive than adult nonfilter-feeding species. Quantitative estimation of such impacts is not practical since population numbers and susceptibility to stress both vary by species and with time factors. However, the effects would be minor and short-term coinciding with the duration of dredging activity. No significant reduction in numbers or viability of fishes is anticipated.

4.10 Dredging may provide temporary benefits to those fish species which prey on benthic invertebrates since many would be dislodged from the bottom substrate during dredging activity. Likewise, deposition of sediments on the beach would result in a similar dislodging of invertebrates which would increase the food supply available to those fish inhabiting the surf zone. Temporary availability of food organisms may result in greater concentrations of fish in the project area during construction and maintenance operations.

4.11 Commercial and Sport Fisheries. The proposed action offers little potential for adversely affecting the commercial or sport fishing activities of the area. The presence of the dredge and associated equipment could create minor inconveniences for boats operating in the vicinity.

4.12 Shellfish Resources. Material selected for beach nourishment would consist only of sandy, relatively silt-free sediments which would minimize potential problems associated with siltation or dissolved oxygen depression. No dredging would occur in the immediate vicinity of oyster or clam beds. Shellfish resources should not experience any significant adverse impacts from project construction or periodic nourishment.

4.13 Beach Community. Restoration and nourishment of Folly Island beaches would involve deposition of sediments which would cause suffocation and mortality of many relatively immobile inhabitants of the beach fill zone. These inhabitants consist primarily of invertebrates adapted to shifting sand environments (discussed in paragraphs 15, 16). High mortality rates would occur coinciding with project construction activities. The initial loss could be large, but colonizers from adjacent areas would rapidly establish new and similar populations in the affected areas. Periodic beach renourishment would also result in loss of many invertebrate beach inhabitants, but rapid recovery would likewise occur.

4.14 Neither shorebirds nor sea turtles are known to nest in the proposed construction area and they should not be adversely affected by implementation of the proposed project.

4.15 Marsh. Utilization of sandy shoals in Folly River as borrow areas would adversely impact marsh to the extent of placing pipeline over it from the dredge to the beach fill sites. This impact would be both minor and temporary. Utilization of shoals at Lighthouse or Stono Inlets would not require crossing marsh with pipeline.

4.16 The proposed project demands the utilization of sandy sediments for beach restoration and nourishment, and no diked disposal areas would be involved. Hence no increase in mosquito breeding would result from construction or maintenance of the proposed project.

4.17 Endangered and Threatened Species. There is no critical habitat of any endangered species in the vicinity of this project. The only endangered species known to occur in the project area in recent years are the brown pelican, peregrine falcon, and shortnose sturgeon. The project would in no way directly affect these three species. The project activity would take place in such a small portion of the range of these three species and the habitat alteration would be so slight and transistory as to lead to the conclusion that the project would have no effect on either endangered species or their habitat.

4.18 Recreational Values. Construction and maintenance of the project would temporarily interfere with use of the affected beach areas by the public. Scheduling these construction activities during the winter or slack season for recreation could minimize this inconvenience. Completion of the proposed project would provide about 19 acres of improved beach for public recreation.

4.19 Esthetics. The presence of the dredge, pipeline, and other construction equipment would temporarily intrude upon the view of some residents, boaters, and other recreationists during construction or maintenance.

4.20 The improved beach resulting from project implementation would exceed the present beach in esthetic qualities since unsightly features such as erosional scars and erosion control structures would be at least partly covered. Also, the dry beach area would no longer disappear at high tide.

4.21 Noise and Air Quality. Operating dredges are generally quiet and contribute less to ambient noise levels than normal motorboat traffic. Air pollution derived from the dredge and other construction equipment should be insignificant during both construction and maintenance of the project. Higher visitation rates to the improved recreational beach would likely increase auto emissions and noise levels in the Folly Island vicinity.

4.22 Cultural Resources. The project area contains no structures, places, or objects of historic significance which are listed on the National Register of Historic Places. However, in view of the possible occurrence of undiscovered sites in potential borrow areas and sites of the new sanitary facilities, magnetometer surveys or other appropriate investigations of those areas would be conducted prior to initiation of dredging.

4.23 Economy. The proposed project would have a favorable economic impact on the study area by providing recreation benefits estimated at $681,500 annually and by preventing erosional loss of land and homes and enhancement of private land estimated at $205,700 annually. Indirect benefits would accrue to the area through increases in business activity, property values, and tax revenues.

4.24 Total project first cost would be $2,393,000, and a proper project maintenance would require renourishment at five-year intervals at a cost of $1,292,000 each time. Annual charges are estimated at $396,300 and the project benefit-cost ratio is 2.2.

4.25 Maintenance Dredging. The proposed beach restoration would require renourishment in order to maintain the berm. Estimated replacement requirement is about 354,000 cubic yards of fill at five-year intervals. Impacts of maintenance would be similar to those of project construction but would be of a smaller order of magnitude.

5. ANY PROBABLE ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED.

5.1 Minor and temporary water quality degradation would occur as increased turbidity created by dredging of sediments for beach fill. Attendant reduction of the euphotic zone would temporarily reduce primary productivity of phytoplankton. Entrainment would likely injure or destroy some plankton, but the quantity of organisms affected would not be significant. Many sedentary benthic invertebrates in the borrow and deposition sites would suffer injury or mortality from mechanical action of the dredge, suffocation by fill deposits, or predation by fishes or birds after being dislodged from the sediments. Impacts on benthos would be temporary since affected areas would be repopulated within a few months by immigration of similar organisms from unaffected areas. During construction activities fish populations in the immediate area may sustain damage through entrainment of embryonic and larval stages, although the density of these animals in the affected area should not be sufficient to result in loss of significant numbers. The proposed project would reduce the esthetic appearance and recreational beach use during the period of construction. Indirect project impacts include future increases in auto emissions and noise levels coinciding with higher visitation rates to the improved beach.

6. ALTERNATIVES TO THE PROPOSED ACTION.

6.1 The feasibility of providing erosion control, hurricane protection, and recreational beach at Folly Island was investigated in terms of both nonstructural and structural measures. A variety of measures was considered and each was evaluated on the basis of technical, economic, social, environmental, and institutional criteria.

6.2 Nonstructural Alternatives. Nonstructural alternatives which were considered included flood insurance, zoning and modification of building codes, evacuation planning, flood proofing, grassing existing beaches, relocation of structures, no growth, and no action.

6.3 The City of Folly Beach is already participating in a Federal Flood Insurance Program which requires flood plain zoning and reasonable building codes. Evacuation routes, storm shelters, and evacuation instructions are all part of an evacuation plan established by the Charleston County Disaster Preparedness Agency. Flood proofing is generally more effective in still-water flood areas and is not appropriate for Folly Beach. Flood proofing which involves techniques such as raising structures and erecting concrete barriers has been implemented by many local residents on Folly Beach without success. Grassing existing beaches, even if technically possible, would not be appropriate on Folly Beach because it would limit recreational beach use. Relocation of beachfront structures would involve high costs and would provide only a temporary solution if erosion continues unchecked. The no growth alternative would prevent some future damages but fails to address current erosional losses and declining recreational opportunities and would impede the generation of tax revenues. The no action alternative fails to address the problems of beach erosion and diminishing recreational beach. Henc all nonstructural plans were found to be inadequate, inappropriate, or already implemented.

6.4 Structural Alternatives. Consideration was given to five structural alternatives, including seawalls, beach revetments, offshore breakwaters, beach development, and beach and dune development.

6.5 Neither seawalls nor revetments would serve the need for recreational beach, although they could be utilized to halt erosion. Offshore breakwaters were far too costly to be justifiable based on benefits derived.

6.6 Beach development and beach and dune development offered the overall best solutions to problems at Folly Beach. Both alternatives would provide erosion control and recreational beach. Dunes could also provide environmental quality enhancement.

6.7 Consequently these alternatives were expanded to allow comparison and evaluation of several dimensional variations of each (A-0 through A-5 and B-1 through B-3 as shown in Figure 2). All the beach development plans offered better benefit-cost ratios and greater excess benefits over

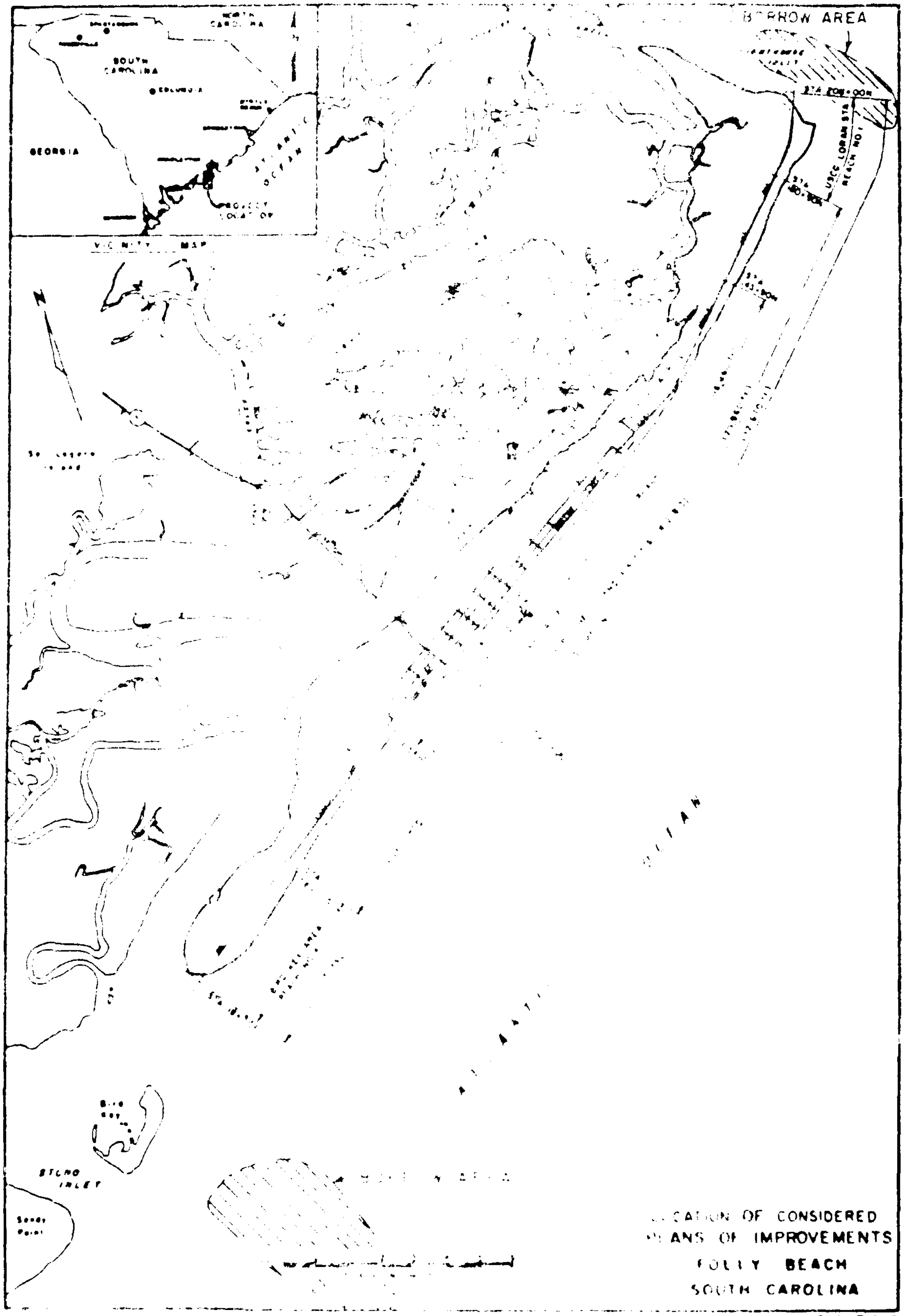
BORROW AREA
STA 208+00R
USCG LORAN STA BEACH NO 1
NORTH CAROLINA
SOUTH CAROLINA
COLUMBIA
GEORGIA
ATLANTIC OCEAN
PROJECT LOCATION
VICINITY MAP
STONO INLET
LOCATION OF CONSIDERED
PLANS OF IMPROVEMENTS
FOLLY BEACH
SOUTH CAROLINA

FIGURE 2

costs than any of the beach and dune plans. Hence, the plan with the greatest excess benefits over costs ($539,600) and which was designated as the NED plan was a beach development plan (A-4). Institutional monetary constraints would likely prevent construction of the NED plan, so the beach development plan with the lowest non-Federal investment was considered more implementable and was designated the recommended plan (A-0). The recommended plan has the benefit-cost ratio (2.2). The beach and dune plans were less cost-effective but did offer the advantages of improved wildlife habitat and visual enhancement for beach users. The beach and dune development plan (B-1) was selected as the EQ plan because it would provide the most favorable environmental enhancement features. The plan would provide a diverse wildlife habitat, increase aesthetic beauty, and add to recreational enhancement. Of the three beach and dune plans proposed, plan B-1 was selected because it would provide the desired environmental enhancement features with less disruption of ocean views and existing habitat than the larger beach and dune plan.

6.8 Alternative Borrow Areas. A total of four alternative borrow areas were investigated as a possible source of material for nourishing the beach. Findings from the alternative borrow areas follow:

Lighthouse Creek - Samples of shoal areas in Lighthouse Creek revealed the material to be organic, silty, and very fine sand. These materials would not be suitable for beach nourishment.

Charleston Harbor Entrance Channel - More than one million cubic yards of sandy material suitable for beach nourishment are taken from the entrance channel via hopper dredge each year. Techniques for transferring the material for deposit on Folly Beach are currently economically unfeasible.

Folly River - Bottom samples from Folly River were classified as fine sands of the type suitable for beach nourishment purposes. However, impacts to the surrounding environment (flora and fauna) associated with Folly River dredging precluded the use of the site as a borrow area.

Off-Shore Borrow Area - An abundance of material suitable for beach nourishment lies off-shore in waters deeper than 40 feet. The mechanics and economics of retrieving and depositing the material on Folly Beach are presently economically unjustifiable.

6.9 No economically justifiable structural plan was found to provide adequate hurricane protection.

6.10 Impacts Common to All Beach and Beach Plus Dune Plans. All these plans (A-0 through A-5 and B-1 through B-3) would involve the removal of sandy sediments from shoals near Folly Island by hydraulic pipeline and subsequent deposition of this material on existing sandy beaches or adjacent ocean bottom.

6.11 The adverse environmental impacts likely to result from implementation of either of the beach or beach and dune plans would include temporary reduction of benthic populations in the borrow and beachfill areas and short-term minor increases in turbidity of adjacent waters. Improved beach leading to higher future visitation rates would contribute to greater traffic congestion, litter, noise, and air pollution. However, overall adverse environmental impacts for any beach or beach and dune plan considered would not be serious enough to preclude its implementation. None would produce significant adverse impacts on esthetics, fish and wildlife resources, endangered species, or cultural resources.

6.12 Beneficial impacts resulting from implementation of any beach development or beach and dune development plan would include beach restoration, erosional control, and enhanced recreational opportunities. The community would derive additional benefits through increases in property values, higher tax revenues, and more business activity.

6.13 Recreational Park Alternative. During the Folly River Navigation Study of 1977, the development of a beach access/biological observation park was proposed for the undeveloped southwest end of Folly Island. The park would have included a short access road, parking lot, comfort station, walkway to the front beach, fishing dock, and nature trails. Development of the park would prevent residential or commercial development of this natural area, would relieve some congestion in the center of town, and would provide a controlled beach access area.

6.14 Public opinion as reflected by a public referendum indicated general opposition to this proposal by the citizens of Folly Beach. Consequently, the park was not included as a feature of any beach erosion control plan even though it would have contributed greatly to the environmental quality enhancement.

7. THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY.

Restoration and periodic maintenance of the front beach at Folly Island would provide recreational opportunity and protection of shore structures from erosion. Thus the proposed project would promote both the short-term and long-term productive use of the affected beach relative to human interests and values. Overall biological productivity of the area would not be appreciably affected by the project.

8. ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES WHICH WOULD BE INVOLVED IN THE PROPOSED PROJECT SHOULD IT BE IMPLEMENTED.

Construction and maintenance of the proposed project would result in only minor environmental impacts. Failure to maintain the project, if constructed, would in the future allow conditions to revert to their present state. Hence, the modifications to the beach and nearshore ocean bottom are not irreversible. There would be irretrievable commitment of the manpower and fuel necessary for completion of the project.

9. COORDINATION AND COMMENT AND RESPONSE.

9.1 Public Participation. An initial public meeting was held 8 March 197[illegible] to establish the nature and scope of the problems at Folly Beach, and the

City of Folly Beach agreed by letter of 24 May 1976 to act as sponsor of the study. A second public meeting was held 29 November 1977 to obtain the views of the public regarding proposed improvements. On numerous occasions from 1976 through 1978, Charleston District representatives informally discussed study progress and findings with officials and residents of Folly Beach. The sentiments expressed most frequently included the following:

a. Critical need by oceanfront property owners to implement beach erosion control measures at the earliest possible date.

b. Reluctance of most island residents to make a significant commitment to financially support construction and maintenance of improvements at Folly Beach.

