Coastal Branch
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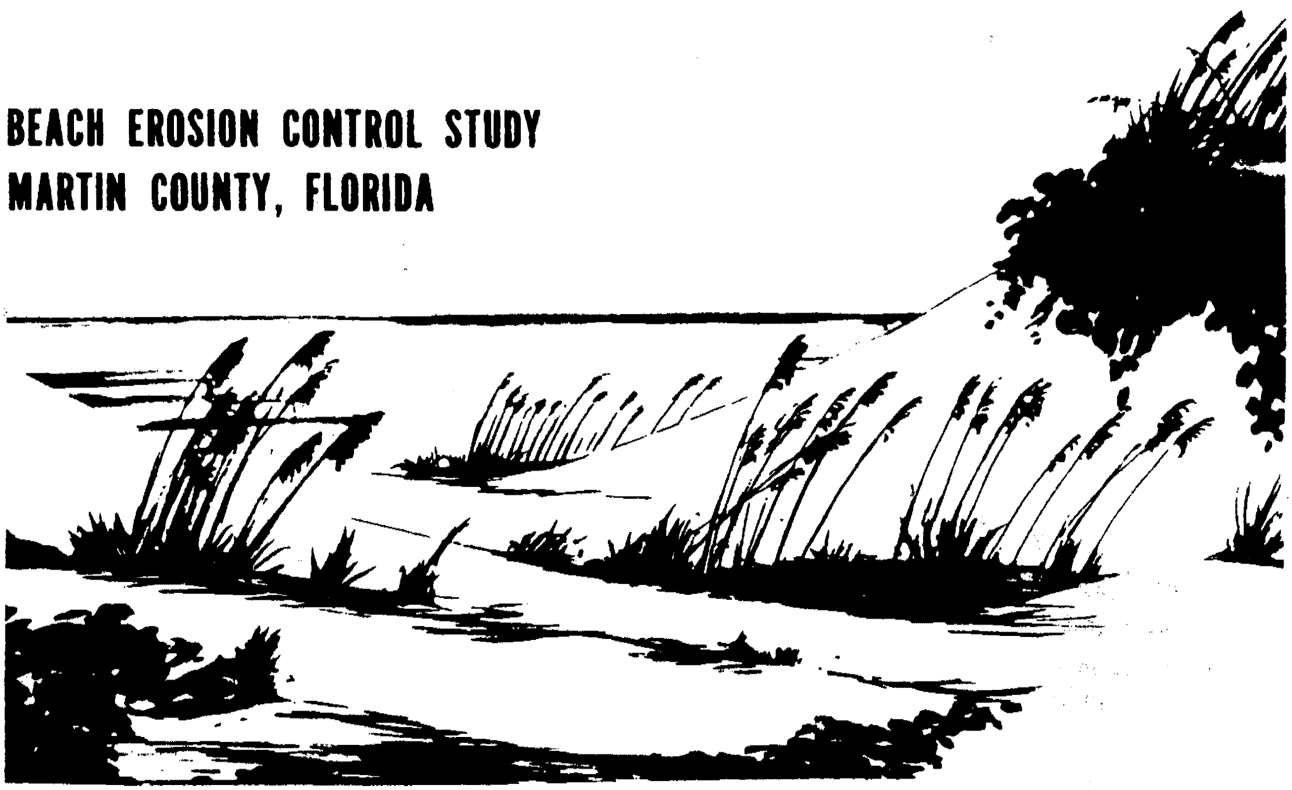
SEPTEMBER 1985
(REV. JUNE 1986)

FEASIBILITY REPORT WITH ENVIRONMENTAL IMPACT STATEMENT

BEACH EROSION CONTROL STUDY MARTIN COUNTY, FLORIDA



US Army Corps of Engineers
Jacksonville District

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314-1000

REPLY TO
ATTENTION OF:

CECW-PE

November 20, 1989

SUBJECT: Martin County, Florida

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on Martin County, Florida. It is accompanied by the reports of the Board of Engineers for Rivers and Harbors and the district and division engineers. These reports are in response to a resolution adopted 18 May 1973 by the Committee on Public Works of the United States Senate. The Committee requested that a survey be made of the shores of Martin County, Florida, and such adjacent shores as may be necessary in the interest of beach erosion control, hurricane protection, and related purposes in accordance with Section 110 of the River and Harbor Act of 1962.

2. The district and division engineers considered structural and nonstructural measures to reduce beach, land, and property losses resulting from erosion, storms, and hurricanes along the 22 miles of Atlantic coastline, Martin County. The reporting officers recommend a protective beach, with subsequent periodic nourishment, extending over 4 miles of shoreline from the St. Lucie County line to near the southern limit of Stuart Public Beach Park. The plan would include restoration of the primary dune as needed to an elevation of 12.5 above mean sea level (m.s.l.) and a top width of 20 feet. A 35-foot-wide protective berm would be provided at elevation 8.0 above m.s.l., and continued fill would gradually slope seaward of the berm to the existing offshore bottom. Advanced nourishment sufficient for an estimated 8 years of erosion losses would be included as part of initial construction. Beach fill material would be obtained from a borrow area located 1/2-miles offshore from Stuart Public Beach. Relocation and incubation of sea turtle eggs are included as part of construction and subsequent periodic nourishment. Alternatives considered for the balance of the Martin County coastal shoreline are not economically feasible.

3. The Board of Engineers for Rivers and Harbors concurs with the findings of the reporting officers. The recommended plan maximizes net National Economic Development (NED) benefits. The Board recommends the plan for a protective beach, generally in accordance with the reporting officers' report, with such modifications as, in the discretion of the Chief of Engineers, may be advisable, and subject to cost-sharing provisions of the Water Resources Development Act of 1986, as amended.

CECW-PE
SUBJECT: Martin County, Florida

4. I generally concur in the findings, conclusions, and recommendations of the Board. Since preparation of the Board's report, policy on recreation development has evolved and changes have occurred in shore protection policy pursuant to the Water Resources Development Act of 1986. To indicate how these changes impact the Martin County report, I have enclosed a supplemental information paper. The recommended plan, with a currently estimated length of 21,120 feet, has been formulated basically for hurricane and storm damage reduction purposes, and remains the NED plan. The recommended plan also is justified economically when recreation benefits are limited to 50 percent of total project benefits. Based on October 1989 price levels, the recommended plan has a total first cost of $9,391,000. Under current policies, first costs of the recommended plan would be shared $3,850,000 Federal and $5,541,000 non-Federal. The project also includes periodic nourishment at a cost of $5,213,000, estimated to occur every 8 years. The nourishment cost is estimated at $2,137,000 Federal cost and $3,076,000 non-Federal. Average annual costs, at an interest rate of 8-7/8 percent and a 50-year period for economic analysis, are $1,322,400. Average annual benefits are $1,988,700, resulting in a benefit cost ratio of 1.5.

5. The recommendations contained herein reflect the policies governing formulation of individual projects and the information available at this time. They do not necessarily reflect program and budgeting priorities inherent in local and state programs or in the formulation of a national Civil Works construction program. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, the sponsor, the State of Florida, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

H. J. HATCH
Lieutenant General, USA
Chief of Engineers

1 Enclosure

DEPARTMENT OF THE ARMY

BOARD OF ENGINEERS FOR RIVERS AND HARBORS

KINGMAN BUILDING

FORT BELVOIR, VIRGINIA 22060-5576

REPLY TO
ATTENTION OF:

BERH-PLN

3 June 1986

SUBJECT: Martin County, Florida

Chief of Engineers
Department of the Army
Washington, DC 20314-1000

SUMMARY OF BOARD ACTION

The Board concurs in the recommendation of the reporting officers for beach erosion control measures in Martin County, Florida. The proposed plan consists of restoration and subsequent periodic nourishment of 20,215 feet of Atlantic Coast shoreline extending from near the southern limit of Stuart Public Beach north to the St. Lucie County line. The improvements are needed for the reduction of storm and hurricane damages and to meet projected beach recreation demand. The first cost of the recommended project is estimated to be $9,419,000, and the benefit-cost ratio is 1.7. The Board recommends the plan subject to cost-sharing and financing arrangements satisfactory to the President and the Congress.

SUMMARY OF REPORT UNDER REVIEW

1. AUTHORITY. This report is in response to a resolution adopted 18 May 1973 by the Committee on Public Works of the United States Senate requesting that a survey of the shores of Martin County, Florida, be conducted in the interest of beach erosion control, hurricane protection, and related purposes. The resolution is quoted in the District Engineer's report.

2. DESCRIPTION OF THE STUDY AREA. The study area includes 22 miles of coastal lands in Martin County, Florida. Martin County is located 100 miles north of Miami and due east of Lake Okeechobee. The coastal area of the county consists of parts of Hutchinson and Jupiter Islands, two barrier islands separated from each other by St. Lucie Inlet and from the mainland by Indian River. Two causeways over Indian River provide access to Hutchinson Island. Elevations on the barrier islands vary from 5 to 25 feet mean sea level (m.s.l.), while widths range from 200 feet to nearly 1 mile. Beaches are composed of shell fragments and fine sand. Coquina rock outcroppings occur periodically along the shore on both barrier islands. Martin County beaches also provide nesting sites for sea turtles.

3. ECONOMIC DEVELOPMENT. Martin County is a rapidly developing region in southern Florida. The estimated 1985 population for the County is over 80,000, compared with 64,000 in 1980. Population is expected to reach 165,000 by year 2020. Economic development depends heavily upon tourism. Other major industries include aerospace, plastics, and agriculture. Most of the development on Hutchinson Island within Martin County has occurred within the last 10 years and consists primarily of multiunit residential structures. In contrast, development on Jupiter Island consists predominantly of single family estates.

4. EXISTING IMPROVEMENTS. A Federal navigation project was constructed at St. Lucie Inlet by the U.S. Army Corps of Engineers in 1982. This project provides a 650-foot extension to a locally constructed north jetty at the inlet, a 400-foot detached breakwater, a 1,200-foot south jetty, an impoundment basin, and a channel varying from 16 feet deep by 300 feet wide at the entrance to 7 feet deep by 100 feet. On Hutchinson Island, local interests have constructed 3,500 linear feet of stone revetments fronting their properties. Local interests on Jupiter Island have provided both periodic beach fill and protective structures to reduce erosion.

5. PROBLEMS AND NEEDS. Erosion of land and beaches has occurred in the past and is expected to continue along the shoreline except in areas of exposed coquina rock outcroppings. Severe storms and hurricanes pose a significant damage potential to private and public development. The primary needs are protection from damaging waves and enhancement of public beach use. Control of beach erosion is deemed to be critically important to the tourist-based economy and future prospects for economic development in Martin County.

6. IMPROVEMENTS DESIRED. Local interests generally desire protection of public beach developments by means of beach fill and periodic nourishment. Private developments, concentrated between the two major public beaches on Hutchinson Island, Stuart and Jensen, also desire protection against erosion and damage from storms and hurricanes. Martin County, which already has expended considerable funds to acquire additional public land for access and support of public beach use, desires to preserve its investments.

7. ALTERNATIVES CONSIDERED. A broad range of both structural and nonstructural measures were considered during the planning process. These measures ranged from use of revetments, seawalls, bulkheads, and groins; control of development; and beach fill with periodic nourishment. Alternatives considered in detail included beach fill at the two major public beach parks on

Hutchinson Island alone, and in combination with beach fill along the shoreline in between.

8. PLAN OF IMPROVEMENT. The District Engineer recommends improvements on Hutchinson Island extending south from the border of Martin and St. Lucie Counties for a distance of about 4 miles to near the southern end of Stuart Public Beach. The recommended plan provides for restoration and addition to the primary dune to a height of +12.5 m.s.l. and a crest width of 20 feet. A protective berm 35 feet wide would extend seaward of the primary dune at elevation +8.0 m.s.l. The beach fill would then slope to the existing bottom offshore. Initial construction would also include provision for advanced nourishment. Sand for the recommended plan would be obtained from a borrow area about one-half mile offshore. Relocation and incubation of sea turtle eggs would be an integral part of beach fill construction. Measures considered for the remaining portion of Hutchinson Island and for all of Jupiter Island were not economically justified.

9. ECONOMIC EVALUATION. The District Engineer estimates the first cost for the recommended improvements to be $9,419,000 based on June 1985 price levels. Under traditional cost-sharing policies, the non-Federal share would be $5,038,500. Annual costs at an interest rate of 8 5/8 percent and a 50-year period for economic analysis are $1,340,300. Average annual benefits are estimated at $2,225,000, and the benefit-cost ratio is 1.7.

10. PROJECT EFFECTS. Construction of the protective beach would provide a significant reduction in storm and hurricane damage to upland property. Storm damage in the project reach for a 40-year recurrence interval event would be eliminated. Damages from a 100-year-frequency event would be reduced about 85 percent. Erosion of land and beaches in the project reach would be controlled, and additional public area provided by the protective beach would meet the projected demand for beach recreation. Dredging in the selected borrow area would result in short-term impacts on submerged sabellariid worm reefs. Increased turbidity levels during dredging and construction may reduce offshore and onshore fishing. Construction activities would limit beach recreation throughout the project reach. Increased local expenditures for periodic nourishment and operation and maintenance of public beaches would be incurred. Vehicular traffic associated with the increased recreation use of the public beaches would be greater, especially on the two causeways connecting Hutchinson Island with the mainland.

11. RECOMMENDATION OF THE REPORTING OFFICERS. The District Engineer recommends authorization for construction of beach

erosion control improvements at Hutchinson Island, Martin County, in accordance with the plan described in his report, and in accordance with cost-sharing and financing arrangements which are satisfactory to the President and the Congress. The Division Engineer concurs.

REVIEW BY THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS

12. GENERAL. The Board's review encompassed the overall technical, economic, social, environmental, and policy aspects involved in the erosion control plan proposed by the reporting officers, including conformance with the Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. The Board also considered the views of local interests, as well as those of Federal and State agencies.

13. RESPONSES TO THE DIVISION ENGINEER'S PUBLIC NOTICE. The Division Engineer issued a public notice on 30 September 1985 stating the recommendations of the reporting officers and inviting interested parties to provide comments to the Board. The Board did not receive any letters in response to the public notice.

14. FINDINGS AND CONCLUSIONS. The Board of Engineers for Rivers and Harbors concurs in the findings and recommendations of the reporting officers. The proposed improvements are engineeringly feasible, economically justified, and environmentally acceptable. The recommended plan reasonably maximizes net benefits and is the national economic development plan. The proposed project would not result in any significant adverse environmental impacts. The Board believes the report essentially complies with applicable policies and guidelines.

15. The Board notes that Martin County has devoted considerable effort to preserving and enhancing dune vegetation on Hutchinson Island. Construction and placement of beach fill should attempt to preserve as much dune vegetation as possible.

16. The recommended plan would provide a significant reduction in storm damage to property within the project reach in Martin County. The Board is aware of the increasing nationwide concern regarding recent development trends in coastal areas vulnerable to storm and hurricane damage. Martin County has adopted coastal development controls and dune preservation ordinances that are among the most stringent in Florida and the Nation. These controls are expected to significantly limit increases in storm damage resulting from future development. The economic analysis supporting the recommended plan is based only on existing development.

17. The Board notes that Martin County is a rapidly growing area. The control of beach erosion and the additional public beach area provided as a result of project design to reduce storm damage would be a significant and widespread benefit to the public. Beneficiaries of this public beach would extend far beyond the residents of Martin County and vicinity due to the large number of tourists.

18. The Administration's policy on water project financing and cost sharing is that all Federal water development agencies will continue to seek out new partnership arrangements with the States and other non-Federal interests in the financing and cost sharing of the proposed projects. Each such agency will negotiate reasonable financing arrangements for every project within its respective area of responsibility. In addition, prior commitments to individual States with regard to water development within their borders will be considered and shall be a factor in negotiations leading up to project construction; and consistency in cost sharing for individual project purposes, with attendant equity, will be sought. Project beneficiaries, not necessarily governmental entities, should ultimately bear a substantial part of the cost of all project development.

19. RECOMMENDATIONS. The Board recommends that beach erosion control improvements for Martin County, Florida, be authorized for implementation generally in accordance with the reporting officers' recommended plan, with such modifications as in the discretion of the Chief of Engineers may be advisable and subject to cost-sharing and financing arrangements satisfactory to the President and the Congress. This recommendation is made with the provision that, prior to implementation, non-Federal interests will agree to comply with the following requirements:

a. Provide without cost to the United States all necessary lands, easements, rights-of-way, and relocations required for construction, operation, and maintenance of the project, including that required for periodic nourishment;

b. Hold and save the United States free from claims for damages which may result from construction and subsequent operation, maintenance, and public use of the project, except damages due to the fault or negligence of the United States or its contractors;

c. Assure continued conditions of public ownership and use of the shore upon which the amount of Federal participation is based during the economic life of the project;

d. Assure maintenance and repair during the economic life of the project as required to serve the project's intended purposes, in accordance with regulations prescribed by the Secretary of the Army;

e. Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms, and as required to realize the benefits upon which Federal participation is based;

f. Provide a cash contribution for beach erosion control equal to the appropriate percentage of the final construction cost allocated to this function, exclusive of lands, easements, rights-of-way, alterations, and relocations, the percentage to be in accordance with existing law and based on shore ownership at the time of implementation;

g. Provide a cash contribution for periodic nourishment during the useful life of the project, such contribution to be made prior to each nourishment, with the actual amount to be based on existing law and conditions of ownership at the time of each nourishment; and

h. Provide a cash contribution for the cost of beach fill placed landward of the erosion control line on private lands, during initial construction or subsequent nourishment, the cost to be determined at the time of construction or periodic nourishment.

20. The recommendations contained herein reflect information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program nor the perspective of higher review levels within the Executive Branch. Accordingly, the Board acknowledges that the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and/or implementation funding.

FOR THE BOARD:

N. G. DELBRIDGE, JR.
Major General, USA
Chairman

MARTIN COUNTY, FLORIDA - SUPPLEMENTAL INFORMATION

1. Land Loss Benefits. - Land loss benefits have been recalculated based on changes in shore protection policy. The report of the Board of Engineers for Rivers and Harbors reflected benefits for prevention of loss of public lands at six public beach park areas. Recreation use benefits were also claimed for these beach park areas. The land loss benefits in these areas have been eliminated on the basis that these benefits may double count the recreation use benefits. The table below shows the calculation of the loss of private land. This is the basis of the remaining land loss benefits after the public park areas are eliminated. These lands would be lost in the absence of construction of a protective beach and consist of privately owned developed and undeveloped lots landward of the beach and dune. No land loss is claimed for areas behind existing shorefront protective structures. The location/access in the left column identifies the land in relationship to the nearest public access point (private land to the north or south of the public access area).

Table 1
Loss of Land Prevented

Location/ Access	Shorefront Ownership	Distance (ft.)	Erosion Rate (ft. per yr.)	Surface Area (sq. ft.)
North County Access	private	1155	0.7	809
Jensen Beach Park	private	820	3.0	2460
Bob Graham Park	private	268	2.0	536
	private	745	2.0	1490
Alex's Beach	private	745	0.8	596
	private	1470	0.8	1176
Virginia Forest	private	1667	0.6	1000
Tiger Shores	private	875	2.9	2538
Stuart Beach Park	private	1025	2.9	2973
		1320	0.7	924
	Total	10,090		14,502

The loss of land prevention benefit is calculated by multiplying the without project annual land loss area (in this case 14,502 sq. ft.) by the value of the land. The report of the Board of Engineers for Rivers and Harbors reflected a land value of $10 per square foot based on shorefront land value. In accordance with current policy, the prevention of land loss benefit has been recalculated based on a nearshore land value of $4 per square foot. This results in an annual benefit of $58,000. The elimination

of the land loss benefit for public beach parks and the use of nearshore values results in a reduction of $150,600 in the loss of land benefit. This benefit reduction does not change the designation of the recommended plan as the NED plan since the reduction would apply to the entire array of beach fill alternatives.

2. Revised Cost Estimate. The cost estimate for the recommended plan has been revised to reflect unit costs as of October 1989 and to adjust for erosion that has occurred since initial shoreline surveys were conducted. The revised estimate is presented on Table 2 which follows.

Table 2
Estimate Costs for Recommended
Martin County Hurricane and Storm Damage Reduction Project

Item	Quantity & Unit	Unit Cost	Total
Mobilization & Demobilization	Lump Sum		$ 800,000
Beach Fill (Includes Advance Nourishment)	1,065,300 cu yds	$5.30	5,646,000
Establish ECL	Lump Sum		20,000
Monitoring	Lump Sum		12,000
Relocation of Turtle Eggs	Lump Sum		28,000
Lands Easements and Rights-of-way	Lump Sum		27,000
SUBTOTAL			$ 6,533,000
Contingencies @ 25%			1,633,000
SUBTOTAL			8,166,000
Engineering & Design and Supervision & Administration @ 15%			1,225,000
TOTAL FIRST COST			$9,391,000
Interest During Construction			102,000
TOTAL INVESTMENT			$9,493,000

ESTIMATED ANNUAL COST

Item	Annual Cost
Interest and Amortization ($9,493,000 @ 8 7/8)	$ 854,700
Periodic Nourishment (488,000 cy @ 8-yr intervals)	467,700
TOTAL ANNUAL COST	$ 1,322,400

3. Revised Cost-Sharing. Cost-sharing for the recommended plan has been recalculated based on policies resulting from the Water Resources Development Act of 1986. The estimated Federal share of the project is about 41 percent based on current conditions of shoreline ownership, development and use. The cost-sharing calculations are presented on Table 3 which follows.

Table 3
Cost-Sharing Calculation for Recommended
Martin County Hurricane and Storm Damage Reduction Project

	Public Shores	Private Shores			
	Non-Fed (Park)	Developed Public Use	Developed No Public Use	Not Developed	Total
Reach	1	2	3	4	
Length (ft)	7,055	7,840	1,200	5,025	21,120
Benefits					
Damage Reduction					
Facilities	$10,000	$761,400	$100,800	$ 0	$872,200
Land Loss	0	32,300	5,000	20,700	58,000
Recreation	(1,058,500)	0	0	0	(1,058,500)
Total	$10,000	$793,700	$105,800	$20,700	$930,200

Federal Share:
Reach

1 $$\frac{7,055}{21,120} \quad X \quad \frac{10,000}{10,000} \quad X \quad 50\% = .1670$$

2 $$\frac{7,840}{21,120} \quad X \quad \frac{761,400}{793,700} \quad X \quad 65\% + \frac{32,300}{793,700} \quad X \quad 65\% = .2413$$

3 $$\frac{1,200}{21,120} \quad X \quad 0\% = 0$$

4 $$\frac{5,025}{21,120} \quad X \quad 0\% = 0$$

Total Federal: .1670 + .2413 = .4083 or about 41%

4. Economic Summary. An economic summary for the recommended hurricane and storm damage reduction project for Martin County is presented below. The project first costs at a October 1989 cost level is estimated at $8,775,000. This is a reduction from the June 1985 cost estimate and reflects a decrease in the estimated cost of dredging. The economic summary is based on the current Federal interest rate of 8 7/8% and a 50 year project life. The project benefit-cost ratio is 1.5 when all benefits are considered. When incidental recreation benefits are limited to 50% of the total benefits, the benefit-cost ratio is 1.4.

Table 4
Economic Summary for Recommended
Martin County Hurricane and Storm Damage Reduction Project

Average Annual Benefits	
Loss of Land	$ 58,000
Damage to Upland Development	858,400
Damage to Existing Shorefront Protective Structures	13,800
Recreation	1,058,500
Total Benefits	$ 1,988,700
Average Annual Costs	$ 1,322,400
B/C Ratio	1.5

w

CESAJ-PD-C (CECW-PE/22 Mar 88) (1110-2-10c) 2nd End Mr. Stevens/kcs/904-791-2204
SUBJECT: Martin County, Florida

Cdr, Jacksonville District, Corps of Engineers, P.O. Box 4970, Jacksonville, Florida 32232-0019
13 May 1988

FOR: Commander, South Atlantic Division, ATTN: CESAD-PD-P, Atlanta, Georgia 30335-6801

Information requested in Enclosure 2 of the basic letter is furnished herewith.

FOR THE COMMANDER:

2 Encls

A. J. SALEM
Chief, Planning Division

CF:
CECW-PE

Stevens/CESAJ-PD-C/kcs/2204
Hobbs/CESAJ-PD-C
Bonner/CESAJ-PD-A
Salem/CESAJ-PD

CESAJ-PD-C (CECW-PE/22 Mar 88) (1110-2-10c) 2nd End Mr. Stevens/kcs/904-791-2204
SUBJECT: Martin County, Florida

Cdr, Jacksonville District, Corps of Engineers, P.O. Box 4970, Jacksonville, Florida 32232-0019 13 May 1988

FOR: Commander, South Atlantic Division, ATTN: CESAD-PD-P, Atlanta, Georgia 30335-6801

Information requested in Enclosure 2 of the basic letter is furnished herewith.

FOR THE COMMANDER:

2 Encls

A. J. SALEM
Chief, Planning Division

CF:
CECW-PE

Stevens/CESAJ-PD-C/kcs/2204
Hobbs/CESAJ-PD-C
Bonner/CESAJ-PD-A
Salem/CESAJ-PD

CESAD-PD-P (CECW-PE/22 Mar 88) (1110-2-10c) 1st End Mr. Foreman/sg/331-6260
SUBJECT: Martin County, Florida

Cdr, South Atlantic Division, Corps of Engineers, 510 Title Building,
30 Pryor Street, S.W., Atlanta, GA 30335-6801 30 MAR 1988

FOR: Commander, Jacksonville District, ATTN: CESAJ-PD

Information requested in Enclosure 2 of the basic letter should be furnished to this office by 22 April 1988.

FOR THE COMMANDER:

John W. Rushing

2 Encls
nc

JOHN W. RUSHING
Chief, Planning Division

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314-1000

REPLY TO
ATTENTION OF:

CECW-PE

22 MAR 1988

MEMORANDUM FOR: Commander, South Atlantic Division, ATTN: CESAD-PD

SUBJECT: Martin County, Florida

1. The subject feasibility report, dated September 1985, has been reviewed by the Board of Engineers for Rivers and Harbors (Board Report dated 3 June 1986). Since Board action, processing of the report has been delayed by evolving policy on recreation development and changes in shore protection policy resulting from passage of the Water Resources Development Act of 1986.

2. EC 1165-2-149 dated 15 March 1988 (Enclosure 1) provides definitive guidance in areas of concern on the Martin County project. Enclosure 2 defines the information we will need from you in order for us to revise the proposed report of the Chief of Engineers. Request this information be furnished by 29 April 1988.

3. Upon revision of the Chief's report, it will be transmitted to states and agencies for the 90-day review period.

FOR THE CHIEF OF ENGINEERS:

DAN M. MAULDIN
Chief, Planning Division
Directorate of Civil Works

2 Enclosures

MARTIN COUNTY, FLORIDA
INFORMATION FOR CHIEF'S REPORT

1. Land Loss Benefits - The average annual land loss benefit for the recommended plan is based on an appraised value of $10 per square foot. This presumably represents a shorefront land value. Paragraph 7a.(2) of EC 1165-2-149 indicates that determination of the market value for land loss benefits must be based on nearshore land value. The EC provides a definition of nearshore land. The land loss benefits should be recalculated and total benefits adjusted to reflect this policy change. The revised land loss benefit should be incorporated into a revised economic analysis that should be furnished, with appropriate supporting documentation, for incorporation into the Chief's report.

2. Land Loss Benefits in Recreational Areas - The recommended NED plan includes both land loss and recreation use benefits on six public beach areas (reference Table 30, page 53, Appendix 5). Land loss benefits are claimed on public shore frontage that is not needed to support recreation use based on application of design standards. These public land loss benefits represent about 30.5 percent of the total land loss benefits. We believe that the land loss benefits double count the recreation use benefits. EC 1165-2-149 provides that the benefits of protecting public shores will be based on the loss in recreation outputs in the absence of protection (reference paragraph 7b.(1)). If the recreation use of the area cannot be calculated in economic terms, the value of nearshore land may be applied and a prevention of land loss benefit calculated. However, a land loss benefit and recreation use benefit may not be claimed for the same public beach area regardless of how much of the public beach is "needed " to satisfy projected recreation use. The land loss benefit should be recalculated in accordance with comment 1 with the public park areas deleted from the calculation. The results should be incorporated into a revised economic analysis as discussed in comment 1.

3. NED Plan Documentation. - Documentation must be provided to show that the recommended plan remains the NED plan with the changes necessitated by comments 1 & 2.

4. Demonstration of Economic Justification with Recreation Benefits Limited to 50 Percent. - In accordance with paragraph 15a. of EC 1165-2-149, an economic analysis should be furnished demonstrating that the recommended project is justified with recreation benefits limited to 50 percent of total benefits.

5. Cost-Sharing Revisions.- Cost-sharing for the project should be calculated based on guidance provided in paragraph 7 of EC 1165-2-149. Supporting documentation in the format of the enclosure to the EC should be provided.

Encl 2

CESAJ-PD-C Responses to CECW-PE Comments 13 May 1988

Martin County Florida Shore Protection Study
Information for Chief's Report

Comments 1 and 2. Land Loss Benefits. The average annual prevention of loss of land benefit now attributed to the recommended plan, based upon the 11 May 1988 real estate appraisal of $4 per square foot for the fair market value of nearshore land, is $58,000. As per Comment 2, all benefits were deleted for the unused public shorefront. This equates to 3,556 linear feet of public shorefront as determined from table 30 of Appendix 5 of the feasibility report (revised June 1986). The 6,362 square feet of land loss along public shorefronts per year was subtracted from the total 20,864 square feet of surface area in table 30 prior to the calculation of the prevention of loss of land benefit now attributed to the recommended plan. A copy of table 30 with these revisions is attached.

Comment 3. NED Plan Documentation. The elimination of $150,600 in prevention of loss of land benefits would apply to the entire array of beach fill alternatives. Therefore, the net NED benefits would change by $150,600 for each beach fill alternative and the recommended plan (S-2A) would remain the NED plan.

Comment 4. Demonstration of Economic Justification with Recreation Benefits Limited to 50 Percent. The revision of prevention of loss of land benefits is incorporated into the copy of table 33 of Appendix 5 of the feasibility report attached. The table was further revised to demonstrate that the recommended plan is economically justified with recreation benefits limited to 50 percent of total benefits. The B/C ratio is 1.6 to 1 with recreation benefits limited to 50 percent of the total benefits.

Comment 5. Cost-Sharing Revisions. Cost-sharing for the recommended plan is provided on the attached form as provided in the referenced EC.

TABLE 30
LOSS OF LAND PREVENTED

Location/Access	Shorefront Ownership	Distance (ft.)	Erosion Rate (ft. per yr.)	Surface Area (sq. ft.)
North County Access	private	1155	0.7	809
Jensen Beach Park	private	820*	3.0	2460
	private	268*	2.0	536
Bob Graham Beach	private	745	2.0	1490
	private	745	0.8	596
Alex's Beach	private	1420	0.8	1136
	private	50*	0.8	40
Virginia Forest	private	1320	0.6	792
	private	347	0.6	208
Tiger Shores	private	875*	2.9	2538
	private	1025	2.9	2973
Stuart Beach Park	private	1320	.7	924
	Total	10,090		14,502

*Reduced distance to account for existing shorefront protective structures.

TABLE 33

ECONOMIC SUMMARY 1/

HUTCHINSON AND JUPITER ISLANDS

	HUTCHINSON ISLAND (PLAN S-2A)	JUPITER ISLAND (PLAN S-2B)
AVERAGE ANNUAL BENEFITS		
Loss of land	$ 58,000	$319,300
Damage to Upland Development	858,400	84,200
Damage to Existing Shorefront Protective Structures 2/	13,800	92,500
Recreation 3/	1,144,200	103,400
Total 4/	$2,074,400	$ 599,400
AVERAGE ANNUAL COSTS	$1,196,000 5/	$3,349,400
B/C Ratio	1.7	.18

1/Using the current Federal interest rate, 8 5/8%, a 50-year project life and ~~June 1985~~ May 88 price levels.

2/Includes reduction in maintenance.

3/Reduced to account for increased maintenance costs ($60,500 annually) anticipated with implementation of the project.

4/As required by EC 1165-2-149, the B/C ratio for the recommended plan S-2A is 1.6 with recreation benefits limited to 50 percent of the total benefits.

5/Based upon a 13 May 1988 cost estimate.

COST SHARING CALCULATION FOR MARTIN COUNTY SHORE PROTECTION STUDY

	Public Shores	Private Shores			
	Non-Fed (Park)	Developed Public Use	Developed No Public Use	Not Developed (5)	Total
Reach	1	2	3	4	
Length (ft) (1)	7,055	7,840	1,200	5,025	21,12(
Benefits					
Damage Reduction					
Facilities	10,000 (3)	761,400	100,800	0	872,20(
Land Loss	0	32,300 (4)	5,000	20,700	58,00(
Recreation (2)	(1,144,200)	0	0	0	(1,144,20(
TOTAL	10,000	793,700	105,800	20,700	930,20(

Federal Share:

Reach

1 $$\left[\frac{7,055}{21,120}\right] \times \left(\frac{10,000}{10,000} \times 50\%\right) = .1670$$

2 $$\left[\frac{7,840}{21,120}\right] \times \left[\left(\frac{761,400}{793,700} \times 65\%\right) + \left(\frac{32,300}{793,700} \times 65\%\right)\right] = .2413$$

3 $$\left[\frac{1,200}{21,120}\right] \times 0 = 0$$

4 $$\left[\frac{5,025}{21,120}\right] \times 0 = 0$$

Total Federal: .1670 + .2413 = .4083 or 40.83%

(1) Assumes a relatively linear distribution of costs.
(2) No costs assigned to recreation (benefits incidental, see paragraph 5a).
(3) Assumes facilities subject to damage serve recreation use.
(4) Land component of developed properties subject to damage.
(5) Based upon Dec 84 aerial photos which are the most recent aerial photos available.

13 May 88
Nourishment Sand Value
update for OCE GPS

TABLE 4

ESTIMATED COSTS

RECOMMENDED PLAN (PLAN S-2A)

40-YEAR DESIGN

JUNE 1985 PRICE LEVELS

Item	Quanity & Unit	Unit Cost	Total	INITIAL FILL 942 000 cu yds 13 May 88 Update	P.N. 488000 cy yd 13 May 88 update
Mobilization & Demobilization	Lump Sum		$1,000,000	$ 800,000	$ 800,000
Beach Fill (includes advance nourishment)	942,000 cu. yds.	5.80 per cu. yd. 5.30 (PIPELINE DREDGE)	5,464,000	4992600	2,586,400
Establish the ECL	Lump Sum		20,000*	20,000	
Monitoring	Lump sum		12,000	12 000	12,000
Relocation of Turtle Eggs	Lump sum		28,800*	28800	28800
Lands, Easements and Rights-of-way	Lump sum		27,500*	27,500	27,500
SUBTOTAL			$6,552,300	$ 5,880,900	$ 3,454,70[illegible]
Contingencies	25%		1,638,100	1470200	863 700
SUBTOTAL			$8,190,400	$ 7,351,100	4318 40[illegible]
Engineering & Design Supervision & Administration	15%		1,228,[illegible]00	1102700	647800
TOTAL FIRST COST			$ 9,419,000 1/	$ 8453800	$ 4,966,20[illegible]
Interest During Construction			102,000*		
TOTAL INVESTMENT			$ 9,521,000		

Esc factor 8yr intervals
8 5/8% = 1.0455B

ESTIMATED ANNUAL COST 2/

Item	Annual Cost		
			4966200 x 1.0455[illegible]
Interest and Amorization ($9,521,000 @ 8 5/8%)	$834,500	741,000	5192600 x .09765
Periodic Nourishment (488,000 cy @ 8-yr interval)	505,800	455100	455,100
Project Monitoring (included in above)	-	1,196,100	
TOTAL	$1,340,300		

Charge $ 764,000

1/ The difference in first costs (versus that shown on page 14, table 3) is due to the additional costs for: establishment of the Erosion Control Line, relocating turtle eggs, and land costs. Table 3 compares alternatives on an equal basis without these additional costs, which would increase the costs for all alternatives equally.

2/ Annual operation and maintenance costs for recreation, of $60,500, are not shown because they were netted out in calculation of recreation benefits.

CESAJ-PD-C 8 FEB 1988

MARTIN COUNTY, FLORIDA
SHORE PROTECTION STUDY
BACKGROUND INFORMATION REGARDING THE
SUMMARY OF THE CORPS FEASIBILITY REPORT
(JANUARY 1988)

The calculation of average annual recreation benefits in the January 1988 Summary included revision of the average variable cost to own and operate an automobile to reflect the trend for reduced gasoline prices since the feasibility report was prepared. Data from the U.S. Department of Transportation Federal Highway Administration pamphlet, "Cost of Owning and Operating Automobiles and Vans 1984," was utilized in the preparation of the report. Information utilized to update the subject summary was based on data contained in the American Automobile Association (AAA) pamphlet, "Your Driving Cost 1986". The Federal Highway Administration no longer prepares the data and referred this office to the data from the AAA.

The Federal Highway Administration data for 1984 was escalated based upon the consumer price index to January 1985 price levels for the feasibility report. The average cost to own and operate intermediate, compact, and subcompact automobiles utilized in the report was 12.3 cents per mile. The average cost decreased to 11.8 cents per mile based upon the AAA data for 1986, which was the most recent data available.

The change from 12.3 to 11.8 cents per mile resulted in a 4.06 percent reduction. This reduction was applied to the recreation benefits of $1,140,600 determined for the 8 5/8 percent interest rate and resulted in $1,094,300 for the average annual recreation benefits shown in the January 1988 Summary.

SADPD-P (SAJPD-C/24 Sep 85) 1st End
SUBJECT: Feasibility Report with EIS for Beach Erosion Control, Martin County, Florida - 13009

DA, South Atlantic Division, Corps of Engineers, 510 Title Building, 30 Pryor Street, S.W., Atlanta, Georgia 30335-6801 26 September 1985

TO: Board of Engineers for Rivers and Harbors, Kingman Building, Fort Belvoir, VA 22060-5576

I concur in the recommendations of the District Engineer.

C. E. EDGAR III
Brigadier General, USA
Commanding

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
P. O. BOX 4970
JACKSONVILLE, FLORIDA 32232-0019

REPLY TO
ATTENTION OF
SAJPD-C

MARTIN COUNTY, FLORIDA

BEACH EROSION CONTROL STUDY

FINAL FEASIBILITY REPORT
AND FINAL ENVIRONMENTAL IMPACT STATEMENT

SEPTEMBER 1985

(Revised June 1986)

MARTIN COUNTY, FLORIDA

FEASIBILITY REPORT
FOR BEACH EROSION CONTROL

SYLLABUS

This report on beach erosion control in Martin County, Florida, was prepared in response to a Congressional resolution adopted 18 May 1973 by the Committee on Public Works of the U.S. Senate.

The primary areas in Martin County that were identified during this study as experiencing problems included most of the Atlantic shorefront of Hutchinson and Jupiter Islands. In evaluating the existing conditions and the continued problem of erosion and wave attack, it was determined that a shore protection plan could be recommended on Hutchinson Island only.

The recommended plan provides for a protective and recreational beach along 4 miles of the northernmost shorefront of Hutchinson Island in Martin County. The plan of improvement for initial beach fill and periodic nourishment would;restore the primary dune to a 20-foot-wide crest width at +12.5 feet mean sea level (m.s.l.); provide a 35-foot-wide berm at +8 feet, m.s.l., with a 1 vertical on 8.5 horizontal foreshore slope to mean low water, then a 1 vertical on 20 horizontal slope to the existing bottom. In order to maintain the protective beach, advance nourishment is included in the initial beach fill, and periodic nourishment would be provided at 8 year intervals to replace anticipated erosion losses. The estimated first cost of initial construction is estimated at $9,419,000. The annual cost, including interest and amortization, would be $1,340,300. The annual benefits resulting from prevention of damages, loss of land, and recreation would be $2,225,000 resulting in a benefit to cost ratio of 1.7 to 1. The Federal share of the project cost is estimated at $4,380,500 under existing conditions.

The study findings indicate lack of economic feasibility for recommendation of a Federal project for Jupiter Island, at this time.