9.2 A draft EIS was distributed for public review on 8 June 1979. All letters of comment on the draft EIS are contained in Appendix E. The comments contained in these letters are discussed in the following section.

9.3 Coordination of Draft Report and Draft EIS.

Federal Energy Regulatory Commission

Comment: This is in response to your letter dated June 8, 1979, with attachment, requesting our comments on the Draft Environmental Impact Statement and Preliminary Survey Report on Beach Erosion Control and Hurricane Protection, Folly Beach, South Carolina.

The Commission's principal concern in regard to developments affecting land and water resources is the possible impacts of such projects on the construction and operation of bulk electric power facilities and interstate natural gas systems.

In reviewing the study area we noted nothing that should interfere with any of the Commission's licensed hydroelectric projects. However, provision should be made to protect electrical transmission lines and natural gas pipelines in the construction area.

Response. Concur.

U. S. Department of Commerce, National Oceanic and Atmospheric Administration

Comment: Appendix 5, paragraph 2.2: Though hurricane protection is a major goal of the project, the climate discussion gives no information on hurricanes. The EIS should indicate the extent of the danger from tropical cyclones to Folly Beach, and a description of damage from past storms should be given. A good source for frequency data on tropical cyclones is Simpson and Lawrence's "Atlantic Hurricane Frequencies Along the U. S. Coastline" (NOAA Technical Memorandum NWS SR-58, 1971). The graphs in this report indicate that the probability of a hurricane occurring in any one year in a 50-mile segment of the coastline which includes Folly Beach is 8%, and the average number of years between hurricanes is 12.

Response: Information on hurricanes is thoroughly discussed in Technical Report, Appendix 1, C-11 through C-19. Appendix 1 is available upon request for public review.

Department of Health, Education and Welfare

Comment: We have reviewed the subject draft Environmental Impact Statement. Based upon the data contained in the draft, it is our opinion that the proposed action will have only a minor impact upon the human environment within the scope of this Department's review. The impact statement has been adequately addressed for our comments.

Response: No response needed.

Environmental Protection Agency

1. Comment: We have reviewed the Draft Environmental Impact Statement on beach nourishment of Folly Island, South Carolina, and are concerned about the long-term consequences of this action together with your prima facie decision to eliminate all nonstructural alternatives from real consideration.

Response: The Charleston District did not arbitrarily eliminate all nonstructural alternatives from consideration during the study process. Numerous nonstructural measures were evaluated during the study (see page 21 of the Survey Report). All of the nonstructural alternatives evaluated were found to be unsuitable either because they did not significantly reduce beach erosion or they were totally unacceptable to the local residents.

The City of Folly Beach is already participating in the National Flood Insurance Program and has implemented corresponding flood plain regulations and evacuation planning procedures. Floodproofing which involves techniques such as raising structures and erecting concrete barriers has been implemented by many local residents without success.

The practice of establishing native vegetation on beaches and dunes for erosion control has been tried with other beaches in the Charleston area with limited success. Heavy pedestrian traffic coupled with rapidly eroding sand precludes the establishment of vegetation.

The relocation of structures alternative was considered in greater detail as discussed on page 21 of the Survey Report. Although this alternative was considered economically feasible, it was strenuously not favored by the local residents particularly those directly affected by erosion. Likewise, the no action alternative received unfavorable reactions from local residents.

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The following should [illegible] responsibilities and study process so that future misunderstanding may be averted.

The Corps of Engineers does not initiate studies. Our studies and projects are [illegible] to authorities and requests provided [illegible]. Procedures for evaluating water resources projects result from actions of the three branches of [illegible] government: the Legislative Branch, through [illegible] legislation; the Executive Branch, with directives [illegible] to implement legislation; and the Judicial Branch, through [illegible] cases which clarify and test the legislative basis [illegible]. Corps of Engineers policy is now established [illegible] legislation, requiring consistency with the planning [illegible] of the Water Resources Council Principles [illegible].

2. Comment. [illegible] at Folly Beach is not the erosion, but the [illegible] businessmen, etc. to place structures in [illegible]. It is well documented that barrier islands are dynamic [illegible] features. They experience almost daily fluctuations [illegible] extent due to marine processes. Added to this alteration are those from the long-term phenomena of sea level rise and [illegible]. All strand/insular ecosystems are influenced [illegible] processes to some degree. While acknowledging the [illegible] abilities and resources of the Corps, we suggest that it is impractical to assume that it can provide [illegible] to all those coastal areas which need [illegible] especially true given the extent of the [illegible] magnitude of these phenomena.

Response. The comment implies the Corps of Engineers should not undertake [illegible] Folly Beach involving erosion of barrier islands. [illegible] authority for such studies in Public Law 87-874 [illegible] Harbors Act of 1962. The

Committee on Public Works of the Senate adopted a resolution on 15 June 1972 requesting the Secretary of the Army to direct the Chief of Engineers to undertake a survey of the shores at and in the vicinity of Folly Beach in the interest of beach erosion control, hurricane protection and related purposes. The Corps would be derelict in meeting its delegated responsibilities if it did not respond to such Congressional requests.

3. Comment: An important point to emphasize is that "short-term" protection is all that is being offered. At the end of the 50-year project life will the situation be any different? The Summary Report indicates that the exact cause of the beach losses is not known. Are studies planned which will research the causes of this erosion and attempt to effect a solution? In our opinion, the nonstructural alternative of building relocation provides the only long-term solution to the situation. The nourishment proposal merely postpones the inevitable. In the light of recent decisions to restrict petroleum utilization, the Final EIS should examine whether or not the selected energy intensive plan can be maintained over its projected 50-year life. It may well happen that maintenance dredging will have to be curtailed, thereby increasing the potential monetary losses from subsequent erosion. The FEIS should detail both possibilities. Additionally, determinations should be made to ascertain whether rising sea level and/or subsidence is influencing the marine processes at Folly Beach. If this proves to be the case, how will the project be affected and what actions will the Corps take?

Response: This comment is concerned with the issue of nonstructural solutions and emphasizes that the proposed project provides only "short term" protection. During the course of the Folly Beach study, public meetings were held on 8 April 1976, 29 November 1977, and 7 December 1978 to allow all interested parties and the general public an opportunity to express their views concerning the improvements desired and the need and advisability of their implementation. The list of considered alternatives, nonstructural and structural, was developed from the public input as well as meetings with elected officials. Very early in the study it was apparent that residents did not desire to be relocated. Some nonstructural alternatives had been adopted by locals prior to our study. Others were identified and evaluated in our studies. All were considered to be ineffective in solving the existing problem at Folly Beach. Corps policy provides that the local populace be given the list of alternatives available to them and play an active part in the selection process. As stated in the first sentence on page 18 of the report "the plans must be institutionally feasible." Based on the views obtained during the above, it was clear that relocation was not desired and therefore not institutionally feasible. The Corps does not dictate what plan is to be recommended, but presents the options available and allows the local populace to decide on the desired alternative consistent with required economic and environmental considerations.

This comment emphasizes that the recommended plan will provide only "short term" protection. At no time has the Corps implied or stated that the proposed project will eliminate the erosion problem for all time. This should be obvious from the report presentation concerning periodic renourishment to maintain the project. "Short term" is totally relative to one's view. To one directly affected 50 years of protection is not viewed as "short term." Determination of a benefit-to-cost ratio is required to provide an approximate indicator of project efficiency and the formulation of projects such as Folly Beach. If current legislation remains unchanged and we are requested to do so, the project will be reevaluated at the end of the 50-year period to determine whether or not justification exists for continuation of the project.

At present the Corps does not have any additional studies planned to research the cause of erosion or additional solutions. Several other agencies are conducting studies relative to the erosion of Folly Beach. During the course of our study, direct contact was made with these agencies and available pertinent information obtained from them for use in our study.

4. Comment: Relative to decision making, the EIS is the vehicle through which an alternative is supposed to be selected. By structuring your objective so that only an enlarged beach would meet your criteria, the EIS merely becomes a mechanism to legitimize a previously made decision. The nonstructural alternative has a favorable cost ratio, yet is dismissed as not being favored by local interests. We understand that certain of these local interests are demanding a nourishment project far in excess of that currently planned. Considering the rather modest financial commitment of the local interests, how are their desires factored into the Corps' decision making process relative to facility type and size? Are there any plans to accede to the latter group's wishes?

Response: The statement that the EIS is the vehicle through which an alternative is supposed to be selected is misleading. Corps studies are carried out through a three-stage iterative planning process. The objective of the multiobjective planning framework is to guide planning for the conservation, development and management of water and related land resources. The framework requires the systematic preparation and evaluation of alternative ways of addressing problems, needs, concerns, and opportunities under the Principle and Standards objectives of National Economic Development (NED) and Environmental Quality (EQ). Alternative plans are formulated without bias to structural or nonstructural measures. This procedure develops the information necessary to make effective choices regarding resource management under existing and projected conditions. The EIS contributes to the selection of the recommended plan, but factors other than environmental considerations also influence plan selection.

Rev
28 Mar 80

U. S. Department of the Interior, Fish and Wildlife Service

1. Comment: Section 662(a) of the Fish and Wildlife Coordination Act (FWCA) requires the Corps of Engineers to consult with the Fish and Wildlife Service (FWS) and the State fish and wildlife agencies regarding proposed or authorized water resources development projects. This required coordination has not occurred in the Folly Beach study resulting in potential adverse impacts on the area's fish and wildlife resources being inadequately addressed. Additional comments on the recommended plan will be provided by the FWS in the FWCA report which, according to Section 662(b) of the FWCA, must be made an integral part of the survey report before it is submitted to Congress for authorization.

Response: Contrary to the position of the USDI on the adequacy of coordination of the Folly Beach study, the FWS was consulted at regular intervals beginning with the first public meeting held on 8 March 1976. Subsequent coordination including a joint field trip on 28 September 1977 and discussions over the telephone and during meetings concerning the transfer of funds from the Corps to the FWS all indicated little interest on the part of the FWS in this study. This lack of interest derived from an understanding since the beginning of the study that the most practical solution to the beach erosion problem at Folly Island appeared to be beach nourishment with sand to be obtained from either end of the island. It was the opinion of the FWS that such a project would have little effect on fish and wildlife resources; the Corps concurred in this opinion. Even though the FWS expressed little interst in this study, full consideration was given to fish and wildlife resources during the entire course of this study. Although the USDI states that potential adverse impacts of fish and wildlife resources were inadequately addressed, responses to other parts of the USDI letter show that these fish and wildlife losses are incorrectly attributed to the recommended project. These responses clearly show that there are no significant fish and wildlife losses associated with the recommended plan and that any inference by the USDI to the contrary has not been clearly documented.

2. Comment: During the Folly Beach study, the Corps of Engineers did not request FWS comments concerning problem identification and possible solutions. As discussed above, FWS had no involvement in this study until this draft survey report was submitted on June 1, 1979, for coordination review. The FWS maintains that this is a project review and should meet the requirements of the Fish and Wildlife Coordination Act.

Response: See Response number 1.

3. Comments: We request that the U. S. Bureau of Sport Fisheries and Wildlife be referred to as the U. S. Fish and Wildlife Service. It should be removed from the list of agencies from whom the Charleston District requested and received comments concerning problem indentification and possible solutions.

Response: The U. S. Bureau of Sport Fisheries and Wildlife has been changed to the U. S. Fish and Wildlife Service. The Charleston District requested comments from the Fish and Wildlife Service on several occasions concerning problem identification and possible solutions, consequently the Fish and Wildlife Service will remain on the list of agencies consulted.

4. Comment: Page 11, Land Use Analysis

The undeveloped southwest end of Folly Island is erroneously referred to as a 55-acre parcel. This should be a 190-acre parcel.

Response: The 55 acres shown in the report refers to the amount of high land (above mean high water) on the southwest end of Folly Island. Approximately 135 acres of saltmarsh lies between the highland and Folly River.

5. Comment: Page 34, Division of Plan Responsibility

Day visitor access, a problem along the entire South Carolina coast, is particularly critical in the Charleston area. Parking is perhaps the most critical factor affecting day use of Charleston's beaches, especially Folly Beach. A conservative capacity analysis identified a need for twice as many legal parking spaces as are currently available at Folly Island to merely accommodate the 1975 level of demand (Hartzog, Lader and Richards, Inc., "Public Beach Access and Recreation in South Carolina", 1975). This finding appears incompatible with the Corps finding that only 92 additional spaces are needed to satisfy parking needs associated with the proposed public beach development project. Additional discussion of this situation should be included.

The Hartzog, Lader and Richards report calculated recreational carrying capacity based on an optimum recreational density of 200 square feet per person. In calculating Folly Beach project benefits, the beach carrying capacity was determined by dividing the dry beach areas by 100 square feet per person and multiplying by 2 (turnover rate). The final statement should discuss the various formulas for determining beach carrying capacity and why selected formula was chosen.

Response: The survey report analysis of beach access and parking has been reviewed and is reaffirmed. The dry beach area of 100 square feet per bather at time of peak use is considered appropriate in computing beach capacity on this type beach and is in accordance with Corps standards.

6. Comments: Pages 23-31, Probable Impact of the Proposed Action on the Environment

This section does not assess the indirect, long-term project impacts of the recommended plan; i.e., future development spurred by renourishment and stabilization of the beach. Approximately 300 acres of high land within the corporate limits of the City of Folly Beach are now undeveloped and provide habitat for the island's wildlife. The approximately [illegible] undeveloped acres on the southwest end of the island consist principally of primary dunes and salt marsh and provide habitat for a large variety of shorebirds, finfish, shellfish, waterfowl, and other wildlife. Development of this area subsequent to project implementation would result in degradation, if not loss, of much of the existing habitats. These secondary project impacts should be addressed in this section.

Response: With the exception of 25 ocean front lots, the forecasted increase in land development and its induced impacts will not be a direct or indirect result of the beach nourishment project. The approximately 300 acres of high land within the corporate limits of the City of Folly Beach and 55 acres of high land on the southwest end of the island will probably be developed with or without the beach nourishment project.

The project would require the local sponsor to provide additional parking facilities, comfort stations and outside showers for public use. These facilities, while a very minor part of the future development of the area, would have an indirect effect on land use, and sanitary waste disposal plans.

7. Comment: Page 29, Paragraph 4.17

The shortnose sturgeon, in addition to the brown pelican and peregrine falcon, is known to occur in the project area.

The statement should include a discussion of why project construction and maintenance would result in no adverse impact on endangered species in the project area.

Response: The discussion of endangered species has been clarified.

8. Comment: Page 33, Paragraph 6.6

Creation of artificial dunes would provide additional dune habitat, but this habitat type is utilized by few wildlife species. Artificial dune maintenance with its subsequent reduction of oceanic overwash decreases bird nesting habitat on barrier islands, and artificial planting of dune grasses results in dense vegetative cover which is not tolerated by most ground nesting bird species. The false impression of safety and stability created by an artificial dune system encourages further development which results in loss of wildlife habitat and degradation and/or loss of marsh and adjacent aquatic habitats. The FWS recommends that dune creation be considered very carefully as a viable part of the project plan.

Response: The creation of artificial dunes was listed on page 33, paragraph 6.6 as a structural alternative. Artificial dune creation is not part of the selected plan. Although dunes are not included in the recommended plan, it is noted that in this comment the USDI states that dunes are utilized by few wildlife species, but in comment numbers 6 and 9, the USDI indicates that dunes provide habitat for a large variety of wildlife and are productive.

9. Comment: Page 37, Paragraph 6.11

Loss of the 190-acre southwest end of the island to development would result in loss of a unique natural area. Fragile dunes, productive salt marsh areas, and shellfish beds would likely be degraded if not destroyed. If this occurs, it would be a significant adverse project impact on fish and wildlife resources of the project area. The statement should include a discussion of why project construction and maintenance would result in no adverse impact on endangered species in the project area.

Response: The 190-acre southwest end of Folly Island is outside the proposed beach nourishment project area. Of the total 190 acres, approximately 55 is high land, and the remaining acreage consists principally of saltmarsh. The forecasted increase in land development and its induced impacts will not be a direct or indirect result of the beach nourishment project. The southwest end of the island will probably be developed with or without the beach nourishment project.

10. Comment: Page 37, Paragraphs 6.13 and 6.14

We concur in the Corps finding that development of a beach access/biological observation park on the undeveloped southwest end of Folly Island would contribute greatly to the environmental quality enhancement of the recommended plan which currently has no environmental quality or fish and wildlife enhancement features. Such a park would also help alleviate congestion in Folly Beach and would provide much-needed beach access and public use facilities. We recommended that this feature be incorporated into the selected plan in order to assure the continued existence of this natural area and its associated fish and wildlife resources as well as to provide the public access and public use facilities necessary to meeting the projected public use upon which the benefits of the project are based.

Response: During the Folly River Navigation Study of 1977, the Charleston District proposed the development of a beach access/ biological observation park for the undeveloped southwest end of Folly Island. The project manager attempted to persuade the U. S. Fish and Wildlife representative working on this study and representatives of the local Audubon Society and Sierra Club to make a statement supporting this park at the forthcoming public meeting. The requested support was not provided. Public opinion as reflected by a public referendum indicated opposition to the proposed park by the citizens of Folly Beach. In view of this opposition and the lack of support from environmentally oriented groups, the Charleston District believes it imprudent to try to force acceptance of the proposed park.

South Carolina Coastal Council

1. Comment: The proposed project is approved with two conditions:

1) Provided that the applicant acquire all ownership rights prior to the commencement of work as authorized by issuance of this permit.

2) Provided that any work done in the vicinity (500 feet) of Bird Key be restricted to September through March to minimize the impact on nesting seabirds.

Response: The project sponsor would require the necessary rights-of-way. Work in the vicinity of Stono Inlet will be no closer than 2,000 feet from Bird Key.

2. Comment: The estimated schedule for completion of the initial proposed project does not seem to appear in either the EIS, the Survey Report or Appendix 4. Some type of "time-line" which estimates the length of time for permit approval, Congressional funding authorization and actual project construction should be included. This is particularly important for reviewers in assessing the impacts of temporary dredging-related environmental effects during actual fill activity. Also, such a time-line is helpful for recognition of the possible inflationary costs associated with project delays.

Response: Information regarding the time period required for completion of the initial proposed project is covered under Plan Implementation in the Survey Report. Although it is not possible to accurately estimate a schedule for completion of the project, it is possible to complete design and construction in about two and one-half (2-1/2) years if subsequent appropriations are forthcoming as needed. Actual dredging and sand movement would take less than a year.

3. Comment: Paragraph 4.25, Maintenance Dredging. The projected life of the proposed source(s) for suitable sand material should be identified. Environmentally acceptable dredge sites with appropriate quality sand are vital to the feasibility of long-term beach maintenance at five-year intervals. Although one map shows the general area of the two inlets, approximate locations of actual dredge sites have not been indicated in the DEIS. This appears to be a serious deficiency.

Response: The source of material for periodic beach renourishment would be the shoals in the inlets at either end of Folly Island. These shoals would quickly reform following dredging as can be seen at Murrells Inlet and Little River Inlet where the navigation channels quickly shoal up following maintenance dredging. Figure 2 has been revised to show the approximate location of borrow sites.

4. Comment: Paragraph 6, Alternatives.

a. Review of the more detailed discussions of nonstructural alternatives provided in the Survey Report indicates that the cost-benefit ratio calculated for the relocation of structures included no benefits for continued provision of public beach areas. The only benefit figured in was for reduced damage from property loss, while this type of alternative would clearly allow the natural beach to shift and realign itself, and therefore the public recreational value would be maintained if not enhanced (Some limited additional costs would also result in relocating public facilities and roadways.)

b. The evaluations and cost-benefit calculations for combined beach/dune development alternatives (B-1 through B-3) were only examined for the longest stretch of beach (Sta 78+70S to 180+90N). No rationale was provided for this approach. The concern here is that the resulting cost-benefit ratios cannot be compared relative to others. The EIS indicates on page 35 that Alternative B-1 was designated as the EQ plan. The comment is added that larger projects, in terms of dune height, had lower proportional benefits. The question which is not addressed is whether project B-1 over shorter distances, similar to A-1, would have provided a higher cost-benefit ratio.

Response:

a. Relocation of structures would not be accomplished at once. Rather, each building would be moved only when it became apparent it would be lost to erosion. This point in time was assumed to be when erosion of the mean high water shoreline reached the ocean side of the endangered structure. The beach would be allowed to continue to erode and realign itself but no appreciable amount of additional recreational beach areas or increased recreational value of the beach would be expected. Additionally, this alternative was neither desired nor deemed acceptable by local interests.

b. Shorter sections of beach/dune development was not considered appropriate by local interest since all the shoreline is similarily developed and would be subjected to about the same storm wave forces. Additionally, shorter sections of beach/dune development did not provide a higher cost-benefit ratio.

5. Comment: A discussion should be added to the DEIS indicating (1) the relationship of beach renourishment to the Folly River Navigation project (briefly mentioned on p. 27 of the Survey Report), and (2) the relationship to the current proposal and permit application made by the City of Folly Beach (briefly mentioned on p. 13 in the Survey Report).

Response:

a. The proposed beach renourishment project was coordinated with the Folly River Navigation Project during the initiation stages. However, time limit requirements for completion of the separate projects, precluded compatibility of the projects. The Folly River Navigation

Project dredging was recently completed. In the event the beach nourishment project is constructed, future maintenance renourishment would be correlated with maintenance dredging of the Folly River Navigation Project if the shoal material in Folly River is suitable for renourishing the beach.

b. The proposed beach renourishment project was coordinated with the City of Folly Beach's proposed renourishment plan. Results from the coordination indicate the city's smaller emergency renourishment project may lessen the extent and subsequent costs of implementation of the Corps proposed renourishment project.

6. Comment: Appendix 1, Technical Report was not circulated with the DEIS. This material would have been very helpful to reviewers of the document.

Response: Appendix 1 of the Technical Report was not circulated with the DEIS and Survey Report due to its large size and costs of publication and mailing. All appendixes, however, are available upon request.

7. Comment: It is not clear whether paragraph 9.3, Government Agencies, and/or Appendix 3 would be more appropriate, but the EIS should contain in some section (1) a list of agencies and interest groups receiving copies of the DEIS, (2) other agency approvals or permits which will be required for implementation of the project and (3) such relevant information as that presented above under General Comments.

Response: A list of those from whom comments are requested is supposed to be contained in the summary section of the draft EIS, and a list of those who submitted comments is contained in the summary sheet of the final EIS. Unfortunately, the summary sheet for the draft EIS was inadvertently omitted. Since the final EIS with a Section 404(b) evaluation will be sent to the Congress, no other agency permits will be required for construction of the project.

APPENDIX A

Common and scientific names of vascular plants common in the vicinity of Folly Beach, South Carolina.

Common Name[a]	Scientific Name[b]	Common Name[a]	Scientific Name[b]
Bayberry	Myrica pensylvanica	Salt grass	Distichlis spicata
Beach-sponge	Euphorbia polygonifolia	Saltmeadow cordgrass	Spartina patens
Bitter panic grass	Panicum amarum	Sandspur	Cenchrus tribuloides
Black needlerush	Juncus roemerianus	Seabeach orach	Atriplex arenaria
Broomsedge	Andropogon virginicus	Sea lavender	Limonium carolinianum
Carolina laurel cherry	Prunus caroliniana	Sea oats	Uniola paniculata
Evening primrose	Oenothera spp.	Sea ox-eye	Borrichia frutescens
Fimbristylis	Fimbristylis spp.	Sea rocket	Cakile edentula
Glasswort	Salicornia virginica	Seaside croton	Croton punctatus
Greenbrier	Smilax spp.	Seaside elder	Iva imbricata
Hercules club	Zanthoxylum clava-herculis	Silverling	Baccharis halimifolia
Live oak	Quercus virginiana	Smooth cordgrass	Spartina alterniflora
Marsh aster	Boltonia asteroides	Virginia creeper	Parthenocissus quinquefolia
Marsh elder	Iva frutescens	Wax myrtle	Myrica cerifera
Poison ivy	Rhus radicans	Wild grape	Vitis rotundifolia
Purple sandgrass	Triplasis spp.	Winged sumac	Rhus copallina
Red cedar	Juniperus virginiana	Yaupon	Ilex vomitoria
Russian thistle	Salsola kali		

[a]Common names are arranged in alphabetical order to assist readers unfamiliar with scientific nomenclature and phylogenetic relationships.

[b]Scientific names are based on: Radford, A. E., H. E. Ahles, and C. R. Bell. 1968. Manual of the vascular flora of the Carolinas. The University of North Carolina Press, Chapel Hill. 1183 pp.

APPENDIX B

Common and scientific names of some animals commonly occurring in the vicinity of Folly Beach, South Carolina.

Common Name[a]	Scientific Name[b]
Mollusks	
Eastern oyster	*Crassostrea virginica*
Hard clam	*Mercenaria mercenaria*
Marsh periwinkle	*Littorina sp.*
Marsh snail	*Galba polustris*
Ribbed mussel	*Geukensia demissa*
Arthropods	
Amphipods	*Haustorius* spp.
Beach flea	*Orchestia gammarella*
Blue crab	*Callinectes sapidus*
Brown shrimp	*Penaeus aztecus*
Coquina	*Donax sp.*
Dragonfly	*Libellula sp.*
Ghost crab	*Ocypode sp.*
Horseshoe crab	*Limulus*
Mole crab	*Emerita talpoida*
Mud fiddler	*Uca minax*
Sand fiddler	*Uca pugilator*
Tiger beetle	*Cicindelidae sp.*
White shrimp	*Penaeus setiferus*
Echinoderms	
Sea cucumber	*Cucumaria sp.*
Sand dollar	*Mellita quinqiesperforata*
Fishes	
Atlantic croaker	*Micropogon undulatus*
Atlantic menhaden	*Brevoorita tyrannus*
Atlantic silverside	*Menidia menidia*
Bay anchovy	*Anchoa mitchilli*

[a] Common names are arranged in alphabetical order to assist readers unfamiliar with scientific nomenclature and phylogenetic relationships.

[b] Scientific names are based on the following:

Appendix B (continued).

Common Name[a]	Scientific Name[b]
Fishes (cont.)	
Black drum	*Pogonias cromis*
Blueback herring	*Alosa aestivalis*
Bluefish	*Pomatomus saltatrix*
Florida pompano	*Trachinotus carolinus*
Gizzard shad	*Dorosoma cepedianum*
Mummichog	*Fundulus heteroclitus*
Permit	*Trachinotus falcatus*
Planehead filefish	*Monacanthus hispidus*
Red drum	*Sciaenops ocellata*
Rough silverside	*Membras martinica*
Sea catfish	*Arius felis*
Sheepshead	*Archosargus probatocephalus*
Southern flounder	*Paralichthys lethostigma*
Southern kingfish	*Menticirrhus americanus*
Spot	*Leiostomus xanthurus*
Spotted seatrout	*Cynoscion nebulosus*
Striped anchovy	*Anchoa hepsetus*
Striped killifish	*Fundulus majalis*
Striped mullet	*Mugil cephalus*
Summer flounder	*Paralichthys dentatus*
Weakfish	*Cynoscion regalis*
Reptiles	
Diamondback terrapin	*Malaclemys terrapin*
Eastern glass lizard	*Ophisaurus ventralis*
Six-lined racerunner	*Cnemidophorus sexlineatus*
Slender glass lizard	*Ophisaurus attenuatus*
Birds	
American oystercatcher	*Haematopus palliatus*
Barn swallow	*Hirundo rustica*

Appendix B (continued).

Common Name[a]	Scientific Name[b]
Birds (cont.)	
Black skimmer	*Rhynchops nigra*
Blue-winged teal	*Anas discors*
Boat-tailed grackle	*Cassidix mexicanus*
Clapper rail	*Rallus longirostris*
Common grackle	*Quiscalus quiscula*
Common tern	*Sterna hirundo*
Dowitcher	*Limnodromus griseus*
Great blue heron	*Ardea herodias*
Greater yellowlegs	*Totanus melanoleucas*
Ground dove	*Columbigallina passerina*
Gull-billed tern	*Gelochelidon nilotica*
Herring gull	*Larus argentatus*
Laughing gull	*Larus atricilla*
Least tern	*Sterna albifrons*
Lesser yellowlegs	*Totanus flavipes*
Marsh hawk	*Circus cyaneus*
Mockingbird	*Mimus polyglottos*
Osprey	*Pandion haliaetus*
Red-winged blackbird	*Agelaius phoeniceus*
Robin	*Turdus migratorius*
Savannah sparrow	*Passerculus sandwichensis*
Snowy egret	*Leucophoyx thula*
Song sparrow	*Melospiza melodia*
Willet	*Catoptrophorus semipalmatus*
Wilson's plover	*Charadrius wilsonia*
Mammals	
Gray squirrel	*Sciurus carolinensis*
Marsh rabbit	*Sylvilagus palustris*
Opossum	*Didelphis marsupialis*
Raccoon	*Procyon lotor*
Rice rat	*Oryzomys palustris*

APPENDIX C

Common and scientific names of endangered and threatened species which may or do occur in the vicinity of Folly Beach, South Carolina.[a]

Common Name		Scientific Name
	Reptiles	
Atlantic ridley sea turtle	(E)[b]	Lepidochelys kempii
Green sea turtle	(T)[c]	Chelonia mydas
Hawksbill sea turtle	(E)	Eretmochelys imbricata
Leatherback sea turtle	(E)	Dermochelys coriacea
Loggerhead sea turtle	(T)	Caretta caretta
Eastern indigo snake	(T)	Drymarchon corais couperi
American alligator	(T)	Alligator mississippiensis
	Birds	
Arctic peregrine falcon	(E)	Falco peregrinus tundrius
Bachman's warbler	(E)	Vermivora bachmanii
Brown pelican	(E)	Pelecanus occidentalis
Eskimo curlew	(E)	Numenius borealis
Kirtland's warbler	(E)	Dendroica kirtlandii
Red-cockaded woodpecker	(E)	Dendrocopus borealis
Bald eagle	(E)	Haliaeetus leucocephalus
Ivory-billed woodpecker	(E)	Campephilus principalis
	Mammals	
Eastern cougar	(E)	Felis concolor cougar
Florida manatee	(E)	Trichechus manatus
	Fishes	
Shortnose sturgeon	(E)	Acipenser brevirostrum

[a] Source of species status and scientific names: Fish and Wildlife Service list of endangered and threatened wildlife, 50 CFR 17:11, as amended 17 January 1979. The Bureau of National Affairs, Inc., Washington, D. C.

[b] Endangered

[c] Threatened

APPENDIX D

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U. S. Department of Commerce, National Oceanic and Atmospheric Administration. 1973. Climatography of the United States No. 81 (By State): Monthly Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1941-1970. National Climatic Center, Asheville, N. C. n.p.

APPENDIX E

Letters received by the District Engineer
on the Draft Environmental Statement

DEPARTMENT OF HEALTH EDUCATION AND WELFARE
REGION [illegible]
101 MARIETTA TOWER Suite 1503
ATLANTA GEORGIA 30323
June 15, 1979

HEW-930-6-79

William W. Brown
Colonel, Corps of Engineers
District Engineer
Department of the Army
Charleston District Corps of Engineer
P. O. Box 919
Charleston, South Carolina 29402

Subject: DEIS, Beach Erosion Control and Hurricane Protection, Folly Beach, S. C.

Dear Colonel Brown:

We have reviewed the subject Draft Environmental Impact Statement. Based upon the data contained in the Draft, it is our opinion that the proposed action will have only a minor impact upon the human environment within the scope of this Department's review. The impact statement has been adequately addressed for our comments.

Sincerely yours,

James E. Yarbrough
Regional Environmental Officer

cc: [illegible] McGee
F. Krebs

FEDERAL ENERGY REGULATORY COMMISSION
REGIONAL OFFICE
[illegible] Peachtree Street, N. E.
Atlanta, Georgia 30309
July 3, 1979

Colonel William W. Brown
District Engineer
Corps of Engineers
Department of the Army
Post Office Box 919
Charleston, SC 29402

Dear Colonel Brown:

This is in response to your letter dated June 8, 1979, with attachment, requesting our comments on the Draft Environmental Impact Statement and Preliminary [illegible] Report [illegible] Beach Erosion Control and Hurricane Protection, Folly Beach, South Carolina.

The Commission's principal concern in regard to development [illegible] [illegible] [illegible] [illegible] natural gas [illegible].

In reviewing the study area we noted nothing that should interfere with any of the Commission's licensed hydroelectric projects. However, provision should be made to protect electrical transmission lines and natural gas pipelines in the construction area.

We appreciate the opportunity to comment on your proposed project.

Very truly yours,

[illegible] Kauranen
Regional Engineer

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Science and Technology

July 24, 1979

Colonel William W. Brown
Charleston District, Corps of Engineers
Department of the Army
Post Office Box 919
Charleston, South Carolina

Dear Colonel Brown:

This is in reference to ... Environmental Impact Statement entitled "Beach ... and Hurricane Protection, Folly Beach ..." ... the enclosed comment from the National Oceanic and Atmospheric Administration is forwarded for your consideration.

Thank you for giving us an opportunity to provide this comment, which we hope will be helpful to you. ... appropriate ... environmental impact statement ...

Sincerely,

Enclosure — Memo from: Douglas M. LeComte, Environmental Data and Information Service, OA/Dxx1

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

OA/Dxx1

TO: ... LeComte

FROM: OA/Dxx1 - Douglas M. LeComte

SUBJECT: DEIS 7906.11 ... Report ... Draft Environmental Impact Statement ... Folly Beach, South Carolina

Appendix ..., paragraph ...