DATA PERTINENT TO THE RECOMMENDED PLAN
MARTIN COUNTY BEC STUDY
(HUTCHINSON ISLAND)

Length of Project	4.0 miles
Length of Initial Fill	4.0 miles
Quantity	
Beach Fill	454,000 cubic yards
Advance Nourishment (8 yr)	488,000 cubic yards
Total Initial Fill	942,000 cubic yards
Crest Elevation (Dune)	12.5 feet (msl)
Crest Width (Dune)	20.0 feet
Berm Elevation	8.0 feet
Berm Width	35.0 feet
Project Dry Beach Width	111 feet (average)
Existing Dry Beach Width	65 feet (average)
Level of Protection Provided	40 year
Borrow Area Location	3,000 feet offshore, 3 miles N.E. of St. Lucie Inlet
Borrow Area Volume	8.0 million cubic yards
Overfill Factor (Nourishment Only)	1.15
Construction Method	Hopper Dredge with Monobuoy
First Cost (including advanced nourishment)	$9,419,000
Interest During Construction	102,000
Total Investment	$9,521,000
Annual Cost (8 5/8%)	
I&A	$ 834,500
Periodic Nourishment	505,800
Total Annual Cost	$1,340,300
Annual Benefits (8 5/8%)	
Loss of Land	$ 208,600
Damage to Development	858,400
Erosion Control Structures	13,800
Recreation	1,144,200
Total Annual Benefits	$2,225,000
Net Benefits	$ 884,700
Benefit-to-Cost Ratio	1.7

Cost Apportionment
(Existing Ownership & Use)

	First Cost
Federal	$4,380,500 (50.3%)
Non-Federal	$5,038,500 (49.7%)
Total	$9,419,000

Note: With parking and access development proposed by Martin County, the Federal share of project costs could increase slightly.

MARTIN COUNTY, FLORIDA

FEASIBILITY REPORT FOR BEACH EROSION CONTROL

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SAJPD-C

MARTIN COUNTY, FLORIDA

FEASIBILITY REPORT FOR BEACH EROSION CONTROL

THE STUDY

STUDY AUTHORITY

1. This study on beach erosion control in Martin County is being conducted in response to the following resolution adopted 18 May 1973 by the Committee on Public Works of the Senate which reads:

> RESOLVED, by the committee on public works of the United States Senate, that, in accordance with Section 110 of the River and Harbor Act of 1962, the Secretary of the Army is hereby requested to direct the Chief of Engineers, to make a survey of the shores of Martin County, Florida, and such adjacent shores as may be necessary in the interest of beach erosion control, hurricane protection, and related purposes.

Authority, policy, and guidelines forming a basis for the recommendations contained in the report are established by the 1974 Water Recources Act, the National Environmental Policy Act of 1969 and the following laws governing Federal beach erosion control studies and projects.

Public Law	Date
727, 79th Congress	13 Aug 1946
826, 84th Congress	28 Jul 1956
645, 86th Congress	14 Jul 1960
874, 87th Congress	23 Oct 1962
172, 88th Congress	7 Nov 1963

SCOPE OF THE STUDY

2. The study is of survey scope and encompasses the Atlantic shoreline of Martin County as shown on plates 1 and 3. The study area is about 22 miles in length and extends south from the north county line to a point about 2 miles north of Jupiter Inlet. The purpose of the study is to survey the shores of the study area and to determine the need and feasibility of providing measures for beach erosion control and hurricane protection.

3. The study includes an economic analysis of the problem and a determination of the extent to which the study area qualifies for Federal assistance under the terms of Public Law 826, 84th Congress, as amended by Public Law 874, 87th Congress. Consideration is given to a wide range of alternative plans in addressing the erosion problems and needs of the study area. These plans include nonstructural plans, which seek to preclude any significant form of physical development or construction which emphasize management measures rather than structural ones.

4. Sufficient in-depth investigations were made to determine damages and the extent of beach erosion and shoreline recession, including damages caused by storm tides and waves, coastal recreation needs, alternative plans required to satisfy planning objectives for enhancement of national economic development and environmental quality, possible impacts of the alternative plans, and the most practicable plan that maximizes the planning objectives. In this report, available data, augmented as necessary, were used to determine the feasibility of several alternatives. The unit cost incorporated in the evaluations is based on the cost of similar work at other locations and information received from suppliers of material.

STUDY PARTICIPANTS AND COORDINATION

5. The Corps of Engineers is principally responsible for accomplishing and coordinating the study, plan formuation, consolidating information from other agencies, and preparing the report. The Martin County Board of Commissioners, acting as the duly constituted beach and shore preservation authority for the county, is the local sponsor of the study. Other agencies or organizations assisting in the investigations and providing useful information include the State of Florida Department of Natural Resources, Division of Beaches and Shores, the State Division of Outdoor Recreation, and the Treasure Coast Regional Planning Council.

6. An initial public workshop was held 4 May 1977 and the initial stage public meeting was held on 23 May 1977. The second public meeting was held on 5 December 1979. The third public meeting was held on 8 September 1980. Involvement of the public and appropriate State and Federal agencies has been maintained throughout the study.

7. Local organizations have, through private and public contributions, acquired public ocean front lands along the Martin County shoreline of Hutchinson Island. A detailed description of the local acquisition of public access is referenced in report titled, "Complete Report Covering All Achievements to Date of the Martin County (Fla.) Public Beach Fund Campaign Committee."

STUDIES OF OTHERS

8. Prior reports bearing on the subject of beach erosion or including data on shore processes in the area under consideration have been made by the Corps of Engineers, by private engineering firms, and by the Coastal Engineering Laboratory of the University of Florida. Those references written by other than government agencies are shown in table 1. Summaries and appropriate details of pertinent reports are presented in appendix 1, section A.

TABLE 1

PRIOR REPORTS AND STUDIES BY OTHERS

Name of Report	Date	Publication
Jupiter Inlet, Fla.	1946	Knappen Engineering Company
Jupiter Island, Fla.	1946	Robert M. Angas, Civil Eng.
Jupiter Island, Fla.	1947	Bec. Ero. Board, Wash., D.C.
Jupiter Island, Fla.	1957	Coastal Eng. Lab., Univ. of Fla.
Jupiter Island, Fla.	1960	Coastal Eng. Lab., Univ. of Fla.
Jupiter Island, Fla.	1962	Coastal Eng. Lab., Univ. of Fla.
Jupiter Island, Fla.	1963	Gee and Jenson, Consulting Engrs.
Town of Jupiter Island, Fla.	1966	Gahagan & Bryant Assoc.
Jupiter Island, Fla.	1967	Coastal Eng. Lab., Univ. of Fla.
St. Lucie Inlet	1967	Coastal Eng. Lab., Univ. of Fla.
Jupiter Island, Fla.	1969	Coastal Eng. Lab., Univ. of Fla.
Jupiter Island, Fla.	1972	Arthur V. Strock & Assoc., Inc.
Martin County, Fla.	1972	Coastal Eng. Lab., Univ. of Fla.
Town of Jupiter Island, Fla.	1973	Arthur V. Strock & Assoc., Inc.
St. Lucie Inlet, Fla.	1974	Arthur V. Strock & Assoc., Inc.
Town of Jupiter Island, Fla.	1974	Arthur V. Strock & Assoc., Inc.
Town of Jupiter Island, Fla.	1975	Arthur V. Strock & Assoc., Inc.
Town of Jupiter Island, Fla.	1977	Gahagan & Bryant Assoc.
Town of Jupiter Island, Fla.	1978	Gahagan & Bryant Assoc.
Jupiter Inlet, Fla.	1979	Geology Dept., Univ. of Kentucky
Martin, Co., Fla.	1979	Federal Insurance Administration
Town of Jupiter Island, Fla.	1981	Arthur V. Strock & Assoc., Inc.
Jupiter Island, Fla.	1982	Arthur V. Strock & Assoc., Inc.
Jupiter Island, Fla.	1982	Arthur V. Strock & Assoc., Inc.

THE REPORT AND STUDY PROCESS

9. For clarity and ease of presentation, the report has been arranged into a main report, which includes an Environmental Impact Statement (EIS) and a Section 404 Evaluation Report, and supporting appendices. The main report is the basic document which describes the study and investigations conducted and provides the rationale and support for the conclusions and recommendations. The main report is intended to be of sufficient detail to permit the reader to determine the adequacy of the investigations conducted and the appropriateness of the conclusions reached. The technical appendices provide detailed backup data to support summaries found in the main report and indepth technical data where necessary. A list and description of appendices follows:

. Appendix 1 contains descriptions and data to support the Introduction and Problem Identification sections of the main report. Included are data on existing conditions, problems and needs, population and land use, economic conditions.

. Appendix 2 contains information on the effects assessment of detailed plans and displays the system of accounts.

. Appendix 3 contains pertinent correspondence relating to this study.

. Appendix 4 contains engineering investigations, design and cost estimates for the considered detailed plans.

. Appendix 5 contains the economic analysis of the detailed alternatives.

10. During the initial stage of this investigation, studies focused on identifying the specific areas of concern and problems being experienced. Following this, attention was placed on analyzing the problems being experienced and potential solutions to those problems. This was subsequently followed by detailed analysis and evaluation of those potential solutions that appeared to offer the best means for reducing the problems. At various points in this process, meetings were held with the local interests and general public to discuss the study progress and findings to date and obtain public input.

11. Prior to being forwarded to Congress, this report will be reviewed by the Corps' South Atlantic Division Office, the Board of Engineers for Rivers and Harbors, and the Office of the Chief of Engineers to insure technical adequacy and conformance to established laws and regulations. The Chief of Engineers will obtain the views of the Governor of Florida and various Federal agencies prior to forwarding this report to the Secretary of the Army. The Secretary will review the report and obtain the views of the Office of Management and Budget (OMB) prior to forwarding the report to Congress. Once in Congress, further action by the Corps is dependent upon project authorization and funding.

PROBLEM IDENTIFICATION

12. This section of the report discusses the problems and needs to which this study addresses itself. It presents a summary of the natural and human resources as well as the development and economy of the area. In addition, a summary of natural forces and their influence on the coastal areas of the county is presented. Details of the resources and economy, and problems and needs of the area are contained in appendix I.

TABLE 33

ECONOMIC SUMMARY [1/]

HUTCHINSON AND JUPITER ISLANDS

	HUTCHINSON ISLAND (PLAN S-2A)	JUPITER ISLAND (PLAN S-2B)
AVERAGE ANNUAL BENEFITS		
Loss of land	$ 208,600	$798,300
Damage to Upland Development	858,400	84,200
Damage to Existing Shorefront Protective Structures [2/]	13,800	92,500
Recreation [3/]	1,144,200	103,400
Total	$2,225,000	$1,078,400
AVERAGE ANNUAL COSTS	$1,340,300	$3,349,400
B/C Ratio	1.7	.32

[1/] Using the current Federal interest rate, 8 5/8%, a 50-year project life and June 1985 price levels.

[2/] Includes reduction in maintenance.

[3/] Reduced to account for increased maintenance costs ($60,500 annually) anticipated with implementation of the project.

NATIONAL OBJECTIVES

13. Federal policy on multiobjective planning derived from legislative acts which in major part establish and define the national objectives for water resource planning and specify the range of management measures that must be assessed. The conditions and criteria which must be applied when evaluating these measures in this study are contained in the Water Resources Council's Economic and Environmental Principles and Guidelines For Water and Related Land Resources Implementation Studies, published March 10, 1983.

14. The Federal objective of water and related land resources planning is to contribute to National Economic Development (NED), consistent with protecting the Nation's environment. Project plans are formulated to alleviate problems and take advantage of opportunities in ways that contribute to this objective. Of the array of alternative plans formulated, a plan that maximizes net national economic development benefits, consistent with the Federal objective is to be formulated and identified as the NED plan.

EXISTING CONDITIONS

Hutchinson Island

15. Of the 24.5 miles of study shoreline, 7 miles are north of St. Lucie Inlet. The southerly 1.0 mile of shoreline on Hutchinson Island has been accreting as a result of the sand impoundment adjacent to the north jetty. The next 0.6 mile of shoreline to the north is characterized by offshore coquina rock outcrops fronting a sand beach. The past erosion for this reach is in part due to its orientation which tends to accelerate the littoral transport for that reach. This reach of shoreline is not afforded the protection of the coquina onshore outcrops which prevail to the north and act as semipermanent shore protection preventing further shoreline recession. For that reach of shoreline from 1.6 miles to 3.0 miles north of the inlet, the shoreline is characterized by coquina outcrops. The elevation to top of rocks varies from +16 feet mean sea level* to mean sea level along the 1.4 miles of exposed length. Although there may be erosion where the rock outcrops do not form a continuous line, it is believed that an equilibrium shoreline exists and no further shoreline recession will take place in this reach.

16. The reach of shoreline from 3 miles north of the St. Lucie Inlet to the St. Lucie County line is characterized by a sand beach fronting a continuous dune line ranging in elevation from about 10 to 20 feet*. An average mean high water (m.h.w.) recession rate for this reach is about 2.0 ft./yr. The erosion rate is 2.5 cubic yards per foot of shoreline per year for this reach.

*All elevations refer to the NVGD (msl) datum unless otherwise indicated.

Jupiter Island

17. The beaches of Jupiter Island are composed of fine sand and shell fragments, and in some locations, exposed coquina rock. The sand and shell are easily moved by wave action and littoral currents. The outcroppings of coquina found along the beach have a material effect on the shore processes. In general, the effect is beneficial. The coquina outcroppings offshore form a semipermanent bar, which, together with the shifting sand bars, acts to retard the rate of erosion of the offshore area and to reduce the intensity of wave action on the shore. The slow disintegration of the coquina outcroppings along the shore has also furnished a large volume of shell fragments to the beach.

18. The shores of Jupiter Island have had a long history of erosion. The erosion damage to the beach, seawalls, and oceanfront property are accelerated and greatly magnified during storms of tropical and extra-tropical origin which frequent the area. As a result of several northeast storms the beach level is lowered, structures are damaged or destroyed, and valuable oceanfront property is eroded. Natural buildup of the beach during summer months generally alleviates the situation to some degree, though complete recovery seldom occurs. However, erosion during the winter months still leaves the shore vulnerable to possible severe damage from storms. Significant mean high waterline recession has occurred in the past along the northern 5.5 mile reach of Jupiter Island. Average annual recession decreases in the southerly direction to an average of about 3.4 feet along the major portion of the shorefront.

GEOLOGY

19. The State of Florida occupies only a part of a much larger geographic unit, the Floridian Plateau. The deep water of the Gulf of Mexico is separated from the deep water in the Atlantic Ocean by a partially submerged platform nearly 500 miles long and about 250 to 450 miles wide. This plateau has existed since the Paleozoic era and was above sea level until submerged for the first time during the Upper Cretaceous period. During this submergence, limestones and calcareous muds were deposited. The topmost of these units is the Ocala limestone.

20. The next period in the history of the peninsula was one of emergence, when the strata were slightly arched just after the Eocene epoch. The uplift was slow, the land first appearing as a series of islands, as is evidenced by the existence of fossil sand bars in the middle of the present peninsula. Superficial sand beds overlay the entire peninsula, but denudation of some of this sand to the present coast has undoubtedly occurred. With further uplift the islands enlarged and merged until the present peninsula resulted.

21. Following the Eocene uplift, the land was again depressed in the Middle Oligocene epoch to be elevated once more in the Late Oligocene epoch. It remained above sea level until the middle of the Miocene epoch when submergence again occurred with the deposition of some 200 feet of sand limestone (Hawthorne beds). Before the close of the Miocene epoch, the region emerged once more and the central part of Florida has been a land area since that time. The low-lying east and west coasts were repeatedly submerged during Pleistocene time when the Anastasia sands and limestones were laid down.

22. Either following or concurrent with one of the later periods of emergence, there appears to have been a tilting of the plateau about its longitudinal axis. The west coast was partially submerged, as indicated by the wide estuaries and offshore channels of its streams, while the east coast was correspondingly elevated. As a result of that movement, the east coast manifests the characteristics of an emergent coastline. It is probable that the barrier strip forming the present Atlantic shoreline was started, at least in some sections, as an offshore bar, which was elevated above the water surface by the tilting of the plateau and built up to its present condition by wave and wind action. This hypothesis permits an explanation of the presence of successive parallel ridges consisting principally of silica sand.

23. The east coast of Florida from the Georgia line to the study area, about 250 miles, consists of a series of sandy barrier islands separated by eight inlets. For the most part, the beach is rather straight. The sand is composed of fine quartz grains and finely divided shell fragments.

24. The Anastasia formation extends along the Atlantic coast of Florida from Anastasia Island to Boca Raton. This unit consists primarily of a sandy shell loosely held together by calcareous cement. In some areas the rock is composed of sandy limestone, calcareous sandstone and unconsolidated sand and shell. North of Boca Raton, the Anastasia formation forms the backbone of the Atlantic Ridge and is exposed along the coast of Martin County.

25. The Martin County shoreline, a barrier bar with a lagoon behind it for the most part, is typical of young shorelines of emergence. Within the last few years strong evidence has been produced of a small general rise in sea level along the coasts of the United States. The indicated rate of rise for Florida is about .006 foot a year.

Potential Source Material

26. The sediments found offshore of Martin County are generally slightly silty, medium to fine, slightly graded, shelly sand. The mean grain size is 0.29 mm. The visual estimate of shell content ranges from 1 percent to 95 percent with a mean value of 27 percent. The suitability of this material for beach fill was evaluated using methods presented and discussed by James in the Coastal Engineering Research Center (CERC) Technical Memorandum No.

60, "Techniques in Evaluating the Suitability of Borrow Material for Beach Nourishment." Using the composite grain size distributions for native beach and borrow area materials, the computed overfill ratio was 1.15.

27. Data concerning the portion of the Federal navigation project for the Intracoastal Waterway (IWW) located in the vicinity of the study area was evaluated for a potential source of beach fill material. Since 1957 maintenance dredging has provided an average of 6,500 cubic yards of material to the disposal area located on the northern end of Jupiter Island (along the western side). Dredging is performed on an average of 5.8 years. This vicinity of the IWW is not considered to be a high shoaling area. At present, an estimated 200,000 cubic yards of fill material would be located at this disposal site. Due to the location of and distance to this disposal site and the limited quantity of material available, this alternative source of material is not considered for initial beach fill. However, this site will be evaluated as a source for periodic nourishment material to reduce periodic nourishment costs of beach fill alternatives.

Offshore Reefs

28. A worm reef survey was conducted along a 7-mile reach of ocean front from St. Lucie Inlet north to the Martin-St. Lucie County line. With a few exceptions such as the pilings at Rand's Pier, intertidal reefs provide most of the substrate available for colonization by *Phragmatopoma lapidosa*, a sabellariid worm. In the study area, worm reefs were limited to the area from the House of Refuge museum south to Rand's Pier in Seminole Shores, with occurrence increasing to the south. No colonies of *Phragmatopoma lapidosa* were found in association with coquina outcrops north of the House of Refuge to the county line.

29. The geographical range of the sabellariid worm reefs extends from the United States to Brazil; therefore, it is very probable, that these reefs do occur, at least in patches, throughout the length of Martin County. The worm reefs support a variety of marine organisms. Seventy-three species of algae, 118 species of fishes, and 150 species of invertebrates have been reported from worm reefs between Cape Canaveral and St. Lucie Inlet.

BIOLOGY

30. Existing vegetation in the general project area includes shrubs and trees such as sand pine, Australian pine, sea grape, and wax myrtle. Watercourses, exclusive of the ocean shore, are bordered by cordgrass, glasswort-salt grass and rush marshes, often in extensive stands, in the interior. Closer to the ocean and on the dunes, the vegetation is primarily pioneer and/or salt-tolerant species such as salt grass, sand spur, wild bean, seaside spurge, and sea oats.

31. Wildlife in the project area is limited to small mammals such as raccoon, opossum, rabbit and small rodents, birds, amphibians, and reptiles. Birds are abundant on the beaches and in estuarine habitats, with shore and wading birds comprising the bulk of the avifauna, along with some waterfowl and songbirds. Beaches throughout Martin County are used for nesting by several species of sea turtles. To date, the Indian River Study conducted by the Harbor Branch of the Smithsonian Institute represents the most comprehensive undertaking in definition of floral and faunal distributions throughout the Indian River vicinity. Much of the following discussion is based on the finding of that report (Indian River Study, Annual Report 1973-1974, Volumes I and II, Harbor Branch Consortium, October 1974).

32. Limited data exist on fisheries along offshore continental shelf areas. Data taken in an offshore shark fishery based at Salerno in Martin County by Springer (1963) accounted for 17 species of sharks in the area. A published report by Anderson and Gehringer (1965) on offshore and inshore fishery in the Cape Canaveral region listed 134 species, while Bullis and Thompson (1965) recorded 105 species.

33. Marine habitats of particular concern along the continental shelf include surf zone, offshore reefs, benthic-open shelf areas, and neritic zone.

34. The surf zone is relatively devoid of macroscopic, attached vegetation and is characterized by a sand-shell bottom under the influence of continuous wave action. Lack of cover appears to be the major limiting factor inhibiting species diversity and populations; however, many benthic invertebrates are common (e.g., *Emerita* sp. and *Donax* sp.). Of the fishes that do inhabit the surf zone, the bottom feeding carnivores (catfishes, croackers, lizardfishes, pompanos, and threadfins) predominate, although roving carnivores (bluefish, jacks, ladyfish, and mackerels) and planktivores (anchovies, herring, etc.) also occur.

35. A wide variety of fishes and crustaceans inhabit coastal Martin County, supporting a substantial sport and commercial fishery. Also of interest are the coquina rock outcrops that occur intermittently along Martin County beaches.

Endangered and Threatened Species

36. Species listed as threatened or endangered by the U.S. Fish and Wildlife Service which might occur in the project area include the brown pelican, southern bald eagle, Florida manatee, and Atlantic Ridley, green, loggerhead, and leatherback sea turtles. Species considered threatened or endangered by the State of Florida, exclusive of the above, include the osprey, magnificent frigatebird, sparrow hawk, peregrine falcon, short-tail hawk, least tern, scrub jay, roseate spoonbill, great white heron, Caracara, grasshopper sparrow, Bachmans warbler, and Kirtlands warbler. No designated critical habitat exists along the shorefront in the study area.

WATER RESOURCES

37. The hydrologic boundaries of the study area north of St. Lucie Inlet are the Atlantic Ocean to the east and the Indian River to the west. The boundary south of the inlet is the Intracoastal Waterway system to the west and the Atlantic Ocean to the east.

38. The results of a subsurface hydrologic study encompassing the counties of St. Lucie, Martin, Indian River, and Okeechobee counties indicate that two main aquifers are found in this region: a shallow nonartesian or locally artesian aquifer, and a deep artesian aquifer.

39. The shallow aquifer is the principal source of fresh water in Martin County. It consists of the Anastasia formation and extends to a depth of about 150 feet below the land surface. It is composed principally of sand that contains thin lenses of shell, limestone, or sandstone.

40. The shallow aquifer receives most of its recharge from rainfall in the immediate surface area. In general, surface water runoff is small. A small amount of recharge to the shallow aquifer also comes from downward seepage of artesian water used for irrigation.

41. The major water courses in Martin County are in the coastal areas. North Fork St. Lucie River is joined by Bessey Creek just upstream of its confluence with South Fork St. Lucie River at Stuart. St. Lucie River flows easterly from this confluence to the Atlantic Ocean by way of St. Lucie Inlet. Indian River water movements are tidal and wind-driven.

LAND USE

42. Martin County occupies an area of 582 square miles in southeastern Florida. The City of Stuart, the county seat and largest city in Martin County, is approximately 100 miles north of the city of Miami, 40 miles north of the city of West Palm Beach, and approximately 240 miles south of the city of Jacksonville. The U.S. Bureau of the Census recorded the 1980 population of Martin County at 64,014.

43. Most of the developed land in the county is in the coastal area. Commercial and residential development is associated with the expansion of tourism and water-related recreation. Industrial development includes the manufacture of aerospace components, building materials, and various plastic products. The inland portions of the county consist primarily of pastureland and extensive croplands and citrus groves in areas near primary drainage outlets. Development along the Atlantic Ocean is both residential and commercial. Heavy development along the St. Lucie River, South Fork St. Lucie River, North Fork St. Lucie River, and the Indian River is primarily residential. Existing land use is summarized in section B of appendix 1.

CLIMATE

44. The climate of Martin County is subtropical, having an average annual temperature of 75.2°F. Rainfall is seasonal as 64 percent occurs during the rainy season from June through October. The average annual rainfall at Stuart is 56.14 inches. In general, the climate is featured by a long, warm summer with abundant rainfall followed by a mild, dry winter. Due to the high frequency of onshore winds and the proximity of the warm waters of the gulfstream, warm humid conditions occur during most of the year. However, during the winter months, the area is occasionally subjected to outbreaks of cold continental air which are in short duration and moderate rapidly. Consequently, subfreezing temperatures rarely occur in the area.

45. Rainfall is unevenly distributed during the year. The heaviest rainfall occurs during the period of June through October, followed by a distinct dry period from November through March.

46. It has been reported that the average daily temperature ranges from 64.7°F in January to 81.8°F in August. The highest temperature on record is 101°F occurring in June, while the record lowest temperature is 24°F recorded in January.

TRANSPORTATION

47. At present, there are no public transportation facilities the city or county maintains for easy public access to the beach. On Hutchinson Island, parking on State road rights-of-way is prohibited. However, the community has provided, and is developing, parking areas for all public access strips to the beach. The area is served by the Florida East Coast Railway, the Intracoastal Waterway, Interstate Route 95, the Sunshine State Parkway, U.S. Highway 1, State Highway A1A, and numerous paved and improved connecting roads. Two causeways, one from Jensen Beach and another from Stuart connect with A1A that parallels the shoreline on Hutchinson Island. There are no bridges connecting Hutchinson and Jupiter Islands at the time of this study. Access to Jupiter Island beaches is by way of U.S. 1, Bridge Road, and State Highway A1A.

HUMAN RESOURCES

48. Martin County was formed in 1925 from parts of Palm Beach and St. Lucie Counties. The county was named in honor of the late Governor John W. Martin. Martin County's development was that of a typical agricultural and fishing community. However, rapid residential development has occurred in the sixties, seventies, and eighties. The three principal employers in the county include Grumman Aerospace Corporation, Martin Memorial Hospital, and Martin County High School.

49. The average density of residents has increased from 30 to 50 residents per square mile between 1970 and 1978. A more detailed analysis of the population is presented in section B, appendix 1.

50. There are four incorporated municipalities within the study area in Martin County. These municipalities are Stuart, Ocean Breeze Park, Seawall Point, and Jupiter Island. Planning areas including the study area include Hutchinson Island, Greater Port Salerno, and South County.

51. In the Hutchinson Island Planning Area, residential, public, quasi-public, and one commercial structure are the only developed uses on Hutchinson Island. Eighty percent of Hutchinson Island was vacant land in 1976. However, there has been significant growth in the number of condominiums since this period. Over 80 percent of Hutchinson Island is planned for residential development in the future with 40 percent of the residential usage planned for estates and, 30 percent and 26 percent is planned for high and low density residential, respectively.

52. The Jupiter Island coastline is predominantly single family structures. On Jupiter Island, future construction will be single family residential exclusively. Approximately 52 new single family residences have been built on Jupiter since 1976. Approximately 20 percent of these homes are on the beach. Taking into account the size of useable lots behind the setback line, approximately 20 more homes can be built on ocean front property in the future. Local sources estimate that 200 new homes may be built on the island in the next 20 years.

53. The St. Lucie Skyways Public Airport is located in Martin County. Passenger service is provided by State and interstate buslines in Stuart. Martin County has nine major water supply systems, eight of which are in the general proximity of the coast. All systems produce a minimum of 100 gallons per capita per day. Also, there are five major sewage treatment facilities in the county. These systems have a minimum 200,000 gallons per day design flow. Southern Bell Telephone and Telegraph Company and Western Union Telegraph serve Martin County.

DEVELOPMENT AND ECONOMICS

54. The total employed labor force of Martin County was 17,799 in 1976. In the planning region, Martin County has the greatest share of employment in farming. Its 11 percent clearly exceeds the region's 7 percent which also surpasses State and national averages of 2 and 1 percent, respectively. However, employment distribution has changed significantly from 1969 to 1976. In-migration of retirees and substantial service employment increases have resulted in a decline of 11 percent in agricultural employment. Employment in construction has increased notably.

55. Total personal income in Martin County in 1975 was $260.7 million representing a 101.5 percent increase over the 1971 value. Per capita personal income rose 34.7 percent in the same period from $4,258 to $5,735. Wages and salaries accounted for 41.6 percent of total personal income in 1975.

56. Tax collections by Martin County within the county totaled $12,853,000 in the fiscal year 1976-1977. Of this total, 63.1 percent was provided by sales and use taxes, 17.0 percent by gasoline taxes, 11.9 percent by motor vehicle licenses, and 8.0 percent by documentary stamp tax and surtax. Also, State distributions include $1,922,000 from taxes, $3,191,000 from the Florida Education Finance Program to school districts, and $976,000 assistance to disabled persons and dependent children.

57. In Stuart, total revenue collected by the municipality totaled $2,173,000 or a per capita amount of $255. Total expenditures by the municipality and per capita amounts totaled $2,013,000 and $236, respectively.

58. The town of Jupiter Island is quite unique for its size. Per capita revenues and expenditures in fiscal year 1977 totaled $2,618 and $3,343, respectively. Most services on the island are provided from within the town without need from outside financial sources. The community spent more for maintaining and improving the physical environment of the island ($788,000 in FY 1977) than was spent by any other municipality in the region during the period. A comparative statement of revenues and expenditures for the study area is contained in section B of appendix 1.

PARKS AND RECREATION

59. The county is in the process of completing 10 public access strips to the beach on Hutchinson Island. This is in addition to the two public beaches, Stuart and Jensen. Parking, when completed, will be allowed in the strips and in some cases west of McArthur Boulevard. No bus or shuttle service is currently provided or planned in the future for the purpose of transporting people to the beach. Plans are being formulated to develope the St. Lucie Inlet State park on the north side of Jupiter Island adjacent to the inlet. Access would be provided by ferry and parking would be provided on the mainland. South of the proposed park is the Hobe Sound National Wildlife Refuge. Currently, Hobe Sound County Beach, located along 200 feet of shorefront adjacent to State Road A1A is the only county supported beach on Jupiter Island. The township currently allows access at Ocean Avenue, Ocean Ridge and at Hobe; however, parking and access is privately owned and not expected to be provided in the future. Blowing Rock Preserve is located on the south side of the island approximately six-tenths of a mile north of the Palm Beach county line. This area is not used for beach activities. No parking is allowed on the right-of-way on Jupiter Island. A more detailed discussion of parks and recreation within the study area is presented in section B of appendix 1.

Archeological and Historical Sites

60. The National Register of Historic Places lists one site, the House of Refuge at Gilbert's Bar on Hutchinson Island. This is the only one of 10 houses of refuge erected by the U.S. Life Saving Service in 1876 that still exists. Coordination with interested agencies such as the State Division of Archives, History, and Records Management and the Interagency Archeological Services Division, Department of the Interior has indicated that no detrimental effects are anticipated with implementation of the proposed plan. The House of Refuge is situated in back of a rock outcropping which acts as a semipermanent barrier for natural shore protection.

Air and Acoustical Quality

61. There is no documented air quality monitoring available for the project area. Relatively speaking, however, the air within the immediate study area is pollution-free. Slight amounts of air pollution originate from construction operations in the immediate vicinity and from automobile traffic during peak tourist seasons. However, due to the coastal wind regime, pollutants disperse rapidly.

PROBLEMS, NEEDS AND OPPORTUNITIES

NATURAL FORCES

62. Whether a shoreline erodes, accretes, or remains stable, depends upon various interrelated phenomena. Driving forces such as winds, waves, and currents combine to provide the energy that shapes the coastline in the study area.

Rising Sea Level

63. An important factor on the erosion situation of the Florida east coast is the average sea level. Available data do not yet permit a definitive conclusion on whether the sea is rising or the land is lowering. Indications are that the sea level along the Atlantic coast, in general, has been rising at a rate of .006[1] foot per year. Changes in sea level have great ramifications in flat coastal regions. An increase in the level of the ocean along the flat beaches of the Florida east coast, though very small vertically, would move the shoreline landward a noticeable distance due to the flat beach slope.

64. Coastal field data regarding such variables as winds, waves, currents, storms, and shore zone processes within the study area are limited. However, by interpolation of data obtained from such data collection points

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[1] Dr. 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, Florida.

at nearby locations on the Florida east coast and disaggregation of generalized data available in general for Florida's east coast, reasonable estimates are obtained of the magnitude of these variables within the study area.

Winds

65. A study of recorded and possible wind velocities, duration, and direction is necessary to determine their effect on characteristics of waves likely to be experienced in the study area. Wind-generated waves are a cause of loss of material from the beaches. In addition, the design height of shore protection structures is dictated to a great degree by the height and force of the waves likely to be experienced during storms which raise the still water surface elevation and transmit larger waves further landward than would occur under normal conditions.

66. The wind directional statistics are developed from data based on observations made by ships in passage. It should be stated that such ships tend to avoid bad weather when possible, thus biasing the data toward good weather samples. Also, the observations themselves are generally estimates based on the appearance of the waves, the drifting of smoke, or the flapping of flags, although some are anemometer measurements. In any event, the statistics are more representative of winds that can directly or indirectly affect the shoreline than shore-based inland observation facilities. The following table gives the percent of time and direction from which winds blow as indicated by shipboard meteorological records.

YEARLY AVERAGE WINDS

Direction	Percent of Time
North	10.6
Northeast	15.3
East	22.9
Southeast	14.2
South	12.6
Southwest	7.6
West	6.4
Northwest	8.1
	97.7 1/

1/2.3 percent of the time it is calm.

Waves

67. The most familiar ocean waves are wind-generated waves. They are formed by the transfer of energy from winds blowing over the water surface. They can vary in size from ripples to as large as 10 feet or more in height.

Their size and frequency of occurrence are important factors in shaping the shoreline on Florida's sandy coasts. Storm waves generated by the wind are the primary cause of losses of sand from the beaches, and the shoreline damage in the study area.

68. The wind waves that occur in the study area vicinity consists of "sea" and "swell." Seas are waves generated by local winds and are observed as traveling with the wind. Swells are waves generated from distant storms that enter the study area independent of the local wind conditions. In addition to the Wave Information Study (WIS) conducted by the U.S. Army Engineer Waterways Experiment Station (WES), available wave data sources include records from two pier-mounted wave gages that have been operated by the U.S. Army Coastal Engineering Research Center (CERC) at Daytona Beach to the north and one at Palm Beach to the south of the study area. The data recorded at each gage include a summary by month of the significant wave heights and periods (but not the directions), significant wave height distributions, and printed or plotted wave energy spectra. Linear interpolation of these results--derived from the two gages--provides a first approximation of typical wave conditions that exist in the study area.

69. Another source of wave data is the University of Florida's Coastal Data Network of wave gages. The gages closest to the study area are located at Vero Beach and Palm Beach. Monthly reports present significant wave heights and periods (but not directions), significant wave height distributions, and printed wave energy spectra.

70. Records of offshore wave and swell from shipboard observations are compiled by the U.S. Naval Weather Service Command. These data are available in the "Summary of Synoptic Meteorological Observations," Volume 4, hereafter referred to as SSMO. Data given in the SSMO is used to estimate the wave climate near the study area using the following accepted assumptions:

- swells are traveling in the same direction as sea waves, which in turn corresponds to wind direction;

- waves are propagated in one direction only, the observed direction, in any specific time interval;

- sea and swell waves of the same period can be treated alike, and will not lose energy to the atmosphere between the point of observation and the study area;

- no other wave heights or periods are present during the observation;

- all observations were made in water deeper than 2.56 times the square of the wave period for the wave periods recorded (i.e., "deep water" or shore waves).

71. The annual average deepwater significant wave height diagram shown in the following figure is derived from the SSMO data for an ocean area near the study area having an approximate boundaries of 80° W. latitude to the coast and 26° N. to 30° N. longitude. As with the wind data, it should

be stated that ships tend to avoid bad weather when possible. This being the case, the data are biased toward good weather and lower wave height observations. The diagram indicates that in deep water the majority of medium waves approach from the north through eastern quadrants and most of the largest waves from the northeastern quadrant.

72. By correlating the SSMO data with the wave gages operated by CERC it can be found that the average annual wave periods from the northeast, east, and southeast that strike the shoreline of the study area are approximately 7.3, 6.6, and 6.2 seconds, respectively. Also, the average annual wave height to be expected just seaward of the surf zone is about 2.1 feet.

73. Water waves as they approach the shoreline are affected by the ocean's bottom. For example, in Palm Beach where deep water is relatively close to the shoreline, the average annual significant wave height just seaward of the surf zone is about 2.3 feet, with approximately 1 percent of those observed above 7 feet. At Daytona Beach, where the continental shelf slopes more gradually and more significantly affects the incoming waves, the average annual wave height is about 1.8 feet with 1 percent or more observed above about 4.8 feet.

Tides

74. Tides near the study area are termed "semidiurnal" and are predictable. The mean range of tides in the Atlantic Ocean at Jupiter Island is 2.6 feet; the spring range is 3.0 feet.

75. Storms and hurricane winds blowing from the sea can create abnormally high tides in the coastal area. Tropical storms in this vicinity occasionally increase the tide range to about 7 feet. The lowest tide to be expected is 2 feet below mean low water.

76. Wind set-up is a local phenomena and occurs most dramatically in shallow water. Wind set-up has significantly more effect on seasonal and long-term erosion than astronomical tides. During severe onshore winds, wind set-up of 3 to 4 feet is not uncommon. As developed by NOAA, the storm surge levels with a frequency of occurrence of once in 10 years, 50 years, and 100 years would be 3.7, 5.2, and 6.1 feet above m.s.l., respectively.

77. The most significant ocean current that exists off the east coast of Florida is known as the Florida Gulf Stream. With the exception of intermittent local reversals, its flow is northward. The average annual current is approximately 28 miles per day varying from an average monthly low of about 17 miles per day in November to an average monthly high of approximately 37 miles per day in July. Tidal currents in the ocean, with the exception of the waters under the influence of St. Lucie and Jupiter Inlet, are believed to be very weak.

Hurricane and Northeast Storms

78. The study area is in a zone subjected to tropical storms of hurricane intensity. The study area is also subjected to relatively frequent coastal storms from the northeast (extra-tropical). Specific hurricanes and northeast storms that affected the beaches of Martin County are listed below. Northeast storm history will be updated when the data become available.

79. The study area has experienced, within a 150-mile radius, 52 storms of hurricane intensity between 1830 and 1965, inclusive, or an average of one hurricane every 2.6 years. However, only 15 hurricanes passed within a 50-mile radius in that period, or an average of one hurricane in nine years. The effect of hurricanes on the beaches of Martin and North Palm Beach Counties has not been as severe as that of many northeast storms. The short duration of hurricane-force winds and waves in the area has usually limited the severity of erosion damage. The paths of hurricanes affecting the study area from 1830 to 1979 is indicated on plate 1.

HURRICANES	NORTHEAST STORMS
August 23, 1885	November 1956
October 10-13, 1904	December 1957
July-August 1926	March 1962
September 6-22, 1926	November-December 1962
September 6-22, 1928	December 1963
August 31-September 7, 1933	January 1964
August 24-29, 1944	
August 23-31, 1949	
October 15-19, 1950	
October 16-30, 1963	
August 17-29, 1964	
October 7-14, 1964	
August 27-September 10, 1965	
September 4, 1979	

Flood Insurance Study

80. A Flood Plain Information report was prepared for the Board of County Commissioners of Martin County in 1973 by the Corps of Engineers. That report was prepared to provide knowledge of flood potential and flood hazards in regard to developing a basis for land use planning and management decisions affecting flood plain utilization.

81. The Federal Insurance Administration (FIA) has conducted a study to provide information on the flood elevations that can be expected along the Martin County shoreline.

THE STORM PROBLEM

82. The problem along the study area is one of erosion and lowering of the beach profile and recession of the shoreline and dunes. Hurricanes and severe northeast storms have caused considerable erosion and damage. Along parts of the shore within the study area erosion of the beach and dune has placed seawalls, buildings, and other structures in a position vulnerable to severe damage during storms.

83. Hurricanes and severe northeast storms have caused considerable erosion and damage at Jensen Beach. Many of the major storms of record occurred prior to full development of the area. However, the storms of October 1963 and August 1965 (hurricanes), and December 1963 and January 1964 (northeasters) damaged or destroyed seawalls, retaining walls, and upland buildings and facilities, and eroded the recreational beach completely, lowering the profile as much as 6 feet. The beach and recreational areas were partially replenished by the use of bulldozers, draglines, and trucks in distributing sand gained during favorable weather. During Hurricane Betsy in September 1965, storm tides, waves, and currents completely eroded the public recreational beach area and lowered the profile 7 feet in front of the seawall that was constructed between 1957 and 1968 at Jensen Beach Park. The southern end of the 254-foot-long concrete sheet pile seawall at Jensen Beach Park was flanked and the washout extended about 40 feet upland. The seawall was destroyed by the Thanksgiving Day storm in November 1984. Both storm wave action and the average annual erosion rate of the mean high water shoreline have significantly receeded the shoreline from the historical shoreline documented by 1882 surveys (see plate 2).

84. The county beach in the city of Stuart, as is the case of Jensen Beach, has been repeatedly eroded during storms of record and was completely eroded as a result of Hurricane Betsy in September 1965. The Thanksgiving Day Storm of 1984 eroded approximately 25 feet of primary dune width based upon site inspections in January 1984 and March 1985 by district personnel. Development at the county parks consisting of wooden cross walks and life guard towers on pilings are currently susceptible to damage as a result of that storm.

85. Along parts of Jupiter Island shore, erosion of the beach and dune places seawalls, buildings, and other structures in a position vulnerable to severe damage, especially during storms. The shores of Jupiter Island have had a long history of erosion. The erosion and damage to the beach, seawalls and oceanfront property are accelerated and greatly magnified during storms of tropical and extra-tropical origin which frequent the area. As a result of several northeast storms the beach level is lowered, structures are damaged or destroyed, and valuable oceanfront property is eroded. Natural buildup of the beach during summer months generally alleviates the situation to some degree, though complete recovery seldom occurs. However, erosion during the winter months still leaves the shore vulnerable to possible severe damage from storms.

THE BEACH EROSION PROBLEM

Hutchinson Island

86. A previously authorized beach erosion control study for Martin County, completed in 1968, recognized the need for erosion control measures for three separate areas. However, due to predominately private ownership of most of the shore, Federal assistance could not be recommended in improvements needed. Local organizations have subsequently, through private and county contributions, acquired public ocean front lands and the State has enacted laws to provide public beach in front of private property that would result in increased Federal participation in any future plans developed.

87. The previous study determined that remedial measures needed would involve placement of fill to form a protective and recreational beach for shoreline of Jensen Public Beach and Stuart Public Beach and Jupiter Island. The present beach erosion trend for the mean high water shoreline at Jensen Beach county park is about 1 foot of recession per year. At Stuart public beach, the recent average mean high water shoreline erosion trend is about 2 feet of recession per year. The past recession of the shoreline has left these beaches susceptible to further storm damage and without sufficient capacity to meet recreational needs. Without erosion control measures, continued recession will further diminish natural protection afforded by the backshore of the beach and the primary dune to upland property. At Jensen Beach Park the upland property includes a concrete block house used for storage of life saving equipment, a wooden life guard tower with wooden cross walks on piling, pedestrian cross walks, restrooms, and parking areas. Considerable structural upland development at Stuart Public Beach has included dune cross-overs, covered shelters, concrete pathways, landscaping, restrooms and parking areas. An evaluation of erosion damage prevention benefits attributed to proposed erosion control measures is contained in the economics section of this report.

88. At Jensen and Stuart Public Beach Parks and between, a significant erosion trend occurs. Along the ocean frontage at Tiger Shores access point and private property located 150 feet north of the northern limit of the Stuart Public Beach Park (DNR Profile R-20) the mean high water shoreline erosion rate is about 3 feet per year and only 7 feet of primary dune width remains. Another significant problem area is located along the ocean frontage of private property 1,900 feet south of the southern limit of Stuart Public Beach Park. Recession of the shoreline there (DNR Profile R25 and R26) is currently 4.3 feet per year and only 5 to 15 feet of primary dune width presently exists. Locations of profile lines are indicated on plate 3.

St. Lucie Inlet

89. St. Lucie Inlet was created by an artificial cut into the barrier 30 feet wide and 5 feet deep by local interests in 1892. By 1898 the inlet widened to 1,700 feet and by 1922 to 2,600 feet. Between 1926 and 1929 the St. Lucie Inlet District and Port Authority constructed a stone jetty 3,325 feet long on the north side of the inlet.

90. Before construction of the north jetty, St. Lucie Inlet was typical of all unprotected inlets across a sandy beach with an alongshore movement of drift material. The inlet acted as a barrier in itself by trapping littoral-drift material in a middle-ground shoal and in a bar across the mouth of the inlet. Littoral drift across the inlet was irregular. The inlet and adjacent shores both to the north and south were unstable. Historic surveys show that between 1882 and 1928 the shoreline for about 1.5 miles north of the inlet receded considerably.

91. When the north jetty was constructed at St. Lucie Inlet, the north side of the inlet was stabilized and accretion on the north side of the jetty took place, moving the shoreline back seaward to a position in 1946 that approximately conincided with the 1882 position. However, the jetty affected the inlet as a littoral barrier and the shore to the south continued to recede. Shoreline recession south of the inlet has continued since 1882. Between 1882 and 1946 the shoreline recession was at a maximum of about 2,500 feet at the inlet and gradually decreased southward. Between 1946 and 1964 shoreline recession south of the inlet continued, with the most severe being immediately south of the inlet along the access frontage of St. Lucie Inlet State Park and Hobe Sound National Wildlife Refuge.

92. Erosion and shoreline recession in the study area have been occurring since at least 1882 (before the inlet opening and jetty construction). Since the dominant littoral drift in the area is from north to south, it would be most unusual were the inlet and jetty not a contributing factor to erosion south of the inlet. Data are insufficient to make a quantitative determination of the extent of that contribution. However, even full bypass of the littoral drift across St. Lucie Inlet, though beneficial, would not eliminate the erosion problems at Jupiter Island.

Jupiter Island

93. The beaches of Jupiter Island are composed of fine sand and shell fragments, and in some locations, exposed coquina rock. The sand and shell are easily moved by wave action and littoral currents. The outcroppings of coquina found along the beach have a material effect on the shore processes. In general, the effect is beneficial. The coquina outcroppings offshore form a semipermanent bar, which, together with the shifting sand bars, acts to retard the rate of erosion of the offshore area and to reduce the intensity of wave action on the shore. The slow disintegration of the coquina outcroppings along the shore has also furnished a large volume of shell fragments to the beach.

94. The direction of littoral drift is reversed during the summer months when normally gentle southeasterly winds create waves which cause movement from south to north. The drift reversal is more than offset by the large and rapid movement of beach material from north to south during the fall and winter months when the more violent action of waves from the northeast prevails. The behavior of the shore of Jupiter Island is influenced by two inlets, St. Lucie and Jupiter. The inlets are protected by jetties of varying length and effectiveness. The inlets constitute partial littoral barriers.

95. Analysis of the littoral movement along the southeast coast of Florida, to the extent that available data permit indicates that in the shore segment near Jupiter and Palm Beach Islands, the southerly drift is appreciable. Analysis also shows that although erosion of the foreshore prevails in much of the area, there is no significant accumulation of the eroded material in quantities comparable to the eroded quantities at any of the littoral barriers along this sector of the coast. The average annual beach erosion losses (described in appendix A on the Beach Erosion Problem) of 6.8 cubic yards per foot of shorefront per year for the 16.5 mile length of Jupiter Island indicates that the anticipated annual erosion losses for this reach total 592,400 cubic yards. Since this annual loss (592,400 cubic yards) is greater than the estimated southerly net littoral drift (230,000 cubic yards per year), the data suggest that erosion of the shore south of St. Lucie Inlet would be inevitable even if the natural drift rate were restored south of St. Lucie Inlet. Sand bypassing across St. Lucie Inlet, even if all the littoral drift were bypassed, would be helpful but would not solve the problem. Based upon previous records, an estimated quantity of about 70,000 cubic yards is deposited in the channel at St. Lucie Inlet each year.

96. An important aspect of littoral movement in the area is the degree of exposure of the coast to high- and low-steepness waves. The Little Bahama and Great Bahama Banks are located about 60 miles to the east of the Florida coast and virtually prevent attack of the shore by long-period or swell-type waves from the east. The shoreline for some distance north of Lake Worth Inlet is oriented so it is exposed for about an 80- to 90-degree sector to the northeast between the mainland and the Bahama Banks. This means that the shore is subjected to some low-steepness waves (long-period swells) which would transport back to the beach zone material which has been eroded from the beach and carried to the offshore zones by high-steepness waves (storm-type waves).

97. Many structures have been built along the shoreline of the area in an effort to stabilize the shore and no doubt those structures have diverted littoral drift to deeper waters and reduced the net southerly rate of drift. Wind transport of beach material to the backshore and possibly shell ground to powder or dissolved in sea water could account for some losses but undoubtedly these would only be a small fraction of the net residual loss. This provides strong evidence that material is being transported to the offshore zone where, for all practicable purposes, it is lost from the nearshore system of onshore-offshore transport.

Jupiter Inlet

98. Jupiter Inlet is in northern Palm Beach County about 16.5 miles south of St. Lucie Inlet and within the limits of the study area. The inlet is a natural waterway connecting the Atlantic Ocean with Loxahatchee River. According to historical accounts, Jupiter Inlet, when open, has been used for navigation for about 300 years. In the past, severe storms closed the inlet. The most recent closure was from 1942 through 1947. Since 1947 the inlet has been dredged periodically by the Jupiter Inlet District, a local taxing district. Often a fan-shaped bar lies across the ocean entrance.

Mean range of tide inside the inlet averages about 1.3 feet. Mean tidal range in the ocean at Jupiter Inlet is 2.6 feet. Littoral drift in the vicinity of Jupiter Inlet is predominantly southerly; net southward movement is estimated to be about 230,000 cubic yards annually.

Improvements

99. Between 1896 and 1909, under special emergency authority, the Federal Government reopened Jupiter Inlet three times. Local interests also re-opened the inlet several times between 1896 and 1922. The Jupiter Inlet District, created in 1921 by special act of the Florida Legislature, spent in excess of $400,000 improving and maintaining the inlet between 1922 and 1960. In 1922 the Inlet District built parallel jetties about 350 feet apart. Subsequently, the jetties were extended and strengthened. In 1940, the Inlet District built an angular groin at the seaward end of the south jetty. The intended purpose was to increase current velocities and induce scouring between the jetties where closure of the inlet had recurred. However, the inlet again closed in 1942 and remained closed until 1947. Since the inlet district reopened the inlet in 1947, biannual maintenance dredging has kept the inlet open for small-craft navigation.

Conditions if No Federal Action is Taken

100. The "no action"alternative perceives a continuation of the existing conditions and provides no solution to existing problems. This alternative avoids any undesirable effect that may be associated with structural and non-structural plans for beach erosion control. This option, although not favored by local interests, is maintained throughout the study process to provide a basis of comparison of effects of other alternatives.

THE NEED FOR BEACH

101. Martin County is experiencing a sustained growth rate and development trend because of a favorable location and subtropical climate. Correspond ing with progressive development, the recreational need for sufficient beach area is increasing. Long-term storm damage to the area beaches has resulted in reduced beach widths, thereby diminishing the shoreline's natural protection, leaving the backshore and primary dune susceptible to accelerated erosion during future storms. Loss of the 254-foot-long concrete seawall at Jensen Beach public park during the Thanksgiving Day Storm of 1985 is a prominent example of the damages experienced along the study area. Even though the ongoing erosion of the backshore adds to the active foreshore slope of the beach, the mean high water shoreline exhibits a recession trend. In summary, the area beaches are in state of reduced capacity for the purpose of providing protection for upland development and to meet the long-term recreational needs of the study area.

PRIOR CORRECTIVE ACTION

102. Along the Atlantic shores of Jensen Beach county park a 254-foot long concrete seawall was built from 1965-1968. Previous erosion control mea-

sures at Stuart county park have been limited to the use of road equipment in 1978 to readjust the beach profile. The result of this action was that the mean high water shoreline areas temporarily moved seaward to provide protection to the primary dune and surface area for visitors.

103. The only other prior shore protection measures along Hutchinson Island consists of 300 feet of rubble revetment at Little Ocean Club and 750 feet of dura-bag (three bag sill revetment containerized sand) at Sun Tide Condominiums and Tiger Shores public access from 2,625 to 3,250 feet north of Stuart county park. On the north side of St. Lucie Inlet the stone jetty is about 3,325 feet long. Rand's pier is located on Hutchinson Island just north of St. Lucie Inlet and is currently in disrepair and not being used.

104. Previous erosion control endeavors employed along the Jupiter Island shorefront consisted of about 16,000 linear feet of seawall, 7,000 linear feet of which are precast concrete-block sloping revetment and the remainder are vertical steel-sheet-pile walls. About half of the vertical seawalls have abutting groins of various designs and lengths. There are two rock jetties about 350 feet apart at Jupiter Inlet. The north jetty is 600 feet long and the south about 475 feet long. In 1956 a 300-foot concrete-capped steel-sheet-pile jetty was constructed parallel to and about 100 feet north of the original north jetty.

105. Corrective action by the residents and town of Jupiter Island, relative to protection of property and development from the ocean forces, has been extensive. Seawalls, sloping revetments, groins, and artificial nourishment have been provided by local interests. Vertical seawalls, generally along an established bulkhead line and constructed in stages as recommended by the 1947 Beach Erosion Board report, were built along much of the developed part of Jupiter Island. The walls were mostly of steel-sheet-pile construction with concrete caps at elevation 16 feet, mean low water. Groin construction, which was deferred as long as adequate beach remained in front of the seawalls began in the early 1950's. Since that time, local interests have constructed numerous groins of varying types, lengths, and design.

106. In 1956, the town of Jupiter Island began a beach nourishment program. Beach fill material was dredged from inland sources, generally from Hobe Sound and the Intracoastal Waterway. From 1956 to 1963, a total of about 700,000 cubic yards of material was deposited on the beach. Beach nourishments that have been accomplished at Jupiter Island are indicated on plate C-1, appendix 1.

107. Until 1960, most damaged or destroyed vertical seawalls were replaced by ones of similar type. In the summer of 1960, the first precast concrete-block revetment was constructed on Jupiter Island. Since that time, that type of revetment has been installed over considerable lengths of the Jupiter Island shore.

108. In 1963, an erosion-prevention plan for Jupiter Island was developed by a private engineering concern. The plan provided for beach nourishment,

protection and strengthening of existing seawalls, and annual periodic nourishment as needed thereafter. Beach nourishment has been accomplished by use of a Sauerman scraper rig hauling sand to the beach from offshore. The system consists of a barge anchored 500 to 800 feet offshore and a bucket picks up material from a predetermined shoal and carries it to shore. The sand-scraper operation at Jupiter Island was evaluated by a cooperative program between the Corps of Engineers and the University of Florida. Although the equipment did move sand from up to 700 feet offshore, monitoring studies of the operation by the University of Florida Coastal and Oceanographic Laboratory showed that the scraping system should be designed to work further offshore. The study also showed that the scraper should not return to the same sites as the material refilling the borrow pits is unsuitable for beach nourishment. This latter restraint would limit the life of this type operations as undisturbed areas suitable for beach fill were exhausted. In the past, the beach fills provided by the town of Jupiter Island residents are: 254,000 cubic yards in 1957, 366,000 cubic yards in 1961; 363,000 cubic yards between 1964-1968; 280,000 cubic yards between 1970-1972; 2,376,000 cubic yards in 1973-1974; 1,327,000 cubic yards in 1977-1978, and 1,000,000 cubic yards in 1983. Future plans for beach nourishment include placement of periodic nourishment as needed.

STATUS OF PLANS AND IMPROVEMENTS

109. Along the shores under study, there is one Federal project authorized. This is the Federal navigation project construction at St. Lucie Inlet. The authorized project at St. Lucie Inlet consists of a modified jetty-weir plan that includes, extension of the north jetty by 650 feet, an impoundment basin, a detached breakwater 400 feet long, construction of a south jetty 1,200 feet long past the existing shoreline, and a channel. Initial beach fill of about 451,000 cubic yards was provided along publicly owned shorefront beginning 1,500 feet south of St. Lucie Inlet for a distance of up to 3.5 miles from the authorized Federal navigation improvements at St. Lucie Inlet constructed in September 1982. Maintenance of the authorized Federal navigation channel at St. Lucie Inlet in 1984 and 1985 provided an estimated 377,300 cubic yards of beach fill to the shorefront beginning 3,500 feet south of the south jetty. It is anticipated that maintenance dredging disposal will provide an estimated 190,000 cubic yards of beach fill material to this reach of shorefront on an average annual basis.

110. In 1970, Florida passed a law requiring that along sand beaches facing the open waters of the Atlantic Ocean or Gulf of Mexico, any construction or excavation must be at least 50 feet upland of the line of mean high water. This was found inadequate and difficult to enforce. In 1971, another law, the Coastal Construction Setback Line Law, was passed. The objectives of this law are to prevent beach encroachment that would endanger the existing beach-dune system and to help prevent damage to existing and future buildings. The previous control line for the Martin County beaches was *
established officially by the State of Florida on 23 May 1972.

At the time this report was prepared, a revised control line was established landward of the existing line in July 1985. Martin County currently has evacuation plans in place for the effect of hurricanes. *

PLANNING CONSTRAINTS

111. As previously discussed, nearly all of the study area's shoreline, with the exception of the publicly owned shores; fronting the county parks of Jensen Beach and Stuart, south of St. Lucie Inlet, south of Jupiter Inlet, and 10 access strips on Hutchinson Island, are privately owned, sparsely developed, and without public access. Viable alternative plans for beach erosion control were developed to address the needs of the study area and formulated to address the desires of local interests.

PLAN FORMULATION

GENERAL

112. With respect to the local planning objectives and the Water Resources Council's Principles and Guidelines objectives, a preliminary formulation and evaluation process was conducted using all appropriate measures identified, without bias, including those proposed or suggested by different groups and agencies to determine which warrant further detailed analysis. Both structural and nonstructural means were given equal consideration during this analysis.

EVALUATION CRITERIA

113. The "Principles and Guidelines" require the systematic preparation and evaluation of alternative ways of addressing identified problems, needs and concerns, and opportunities under the objective of National Economic Development (NED) consistent with protecting the nation's environment. 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 the four accounts of: NED, Environmental Quality (EQ), Regional Economic Development (RED), and Other Social Effects (OSE). The following economic, socioeconomic, and environmental criteria was adopted during the formulation process:

- Tangible benefits should exceed project economic costs;
- Each separable unit of improvement or purpose should provide benefits at least equal to its cost;
- Within the framework of the formulation criteria the scope of the development should provide the maximum net benefits;

• The costs for alternative plans of development should be based on preliminary layouts, estimates of quantities, and June 1985 unit prices;

• The benefits and costs should be in comparable quantitative economic terms to the fullest extent possible;

• Annual costs and benefits should be based on a 50-year amortization (project economic life) period and the authorized interest rate;

• The annual charges should include the cost of operation and maintenance of the considered plans.

• Plans should avoid all detrimental environmental effects to the extent feasible; and,

• Unavoidable adverse environmental impacts should be fully noted, quantified when possible and qualified in any case to facilitate a knowledgeable decision making process.

Environmentally, plans should also:

• preserve unique and important ecological, esthetic, and cultural values of our national heritage.

• conserve and use wisely the natural resources of our nation for the benefit of present and future generations.

• restore, maintain, and enhance, the natural and manmade environment in terms of its productivity, variety, spaciousness, beauty, and other measures of quality.

• create new opportunities for the American people to use and enjoy their environment.

Socioeconomically, plans should minimize and, if possible, avoid:

• Destruction or disruption of community cohesion;

• Injurious displacement of people, and,

• Disruption of desirable community growth;

Considerations should be given to protection of historical, archeological, and other public interest areas;

• 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,

• Provisions should be made during project formulation to afford interested locals an opportunity to participate in the selection of a plan.

TECHNICAL CRITERIA

114. Within the planning framework the following technical criteria were adopted for use in formulating a plan:

- The plan proposed should alleviate the effect of or prevent the erosion now being experienced;

- The plan should enhance the recreational potential of the area;

- The plan should, to the extent that is practicable, provide as a minimum, protection against the 10-year storm surge and waves;

- Protective works should be planned to prevent overtopping by the design storm;

- Wave heights considered should be those expected to occur with the design storm;

- A beach berm, if included in a plan of protection, should have height and width dimensions adequate to dissipate the wave energy produced by the design storm and to resist erosion to the extent that the protective works will not fail.

Flood Plain Management Criteria

115. Executive Order 11988, Flood Plain Management, signed 24 May 1977, requires Federal agencies to recognize significant values of flood plains and to consider the public benefits that would be realized from restoring and preserving flood plains. In development of alternative solutions to the erosion problem in Martin County, consideration is given to the following:

- Avoid development in the base flood plain (100-year flood) unless it is the only practicable alternative;

- Reduce the hazard and risk associated with floods;

- Minimize the impact of floods on human safety, health, and welfare; and

- Restore and preserve the natural and beneficial values of the base flood plain.

FORMULATION METHODOLOGY

116. The final plans selected for detailed analysis reporting were developed through a three-step planning process. These steps were: (1) Identification of possible solutions; (2) Development of alternatives, and (3) Assessment of alternatives. Each step was iterative in the process of identifying and selecting the best possible courses of action for the study area.

117. During the first step, the population of alternatives developed included traditional type projects, programs that could be carried out by local interests and all suggestions surfaced by participants in the public meetings. Each plan in the array was screened based on its ability to satisfy the planning objectives. The viable plans were developed sufficiently to assess generalized benefits, costs, and impacts. Those plans meriting closer evaluation were carried into the second step.

118. In the second step, the problems of the project site were reevaluated and the local planning objectives specified. The alternative plans carried over from step one were then refined to an increased level of design with emphasis on the overall capability and reliability of each plan to meet the specific planning objectives. These intermediate plans were screened according to the established criteria and those meriting more detailed study were carried into the third step.

119. In the third step, detailed analyses were conducted on those plans carried over from Step 2. Based on the result of these analyses, a plan was developed for implementation.

FORMULATION OF PRELIMINARY PLANS

120. This section of the report summarizes stage 1 and stage 2 of the plan formulation process.

MANAGEMENT MEASURES

121. The possible management measures considered in the first stage of project formulation include structural and nonstructural solutions. During stage 1 planning, all reasonable management measures were considered.

PLANS OF OTHERS

122. During the study, several public meetings were held with the County Commissioners, city officials, and interested organizations and individuals. The plan most supported by local interests consisted of a 4-mile beach fill from the north county line to the south of Stuart Beach Park.

123. Nourishment of the 1977-1978 beach fill areas along Jupiter Island was accomplished in 1983 as shown on plate C-1.

ANALYSIS OF PLANS CONSIDERED IN STAGE I

DESCRIPTION, ASSESSMENT, AND EVALUATION OF PLANS

124. The possible management measures considered in the first stage of project formulation are listed in table 2 on the following page. The matrix of this table further shows the planning objectives that each management measure would meet. As indicated, many of the alternatives listed do not fully address the planning objectives. Planning objectives considered in the preparation of this table include the local planning objectives and the accounts required by the Water Resources Council's "Principles and Guidelines." These alternatives are discussed in the following paragraphs.

TABLE 2

POSSIBLE SOLUTIONS AND PLANNING ACCOMPLISHMENTS

POSSIBLE MEASURES		LOCAL PLANNING OBJECTIVES[1]				PRINCIPLES AND GUIDELINES[2]			
		PB	FP	EC	TBE	NED	EQ	OSE	RD
NA	NO ACTION	0[3]	0	0	0	0	0	0	0
	NONSTRUCTURAL MEASURES								
NS-1	Rezoning of beach area	0	P	0	P	0	0	P	P
NS-2	Modification of building codes	0	P	0	0	0	0	P	0
NS-3	Construction setback line	0	P	0	P	0	P	P	P
NS-4	Moratorium on construction	0	P	0	0	0	0	0	0
NS-5	Flood insurance	0	0	0	P	0	0	P	0
NS-6	Evacuation planning	0	0	0	0	0	0	P	0
NS-7	Establish a no-growth program	0	0	0	0	0	0	0	0
NS-8	Other recreational facilities	0	0	0	0	0	0	0	0
	STRUCTURAL MEASURES								
S-1	Modification of St. Lucie Inlet	P	P	P	P	P	P	P	P
S-2	Beach fill with periodic nourishment	F	P	F	F	F	F	F	F
S-3	Beach fill with hurricane surge protection sand dune and periodic nourishment	F	P	F	P	P	P	0	P
S-4	Beach fill with periodic nourishment and offshore breakwater	F	P	P	P	P	P	0	P
S-5	Corps 1968 Plan of Improvement	P	P	P	P	P	0	P	P
S-6	Hurricane surge protection-sand dune	P	P	P	P	0	P	P	0
S-7	Revetment	0	P	P	0	0	0	P	0
S-8	Seawall	0	P	P	P	P	0	P	0
S-9	Stabilization of beaches and dunes by vegetation	0	P	P	0	0	P	0	0
S-10	Modification of building codes and rezoning of beach area	0	P	P	0	P	P	0	0
S-11	Flood proofing of structures	0	P	0	0	0	0	P	0
S-12	Condemnation of land and relocation of structures	0	P	0	0	0	0	P	0

NOTES:

[1] PB - Provision of recreation beach
FP - Protection of flooding and wave damage
EC - Beach erosion control
TBE- Protection of tourist base economy

[2] NED- National Economic Development
EQ - Environmental Quality
OSE- Other Social Effects
RD - Regional Development

[3] F - Meet fully objective
P - Meet partially objective
0 - Not meeting objective

SCREENING OF ALTERNATIVES

125. After initial appraisal and preliminary evaluation of the 21 possible solutions and combinations thereof, within the guidelines and criteria established by the study objectives, those alternatives that could be considered no further as viable solutions and could not be implemented, were eliminated. Those alternative solutions warranting further study are as follows:

No Action (NA)

126. The "no action" alternative perceives the continuation of existing conditions and provides no solution to existing problems. However, it also avoids any undesirable effects that may be asociated with structural or nonstructural plans for beach erosion control. This option, although not favored by local interests, is considered in relation to the effects of other alternatives.

Rezoning of Beach Area (NS-1)

127. Rezoning of the beach area and modification of building codes as a result from implementation of the construction setback line and the impact thereof on land use planning.

Modification of Building Codes (NS-2)

128. Modification of building codes and rezoning of the beach area considered as subfeatures of the entire concept--and the intent and purpose--of the construction setback laws.

Construction Setback Line (NS-3)

129. The State construction setback line for Martin County was established with State approval on 23 May 1972. This alternative is therefore accepted as an existing condition and will be included in the nonstructural combination plan.

Moratorium on Construction (NS-4)

130. Moratorium on construction is rejected by local interests since the desired growth of the area is oriented towards tourism and recreation, attracting retirees, and promoting a stable construction industry.

Flood Insurance (NS-5)

131. Local interests participation in the Federal Flood Insurance Program involves steps being taken toward enacting building codes that require more flood protection to be built into new structures. This is a local option and will be included in the nonstructural combination plan.

Evacuation Planning (NS-6)

132. This is a nonstructural alternative which will be incorporated in the nonstructural combination plan.

Establish A No-Growth Program (NS-7)

133. The establishment of a no-growth program is rejected by local interests. Growth in the area, particularly that in connection with beach activities, is needed to provide economic depth to the communities. This alternative is therefore excluded from detailed studies.

Other Recreational Facilities (NS-8)

134. Martin County is fortunate to have had the foresight to reserve portions of the ocean front for public use. Relatively few communities with sandy beaches on Florida's lower east coast can claim to be more oriented toward beach activities. Without some type of protection the county will lose their capability to support expanding public use.

Modification of St. Lucie Inlet (S-1)

135. The modification of the inlet as recommended by the existing Federal project is accepted as an existing condition that will nourish the beaches for about 3.5 miles south of St. Lucie Inlet. Therefore, the alternative will not be reconsidered by this report.

Beach Fill with Periodic Nourishment (S-2)

136. This alternative would provide protective and recreational beach. An offshore source of sand is considered. Renourishment of the beach would be undertaken periodically to maintain a protective and recreational beach of suitable dimensions.

Beach Fill with Hurricane Surge Protection Sand Dune and Periodic Nourishment (S-3)

137. This alternative is considered to represent a variation of the beach fill and periodic nourishment alternative (S-2) with the added feature of hurricane surge protection. The existing heights of the primary dune are considered in the formulation of the beach fill alternative and the degree that the existing dune contributes to storm surge protection is evaluated in overall plan formulation. Refer to paragraph 142 for additional background information on hurricane surge protection.

Beach Fills with Periodic Nourishment in Conjunction with Offshore Breakwater (S-4)

138. The construction of breakwaters offshore along the Martin County problem areas is considered as viable alternative solution for beach erosion in combination with a beach fill. Such structures would reduce the amount of wave energy reaching the shoreline in their lee. The formation of a partial tombolo could occur if the breakwaters are of sufficient size, thus, decreasing the rate of annual erosion and thereby possibly decreasing the annual nourishment requirements. The local sponsor could not support the use of offshore breakwaters for inclusion in the recommended plan during the September 1980 public meeting. This alternative is therefore excluded from further consideration.

1968 Corps Plan of Improvement (S-5)

Plan for Jupiter Island

139. Initial restoration is required for 29,000 linear feet (5.5 miles) of shore at Jupiter Island. That area extends from a point about 1,000 feet north of Bridge Road (500 feet north of profile 14-S) southerly 5.5 miles to a point about 1.6 miles north of the Martin County-Palm Beach County line (500 feet south of profile 26-S). The estimated volume of material required for initial restoration is 2,430,000 cubic yards. Periodic nourishment would be provided when needed. The average annual nourishment requirement for the restored reach is 150,000 cubic yards. The above quantities include an allowance for loss of fines in dredging.

Plan for Jensen Beach

140. Initial partial restoration, periodic nourishment, and four groins are required for about 1,500 linear feet (0.3 mile) of beach, the entire ocean shore of the county park at Jensen Beach. That reach extends southerly for a distance of 1,500 feet from the ocean end of the Jensen Beach Causeway. A 400-foot transition zone, extending southerly from the southerly park limit, is also required to minimize possible adverse effects of the groins on adjacent downdrift private property. The estimated volume of material required for initial restoration is 220,000 cubic yards, including a quantity for the transition. Periodic nourishment would be provided when needed. The average annual nourishment requirement for the restored beach is 24,000 cubic yards. The above quantities include an allowance for loss of fines in dredging. The groins--concrete H-pile structures with adjustable concrete panels--would each be about 250 feet long. Top elevation of each groin would be at 6 feet, and the structures would extend seaward from the existing bank to prevent possible flanking. From elevation 6, the top of the seaward half of each groin would generally slope seaward 1 on 20. Top elevation of the seawardmost 10 feet of each groin would be at mean low water.

Plan for Stuart Beach

141. Initial partial restoration, periodic nourishment, and three groins are required for about 1,150 linear feet (0.2 mile) of beach, the entire ocean shore of the county park at Stuart Beach. That reach extends southerly for a distance of 1,150 feet from the ocean end of the road extending seaward from the Stuart Causeway. A 400-foot transition zone, extending southerly from the southerly park limit, is also required to minimize possible adverse effects of the groins on adjacent downdrift private property. The estimated volume of material required for initial restoration, including a quantity for the transition, is 170,000 cubic yards. Periodic nourishment would be provided when needed. The average annual nourishment requirement for the restored beach is 24,000 cubic yards. The above quantities include an allowance for loss of fines in dredging.

Hurricane Surge Protection - Sand Dune (S-6)

142. Measures to prevent damages from hurricane-induced tidal overtopping and flooding were considered. Previous damages along the study area have resulted from beach erosion and destruction of the seawalls during severe northeast storms and hurricanes. Hurricane flooding damages from the oceanside have been relatively small in comparison to erosion damages and in many instances have been nonexistent because of the natural high dunes. Based on previous hurricane frequency and flooding damages, the 1968 Corps Beach Erosion Control Report concluded that measures in addition to those required for beach erosion control were not warranted. Subsequent development of the Martin County shoreline was affected by the establishment of the Construction Control Line (CCL). The CCL was initiated in May 1972 and is a result of comprehensive engineering and topographic surveys, erosion analyses, prediction of storm tides and wave runup, and other analyses. It represents the landward encroachment of storm erosion for an estimate storm occurrence of 1 in 100 years. From 1968 to date it is estimated that 4 single-family dwelling units have been constructed seaward of the CCL. It is believed that this shoreline development does not significantly impact on the previous storm frequency and damage analysis; therefore, no further consideration was given to this alternative.

Revetments (S-7)

143. Revetments have been placed on the beach over the past to protect critically damaged or eroding areas on Jupiter Island. These measures have provided temporary relief for recession of the primary dune, but have not reduced the erosion of the beaches. The hardening of the shorefront with structures in one area will merely transfer the location of the problems further down the beach. Therefore, this alternative was not carried forward for further evaluation.

Seawalls (S-8)

144. The construction of concrete seawalls or improvements to and maintenance of the existing seawalls would provide a limited degree of protection; however, this would be accomplished at the expense of a recreational beach, resulting in substantial economic loss to the area. Reflecting wave energy off the existing seawalls and revetments has resulted in a steepening of the offshore profiles with resulting hazardous bathing conditions due to increased undertow and runouts. The effect of transferring the erosion problem along the shoreline is often caused by seawalls. High initial costs in addition to these reasons eliminate these alternatives from further consideration.

Stabilization of Beaches by Vegetation (S-9)

145. Stabilization of the beaches with vegetation is, for the most part, not applicable in the present situation. Beach grassing, if it could be accomplished, would deprive the area of a sandy beach. A variation of this alternative could be implemented in combination with beach fill if the formation of windblown sand and landward migration of dunes became a problem. Due to the relatively high elevation of the design dune, windblown sand is not considered to become a problem along the project area. In addition, the existing remnant of the primary dune has sufficient vegetation to act as an efficient trap for windblown sand.

Modification of Building Codes and Rezoning of Beach Area (S-10)

146. This alternative is considered as a feature of the Federal Insurance Administration Flood Study underway at the time of this report preparation and the intent of the purpose of the State construction setback laws.

Floodproofing of Structures (S-11)

147. This is also considered to be a part of the previously referenced Flood Study results in order for property owners to secure low interest insurance in the study area.

Condemnation of Land and Relocation of Structures (S-12)

148. The relocation of the structures in the Martin County problem area would allow the area to continue to erode. The land in this area would be lost until an equilibrium shoreline is reached. This alternative is excluded as it does not meet the planning objectives and this would not be favored by local sponsors.

149. The preliminary evaluation of possible management measures listed in table 1 within the multiobjective guidelines, eliminates some measures from further consideration and combines others.

COMPARATIVE ASSESSMENT AND EVALUATION OF PLANS

ANALYSIS OF PLANS CONSIDERED IN STAGE 2

150. A general investigation was made of the preliminary alternatives. Each plan was screened on its ability to satisfy the planning objectives. The findings of these analyses are summarized in the following paragraphs.

150. Evaluation of the preliminary plans elimiated and combined many of those considered. The no action plan allows the continuation of the existing erosion conditions and provides no solution to the existing problems. The no action plan is therefore only carried forward for comparison with viable plans. The nonstructural alternatives are further combined to make up a nonstructural combination plan which in addition to the no action alternative is carried throughout the plan formulation for consideration and comparison. The nonstructural combination plan consists of alternatives NS-1, 2, 3, 5, 6, and 8. The intermediate alternatives, thus considered, are listed in the following table.

INTERMEDIATE ALTERNATIVES

- no action
- nonstructural combination plan
- beach fill and periodic nourishment (Hutchinson Island)
- beach fill and periodic nourishment (Jupiter Island)
- beach fill and periodic nourishment (Hutchinson and Jupiter Islands)
- Corps 1968 Plan of Improvement

152. The nonstructural combination plan consists of all the nonstructural alternatives considered in stage 1 of the plan formulation process taken as a single plan. The adoption of effective regulatory measures to prohibit development of homes, subdivisions, and commercial centers in hazardous flood areas is a local responsibility. This alternative would not meet the needs of the study area or the study objectives and is carried forward for the sole purpose of comparison with the no action plan and viable structural alternatives.

153. Preliminary plans, designs, and cost estimates were formulated for the structural alternatives. Nonstructural plans and structural plans developed during the second stage of analysis were further refined to better address the needs of the study area. The authorized modification to the St. Lucie was completed as discussed in sections of existing Federal projects. For this reason, a development of plans for the St. Lucie Inlet will not be undertaken.

154. The alternative provided by the Corps 1968 Plan of Improvement of including groins at Hutchinson and Jupiter Islands is not considered to provide a complete solution to the beach erosion problem based upon previous results along the study area. Updrift and downdrift shores would suffer accelerated erosion and groins have not proved effective in stemming the erosion problem at Jupiter Island. Therefore, this alternative is removed from further consideration in the development of alternatives and the formulation of a proposed plan.

DESCRIPTION OF PLANS

155A. The screening process eliminates those alternatives that do not respond to the needs of the problem area or the overall planning objectives from further consideration in the formulation of the intermediate range of alternatives. The Federal planning objectives, as determined by the Principles and Guidelines, are to address the erosion problem by identifying and selecting the best possible course of action. The local planning objectives are incorporated in the overall screening process based upon the expressed desires of the local sponsor. Only those alternatives that warranted consideration based upon the overall planning objectives were brought forward for further evaluation as intermediate alternatives. The elimination of the various alternative methods of hardened shore protection such as revetments and seawalls from further consideration is due to the findings that such measures do not function well in the study area and would not solve the erosion problem. The non-structural combination plan does not provide a solution to the erosion problems, and represents a management measure to respond to the continual effects of such problems. Since the beach fill alternative offers a better course of action and opportunities to address the NED objective, the non-structural combination plan is also removed from further consideration in the formulation of viable plans. *

155B. Analyses of the economic feasibility of the various shore protection alternatives in Florida most often indicate that beach fill with periodic nourishment represents the optimum solution to the erosion problems within the framework of Federal guidelines. Beach fill alternative designs are formulated to provide various levels of protection to development, prevention of loss of land, and recreation benefits. From an array of such alternatives, a selected plan's features are determined which will optimize benefits in relation to costs. Shore protection alternatives such as revetments and seawalls do not provide enhanced recreational benefits and are therefore not usually found to represent the NED plan where the existing public shorefront provides a valuable recreational resource as in Martin County. *

155C. For the purpose of evaluating intermediate beach fill alternatives, a preliminary analysis was conducted to determine the beach fill design cross section and periodic nourishment interval that would be the basis of the economic analysis. Costs for various design berm widths; 0, 20, 35, and 60 feet for 3.3, 10, 40, and 59 year protection levels, respectively, were evaluated in conjunction with renourishment intervals of 2, 5, 8, and 15 years * to arrive at a consistent design for comparison of alternative beach fill plans. From the benefits and costs of the beach fill alternatives that were determined for preliminary designs, a 40-year return interval level of storm protection consisting of restoration of the primary dune to a 20-foot-wide crest width at +12.5 feet, m.s.l., with a 35-foot-wide berm at +8 feet, m.s.l., with 1 vertical on 8.5 horizontal (1V:8.5H) seaward slopes with renourishment at 8-year intervals was the optimum design of those initially considered for Hutchinson Island. This design cross section for the beach fill plan would provide a total 65-foot-wide protection beach width at +8 feet, which is 3.5 feet above the 30 year return interval storm surge still water surface elevation. In addition, the 35-foot-wide berm at +8 feet would have advanced nourishment placed seaward as increased width. The Engineering Appendix (4) contains a discussion of the optimization of the renourishment interval based upon the economic analysis of the selected plan of improvement. Average annual benefits and costs for the alternatives developed in the second stage of analysis are computed at 8 5/8 percent interest and June 1985 price levels. A summary of the economic analyses is contained in Appendix 5.

Hutchinson Island (Plan S-2A)

156. This alternative would provide for an initial beach fill and periodic nourishment along 4 miles of shorefront. The initial beach fill would be comprised of 942,000 cubic yards of material which includes 8 years advance nourishment with an overfill ratio of 1.15. The annual nourishment rate for this reach is 61,000 cubic yards [1/]. The cross section of the beach fill would be comprised of a restored primary dune with a 20-foot-wide crest at +12.5 feet, m.s.l., a berm 35 feet wide at an elevation of +8 feet, and seaward slopes of 1V:8.5H to an elevation of mean low water, then 1V:20H to the existing bottom.

157. The selected borrow area for beach fill material is located from 1/2 mile to 1 mile offshore of Stuart Public Beach Park. Approximately 8 million cubic yards of sand are located in the shoal area of this selected borrow area. The overfill ratio of 1.15 has been determined for material from this source. Renourishment of 488,000 cubic yards would be required at 8-year intervals to replace anticipated losses.

158. The cost of initial beach fill is estimated at $9,521,000. The average annual benefits for this alternative are estimated at $2,225,000. The average annual cost of constructing this alternative is $1,340,300. The benefit to cost ratio for this plan is 1.7 to 1. *

Environmental Considerations

159. The principle adverse impact anticipated with the construction of this alternative would be the temporary disturbance of biotic habitat in the borrow areas and along the nearshore zones in the immediate proximity of construction activities. The initial beach fill length of 4 miles is the

[1/] All Periodic Nourishment Quantities Include A 1.15 Overfill Ratio.

maximum length considered due to the existence of rock outcroppings south of Stuart Public Park that help maintain the existing shorefront and the location of the nearshore emergent reef at Bathtub Reef Park. The considered beach fill cross section incorporates a relatively steep foreshore slope (1V:8.5H) to represent prevailing conditions and to address an environmental consideration of not impacting excess nearshore bottom.

Jupiter Island (Plan S-2B)

160. Plan S-2B consists of 5.6 miles of beach fill and periodic nourishment along the developed shorefront of Jupiter Island. The considered reach along Jupiter Island would begin about .5 mile north of Bridge Road and terminate 5.6 miles south. The initial beach fill along 5.6 miles of developed shorefront on Jupiter Island would contain 2,318,000 cubic yards of material including 8 years advanced nourishment. The annual nourishment rate for the reach is 221,000 cubic yards. The cross section would be comprised of a berm 35 feet wide at +8 and seaward slopes of 1V:10H to to an elevation of 0 m.l.w., thence 1V:20H to the existing bottom.