... hurricane protection is a major goal of the project, the climate discussion ... information on hurricanes. The EIS should indicate the extent of the danger from tropical cyclones ... Folly Beach, and a description of damage from past storms should be given. A good source ... data ... by ... and ... "Atlantic Hurricane Frequencies Along the ... Coastline" (NOAA Technical Memorandum NWS SR-58, 1971). The ... in this report ... hurricane ... Folly Beach ... average ... years between hurricanes ...

RECEIVED
JUL ... 1979

United States Department of the Interior

OFFICE OF THE SECRETARY

Southeast Region [illegible] Suite 1412 Atlanta, [illegible] 30303
Richard B. Russell Federal Building
75 Spring Street, S.W.

July 26, 1979

ER-79/543

District Engineer
[illegible] of Engineers
[illegible]
[illegible], South Carolina [illegible]

Dear Sir:

[illegible] the following comments:

General Comments

The statement appears to adequately address the [illegible] impacts of the recommended plan on the area's fish and [illegible]. However, [illegible] secondary environmental impacts are not addressed.

Section 662(a) of the Fish and Wildlife Coordination Act (FWCA) requires the Corps of Engineers to consult with the Fish and Wildlife Service (FWS) and with State fish and wildlife agencies regarding proposed or authorized water resources development projects. This required coordination has not occurred in the Folly Beach study resulting in potential adverse impacts on the area's fish and wildlife resources being inadequately addressed. Additional comments on the recommended plan will be provided by the FWS in the FWCA report which, according to Section [illegible] of the FWCA, [illegible] be made an integral part of the survey report [illegible] Congress for authorization.

The proposed [illegible] will [illegible] [illegible]

-2-

discussed above, FWS had no involvement in this study until this draft survey report was submitted on June [illegible], 1979, for coordination review. The FWS maintains that this is a project review and should meet the requirements of the Fish and Wildlife Coordination Act.

We request that the U.S. Bureau of Sport Fisheries and Wildlife be referred to as the U.S. Fish and Wildlife Service. It should be removed [illegible] the list of agencies from whom the Charleston [illegible] District requested and received comments concerning problem identification and possible solution[illegible]

Page [illegible], Land Use Analysis

[illegible]

The [illegible] report calculated [illegible] recreational carrying [illegible] 200 square feet [illegible] the [illegible] carrying [illegible] determined [illegible] 100 square feet [illegible] turnover rate [illegible] final statement [illegible]

Appendix

area subsequent to project implementation would result in degradation, if not loss, of much of the existing habitats. These secondary project impacts should be addressed in this section.

Page 29, paragraph 4.17

The shortnose sturgeon, in addition to the brown pelican and peregrine falcon, is known to occur in the project area.

The statement should include a discussion of why project construction and maintenance would result in no adverse impact on endangered species in the project area.

Page 33, paragraph 6.6

Creation of artificial dunes would provide additional dune habitat, but this habitat type is utilized by few wildlife species. Artificial dune maintenance with its subsequent reduction of oceanic overwash decreases bird nesting habitat on barrier islands, and artificial planting of dune grasses results in dense vegetative cover which is not tolerated by most ground nesting bird species. The false impression of safety and stability created by an artificial dune system encourages further development which results in loss of wildlife habitat and degradation and/or loss of marsh and adjacent aquatic habitats. The FWS recommends that dune creation be considered very carefully as a viable part of the project plan.

Page 37, paragraph 6.11

Loss of the 190-acre southwest end of the island to development would result in loss of a unique natural area. Fragile dunes, productive salt marsh areas, and shellfish beds would likely be degraded if not destroyed. If this occurs, it would be a significant adverse project impact on fish and wildlife resources of the project area. The statement should include a discussion of why project construction and maintenance would result in no adverse impact on endangered species in the project area.

Page 37, paragraphs 6.13 and 6.14

We concur in the Corps finding that development of a beach access/biological observation park on the undeveloped southwest end of Folly Island would contribute greatly to the environmental quality enhancement of the recommended plan which currently has no environmental quality or fish and wildlife enhancement features. Such a park would also help alleviate congestion in Folly Beach and would provide much-needed beach access and public use facilities. We recommend that this feature be incorporated into the selected plan in order to assure the continued existence of this natural area and its associated fish and wildlife resources as well as to provide the public access and public use facilities necessary to meeting the projected public use upon which the benefits of the project are based.

Summary

Full consultation was not used regarding problem identification on Folly Beach or possible solutions to identified problems. Due to the lack of consultation in the Folly Beach study, wildlife conservation did not receive equal consideration, and no features with a view to the conservation of wildlife resources were incorporated into the recommended plan. The secondary impacts of development generated by the project were not evaluated. We maintain that development subsequent to project implementation would produce adverse impacts on the area's fish and wildlife resources. In order to lessen these adverse impacts and to provide environmental quality enhancement, we recommend that a plan to preserve the biological integrity of the southwest end of the island be incorporated into the Folly Beach project.

We appreciate the opportunity to review and comment on this draft environmental impact statement and preliminary survey report.

Sincerely yours,

James H. Lee

James H. Lee
Regional Environmental Officer

AD-A115 708 CORPS OF ENGINEERS CHARLESTON SC CHARLESTON DISTRICT F/G 13/2
FOLLY BEACH, SOUTH CAROLINA. SURVEY REPORT ON BEACH EROSION CON--ETC(U)
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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IV

345 COURTLAND STREET
ATLANTA, GEORGIA 30308

July 27, 1979

4SA-EIS

Colonel William W. Brown, USA
Corps of Engineers, Charleston District
P. O. Box 919
Charleston, South Carolina 29420

Dear Colonel Brown:

We have reviewed the Draft Environmental Impact Statement on beach nourishment of Folly Island, South Carolina, and are concerned about the long-term consequences of this action together with your prima facie decision to eliminate all nonstructural alternatives from real consideration.

The real problem at Folly Beach is not the erosion, but the election of home owners, businessmen, etc., to place structures in improvident locations. It is well documented that barrier islands are dynamic physiographic features. They experience almost daily fluctuations in their aereal extent due to marine processes. Added to this alteration are those from the long-term phenomena of sea level rise and regional subsidence. All strand/insular ecosystems are influenced by these processes to some degree. While acknowledging the considerable abilities and resources of the Corps, we suggest that it is impractical to assume that it can provide even short-term stability to all those coastal areas which need protection. This is especially true given the extent of the area involved and the magnitude of these phenomena.

An important point to emphasize is that "short-term" protection is all that is being offered. At the end of the 50-year project life will the situation be any different? The Summary Report indicates that the exact cause of the beach losses is not known. Are studies planned which will research the causes of this erosion and attempt to effect a solution? In our opinion, the nonstructural alternative of building relocation provides the only long-term solution to the situation. The nourishment proposal merely postpones the inevitable. In the light of recent decisions to restrict petroleum utilization, the Final EIS should examine whether or not the selected energy intensive plan can be maintained over its projected 50-year life. It may well happen that mainenance dredging will have to be curtailed, thereby increasing the potential monetary losses from subsequent erosion. The FEIS should detail both possibilities. Additionally, determinations should be

made to ascertain whether rising sea level and/or subsidence is influencing the marine processes at Folly Beach. If this proves to be the case, how will the project be affected and what actions will the Corps take?

Relative to decision making, the EIS is the vehicle through which an alternative is supposed to be selected. By structuring your objective so that only an enlarged beach would meet your criteria, the EIS merely becomes a mechanism to legitimize a previously made decision. The nonstructural alternative has a favorable cost ratio, yet is dismissed as not being favored by local interests. We understand that certain of these *local interests* are demanding a nourishment project far in excess of that currently planned. Considering the rather modest financial commitment of the local interests, how are their desires factored into the Corps' decision making process relative to facility type and size? Are there any plans to accede to the latter group's wishes?

We have some generic problems with your attempt to alter natural coastal geomorphic processes, especially as this is just one of many similar Corps projects planned within EPA, Region IV. Therefore, on the basis of our appraisal the facility was rated ER-2, i.e., we have reservations regarding this facility and request answers to the questions we posed. If you wish to discuss this matter in more detail, Mr. Gerald Miller, EIS Review, FTS 8-257-7458, will serve as our point of contact.

Sincerely yours,

John C. White
Regional Administrator

South Carolina Coastal Council

James M Waddell, Jr
Chairman

H Wayne Beam, Ph D
Executive Director

August 14, 1979

Colonel William W. Brown
District Engineer, Charleston District
U. S. Army, Corps of Engineers
P. O. Box 919
Charleston, S. C. 29402

Dear Colonel Brown:

Enclosed are the comments of the South Carolina Coastal Council on the Draft Environmental Impact Statement for Folly Beach Renourishment. Thank you for the opportunity to review the draft and for the extension of the comment period through August 15.

Sincerely,

H. Wayne Beam
Executive Director

HWB:jl
Enclosure
cc: Sen. James M. Waddell, Jr., Chairman
Mr. Elmer Whitten

Comments on Draft E.I.S.
Folly Beach Renourishment Project

General Comments

The South Carolina Coastal Council has officially gone on record in support of beach renourishment on Folly Beach, S. C. This endorsement came in two forms:

- Permit approval (P/N 79-2H-039) to the City of Folly Beach for renourishment of 22,000 linear feet of Atlantic Ocean beach front [illegible] cubic yards of sand), with conditions that ensure provision of public beach areas and minimize impacts on the adjacent rookery, as follows:

1) Provided that the applicant acquire all ownership rights prior to the commencement of work as authorized by issuance of this permit.

2) Provided that any work done in the vicinity (50 feet) of Bird Key be restricted to September through March to minimize the impact on nesting seabirds.

(Approved May 19, 1979, issued 5/22/79 and accepted 5/29/79)

- Approval of up to $440,[illegible] of State funds to Folly Beach for erosion control provided the specific project plans receive Council approval ([illegible] 1979).

Specific Comments

1. The estimated schedule for completion of the initial proposed project does not seem to appear in either the EIS, The Survey Report or Appendix A. Some type of "time-line" which estimates the length of time for permit approval, Congressional funding authorization and actual project construction should be included. This is particularly important for reviewers in assessing the impacts of temporary dredging-related environmental effects during actual fill activity. Also, such a time-line is helpful for recognition of the possible inflationary costs associated with project delays.

2. Paragraph 4.25, Maintenance Dredging

The projected life of the proposed source(s) for suitable sand material should be identified. Environmentally acceptable dredge sites with appropriate quality sand are vital to the feasibility of long-term beach maintenance at five-year intervals. Although one map shows the general area of the two inlets, approximate locations of actual dredge sites have not been indicated in the DEIS. This appears to be a serious deficiency.

3. Paragraph 6, Alternatives

Review of the more detailed discussion of nonstructural alternatives provided in the Survey Report indicates that the cost-benefit ratio calculated for the relocation of structures included no benefits for continued provision of public beach areas. The only benefit figured in was for reduced damage from property loss, while this type of alternative would clearly allow the natural beach to shift and re-align itself, and [illegible] the public recreational value [illegible]

FOLLY BEACH

SOUTH CAROLINA

PERTINENT CORRESPONDENCE

APPENDIX 3

PREPARED BY THE

CHARLESTON DISTRICT, CORPS OF ENGINEERS

DEPARTMENT OF THE ARMY

PERTINENT CORRESPONDENCE

TABLE OF CONTENTS

Rev

28 March 80

City Of Folly Beach

May 24, 1976

Colonel Harry S. Wilson, Jr.
District Engineer
U. S. Army Engineer District, Charleston
P. O. Box 919
Charleston, South Carolina 29402

Dear Colonel Wilson:

At the public meeting of 8 April 1976, it was stated that the city of Folly Beach should provide a letter of sponsorship for the Federally-funded study on beach erosion and hurricane protection presently being made by the Corps of Engineers under the resolution adopted 15 June 1972 by the Senate Committee on Public Works at the request of Senator Hollings.

It is understood that definite commitments are not required until a specific plan of improvement is proposed and its features and costs are made known to the City. The purpose of this letter is to signify the present intentions of the city of Folly Beach to provide the non-Federal funds and other items of local cooperation that might be specified in a project, provided these are within the city's means and otherwise acceptable. It is further understood that, at the appropriate time, the city can give such assurances alone or jointly with Charleston County and/or the State of South Carolina, as required to provide for the total of all non-Federal items of cooperation.

Subject to the above understanding, the city of Folly Beach hereby indicates its sponsorship of the above study.

Very truly yours,

Fred J. Adams
Mayor

South Carolina Department of Archives and History
1430 Senate Street
Columbia, S. C.

P. O. Box 11,669
Capitol Station 29211
803 — 758-5816

April 4, 1978

Mr. Jack J. Lesemann
Chief, Engineering Division
Charleston District Corps of Engineers
Post Office Box 919
Charleston, South Carolina 29402

Dear Mr. Lesemann:

Your letter of 23 February 1978, to Mr. Charles Lee regarding magnetometer surveys of borrow sites in the waters near Folly Beach has been referred to me for response.

Your proposal for magnetometer surveys of the type described appears to us an appropriate response to the situation at hand. Because, however, the results obtained from the magnetometer varies according to the manner in which it is used, we are unable without more detailed information to comment on the technical adequacy of the survey. The best source of information in South Carolina on evaluating and refining magnetometer survey techniques, if you wish such information, is Mr. Alan Albright at the Institute of Archeology and Anthropology, University of South Carolina.

Should any shipwrecks be encountered by your survey, this office should be contacted as the formal procedures specified in 36 Code of Federal Regulations 800.4 and 5 for implementing Section 106 of the National Historic Preservation Act of 1966 are carried out.

Sincerely,

Donald R. Sutherland, PhD.
Staff Archeologist
Historic Preservation Division

DRS/sa
CC: Mr. Elias B. Bull
Historic Preservation Planner
Berkeley-Charleston-Dorchester Council of Governments
157 East Bay Street
Charleston, South Carolina 29401

City Of Folly Beach

SOUTH CAROLINA
29439

FEBRUARY 8, 1979

COLONEL WILLIAM W. BROWN
DISTRICT ENGINEER
U. S. ARMY ENGINEER DISTRICT, CHARLESTON
P. O. BOX 919
CHARLESTON, SOUTH CAROLINA 29402

Dear Colonel Brown:

On behalf of Mayor Regas M. Kennedy and the City Council, with this letter the City of Folly Beach is requesting an extension of time for the submission of a "Letter of Intent" for the sponsorship for a Corps of Engineers beach erosion control project for the ocean shore of Folly Island.

As you have previously recognized, the City of Folly Beach has too small a tax base to be able to provide the funds necessary to cover the non-Federal share of the costs associated with the proposed project. Recognizing that the beneficiaries of such a project reside outside our taxing boundaries, we have gone to the legally constituted governing bodies representing these beneficiaries to arrange for their participation in the sponsorship of the project. Our state representative, the Honorable Paul Gelegotis, will be seeking a commitment from the state legislature. This body does not reconvene until 9 January and approximately three months will be required for him to get a commitment from that body.

We are, therefore, requesting that your deadline for receipt of an acceptable "Letter of Intent" be moved from 2 January to 16 April 1979.

Again, I would like to thank you for your efforts in helping us with our erosion problem.

Sincerely yours,

Robert M. Grooms

Robert M. Grooms
City Administrator

South Carolina Department of Archives and History
1430 Senate Street
Columbia, S. C.

P. O. Box 11,669
Capitol Station 2921
803 — 758-5816

March 14, 1979

Colonel William W. Brown
District Engineer
Corps of Engineers
Charleston District
Post Office Box 919
Charleston, S.C. 29402

Re: P/N 79-2H-039 -- To restore and maintain Folly Beach.

Dear Colonel Brown:

While no properties in, or eligible for inclusion in, the National Register of Historic Places are currently on record for the area to be affected by the above referenced project, it should be noted that an iron clad monitor, the Keokuk (survey site #38CH271), lies on the bottom of Charleston Harbor in the vicinity of the #2 choice borrow area. Caution should be taken to locate and avoid the wreck should this borrow area be used.

Further information on the Keokuk, plus an assessment of the possibility that the #1 or #3 choice borrow areas might contain undiscovered wrecks or archeological remains, can be obtained in consultation with State Underwater Archeologist, Alan Albright, at the Institute of Archeology and Anthropology, University of South Carolina.

The above comments are furnished so that both the applicant and the pertinent Federal agency may comply with Section 106 of the National Historic Preservation Act of 1966, as amended. Federal and State laws do not give the State Historic Preservation Officer the authority or the responsibility of approving or denying the application. This authority and responsibility remains with the Federal agency involved.

Sincerely,

Donald R. Sutherland, PhD.
Staff Archeologist
Historic Preservation Division

DRS/dkn

City Of Folly Beach

SOUTH CAROLINA
29439

June 13, 1979

Col. William W. Brown
District Engineer
U. S. Army Corps of Engineers
Charleston District
Post Office Box 919
Charleston, South Carolina 29402

Re: Letter of intent:
Folly Beach Renourishment
Project

Dear Col. Brown:

The City has had an opportunity to review the Folly Beach Survey Report on Beach Erosion Control Draft dated May, 1979, and we concur with the selected plan which would provide for beach restoration and periodic renourishment for the 16,860 foot developed reach of Folly Beach. This plan would provide a berm width of 25 feet, and the beach fill section would provide an average usable width above the mean high water line of 50 feet, as set out in the above mentioned Draft.