161. The selected borrow area for the beach fill area at Jupiter Island lies about 3,000 to 7,000 feet offshore and contains in excess of 77 million cubic yards of material. Renourishment with 1,768,000 cubic yards would be required at 8-year intervals to replace anticipated losses.

162. The initial cost of constructing this alternative is estimated at $20,794,000. The estimated annual benefits and costs that would result from implementing this alterative are $1,078,400 and $3,306,300, respectively. *
The benefit to cost ratio for this plan would be .32 to 1. Local interests at Jupiter Island have a 5-year schedule for renourishment of the shorefront within the limits of Plan S-2B with private funding. Past nourishment quantities and dates are indicated on plate C-1.

Environmental Considerations

163. Anticipated adverse impacts of construction are considered to be the temporary disturbance of biotic habitat in the borow area and along the nearshore zone adjacent to construction activities. The considered beach fill cross section incorporates a steep foreshore slope (1V:10 H) to represent prevailing conditions and to address environmental consideration of not impacting excess nearshore bottom.

Hutchinson Island (Plan S-2C)

164. This alternative is comprised of two beach fills consisting of a total of 420,800 cubic yards of material at Jensen and Stuart Public Beach Parks. The initial beach fill would consist of 230,400 cubic yards of material along 4,100 feet of shorefront from .25 mile north to .25 mile south of at Jensen Public Beach Park and 107,800 cubic yards of material along 3,800 feet of shorefront from .25 mile north to .25 mile south of Stuart Public Beach Park including 8 years advanced nourishment. The beach fill cross

section would provide a 35-foot-wide berm at +8 feet, and seaward slopes of 1 on 8.5 to mean low water, thence 1 on 20 to the existing bottom. Annual nourishment requirements for the entire 7,900-foot length of beach restoration are 22,800 cubic yards. Beach fill material would be obtained from the offshore borrow area indicated for plan S-2A. Included as an integral part of this plan is the option that the shorefronts adjacent to the beach fills on Hutchinson Island would be provided with periodic nourishment as needed and justified.

165. Average annual benefits for the plan would be $834,000. The average annual cost of constructing this alternative of beach fills with advance nourishment and periodic nourishment at 8-year intervals is estimated at $697,900. The benefit to cost ratio for this plan would be 1.2 to 1.

166. Limited expansion of this plan would not significantly improve the benefit-to-cost ratio. The average annual costs of periodic nourishment along relatively short reaches of beach fill would be greater than initially anticipated due to excessive losses associated with short beach fills. Plan S-2A is considered to encompass the magnitude of shorefront that would not experience excessive losses due to length effects. Plan S-2A provides a more favorable benefit to cost ratio and net benefits, therefore, further refinement of this plan is not considered desirable and this alternative is removed from further consideration in the development of detailed plans.

Hutchinson and Jupiter Islands (Plans S-2A and S-2B)

167. This alternative combines the features of plan S-2A for Hutchinson Island with beach fill along the developed shorefront at Jupiter Island, plan S-2B. The dimensions of the beach fill cross section at Jupiter Island would provide a 35-foot-wide beach berm at +8 feet, with a beach face slope of about 1 vertical on 10 horizontal to mean low water then 1 vertical on 20 horizontal to the existing bottom. The initial beach fill volume would be comprised of 3,373,000 cubic yards of suitable material including 8 years advanced nourishment. Renourishment of the beach fill is estimated at 2,256,000 cubic yards at 8-year intervals. The initial cost would be $26,600,000. The initial fill and periodic nourishment quantities would be dredged from the selected borrow areas located 1/2 mile offshore of Stuart Beach Park on Hutchinson Island and about 3,000 to 7,000 feet offshore of Jupiter Island. The average annual cost of constructing this alternative is estimated at $4,611,300. Average annual benefits estimated at $2,927,500. The benefit to cost ratio for this plan would be .64 to 1.

COMPARATIVE ASSESSMENT AND EVALUATION OF DETAILED PLANS

168. Analysis of possible solutions, as summarized in previous paragraphs, indicates that structural measures coupled with existing nonstructural measures best meet the needs of the study area. It was established that, within the framework of the planning criteria, beach restoration with periodic nourishment is a practicable solution to the existing problem. It was determined that the eroding shore could be stabilized with beach nourishment.

169. Of the structural alternatives carried through the plan formulation process to the second stage of analysis as viable plans, one met the needs of the study area and the planning objectives. This alternative, plan S-2A, provides for the planning objectives, anticipated beach erosion losses, and considers needs of the study area. The no action and nonstructural combination plan offer no solution to the beach erosion problem and are carried through the plan selection process in order to provide a basis for comparison and evaluation.

170. The structural measures for beach erosion control with beach fills and periodic nourishment, plans S-2B and S-2C would not meet the planning objectives and were determined as being unsatisfactory. These alternatives were therefore removed from further consideration in the formulation of a proposed plan. Plan S-2B is carried forward to the next stage of plan formulation to address the erosion problem at Jupiter Island and for consideration for implementation by non-Federal interests.

171. The following plans are further considered in the analysis of detailed plans:

No Action
Nonstructural Combination Plan
Plan S-2A - Beach Fill and Periodic Nourishment (Hutchinson Island)
Plan S-2B - Beach Fill with Periodic Nourishment (Jupiter Island)

172. As previously stated, the no action and nonstructural alternatives are carried throughout plan formulation as a basis of comparing the effects of other alternatives. An effect assessment carried out in terms of the considered plans contributing to the four accounts of NED, EQ, RD, and OSE was made. Also, as required by the Principles and Guidelines, a system of accounts displaying the results of this assessment was prepared and is shown in table 1a through 1d of appendix 2. Additionally, the 17 areas of concern specifically mentioned in Section 122 of Public Law 91-611 as being of critical concern are indicated on these tables. A summary of the effects of the considered plans is presented in the section following the recommendations at the end of the main report.

173. As previously stated, the selected plan should maximize net benefits to the extent practicable. Maximizing net benefits is an economic concept aimed at sizing a project to the point where the greatest excess of benefits over cost occurs.

DESCRIPTION OF PLAN S-2A

Beach Fill and Periodic Nourishment for 4 miles at Hutchinson Island

174. This alternative provides for 4 miles of continuous beach fill from the north county line to about 0.25 mile south of the southern boundary of Stuart Public Beach Park. The initial beach fill along 4 miles of continuous shorefront at Hutchinson Island would contain 942,000 cubic yards

of material. The annual nourishment rate for this reach is 61,000 cubic yards. The beach fill design cross section would provide a restored primary dune crest 20-feet wide at +12.5 feet, m.s.l., a 35-foot-wide beach berm at +8 feet, and seaward slopes of 1V:8.5H to 0 m.l.w., then 1V:20H to the existing bottom. The plan developed for beach fill and periodic nourishment along 4 miles of shorefront has a benefit to cost ratio of 1.7 to 1. The economic analysis indicates that at the time of this study, average annual benefits exceed average annual costs by $884,700, as shown on table 5. *

IMPLEMENTATION RESPONSIBILITIES

COST ALLOCATION

175. The allocation of costs between Federal and non-Federal interests for the considered works is based on Federal legislative and administrative policies governing beach erosion control protection. The current beach erosion control cost sharing policies are indicated in the following paragraphs. *

176. Under Public Law 826, 84th Congress, as amended by the River and Harbor Act of 1962, Public Law 87-874, Federal participation in the cost of a project for restoration or protection of State, county, and other publicly owned shore parks and conservation areas may be up to but not more than 70 percent of the total cost exclusive of lands easements and rights-of-way costs, when such areas meet the following requirements:

a. Include a zone which excludes permanent human habitation;

b. Include, but are not limited to, recreational beaches;

c. Satisfy adequate criteria for conservation and development of the natural resources of the environment;

d. Extend landward a sufficient distance to include, where appropriate, protective dunes, bluffs, or other natural features which serve to protect the uplands from damage; and

e. Provide essentially full park facilities for the appropriate public use, all of which shall meet the approval of the Chief of Engineers.

Where the above criteria are not met, Federal contribution toward the cost of construction of protective works along publicly owned shores is normally equal to one-half of the cost. However, if private benefits stem from the works, the Federal contribution to the project is adjusted in accordance with the degree of such benefits.

177. Within the shorefront limits of this alternative plan, the 2,600 linear feet of shorefront of the public beach parks at Jensen (1,450 feet) and Stuart (1,150 feet) currently qualify for 70 percent Federal cost

sharing in erosion control measures. Martin County's proposed development plans indicate that improvements to the existing public shorefront at the Jensen north access (1,600 feet), Bob Graham Beach (1,990 feet), and Alex's Beach (565 feet) will be eligible for Federal cost sharing up to 70 percent for construction of erosion control measures by 1990. There are currently 765 feet of additional public shorefront at three access points: North County Access, Virginia Forrest Beach, and Tiger Shores that qualify for 50 percent Federal cost sharing. Table 3 indicates the shorefront distances and the cost apportionment that this alternative would be eligible for based upon either existing park development, or current park development plans.

Federal Responsibilities

178. The Federal share of first costs for the recommended plan is estimated at $4,380,500 based on existing park development conditions. The Federal share would increase slightly if the proposed park development plans are implemented by local interests prior to construction of the recommended plan. Details for determining cost apportionment are shown in table 4. *

Non-Federal Responsibilities

179. Non-Federal interests would provide all lands, easements and rights of way; relocations (if required); establish the Erosion Control Line (ECL) and pay for all beach fill placed landward of the ECL. Non-Federal interests would also provide a cash contribution, estimated at $5,038,500 based on existing park development conditions. In addition, non-Federal interests would operate and maintain the project, participate in the cost of periodic nourishment and provide appurtenant facilities as required to assure public use of the restored beach. Appurtenant facilities include parking areas and beach access as required to insure the realization of the forecasted project benefits. *

COST APPORTIONMENT BASED ON RELINE DEVELOPMENT

Access	Existing Public Shoreline Distance (ft)	Existing Park Developmen 1/: w/project public shoreline (ft)	Existing Park Developmen 1/: Cost Apportionment % Fed.	Existing Park Developmen 1/: Cost Apportionment % Non-Fed.	Proposed Park Development 2/: w/project public shoreline (ft)	Proposed Park Development 2/: Cost Apportionment % Fed.	Proposed Park Development 2/: Cost Apportionment % Non-Fed.
North County Access	100	1255	50	50	1255	50	50
Jensen Beach North	1600	1600	50	50	1600	70	30
Jensen Beach Park	1450	1450	70	30	1450	70	30
		1320	50	50	1320	50	50
Bob Graham Beach	1990	3180	50	50	1990	50	50
					1190	50	50
Alex's Beach	565	2730	50	50	565	70	30
					2165	50	50
Virginia Forrest Beach	100	2740	50	50	2740	50	50
Tiger Shores	100	2445	50	50	2445	50	50
Stuart Beach	1150	1150	70	30	1150	70	30
		2345	50	50	2345	50	50
TOTAL	7055	20,215 3/			20,215		

1/ Public shoreline with full park facilities is eligible for 70% Federal cost-sharing. The remaining publicly owned shoreline is eligible for 50% Federal cost sharing. Under existing conditions, 2,600 feet of shoreline qualifies for 70% Federal participation. The Federal share of project costs is $\frac{2{,}600\ (.7) + 17{,}615\ (.5) + 905\ (0)}{21{,}120} = 50.3\%$

2/ With proposed park development, 6,755 feet of public qualify for 70% Federal cost-sharing. The Federal share of project costs would be $\frac{6{,}755\ (.7) + 13{,}460\ (.5) + 905\ (0)}{21{,}120} = 54.3\%$

3/ This length of shorefront qualifies for Federal participation in cost sharing. An additional 905 feet front private property without public access and would therefore not qualify for Federal cost-sharing under current criteria. However, the total project length for the cost apportionment calculation is 21,120 feet (4.0 miles).

TABLE 4

COST APPORTIONMENT FOR THE RECOMMENDED PLAN (S-2A)

Item	Non-Federal $	Other 1/ $	Total $
	First Costs (6/85 prices)		
Mobilization & Demobilization		1,000,000	1,000,000
Beach Fill (includes advance nourishment)	446,600 2/	5,017,400	5,464,000
Monitoring		12,000	12,000
Relocation of Turtle Eggs		28,800	28,800
Lands	27,500		27,500
Establish ECL	20,000		20,000
Contingencies (25%)	123,600	1,514,600	1,638,200
E&D, S&A (15%)	92,600	1,135,900	1,228,500
Total	710,300	8,708,700	9,419,000

Federal Share of First Costs

50.3% x $8,708,700 = $4,380,500

Non-Federal Share of First Costs

(49.7% x $8,708,700) + $710,300 = $5,038,500

1/ "Other" costs are those first costs eligible for cost sharing in accordance with the formula shown in Table 3. For existing conditions, these costs are apportioned 50.3% Federal and 49.7% non-Federal. The percentages will be reevaluated at time of initial construction and for each future nourishment to reflect the amount of shoreline eligible 70% Federal cost sharing and the amount eligible for 50% Federal cost sharing.

2/ It is estimated that about 77,000 cubic yards of fill will be placed landward of the ECL at a unit cost of $5.80. This work would be 100% non-Federal.

180. The State of Florida in considering beach erosion a serious menace to the economy and general welfare of the people of the State declared it to be in the public interest that the legislature of the State of Florida make provision for publicly financed beach nourishment and restoration programs by establishing and clarifying the property rights of the State and private upland owners arising from or created by such programs. The legislature declared that it is the public policy of the State of Florida and its intention to cause to be fixed and determined, pursuant to beach restoration projects, the boundary line between sovereignty lands of the State bordering on the Atlantic Ocean, the Gulf of Mexico and the bays, lagoons and other tidal reaches thereof, and the upland properties adjacent thereto.

181. It was further declared that there is no intention on the part of the State to extend its claims to lands not already held by it, nor to deprive any upland or submerged owner of the legitimate and constitutional use and enjoyment of his property. However, if a requested and authorized beach erosion control project cannot reasonably be accomplished without the taking of private property, then such taking shall be made by the requesting authority by eminent domain proceedings. To effect this policy, the Trustees of the Internal Improvement Fund are authorized by chapter 161 of the Florida Statutes to establish an erosion control line (ECL) at the request of the county or city, provided the owners of more than 50 percent of the number of linear feet of property abutting the proposed line consent thereto in writing. The establishment of such a line and the restoration or creation of public beaches seaward of said line will be of considerable benefit to the owners of upland property as well as to the public.

182. The ECL, when established, will be the seaward boundary of private property. Upland property owners will not gain any lands resulting from the nourishment program or from natural accretion seaward of the ECL, and will not lose title to land which may be submerged due to erosion by natural actions of the wind and waters. If the ECL is placed any point seaward of mean high water line abutting property then such submerged land becomes the property of the upland owners and they will not be required to pay any compensation for this submerged land. *

PUBLIC VIEWS

183. Comments received from coordination of the draft report with Federal, State, regional and local agencies, and with the general public will be contained in appendix 3.

DESCRIPTION OF PLAN S-2B

Beach Fill and Periodic Nourishment at Jupiter Island (Plans S-2B)

184. This alternative plan features 5.6 miles of beach fill along the developed shorefront at Jupiter Island with periodic nourishment at 8-year intervals. The shorefront considered ranges from about 0.5 mile north of

Bridge Road to 5.6 miles south. The dimensions of the beach fill cross section would provide a 35-foot-wide beach berm at +8 feet, with a foreshore slope of 1 vertical on 10 horizontal to mean low water then 1 vertical on 20 horizontal to the existing bottom.

185. This alternative plan considers placement of initial beach fill of 2,318,000 cubic yards of material along the 5.6 mile problem area at Jupiter Island. Material for initial restoration and periodic nourishment would be obtained from the selected borrow area located 3,000 to 7,000 feet offshore. Subsurface investigations and laboratory grain-size analysis indicate that sufficient quantity (77 million cubic yards) of suitable sand exists there.

186. The design beach fill cross section includes a quantity of 550,000 cubic yards of material. In addition, 1,768,000 cubic yards of material is included in the initial beach fill for advanced nourishment for 8 years. This quantity would provide an average cross section of 78 cubic yards per foot of shorefront. The considered cross section would provide for 8 years of the average annual erosion rate of 6.5 cubic yards with 19 cubic yards per foot of shoreline remaining from the initial beach fill at the 8-year interval during renourishment. The average annual nourishment requirement for the restored reach would be about 221,000 cubic yards with the overfill ratio of 1.15 included.

187. Based upon the economic analyses conducted, and shown in table 5 (and table 31 of the Economics appendix), plan S-2B lacks sufficient economic justification for further consideration. This alternative is carried through to the formulation of detailed plans in order to evaluate an alternative of sufficient scope that would address the erosion problem at Jupiter Island and determine the benefit to cost ratio. The provision of a sand beach of increased dimensions will augment the natural protection affor ded by the beach in mitigating erosion damage to the upland property. Wider beaches will also provide increased area for turtle nesting and recreation activities.

IMPLEMENTATION RESPONSIBILITIES

COST ALLOCATION

188. This alternative lacks sufficient benefits to exceed costs on an average annual basis and therefore could not be considered further for recommendation as a proposed plan for Federal cost sharing.

Non-Federal responsibilities

189. Non-Federal interests would have responsibility to construct and maintain the considered plan.

PUBLIC VIEWS

190. Comments received from coordination of the draft report with Federal, State, regional and local agencies, and with the general public are contained in appendix 3.

COMPARISON OF DETAILED PLANS

COMPARISION OF PLANS

191. An "effect assessment" carried out in terms of the plans' contribution to the four accounts of NED, EQ, RD and OSE is contained in the section following the recommendations of this report. Highlights from this assessment are presented in the following paragraphs. In addition, pertinent economic data are presented in the accompanying table.

192. The "no action" alternative perceives the continuation of existing conditions and provides no solution to existing problems. However, it also avoids any undesirable effects that may be associated with considered structural solutions. This option, although not favored by the local sponsors, was considered as a basis for comparing other alternatives.

193. If steps are not taken to counteract the erosion occurring along the shores under study, further erosion and recession of the shoreline will occur, with subsequent loss of property and undermining of structures along the shore. Loss of the beach would reduce the attractiveness of the area to tourists and local residents, thus exerting a negative impact on the local economy. The nonstructural combination plan consists of management measures that are within the discretion of local interests to employ. Most of the components of this alternative are included in the coastal zone management measures undertaken by Martin County. This alternative alone would not prevent, control, or mitigate the erosion problem experienced along the study area. Therefore, this option is considered to be part of the existing management measures underway.

194. An "effect assessment" is an objective analysis carried out in terms of the considered plans' contributions to the four accounts: NED, EQ, RD, and OSE. As required by the Water Resources Council's Principles and Guidelines, an effect assessment was made of the alternatives considered herein. The results of this assessment for the plans carried forward for detailed evaluation are presented in the "System of Accounts" table in appendix 2 of this report. Also included in this table is an enumeration of the 17 areas of concern specifically defined by Section 122 of Public Law 91-611 as being of critical importance. A summary of the effects of the considered plans is presented at the end of the conclusions section of this report and discussed in the following paragraphs.

195. Average annual benefits and costs for the plans referred to in the evaluation of detailed plans are illustrated in table 5. The investigations conducted to determine the economic justification for detailed plans S-2A and S-2B are contained in appendix 5 and are summarized in table 33 of that appendix. *

TABLE 5

ECONOMIC SUMMARY @ 8 5/8%

Average Annual Benefits	PLANS S-2A (Hutchinson Island)	S-2B (Jupiter Island)
Recreation Benefits	$1,144,200	$ 103,400
Loss of Land Prevented	208,600	798,300
Damage to Development Prevented	858,400	84,200
Prevention of Damage to Existing Erosion Control Structures 1/	13,800	92,500
Total	$2,225,000	$1,078,400
AVERAGE ANNUAL COSTS	$1,340,300	$3,349,400
NET BENEFITS	$ 884,700	0
B/C RATIO	1.7	.32

1/ Includes reduction in maintenance costs.

196. A description of these benefits and the analyses conducted are contained in the Economics appendix. The value of these benefits is dependent upon the location and length of shoreline and the types of development protected.

RATIONALE FOR DESIGNATION OF NED PLAN

197. The National Economic Development (NED) Alternative by definition is the alternative formulated for maximization of contributions to the NED objective, viz. the alternative should produce the maximum benefits in relation to costs to the extent practicable.

NED PLANS

198. None of the alternatives considered for Jupiter Island were economically justified. Therefore, there is no NED plan for Jupiter Island. An NED plan was developed for Hutchinson Island only. Each alternative plan was developed and net benefits calculated. Alternative plan S-2A which provides for construction of a protective beach along about 4 miles of the ocean shore and for periodic nourishment to provide 40-year storm protection would maximize net NED benefits. The following table indicates the array of beach fill designs considered in formulation of the NED plan.

AVERAGE ANNUAL BENEFITS AND COSTS [1/] (x $1000)

STORM RETURN INTERVAL (DESIGN LEVEL) Yrs	BERM WIDTH ft	LOSS OF LAND $	PREVENTION OF DAMAGE TO EROSION CONTROL STRUCTURES $	PREVENTION OF DAMAGE TO DEVELOPMENT $	RECREATION $	TOTAL AVERAGE ANNUAL BENEFITS $	TOTAL ANNUAL COSTS $	NET BENEFITS $
3.3	0	191.5	13.8	582.9	1,138.3	1,926.5	1071.4	855.1
10	20	202.3	13.8	703.1	1,144.2	2,063.4	1185.1	878.3
40	35	208.6	13.8	858.4	1,144.2	2,225.0	1340.3	884.7
59	60	214.4	13.8	861.8	1,144.2	2,234.2	1454.0	780.2

*

1/ At 8 5/8% Interest Rate. See appendix 4 for details.

RATIONALE FOR THE TENTATIVELY SELECTED PLAN

199. Environmental and socioeconomic criteria for consideration in water resource planning are as prescribed by the National Environmental Policy Act of 1969 (Public Law 91-190) and Section 122 of the River and Harbor and Flood Control Act of 1970 (Public Law 91-611). The criteria prescribe that all significant adverse and beneficial economic, social, and environmental effects of considered erosion control solutions be considered and evaluated when selecting a plan for recommendation as a Federal project. The highlights of these criteria were presented earlier in this report.

200. The economic criteria require that the selected plan be justified with NED benefits that exceed the costs. The selected plan should also be the most economical means of meeting the planning objectives.

201. Planning criteria also require that the selected plan must be technically and institutionally implementable. The institutional authority, and financial capability, of the non-Federal sponsor must be sufficiently established to allow recommendation of the selected plan as a Federal project with knowledge that it can be implemented. The plan must be acceptable to and indorsed by State and local authorities.

SELECTION OF A PLAN

202. Since none of the alternatives considered for Jupiter Island are economically justified, no Federal action can be recommended for this island.

Selection of the best plan for Hutchinson Island to solve the erosion problem and meet the needs of the study area was based on contributions to the four accounts of NED, EQ, RD, and OSE; responsiveness to specific evaluation criteria; and the desires of local interests.

203. Of the alternatives investigated, plan S-2A is considered to provide the optimum solution within the framework of the formulation concepts. Implementation of this plan would provide a practical, efficient, and an environmentally and socially acceptable means of resolving the erosion problem. Plan S-2A provides for restoration of the primary dune and a protective beach along 4 miles of the ocean shore of Hutchinson Island from the north county line south to Stuart Public Beach with periodic nourishment at 8-year intervals.

204. In light of the overall public interest, the documents concerning the proposed action, as well as the stated views of other interested agencies and the concerned public, relative to the various practicable alternatives in accomplishing remedial measures for beach erosion control in Martin County were reviewed. The possible consequences of the detail alternatives * have been studied for environmental, social well-being, and economic effects, including regional and national economic development, and engineering feasibility. The alternatives have addressed the need for an adequate protective and recreational beach at Hutchinson Island and protective beach at Jupiter Island.

ENVIRONMENTAL CONSIDERATIONS

205. Completion of the considered plans would produce what may be considered a more favorable environmental condition than exists at present, although some temporary adverse effect can be expected during construction operations. There would be temporary adverse effects caused by turbidity during dredging operations and nourishment of the beaches. However, the turbidity created would be no worse than that caused by severe storms. Turbid conditions would also occur in localized waters during periodic nourishment of the beaches. The animal life which would be most affected by the project would be the benthic invertebrates associated with the offshore borrow and beach fill areas. Fishes would tend to be less affected by the project than benthic organisms and seaside invertebrates. Further, the temporary increases in turbidity which would occur would have short-term effects since fish can avoid areas of high turbidity. The area bird population should escape most of the adverse effects resulting from dredging operations.

206. No rare or endangered botanical or zoological species are expected to be adversely affected by the project. Although there are no known objects of archeological or historical significance located within the borrow sites, magnetometer surveys of both borrow areas will be made prior to project construction. In summary, the selected plan of protection would insure the

provision of additional beach for protecting existing property and for recreational use. With the plans implemented, the general appearance of the area will be improved, extensive public beach will be provided, and no permanent damage to the environment will ensue. Provisions will be required for relocation of turtle nests should the construction occur during the nesting season of May through October.

OTHER SOCIAL EFFECTS CONSIDERATIONS

207. The resulting advantages gained through provision of additional public beach surface area would be enhancement of the quality and opportunities for recreational experiences enjoyed by the public along Hutchinson Island while providing for conservation of the shorefront as a natural resource. Resolution of the problem of continued erosion along Jupiter Island's shoreline would result in improved social well-being of shorefront property owners.

ENGINEERING CONSIDERATIONS

208. The selected plan for initial beach restoration and periodic beach nourishment, as described in this report, represents the most practicable and economical plan of improvement for the shorefront in Martin County. It represents the most feasible project possible for the intended purpose, maximizes net benefits, affords partial restoration, and maximizes conservation and use of restored natural resources. For the remainder of the county shoreline, the most desirable plan is the prudent development of the natural coastal areas.

ECONOMIC CONSIDERATIONS

209. Based upon data available, study findings indicate under current guidelines the proposed improvements represent the most practicable approach to meet the needs of the study area and the study objectives. Lesser improvements would not respond to the expressed desires of the local sponsor nor would they provide a necessary level of protection consistent with formulation of the NED plan.

NATIONAL INTEREST CONSIDERATIONS

210. The improvement proposed and described as the selected plan in this report is based on thorough analysis and evaluation of various practicable alternative courses of action for achieving the State and county objectives;

that wherever adverse effects are found to be involved they cannot be avoided by following reasonable alternative courses of action which would achieve the congressionally specified purposes; that where the proposed action has an adverse effect, this effect is either ameliorated or substantially outweighed by other considerations of national policy; that the recommended action is consonant with national policy, statutes, and administrative directives; and that on balance the overall public interest should best be served by the implementation of the recommendations.

FLOOD PLAIN DEVELOPMENT

211. The considered improvements are within the base flood plain (100-year flood). Relocation of the proposed project outside the flood plain would not be possible or be responsible to the problems and needs of the study area and was not considered further. A non-flood-plain alternative for the potential development with the project would be to restrict all future development to those areas outside the flood plain or elevated above the flood plain. A report on Flood Plain Information, Coastal Areas, Martin County, Florida, was prepared in June 1973 by the Corps of Engineers. A study was conducted for the Federal Insurance Administration to provide guidelines for building codes in Martin County in order for buildings to meet criteria for flood insurance. Potential flood plain development with the project would be restricted as a result of local building ordinances and State law. Any induced potential damage as a result of project implementation to development within the flood plain would be minimal. The proposed project complies with applicable State and local laws and regulations concerning flood plain protection standards. The proposed project will have minimum impact on the natural and beneficial values of the flood plain. In the without project flood plain (that area immediately adjacent to the proposed project), there will be minimal loss of natural resources due to project-induced potential development. Implementation of the nonstructural combination plan would minimize potential damage to or within the flood plain. Local interests have adopted many parts of the nonstructural plan and are considering others. Implementation of the nonstructural plan is a local responsibility. Pertinent correspondence from involved agencies, groups, and organizations is provided in appendix 3.

INSTITUTIONAL CONSIDERATIONS

212. The legal capability of the non-Federal sponsors, the Martin County Board of Commissioners and the State of Florida, to assume non-Federal responsibilities is specifically defined in State law. The county is a State political subdivision, duly constituted the beach and shore preservation authority for Martin County, with the authority to enter into contract with the Secretary of the Army and to provide the non-Federal requirements for implementing the selected plan.

CONCLUSIONS

213. I have given consideration to all significant aspects in the overall public interest, including engineering feasibility, economic, social, and environmental effects. The selected plan described in the report provides the optimum solution for protection of the eroded shores of Hutchinson Island within the framework of the formulation concepts.

RECOMMENDATIONS

PLAN FOR HUTCHINSON ISLAND

214. I recommend that beach erosion control improvements along the Atlantic Ocean shore of Hutchinson Island, Martin County, Florida, be authorized for Federal implementation, generally in accordance with the selected plan (S-2A) described below, with such modifications as in the discretion of the Chief of Engineers may be advisable, and subject to cost sharing and financing arrangements satisfactory to the President and the Congress. The first cost to the United States is presently estimated at $4,380,500 with average annual periodic nourishment costs to the United States presently estimated at $254,400. *

215. Plan S-2A provides for initial beach fill and periodic nourishment along 4 miles of shorefront at the northern most reach of Hutchinson Island in Martin County. The initial beach fill would be comprised of 942,000 cubic yards of material which includes 8 years advanced nourishment. The cross section of the beach fill would be comprised of a restored primary dune with a 20 foot wide crest width at +12.5 ft., m.s.l., a berm 35 feet wide at +8.0 ft. m.s.l. and seaward slopes of 1V:8.5 H to an elevation of mean low water, then 1V:20 H to the existing bottom.

216. This recommendation is made with the provision that, prior to implementation, local interests will, in addition to the general requirements of law for this type of project, agree to comply with the following requirements:

a. Provide without cost to the United States all necessary lands, easements, rights-of-way and relocations required for construction of the project, including that required for periodic nourishment.

b. Hold and save the United States free from claims for damages which may result from construction and subsequent maintenance of the project, except damages due to the fault or negligence of the United States or its contractors.

c. Assure continued conditions of public ownership and use of the shore upon which the amount of Federal participation is based during the economic life of the project.

d. Assure maintenance and repair during the economic life of the project as required to serve the project's intended purposes.

e. Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms, and as required to realize the benefits upon which Federal participation is based;

f. Provide a cash contribution for beach erosion control equal to the appropriate percentage of the final construction cost allocated to this function, exclusive of lands, easements, rights-of-way, alterations, and relocations, the percentage to be in accordance with existing law and based on shore ownership at the time of implementation;

g. Provide a cash contribution for periodic nourishment during the useful life of the project, such contribution to be made prior to each nourishment, with the actual amount to be based on existing law and conditions of ownership at the time of each nourishment;

217. The recommendations contained herein reflect information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and/or implementation funding.

Charles T. Myers III

CHARLES T. MYERS III
Colonel, Corps of Engineers
District Engineer

SUMMARY OF EFFECTS

	No Action	Nonstructural Combination Plan	Hutchinson Island Beach Fill & Periodic Nourishment (Plan S-2A) NED & EQ Plan	Jupiter Island Beach Fill & Periodic Nourishment (Plan S-2B) EQ Plan
A. Plan Description	Do nothing	Nonstructural measures.	Beach fill 21,100 feet along with periodic nourishment.	Beach fill and periodic nourishment along 29,600 feet of shoreline.
B. Significant Impacts	Beach erosion continues.	Beach erosion continues.		
1. National Economic Development				
a. Beneficial Impacts				
(1) Average annual damage prevented	None	None	$1,080,800	$975,000
(2) Average annual beach recreation benefits	None	None	$1,144,200	$103,400
(3) Preservation of natural resources	None	None	Dune and beach restoration	-
Total beneficial	None	None	$2,225,000	$1,078,400
b. Adverse Impacts				
(1) Project first cost	No commitment.	No direct commitment.	$9,521,000	$20,794,000
(2) Annual charges	Storm damage continues.	Storm damage continues.	$1,340,300	$3,349,400
c. B/C Ratio	Tax and business revenues decline.	Tax and business revenues decline.	1.7	0.32

TABLE 6 - Continued
SUMMARY OF EFFECTS

	No Action	Nonstructural Combination Plan	Hutchinson Island Beach Fill & Periodic Nourishment (Plan S-2A) NED & EQ Plan	Jupiter Island Beach Fill & Periodic Nourishment (Plan S-2B) EQ Plan
2. Environmental Quality				
a. Beneficial Impacts				
(1) Beaches	No effects from construction.	No effects from construction.	Restore the natural protection of the primary dune and beach and provide recreational space	Restore proective beach and provide recreational space
(2) Manmade resources*			Protect structures from wave damage up to 40-year storm surge level	Protect structures from wave damage up to 10-year storm surge level *
(3) Noise level changes*	Slight decrease if tourism drops.	Slight decrease if tourism drops.	Temporary increase during construction	Temporary increase during construction
(4) Public facilities*	None	Potential loss of recreational area and restrooms.	Local interests provide parking and beach access	Local interests provide parking and beach access
(5) Security of life,	None	Minimal	Reduce threat to health and safety from erosion	Reduce threat to health and safety from erosion
(6) Tax changes*	None	None	Increase tax base as area develops	Increase tax base as area develops

TABLE [illegible]

SUMMARY OF EFFECTS

	No Action	Nonstructural Combination Plan	(NED and EQ Plan) Beach Fill & Periodic Nourishment (Plan S-2A) (Hutchinson Island)	(EQ Plan) Beach Fill & Periodic Nourishment (Plan S-2B) (Jupiter Island)
A. Plan Description	Do nothing	Nonstructural measures.	Beach fill 21,100 feet along with periodic nourishment.	Beach fill and periodic nourishment along 29,600 feet of shoreline.
B. Significant Impacts	Beach erosion continues.	Beach erosion continues.		
1. National Economic Development				
a. Beneficial Impacts				
(1) Average annual damage prevented	None	None	$1,080,800	$975,000
(2) Average annual beach recreation benefits	None	None	$1,144,200	$103,400
(3) Preservation of natural resources	None	None	Dune and beach restoration	-
Total beneficial	None	None	$2,225,000	$1,078,400
b. Adverse Impacts				
(1) Project first cost	No commitment.	No direct commitment.	$9,521,000	$20,794,000
(2) Annual charges	Storm damage continues.	Storm damage continues.	$1,340,300	$3,349,400
c. B/C Ratio	Tax and business revenues decline.	Tax and business revenues decline.	1.7	0.32

TABLE 6 - Continued

SUMMARY OF EFFECTS

	No Action	Nonstructural Combination Plan	Hutchinson Island Beach Fill & Periodic Nourishment (Plan S-2A) NED & EQ Plan	Jupiter Island Beach Fill & Periodic Nourishment (Plan S-2B) EQ Plan
(7) Esthetic values*	None	Locating new structures in compliance with criteria would benefit all by limiting construction impact on dunes	Wider, more attractive beach with plan	Wider, more attractive beach with plan
(3) Natural resources*	Loss of valuable shorefront with continued erosion	Locating new structures in compliance with criteria would benefit all by limiting impacts on dunes	Place 942,000 cubic yards of sand on beach	Placement of 2,318,000 cubic yards of sand initially and 221,000 of average annual nourishment *
b. Adverse Impacts				
(1) Beach	Erosion will continue with resultant loss in developed reaches	Erosion will continue with resultant loss of beaches in developed reaches	Temporary disruption of beach recreation during construction	Temporary disruption of beach recreation during construction
(2) Air quality*	No effect	No effect	No significant decrease due to construction	No significant decrease due to construction

TABLE 6 Continued
SUMMARY OF EFFECTS

	No Action	Nonstructural Combination Plan	Hutchinson Island Beach Fill & Periodic Nourishment (Plan S-2A) NED & EQ Plan	Jupiter Island Beach Fill & Periodic Nourishment (Plan S-2B) EQ Plan
(3) Noise level changes*		None	Increase due to larger crowds and more traffic	Increase due to larger crowds and more traffic
(4) Water quality*		No effect	Temporary turbidity during construction and maintenance	Temporary turbidity during construction and maintenance
(5) Manmade resources*	Highways, buildings, & beach facilities subject to damage as beach erodes	Highways, buildings, and beach facilities subject to damage as beach erodes	Increases possibility of further development in beach areas	Increases possibility of further development in beach areas
(6) Natural resources*	Continued erosion	Continued erosion	Temporary adverse effects on beach and offshore borrow area	Temporary adverse effects on beach and offshore borrow area
(7) Esthetic values*	Continued erosion; relocation & modification may affect views in area	Continued erosion; relocation and modification may affect views in area	Temporary unsightliness during construction and nourishment	Temporary unsightliness during construction and nourishment

TABLE 6 - Continued
SUMMARY OF EFFECTS

	No Action	Nonstructural Combination Plan	Hutchinson Island Beach Fill & Periodic Nourishment (Plan S-2A) NED & EQ Plan	Jupiter Island Beach Fill & Periodic Nourishment (Plan S-2B) EQ Plan
(8) Biological resources*	None	None	Temporary disruption of beach ecosystems Possible loss of benthic community in work areas Temporary disruption of fishing during construction New species should re-establish in borrow area	Temporary disruption of beach ecosystems Possible loss of benthic community in work areas Temporary disruption of fishing during construction New species should reestablish in borrow area
(9) Public facilities*	Potential loss of recreation areas	None	Beach access and public facilities necessary for realization of project benefits	Beach access and public facilites necessary for realization of project benefits
(10) Public services*	None	None	Some potential for increased need for water supply, sewer service, and other utilities as area continues to develop	Some potential for increased need for water supply, sewer service, and other utilities as area continues to develop
(11) Noise level change*	None	None	Temporary increase during construction Increases as crowds and traffic increase	Temporary increase during construction Increases as crowds and traffic increase

TABLE 6 Continued
SUMMARY OF EFFECTS

	No Action	Nonstructural Combination Plan	Hutchinson Island Beach Fill & Periodic Nourishment (Plan S-2A) NED & EQ Plan	Jupiter Island Beach Fill & Periodic Nourishment (Plan S-2B) EQ Plan
(12) Tax changes*	None		Expenditure for project construction and maintenance Increase expenditure for public facilities and services as area develops	Expenditure for project construction and maintenance Increase expenditure for implementing plan
3. Regional Development	None	(Not displayed; major impacts are indicated under the other three accounts. Only major concern relating to this account is the maintenance of the tourist bsae economy which is accomplished by providing an improved beach.)		
4. Social Well-Being				
a. Beneficial Impacts				
(1) Community cohesion*	None	None	Increase leisure opportunity	Increase leisure opportunity
(2) Employment*	Continued erosion causes job availability in beach areas to diminish	Continued erosion causes job availability in beach areas to diminish	Some jobs during construction Job availability increases as area develops	Some jobs during construction Job availability increases as area develops
(3) Property values*	Possible decline in project area	Possible decline in project area	Stabilized beach should enhance beachfront perperty values	Stabilized beach should enhance beachfront property values

TABLE 6 - Continued
SUMMARY OF EFFECTS

	No Action	Nonstructural Combination Plan	Hutchinson Island Beach Fill & Periodic Nourishment (Plan S-2A) NED & EQ Plan	Jupiter Island Beach Fill & Periodic Nourishment (Plan S-2B) EQ Plan
(4) Community growth*	Continued erosion would interfere with present growth trend	Continued erosion would interfere with present growth trend	Present growth trends would be enhanced	Present growth trends would be enhanced
(5) Regional growth*	Loss of beach opportunity will affect present growth trends	Loss of beach opportunity will affect present growth trends	Enhance businesses along highways leading to beaches	Enhance businesses along highways leading to beaches
b. Adverse Impacts				
(1) Security of life, health and safety	Continued erosion will increase threat to health & safety from flood & wave damage	Continued erosion will increase threat to health and safety from flood and wave damage	Contributes toward the feeling of security and safety	Contributes toward the feeling of security and safety
(2) Community cohesion*	Patterns of social and economic cohesion will be altered by continued erosion	Patterns of social and economic cohesion will be altered by continued erosion	Shift in community pattern as condominimum residents become more prevalent	Majority of concerned residents become involved with plan implementation

TABLE 6 - Continued
SUMMARY OF EFFECTS

	No Action	Nonstructural Combination Plan	Hutchinson Island Beach Fill & Periodic Nourishment (Plan S-2A) NED & EQ Plan	Jupiter Island Beach Fill & Periodic Nourishment (Plan S-2B) EQ Plan
(3) Displacement of people*	Some will be forced to move as erosion continues	Some will be forced to move as erosion continues	As value of property increases, many owners may sell and move	As value of property increases, many owners may sell and move
(4) Tax change*	Decline in tax base as property values decrease	Decline in tax base as property values decrease	Local contribution for construction and maintenance	Local contribution for construction and maintenance
(5) Property values*	Decrease as erosion continues	Decrease as erosion continues	Enhanced due to additional shore protection and recreational beach	Enhanced due to additional shore protection and recreational beach
(6) Displacement of businesses*	Continued erosion will force some establishments to move	Continued erosion will force some establishments to move	Attraction for business investments	Attraction for business investments
(7) Community growth*	Loss of beach will retard present growth trends	Loss of beach will retard present growth trends	Encourages developments in areas near restoration	Encourages developments in areas near restoration
(8) Public facilities*	Continued erosion eventually affects available facilities	Continued erosion eventully affects available facilities	Additional facilities required to develop beach use benefits	Additional facilities required to develop beach use benefits

TABLE 6 - Continued
SUMMARY OF EFFECTS

	No Action	Nonstructural Combination Plan	Hutchinson Island Beach Fill & Periodic Nourishment (Plan S-2A) NED & EQ Plan	Jupiter Island Beach Fill & Periodic Nourishment (Plan S-2B) EQ Plan
C. Plan Evaluation				
1. Contributions to Planning Objectives				
a. Provide recreation beach		In developed reaches, beach width diminishes as erosion continues	Provides adequate recreational beach	Provides adequate recreational beach
b. Protection from flooding and wave damage	Protection decreases as erosion continues	Protection decreases as erosion continues	Protects against erosion damage	Protects against erosion damage
c. Beach erosion control	Erosion continues	Erosion continues	Erosion effects offset	Erosion effects offset
d. Protection of tourist based economy	No protection	No protection	Provides effective protection for economy	Provides effective protection for economy
2. Relationship to Four National Accounts				
a. NED Account	Most adverse impact. No capital outlay for construction, but damages continue	Most adverse impact. No capital outlay for construction, but damages continue	Annual net benefit equal $884,700	No net annual beneftis *

TABLE 6 Continued

SUMMARY OF EFFECTS

	No Action	Nonstructural Combination Plan	Hutchinson Island Beach Fill & Periodic Nourishment (Plan S-2A) NED & EQ Plan	Jupiter Island Beach Fill & Periodic Nourishment (Plan S-2B) EQ Plan
b. EQ Account	Erosion and storm damage continues	Erosion and storm damage continues	Has intermediate temporary adverse effects during construction and subsequent maintenance and nourishment. Intermediate beneficial effect from wider beach	Has intermediate temporary adverse effects during construction and subsequent maintenance and nourishment. Intermediate beneficial effect from wider beach
c. SWB Account	Most adverse impacts. Continued erosion will force persons and businesses to move, decrease beachfront property values, retard growth	Most adverse impacts. Continued erosion will force persons and businesses to move, decrease beachfront property values, retard growth	Intermediate beneficial effect. Increased property values, job opportunity, leisure opportunity. Minor adverse impacts.	Intermediate beneficial effect. Increased property values, job opportunity, leisure opportunity. Minor adverse impacts.
d. RD Account			Not evaluated - see comment under Item No. B.3.	
3. Plan Response to Associated Evaluation Criteria				

TABLE 6 - Continued
SUMMARY OF EFFECTS

	No Action	Nonstructural Combination Plan	Hutchinson Island Beach Fill & Periodic Nourishment (Plan S-2A) NED & EQ Plan	Jupiter Island Beach Fill & Periodic Nourishment (Plan S-2B) EQ Plan
a. Acceptability	Unacceptable to local interests	Unacceptable to local interests	Acceptable to beach interests	Acceptable to beach interests
b. Completeness	No investments or actions necessary	No investments or actions necessary	All necessary actions included	All necessary actions included
c. Effectiveness	Does not adequately address problems & needs of area. Does not meet planning objectives. Overall impact adverse.	Does not adequately address problems and needs of area. Does not meet planing objectives Overall impact adverse	Technical aspect adequate. Meets planning objectives adequately. Overall impact beneficial	Technical aspect adequate. Does not meet NED objectives
d. Efficiency	Not efficient	Not efficient	Plan meets planning objectives. EQ output higher than other plans considered for the area	Technical aspects adequate

SUMMARY OF EFFECTS

	No Action	Nonstructural Combination Plan	Hutchinson Island Beach Fill & Periodic Nourishment (Plan S-2A) NED & EQ Plan	Jupiter Island Beach Fill & Periodic Nourishment (Plan S-2B) EQ Plan
e. Certainty	Will not achieve any planning objectives since they were formulated to counter these effects	Will not achieve any planning objectives since they were formulated to counter these effects	If implemented, this plan would meet objectives as indicated under "effectiveness." The plan would also meet NED and EQ output as indicated under "efficiency." If erosion rate is higher than estimated, NED output would be lower than anticipated. If maintenance is inadequate or delayed, both NED and EQ objectives will suffer.	Same as for other plans except does not meet NED objective
f. Reversibility	Could be reversed at any time by implementing beach nourishment except for structural damage incurred in interim	Could be reversed at any time by implementing beach nourishment, except for structural damage incurred in interim	All plans could be reversed at any time.	
Implementing Responsibility	None	None	Federal Government plus local sponsor (Martin County) or suitable substitute such as a Beach Erosion Control District or county	Federal Government plus local sponsor (Martin County) or suitable substitute such as a Beach Erosion Control District

* Items specifically required in Section 122.