Please consider this a letter of intent from Folly Beach to participate in the selected plans. We intend to fully cooperate with the Corps and provide those items required by law, specifically:

A. All lands, easements, and rights-of-way necessary for construction;

B. All alterations and relocations of buildings, transportation facilities, utilities, and other structures necessary to the construction project;

C. The City will hold and save the United States free from claims for damages which may result from construction and subsequent maintenance of the project, other than damages due to the fault or negligence of the United States or its contractors;

City Of Folly Beach

SOUTH CAROLINA
29439

D. The City will provide a cash contribution for beach erosion control, including periodic renourishment for the 50 year project life equal to the percentages as outlined in your May, 1979 Draft;

E. The City will establish, prior to construction, a property hold line which will separate public from private property when the beach restoration projects are constructed, and will provide appropriate access facilities and sanitation facilities necessary for the realization of the public benefit upon which the Federal participation is based;

F. The City will adopt appropriate ordinances and provide other means to insure the preservation of the improvement;

G. The City will maintain and operate all the works after completion in accordance with the regulations as prescribed by the Secretary of the Army;

H. Furthermore, the City will make a maximum effort to insure that the State of South Carolina meets the new Federal requirement of an initial cash contribution equaling 5% of the project.

It is my understanding that this letter of intent does not immediately bind the City of Folly Beach but merely provides the necessary authorization from the City, as the local sponsor, for the Corps to proceed with the next steps in funding and planning this project.

City Of Folly Beach

SOUTH CAROLINA
29439

Page Three
Col. Brown
June 13, 1979

If there are any items that we can provide you, or if there are any questions about this matter, please call me or the City Attorney, Ben Peeples, (722-4041).

Very truly yours,

Regas M. Kennedy
Mayor

RMK:ftp

FEDERAL ENERGY REGULATORY COMMISSION

REGIONAL OFFICE

730 Peachtree Street, N. E.
Atlanta, Georgia 30308
July 3, 1979

Colonel William W. Brown
District Engineer
Corps of Engineers
Department of the Army
Post Office Box 919
Charleston, SC 29402

Dear Colonel Brown:

This is in response to your letter dated June 8, 1979, with attachment, requesting our comments on the Draft Environmental Impact Statement and Preliminary Survey Report on Beach Erosion Control and Hurricane Protection, Folly Beach, South Carolina.

The Commission's principal concern in regard to developments affecting land and water resources is the possible impacts of such projects on the construction and operation of bulk electric power facilities and interstate natural gas systems.

In reviewing the study area we noted nothing that should interfere with any of the Commission's licensed hydroelectric projects. However, provision should be made to protect electrical transmission lines and natural gas pipelines in the construction area.

We appreciate the opportunity to comment on your proposed project.

Very truly yours,

Aarne O. Kauranen
Regional Engineer

County of Charleston
Charleston, South Carolina

County Manager
County Office Building
2 Court House Square

July 18, 1979

Colonel William W. Brown
District Engineer
U. S. Army Corps of Engineers
Charleston District
Post Office Box 919
Charleston, S.C. 29402

Dear Colonel Brown:

Reference is made to the letter received from your office dated June 22, 1979. By this letter Charleston County wishes to express its support for this project and the County's agreement that the City of Folly Beach act as local sponsor for the Folly Beach Nourishment Project. The City of Folly Beach has been informed that the extent of the County's financial contribution will be limited. The limit of the County's participation is not known at this time. If the County does make a financial contribution it wishes to be informed of all major decisions involved in the project particularly those decisions involving any funds contributed by Charleston County.

If I can be of further assistance feel free to contact me.

Sincerely,

Richard L. Black
County Administrator

RLB:da

cc: County Council
Hon. Paul Gelegotis
Mr. Robert Grooms

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Science and Technology
Washington, D.C. 20230
(202) 377-XXX 4335

July 24, 1979

Colonel William W. Brown
Charleston District, Corps of Engineers
Department of the Army
Post Office Box 919
Charleston, South Carolina 29402

Dear Colonel Brown:

This is in reference to your draft environmental impact statement entitled, "Beach Erosion Control and Hurricane Protection, Folly Beach, South Carolina." The enclosed comment from the National Oceanic and Atmospheric Administration is forwarded for your consideration.

Thank you for giving us an opportunity to provide this comment, which we hope will be of assistance to you. We would appreciate receiving eight (8) copies of the final environmental impact statement.

Sincerely,

Sidney R. Galler
Deputy Assistant Secretary
for Environmental Affairs

Enclosure

Memo from: Mr. Douglas M. LeComte
Environmental Data and Information Service
OA/Dx61

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL DATA AND INFORMATION SERVICE
Washington, D.C. 20235

July 2, 1979 OA/Dx61

TO: PP/EC - R. Lehman

FROM: OA/Dx61 - Douglas M. LeComte

SUBJECT: DEIS 7906.12 - Survey Report and Draft Environmental Impact Statement (Folly Beach, South Carolina)

Appendix 5, paragraph 2.2:

Though hurricane protection is a major goal of the project, the climate discussion gives no information on hurricanes. The EIS should indicate the extent of the danger from tropical cyclones to Folly Beach, and a description of damage from past storms should be given. A good source for frequency data on tropical cyclones is Simpson and Lawrence's "Atlantic Hurrican Frequencies Along the U.S. Coastline" (NOAA Technical Memorandum NWS SR-58, 1971). The graphs in this report indicate that the probability of a hurricane occurring in any one year in a 50 mile segment of the coastline which includes Folly Beach is 8%, and the average number of years between hurricanes is 12.

United States Department of the Interior

OFFICE OF THE SECRETARY

Southeast Region / Suite 1412 / Atlanta, Ga. 30303
Richard B. Russell Federal Building
75 Spring Street, S. W.

July 26, 1979

ER-79/549

District Engineer
U. S. Army Corps of Engineers
Post Office Box 919
Charleston, South Carolina 29402

Dear Sir:

We have reviewed the draft environmental statement and preliminary survey report for beach erosion control and hurricane protection, Folly Beach, Charleston County, South Carolina, as requested by your letter of June 8, 1979. We offer the following comments.

General Comments

The statement appears to adequately address the direct impacts of the recommended plan on the area's fish and wildlife resources. However, the secondary environmental impacts are not addressed.

Section 662(a) of the Fish and Wildlife Coordination Act (FWCA) requires the Corps of Engineers to consult with the Fish and Wildlife Service (FWS) and with State fish and wildlife agencies regarding proposed or authorized water resources development projects. This required coordination has not occurred in the Folly Beach study resulting in potential adverse impacts on the area's fish and wildlife resources being inadequately addressed. Additional comments on the recommended plan will be provided by the FWS in the FWCA report which, according to Section 662(b) of the FWCA, must be made an integral part of the survey report before it is submitted to Congress for authorization.

The proposed action will not adversely affect any existing, proposed, or known potential units of the National Park System or subject areas for which the National Park Service is qualified to comment by virtue of expertise.

Specific Comments

Survey Report

Page 2, Study Participants and Coordination

During the Folly Beach study, the Corps of Engineers did not request FWS comments concerning problem identification and possible solutions. As discussed above, FWS had no involvement in this study until this draft survey report was submitted on June 1, 1979, for coordination review. The FWS maintains that this is a project review and should meet the requirements of the Fish and Wildlife Coordination Act.

We request that the U.S. [illegible] Fisheries and Wildlife [illegible] referred to as the U.S. Fish and Wildlife Service. It should be removed from the list of agencies from whom the Charleston District requested and received comments concerning problem identification and possible solutions

Page 11, Land Use Analysis

The undeveloped southwest end of Folly Island is erroneously referred to as a 55-acre parcel. This should be a 190-acre parcel.

Page 34, Division of Plan Responsibility

Day visitor access, a problem along the entire South Carolina coast, is particularly critical in the Charleston area. Parking is perhaps the most critical factor affecting the use of Charleston's beaches, especially Folly Beach. A conservative capacity [illegible] identified a need for [illegible] as many legal parking spaces as are currently available at Folly Island to merely accommodate the 1977 level of demand (Hartzog, Lader and Richards, Inc., "Public Beach Access and Recreation in South Carolina", 1975). This finding appears incompatible with the [illegible] finding that only [illegible] additional spaces are needed to satisfy parking [illegible] associated with the [illegible] public beach development project. Additional discussion of this situation should be included.

The Hartzog, Lader and Richards report calculated recreational carrying capacity based on an optimum recreational density of 200 square feet per person. In calculating Folly Beach project benefits, the beach carrying capacity was determined by dividing the dry beach area by 100 square feet per person and multiplying by 2 (turnover rate). The final statement should discuss the various formulas for determining beach carrying capacity and why the selected formula was chosen.

Appendix 2

Pages 23-31, Probable Impact of the Proposed Action on the En[illegible]

This section does not assess the indirect, long-term project i[illegible] of the recommended plan, i.e., future development spurred by renourish[illegible] and stabilization of the beach. Approximately 300 acres of high land within the corporate limits of the city of Folly Beach are now undevelop[illegible] and provide habitat for the island's wildlife. The approximately 190 undeveloped acres on the southwest end of the island consist principally of [illegible] dunes and salt marsh and provide habitat for a large variety of shorebirds, finfish, shellfish, waterfowl, and other wildlife. Development of this area subsequent to project implementation would result in degradation, if not loss, of much of the existing habitats. These secondary project impacts should be addressed in this section.

Page 29, paragraph 4.17

The shortnose sturgeon, in addition to the brown pelican and peregrine falcon, is known to occur in the project area.

The statement should include a discussion of why project construction and maintenance would result in no adverse impact on endangered species in the project area.

Page 33, paragraph 6.6

Creation of artificial dunes would provide additional dune habitat, but this habitat type is utilized by few wildlife species. Artificial dune maintenance with its subsequent reduction of oceanic overwash decreases bird nesting habitat on barrier islands, and artificial planting of dune grasses results in dense vegetative cover which is not tolerated by most ground nesting bird species. The false impression of safety and stability created by an artificial dune system encourages further development which results in loss of wildlife habitat and degradation and/or loss of marsh and adjacent aquatic habitats. The FWS recommends that dune creation be considered very carefully as a viable part of the project plan.

Page 37, paragraph 6.11

Loss of the 190-acre southwest end of the island to development would result in loss of a unique natural area. Fragile dunes, productive salt marsh areas, and shellfish beds would likely be degraded if not destroyed. If this occurs, it would be a significant adverse project impact on fish and wildlife resources of the project area. The statement should include a discussion of why project construction and maintenance would result in no adverse impact on endangered species in the project area.

Page 37, paragraphs 6.13 and 6.14

We concur in the Corps finding that development of a beach access/biological observation park on the undeveloped southwest end of Folly Island would contribute greatly to the environmental quality enhancement of the recommended plan which currently has no environmental quality or fish and wildlife enhancement features. Such a park would also help alleviate congestion in Folly Beach and would provide much-needed beach access and public use facilities. We recommend that this feature be incorporated into the selected plan in order to assure the continued existence of this natural area and its associated fish and wildlife resources as well as to provide the public access and public use facilities necessary to meeting the projected public use upon which the benefits of the project are based.

Summary

Full consultation was not used regarding problem identification on Folly Beach or possible solutions to identified problems. Due to the lack of consultation in the Folly Beach study, wildlife conservation did not receive equal consideration, and no features with a view to the conservation of wildlife resources were incorporated into the recommended plan. The secondary impacts of development generated by the project were not evaluated. We maintain that development subsequent to project implementation would produce adverse impacts on the area's fish and wildlife resources. In order to lessen these adverse impacts and to provide environmental quality enhancement, we recommend that a plan to preserve the biological integrity of the southwest end of the island be incorporated into the Folly Beach project.

We appreciate the opportunity to review and comment on this draft environmental impact statement and preliminary survey report.

Sincerely yours,

James H. Lee

James H. Lee
Regional Environmental Officer

1103 E. Atlantic Avenue
Folly Beach, South Carolina

July 26, 1979

William W. Brown, Colonel
Corps of Engineers
Department of the Army
Charleston District Corps of Engineers
P.O. Box 919
Charleston, South Carolina 29402

Dear Colonel Brown:

In accordance with your letter dated June 8, 1979 the following comments are made about the preliminary draft of the survey report on beach erosion control and hurricane protection dated May, 1979.

Inadequate parking is noted on pages 8,11,16, and 34 with a final conclusion that 92 additional parking spaces must be provided if federal funds are going to be utilized. It is submitted that it is doubtful if another beach community on the east coast could be found with more FREE parking per mile of beach. Certainly not within twenty-five miles of the city of Charleston, Considering the energy problems and the government dictate to shrink the size of automobiles probably the existing parking facilaties will be able to accomodate an additional 92 automobiles by the time the project would be completed.

It is even more doubtful if the Corps of Engineers could find another beach community with better public access to the beach. There is public right-of-way to the beach every 350 feet. The <u>most distant</u> parking space is less than one quater of a mile from the public beach. In most instances the distance is less than five hundred feet. Certainly in the Charleston area there is no other beach with free parking and access that can match Folly Beach.

It should be noted that the eight acres of property in the center of Folly Beach mentioned on page 11 are in financial trouble and disputed ownership.

The Corps of Engineers has taken the position that the jetties and harbor improvement (Charleston) has not contributed to the erosion problem. It is a known fact that sand travels from the North to the South along the East Coast. The fact that the islands immediately North of the harbor have built-up, accreted, enlarged can not be disputed. The Corps of Engineers points out (pg. 16) that the "dynamite hole" was designed to allow sand to pass to the South and works with an efficientry in the area of ninety percent. Even with 99% efficientry the harbor improvements would have deprived Folly Beach and Morris Island of the sand they need (1%) to remain stable. Is the 684,000 cubic yards of sand needed to rebuild the beach greater or less than the sand accreted to the islands north of the harbor?

The Corps of Engineers while defending their man made structures have indited the other man made structures (pgs. 14 and 15) as being harmful. As proof of their statement they site figure 10. Figure 10 is the equivalent of a picture of a burning house caused by the fire department. The chronologic order is that the harbor jetties were built, Morris Island and Folly Beach suffered from erosion and then the "harmful man made structures" were erected. All of the "harmful man made structures" were made because erosion had occurred. Their effect- tiveness of the "dynamite hole". In either case the conclusion is based on postulations, speculations and other gusses indirectly related to facts.

As a front beach owner I disagree with the general descrip- tions given on pages 15&16 of the preliminary draft. All of the residents of Folly Beach share common feelings. They feel they are the whipping boy for the low country area. The public news media only publicizes negative events. The newspaper considers Folly Beach as a lost cause. The visitors expect Folly Beach to provide better parking, life gaurds, beach improvements and sanitary facilaties but contribute no money for those pur- poses. In general they purchase food such as McDonalds' ham burgers on the mainland and leave the wrappers on the beach. The Corps of Engineers has been studying the beach erosion pro- blem for seven years and estimates another three (minimum time pgs. 37&38) years before anything could be done. In the past seven years, while the Corps of Engineers has been studying the problem, considerable erosion has taken place and in desperation a majority of the "harmful man made structures" have been erected. After the residents of Folly Beach have spent their personal money protecting their property while the problem was being studied they have little or no interest in providing a public beach for visitors.

It would seem that further exploration of constructing a barrier reef or break water should have been made. A one time expenditure of thirteen million dollars might be better than three million now and two million over and over and over. While it seems impractical to provide hurricane protection as such; a barrier reef might surrendipitously also provide some hurricane protection.

No mention was made of the fact that particle size plays an important role in erosion. Rock revetment (figure 8) is fairly resistant to erosion and may have a slope of one vertical foot for two horizontal feet. The sand at Folly Beach can not be placed at a greater slope than one vertical foot for thirty horizontal feet. Many atlantic coast beaches with a gravel type sand are fairly stable with a slope of one foot vertical per six to eight horizontal feet. Has the possibility of using "river rocks", gravel and coarse sand to rebuild the beach instead of the vulnerable sand proposed in the study? Currently sand in trucks cost $3.30 per cubic yard vs the $2.40 per cubic yard for dredged sand. If the coarse sand increased the renourishment time only a little it would be more economical than the current proposal; especially if the sand source was only from the Lighthouse Inlet.

It can not be denied that "Charlestons'" economic success and the Naval defense of this country is dependent upon the harbor improvements. How much sand would one tenth of one percent of the harbors' profits over the past 128 years place on Folly Beach?

Table eleven summarizes the non-federal cost to be $1,796, 900.00 which does not include the stipulated requirements of 92 additional parking spaces and sanitary facilaties every half mile. When these are included the figure approches two million dollars. There is no way that 1,500 residents (pg. 10) can raise that amount of money. Based on past performance there is no way immaginable that the county, state or surrounding communities are going to provide the matching funds stipulated.