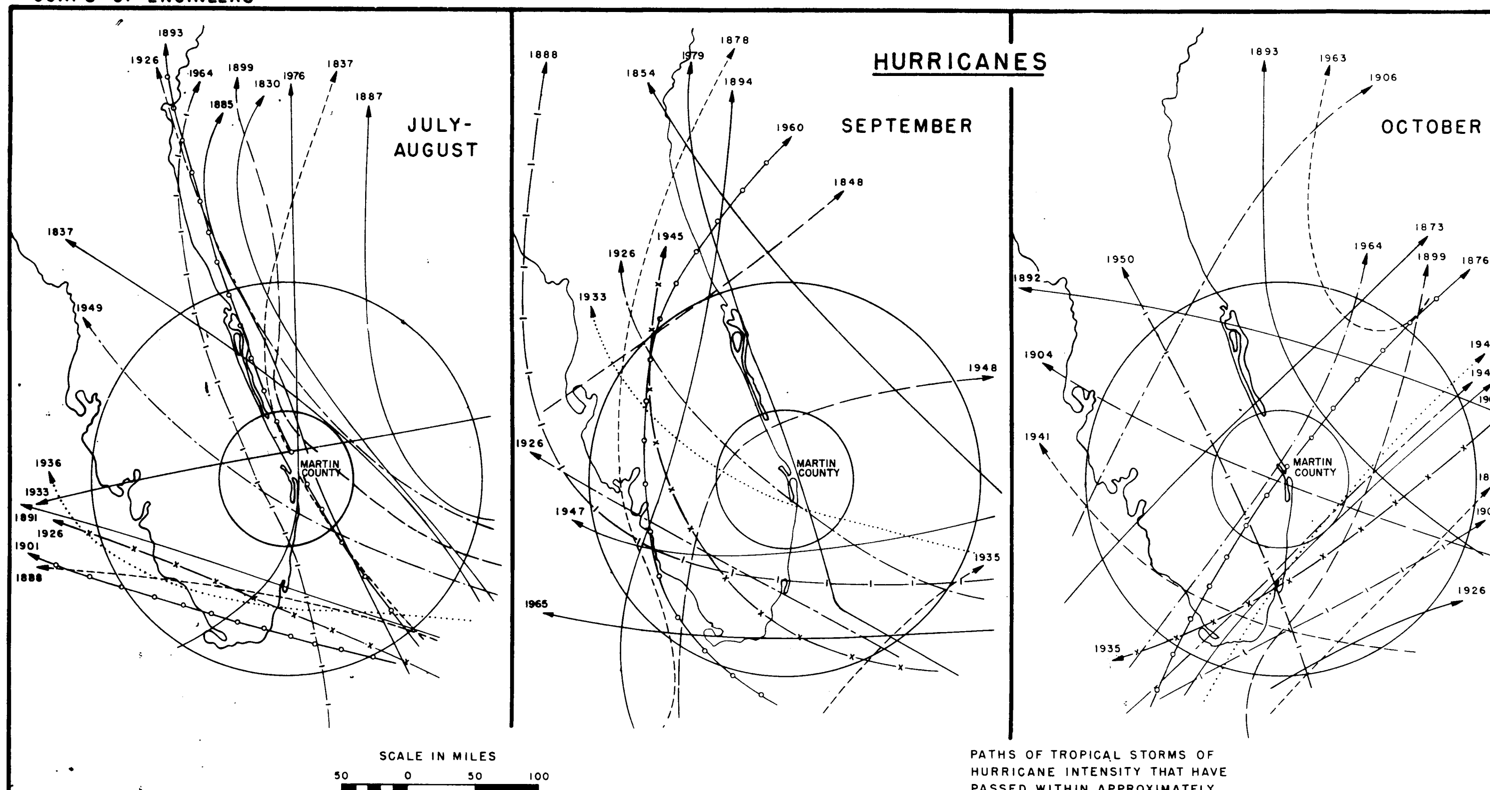
TABLE 6 - Continued

SUMMARY OF EFFECTS

	No Action	Nonstructural Combination Plan	(NED and EQ Plan) Beach Fill & Periodic Nourishment (Plan S-2A) (Hutchinson Island)	(EQ Plan) Beach Fill & Periodic Nourishment (Plan S-2B) (Jupiter Island)
e. Certainty	Will not achieve any planning objectives since they were formulated to counter these effects	Will not achieve any planning objectives since they were formulated to counter these effects	If implemented, this plan would meet objectives as indicated under "effectiveness." The plan would also meet NED and EQ output as indicated under "efficiency." If erosion rate is higher than estimated, NED output would be lower than anticipated. If maintenance is inadequate or delayed, both NED and EQ objectives will suffer.	Same as for other plans except does not meet NED objective
f. Reversibility	Could be reversed at any time by implementing beach nourishment except for structural damage incurred in interim	Could be reversed at any time by implementing beach nourishment, except for structural damage incurred in interim	All plans could be reversed at any time.	
Implementing Responsibility	None	None	Federal Government plus local sponsor (Martin County) or suitable substitute such as a Beach Erosion Control Dis-[illegible]ct or county	Federal Government plus local sponsor (Martin County) or suitable substitute such as a Beach Erosion Control District

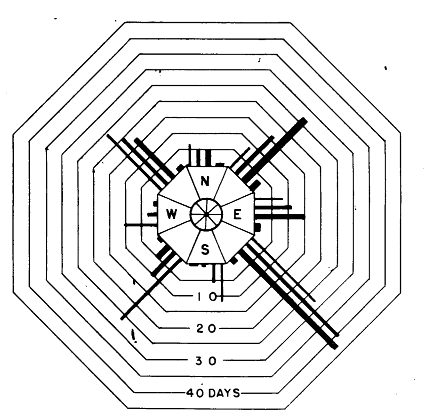
* specifically required in Section 122.

HURRICANES



PATHS OF TROPICAL STORMS OF HURRICANE INTENSITY THAT HAVE PASSED WITHIN APPROXIMATELY 50-MILE AND 150-MILE RADIUS OF JUPITER ISLAND FROM 1830 TO SEPTEMBER 1985 INCLUSIVE.

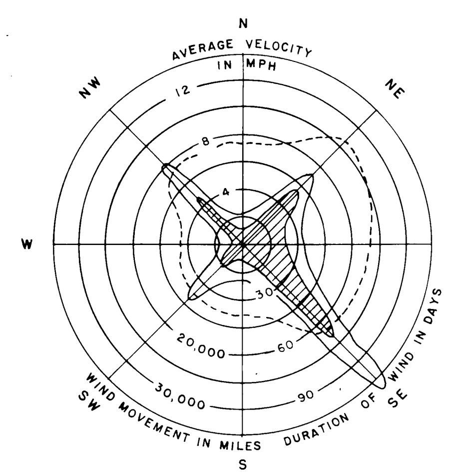
WIND DIAGRAMS



AVERAGE DIRECTION, DURATION, AND VELOCITY OF WINDS FOR ONE YEAR AT WEST PALM BEACH, FLORIDA

VELOCITIES	MPH
	0 TO 5
	6 TO 10
	11 TO 20
	21 TO 30
	31 AND OVER

BASED ON SIX-HOUR READINGS OVER AN EIGHT-YEAR PERIOD FROM 1 JULY 1938 TO 31 JULY 1916 BY THE U.S. WEATHER BUREAU AT WEST PALM BEACH, FLORIDA.

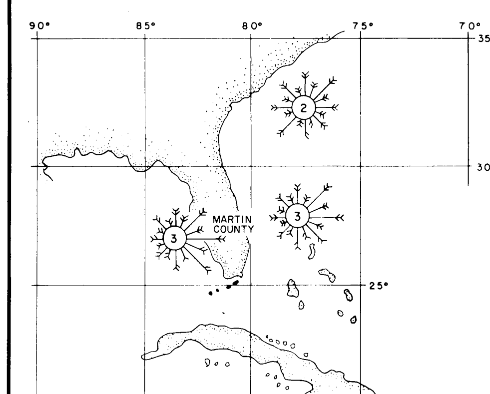


AVERAGE VELOCITY, DURATION, AND MOVEMENT OF WINDS FOR ONE YEAR AT WEST PALM BEACH, FLORIDA

AVERAGE VELOCITY IN MPH
DURATION OF WIND IN DAYS
WIND MOVEMENT IN MILES

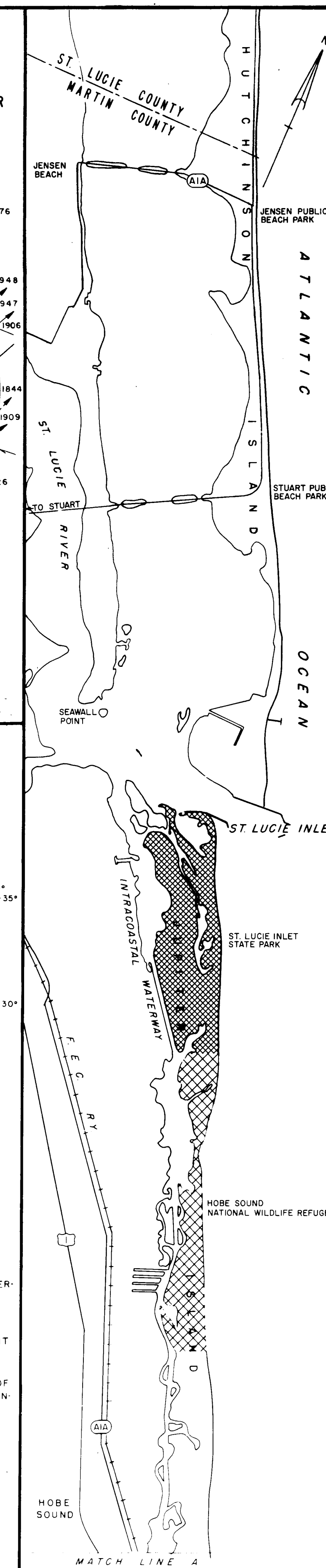
BASED ON SIX-HOUR READINGS OVER AN EIGHT-YEAR PERIOD FROM 1 JULY 1938 TO 31 JULY 1946 BY THE U.S. WEATHER BUREAU AT WEST PALM BEACH, FLORIDA.

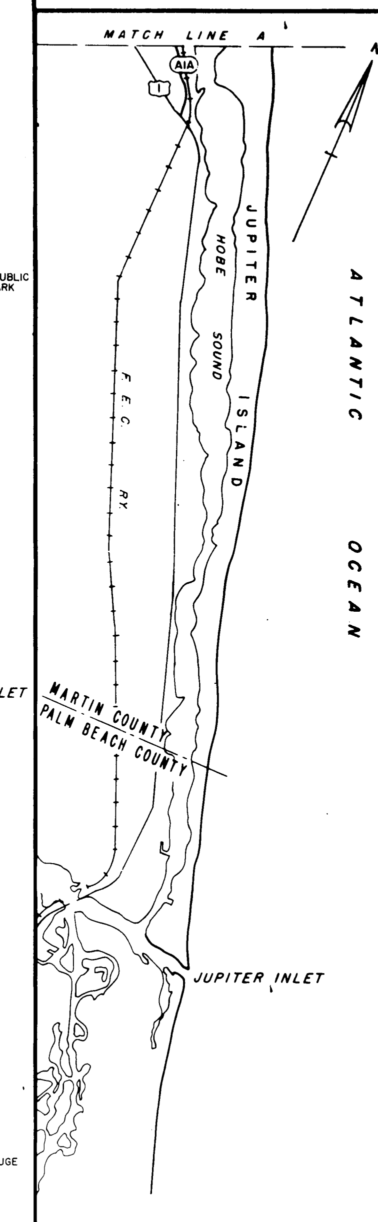
PREVAILING WINDS ATLANTIC & GULF COASTS



THE WIND ROSE IN EACH 5° SQUARE SHOWS THE YEARLY AVERAGE WINDS THAT HAVE PREVAILED WITHIN THAT SQUARE. THE ARROWS FLY WITH THE WIND. THE LENGTH OF THE ARROW MEASURED FROM THE OUTSIDE OF THE CIRCLE AS DEMONSTRATED ON THE SCALE BELOW, GIVES THE PERCENT OF THE TOTAL NUMBER OF OBSERVATIONS IN WHICH THE WIND HAS BLOWN FROM OR NEAR THE GIVEN DIRECTION. THE NUMBER OF FEATHERS SHOWS THE AVERAGE FORCE OF THE WIND ON THE BEAUFORT SCALE. THE FIGURE IN THE CENTER GIVES THE PERCENTAGE OF CALMS.

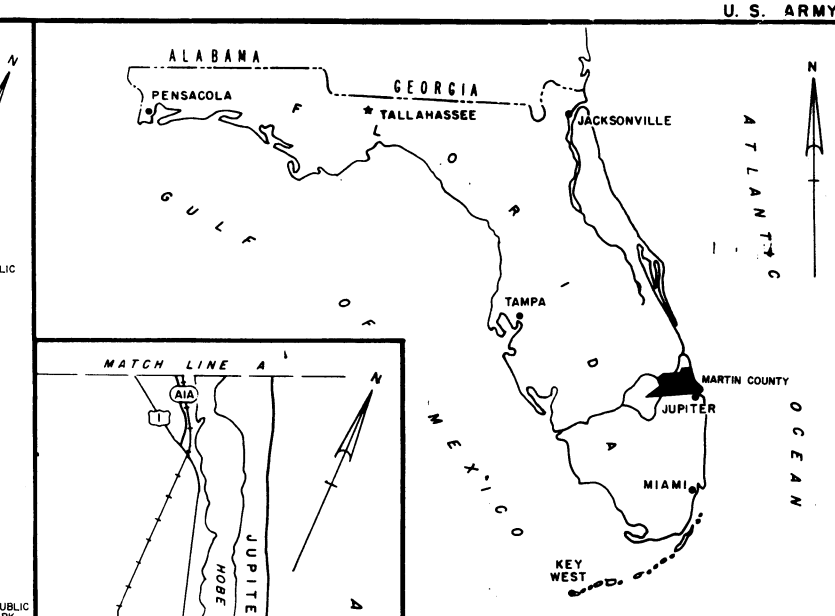
SCALE OF WIND PERCENTAGES
10 0 10 20 30 40





VICINITY MAP

SCALE IN MILES
1 0 1 2



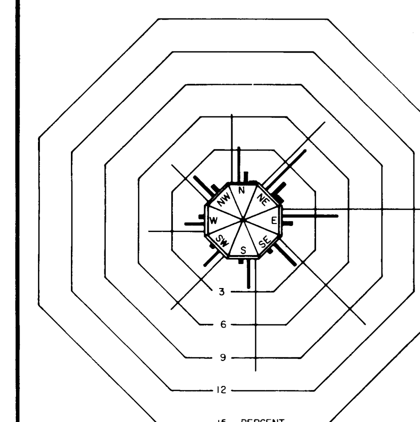
LOCATION MAP

SCALE IN MILES
50 0 50 100

SWELL DIAGRAM

THE LENGTH OF THE BAR DENOTES THE PERCENT OF TIME THAT WAVES OF EACH TYPE (SEA + SWELL) APPROACHED FROM OR NEAR THE GIVEN DIRECTION.

WAVE DATA IS BASED ON SHIPBOARD OBSERVATIONS OF EVENTS OCCURRING WITHIN A DATA SQUARE FOR A 5-YEAR PERIOD FROM 1963-1968. THE DATA SQUARES APPROXIMATE BOUNDARIES ARE 81°W — COAST AND 26° — 30°N.



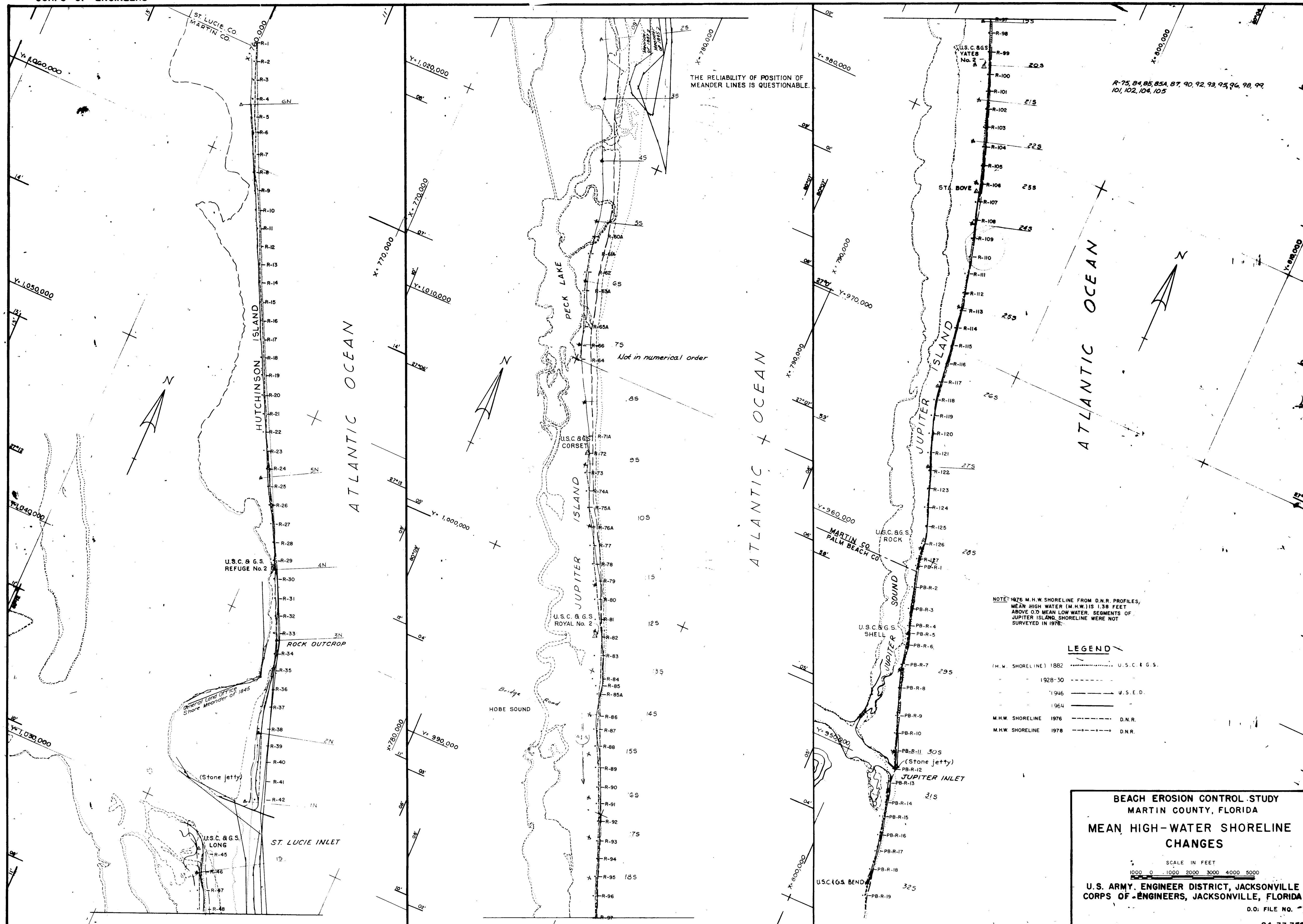
0 - 4 FT (0 - 1.2 M)
4 - 8 FT (1.2 - 2.4 M)
8 - 12 FT (2.4 - 3.6 M)
OVER 12 FT (OVER 3.6 M)

BEACH EROSION CONTROL STUDY
MARTIN COUNTY, FLORIDA

LOCATION AND VICINITY MAPS
HURRICANE, WIND, AND SWELL DIAGRAMS

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

D.O. FILE NO.
24-33,359



BEACH EROSION CONTROL STUDY
MARTIN COUNTY, FLORIDA

MEAN HIGH-WATER SHORELINE CHANGES

SCALE IN FEET
1000 0 1000 2000 3000 4000 5000

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

D.O. FILE NO.
24-33,359

PLATE 2

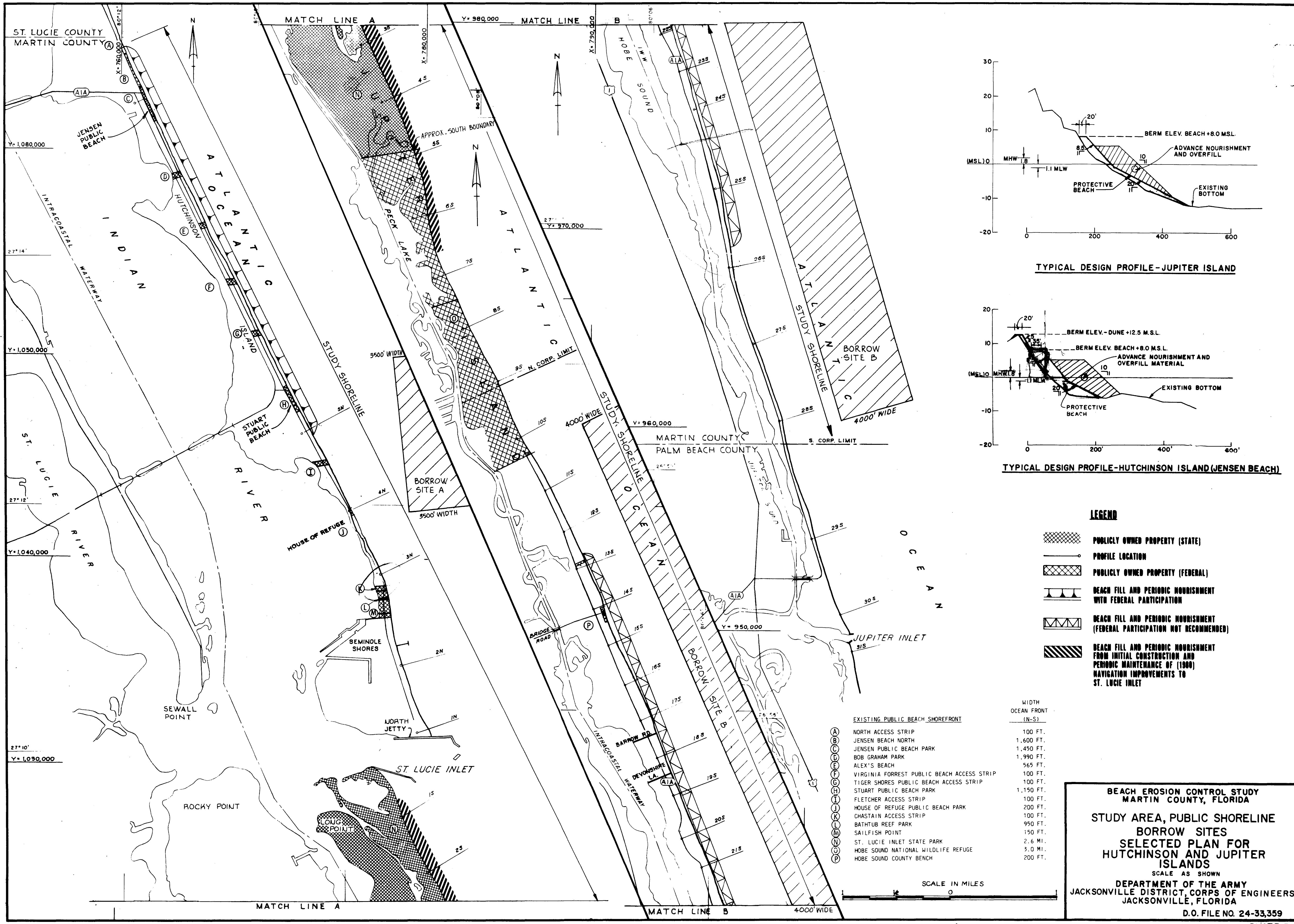

MATCH LINE A
MATCH LINE B
ST. LUCIE COUNTY
MARTIN COUNTY
JENSEN PUBLIC BEACH
STUART PUBLIC BEACH
HOUSE OF REFUGE
SEMINOLE SHORES
NORTH JETTY
ST LUCIE INLET
SEWALL POINT
ROCKY POINT
LONG POINT
ATLANTIC OCEAN
INDIAN RIVER
ST. LUCIE RIVER
INTRACOASTAL WATERWAY
HUTCHINSON ISLAND
STUDY SHORELINE
BORROW SITE A
3500' WIDTH
PECK LAKE
APPROX. SOUTH BOUNDARY
N. CORP. LIMIT
BRIDGE ROAD
BARROW RD.
DEVONSHIRE LA.
HOBE SOUND
BORROW SITE B
4000' WIDE
MARTIN COUNTY
PALM BEACH COUNTY
S. CORP. LIMIT
JUPITER INLET
OCEAN
TYPICAL DESIGN PROFILE-JUPITER ISLAND
BERM ELEV. BEACH +8.0 M.S.L.
ADVANCE NOURISHMENT AND OVERFILL
PROTECTIVE BEACH
EXISTING BOTTOM
MHW 1.8
1.1 MLW
(MSL) 0
TYPICAL DESIGN PROFILE-HUTCHINSON ISLAND (JENSEN BEACH)
BERM ELEV.-DUNE +12.5 M.S.L.
BERM ELEV. BEACH +8.0 M.S.L.
ADVANCE NOURISHMENT AND OVERFILL MATERIAL
EXISTING BOTTOM
PROTECTIVE BEACH
LEGEND
PUBLICLY OWNED PROPERTY (STATE)
PROFILE LOCATION
PUBLICLY OWNED PROPERTY (FEDERAL)
BEACH FILL AND PERIODIC NOURISHMENT WITH FEDERAL PARTICIPATION
BEACH FILL AND PERIODIC NOURISHMENT (FEDERAL PARTICIPATION NOT RECOMMENDED)
BEACH FILL AND PERIODIC NOURISHMENT FROM INITIAL CONSTRUCTION AND PERIODIC MAINTENANCE OF (1980) NAVIGATION IMPROVEMENTS TO ST. LUCIE INLET
EXISTING PUBLIC BEACH SHOREFRONT — WIDTH OCEAN FRONT (N-S)
(A) NORTH ACCESS STRIP 100 FT.
(B) JENSEN BEACH NORTH 1,600 FT.
(C) JENSEN PUBLIC BEACH PARK 1,450 FT.
(D) BOB GRAHAM PARK 1,990 FT.
(E) ALEX'S BEACH 565 FT.
(F) VIRGINIA FORREST PUBLIC BEACH ACCESS STRIP 100 FT.
(G) TIGER SHORES PUBLIC BEACH ACCESS STRIP 100 FT.
(H) STUART PUBLIC BEACH PARK 1,150 FT.
(I) FLETCHER ACCESS STRIP 100 FT.
(J) HOUSE OF REFUGE PUBLIC BEACH PARK 200 FT.
(K) CHASTAIN ACCESS STRIP 100 FT.
(L) BATHTUB REEF PARK 950 FT.
(M) SAILFISH POINT 150 FT.
(N) ST. LUCIE INLET STATE PARK 2.6 MI.
(O) HOBE SOUND NATIONAL WILDLIFE REFUGE 3.0 MI.
(P) HOBE SOUND COUNTY BENCH 200 FT.
SCALE IN MILES
BEACH EROSION CONTROL STUDY
MARTIN COUNTY, FLORIDA
STUDY AREA, PUBLIC SHORELINE
BORROW SITES
SELECTED PLAN FOR
HUTCHINSON AND JUPITER ISLANDS
SCALE AS SHOWN
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
D.O. FILE NO. 24-33,359

PLATE 3

ENVIRONMENTAL

IMPACT

STATEMENT

FINAL
ENVIRONMENTAL IMPACT STATEMENT

BEACH EROSION CONTROL STUDY
MARTIN COUNTY, FLORIDA

The responsible lead agency is the U.S. Army Engineer District, Jacksonville.

Abstract. The study was conducted in response to a resolution adopted by the Committee on Public Works of the U.S. Senate on 18 May 1973. The purpose, as stated in the resolution, was to investigate beach erosion problems along the coastal shores of Martin County, Florida, and to determine the most suitable plan for alleviating the problems. The Jacksonville District investigated public concerns related to the loss of recreational beach and attendant recreational opportunities in Martin County, Florida.

A no action plan, a combination nonstructural plan, a structural plan for Hutchinson Island (Plan S-2A), and a structural plan for Jupiter Island (Plan S-2B) were investigated in detail. The no action plan would perpetuate existing conditions, i.e., the beaches in the project area would continue to erode. This plan would avoid any environmental impacts. The combination nonstructural plan would minimize environmental impacts and would help to alleviate economic impacts on oceanside property owners but would not meet study objectives because the beaches in the project area would continue to erode. Plan S-2A would involve the placement of 942,000 cubic yards of sand along 4.0 miles of beach on Hutchinson Island. Plan S-2B would involve the placement of 2,318,000 yards of sand along 5.6 miles of Jupiter Island. The source of the sand in both plans would be offshore borrow areas. Both structural plans would meet study objectives with minimal environmental impacts.

SEND YOUR COMMENTS TO THE DISTRICT ENGINEER BY

If you would like further information on this statement, please contact:

Mr. Dan Malanchuk
U.S. Army Engineer District, Jacksonville
400 West Bay Street
Jacksonville, Florida 32232-0019
Commercial Telephone: (904) 791-1689
FTS Telephone: 8-946-1689

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FINAL
ENVIRONMENTAL IMPACT STATEMENT
BEACH EROSION CONTROL STUDY
MARTIN COUNTY, FLORIDA

Responsible Office: U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019
Telephone (904) 791-1689

1.00 SUMMARY.

1.01 Major Conclusions and Findings.

1.02 Investigations concerning the beach erosion problem along the shore of Martin County indicate that remedial measures in the form of shore protection works are required to mitigate the present shoreline recession trend.

1.03 During an initial screening, those plans which were not economically feasible or which would cause unacceptable negative impacts on the environment were dropped from further consideration. This approach was taken to allow for a more thorough analysis of the remaining alternatives in terms of environmental, social, economic, and institutional impacts.

1.04 Each of the alternative plans carried forward for detailed analysis were developed to yield the maximum net benefits. The optimum plan for Hutchinson Island (Plan S-2A) developed during plan formulation is one which provides for beach fill and periodic nourishment along 4.0 miles of beach. This plan would minimize beach erosion losses over the life of the project. The beach fill cross section would eliminate normal erosion losses that would be incurred with the occurrence of a 10-year storm.

1.05 The plan for Jupiter Island (Plan S-2B) provides for beach fill and periodic nourishment along 5.6 miles of beach. The source of fill material for both plans would be offshore borrow areas.

1.06 Section 404(b) Evaluation Report Determinations. The District Engineer has evaluated the project in light of the guidelines contained in Section 404(b) of Public Law 92-500 and found it to be consistent with the public interest. The determinations are presented below and the complete 404 Evaluation Report is in appendix A.

a. All feasible alternatives to the proposed discharge have been considered and none that are practicable will have less adverse impact on the ecosystem.

b. There are no unacceptable environmental impacts on the aquatic ecosystem as a result of the discharge.

c. The discharge of the dredged and fill material will be accomplished under conditions which will minimize, to the extent practicable, adverse environmental effect to the aquatic and semiaquatic ecosystem.

1.07 Areas of Controversy. There are no known areas of controversy at this time.

1.08 Unresolved Issues. There are no significant unresolved issues at this time.

1.09 Relationship of Plans to Environmental Requirements - Table 1 indicates the relationship of the alternative plans to applicable environmental statutes.

1.10 Part of the project area of Plan 5-2B (Jupiter Island) is presently a part of the Coastal Barrier Resource System (Unit P-12). Because the B/C of Plan S-2B is less than unity, it is unlikely that this plan will be implemented. If this plan could be economically justified, the proposed action would come under the Section 6 exemption of the Coastal Barrier Resources Act.

2.00 NEED FOR AND OBJECTIVES OF ACTION.

2.01 Study Authority. The study was initiated at the request of local interests in Martin County and was conducted in response to a resolution adopted by the Committee on Public Works of the U.S. Senate on 18 May 1973.

2.02 Public Concerns. The problem along the study area beach is one of erosion and lowering of the beach profile and recession of the shoreline and dunes. Hurricanes and severe northeasters have caused considerable erosion and damage in the past. Along parts of the shoreline, erosion of the beach and dune has made seawalls, buildings, and other structures vulnerable to severe storm damage.

2.03 The Martin County erosion problem, which has existed since 1945, has required the largest non-Federal local erosion effort on the Florida east coast. Between 1945 and 1955, 8,000 feet of seawall was constructed on Jupiter Island. By 1970, 1,200 feet of the seawall was lost to erosion. Other work included 7,760 feet of sloping block revetment that was constructed in 1961, of which 1,700 feet was lost in 1972 and five occasions of beach nourishment, including 254,000 cubic yards in 1957, 366,000 cubic yards in 1961, 363,000 cubic yards from 1964-1968, 280,000 cubic yards between 1970-1972 and 2,376,000 cubic yards in 1973-1974.

2.04 Local interests, through the Martin County Board of Commissioners have requested the study to evaluate erosion control plans that could be implemented along the Martin County shoreline.

TABLE 1

RELATIONSHIP OF PLANS TO ENVIRONMENTAL REQUIREMENTS

Federal Policies	No Action	Plan S-2A	Plan S-2B	Non-Structural Combination Plan
Fish and Wildlife Coordination Act	All plans in full compliance.			
Federal Water Project Recreation Act	All plans in full compliance.			
Water Resources Planning Act of 1965	All plans in full compliance.			
National Historic Preservation Act of 1966	All plans in full compliance.			
Wild and Scenic Rivers Act	Not applicable.			
National Environmental Policy Act	All plans in full compliance.			
Federal Water Pollution Control Act Amendments of 1972	All plans in full compliance.			
Coastal Zone Management Act of 1972	All plans in full compliance.			
Endangered Species Act of 1972	All plans in full compliance.			
Flood Plain Management (E.O. 11988)	All plans in full compliance.			
Protection of Wetlands (E.O. 11990)	N/A			
Archeological and Historic Preservation Act	All plans in full compliance.			
Clean Air Act	All plans in full compliance.			
Estuary Protection Act	All plans in full compliance.			
Land and Water Conservation Fund Act	All plans in full compliance.			
Marine Protection, Research, and Sanctuaries Act	All plans in full compliance.			
Rivers and Harbors Act	N/A			
Watershed Protection and Flood Prevention Act	All plans in full compliance.			
Environmental Effects Abroad of Major Federal Actions	N/A			
Analysis of Impacts on River and Unique Farmlands	All plans in full compliance.			
Coastal Barrier Resources Act	All plans in full compliance.			

2.05 Planning Objectives. The overall objective for water resource planning is to develop a plan which best satisfies present and projected future beach erosion control needs of the area while preserving and/or enhancing natural and recreational resources. The specific planning objectives used in conducting the study include:

a. Determination of the nature and extent of the erosion problems along the Martin County shoreline.

b. Determination of the pertinent factors which influence shoreline erosion along Martin County.

c. Determination of expected growth and future needs of the area.

d. Determination of the existing shorefront condition and recreational needs and the probable impacts on same by alternative measures for preservation and/or enhancement of these resources.

3.00 ALTERNATIVES.

3.01 During the plan formulation process, an array of preliminary alternatives was developed. From this array, various plans were eliminated for reasons ranging from economic to environmental. The plans presented in the following paragraphs were evaluated during the intermediate stage of the study.

3.02 Without Conditions (No Action). The "no action" alternative perpetuates existing conditions and provides no solution to existing problems. However, it also avoids any undesirable effects that may be associated with structural or nonstructural plans for erosion control. This option, although not favored by local interests, is considered in relation to the effects of other alternatives. This plan would provide no corrective measures but would allow tidal and shoreline processes to continue present trends. Present development trends and local planning goals for area land use and growth indicates that development and a steady influx of residents into the study area would continue regardless of improvements. Even with reduced beach capacity, recreational usage is expected to continue. With the reduced beach width, the shoreline erosion will continue to endanger the primary dune and associated vegetation.