Therefore in recognition of the above statements the Corps of Engineers should immediately cease and decease all further action on the erosion control study.

Sincerely yours,

Stephen C. Bartlett, D.D.S.

South Carolina Coastal Council

James M. Waddell, Jr.
Chairman

H. Wayne Beam, Ph.D
Executive Director

August 14, 1979

Colonel William W. Brown
District Engineer, Charleston District
U. S. Army, Corps of Engineers
P. O. Box 919
Charleston, S. C. 29402

Dear Colonel Brown:

Enclosed are the comments of the South Carolina Coastal Council on the Draft Environmental Impact Statement for Folly Beach Renourishment. Thank you for the opportunity to review the draft and for the extension of the comment period through August 15.

Sincerely,

H. Wayne Beam
Executive Director

HWB:jl
Enclosure
cc: Sen. James M. Waddell, Jr., Chairman
Mr. Elmer Whitten

Comments on Draft E.I.S.
Folly Beach Renourishment Project

General Comments

The South Carolina Coastal Council has officially [illegible] support of beach renourishment on Folly Beach, S. C. [illegible] came in two forms:

- Permit approval (P/N 79-2H-059) to the City of [illegible] renourishment of 22,000 linear feet of Atlantic Ocean [illegible] (700,000 cubic yards of sand), with conditions that ensure [illegible] public beach areas and minimize impacts on the adjacent [illegible], as [illegible]

1) Provided that the applicant acquire all [illegible] rights [illegible] to the commencement of work as authorized by issuance [illegible] permit.

2) Provided that any work done in the vicinity [illegible] Key be restricted to September through March to [illegible] nesting seabirds.

(Approved May 18, 1979, issued [illegible])

- Approval of up to $440,000 of State funds [illegible] control, provided the specific project plans [illegible] (June 29, 1979).

Spec[illegible] Comments

1. The estimated schedule for completion of the [illegible] does not seem to appear in either the EIS, The Survey [illegible] Some type of "time-line" which estimates the length [illegible] approval, Congressional funding authorization and [illegible] tion should be included. This is particularly important [illegible] in assessing the impacts of temporary dredging-related [illegible] during actual fill activity. Also, such a time-line [illegible] recognition of the possible inflationary costs associated with [illegible] delays.

2. Paragraph 4.25, Maintenance Dredging

The projected life of the proposed source [illegible] should be identified. Environmentally acceptable dr[illegible] appropriate quality sand are vital to the feasibility [illegible] maintenance at five-year intervals. Although one may [illegible] area of the two inlets, approximate locations of [illegible] not been indicated in the DEIS. This appears to be [illegible]

3. Paragraph 6, Alternatives

Review of the more detailed discussion of [illegible] provided in the Survey Report indicates that the [illegible] calculated for the relocation of structures included [illegible] continued provision of public beach areas. The only [illegible] was for reduced damage from property loss, while this [illegible] would clearly allow the natural beach to shift and [illegible] therefore the pub[illegible] recreational value would be maintained [illegible]

(Some limited additional costs would also result in relocating public facilities and roadways.)

The evaluations and cost-benefit calculations for combined beach/dune development alternatives (B-1 through B-3) were only examined for the longest stretch of beach (Sta 78+70S to 180+90N). No rationale was provided for this approach. The concern here is that the resulting cost-benefit ratios cannot be compared relative to others. The EIS indicates on page 35 that Alternative B-1 was designated as the EQ plan. The comment is added that larger projects - in terms of dune height - had lower proportional benefits. The question which is not addressed is whether project B-1 over shorter distances, similar to A-1, would have provided a higher cost-benefit ratio.

4. A discussion should be added to the DEIS indicating (1) the relationship of beach renourishment to the Folly River Navigation project (briefly mentioned on p.27 of the Survey Report), and (2) the relationship to the current proposal and permit application made by the City of Folly Beach (briefly mentioned on p.13 in the Survey Report.)

5. Appendix 1, Technical Report was not circulated with the DEIS. This material would have been very helpful to reviewers of the document.

6. It is not clear whether Paragraph 9.3, Government Agencies, and/or Appendix 3 would be more appropriate, but the EIS should contain in some section (1) a list of agencies and interest groups receiving copies of the DEIS, (2) other agency approvals or permits which will be required for implementation of the project and (3) such relevant information as that presented above under General Comments.

To: [illegible]

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Asheville Area Office
Room 279, Federal Building
Asheville, North Carolina 28802

September 12, 1979

Colonel William W. Brown
District Engineer
U.S. Army Corps of Engineers
P.O. Box 919
Charleston, S.C. 29402

Dear Colonel Brown:

Enclosed is the Service's Fish and Wildlife Coordination Act Report on the proposed Folly Beach Erosion Control and Hurricane Protection Project. The report was prepared in cooperation with the S.C. Wildlife and Marine Resources Department and the National Marine Fisheries Service; these agencies' comments are attached to the report.

As you are aware, coordination between the Corps and the FWS has been less than adequate on this project. Therefore, preparation of the FWCA report has lagged behind schedule. In the future, with better coordination between our offices, the Service hopes to provide a preliminary draft, a draft, and a final FWCA report to be coordinated throughout the planning process with the Corps and with other involved agencies. In addition to resulting in a more environmentally sound project, this would avoid last minute delays in schedule and/or late submission of the required FWCA report.

Very truly yours,

William C. Hickling

William C. Hickling
Area Manager

Fish and Wildlife Coordination Act Report
Beach Erosion Control and Hurricane Protection
Folly Beach, South Carolina

I. Introduction

The U.S. Senate Committee on Public Works adopted a resolution on June ?, 1972, requesting that the Secretary of the Army direct the Chief of Engineers to make a survey at and in the vicinity of Folly Beach, Charleston County, South Carolina, in the interests of beach erosion control, hurricane protection, and related purposes. This survey, which encompassed the 6 miles of coastline of Folly Island, was conducted by the Charleston District, U.S. Army Corps of Engineers (USACOE) in accordance with Section 10 of the River and Harbor Act of 1962. Investigations in this area were made to determine damages, either by erosion of the shoreline or by storm tides and waves; measures for protecting the area and preventing the damages; accompanying costs and benefits of such measures; the selection of the most feasible plan; and related matters. The resultant draft survey report, entitled Survey Report on Beach Erosion Control and Hurricane Protection, Folly Beach, South Carolina, was completed and submitted to the South Atlantic Division Office, COE, in July 1978. After receiving comments from SAD, the District revised this initial report; the revised draft, and accompanying EIS were completed in May 1979 and submitted for official coordination review in June 1979.

The U.S. Fish and Wildlife Service (FWS) has reviewed the Corps survey report and has prepared and is submitting the following report under authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.). This report was prepared in cooperation with the South Carolina Wildlife and Marine Resources Department (SCWMRD) and the National Marine Fisheries Service (NMFS) and has received their concurrence as indicated in the attached letters from Dr. James Timmerman, Executive Director, SCWMRD, dated August 22, 1979, and William H. Stevenson, Regional Director, NMFS, dated August 29, 1979. In accordance with section 662(b) of the Fish and Wildlife Coordination Act (FWCA), this report should be attached to and made an integral part of the Survey Report.

A brief review of the Corps' past project coordination with the FWS and with other agencies responsible for the fish and wildlife resources of the project area is appropriate and necessary. Section 662(a) of the FWCA requires the USACOE to consult with the FWS and with State fish and wildlife agencies regarding proposed or authorized water resources development projects. This required coordination, however, has been non-existent throughout the course of the Folly Beach study. Stages 1 and 2 of the Corps' planning process were accomplished and the draft survey report was submitted without any involvement of the FWS. Exemplary of this lack of coordination is the fact that the Service was loaned a copy of the July 1978 draft feasibility report, which contained the alternative solutions developed by the Corps, in February 1979.

II. Description of Project Area

A. Location. Folly Beach is located on Folly Island in Charleston County, South Carolina, about 10 miles south of the City of Charleston and about 6 miles south of the Charleston Harbor entrance channel. Folly Island, a typical barrier island that has a northeast-southwest alignment, is bounded on the northeast by Lighthouse Inlet, on the southwest by Stono River and Inlet, on the northwest by Folly River, and on the east by the Atlantic Ocean. The town of Folly Beach lies in the middle of the island, between the U.S. Coast Guard Loran Station to the northeast and 190 acres of undeveloped land to the southwest. Highway access to the island is limited to S.C. Highway 171.

B. General Features. Folly Island is approximately 6 miles long and 0.5 mile wide at its widest point. The island has a comparitively flat, gently-sloping ocean beach composed of fine sands. The mean tide range is 5.2 feet, with a spring tide range of 6.1 feet. Along the developed portion immediately shoreward of the beach, elevations range from 6 to 15 feet above mean sea level (msl). Total island acreage is approximately 1,400 acres; only 710 acres are classified as highland (i.e., acreage above the mean high waterline), while the remaining 690 acres are marsh (Warner 1976). Typical island vegetation consists of salt-tolerant perennial grasses such as sea oats (*Uniola paniculata*), bitter panic grass (*Panicum amarum*), and saltmeadow cordgrass (*Spartina patens*) on and immediately landward of the dunes; wax myrtle (*Myrica cerifera*), silverling (*Baccharis halimifolia*), live oak (*Quercus virginiana*), and palmetto (*Sabal* spp.) are typical behind the dunes; and saltmarsh cordgrass (*Spartina alterniflora*), black needlerush (*Juncus roemerianus*), sea-oxeye (*Borrichia frutescens*), glasswort (*Salicornia* spp.), and saltgrass (*Distichlis spicata*) are found in marsh areas.

C. Development Status. Resort development extends along 4.9 miles of the Island's 6-mile ocean shoreline. This development began around 1920 and is typical of seashore development, with mostly frame-structure buildings consisting of cottages, homes, concessions, and small shops. Of the approximately 700 acres of high ground within the corporate town limits, around 420 acres are developed. About half of the presently developed acreage is in residential usage; approximately 80 percent of the 1,329 housing units are single family cottages (USACOE 1978). The

1975 resident population of Folly B[illegible] 4,500 persons during the summer month[illegible] Folly Island may exceed 30,000 [illegible] Station covers 32 acres on the northe[illegible] southwest end, a narrow, 190-acre [illegible] long primary and secondary dune syst[illegible] salt marsh, and Folly River, [illegible]

D. Specific Features. The southe[illegible] valuable area in terms of natural [illegible] 190-acre parcel is the only remai[illegible] been developed and it contains [illegible] combination of various habitat [illegible] waters, beach, dunes, high and [illegible] and unvegetated sand and mudflats [illegible] could be considered developable [illegible] beaches, primary oceanfront sand [illegible] the S.C. Coastal Council's critic[illegible] 75 acres of regularly-flooded salt [illegible] Spartina alterniflora and [illegible] areas which are not regularly [illegible] productivity of such an area is [illegible] ecosystem is extremely important [illegible] marine finfish and shellfish [illegible] all commercial finfish and shellfish [illegible] estuarine areas during all or part [illegible] providing both inorganic nutrients [illegible] communities, tidal marshes act as [illegible] and also as a sediment trap, retardi[illegible] the inlet and subsequent loss [illegible] marsh and upland areas comprising [illegible] for a variety of waterfowl and othe[illegible]

During recent years several land [illegible] interest in this area. In 1974, [illegible] permit to dredge and fill this are[illegible] yacht club, and condominiums [illegible] 77.5 acres of highly productive salt [illegible] high water line and either destroyed [illegible] wetlands and a natural dune system [illegible] Currently, First Citizens Bank in [illegible] which, according to a bank official, [illegible] development. The official, however, [illegible] erosion problem on Folly Beach has [illegible] property.

Southwest of this undeveloped area, across a series of sand flats, lies Bird Key, a small sand island that serves as an important nesting area for several species of shorebirds and also as a mass roosting area for migrating blue-winged teal.

D. Beach Erosion. Since 1849 approximately 560 acres of beachfront have been lost from Folly Island. This is equivalent to an average annual erosion rate of 5.9 feet over the entire length of the ocean shoreline.

Prior corrective action against this erosion has been taken by the Coast Guard, the S.C. Highway Department, and some beachfront property owners. At the Loran Station on the northeast end of Folly Island, the U.S. Coast Guard has constructed a combination groin-retaining wall structure which apparently has significantly reduced erosion at that site. The stabilization structures consist of a timber seawall around the east end of the island, from which six groins spring oceanward, and a combination training-breakwater structure composed of segments of stone and fabric sand bags on the inlet side. The timber wall and much of the six timber and rock groins have been covered with sand, and vegetation is migrating oceanward beyond the wall along most of this reach. The S.C. Highway Department has constructed and is maintaining 41 timber and rock groins along the developed coastline of Folly Beach from the Loran Station to within approximately 4,000 feet of the southwest end of the island. A rock revetment approximately 1,200 feet long has also been constructed between Groins 16 and 18 where erosion narrowed the island to the point that a breakthrough might occur. Beachfront property owners are using many different type structures to protect their property. These include concrete sheet-pile, asbestos corrugated sheet-pile, timber seawalls, rock revetment, rubber tire walls, and sand-fencing; one property owner is experimenting with concrete block breakwaters constructed just oceanward of the mean high water line. Property owners have had varying degrees of success with their erosion control efforts, one problem stemming from the piecemeal way in which these structures were constructed. Some property owners are unable or unwilling to attempt to control the erosion of their property while others cannot agree with their neighbors on the best solution to the erosion problem.

III Description of Alternative Plans

Alternative plans that were selected by the Corps for Stage 3 consideration fall into four major categories: 1) no action; 2) relocation of structures; 3) beach development, and 4) beach and dune development (USACOE 1979).

A. No Action Alternative. This alternative proposes that no action be taken in the project area; i.e., a continuation of existing conditions. No monetary investment would be required and the environmental impacts associated with a structural plan would not occur.

B. Relocation of Structures. This alternative would consist of allowing the shoreline to continue to erode and relocating beachfront buildings. Based on the predicted shoreline, if erosion continues at the long-term (1849-1977) erosion rate, about 260 buildings would be destroyed within 50 years if they are not relocated. The present cost of relocating these structures and purchasing new lots is estimated at $3,502,000, while the value of the buildings that would be lost to erosion over the life of the project without relocation is estimated at $6,425,000. Comparing the annual cost of relocating, $73,000, with the resulting average annual losses of buildings without relocation, $79,000, the benefit to cost ratio for the relocation plan is 1.08; thus, this alternative is economically feasible.

C. Beach Development Alternative. The beach development alternative was evaluated through the analysis of six different options that differ only in scale. These optional plans are designated as plans A-0 through A-5. The Beach Development Plans would involve borrowing sand from offshore and restoring the beach to a fuller, wider section. Since natural erosion would continue, the beach would require periodic renourishment by pumping in more sand. A minimal beach berm elevation of 4 feet above msl and a minimal dry-beach width which would average 38 feet between periodic nourishment operations was determined through stage frequency and design analysis as that necessary to effectively resist attack by normal wave action and the effects of frequent storms. The usable dry-beach was considered to be the expanse between the hold line and mean high water. Where a dune is incorporated in the protective scheme, the usable dry-beach would be the expanse between the oceanward toe of the dune and the beach face at mean high water.

D. Beach and Dune Development Alternatives. Three beach and dune development plans, designated as B-1 through B-3, were analyzed in Stage 3. The three plans encompass the same reach of beach, Station 78+70S to 180+90N (as shown on Figure 11 in USACOE 1979). The major difference in these plans is in the degree of protection provided by the three different dune heights.

The main difference between the beach and dune development plans and the beach development plans is the provision of an artificial dune system. Derivation of the minimal widths of dune and beach berms necessary for storm protection was based on an analysis of design storm parameters and estimated corresponding erosion rates. Dune shore and seaward slopes of 1-vertical and 5-horizontal and shore berm and beach nourishment fill slopes of 1-vertical to 30-horizontal were selected for stability.

After establishing horizontal dimensions on the basis of design analysis, vertical requirements were evaluated. Determination of the optimum dune elevation required a comparison of estimated costs for varying storm protection levels with benefits for each level of improvement. Dune heights of 12 feet msl, 15 feet msl, and 18 feet msl were analyzed. These would provide wave damage protection from storms with frequencies of occurrences of 25, 50, and 100 years, respectively.

E. The Selected Plan. The selected plan, which falls within the Beach Development Alternative, provides for beach restoration and periodic renourishment for that 16,860-foot developed reach of Folly Beach in which manmade improvements are in greatest jeopardy. This reach would have a berm width of 25 feet. The berm would be constructed to an elevation of 4 feet above msl and would be fronted by a beach having its face slope at about 30-horizontal to 1-vertical. The beach fill section would provide an average usable width above the mean high water line of 50 feet. The slope of the beach face would be formed by natural forces during and subsequent to material placement. Machines might be necessary to slope the berm depending upon the skill of the contractor in placing material.

Initial construction would consist of dredging approximately 685,000 cubic yards of material to place 536,000 cubic yards on the beach. The amount of beach fill required for initial construction is based on profiles surveyed in April 1977. Material placed would satisfy three purposes: beach restoration, private fill, and sacrificial nourishment. Approximately one-half of the material would come from the southwestern direction using Stono Inlet ocean bars as the source; the other half would come from Lighthouse Inlet ocean bars, northeast of Folly Island. Laboratory tests of this borrow material indicate that 1.4 times that quantity needed on the beach would have to be taken from these borrow areas.

Periodic renourishment would be required at approximately 5-year intervals. Each of these efforts would require the borrowing of approximately 354,000 cubic yards from the same self-restoring sources. Materials dredged from Folly River shoals in conjunction with the Folly River small navigation project would be utilized when practical for initial construction and renourishment efforts.

B. Fishery Resources. Open marine and estuarine waters within the project area support a wide variety of commercially and recreationally valuable finfish and shellfish. Commercial species in the project area include white and brown shrimp (Penaeus setiferus and P. aztecus), blue crab (Callinectes sapidus), mullet (Mugil cephalus), spot (Leiostomus xanthurus), croaker (Micropogon undulatus), flounder (Paralicthys dentatus), red snapper (Lutjanus campechanus), and vermilion snapper (Rhomoboplites aurorubens). Species constituting the major portion of the sport fishery are flounder, spot, croaker, kingfish (Menticirrhus americanus), black sea bass (Centropristis striata), weakfish (Cynoscion regalis), black drum (Pogonias cromis), red drum (Sciaenops ocellata), sheepshead (Archosargus probatocephalus), and sharks (Theiling 1978). Anadromous species that utilize project areas waters are the American shad (Alosa sapidissima), alewife (A. pseudoharengus), and striped bass (Morone saxatilis). The catadromous American eel (Anguilla rostrata) also uses project area waters. Intertidal and shallow water areas within the Folly Island estuarine system contain commercial leased and public oyster grounds -- virtually all shoreline areas of Folly River and

Lighthouse and Stono Inlets are under lease to private companies (personal communication, S.C. Wildlife and Marine Resources Department, April 3, 1979).

C. Wildlife Resources. Wildlife resources of the project area consist primarily of shorebirds, furbearers, and migratory birds.

1. Birds. Birds in the project area include shorebirds such as gulls, terns, and sandpipers which rest and feed at the water's edge; wading birds such as the great blue heron (Arden herodias), green heron (Rutorides virescens), and snowy egret (Egretta thula) which forage in the shallow waters of the tidal marshes; and waterfowl such as loons, grebes, ducks, and geese which use the open waters within the marsh community for resting and feeding. Bird Key, an island in Stono Inlet, is an important nesting area for least terns (Sterna albifrons), common terns (S. hirundo), gull-billed terns (Gelochelidon nilotica), black skimmers (Rynchops nigra), Wilson's plovers (Charadrius wilsonia), American oystercatchers (Haematopus palliatus), and willets (Catoptrophorus simipalmatus). This island is also a mass roosting area for migrating blue-winged teal (Anas discors).

Upland habitat in the project area is utilized by such species as the meadowlark (Sturnella magna), mourning dove (Zenaida macroura), red-winged blackbird (Agelaius phoeniceus), mockingbird (Mimus polyglottos), boat-tailed grackle (Cassidix mexicanus), common grackle (Quiscalus quiscula), red-shouldered hawk (Buteo jamaicensis), and various sparrows and warblers. Birds such as the clapper rail (Rallus longirostris), long-billed marsh wren (Telmatodytes palustris), and marsh hawk (Circus cyaneus) are typical inhabitants of the marsh community. Ospreys (Pandion haliaetus) may be seen feeding in the area

2. Reptiles and amphibians: Characteristic herptofauna of the project area includes the black racer (Coluber constrictor), six-lined racerunner (Cnemidophorus sexlineatus), southeastern five-lined skink (Eumeces inexpectatus), eastern hognose snake (Heterodon platyrhinos), and banded water snake (Natrix fasciata). The Atlantic green turtle (Chelonia mydas), loggerhead (Caretta caretta) and other pelagic turtles occasionally are seen within the project area. Other amphibians that likely utilize habitat within the project area include the diamondback terrapin (Malaclemys terrapin) and Fowler's toad (Bufo woodhousei fowleri).

3. Mammals: Mammals occurring in the vicinity of the project area include the gray squirrel (Sciurus carolinensis), marsh rice rat (Oryzomys palustris), marsh rabbit (Sylvilagus palustris), opossum (Didelphis marsupialis), and raccoon (Procyon lotor).

C. Endangered and Threatened Species. Several species listed as endangered by the U.S. Fish and Wildlife Service are known to occur in or adjacent to the proposed project area; other endangered or threatened species may occur. To comply with Section 7(c) of the Endangered Species Act Amendments of 1978 (P.L. 95-632), the Corps must request from the Secretary of the Department of the Interior whether any species which is listed or proposed to be listed may be present in the project area.

V. Fish and Wildlife impacts of Each Alternative

A. No Action Alternative. Without any erosion control plan, future conditions on Folly Beach would be essentially the same as past conditions; i.e., erosion would likely continue, perhaps at an accelerated rate due to the reflective nature of existing erosion control structures and oceanfront buildings. With the passage of time, many existing structures would fail and, as these structures failed, Folly Island would return to the natural dynamic state of undeveloped barrier islands in which the natural dune systems present low resistance to storm surges. Therefore, although the no action alternative would likely result in the continued and periodic loss of beach and dune habitat, the long-term environmental impacts would be beneficial as reestablishment of the dynamic stability which characterizes unaltered barrier islands occurs. Natural vegetative communities would reestablish and habitat for fish and wildlife would increase. Under the no action alternative, the southwest end of the island would be expected to remain in its natural state since its future development appears to depend upon a solution to Folly Beach's erosion problem. The area would continue to provide valuable habitat to fish and wildlife species.

B. Relocation of Structures. This non-structural alternative would allow continued erosion of the beach and dunes, but would not result in any structural loss. During the 50-year project life, 260 buildings would require relocation (USACOE 1979). This relocation would result in the loss of wildlife habitat as structures were moved to new lots on the island. Thus, some of the adverse impacts associated with the two structural alternatives would occur. New development, however, would not likely be stimulated, and pressure to develop the southwest end of the island would not be expected. The southwest end would retain its natural dynamic stability with natural communities fluctuating according to the ongoing erosion/accretion/overwash processes. Fish and wildlife resources of this 190 acre parcel would be expected to remain essentially the same as they are today.

C. Beach Development Alternative (Recommended Plan)

1. Short-term impacts.

a. Beneficial impacts: Dredging and disposal activities associated with this alternative may provide temporary benefits to fishes that feed on benthic invertebrates. Dislodged benthos would provide temporarily increased food availability to these fishes and may result in greater fish concentrations in the project area during constructi and maintenance operations. Greater fish concentrations may also occur as a result of the creation of borrow holes -- this increase would last only as long as those borrow holes are not eliminated by alternate scour and sand deposition. Shorebirds in the area would benefit from a temporary increased food supply as material containing benthic invertebrates is pumped onto the beach.

b. Adverse impacts: The dredging and filling operations associated with this alternative would result in the immediate and significant loss of benthic invertebrates in both borrow and disposal areas. The impact, although significant in the immediate project area, would be short-term, as similar organisms from nearby undisturbed bottoms would recolonize the disturbed areas. The time required for recolonization would depend upon several factors, including bottom topography, substrate composition, water velocity, and current patterns, but would most likely be within 18 months.

Fish within the project area may be adversely affected by water quality degradation as well as by the mechanical action of the dredge cutterhead. Water quality degradation would occur within the immediate vicinity of the dredge cutterhead. Due to the typically short-term nature of water quality changes that would result from this project and to most fishes' ability to avoid such areas, fishery resources in the area would not be expected to experience any significant, long-term adverse impacts from water quality degradation associated with this alternative. Fish losses would occur as a result of the mechanical action of the dredge cutterhead. Loss of juveniles and adults would be minor, as most of these fishes would be able to avoid the cutterhead. Less mobile embryonic or larval stages in the vicinity of the cutterhead, however, would be destroyed.

The only reptiles likely to be directly affected by this alternative are the pelagic sea turtles that nest on beaches. Although Folly Beach is not a major turtle nesting area, sea turtles do occasionally nest on the beach and filling operations during the nesting season could disrupt or result in failure of these nesting activities.

Mammal populations in the project area would be adversely affected only by loss of habitat resulting from increased development of Folly Island spurred by completion of the project. Construction and maintenance operations should not have any significant adverse impacts on extant mammalian populations.

2. Long-term impacts. The long term impacts of this alternative would stem not from actual project construction and maintenance but from increased development on the island subsequent to completion of the project. Typically, as residential development increases on a barrier island, available wildlife habitat decreases, natural barrier island functions are lost, and adjoining marsh-estuarine areas deteriorate or

are destroyed. This alternative would likely result in the development of approximately 300 acres of currently undeveloped high land on Folly Island. The island's southwest end, which presently provides valuable habitat for many species of fish and wildlife as well as much-needed public access to the beach, would likely be converted, at least in part, to private residential usage.

D. Beach and Dune Development Alternative

1. Beneficial impacts: Beneficial environmental impacts likely to result from this alternative are basically the same as those expected for the beach development alternative (page 15). In addition, this alternative would provide greater protection to existing dunes and to the more inland vegetative communities now existing behind the dunes.

2. Adverse impacts: All adverse impacts identified in section V.C. would occur with this alternative as well. These identified impacts would occur for a longer period of time, as initial construction would require over 2,000,000 cubic yards of sand compared to approximately 684,000 cubic yards for the recommended plan within the beach development alternative.

Continuous man-made or stabilized dunes act as an impenetrable obstruction to storm surge and therefore appear to provide excellent storm damage protection on barrier islands. Dune stabilization along the Outer Banks of North Carolina, however, has resulted in increased erosion and narrowing of the beach, which in turn has resulted in a gradual undercutting of the dune front, with eventual inevitable destruction of the dune system (Dolan 1973). Also, the stabilized dune system on North Carolina's Outer Banks has allowed the seaward migration of plant species incapable of surviving saltwater overwash and flooding. Should a break occur in these dunes, a major ecological perturbation would result (Godfrey and Godfrey 1973).

Implementation of a beach and dune development alternative on Folly Island would actually increase available dune habitat; but this would not represent a significant benefit to the island's wildlife. In fact, artificial dune maintenance with its subsequent reduction of wave overwash is one factor in the decrease of natural bird nesting habitat on barrier islands. The few seabirds and shorebirds which nest on barrier islands of North Carolina preferentially select overwash sites; artificial planting of dune grasses results in dense vegetative cover which is not tolerated by most of the ground nesting species (Soots and Parnell 1975).

Finally, the false impression of safety and stability created by an artificial dune system encourages development of barrier islands which are inherently unstable systems that are unsuitable for structural development.

Development subsequent to dune "stabilization" results in loss of upland vegetative communities that support an island's wildlife. In addition to this loss of upland habitat behind the dunes, creation of an artificial dune system also often results in encroachment of residential and/or commercial development onto the old dune system now protected by the artificial dunes. As discussed in section V.C.2, the anticipated increased development that would result from beach stabilization on Folly Island would result in the deterioration and loss of fish and wildlife habitat.

VI. Discussion

The long-term effects of the no action alternative (without project conditions) would essentially be the continuation of present conditions. Continued erosion would destroy some existing development and would likely discourage further development, thereby facilitating the partial return of Folly Island to natural barrier island conditions. Natural vegetative patterns would eventually be reestablished, thus providing a benefit to fish and wildlife species that depend upon such systems. Implementation of the recommended plan or any one of the other structural plans discussed would stabilize the frontal dune system at its current location and would provide a wider beach along the developed portion of Folly Island. The impact of this wider beach and stabilized dune system on existing fish and wildlife resources would be negligible and future populations would be expected to be essentially the same as current populations. Historically, however, once a beach is "stabilized," development increases; and, as more areas are developed, fish and wildlife habitat is lost. Since approximately 300 acres of high land on the island are currently undeveloped, it is certain that wildlife habitat would be lost if the recommended project is implemented. The productive salt marshes and shellfish beds adjoining the island would likely be degraded as pollution of estuarine areas from point and non-point sources increased. Also, as development on the island increased, the resk of loss from beach erosion would increase and beach erosion control would become even more essential--this cycle ultimately would result in the severe alternation or destruction of the function and structure of the barrier island as well as in tremendous costs for erosion control and hurricane protection programs.

The southernmost 190 acres on Folly Island consist primarily of fragile oceanfront dunes and highly productive salt marshes. Due, at least in part, to the severe erosion that has occurred on Folly Island since 1955, the extreme southern end of the island has escaped human development and exists in an essentially unaltered, natural state. Within this limited geographic area occur six habitat types ranging from open marine waters to salt marshes contiguous with Folly River. These habitats are utilized by finfish, shellfish, shorebirds, waterfowl, and other wildlife. In addition to its unique character and high biological productivity, this area offers an excellent setting for nature study and interpretation. Not least of all, the southern end of the island currently provides a much-needed public access to the beach.

The FWS has on several occasions expressed concerns over the fate of the southwest end of Folly Island, both in comments on a permit request to develop this area (letter of Colonel Robert C. Nelson, District Engineer, USACOE, Charleston, S.C., November 5, 1973) and in regard to the proposed Folly River Navigation Project (letters to District Engineer, USACOE, Charleston, S.C., December 1, 1976, and February 8, 1977, Folly Beach, S.C.). The FWS also voiced support for a proposal by the Charleston County Parks, Recreation, and Tourism Department to develop this area as a public recreation facility, thus providing much-needed beach access to the public and protection of the delicate dune and salt marsh ecosystems.

In his May 23, 1977, Environmental Message, the President expressed specific concerns about development of barrier islands. These Presidential concerns, combined with the intrinsic natural values of the essentially unaltered communities found on the southwest end of Folly Island and with the likely loss of approximately 300 acres of available wildlife habitat subsequent to project implementation, would appear to mandate that specific features designed to preserve the integrity of the island' southwestern end be incorporated into the recommended project.

Finally, the Service has determined that several endangered or threatened species may occur in or adjacent to the Folly Beach project areas. The Endangered Species Act of 1973, as amended, requires in part, that:

"...Each Federal agency shall, in consultation with and with the assistance of the Secretary, insure that any action authorized, funded, or carried out by such agency...does not jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species which is determined by the Secretary, after consultation as appropriate with the affected States, to be critical..." (Section 7(a)).

"To facilitate compliance with the requirements of subsection (a), each Federal agency shall, with respect to any agency action of such agency for which no contract for construction has been entered into and for which construction has begun on the date of enactment of the Endangered Species Act Amendments of 1978, request of the Secretary information whether any species which is listed or proposed to be listed may be present in the area of such proposed action..." (Section 7(c)).

VII. <u>Recommendations</u>

The Service's recommendations regarding the Folly Beach erosion control project are listed below. These recommendations are derived from our evaluation of the project's impacts on fish and wildlife resources of the project area.

1. Authorization for Phase I only be requested at this time.

2. During Phase I studies the Corps fully evaluate incorporation into the selected plan a natural area/recreation area feature which would preserve the southwest end of Folly Island for fish and wildlife purposes and for public use.

3. The Corps should request from the Secretary of the Interior information regarding the presence of any species which is listed or is proposed to be listed as endangered or threatened. All other requirements of the Endangered Species Act should be complied with.

VIII. Conclusions

The direct short- and long-term impacts of the recommended project on fish and wildlife resources of the project area would be minor--dredging and filling operations would result in significant, immediate loss of benthos; increased turbidity, and decreased food availability for birds and fish that feed on benthic organisms. With the possible exception of endangered species, the construction and maintenance operations associated with the project are not expected to result in significant beneficial or adverse impacts on the area's fish and wildlife resources.

Indirect adverse impacts of project construction would result from future development encouraged by the restoration and stabilization of the beach. Approximately 300 acres of high land within the corporate limits of Folly Beach are currently undeveloped (USACOE 1979)--development of these areas would result in loss of remaining available wildlife habitat and potential deterioration and/or loss of valuable wetland/estuarine areas and associated finfish and shellfish resources. Of particular concern is the potential degradation or destruction of the communities comprising the 190-acre southwest end. Residential or commercial development of this area would result in the loss or degradation of a unique, highly productive natural area and would exacerbate public access problems.

The Service, therefore, recommends that at this time the Corps seek only Phase I authorization for this project and that during Phase I study the Corps evaluate incorporation of the natural area/recreation area feature into the selected plan. The Corps should closely consult with the FWS, NMFS, and SCWMRD in this effort to ensure that fish and wildlife receive equal consideration in project planning, and that all other provisions of the FWCA are fulfilled.