3.03 Nonstructural Combination Plan. The nonstructural plan consists of all of the nonstructural alternatives considered in the formulation process combined into a single plan. This alternative would not meet the needs of the study area but was carried through plan formulation for the purpose of comparison with the no action plan and the viable structural alternatives. The components of this plan are as described below.

3.04 Construction Control Line. The State construction control line for Martin County was established with State approval on 23 May 1972. Rezoning of the beach area and modification of building codes as a result of implementation of the contruction control line will impact land use planning. This alternative is therefore accepted as an existing condition and will be included in the nonstructural combination plan.

3.05 Moratorium on Construction. Moratorium on construction is rejected by local interests because the desired growth of the area is oriented towards tourism and recreation, attracting retirees and promoting a stable construction industry.

3.06 Flood Insurance. Local interests' participation in the Federal Flood Insurance Program involves the enactment of building codes that require that more flood protection be built into new structures. This is a local option and will be included in the nonstructural combination plan.

3.07 Evacuation Planning. This is a nonstructural alternative which will be incorporated into the nonstructural combination plan.

3.08 Establishment of a No-Growth Program. The establishment of a no-growth program was rejected by local interests. Growth in the area, particularly that in connection with beach activities, is needed to provide economic depth to the communities. This alternative is therefore excluded from detailed studies.

3.09 Other Recreational Facilities. Martin County has reserved several stretches of ocean front for present and future public use. Future recreational needs associated with the expanding tourist industry and growing resident population can be accommodated as a result of judicious planning.

3.10 Condemnation of Land and Structures. This alternative would allow the shoreline to erode in the problem areas with a continued loss of land and possible eventual loss of structures along the beach. This alternative was rejected by local residents.

3.11 Structural Alternatives. Preliminary plans, designs, and cost estimates were formulated for an array of structural alternatives. A combination of nonstructural and structural plans developed during the second stage of analysis was reviewed to better address the needs of the study area. Seven additional plans involving structural measures were evaluated in the preliminary stages of plan formulation and subsequently dropped from further consideration. These alternatives are discussed in the following paragraphs.

3.12 Hurricane Surge Protection - Sand Dune. This alternative would help protect the Martin County shoreline from storm damages. Measures to prevent damages from hurricane-induced tidal overtopping and flooding were considered. Previous damages along the study area have resulted from beach erosion and destruction of the seawalls during severe northeast storms and hurricanes. Hurricane flooding damages from the oceanside have been relatively small in comparison to erosion damages and in many instances have been nonexistent because of the naturally high dunes. Based on previous hurricane frequency and flooding damages, the 1968 Corps Beach Erosion Control Report concluded that measures in addition to those required for beach erosion control were not warranted. Subsequent development of the Martin County shoreline was affected by the establishment of the Construction Control Line (CCL). The CCL was initiated in May 1972 and is a result of comprehensive engineering and topographic surveys, erosion analyses, prediction of storm tides and wave runup, and other analyses. It represents the landward encroachment of storm erosion for an estimate storm occurrence of 1 in 70 years. Shoreline development seaward of the CCL will not significantly impact on the previous storm frequency and damage analysis; therefore, no further consideration was given to this alternative.

3.13 Stabilization of Beaches by Vegetation. Stabilization of the beaches with vegetation is, for the most part, not applicable in the present situation. Beach grassing, if it could be accomplished, would be out of character with the predominant use of the area and would deprive the area of a sandy beach. A variation of this alternative could be implemented in combination with beach fill if the formation of windblown sand dunes and landward migration of dunes became a problem.

3.14 Relocation of Structures. The relocation of the structures in the Martin County problem area would allow the area to continue to erode. The land in this area would be lost until an equilibrium shoreline is reached, and most structures would not be able to be economically moved sufficient distances from the area which would be lost. This alternative therefore would necessitate the condemnation of the land and structures in the problem area.

3.15 Flood Proofing of Structures. Flood proofing of existing structures and regulation of flood plain and shorefront development is considered a subfeature of building code modifications.

3.16 1968 Corps Plan of Improvement for Jupiter Island. Initial restoration would be required for 29,000 linear feet (5.5 miles) of shore at Jupiter Island. That area extends from a point about 1,000 feet north of Bridge Road southerly 5.5 miles to a point about 1.6 miles north of the Martin County-Palm Beach County line. The estimated volume of material required for initial restoration is 2,430,000 cubic yards. Periodic nourishment would be provided when needed. The average annual nourishment requirement for the restored reach is 150,000 cubic yards. This plan was not economically justifiable and was eliminated from further consideration.

3.17 1968 Corps Plan of Improvement for Jensen Beach. Initial partial restoration, periodic nourishment, and four groins are required for about 1,500 linear feet (0.3 mile) of beach, the entire ocean shore of the county park at Jensen Beach. That reach extends southerly for a distance of 1,500 feet from the ocean end of the Jensen Beach Bridge Road. The estimated volume of material required for initial restoration is 220,000 cubic yards. Periodic nourishment would be provided when needed. The groins, concrete H-pile structures with adjustable concrete panels, would each be about 250 feet long. The top elevation of each groin would be at 6 feet mean low water (m.l.w.), and the structures would extend seaward from the existing bank to prevent possible flanking. From an elevation of 6 feet, the top of the seaward half of each groin would generally slope seaward 1 on 20. Top elevation of the seawardmost 10 feet of each groin would be at mean low water. This plan was not economically justifiable and had unacceptable adverse impacts associated with the groins, thus it was eliminated from further consideration.

3.18 <u>1968 Corps Plan of Improvement for Stuart Beach</u>. Initial partial restoration, periodic nourishment, and three groins are required for about 1,150 linear feet (0.2 mile) of beach, the entire ocean shore of the county park at Stuart Beach. That reach extends southerly for a distance of 1,150 feet from the ocean end of the road extending from the Stuart Causeway. The estimated volume of material required for initial restoration, including a quantity for the transition zone, is 170,000 cubic yards. Periodic nourishment would be provided when needed. The average annual nourishment requirement for the restored beach is estimated at 24,000 cubic yards. The groins are needed to help retain the initial fill and to reduce annual nourishment requirements. The plan from the 1968 report is rejected due to insufficient economic justification and the adverse effects associated with groins on adjacent shores.

3.19 <u>Seawalls</u>. The construction of concrete seawalls or improvements to and maintenance of the existing seawalls and stone revetment would provide a significant degree of protection; however, this would be accomplished at the expense of a recreational beach, resulting in substantial economic loss to the area. Reflecting wave energy off the existing seawalls and revetments has resulted in a steepening of the offshore profiles with resulting hazardous bathing conditions due to increased undertow and runouts. High initial costs in addition to these above reasons eliminated this alternative from further consideration.

3.20 <u>Revetment</u>. Revetments have been placed on the beach over the past to protect critically damaged or eroding areas on Jupiter Island. These measures have provided temporary relief, but have not reduced the erosion of the beaches. The hardening of the beach in one area merely transfers the location of the problems further down the beach.

3.21 <u>Plans Considered in Detail</u>.

3.22 The No Action plan discussed in paragraph 3.02 and the Nonstructural Combination plan discussed in paragraphs 3.03 to 3.15 were carried forward for evaluation in comparison to the following structural plans.

3.23 Plan S-2A - Beach Fill and Periodic Nourishment for 4 Miles at Hutchinson Island. This alternative provides for 4 miles of continuous beach fill from the north county line to about 0.25 mile south of the southern boundary of Stuart Public Beach Park. The initial beach fill along 4 miles of continuous shorefront at Hutchinson Island would contain 942,000 cubic yards of material. The annual nourishment rate for this reach is 61,000 cubic yards. The beach fill design cross section would provide a restored primary dune crest 20 feet wide at +12.5 feet, m.s.l., a 35-foot-wide beach berm at +8 feet, and seaward slopes of 1 vertical to 8.5 horizontal to 0 m.l.w., thence 1 vertical to 20 horizontal to the existing bottom.

3.24 Beach Fill and Periodic Nourishment at Jupiter Island (Plan S-2B). This alternative plan features 5.6 miles of beach fill along the developed shorefront at Jupiter Island with periodic nourishment at 8-year intervals. The shorefront considered ranges from about 0.5 mile north of Bridge Road to 5.6 miles south. The dimensions of the beach fill cross section would provide a 35-foot-wide beach berm at 8 feet with a foreshore slope of 1 vertical on 10 horizontal to mean low water then 1 vertical on 20 horizontal to the existing bottom.

3.25 This alternative plan considers placement of initial beach fill of 2,318,000 cubic yards of material along the 5.6 mile problem area at Jupiter Island. Material for initial restoration and periodic nourishment would be obtained from the selected borrow area located 3,000 to 7,000 feet offshore. Subsurface investigations and laboratory grain-size analysis indicate that sufficient quantity (77 million cubic yards) of suitable sand exists there.

3.26 The design beach fill cross section includes a quantity of 550,000 cubic yards of material plus 1,768,000 cubic yards for advanced nourishment for 8 years. This quantity would provide an average cross section of 78 cubic yards per foot of shorefront. The considered cross section would provide for 8 years of the average annual erosion rate of 6.5 cubic yards with 19 cubic yards per foot of shoreline remaining from the initial beach fill at the 8-year interval during renourishment. The average annual nourishment requirement for the restored reach would be about 221,000 cubic yards with the overfill ratio of 1.15 included.

3.27 The provision of a sand beach of increased dimensions will augment the natural protection afforded by the beach in mitigating erosion damage to the upland property. Wider beaches will also provide increased area for turtle nesting and recreation activities.

3.28 Characteristics of the Borrow Area and Fill Material. Two borrow areas have been delineated along the Martin County shoreline. The borrow area north of St. Lucie Inlet (Area A) is about 2.7 miles north-northeast of the inlet and about 3,000 feet offshore. The borrow area south of St. Lucie Inlet (Area B) is about 3,000 feet offshore and extends in a seaward direction 4,000 feet. The length of the borrow area is about 10.8 miles, beginning 5.4 miles south of St. Lucie Inlet and extending to Jupiter Inlet. Dimensions and quantities are summarized below:

	Borrow Area (A) North St. Lucie Inlet	Borrow Area (B) South St. Lucie Inlet
Length (ft.)	6,600	56,900
Width (ft.)	3,500	4,000
Distance from m.h.w. shoreline (ft.)	3,000	3,000
Quality material available (c.y.)	8×10^6 c.y.	77×10^6 c.y.
Overfill ratio	1.15	1.15

3.29 Comparative Impacts of Alternatives. See table 2.

4.00 AFFECTED ENVIRONMENT.

4.01 Environmental Conditions.

4.02 General. The Martin County shoreline is composed of coastal barrier islands separated from the mainland by tidal lands, lakes, and bays that are interconnected by a system of tidal waterways maintained as part of the Intracoastal Waterway. The barrier islands are low and narrow, varying in width from 200 feet to nearly a mile and in elevation from 5 to 25 feet. St. Lucie Inlet at the north end of Jupiter Island connects the Atlantic Ocean with Indian River, a lagoon that extends about 10 miles northward. St. Lucie Inlet is an artificial inlet opened into the Atlantic Ocean through the barrier island. Jupiter Inlet, a natural opening at the south end of Jupiter Island, connects the ocean with the Loxahatchee River.

4.03 The project area is undergoing development. Land is being cleared of native vegetation to make room for resort hotels, condominiums and private residences. Much of the replanting that is taking place is introduced ornamentals that are of little use to native wildlife.

4.04 Flora. Existing vegetation in the general project area includes shrubs and trees such as sand pine, Australian pine, sea grape, and wax myrtle. The major water courses in the project area, the Indian and St. Lucie Rivers, are bordered with fringe mangroves. Other flora that can be found around water courses include cordgrass, glasswort-salt grass and rush marshes. Closer to the ocean and on the dunes, the vegetation is primarily pioneer species such as saltgrass, sand spur, wild bean, seaside spurge, and sea oats.

4.05 Fauna. Wildlife in the project area consists of small mammals such as raccoon, opossum, rabbit, and rodents. Birds are abundant on the beaches and in estuarine habitats, with shore and wading birds comprising the bulk of the avifauna, along with some waterfowl and songbirds. Beaches are frequently used for nesting by sea turtles. A wide variety of fishes and crustaceans inhabit coastal Martin County supporting a substantial sport and commercial fishery.

4.06 Significant Resources. The significant resources located in the study area include the wildlife resources located in the proposed offshore borrow areas, Sabellariid worm reefs, endangered species, the public beaches, archeological and historic resources, as well as social, cultural and economic resources.

TABLE 2

* COMPARATIVE IMPACT OF ALTERNATIVES

Base Conditions and Alternatives	Fish and Wildlife Resources	Threatened or Endangered Species	Public Beaches	Water Quality	Archeological and Historical Resources
Base condition (no action alternative).	Continued loss of nesting beaches for sea turtles.	Continued loss of loss of nesting beaches for sea turtles.	Continued loss of public beaches throughout project area.	No impact.	No impact.
Non-Structural Combination Plan	1. May be some minor losses of habitat inland of the project area.	1. Continued loss of nesting beaches for sea turtles.	1. Continued loss of public beaches.	No impact.	No impact.
Plan S-2A	1. Some nearshore benthic organisms will be covered by fill. Some benthos at borrow area(s) will be lost. Other organisms only minimally affected.	1. No adverse impacts expected. 2. Increase in potential sea turtle nesting sites.	1. Short-term loss of some benthic organisms at beach nourishment site. 2. Renourishment of valuable recreational beach and increased protection of shore-front property.	1. Temporary degradation at dredge site and beachfront during construction period. Applicable State Water Quality Standards will be met.	No impacts expected.
Plan S-2B	1. Same as plan S-2A.	1. Same as plan S-2A.	1. Same as plan S-2A. 2. Same as plan S-2A (5.6 mile of beach instead of 4.0 miles involved).	1. Same as plan S-2A.	No impacts expected.

4.07 Proposed Offshore Borrow Areas. Area "A," approximately 6,600 feet long, is located 2.7 miles north-northeast of St. Lucie Inlet, about 3,000 feet offshore and extends 3,500 feet seaward. Borrow area "B," located south of St. Lucie Inlet, extends from a point 5.4 miles south of St. Lucie Inlet to the Jupiter Inlet, for a distance of 10.8 miles. Its 4,000-foot width begins at a point 3,000 feet east of the shoreline and extends seaward. The bottom in both areas is composed of sand and some shell. These areas are used for recreational fishing and diving. A more detailed description is presented in Appendix B.

4.08 Sabellariid Worm Reefs. Sabellariid worm reefs are a prominent feature of the nearshore ocean floor along the Florida east coast from Cape Canaveral to Miami. In the project area, worm reefs are limited to the area from the House of Refuge Museum south to Rand's Pier in Seminole Shores. No colonies were found in association with the small subtidal coquinoid reef outcrops adjacent to Jensen and Stuart public beaches. A detailed description and discussion of worm reefs in the project area is presented in Appendix C. The coquinoid outcroppings provide additional habitat diversity to the area. These outcroppings provide attachment points for algae, which in turn attracts invertebrates and fish.

4.09 Threatened and Endangered Species. Species listed as threatened or endangered by the Department of the Interior, whose ranges encompass the project area include the bald eagle, arctic peregrine falcon, manatee, and the Atlantic ridley, loggerhead, leatherback and green sea turtles. Martin County beaches are heavily utilized by sea turtles for nesting. There is no designated critical habitat in the project area. The Fish and Wildlife Service and the National Marine Fisheries Service concur with the Corps determination that the proposed project would not jeopardize the continued existence of any listed species.

4.10 Public Beaches. Martin County beaches are heavily utilized by local residents as well as tourists throughout the year. The beaches provide the basis of the tourist industry, which in turn plays a substantial role in the Martin County economy.

4.11 Archeological and Historical Resources. The National Register of Historic Places lists one site, the House of Refuge at Gilberts Bar on Hutchinson Island. By letter dated 5 February 1980, the State Division of Archives, History, and Records Management and the Heritage Conservation and Recreation Service were notified of the proposed action and their comments requested (letters attached). Both agencies indicated that the proposed project will not adversely impact any sites listed, or eligible for listing, in the National Register of Historic Places.

4.12 Social, Cultural, and Economic Resources. The permanent 1980 population of Martin County was 64,000 of which approximately 10,000 lived in Stuart. Employment is concentrated in three main industries: service, retail trade, and agriculture.

Retail trade and service employment is centered in Stuart and other beach communities. Tourism plays a substantial role in the Martin County economy and is expected to continue to do so.

5.00 ENVIRONMENTAL EFFECTS.

5.01 Fish and Wildlife Resources.

5.02 Base Conditions and No Action Alternative. Under present conditions, the shoreline is expected to continue to erode. Because this is a natural process, organisms inhabiting the beach zone are adapted to changing conditions and should suffer little adverse effects. Fishes and crustaceans should not be affected. Sea turtles would probably be most affected because of the loss of potential nesting sites. The recreational benefits of the beaches would be lost and property would be lost to erosion and storm damage.

5.03 Non-Structural Combination Plan. The impacts of non-structural measures would be similar to those of the No Action alternative. Natural processes will continue and the shoreline will continue to erode. The non-structural measures would serve to limit economic losses to seaside property owners.

5.04 Plan S-2A - Hutchinson Island Beach Nourishment. Nearshore benthic organisms will be covered throughout the 4-mile segment of beach to be nourished. Many of the benthic organisms at the borrow site(s) will also be lost. Most are adapted to burrow through sand and many will be able to burrow up through the fill material because it is predominantly sand. The organisms involved have high population turnovers and repopulation rates, thus losses should not be severe and recovery should begin as soon as work ceases. Fishes and macrocrustaceans should be only minimally affected. Martin County beaches are heavily utilized by sea turtles for nesting from May through November. If it is not possible to schedule the operation to avoid the turtle nesting season, direct measures for turtle protection will be employed. Turtle eggs will be recovered from nests daily, incubated, and the hatchlings released. The procedure is explained in more detail in paragraph 5.09. Once the operation is completed, additional beach area would be available for nesting turtles. The relatively steep beach profiles will minimize impacts on the sabellariid worm reefs by avoiding the burial of any reefs.

5.05 Plan S-2B - Beach Fill and Periodic Nourishment at Jupiter Island. Impacts along the beachfront would be as described in paragraph 5.04 except that the length of beach involved would be 5.6 miles instead of 4 miles.

5.06 Threatened and Endangered Species.

5.07 Base Conditions, No Action Alternative, and Non-Structural Combination Plan. Although several species listed as threatened or endangered by the U.S. Fish and Wildlife Service may occur in the general project area, the only species that may be adversely affected, if the present situation continues, would be sea turtles. Martin County beaches are used extensively for nesting by sea turtles and continued erosion of the beach would reduce overall area available for such activities.

5.08 Plan S-2A. Of the several species listed as threatened or endangered by the U.S. Fish and Wildlife Service that may occur in the general project area, only sea turtles could be directly affected by construction activities. Because of equipment limitations, it is difficult if not impossible to schedule construction activities to avoid the sea turtle nesting season of May through November. Direct measures for turtle protection will be employed. Turtle eggs will be recovered from nests the morning after they are laid, incubated, and the hatchings released. The procedure is explained in the following paragraph.

5.09 The U.S. Department of the Interior, Fish and Wildlife Service, has by permit to the Florida Department of Natural Resources authorized the taking for scientific purposes and for enhancement of propagation and survival, four species of sea turtles. The State Department of Natural Resources permits, regulates, and monitors the taking of such species. The Corps of Engineers specifies in the dredging contract that the Contractor is responsible for daily inspection of the entire beach work area at daybreak, for the location, taking and incubation of turtle eggs and release of hatchings in accordance with conditions of a permit obtained from the State of Florida. The State of Florida controls the egg recovery operation by specifying the qualifications and procedures of the recovery personnel. If work is scheduled for April to September, the Contractor will be required to begin the turtle egg recovery work 60 days before beginning work or moving equipment to the beach.

5.10 The resource agencies are concerned that because of compaction of the fill material, the beach may be unsuitable for turtle nesting after the project is completed. The Coastal Ecology Group, Waterways Experiment Station, has conducted a study of the effects of beach nourishment on nesting sea turtles using the recently completed Delray Beach project as the primary study site. The results of this study indicate that some compaction of the material deposited on the beach takes place during the first year after deposition. "Tilling" of the beach reduces the degree of compaction considerably.

5.11 An analysis of the existing beach material and of the fill material (See Appendix 4) indicates that the two materials are similar. Once the beach fill is in-place, turtles will have a greatly enlarged area in which to nest.

5.12 Manatees are uncommon in the project area, but project specifications will require that certain precautions be taken by work boats and crews associated with the project. The precautions are as described below.

"The Contractor will instruct all personnel associated with the construction of the project about the presence of manatees in the area and the need to avoid collisions with manatees. All vessels associated with the project shall operate at "no wake" speeds at all times while in shallow waters, or channels, where the draft of the boat provides less than 3 feet clearance of the bottom. Vessels transporting personnel between the landing and the dredge shall follow routes of deep water to the extent possible. All personnel should be advised that there are civil and criminal penalties for harming, harassing, or killing manatees, which are protected under the Endangered Species Act of 1973, as amended, the Marine Mammal Protection Act of 1972, and Section 370.12, Florida Statutes. The Contractor shall be held responsible for any manatee harmed, harassed, or killed as a result of the construction of the project.

The Contractor shall keep a log detailing all sightings, collisions, damage, or killing of manatees which have occurred during the contract period. Any collision with a manatee resulting in death or injury to the animal shall be reported immediately to the Chief, Environment and Resources Branch (Jacksonville District), and the U.S. Fish and Wildlife Service (Jacksonville Area Office). Following project completion, a report summarizing the above incidents shall be submitted to the Chief, Environment and Resources Branch."

5.13 Plan S-2B. Impacts would be essentially as described in paragraphs 5.08, 5.09, and 5.10, except that a 5.6 mile project area would be involved rather than a 4.0 mile area.

5.14 Public Beaches.

5.15 Base Condition, No Action Alternative, and Non-Structural Combination Plan. If no action is taken and the present situation continues, the beaches throughout much of the project area will continue to erode. This will result in the loss of recreational opportunities, reduced protection of beachfront property, and ultimate economic loss of area. The non-structural combination plan would minimize economic impacts.

5.16 Plan S-2A. Implementation of this plan will provide approximately 942,000 cubic yards of sand to 4.0 miles of beachfront from Jensen to Stuart public beaches on Hutchinson Island. This will increase and assure the long-term continuation of recreational opportunities and afford increased protection of shorefront property.

5.17 Plan S-2B. Implementation of this alternative would provide approximately 2,318,000 cubic yards of sand along 5.6 miles of beachfront on Jupiter Island, south of St. Lucie Inlet. Impacts would be essentially as described in paragraph 5.14, but would involve 5.6 miles of beach, rather than 4.0 miles of beach.

5.18 Water Quality.

5.19 Base Condition, No Action Alternative, and Non-Structural Combination Plan. No impacts.

5.20 Plan S-2A. Some degradation of water quality may occur at the borrow area and beach nourishment site during construction activities, but all applicable State Water Quality Standards will be met.

5.21 Plan S-2B. Anticipated impacts are as described in paragraph 5.20.

5.22 Archeological and Historical Resources.

5.23 Base Conditions, No Action Alternative, and All Plans. No archeological or historical resources are known to exist within the project area that would be impacted by the implementation of any of the alternatives.

6.00 PUBLIC INVOLVEMENT.

6.01 Public Involvement Program. The U.S. Army Corps of Engineers, Jacksonville District, was responsible for conducting and coordinating the study and preparing the report. After analyses of field data and the establishment of the existing and without project profiles, various preliminary plans were formulated to meet the area's needs. These plans were coordinated with the U.S. Fish and Wildlife Service. An initial public workshop was conducted on 4 May 1977 with representatives of Federal, State and local interests, and the initial public meeting was held on 23 May 1977. A plan formulation coordination letter was sent to State, regional and local environmental agencies and organizations in May 1980 to coordinate detailed plans that were developed to address the desires of local interests presented during the second public meeting held on 5 December 1980.

6.02 Required Coordination. The Draft Environmental Impact Statement and Feasibility Report were sent to Federal, State and local governmental agencies and to interested organizations and individuals for review and comment. Substantive issues addressed restored beach compatibility with the requirements of nesting sea turtles and potential to affect nearshore biota with fine particles. The Fish and Wildlife Service as well as the National Marine Fisheries Service have concurred with the Corps determination that listed species will not be jeopardized. Impacts on nearshore biota will be minor because fill material is similar to the existing beach and because the new beach will be contoured so as to minimize encroachment on nearshore biota.

6.03 Statement Recipients.

Martin County Board of County Commissioners
Department of Agriculture, Forest Service
Department of Agriculture, Soil Conservation Service
Department of Commerce, National Marine Fisheries Service, Panama City, Florida

6.03 Statement Recipients. (Continued)

Department of Commerce, National Marine Fisheries Service, St. Petersburg, Florida
Department of Interior, Fish and Wildlife Service, Jacksonville, Florida
Department of Interior, Washington, D.C.
Environmental Protection Agency, Atlanta, Georgia
Environmental Protection Agency, Washington, D.C.
Federal Highway Administration
Florida Audubon Society
Florida State Planning & Development Clearinghouse
Florida Wildlife Federation
Marine Mammal Commission, Washington, D.C.
South Florida Water Management District
Tropical Audubon Society, Inc.
U.S. Coast Guard

LIST OF PREPARERS

The following people were primarily responsible for preparing this Environmental Impact Statement:

Name	Expertise	Experience	Professional Discipline
Mr. Dan Malanchuk (Report preparation)	Marine Science	9 years, EIS studies	Biologist
Mr. Charles Stevens (Principal preparer of feasibility report, economics, report coordinator)	Coastal Engineer	8 years, Civil Engineer Jacksonville District	Civil Engineer
Mr. John Hendry	Cost Engineer	30 years, Civil Engineer Corps of Engineers	Civil Engineer
Mr. Andrew Hobbs (Supervision)	Coastal Engineer/ Water Resource Planner	22 years, Civil Engineer Corps of Engineers	Civil Engineer
Dr. Lloyd H. Saunders (Administration)	Supervisory Biologist	14 years, NEPA compliance	Biologist
Dr. Gerald Atmar (Supervision)	Supervisory Biologist	14 years, EIS studies	Bioligist

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APPENDIX A

SECTION 404 EVALUATION REPORT

MARTIN COUNTY FLORIDA, BEACH EROSION CONTROL

1. Project description. Martin County Florida, Beach Erosion Control.

a. Location. The project is located along the Atlantic side of Hutchison and Jupiter Islands, Martin County central Florida.

b. General Description. The beaches in the project area are eroding. Alternative S-2A would provide a protective and recreational beach along 4.0 miles of Hutchison Island Alternative S-2A would provide a protective and recreational beach to 5.6 miles of Jupiter Island.

c. Authority and Purpose. Beacn restoration in Martin County would be done in response to a resolution adopted by the Committee on Public Works of the U S. Senate on 18 May 1973

d. General Description of Dredged or Fill Material.

(1) General characteristics of material. The material that will be placed on the beach is sand

(2) Quantity of material. Depending on which alternative is selected approximately 942.000 to 2 318,000 cubic yards of sand would be placed on the beach.

(3) Source of material. The sand would originate in two borrow areas located offshore. Area A is approximately 3 000 feet offshore 2.7 miles north-northeast of St. Lucie Inlet. It is 6.600 feet long along the North-South axis and 3,500 feet long along the East-West axis. Area B is approximately 3,000 feet offshore 5 4 miles south of St. Lucie Inlet. It is 10 8 miles long along the North-South axis and 4 000 feet along the East-West axis.

e. Description of the Proposed Discharge Site.

(1) Location. The material would be discharged along 4 miles of the Atlantic side of Hutchison Island and 5 6 miles of Jupiter Island, Martin County, Florida.

(2) Size. The discharge site varies in width from a few feet to approximately 100 feet and stretches for 4 miles along Hutchison Island and 5.6 miles along Jupiter Island.

(3) Type of Site. The discharge site is an eroding beach.

(4) Type of habitat. The discharge site is an eroding sand beach with low productivity.

(5) Timing and duration of discharge. The timing and duration of the discharges is not known at this time.

f. Description of Disposal Method. The sand will be dredged offshore, pumped to shore through a pipe and contoured on shore by earthmoving machinery.

2. Factual Determinations.

a. Physical Substrate Determinations.

(1) Substrate elevation and slope. The substrate elevation varies from +9 feet mean low water to the depth at which the fill material would intersect the existing bottom after a 55-foot-wide berm with a 1:8.5 slope is constructed and a 1:20 slope from that point is blended into the existing bottom.

(2) Sediment type. The sediment is sand.

(3) Dredged/fill material movement. Longshore currents will move the fill material in a north to south direction, parallel to the shoreline.

(4) Physical effects on benthos. Benthic organisms will be buried by the fill material. Many benthic organisms inhabiting the disposal area are adapted for burrowing through sand and will not be impacted. Some organisms will be lost, but recolonization will begin as soon as the work is completed

b. Water Circulation, Fluctuation, and Salinity Determination.

(1) Water column effects. The disposal materail is sand and will settle out quickly. thus impacts on the water will be localized and of short duration.

(2) Current patterns and circulation. Current patterns and circulation will not be effected. The project area is subject to East-West tidal currents and a North to South longshore current.

(3) Normal water level fluctuations and salinity gradients. The mean tide range in the project area is 2.8 feet. Salinity is that of seawater.

c. Suspended Particulate/Turbidity Determinations.

(1) Expected changes in suspended particulates and turbidity levels in the vicinity of the disposal site. The material to be placed on the beach is sand, which will settle out quickly and produce only minimal changes of short duration to suspended particulates and to turbidity levels.

(2) Effects on chemical and physical properties of the water column.

(a) Light penetration. There may be short term localized reduction in light penetration as the sand particles settle out.

(b) Dissolved oxygen. Dissolved oxygen concentrations will not be effected.

(c) Toxic metals, organics, and pathogens. The sand is inert, thus there will be no release of toxic metals, organics, or pathogens.

(d) Esthetics. There may be a reduction of esthetic qualities while work is being carried out.

(3) Effects on biota.

(a) Primary productivity and photosynthesis. Only short term and localized reductions in primary productivity and photosynthesis will take place since the disposal site is almost lacking in plants and changes in light penetration will be minor and of short duration.

(b) Suspension/filter feeders. The predominant filter/suspension feeders in the project area, the Sabellaiid worms are adapted for survival in turbulent and turbid water, thus impacts due to the implementation of the project will be minor and of short duration.

(c) Sight feeders. Sight feeders make little use of project area, thus there will be no discernable impacts.

d. Contaminant Determinations. The fill material is inert sand, thus no contaminants will be introduced into the project area.

e. Aquatic Ecosystem and Organism Determinations. The fill material, being inert, will not adversely impact the aquatic ecosystem or any organisms.

(1) Endangered and threatened species. No threatened or endangered species will be adversely impacted by the placement of the fill. Endangered sea turtles will benefit because a nesting beach will be maintained during the project life.

f. Proposed Disposal Site Determinations.

(1) Mixing zone determination. The extent of the mixing zone will depend on the rate that sand is being pumped on the beach and on the stage of the tide. Being inert, the fill material will not introduce any contaminants into the mixing zone. The sand particles will settle out within a short distance of the point of deposition.

(2) Determination of compliance with applicable water quality standards. All applicable water quality criteria will be met.

(3) Potential effects on human use characteristics.

(a) Municipal and private water supplies. The project area is not used for municipal or private water supplies, thus there will be no impact.

(b) Recreational and commercial fisheries. There will be no impact on recreational and commercial fisheries.

(c) Water related recreation. The implementation of the proposed project would ensure the continued availability of recreational beaches for the life of the project.

(d) Esthetics. The creation and maintenance of a wider-then-existing beach will be more esthetically pleasing then the eroded beach that would result if no action were taken.

(e) Parks, national and historic monuments, national seashores, wilderness areas, research sites, and similar preserves. No parks, national and historic monuments, national seashores, wilderness areas, research sites or similar preserves would be adversely impacted by the implementation of the proposed project.

g. Determination of Cumulative Effects on the Aquatic Ecosystem. The implementation of the project will have no cumulative effects on the aquatic ecosystem since maintenance work will be spaced far enough apart so that the system will completely recover.

3. Findings of Compliance or Non-Compliance with the Restrictions on Discharge.

a. No significant adaptations of the guidelines were made relative to this evaluation.

b. No practicable alternative exists which meets the study objectives that does not involve discharge of fill into waters of the United States.

c. The discharge of fill materials will not cause or contribute to, after consideration of disposal site dilution and dispersion, violations of any applicable State water quality standards. The discharge operation will not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

d. The placement of fill material will not jeopardize the continued existence of any species listed as threatened or endangered or result in the likelihood of destruction or adverse modification of any critical habitat as specified by the Endangered Species Act of 1973, as amended.

e. The placement of fill materials will not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreational and commercial fishing, plankton, fish, shellfish, wildlife, and special aquatic sites. The life stages of aquatic species and other wildlife will not be adversely affected. Significant adverse effects on aquatic ecosystem diversity; productivity and stability; and recreational, esthetic, and economic values will not occur.

f. On the basis of the guidelines, the proposed disposal sites for the discharge of fill materials are specified as complying with the requirements of these guidelines.

Charles T. Myers III

CHARLES T. MYERS III
Colonel, Corps of Engineers
District Engineer

APPENDIX B
MARTIN COUNTY, FLORIDA
BEACH EROSION CONTROL STUDY

Proposed Offshore Borrow Areas

Biologists from the U.S. Fish and Wildlife Service's field office in Vero Beach performed underwater reconnaissances using SCUBA of the two designated Martin County borrow areas. The areas, designated areas "A" and "B" on the enclosed location map, are situated north and south of the St. Lucie Inlet, respectively.

The principal offshore fishes in this area include bluefish, grouper, king mackerel, Spanish mackerel, black mullet, and spot. The most obvious wildilfe along the beach are raccoons (Procyon lotor), opposums (Didelphis marsupialis), and beach mice (Peromyscus polionotus). The littoral beach environment is occupied by animals such as polychaete worms, the anomura crab (Emerita talpoida), and the ghost crab (Ocypole allicans). The endangered Florida manatee may also visit the area. This area may also be important for sea turtles.

Several dives were conducted within areas "A" and "B" on May 22, 30, and June 5, 1979. East-west transects across portions of the borrow areas were conducted along a 300-foot line placed on the ocean bottom in 20 to 40 feet of water.

Borrow area "B," located south of St. Lucie Inlet, extends from a point 5.4 miles south of St. Lucie Inlet to the Jupiter Inlet, for a distance of 10.8 miles. Its 4,000-foot width begins at a point 3,000 feet east of the shoreline and extends seaward. Soundings were taken throughout this borrow area using a Ross Depth Recorder to identify rises and high points which might be indicative of underwater reefs. No significant high points were found in area "B."

The first transect in area "B" was located in approximately 25 feet of water just south of the northern boundary of the designated borrow area, 5.9 nautical miles south-southeast of the St. Lucie Inlet, and just south of a rock reef noted visually from the dive boat. This long, rather narrow inshore reef extends from the north and terminates at a point near where borrow area "B" begins. Caution must be exercised to avoid harming this reef either by direct dredging operation or indirectly by siltation associated with such operations. The bottom was composed of fine sand interspersed with sand dollar tests. Mantis shrimp were the only significant benthic fauna observed along this transect.

The second east-west transect was made 2.8 nautical miles south of the initial transect of 8.7 nautical miles south-southesat of the St. Lucie Inlet. The bottom had the same physical and biological characteristics as before, i.e., fine ripple sand and numerous sand dollar tests with little biological activity.

On May 30, 1979, U.S. Fish and Wildlife Service divers conducted two additional transects in area "B." The third 300-foot transect was located east of the Hobe Sound Loran Tower, approximately 9.1 nautical miles south-southeast of St. Lucie Inlet. Again, little obvious biological activity was noted, except as before, fine sand interspersed with sand dollars.

The fourth area "B" transect was made about 0.5 nautical miles north of the Jupiter Inlet. Similar conditions were found along this transect as had been encountered on previous transects. While area "B" is not a diversely populated benthic area, it is important to call attention to extensive marine turtle use of the beaches.

Area "A," approximately 6,600 feet long, is located 2.7 miles north-northeast of St. Lucie Inlet, about 3,000 feet offshore and extends 3,500 feet seaward. On June 10, 1979, several dive boat passes were made through the proposed borrow area using the Ross Recorder to locate bathymetric anomalies which could be reefs or unique areas. Rock outcroppings were observed along the shore and in the shallow water near the House of Refuge. Two bathymetric rises were recorded during each of the two east-west surveys taken in borrow area "A." The first transect started at the beach near the House of Refuge and progressed due east. The two rises were originally thought to be reefs because they extended nearly 10 feet above the surrounding bottom. However, upon underwater examination, it was found to be a shoal area composed primarily of coarse, rippled, shelly sand with numerous live sand dollars interspersed over the bottom.

The second transect in borrow "A" was located approximately 3,000 feet north of the first and exhibited more coarse shelly sand. Visibility underwater was near zero along both transects as a result of an outgoing tide from St. Lucie Inlet dispersing turbid tidal waters from the inlet along the reefs near the shore.

Benthic diversity is low within both areas "A" and "B" and neither area appears to contain any unique bottom features which could serve as reefs. Therefore, the Fish and Wildlife Service concluded that the proposed dredging would have minimal long-term adverse effect on marine organisms occurring in either borrow area. Although most of the sessile animals would likely be killed during dredging, the benthic organisms would likely recolonize the dredge site. The rock reefs in or near these proposed borrow areas should not be covered by beach sand placement and should be protected from siltation resulting from the turbidity plume. These sites include the reef that terminates at the northern boundary of borrow area "B," the inshore reef parallel to and connecting to the rocky outcroppings in area "A" north of St. Lucie Inlet, and the small outcroppings nearshore just north of Jupiter Inlet. The reef area can easily be discerned on the aerial photographs. Rock outcroppings of area "A" can be viewed directly in front of the House of Refuge, a landmark in Martin County.

APPENDIX C
MARTIN COUNTY, FLORIDA
BEACH EROSION CONTROL STUDY

Sabellariid Worm Reef

The intertidal, sabellariid worm reefs in Martin County, Florida, are built by *Phragmatopoma lapidosa* Kinberg, which has a geographic range extending from southern Florida to Brazil. The worm reefs, which look like soft porous stone, have been reported to help stabilize beaches by deflecting waves and provide habitat for many species of flora and fauna.

The distribution of this species in Florida is from Miami to Cape Canaveral in water depths as great as 10 meters. Substrate type and turbulence are important limiting factors governing worm reef occurrence. The size and shape of the worm reefs are determined by prevailing local wave action and water mass circulation.

Factors that inhibit growth or kill worm reefs include: storm-derived mud (which fill open worm tubes and allows algal growth), encrusting barnacles, dense webs of bivalve mollusc byssal threads, and exposure to naturally-occurring temperature extremes.

Worm reefs are well adapted to the rigors of high-energy intertidal zones. In fact, the worms need waves to suspend the sediment they use to build their tubes and to bring in marine algae and small organisms for food. Once established, the worm reef colony absorbs the energy of the waves, and sand builds up in the calmer waters behind the reef. However, both the colony and accumulated sand are susceptible to damage by extreme wave action during storms.

Worm reefs become honeycombed with holes and passageways excavated by a variety of invertebrates. These holes provide a habitat for the many organisms found in assocation with worm reefs.

Reef Elevations and Widths

Cross-sectional views of the Seminole Shores reef show that the coquinoid reef and overlying worm colonies exhibit a gradually declining north-to-south slope. Mean reef levels ranged from +0.7 feet, m.s.l., at Transect 2 to -2.0 feet at Transect 32 near Rand's Pier. The width of the intertidal coquinoid reef substrate at Seminole Shores ranged from 32 feet at Transect 18 to 190 feet at Transect 2.

Species List of Associated Flora and Fauna

Seventy-three (73) species of algae, 118 species of fishes, and 150 species of invertebrates have been reported from worm reefs between Cape Canaveral and the St. Lucie Inlet. Some of the species may be transients in the surf zone rather than inhabitants of worm reef, and some species in obscure or little-studied groups such as the amphipods and cnidarians may have been overlooked.

Location of Worm and Coquina Reefs

Figures 1 and 2 show the location of coquinoid rock outcrops and living worm reefs along Martin County beaches on Hutchinson Island, in August 1978. With a few exceptions such as the pilings at Rand's Pier, intertidal coquina limestone outcrops of the Anastasia Formation provide most of the substrates available for colonization by P. lapisoda. Worm reefs were limited to the area from the House of Refuge Museum south to Rand's Pier in Seminole Shores. No colonies of P. lapisoda were found in association with the small subtidal coquinoid reef outcrops adjacent to Jensen and Stuart public beaches. Since worm reefs undergo cyclic periods of growth and deterioration, it is possible that these substrates are colonized during other times of the year.

Coverage of coquinoid reefs by living worm reefs increased from the House of Refuge south to Rand's Pier. Worm reefs near the House of Refuge consisted of small patches of worm tubes along the intertidal base of exposed beach rock or small, scattered subtidal patches of worm colonies less than 1 m in diameter.

South of the House of Refuge for 1,200 yards the areal coverage of living worm reefs was greater, although the worm reefs were still patchy. Worm reefs in this area were subtidal, with representative sections ranging from -1.6 to -4.6 feet, m.s.l. About 1,400 yards south of the House of Refuge, the coquinoid rock substrate branches to form an extensive limestone reef that extends to the St. Lucie Inlet (figure 2). The limestone reef system is reported to extend for 7.25 km (4.5 miles) and attain a width of 2 km just south of the St. Lucie Inlet.

During this study, P. lapisoda colonies were found only along the western edge of the limestone reef system. The heaviest concentrations of worm colonies extended about 700 yards northward from Rand's Pier. Observations by ABI personnel in previous years showed worm reefs accumulations south of Rand's Pier; however, only small isolated patches were noted here during this study (figure 2).

Survey transect measurements at Seminole Shores showed that the heaviest accumulations of worm reef occurred between transects 7 and 17 (figure 3). Worm colonies covered as much as 70 percent of the intertidal coquinoid rocks in this area. The worm reefs at Seminole Shores did not appear as extensive as the worm reefs observed in previous years.

South of St. Lucie Inlet, the reef system continues along the Martin County shoreline although somewhat sporadically and of inconsistent size, to Jupiter Inlet. The physical structure and species composition of the reef system is similar throughout the area from the Cape to Palm Beach County.

memorials fossil deposits, Indian habitations, ceremonial sites, abandoned settlements, caves, sunken or abandoned ships, historical sites and properties and buildings or objects, or any part thereof, relating to the history, government and culture of the state;	
CHAPTER 288 ECONOMIC DEVELOPEMNT AND TOURISM To diversify and improve the economy of the state.	Chapter 288 F.S. Economic Development and Tourism. The proposed project will restore eroding beaches. The beaches in Martin County attract numerous tourists which have a considerable impact on the local economy.
CHAPTER 334 PUBLIC TRANSPORTATION To insure that transportation planning and development of transportation facilities are consistent with the need to preserve and enhance the environment, conserve natural resources including scenic, historic and recreation assets and to strenghten long-range land use planning.	N/A
CHAPTER 370 SALTWATER LIVING RESOURCES Consideration of the project: 1) impact upon area of unique importance to Florida's recreational or commercial fisheries and/or concentrations of endangered or threatened species; proximity to major spawning grounds which would impact species, nature and extent of bottom habitat for important species, e.g. corals, seafans, sponges, etc. 2) impact upon oceanic currents and larval transport and the related impact on recruitment to nearshore nursery areas; and	Chapter 370 F.S. - Saltwater Fisheries. Coordination is ongoing with the National Marine Fisheries Service and the Fish and Wildlife Service. Concurrence by these agencies will constitute compliance with this statute.

3) impact on the survival of eggs and larvae in the area for important species which are prohibited from harvest a minimal sizes.	
CHAPTER 372 LIVING LAND AND FRESHWATER RESOURCES 1) conservation and protection of endangered and threatened species. 2) conservation of the wide diversity of fish and wildlife in Florida; and 3) protection of lands owned by, leased by, or assigned to the Game and Freshwater Fish Commission for wildlife management.	Chapter 372 F.S. Living Land and Freshwater Resources. The proposed project would restore eroding beaches which are used for nesting by endangered sea turtles.
CHAPTER 373 WITHDRAWAL, DIVERSION, STORAGE, CONSUMPTION OF WATER The promotion of conservation, development, and proper utilization of surface and groundwater; water storage for beneficial purposes; prevention of damage from floods, soil erosion and excessive drainage; preservation of natural resources, fish and wildlife; promotion of recreational development; protection of public lands, and, maintenance of navigability of rivers and harbors.	N/A
CHAPTER 376 POLLUTANT SPILL PREVENTION AND CONTROL Consideration on the transfer, storage, and transportation of pollutants, and the cleanup of pollutant discharges.	N/A

CHAPTER 377 OIL AND GAS PRODUCTION Compliance with the provisions regarding methods of drilling and production to prevent pollution, injury to other property, waste of energy resources, and the alteration of the sheet flow of water.	N/A
CHAPTER 380 ENVIRONMENTAL LAND AND WATER MANAGEMENT 1) concerns under DRI are: Impacts upon the environment and natural resources of the region; impacts on the economy of the region; efficient use of undue burden on water, sewer, solid waste disposal, or other necessary public facilities; efficient use or undue burden on public transportation facilities; effect on ability of people to find adequate housing reasonably accessible to their places of employment. 2) concerns under the designation of Areas of Critical State concern are the direct and secondary impacts upon ACSC resources.	N/A
CHAPTER 388 ARTHROPOD CONTROL The abatement, or suppression of mosquitos and other arthropods within the state: and furtherance of state and local mosquito control efforts.	N/A

CHAPTER 430 ENVIRONMENTAL CONTROL

Our concerns are the impacts upon the conservation and protection of environmentally sensitive living resource systems; conservation and protection of lands and waters specially designated under state and federal law; protection of groundwater quality and quantity; protection of surface water quality and quantity; potable water supply limitations; saltwater intrusion; protecting of air quality; protection of recreational benefits; minimization of adverse hydrographic and hydrogeologic impacts; minimization of adverse solid minerals mining impacts; protection of endangered or threatened species; induced or secondary impacts on area natural resources; solid, sanitrary and hazardous waste disposal; non-structural and observation measures for water control; and protection of floodplains and wetlands.

Chapter 430 F.S. Environmental Control. The purpose of the proposed project is to enhance recreation as well as to reverse erosion. The intended long-term and short-term use of the project area will not violate water quality criteria and will not harm or injure human health or welfare, animal, plant, or aquatic life or property.

CHAPTER 582 SOIL AND WATER CONSERVATION

Concerns for the control and prevention of soil erosion, for the prevention of floodwater and sediment damages, for the fostering of conservation, development and use of soil and water resources to preserve natural resources, control floods, prevent impairment of dams and reservoirs, assist in maintaining the navigability of rivers and harbors, preserve wildlife, protect public lands and the health, safety and welfare of the people of the state.

Chapter 582 F.S. - Soil and Water Conservation. The proposed project is intended to protect public lands which are now eroding and to enhance the public welfare by increasing recreational opportuities.

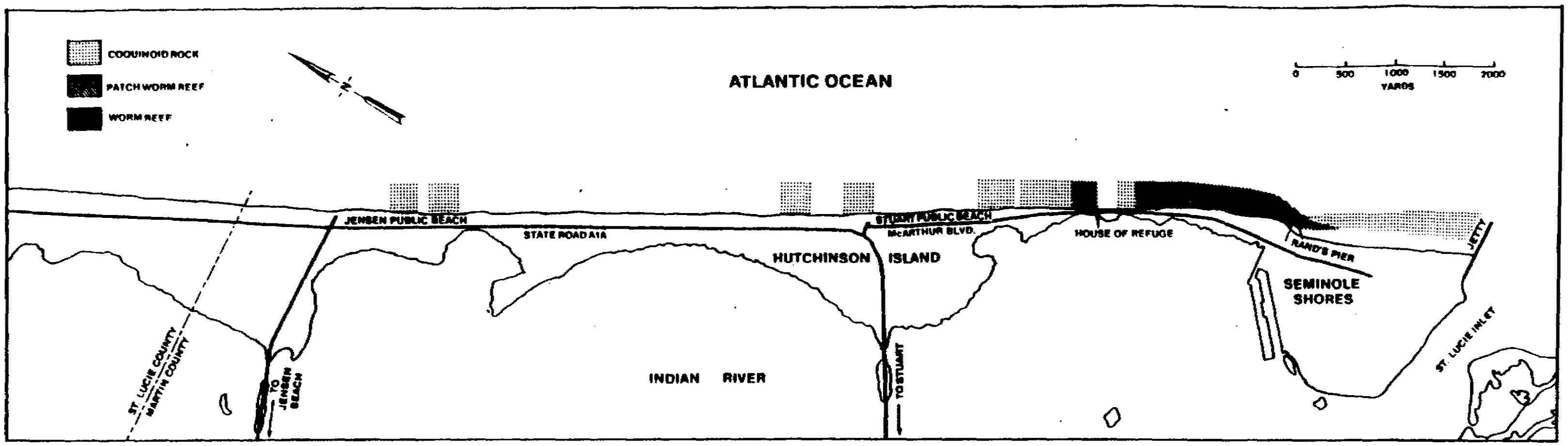

Figure 1. Location and extent of worm reefs and coquinoid rock reefs on Hutchinson Island, Florida from the Martin County line to Seminole Shores. (Seaward dimensions of worm reefs not to scale)

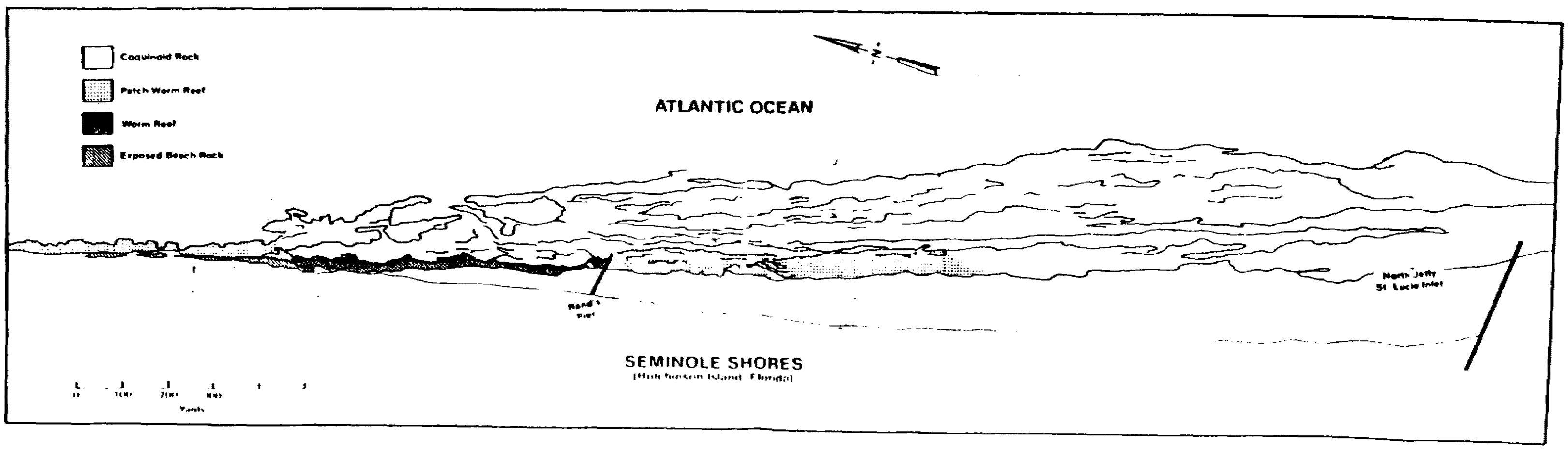

Figure 2. Location and extent of worm reefs and coquinoid rock reefs at Seminole Shores on Hutchinson Island, Florida.

COASTAL ZONE CONSISTENCY DETERMINATION

STATE CONCERNS	CONSISTENCY STATEMENT (Use additional space as needed)
CHAPTER 161 BEACH AND SHORE PRESERVATION a) "Beach and shore preservation", "erosion control, beach preservation and hurricane protection," "beach erosion control" and "erosion control" includes, but is not limited to, erosion control, hurricane protection, coastal flood control, shoreline and offshore rehabilitation, and regulation of work and activities likely to affect the physical condition of the beach or shore. b) Consideration should be given to impacts upon natural coastal processes, activity and use systems and natural vegetation, adjacent property.	Chapter 161 F.S. - Beach and Shore Preservation. The proposed project is intended to preserve the beaches in Martin County. The provisions of this chapter will be satisfied with the issuance of water quality certification by Florida DER.
CHAPTER 252 DISASTER PREPARATION AND RESPONSE 1) Consideration of the impact of the proposed federal action upon the ability to ensure that the state can "deal with, reduce vulnerability to, and recover from " natural or man-made disasters and emergencies. Such considenations will include: a) increase in evacuation times; b) impact on natural systems that serve a hazard moderating or mitigation function; c) the safety of the use, storage, or transportation of hazardous materials; d) the potential for release of [illegible];	Chapter 252 F.S. Disaster Preparation and Response. The proposed project is designed to moderate the impacts of severe storms.

e) the adequacy of any necessary evacuation program; and 2) consistency with the Peacetime Emergency Plan.	
<u>CHAPTER 253 STATE LANDS</u> Consideration of the management, conservation and protection of all state lands so as to assure maximum benefit and use.	Chapter 253 F.S. - <u>State Lands</u>. The proposed project would not result in the destruction of resources or interfere with public usage, but would act to conserve existing resource and enhance public usage.
<u>CHAPTER 258 STATE PARKS AND AQUATIC PRESERVES</u> 1. State Parks direct or indirect adverse environmental impacts on park property, including, the lands, waters and associated natural resources; conflict with on-going or proposed park programs, park management and operations, and public use and activites at the park; 2. Aquatic Preserves - Florida's Aquatic Preserve Act" establishes certain areas of sovereignty submerged land and associated waters, having exceptional biological, aesthetic and scientific values, as aquatic preserves to be maintained essentially in their natural or existing conditions.	N/A
<u>CHAPTER 267 HISTORIC PRESERVATION</u> Consideration of the protection and preservation of historic sites and properties, buildings, artifacts, treasure trove and objects of antiquity which have scientific or historical value or are of interest to the public	Chapter 267 F.S. - <u>Archives, History and Records Management</u>. Coordination with the State Historic Preservation Officer indicates that the implementation of the proposed project would have no effect on any archealogical or historic sites of national, state, or local significance.

United States Department of the Interior
FISH AND WILDLIFE SERVICE
75 SPRING STREET, S.W.
ATLANTA, GEORGIA 30303

December 31, 1985

Colonel Charles T. Myers, III
District Engineer
U.S. Army Corps of Engineers
Post Office Box 4970
Jacksonville, Florida 32232-0019

Dear Colonel Myers:

This letter and the attached Fish and Wildlife Coordination Act report constitutes the report of the U.S. Fish and Wildlife Service relative to the Beach Erosion Control Study for Martin County, Florida. Our report has been prepared under the authority of, and is submitted in accordance with the provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. et seq.). In keeping with the requirements of the FWCA, it should be attached to an made an integral part of your final report.

The Florida Game and Freshwater Fish Commission supports the comments and recommendations contained in this report, and their letter of concurrence is included as Appendix A.

We appreciate the opportunity to review, comment, and make recommendations on the proposed project. Please keep us informed of your action on this study.

Sincerely yours,

Donald J. Hankla

Donald J. Hankla
Acting Assistant Regional
Director--Habitat Resources

Attachments

INTRODUCTION

This Fish and Wildlife Coordination Act (FWCA) report addresses the Beach Erosion Control Study for Martin County, Florida, which is being conducted in response to a Congressional Resolution adopted May 18, 1974 by the Committee on Public Works of the U.S. Senate. The U.S. Fish and Wildlife Service (FWS) has reviewed the available data and prepared this report to provide the Corps of Engineers (CE) with our evaluation and recommendations to facilitate planning efforts. Our report is submitted in accordance with provisions of the FWCA (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) and has been coordinated with the Florida Game and Fresh Water Fish Commission (FG&FWFC).

PROJECT DESCRIPTION

The original study area included the entire Atlantic shoreline of Martin County. We understand that the focus of the study is on a four-mile section of beach on the Atlantic side of Hutchinson Island between the Martin County-St. Lucie County line on the north (Jensen Beach) to a point south of Stuart public beach to the south (Plate 1). The 1,600,000 cubic yards of sand required to restore this segment initially was to be dredged from borrow area "B" located approximately 1/2 mile offshore, extending from Jupiter Inlet north for a distance of approximately 11 miles. The current proposal would use a smaller borrow area (Plate 1).

The fill would be contoured to a 1:20 slope from the seaward crest of the berm to mean high water, then to a 1:30 slope until it blends with the existing bottom. The Chief of your Planning Division has requested that the Service make the necessary investigations of the nearshore environment in the project area from the Martin County-St. Lucie County line to Seminole shores.

PREVIOUS REPORTS

Since 1977, the FWS has provided the Corps six reports on this study including three planning-aid reports, two letters reviewing alternate plans contained in the Draft Feasibility Report and a Section 7 Endangered Species consultation letter. The following is a brief summary of the contents of these reports:

May 2, 1977 - A brief planning-aid report that outlined fish and wildlife resources which could be impacted by the proposed beach nourishment project.

July 20, 1979 - This report addressed the suitability of several potential offshore borrow areas and recommended measures to minimize damage to fish and wildlife resources and habitat.

April 17, 1980 - A planning-aid report on the Draft Stage II Planning for Martin County, Florida - Beach Erosion Control Study.

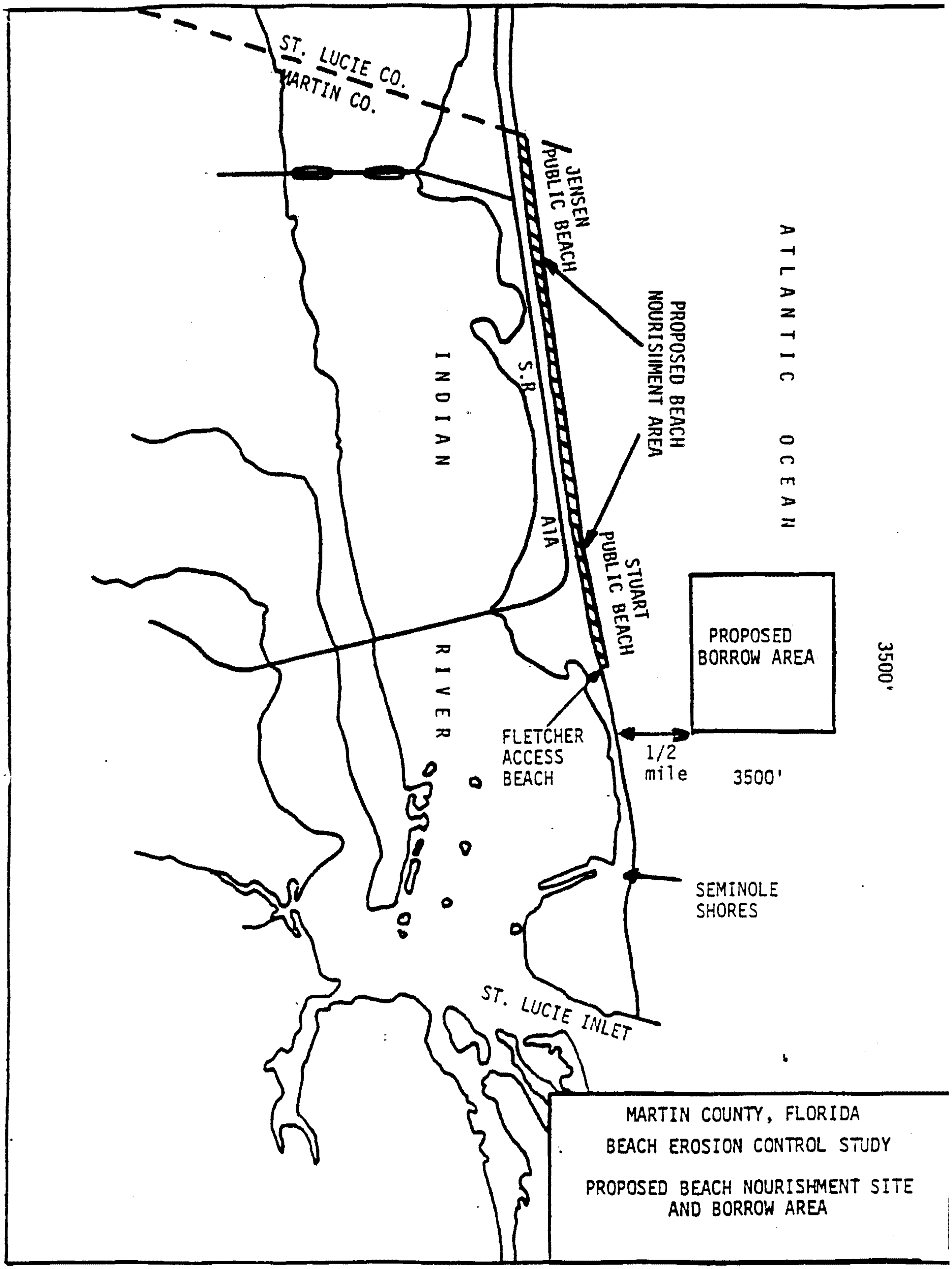
ST. LUCIE CO.
MARTIN CO.
JENSEN PUBLIC BEACH
PROPOSED BEACH NOURISIMENT AREA
ATLANTIC OCEAN
INDIAN RIVER
S.R. A1A
STUART PUBLIC BEACH
PROPOSED BORROW AREA
3500'
3500'
1/2 mile
FLETCHER ACCESS BEACH
SEMINOLE SHORES
ST. LUCIE INLET
MARTIN COUNTY, FLORIDA
BEACH EROSION CONTROL STUDY
PROPOSED BEACH NOURISHMENT SITE AND BORROW AREA

Plate 1.

January 6, 1981 - A report that covered the relative merits of the alternative plan being considered at that time for beach erosion control in Martin County.

June 6, 1985 - Our Jacksonville, Florida, Endangered Species Office responded to a Corps' letter pursuant to Section 7 of the Endangered Species Act of 1973, as amended, regarding this project. We, again, expressed concern that the project may affect nesting loggerhead and green sea turtles. We requested that Section 7 consultation for the project be postponed until the results of the Coastal Ecology Group, Waterway Experiment Station study of the effects of beach nourishment on sea turtles are available.

August 30, 1985 - The Department of the Interior commented on the draft EIS and Feasibility Report for this project. This letter reiterated our co cern over the impact of the project on nesting sea turtle.

is present report is intended as a summary of the above listed eports.

FISH AND WILDLIFE RESOURCES

Fish and wildlife resources in the project area which could be affected by the proposed beach erosion control project include the beach fauna, nearshore coquina rock outcroppings, offshore coquina reefs, and endangered species.

Beach Fauna

The beaches in the project area are typical of other sandy beaches which are subject to the full force of the ocean waves. The species diversity of the sandy beach is low, but the populations of individual species are often immense. Species found here such as annelid worms, coquina clams, ghost shrimp, and mole crabs are highly specialized and adapted to the harsh, dynamic environment. Since these sandy beaches are populated by small, short-lived organisms with great reproductive potential, these communities usually recover quickly from most environmental disturbances.

Nearshore Reefs

Low profile, rock outcroppings occur in the nearshore at various locations throughout the county. Most of the rock is a conglomerate, composed primarily of coquina shell, which is easily weathered and eroded. Generally, these reefs have a low profile, but in some areas along Martin County they rise several feet above the bottom. Most of these reefs are well scoured by wave action and suspended sediments. At some locations, the reefs are frequently covered by a thin layer of sand, leaving only scattered patches of exposed rock.

From the House of Refuge south to the St. Lucie Inlet, some rock outcroppings extend well above mean high water. Near the inlet, many outcroppings are exposed during low tide. Sessile and motile benthic invertebrates are relatively scarce, often limited to a few sparsely distributed octocorals, patches of boring sponge, some coral, and several algal species dominated by Padina and Dictyota.

The most conspicuous invertebrates of the inshore reef are the tube building worms, Phragmatopoma lapidosa. These sabellariid worm communities occur in areas of turbulence where suspended sand is available for them to make their tubes. These worm colonies encrust coquina rock or other hard substrate and construct round boulder-like mounds forming a relatively soft reef structure.

These reefs provide diverse habitat for a variety of other invertebrates as well as fish and algae. The commercially important spiny lobster, Atlantic deer cowrie, grunts, sheepshead, grouper, and snapper occur in the nearshore reef zone although they are more common on the deeper coquina reefs. In addition, since the worms exist in such great densities, their larvae may be an important link in the planktonic food chain. Furthermore, these nearshore rock systems absorb a large portion of the wave energy, helping to minimize the natural erosion process.

Offshore Reefs

Coquina rock outcroppings are not uncommon offshore from Martin County in water depths of 30 to 90 feet. These outcroppings are similar to the nearshore reefs, but because of their more stable environment, they have a greater diversity of attached organisms and associated fish and invertebrate species. Many of these reefs are popular fishing and diving areas.

Endangered Species

Endangered species listed by the Fish and Wildlife Service which occur in the project area of influence include hawksbill turtle, leatherback turtle, Atlantic green turtle, Artic peregrine falcon, brown pelican, and Florida manatee. The loggerhead turtle, listed as threatened, also nests in high numbers in the project area.

Hutchinson Island supports one of the highest loggerhead sea turtle nesting aggregations in the western Atlantic (Harris, et. al.; Hopkins and Richardson, 1984). During the 1985 nesting season, 1,071 loggerhead clutches were deposited on the project beach (Applied Biology, unpublished data). This represents the highest nesting density for loggerheads on this section of Hutchinson Island in the past five years. In addition, over 3,000 (27 nests) green turtle eggs and 1,000 (9) leatherback eggs were deposited in the project beach during the summer of 1985.

DISCUSSION OF IMPACTS

The nearshore outcroppings provide habitat for a wide variety of marine life, especially when encrusted by sabellariid worm colonies. As presently proposed, this project would cover some of the nearshore reefs which provide a unique natural habitat for fish and invertebrates. Even if the rock outcroppings are not presently encrusted with sabellariid worm tubes, they provide suitable substrate for colonization by this species. This loss would cause a corresponding decline in the sport and commercial catch of species which depend on these nearshore habitats. Covering these reefs would also eliminate most of the reef areas which are accessible to people for fishing or diving from shore.

The material in the proposed offshore borrow area appears to contain some material too fine to be considered acceptable for beach nourishment. When the nourishment material contains a large percentage of very fine sediments, indirect impacts occur long after dredging has been completed. In some areas, milky water along the beach, caused by fine silt transported from the beach by wave action, has been observed many months after beach nourishment has stopped. Also, each time a dredge operates within the borrow area, more fine silt is suspended and settles near the dredge site. Thus, more fine material is available for resuspension by wind and wave action. This turbid water can cause long-term impacts to the remaining reefs in the project area.

The potential for the project to impact endangered species varies with each species being impacted. Although manatees are not frequently sighted offshore, they do occur within the Indian River and at the inlets from which the dredge and work boats would operate. These large, slow-moving mammals are vulnerable to collision with crew boats traveling between the dredge and shore facilities. All four species of marine turtles are likely to occur in the dredge and fill areas at different times of the year. The hawksbill turtle is generally associated with reef communities and is occasionally observed on the reefs off the southeast Florida coast. Loggerhead turtles, green turtles, and leatherback turtles use the beaches of Martin County for nesting during the summer months. The beach project could affect their nesting success in several ways (Hopkins and Richardson, 1984). If conducted during the nesting season, excess sand may be deposited over nests, increasing the difficulty of the hatchlings route to the surface. Furthermore, gaseous diffusion in the nest is influenced by sand grain size, fine grain sand having the poorest diffusion rates. Therefore, the grain size of the nourishment material must be compatible with that on site. Additional adverse effects to turtles which may result from the beach nourishment project include:

1. Scarp development at the edge of the beach fill, rendering the beach inaccessible to nesting turtles,

2. entrapment of the hatchlings in the vehicle tracks,

3. alterations in moisture levels or other aspects of the micro-habitat within the nest cavity,

4. alteration of unknown beach signature components which may disrupt nest site fidelity, and

5. compaction and cementation of beach sediments which causes reduced nesting success (nesting emergences/total emergence x100), and aberrant nest cavity construction which in turn can result in broken eggs.

Even if a nest relocation program is established during the nesting season before the beach disposal occurs, micro-habitat alteration, alteration of beach signature components, and compaction could still potentially adversely impact sea turtles.

Potential problems of a large scale relocation project include: reduced hatching success due to handling, determining a relocation site for 100,000 plus eggs, site security from predation, potential alteration of sex ratios, and the probability that some of the nest will be inadvertently missed in the course of daily surveys and subsequently covered in the nourishment operation.

CONCLUSIONS AND RECOMMENDATIONS

The nearshore outcroppings represent a relatively unique fishery habitat and an important recreational resource because of their accessibility. In addition, the reefs naturally limit erosional forces along the beaches where they are present. For these reasons, the toe of the beach fill should not encroach farther seaward than the landward extent of the nearshore reef.

As noted previously, the FWS remains concerned with the potential long-term adverse impacts of this and other proposed beach nourishment projects on sea turtle nesting. We do not believe that the knowledge presently exists to assess the suitability of beach nourishment material in terms of sea turtle nesting. Compaction of beach fill has been demonstrated to adversely impact sea turtle nesting success. The FWS and National Marine Fisheries Service have recommended that Section 7 consultation for this project be postponed until the results of the Corps of Engineers, Coastal Ecology Group, Waterway Experiment Station (WES) studies on the effects of beach nourishment on nesting sea turtles is completed. It may then be possible to assess the project's impacts on nesting sea turtles.

Because of very high density of sea turtle nests and the problems inherent in a large scale relocation, we believe that no beach nourishment should be conducted during the turtle nesting period from April to November along the four-mile segment of beach on Hutchinson Island.

The percent of silts and clays in the borrow material, the location of the borrow site in relation to coquina rock outcroppings, and the compatability of the borrow material with turtle nesting, should all be primary considerations in the borrow site selection. A low silt and clay content in the borrow material and a buffer zone between the borrow area and existing offshore coquina rock reefs are essential if turbidity and siltation impacts to the reefs in the project area are to be avoided. These criteria for fill selection may also be major factors in the compatability of the fill with sea turtle nesting. Material containing silt and clay exceeding that recommended in the WES study should not be used for beach nourishment and the borrow area should be located a minimum of 1,000 feet from any reef feature.

Therefore, based upon discussions contained in this report, the FWS recommends:

1. that the toe of the beach fill not be allowed to encroach farther seaward than the landward extent of the nearshore reef,

2. that no material be used for beach nourishment that exceeds the maximum silt and clay content recommended by the WES study,

3. that the borrow area be located a minimum of 1,000 feet from any reef feature,

4. and that the nourishment of the four-mile segment between the Martin/St. Lucie County line to a point south of Stuart public beach not be conducted during the period from April to November.

LITERATURE CITED

Harris, S.A., W. J. Conley and J. A. Huff. 1984. The status of Florida's nesting sea turtles populations from 1979 through 1983. Florida Department of Natural Resources, Bureau of Marine Research, St. Petersburg, FL. 26pp.

Hopkins, S. R. and J. I. Richardson, ed. 1984. Recovery Plan for Marine Turtles, prepared by the Marine Turtle Recovery team and approved by the National Marine Fisheries Service. 255pp.

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
P. O. BOX 4970
JACKSONVILLE, FLORIDA 32232

April 4, 1985

REPLY TO
ATTENTION OF
Environmental Resources Branch
Planning Division

Mr. David J. Wesley
Field Supervisor
Endangered Species Field Office
Fish and Wildlife Service
2747 Art Museum Drive
Jacksonville, Florida 32207

Dear Mr. Wesley:

The Corps is studying the feasibility of nourishing approximately 4 miles of the Atlantic beach of Hutchison Island with approximately 1,600,000 cubic yards of sand from the St. Lucie County-Martin County line to a point south of the Stuart Public Beach. The sand would be dredged from a borrow area located approximately 1/2 mile offshore and piped to the beach.

Listed species which may occur in the vicinity of the proposed action are the endangered West Indian (Florida) manatee Trichechus manatus, the endangered green sea turtle Chelonia mydas, the threatened loggerhead turtle Dermochelys coriacea, and the endangered hawksbill turtle Eretmochelys imbricata. The project area is not critical habitat for any of the listed species.

In accordance with Section 7(c) of the Endangered Species Act, as amended, the Corps has determined that the proposed activity would have "no effect" on any of the listed species and is enclosing biological information on the species.

This completes coordination under the Act, unless new information should indicate that the proposed action may affect listed species or their habitats, or the proposed action is substantially modified, or a new species is listed which may be affected by the action, of the Service requests consultation. Your response to this notification is requested.

Sincerely,

Richard E. Bonner
Acting Chief
Planning Division

Enclosure

BIOLOGICAL INFORMATION

MARTIN COUNTY BEACH EROSION CONTROL

1. Location. The proposed work would be performed on the Atlantic beach of Hutchison Island in Martin County, Florida and in a 3500 foot by 3500 foot borrow area located approximately 1/2 mile off shore (see attached map).

2. Identification of Listed Species and Critical Habitat in the Area of the Proposed Activity. Listed species which may occur in the vicinity of the proposed activity are the endangered hawksbill turtle, *Eretmochelys imbricata*; the endangered loggerhead turtle, *Caretta caretta*; the endangered leatherback turtle, *Dermochelys coriacea*; the threatened green turtle, *Chelonia mydas*; and the endangered West Indian (Florida) manatee, *Trichechus manatus*.

3. Description of Proposed Activities. The Corps proposes to dredge approximately 1,600,000 cubic yards of sand from a borrow area located approximately 1/2 mile off shore, pipe this sand to the Atlantic side beach of Hutchison Island, and deposit this sand on the beach from the St. Lucie County-Martin County line on the north to Fletcher Beach on the south. The sand would be contoured to a 1:20 slope from the scarp line to mean high water, then to a 1:30 slope until it blends with the existing bottom. Approximately 4 miles of beach will be restored in this manner.

4. Assessment of Potential Impacts of the Proposed Activity on Listed Species. There is the possibility that manatees may travel along the Atlantic side of Hutchison Island rather then using the preferred Indian River and the Intracoastal Waterway. As transients in the project area, manatees may be exposed to the possibility of collision with work boats. The dredge will be sufficiently far offshore, be slow moving enough, be in sufficiently deep water, and in an area with nothing to attract manatees; thus it will pose no danger to manatees. Work boats operated between the dredge and the shore will be primarily in deep water. Work boats operating in shallow water will be in an area where rock outcroppings are common, thus the boat operators and lookouts will be in a state of increased vigilance and the boats will be operating at low speeds. The high state of vigilance and low speeds will minimize the chances of collision with manatees. Safeguards described in Section 5 will be enforced.

Loggerhead, green and leatherback turtles make extensive use of the project area for nesting. The hawksbill may also nest in the project area. The deposition of sand on the beach has the potential of burying turtle nests. The sand that will be placed on the beach is similar enough in grain size distribution so that nesting turtles should not be hindered in future nest construction.

The project area is presently extensively eroded and a scarp exists for much of the four mile stretch of the project area. This scarp prevents the turtles from moving inland from the narrow beach. The narrow beach is extensively used for recreation and undoubtedly many turtle nests are inadvertantly destroyed. The placement of sand on the beach and the grading of the sand so that the scarp is eliminated will enable turtles to crawl off the beach and past the tree line, making a much larger area available for turtle nesting. Nests beyond the tree line are less likely to be disturbed by beach users.

5. Efforts to Eliminate Potential Impacts on Listed Species. The Contractor shall keep construction activities under surveillance, management, and control to minimize interference with, disturbance to, and damage to fish and wildlife resources. Species that require specific attention along with measures for their protection will be listed by the Contractor prior to the beginning of construction operations.

The Corps or the Contractor will monitor and instruct all personnel associated with the construction of the project about the presence of manatees and sea turtles in the area and the need to avoid collisions. The Corps or the Contractor will brief their personnel concerning the civil and criminal penalties for harming, harassing or killing species that are protected under the Endangered Species Act and the Marine Mammal Protection Act.

Placement of sand on the beach between late April and late September could bury turtle nests to the extent that hatching or hatchling survival rates are reduced to zero. Since the period of weather conditions suitable for working coincides with the nesting season, direct measures for turtle protection will be employed, as follows:

The U.S. Department of the Interior, Fish and Wildlife Service, has by permit to the Florida Department of Natural Resources authorized the taking, for scientific purposes and for enhancement of, propagation, and survival, four species of sea turtles. The Department of Natural Resources permits, regulates, and monitors the taking of such species. The Corps of Engineers will specify in the dredging contract that the Contractor is responsible for daily inspections of the entire beach work area at daybreak, for the location, taking, incubation of turtle eggs and release of hatchlings in accordance with conditions of a permit obtained from the State of Florida. The State controls the egg recovery operation by specifying the qualifications and procedures of the recovery personnel. If work is scheduled for April to September, the Contractor will be required to begin the turtle egg recovery work 60 days before beginning work or moving equipment to the beach.

In order to safeguard any manatees which may occur in the project area, the following program will be employed.

The Contractor will instruct all personnel associated with the construction of the project about the presence of manatees in the area and the need to avoid collisions with manatees. All vessels associated with the project shall operate at "no wake" speeds at all times while in shallow waters, or channels, where the draft of the boat provides less than 3 feet clearance of the bottom. Boats used to transport personnel shall be shallow-draft vessels, preferably of the light-displacement category, where navigational safety permits. Vessels transporting personnel between the landing and the dredge shall follow routes of deepwater to the extent possible. Shore crews or personnel assigned to the disposal area for the workshift shall use upland road access if available. All personnel should be advised that there are civil and criminal penalties for harming, harassing, or killing manatees, which are protected under the Endangered Species Act and the Marine Mammal Protection Act. The Contractor shall be held responsible for any manatee harmed, harassed, or killed as a result of the construction of the project.

The Contractor shall keep a log detailing all sightings, collisions with, injuries, or the killing of manatees which have occurred during the contract period. Any collision with a manatee will be reported immediately to the Chief, Environmental Resources Branch, USAED Jacksonville (904) 791-2202 and the Fish and Wildlife Service Jacksonville Endangered Species Field Station (904) 791-2580 for investigations so the appropriate course of action can be taken. Following project completion, a report summarizing the above incidents shall be submitted to the Chief, Environmental Resources Branch, USAED, Jacksonville.

United States Department of the Interior
FISH AND WILDLIFE SERVICE
ENDANGERED SPECIES FIELD STATION
2747 ART MUSEUM DRIVE
JACKSONVILLE, FLORIDA 32207

June 6, 1985

Mr. A. J. Salem
Chief, Planning Division
Jacksonville District
Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232

FWS Log No. 4-1-85-135
Martin County
Beach Nourishment Project

Dear Mr. Salem:

This responds to your letter of April 4, 1985, pursuant to Section 7 of the Endangered Species Act of 1973, as amended, regarding the District's study of the feasibility of beach nourishment for approximately four miles of Atlantic shoreline in Martin County, Florida. You have evaluated the project potential to affect Federally listed threatened and endangered species and determined there would be no effect on listed species.

The U.S. Fish and Wildlife Service is concerned the project may affect nesting loggerhead and green sea turtles in the long term. The sea turtle recovery plan (1984) documents the relative densities of turtle nesting along the Atlantic and Gulf coasts of the United States based on a compilation of records of various studies and surveys. Martin and St. Lucie Counties have historically reported some of the highest density of nesting in the United States.

The basis for our concern is the technology to assess the suitability of borrow sediments for beach nourishment in terms of sea turtle nesting is not sensitive enough to allow prediction of post project beach conditions. Compaction of beach sediments and concurrent reduction of nesting density after nourishment projects is not uncommon, particularly when offshore borrow sites are used.

As you know the Coastal Ecology Group, Waterways Experiment Station (WES), is conducting a study of the effects of beach nourishment on nesting sea turtles using the recently completed Delray Beach project as the primary study site. Results of this study are expected in late

1985. It is requested that Section 7 consultation for the Martin County beach nourishment study be postponed until the results of the WES study are available. Important information on potential impacts, causes, and correction actions may be available at that time.

Please advise this office if this is not acceptable to you. If you have questions regarding this letter please contact Mr. David Smith at FTS 350-7276.

Sincerely yours,

David J. Wesley

David J. Wesley
Field Supervisor

August 27, 1985

Environmental Resources Branch
Planning Division

Mr. David J. Wesley
Field Supervisor
Endangered Species Field Office
2747 Art Museum Drive
Jacksonville, Florida 32207

Dear Mr. Wesley:

In accordance with Section 7(c) of the Endangered Species Act, as amended, Jacksonville District transmitted to your office a determination of "no effect" and pertinent Biological Information for the proposed Martin County Beach Erosion Control project on April 4, 1985.

Your reply, dated June 6, 1985 (FWS Log No. 4-1-85-135) requested that Section 7 consultation on this project be postponed until after the Coastal Ecology Group, Waterways Experiment Station, has concluded its study of the effects of beach nourishment.

Due to time constraints, the Corps is unable to concur with a request for postponement. It is requested that the Service provide the Corps with an opinion based on the best available information as soon as possible.