Finally, review of our records indicates that several endangered or threatened species may occur in or adjacent to the proposed Folly Beach project area. According to Section 7(c) of the Endangered Species Act Amendments of 1978 (P.L. 95-632), the Corps must request a list of endangered and threatened species which may occur within or adjacent to the project area. Your written request for this list of species should

SADPD-P 19 NOV 1979

Honorable Richard W. Riley
Governor of South Carolina
Columbia, South Carolina 29201

Dear Governor Riley:

In a short time I expect to be transmitting to the Board of Engineers for Rivers and Harbors and the Chief of Engineers the report recommending shore protection improvements for Folly Beach, South Carolina. The accompanying recommendations will incorporate the President's proposed new water policy.

The President, in his June 1978 water policy message to Congress, proposed several changes in cost sharing for water resource projects to allow states to participate more actively in project implementation decisions. These changes include a cash contribution from benefiting states of 5 percent of construction (first) costs associated with non-vendible outputs and 10 percent of costs associated with vendible outputs.

Application of this policy to the Folly Beach project requires a cash contribution from the State of South Carolina of an estimated $128,000 (5 percent of $2,554,000 total estimated first costs of construction assigned to nonvendible project purposes, based on April 1979 price levels). This contribution is in addition to other items of local cooperation usually required for shore projects including cost participation based on shore ownership and use. The total non-Federal cost would be $1,782,800. I am recommending construction authorization for the Folly Beach project in accordance with the President's proposed cost sharing policy.

I would like to solicit the views of the State of South Carolina on the financial contribution required under the President's proposed cost sharing policy. Such views should indidate the State's understanding that a firm, binding commitment on the estimated contribution toward the first cost of construction will be required subsequent to Congressional authorization as a basis for the Corps to initiate construction. The views expressed at this time are not binding and do not in any way obligate future state legislatures.

be directed to the Regional Director, Fish and Wildlife Service, Richard B. Russell Federal building, 75 Spring St. S.W., Atlanta, GA 30303. After receipt of the list of species which may be present, the Corps is required by the Act to "conduct a biological assessment for the purpose of identifying any endangered or threatened species which is likely to be affected by such action. Such assessment shall be completed within 180 days after the date on which initiated (or within such other period as is mutually agreed to by the Secretary and such agency) and, before any contract for construction is entered into and before construction is begun with respect to such action. Such assessment may be undertaken as part of a Federal agency's compliance with the requirements of section 102 of the National Environmental Policy Act of 1969 (42 U.S.C. 4332)" (Section 7(c)). Section (d) of the Act underscores the requirement that the Federal agency and the permit or license applicant shall not make any irreversible or irretrievable commitment of resources during the consultation period which in effect would deny the formulation or implementation of reasonable alternatives regarding their actions on any endangered or threatened species.

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SADPD-P
Governor Richard W. Riley

19 NOV 1979

If further information or assistance on this matter is desired, my staff and I will be pleased to respond. Your continuing interest is appreciated.

Sincerely,

J. K. BRATTON
Major General, USA
Division Engineer

CF:
DE, Charleston

State of South Carolina

Office of the Governor

RICHARD W. RILEY
GOVERNOR

POST OFFICE BOX [illegible]
COLUMBIA 29[illegible]

December 19, 1979

Major General J. K. Bratton
Division Engineer, South Atlantic Division
Corps of Engineers
510 Title Building
30 Pryor Street, NW
Atlanta, Georgia 30303

Dear General Bratton:

Thank you for your recent letter concerning the Folly Beach project.

I realize that a firm financial commitment by the state will be required prior to Congressional authorization if President Carter's cost-sharing proposal is passed by Congress. As you know, the Presidents' proposal is one of several being considered by Congress. Until Congress settles on a final bill, I feel it would be premature for the state to formulate a position on President Carter's proposal.

Please let me know when I can be of assistance.

Yours very truly,

Dick Riley

Richard W. Riley

RWR/tcb

FOLLY BEACH
SOUTH CAROLINA

SECTION 404(b) EVALUATION

APPENDIX 4

PREPARED BY THE
CHARLESTON DISTRICT, CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY

404(b) EVALUATION FOR THE RESTORATION AND NOURISHMENT OF FOLLY BEACH, SOUTH CAROLINA

1. Project Description.

a. Description of the proposed discharge of dredged or fill materials.

(1) General characteristics of material: Clean sand from nearby shoals.

(2) Quantity of material proposed for discharge: Initial beach fill operations would require 684,000 cubic yards. Renourishment would require replacement of 354,000 cubic yards of fill at 5-year intervals.

(3) Source of material: Sandy shoals in the mouths of Stono or Lighthouse Inlets (see Figure 1).

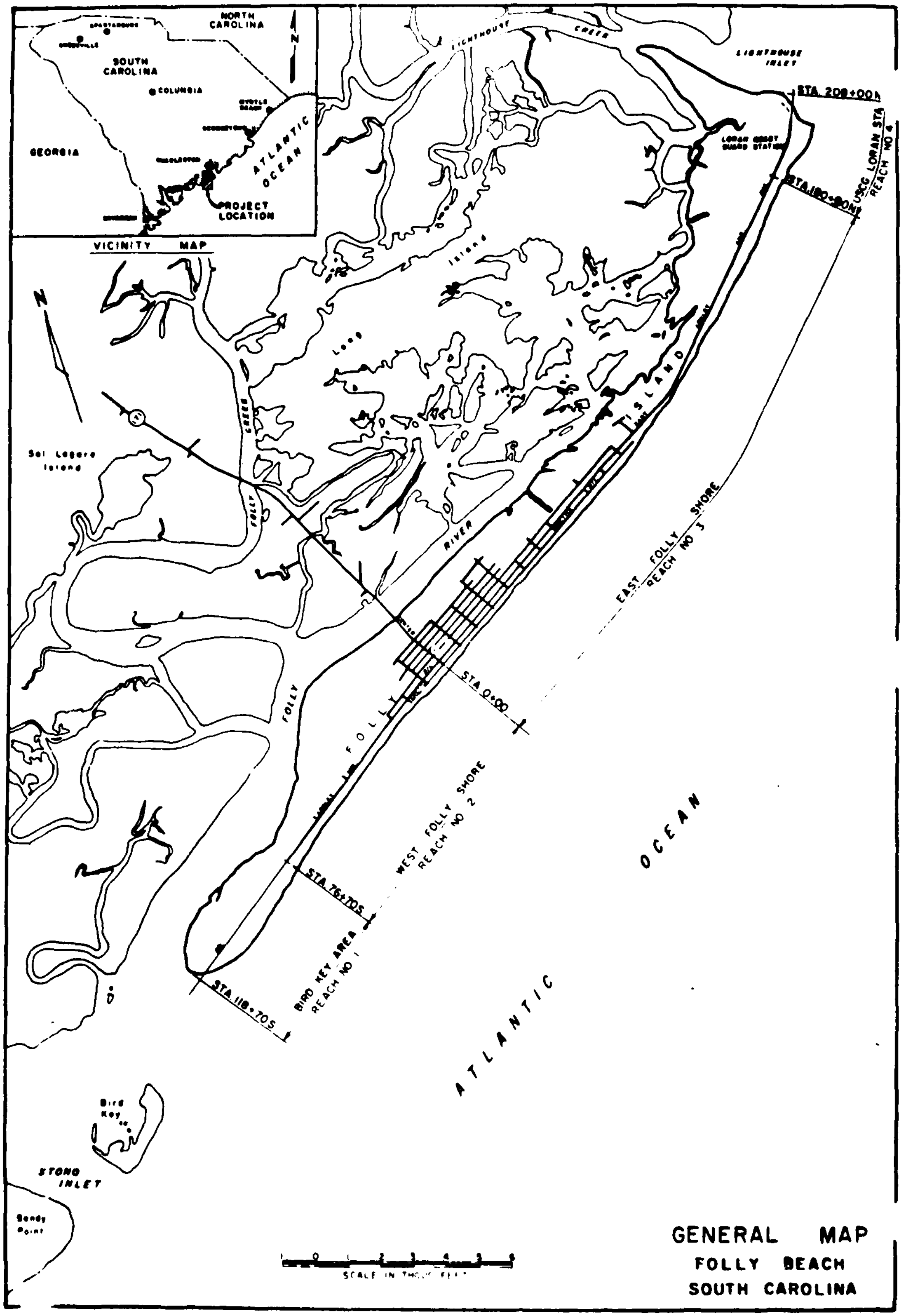
b. Description of the proposed disposal site for dredged or fill materials.

(1) Location: The ocean shoreline along Folly Island, South Carolina. Total project length would be 16,860 feet extending from Station 24+70 South to Station 143+90 North. A 50-foot recreational beach would be constructed over the entire reach of the project.

(2) Type of disposal site: Undiked nourishment area on the above-mentioned beach. This is not a "disposal" site in the usual sense because the primary purpose is to build up an eroding beach, rather than to dispose of unwanted material.

(3) Method of discharge: Hydraulic pipeline.

(4) When will disposal occur: Scheduling will occur after project authorization.



VICINITY MAP
NORTH CAROLINA
SOUTH CAROLINA
COLUMBIA
GEORGIA
ATLANTIC OCEAN
PROJECT LOCATION
LIGHTHOUSE CREEK
LIGHTHOUSE INLET
STA. 209+00N
LORAN COAST GUARD STATION
USCG LORAN STA REACH NO 4
STA 180+80N
EAST FOLLY SHORE REACH NO 3
STA 0+00
WEST FOLLY SHORE REACH NO 2
STA 76+70S
BIRD KEY AREA REACH NO 1
STA 118+70S
FOLLY ISLAND
FOLLY RIVER
FOLLY CREEK
Sol Legare Island
ATLANTIC OCEAN
Bird Key
STONO INLET
Sandy Point
SCALE IN THOUS FEET
GENERAL MAP
FOLLY BEACH
SOUTH CAROLINA

FIGURE 1

(5) Projected life of disposal site: Not applicable. (See b(2) above).

(6) Bathymetry: Not applicable.

2. Physical Effects (40 CFR 230.4-1(a)).

a. Potential destruction of wetlands - effects on 40 CFR 230.4-1 (a)(1)(i-vi): The intertidal nourishment area would not be considered wetlands under the definition given in 33 CFR 323.2. The area could possibly be considered "wetlands" as defined in Executive Order 11990. In any case, the nourishment area can not be considered "highly productive" or said to "perform important functions" as described in 40 CFR 230.4-1(a)(1).

(1) Food chain production: Not significant.

(2) General habitat: Not significant.

(3) Nesting, spawning, rearing and resting sites for aquatic or land species: Not significant for the area affected.

(4) Those set aside for aquatic environment study or sanctuaries or refuges: Not applicable.

(5) Natural drainage characteristics: Not significant.

(6) Sedimentation patterns: Not significant.

(7) Salinity distribution: Not significant.

(8) Flushing characteristics: Not significant.

(9) Current patterns: Not significant, except that existing currents and waves erode the beach severely.

(10) Wave action, erosion or storm damage protection: Highly eroded beach would be restored. Renourishment would be required at 5-year intervals to maintain the beach as erosion continues.

(11) Storage areas for storm and flood waters: Not applicable.

(12) Prime natural recharge areas: Not applicable.

b. Impact on water column (40 CFR 230.4-1(a)(2)). Because of the nature of the nourishment area, the clean nature of the material to be dredged and its large particle size, impacts on the water column are not significant.

(1) Reduction in light transmission: Temporary, not significant.

(2) Aesthetic values: Temporary, not significant.

(3) Direct destructive effects on nektonic and planktonic populations: Temporary, not significant.

c. Covering of benthic communities (40 CFR 230.4-1(a)(3)).

(1) Actual covering of benthic communities: The beach benthic community consists of many individuals of relatively few species. Many inhabitants are relatively immobile and would experience suffocation and mortality from beach fill. Initial losses could be large, but recovery would be rapid due to recruitment from adjacent areas. Long term effects would be minor.

(2) Changes in community structure or function: Not significant (see c(1) above).

d. Other effects (40 CFR 230.4-1(a)).

(1) Changes in bottom geometry and substrate composition: Not significant, except for improvement to existing beach.

(2) Water circulation: Not significant.

(3) Salinity gradients: Not significant.

(4) Exchange of constituents between sediments and overlying water with alterations of biological communities: Not significant.

3. Chemical-Biological Interactive Effects (40 CFR 230.4-1(b)).

a. Does the material meet the exclusion criteria? Yes. The material is predominantly sand and shell with particle sizes larger than silt. The material would be dredged only from sandy shoals near the mouths of Stono or Lighthouse Inlets, and would be compatible with native beach sand upon which it would be deposited as nourishment. Both exclusions (b)(1)(i) and (b)(1)(ii) are met.

b. Water column effects of chemical constituents (40 CFR 230.4-1 (b)(2)): Not applicable.

c. Effects of chemical constituents on benthos (40 CFR 230.4-1 (b)(3)): Not applicable.

4. Description of Site Comparison (40 CFR 230.4-1(c).

a. Total sediment analysis (40 CFR 230.4-1(c)(1)): Not required (see 3.a above).

b. Biological [illegible] CFR 230 4-1(c)
(2)): Not required [illegible]

5. Review Applicable Water [illegible]

a Compare constituent [illegible] applicable (see 3.a).

b. Consider mixing [illegible]

c. Based on a and b [illegible] operation be in conformance with applicable standards [illegible]

6. Selection of Disposal [illegible] Dredged or Fill Material.

a. Need for the [illegible] has experienced severe shoreline [illegible] loss of recreational beach and threat [illegible]

b. Alternatives [illegible] plans considered were either [illegible] project objectives, or had already been [illegible] - 6.3 of Appendix 2 of *the Survey Report*) [illegible] considered, the only alternatives which [illegible] objectives were beach development [illegible]. The selected plan is the smallest [illegible] plans considered. Hence, its requirement [illegible] and beach fill are the lowest capable of meeting [illegible] objectives. Borrow sites would be in areas least [illegible] degradation and the material is clean and compatible [illegible]

c. Objectives to [illegible] determination (40 CFR 230.5(a)):

(1) Impacts [illegible] biological integrity of aquatic ecosystem (40 [illegible] significant.

(2) Impact on [illegible] significant.

(3) Impact on diversity [illegible] animal species: Not significant.

(4) Impact on [illegible] feeding, spawning, breeding and nursery areas [illegible]

(5) Impact on wetland areas having significant functions of water quality maintenance: Not applicable or not significant.

(6) Impact on areas that serve to retain natural high waters or flood waters: Not applicable.

(7) Methods to minimize turbidity: The borrow area of clean, large particles would be utilized to minimize turbidity.

(8) Methods to minimize degradation of aesthetic, recreational, and economic values: The project has as its primary purpose the improvement of recreational and economic features. Aesthetic enhancement would also result from project construction.

(9) Threatened and endangered species: None adversely affected.

(10) Investigate other measures that avoid degradation of aesthetic, recreational, and economic values of navigable waters: Not applicable (see 6.b and 6.c (8)).

d. Impacts on water uses at proposed disposal site (40 CFR 230.5(b) (1-10)):

(1) Municipal water supply intakes: Not applicable.

(2) Shellfish: Not significant.

(3) Fisheries: Not significant.

(4) Wildlife: Not significant.

(5) Recreation activities: Recreational activities would be greatly improved.

(6) Threatened and endangered species: None adversely affected.

(7) Benthic life: Not significant (see 2.c(1)).

(8) Wetlands: Not applicable/not significant.

(9) Submersed vegetation: Not applicable.

(10) Size of disposal site: This project plan was chosen over others that would require more material placed over a larger area.

(11) Coastal Zone Management programs (40 CFR 230.3(e)): The proposed action is consistent with the as-yet-unapproved S.C. CZM program.

e. Considerations to minimize harmful effects (40 CFR 230.5(c) (1-7)):

(1) Water quality criteria: No legally applicable criteria would be exceeded.

(2) Investigate alternatives to open water disposal: Not applicable.

(3) Investigate physical characteristics of alternative disposal sites: Not applicable.

(4) Ocean dumping: Not applicable.

(5) Where possible, investigate covering contaminated dredged material with cleaner material: Not applicable. Material is clean.

(6) Investigate methods to minimize effect of runoff from confined areas on the aquatic environment: Not applicable.

(7) Coordinate potential monitoring activities at disposal site with EPA: Not applicable. No monitoring would be required as material is clean sand and biotic impacts would be minor.

7. Statement as to contamination of fill material if from a land source (40 CFR 230.5d): Not applicable.

8. Determine mixing zone: Not applicable.

9. Conclusions and determinations:

a. Feasible alternatives to the proposed discharge have been considered and none that are practicable will have less adverse impact on the aquatic and semi-aquatic ecosystem.

b. There are no unaceptable environmental impacts on the aquatic and semi-aquatic ecosystem as a result of the discharge.

c. The discharge of the dredged (or fill) material will be accomplished under conditions which will minimize, to the extent practicable, adverse environmental effects on the aquatic and semi-aquatic ecosystem.

10. Findings: Based on the above evaluation and determinations, the proposed discharge site for the Folly Beach Project has been specified through the application of the Section 404(b) Guidelines.

6 November 1979
DATE

William W. Brown
WILLIAM W. BROWN
Colonel, Corps of Engineers
District Engineer

ME
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