Sincerely,

A. J. Salem
Chief, Planning Division

United States Department of the Interior
FISH AND WILDLIFE SERVICE
ENDANGERED SPECIES FIELD STATION
2747 ART MUSEUM DRIVE
JACKSONVILLE, FLORIDA 32207

December 6, 1985

Mr. A. J. Salem
Chief, Planning Division
Jacksonville District
Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232

FWS Log No. 4-1-85-135
Beach Nourishment
Hutchinson Island, Martin County

Dear Mr. Adams:

This represents the biological opinion of the U.S. Fish and Wildlife Service (FWS), in accordance with Section 7 of the Endangered Species Act of 1973 (Act), as amended, regarding the Jacksonville District's feasibility study for nourishing approximately four miles of the Atlantic beach of Hutchinson Island, Martin County, Florida. This Opinion fulfills the requirements of the Act. An administrative record of this consultation is on file in this office.

Project Description

The Corps proposes to dredge approximately 1,600,000 cubic yards of sand from a borrow area located approximately one-half mile off shore, pipe this sand onto the Atlantic beach of Hutchinson Island, from the St. Lucie-Martin County line on the north to Fletcher Beach on the south. The sand would be contoured to a 1:20 slope from the scarp line to mean high water, then to a 1:30 slope until it blends with the existing bottom. Approximately four miles of beach will be nourished in this manner.

Consultation History

The Corps of Engineers determined by letter dated April 4, 1985, that the proposed work would have no effect on any listed species or destroy or adversely modify critical habitat. The following species were considered in this evaluation: West Indian manatee (*Trichechus manatus*), green sea turtle (*Chelonia mydas*), hawksbill sea turtle (*Eretmochelys imbricata*), and the loggerhead sea turtle (*Caretta caretta*). On June 6, the FWS requested that the Corps postpone consultation until fall, 1985, when preliminary results of the Waterways Experiment Station study on beach nourishment effects on sea turtle nesting would be available. On August 27, the Corps responded indicating that the Jacksonville District could not concur with postponement of the consultation and requested that the Service proceed with preparation of a biological opinion based on the best available information.

The Vero Beach Ecological Services Field Office has provided a series of reports to the Jacksonville District under authority of the Fish and Wildlife Coordination Act. The final Fish and Wildlife Coordination Act report will be issued shortly and will contain four recommendations:

1. The toe of the fill should not be allowed to encroach farther seaward than the landward extent of the nearshore reef;

2. The material used for beach fill should meet the criteria on grain size compatibility, maximum silt and clay content, and compaction standards recommended by the Waterways Experiment Station study, if appropriate.

3. The borrow area should be located a minimum of 1,000 feet away from any reef feature.

4. Beach nourishment operations should be confined to the period between November and April.

Biological Opinion

This opinion is based on information furnished in your letters of April 4 and August 27, information available in our files, and consultation with experts.

In addition to the species considered in the Corps letter of April 4, 1985, the endangered leatherback sea turtle (*Dermochelys coriacea*) nests on the beaches of Martin County. This and the other species of sea turtles may be affected by the proposed project by covering of nests during construction, alteration of physical properties of the the nest environment, and changing the sediment characteristics of the beach, all of which may diminish the density or success of sea turtle nesting in subsequent years.

Hutchinson Island supports one of the highest loggerhead sea turtle nesting aggregations in the western Atlantic (Harris, et. al., 1983; Hopkins and Richardson, 1984; Williams-Walls, et. al., 1983). During the 1985 nesting season, 1,071 loggerhead clutches were deposited on the project beach (Applied Biology, unpublished data). This represents the highest nesting density for loggerheads on this section of Hutchinson Island in the past five years. In addition, over 3,000 (27 nests) green turtle eggs and 675 (9 nests) leatherback eggs were deposited in the project beach during the summer of 1985. This nesting density raises some serious concerns with regard to proposed beach nourishment.

First, we question the reasoning for a nourishment program for a beach which currently supports high levels of sea turtle nesting. In this situation, the argument that some beach is better than no beach for turtles is not valid. There exists adequate beach for turtle nesting now and nesting has been successful in recent years. Any action therefore, to nourish the beach should be specifically designed to avoid adversely affecting this significant resource.

Second, if nourishment is planned during the nesting season (between March 14 and November 14) relocation of turtle nests would be required. Such a program is proposed in the Biological Information Report and would be in effect from April to September. For this reach of beach, nesting in 1985 extended from March 14 (first leatherback nest) to November 13 (the approximate date of the last loggerhead nest hatching). Nest relocation would involve moving over 100,000 eggs and would be labor intensive and expensive. In our opinion, this management strategy should be avoided for such an important rookery. Natural incubation and hatching within the proposed beach area has historically been productive with predation levels below 10% (Applied Biology, unpublished data).

Potential problems of a large scale relocation project include: reduced hatching success due to handling, determining a relocation site for about 100,000 eggs, plus protection from predation, potential alteration of sex ratios, and the probability that some of the nests will be inadvertently missed in the course of daily surveys and subsequently covered in the nourishment operation.

In Section 4 of the Biological Information included in your letter of April 4, it is stated that "sand that will be placed on the beach is similar enough in grain size distribution so that nesting turtles should not be hindered in future nest construction." This statement was not supported with data on physical description of borrow versus beach sediments. Furthermore, information available from other nourishment projects indicates this is not likely to be the case (Indiatlantic-Melbourne Beach, Delray Beach). Rather, the nourished beach will likely undergo some level of compaction, reducing the success of nest cavity excavation and increasing nest failures for one or more years.

Nourishment is likely to result in compaction of the beach surface rendering the beach less suitable to nesting in future years. This phenomenon was documented by Ehrhart and Raymond (1983) and Nelson (Unpub. data.). In the first case, a two-year study showed a significant reduction in loggerhead nesting success and a number of aberrant nest cavities (destruction of eggs) on a two-mile section of restored beach in Brevard County, Florida. This study concluded that the primary cause of these adverse impacts was the compaction of the beach fill material.

Nelson's preliminary results from the third nourishment cycle at Delray Beach, Florida, indicated a significant increase in resistance to penetration of surface sediments after nourishment. Further, Nelson was able to identify sediments from the native beach, 1973 nourishment, 1979 nourishment and 1984 nourishment based on their differential penetration values, indicating that at Delray Beach, the nourished areas had not returned to pre-project conditions.

Nelson (pers. comm.) is also evaluating the feasibility of mitigating the effect of compaction through post-nourishment management techniques such as tilling. Results remain preliminary but indicate that tilling can make a compacted beach more penetrable and thus the sand could be more easily dug by nesting sea turtles. The study has not, however, determined how long the tilled beach will remain softened. After 69 and 147 days the tilled plots were softer than before tilling but had become harder to penetrate than immediately after tilling.

We believe that sufficient evidence exists to indicate that the post-project beach will likely support a reduced level of turtle nesting for at least one year after the project. Because of the significance of the nesting beaches in Martin County, including the four miles of beach proposed to be nourished, construction of this project warrants special attention to minimize the adverse effects on these species. Specific measures are identified in the Additional Conservation Recommendations section.

Based upon the anticipated level of adverse effects which will result from this project and the conditions which have been proposed by the Corps of Engineers to reduce those effects, it is the biological opinion of the FWS that the proposed project is not likely to jeopardize the continued existence of any listed sea turtle.

Additional Conservation Recommendations

In accordance with Section 7(a)(1) of the Endangered Species Act, and in order to reduce the risk to sea turtles, the Fish and Wildlife Service recommends that the following conservation recommendations should be incorporated as part of the Federal project for the Martin County Beach Erosion Control Project:

1. Construction of the project, including pumping and spreading of sand and movement of any equipment on the beach will be confined to between November 15 and March 1 of the project year. If this is not possible, then in a nest relocation program as specified in the biological information should be instituted for this time period.

2. Monitor the project beach and an appropriate control beach to determine if and to what extent compaction occurs as a result of the project.

3. Implement measures as necessary, using the best available data at the time of project construction, to alleviate compaction if it is observed.

4. Monitor sea turtle nesting in the season following project construction on the project beach and the control beach to quantify the differences in nesting between the two beaches in terms of nesting success (ratio of crawls to nests), aberrant nesting behavior (behavior which results in egg or nest loss or reduces the chances of hatching), and hatching success (monitor nest hatching <u>in situ</u>, and percent of dead hatchlings and unhatched eggs <u>in nests</u>). Mid-season (July 15) and end of year monitoring reports will be provided to the Service.

We believe that the monitoring and evaluation efforts described above are absolutely essential because of mounting evidence from the cited studies that adverse effects are likely to occur. The Service should be involved in study design and progress for each element of the monitoring program. We suggest that a single comprehensive study be developed to evaluate this project as outlined above. A copy of the final report should be provided to this office.

Incidental Take

In meeting the provisions for incidental take in Section 7(b)(4) of the Act, we have reviewed the Biological Opinion and all available information relevant to this permit action. Based upon our review, incidental take is not authorized for the above listed species during implementation of this project.

This concludes consultation under Section 7 of the Act, as amended. If there are modifications made in the project or if additional information becomes available relating to threatened or endangered species, reinitiation of consultation may be necessary. The Service is aware of additional information being developed and is currently evaluating other information concerning impacts of beach nourishment on sea turtles. Any new findings developed between now and project implementation will be considered new information and will require reinitiation of consultation, if appropriate. We would appreciate your response as to the Corps' decision about our recommendations under Additional Conservation Recommendations.

Sincerely yours,

David J. Wesley
Field Supervisor

REFERENCES CITED

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Ehrhart, L.M. and P.W. Raymond. 1983. The effects of beach restoration on marine turtles nesting in south Brevard County, Florida. Final Report to the U.S. Army Corps of Engineers, Jacksonville, Florida. Contract No. DACW17-81-C-0014. 47pp.

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Nelson. Person. comm.

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DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
P. O. BOX 4970
JACKSONVILLE, FLORIDA 32232

April 4, 1985

REPLY TO
ATTENTION OF
Environmental Resources Branch
Planning Division

Mr. Charles A. Oravetz
Protected Species Management Branch
National Marine Fisheries Service
9450 Koger Boulevard
St. Petersburg, Florida 33702

Dear Mr. Oravetz:

The Corps is studying the feasibility of nourishing approximately 4 miles of the Atlantic beach of Hutchison Island with approximately 1,600,000 cubic yards of sand from the St. Lucie County-Martin County Line to a point south of the Stuart Public Beach. The sand would be dredged from a borrow area located approximately 1/2 mile off shore and piped to the beach.

Listed species which may occur in the vicinity of the proposed action are the endangered humpback whale, Megaptera novaeangliae; the endangered right whale, Eubalaena glacialis; the endangered finback whale, Balaenoptera physalus; the endangered Sei whale, Balaenoptera borealis; the endangered sperm whale, Physeter catodon; the endangered hawksbill turtle, Eretmochelys imbricata; the endangered loggerhead turtle, Caretta caretta; the endangered leatherback turtle, Dermochelys coriacea; the threatened green turtle, Chelonia mydas; and the endangered Kemp's ridley turtle, Lepidochelys kempii. The project area is not critical habitat for any of the listed species.

In accordance with Section 7(c) of the Endangered Species Act, as amended, the Corps of Engineers has determined that the proposed action would have "no effect" on any of the listed species and is enclosing biological information.

This completes coordination under the Act, unless new information should indicate that the proposed action may affect listed species or their habitats, or the proposed action is substantially modified, or a new species is listed which may be affected by the action or the Service requests consultation. Your response to this notification is requested.

Sincerely,

Richard E. Bonner
Acting Chief, Planning Division

Enclosure

BIOLOGICAL INFORMATION

MARTIN COUNTY BEACH EROSION CONTROL

1. Location. The proposed work would be performed on the Atlantic beach of Hutchison Island in Martin County, Florida and in a 3500 foot by 3500 foot borrow area located approximately 1/2 mile off shore (see attached map).

2. Identification of Listed Species and Critical Habitat in the Area of the Proposed Activity. Listed species which may occur in the vicinity of the proposed action are the endangered humpback whale, Megaptera novaeangliae; the endangered right whale, Eubalaena glacialis; the endangered finback whale, Balaenoptera physalus; the endangered Sei whale, Balaenoptera borealis; the endangered sperm whale, Physeter catodon; the endangered hawksbill turtle, Eretmochelys imbricata; the endangered loggerhead turtle, Caretta caretta; the endangered leatherback turtle, Dermochelys coriacea; the threatened green turtle, Chelonia mydas; and the endangered Kemp's ridley turtle, Lepidochelys kempii. The project area is not critical habitat for any of the listed species.

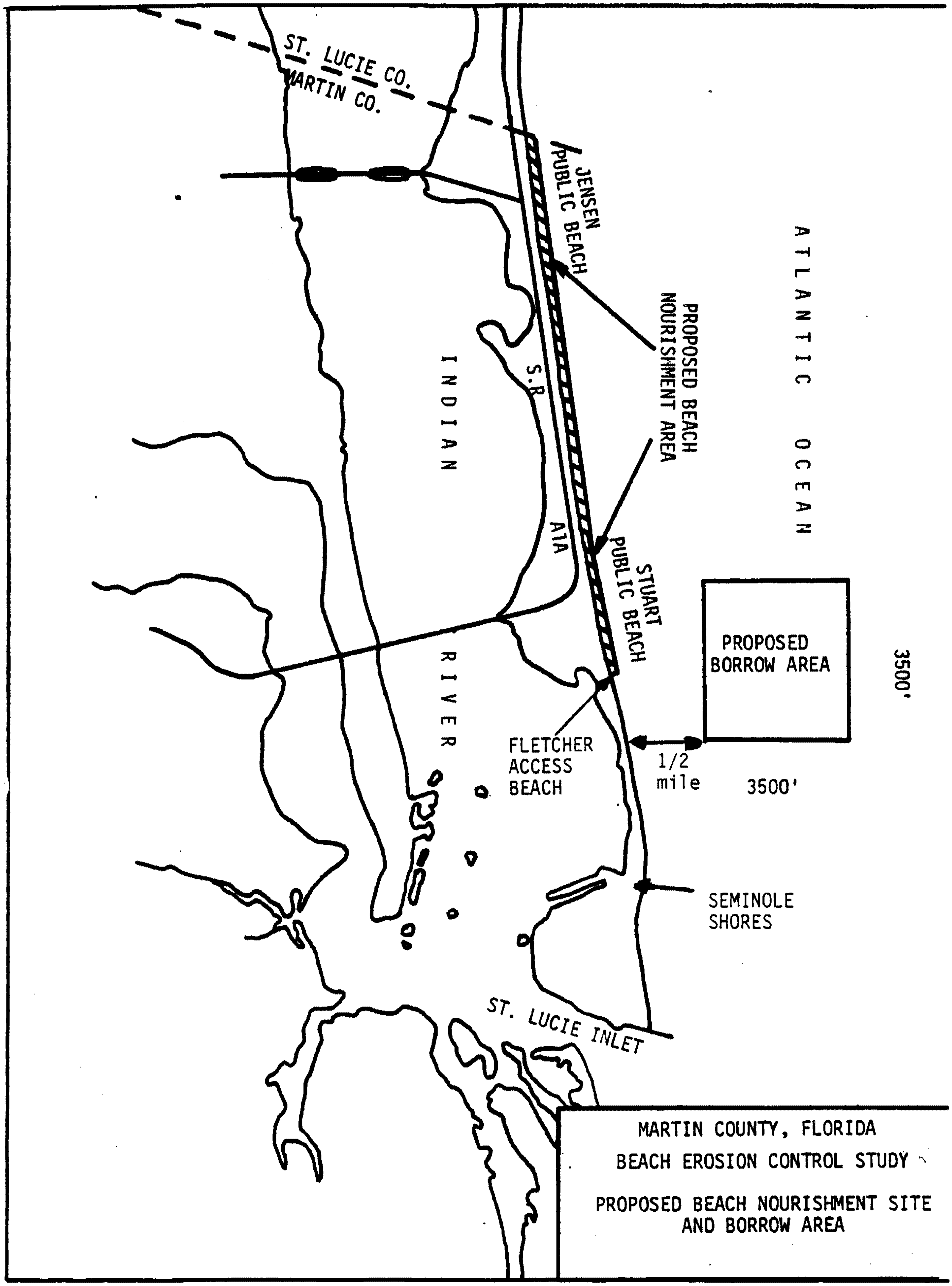
3. Description of Proposed Activities. The Corps proposes to dredge approximately 1,600,000 cubic yards of sand from a borrow area located approximately 1/2 mile off shore, pump this sand through a pipe to Hutchison Island, and deposit it on the Atlantic side beach from the St. Lucie County-Martin County line on the north to Fletcher Beach on the south. Approximately 4 miles of beach would be restored.

4. Assessment of Potential Impacts of the Proposed Activity on Listed Species. The studied work would have no adverse impacts on any of the listed species. The borrow area is located in 20-30 feet of water over a bare sand bottom. There is nothing in the borrow area that would attract any of the listed species although they may move through the area. Any individual moving through the borrow area would be motile enough to avoid the slow moving dredge or the stationary pipeline.

All of the whales are too large for entrainment to be a potential problem. The turtles could be entrained if they were to be found on the bottom of the borrow area, but since the bottom is bare sand with no food sources for turtles, the likelihood of the dredge encountering turtles on the bottom is very low.

5. Efforts to Eliminate Potential Impacts on Listed Species. A variety of boats may be used during the implementation of the project. The Corps will require that the contractor who will perform the work to keep the project area under surveillance, management, and control to minimize interference with, damage to, or disturbance of wildlife. The contractor's personnel will be briefed on the presence of endangered species in the project area and on the civil and criminal penalties for harming, harassing, or killing of species that are protected under the Endangered Species Act. All vessels associated with the project will be

required to operate at "no wake" speeds at all times while in shallow water or in channels where the draft of the boat provides less than 3 feet clearance of the bottom. Boats used to transport personnel will be shallow-draft vessels, preferably of the light-displacement category, where navigation safety permits. The contractor will be held responsible for any threatened or endangered species harmed, harassed, or killed as a result of construction. The contractor will keep a log detailing all sightings, collisions, damage to, or killing of threatened or endangered species which have occurred during construction. Any incident which results in injury to or death of a threatened or endangered species will be reported immediately to the Corps and to the National Marine Fisheries Service. Following project completion, the contractor will submit a report summarizing the above incidents to the National Marine Fisheries Service.



MARTIN COUNTY, FLORIDA
BEACH EROSION CONTROL STUDY

PROPOSED BEACH NOURISHMENT SITE
AND BORROW AREA

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

Southeast Regional Office
9450 Koger Blvd.
St. Petersburg, Florida 33702

June 3, 1985 F/SER23:PR:cbf

Mr. A. J. Salem
Chief, Planning Division
Jacksonville District, COE
P.O. Box 4970
Jacksonville, Florida 32232

Dear Mr. Salem:

This responds to your April 4, 1985, letter regarding your feasibility study of renourishing approximately 4 miles of Atlantic Beach on Hutchison Island, Martin County, Florida. The sand (approximately 1,600,000 cubic yards) would be dredged from a borrow area located .5 mile offshore and piped to the beach. A biological assessment (BA) was transmitted pursuant to Section 7 of the Endangered Species Act (ESA) of 1973.

This proposed renourishment project was discussed at our interagency informal Sec. 7 consultation meeting held in Jacksonville on May 10, 1985. A list of participants and the agenda is enclosed. It was stated to the National Marine Fisheries Service and the Fish and Wildlife Service that the proposed Hutchison Island renourishment project was only in the "feasibility study" stage and that the dates for this project were unknown and may be several years from being initiated.

Consequently, this pending Section 7 consultation will be deferred until additional data concerning potential impacts of the project on listed species is collected. We are particularly concerned with this proposed renourishment project because the 4 miles of targeted beach on Hutchison Island currently supports a high density of loggerhead turtle nesting during the late spring and summer (exceeds 100 nests per kilometer). This beach is also a very important nesting ground for the Florida green turtle and the Florida nesting population of leatherbacks.

The results of the Corps of Engineers' Waterways Experiments Station study concerning the compatibility of renourished beach sand and sea turtle nesting will hopefully continue to add pertinent information to issues such as: sand compaction, sand suitability, sea turtle nesting success, and sea turtle behavioral effects (both on renourished beaches and in near-shore areas). Therefore, it would be premature to complete consultation on this project at this time as many questions remain unanswered that are currently being investigated and analyzed. We look forward to reviewing your BA incorporating current renourishment studies so that we may properly access the effects of the proposed Hutchison Island renourishment work.

If we can be of assistance or if you have any questions, please call our office at FTS 826-3366.

Sincerely yours,

Charles A. Oravetz

Charles A. Oravetz
Chief, Protected Species
Management Branch

Enclosure

cc:
F/M412
F/SER11
R. Whitham, FDNR
FWS, Vero Beach
FWS, Jacksonville
D. Nelson - MS, COE

August 27, 1985

Environmental Resources Branch
Planning Division

Mr. Charles A. Oravetz
Protected Species Management Branch
National Marine Fisheries Service
9450 Koger Boulevard
St. Petersburg, Florida 33702

Dear Mr. Oravetz:

In accordance with Section 7(c) of the Endangered Species Act, as amended, Jacksonville District transmitted to your office a determination of "no effect" and pertinent Biological Information for the proposed Martin County Beach Erosion Control project on April 4, 1985.

Your reply, dated June 3, 1985, deferred consultation pending the collection of additional data by the Waterways Experiment Station. Due to time constraints, Jacksonville District is unable to agree to a deferral of consultation. It is requested that the National Marine Fisheries Service provide the Corps with an opinion based on the best available information as soon as possible.

Sincerely,

A. J. Salem
Chief, Planning Division

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

Southeast Regional Office
9450 Koger Boulevard
St. Petersburg, FL 33702

February 11, 1986 F/SER23:PWR:dcp

Mr. A. J. Salem
Chief, Planning Division
Jacksonville District, COE
P. O. Box 4970
Jacksonville, FL 32232-0019

Dear Mr. Salem:

This concerns our on-going informal Section 7 of the Endangered Species Act (ESA) Consultation regarding the proposed renourishment of approximately 4 miles of Atlantic beach at Hutchinson Island, Martin County, Florida. Approximately 1,600,000 cubic yards of sand would be dredged from a borrow area located .5 miles offshore and piped to the beach. A Biological Assessment (BA) was transmitted pursuant to Section 7 of the ESA. As discussed at our interagency beach renourishment meeting held in Jacksonville on May 10, 1985, the COE's BA contained insufficient information. Consequently, the consultation was deferred by the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (FWS) until available and additional data concerning potential impacts of the project on listed species could be provided (NMFS; June 3, 1985 letter). No existing or new information was provided until January 22, 1986, when we received a "working draft" of a report by the COE's Waterways Experiments Station (Nelson and Mayes, 1986).

This office remains concerned about the proposed renourishment project for the following reasons: (1) Hutchinson Island supports one of the highest loggerhead sea turtle nesting aggregations in the United States (1,071 clutches were laid in 1985 on the proposed project beach); (2) sand compaction has been documented to occur as a result of many renourishment projects; (3) sand compaction can cause short-term adverse impacts to nesting sea turtles (inhibits nest digging and causes aberrant behavior); and (4) the potential problems of a large scale egg relocation project on the remaining high density nesting beaches along the southeast U.S. These concerns have also been expressed by the Fish and Wildlife Service, who have jurisdiction over sea turtles on the nesting beaches (U.S. FWS, 1985).

Renourishment projects should also be assessed for potential "offshore" effects such as the disruption/loss of foraging habitats, disturbance of adult pre-emergence movements, disorientation of both adults and hatchlings caused by project lights, and the unknown effects of repeated unsuccessful nesting attempts caused by an unsuitable compacted beach. We recognize that these offshore impacts are poorly documented in the literature. However, solutions have been identified in the existing literature that would minimize impacts to nesting turtles. These solutions, which include beach renourishment activities scheduled outside the nesting/hatching season and the use of nourishment sand that matches the natural sand in grain size distribution and chemical characteristics, would also minimize the potential offshore impacts to nesting and hatchling turtles. Therefore, we concur with the FWS's conservation recommendations discussed in their December 6, 1985, Biological Opinion on this project (FWS Log No. 4-1-85-135). The NMFS may reconsult with the COE on this project depending on the outcome of studies involving offshore travel movements of prenesting turtles, or if the disorientation of hatchlings by onshore and offshore project lights is documented.

Enclosed is a bibliography of work relating to beach renourishment and sea turtles. Four of these references include management recommendations that can minimize the effects on sea turtles and allow beach renourishment activities to continue (Nagvi and Pullen, 1982; Ehrhart and Raymond, 1983; Nelson W.G., 1985; Nelson and Mayes, 1986). The available literature should be incorporated in future Biological Assessments for projects with similar potential impacts. We will continue to provide relevant references, data, reports, and recommendations of personnel who can provide the best available information. However, as you know, it is the primary responsibility of the Corps to conduct the appropriate studies and to provide the biological information necessary for an adequate review of the effect an identified activity or program has upon listed species or their habitat (50 CFR 402.04 [c] and [d]). We urge you and your staff to better utilize the "informal consultation" procedures and to contact this office prior to the completion of your BAs. We believe this can aid both agencies in developing a better information exchange and working relationship.

This concludes consultation responsibilities under Section 7 of the ESA. However, consultation should be reinitiated if new information reveals impacts of the identified activity that may affect listed species or their critical habitat, a new species is listed, the identified activity is subsequently modified or critical habitat determined that may be affected by the proposed activity. If you have any questions or desire copies of any of the referenced material, please contact this office at FTS 826-3366.

Sincerely yours,

Charles A. Oravetz

Charles A. Oravetz, Chief
Protected Species Management Branch

Enclosure

cc: SER11
F/M412
FWS - Vero Beach

REFERENCES

Ehrhart, L.M. and P.W. Raymond. 1983. The effects of beach restoration on marine turtles nesting in South Brevard County. Report to U.S. Army Corps of Engineers, Jacksonville District, Florida. 100 pp.

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
9450 Koger Boulevard
St. Petersburg, FL 33702

November 8, 1985 F/SER23:PWR:dcp

NOV 12 1985

Mr. Joseph D. Carroll, Jr.
Field Supervisor
Fish and Wildlife Service
P. O. Box 2676
Vero Beach, Florida 32961-2676

Dear Mr. Carroll:

SUBJECT: Beach Erosion Control Study, Martin County, Florida

We have reviewed your proposed draft report to the COE, Jacksonville District, on the subject project and provide the following comments:

1. We strongly concur with the conclusions and recommendations stated in the draft letter. We further recommend that the proposed four-mile stretch of beach on Hutchinson Island (between the Martin County/St. Lucie County line to a point south of the Stuart public beach) not be conducted during the period from April to November. This recommendation is based on the following biological implications:

   a. Hutchinson Island supports one of the highest loggerhead sea turtle nesting aggregations in the western Atlantic. During the 1985 nesting season 1,071 loggerhead clutches were deposited on the proposed renourishment beach (approximately 4 miles). This represents the highest nesting density for loggerheads on this section of Hutchinson Island in the past 5 years. A summer renourishment project would require the relocation of over 100,000 eggs. It is our opinion that this management strategy should be avoided on such an important rookery. Natural incubation and hatching within the proposed beach area has historically been productive with predation levels below 10% (Applied Biology, 1985). A relocation project of this magnitude would be extremely labor intensive and expensive. Potential problems of a large scale relocation project include: (1) reduced hatching success due to handling (Parmenter, 1980; Pritchard et al., 1983); (2) determining a relocation site for 100,000 + eggs; (3) altering the natural sex ratios; (4) increasing predation pressure at the concentrated relocation site; and (5) the inadvertent inability to locate all nests for relocation. Renourishment projects targeted for beaches which support high nesting densities (ex. > 100 nests/km) should be reevaluated and/or scheduled for Nov.-March construction.

   b. Endangered Florida green turtles and leatherback turtles also utilize the Martin County beaches, as stated in your letter. Leatherback nesting (April) begins approximately 1-2 months prior to loggerhead nesting, while green turtles nest later in the summer. This early and late nesting and hatching activity will have to be addressed by the COE. Leatherbacks and green turtles laid over 1,000 and 3,000 eggs respectively in the proposed 4-mile site during the 1985 season.

c. It is well documented that hatchling sea turtles are disoriented by artificial beachfront lights when emerging from the nest. Lights associated with a renourishment project (both on the beach and on the offshore dredge) could reduce hatchling survivorship during the critical emergence and frenzy periods.

d. A recent study has demonstrated that sabellarid worms (Phragmatapoma lapidosa) can tolerate burial by sediment for only 24 hours at summer temperatures (Nelson and Main, 1985). The study also indicated the species may tolerate burial for at least 72 hours at cooler winter temperatures. Consequently, Nelson and Main's report recommends that fill placement and renourishment activities are preferable during cool water periods because of the increased period of time that Phragmatapoma lapidosa burial could be survived. Worm reefs are important elements in the surf zone both biologically and geologically, thus concern over damage to these reefs is warranted.

2. We concur with the statements that the COE has yet to address the problems of sand suitability and sand compaction. High silt and clay content in the renourished fill material can cause long-term damage to the coquina rock/sabellarid worm reefs. Silt and clay particles also compound the problem of sand compaction. Several studies have demonstrated short-term adverse impacts to nesting sea turtles and a reduction of optimal nest site selection as a result of renourishment activities. A two-year study conducted by the University of Central Florida, and funded by the COE, showed significant reduction in loggerhead nesting success and frequent aberrant nesting behavior (destruction of eggs) on a 2-mile section of restored beach in Brevard County, FL (Ehrhart and Raymond, 1983). This study concluded that the primary cause of these adverse impacts was the compaction (or cementation) of the restored beach fill material. Other renourishment projects have had similar sand compaction and similar sea turtle nesting results (Fletemeyer, 1979-81; Witham, 1982; Lund, pers. comm.). Such impacts should be addressed and avoided on high density nesting beaches, such as the proposed 4-mile renourishment site in Martin County. Enclosed is 5-years of nesting data for the proposed beach renourishment site (Areas Z-FF). Data was supplied by E. Martin, Applied Biology, Inc.

We appreciate the opportunity to comment on your proposed report to the COE on this sensitive issue.

Sincerely yours,

Paul W. Raymond
for

Charles A. Oravetz, Chief
Protected Species Management Branch

Enclosure

cc: F/M412
F/SER11
F/SER113

References Cited

Applied Biology, 1985. St. Lucie Unit 2 Annual Environmental Operating Report 1984. Report to Florida Power and Light Company. 72 pp.

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United States Department of the Interior
HERITAGE CONSERVATION AND RECREATION SERVICE
INTERAGENCY ARCHEOLOGICAL SERVICES-ATLANTA
Richard B. Russell Federal Building
75 Spring Street S.W.
Atlanta, Georgia 30303

IN REPLY REFER TO:
W540
1201-02(a)

MAR 25 1980

Mr. James L. Garland
Chief, Engineering Division
Jacksonville District, Corps of Engineers
P. O. Box 4970
Jacksonville, Florida 32201

Re: Beach Erosion Control, Martin County, Florida

Dear Mr. Garland:

We have checked our files and consulted with the Southeast Archeological Center, National Park Service, and find no records of cultural resources having been identified within the project area.

We appreciate this opportunity to comment on these operation announcements.

Sincerely yours,

Stephanie H. Rodeffer

Stephanie H. Rodeffer
Acting Chief

OCT 1? 1985

FLORIDA GAME AND FRESH WATER FISH COMMISSION

P. O. Box 1840
Vero Beach, Florida 32961
October 16, 1985

Mr. Joseph D. Carroll, Jr.
Field Supervisor
United States Department of the Interior
Fish and Wildlife Service
P. O. Box 2676
Vero Beach, Florida 32961-2676

Re: Beach Erosion Control Study,
Martin County, Florida

Dear Joe:

The Office of Environmental Services of the Florida Game and Fresh Water Fish Commission has reviewed your proposed report on the referenced project, and concurs with your findings and recommendations.

Please call me if we can be of further assistance.

Sincerely yours,

Brian Barnett

Brian S. Barnett
South Florida Section Leader

BSB/rs
cc: Mr. Bradley J. Hartman

FLORIDA DEPARTMENT OF STATE
George Firestone
Secretary of State
Ron Levitt
Assistant Secretary of State

March 27, 1980

In reply refer to:

Mr. Louis Tesar
Historic Sites Specialist
(904) 487-2333

Mr. James L. Garland
Chief, Engineering Division
Jacksonville District
Corps of Engineers
Post Office Box 4970
Jacksonville, Florida 32201

Re: February 5, 1980 Letter and Map
Cultural Resource Assessment Request
SAJEN-EE Proposed Beach Nourishment at
Jensen and Stuart Public Beaches and
3500'X3500' Borrow Area near Stuart Public
Beach, Martin County, Florida

Dear Sir:

In accordance with the procedures contained in 36 C.F.R., Part 800 ("Procedures for the Protection of Historic and Cultural Properties"), we have reviewed the above referenced project for possible impact to archaeological and historical sites or properties listed, or eligible for listing, in the National Register of Historic Places. The authorities for these procedures are the National Historic Preservation Act of 1966 (Public Law 89-665) as amended by P.L. 91-243, P.L. 93-54, P.L. 94-422, and P.L. 94-458, and Presidential Executive Order 11593 ("Protection and Enhancement of the Cultural Environment").

A review of the Florida Master Site File indicates that no archaeological or historical sites are recorded for the project area. Furthermore, because of the location of the project, it is considered high unlikely that any significant, unrecorded sites exist in the vicinity. Therefore, it is the opinion of this office that the proposed project will not adversely impact any sites listed, or eligible for listing, in the National Register of Historic Places, or otherwise of national, state, or local significance.

Mr. James L. Garland
March 27, 1980
Page Two

On behalf of the Secretary of State, George Firestone, and his staff at the Bureau of Historic Sites and Properties, I would like to thank you for your interest and cooperation in the protection of Florida's irreplaceable historic resources.

Sincerely,

L. Ross Morrell,
Deputy State Historic
Preservation Officer

LRM:Teh

COMMENT

RESPONSE

United States Department of the Interior

OFFICE OF ENVIRONMENTAL PROJECT REVIEW

Southeast Region / Suite 1360
Richard B. Russell Federal Building
75 Spring Street, S.W. / Atlanta, Ga. 30303

Telephone 404/221-4524 · FTS 242-4524

AUG 30 1985

ER-85/1153

Colonel Charles T. Myers, III
District Engineer
U.S. Army Corps of Engineers
Post Office Box 4970
Jacksonville, Florida 32232-0019

Dear Colonel Myers:

The Department of the Interior has reviewed the Draft Environmental Statement and Feasibility Report, Beach Erosion Control Study, Martin County, Florida, and has the following comments.

General Comments

1 The Fish and Wildlife Service (FWS) recommends that Section 7 consultation for this project be postponed until the results of the Corps of Engineers, Coastal Ecology Group, Waterway Experiment station studies on the effects of beach nourishment on nesting sea turtles is completed. We remain concerned with the potential long-term adverse impacts of beach nourishment projects on sea turtle nesting. Statements made in these reports which indicate there will be no unacceptable environmental impacts on the aquatic system, and that sea turtle nesting will be enhanced, are premature and possibly incorrect.

2 The draft environmental statement does not discuss mineral resources or mineral related facilities. There has been no recorded mineral production in Martin County since 1975, however, and none of the alternate plans discussed in the documents would produce adverse effects on mineral resources or related activities. For completeness, a statement to the effect, that mineral resources would not be impacted, should be included in subsequent versions of the document.

Specific Comments - Feasibility Report

3 Page 8, paragraph 30. The only major "water courses" in the project area are the Indian and the St. Lucie Rivers, neither of which can be characterized by the description in this paragraph. Most of the Indian River is bordered by a fringe of mangroves of varying width most of which have been impounded for mosquito control. A similar description should also be corrected on page 9, paragraph 4.04 of the EIS.

1. Other then localized short term increases in turbidity, no impacts on the aquatic ecosystem are foreseen. Biota in the surf zone are adopted to such localized turbidity. The analysis of the existing beach material and of the fill material contained in Appendix 4 shows that the two materials are very similar.

The statement that turtle nesting will be enhanced is based on the fact that intensively used eroding beaches are used for nesting by turtles. As the beaches continue to erode, less area is available for nesting and what area is available is more intensively used if recreational beach usage remains constant. With nourishment, more area is available for nesting and the available area is less intensively used if recreational beach usage remains constant.

2. Mineral resources or mineral related facilities were not determined to be significant resources in the project area, thus they were not addressed.

3. Paragraph 4.04 has been revised to include the fringe mangroves.

COMMENT

4 Page 10, paragraph 41. The Indian River is a narrow estuarine lagoon whose only water movement is the result of the influence of tidal exchange through six inlets, wind-driven tides and fresh water inflow. Thus, the Indian River is not a river in the traditional sense and does not flow in any direction.

5 Page 52, paragraph 208; page 57, Table 6. The FWS cannot concur with your assessment that no rare or endangered species will be adversely affected by this beach nourishment project. In the FWS letter from the Jacksonville Endangered Species office, dated June 6, 1985, concern was expressed for the project's impacts on loggerhead and green sea turtle nesting. Compaction of beach sediments and concurrent reduction of nesting density after nourishment projects have been documented in several cases (Ehrhart and Raymond, 1983; Fletemeyer, 1978-81; Witham, 1982). The technology to predict these impacts is not currently available, thus, making your conclusions premature and possibly inaccurate. Acquisition of the above referenced studies would add considerable information to the final EIS.

Specific Comments - Environmental Impact Statement

6 Page 3, Table 1. This table should include the Coastal Barrier Resources Act of 1982 since Unit P-12 in Martin County is presently in the system.

7 Page 11, paragraph 4.08. This paragraph and Appendix C fail to discuss the fishery value of the coquinoid reef outcroppings which are not encrusted with sabellariid worms. These coquinoid reefs provide habitat diversity in the nearshore for a large number of benthic invertebrates, algae, and numerous fish species. Covering of any of these reef areas would represent loss of a significant habitat.

We appreciate the opportunity to comment on these documents.

Sincerely yours,

James H. Lee

James H. Lee
Regional Environmental Officer

Attachment

RESPONSE

4. Paragraph 41 has been revised to reflect the tidal and wind driven nature of water movement in the Indian River.

5. See Comment 1.

6. Table 1 has been revised.

7. Paragraph 4.08 has been revised.

COMMENT

RESPONSE

Literature Cited

Ehrhart, L.M. and T.W. Raymond, 1983. The Effects of Beach Restoration on Marine Turtles Nesting in South Brevard County, Florida. A final report to the U.S. Army Corps of Engineers, Jacksonville District Contract No. DA CW17-81-C-0014, 104 P.

Fletemeyer, J. 1979. Sea Turtle Monitoring Project Report to Broward County Environmental Quality Control Board, Ft. Lauderdale, Florida, 1-64.

Witham, R. 1982. Description of Sea Turtle Habitat with Emphasis on Human Influences in Biology and Conservation of Sea Turtles, ed. by K.A. Bjorndal, 519-522. Washington, D.C., Smithsonian Institution Press.

COMMENT

RESPONSE

U.S. Department of Housing and Urban Development
. iar. ‹ Regional Office, Region IV
Richard B Russell Federal Building
75 Spring Street, S.W.
Atlanta, Georgia 30303-3388

August 9, 1985

Mr. A. J. Salem
Chief, Planning Division
ATTENTION: SAJPD-C
Post Office Box 4970
Jacksonville, FL 32232-0019

Dear Mr. Salem:

This refers to your letter transmitting a Draft Feasibility Report (DFR) with Environmental Impact Statement (EIS) concerning Beach Erosion Control Study, Martin County, Florida.

8 Our review indicates there will be no significant adverse impacts on any HUD programs as a result of this Beach Erosion Control program as outlined in your DFR and EIS.

Sincerely,

Freddy E. Arbuckle
for Ivar O. Iverson
Regional Environmental Officer

8. Comment noted.

COMMENT

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Washington, D.C. 20230

OFFICE OF THE ADMINISTRATOR

August 21, 1985

Mr. A. J. Salem
Chief, Planning Division
Jacksonville District, COE
ATTN: SAJPD-C
P.O. Box 4970
Jacksonville, FL 32232

Dear Mr. Salem:

This is in reference to the Draft Environmental Impact Statement for Beach Erosion Control Study Project. Enclosed are comments from the National Oceanic and Atmospheric Administration.

9 We hope our comments will assist you. Thank you for giving us an opportunity to review the document. We would appreciate receiving two copies of the final environmental impact statement.

Sincerely,

David Cottingham

David Cottingham
Ecology and Conservation Division

Enclosure

RESPONSE

9. Comment noted.

COMMENT

RESPONSE

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

Southeast Regional Office
9450 Koger Boulevard
St. Petersburg, FL 33702

August 9, 1985 F/SER23:PWR:dcp

Mr. A. J. Salem
Chief, Planning Division
Jacksonville District, COE
ATTN: SAJPD-C
P. O. Box 4970
Jacksonville, FL 32232

Dear Mr. Salem:

The National Marine Fisheries Service (NMFS), Southeast Region, has reviewed the Draft Environmental Impact Statement (DEIS) and Draft Feasibility Report for the Beach Erosion Control Study at Martin County, Florida. Our comments are offered to the Corps of Engineers (COE) at this time so that they may be considered and incorporated, as appropriate, into the project's Final Environmental Impact Statement. The comments pertain to the COE's Plan S-2A, which involves the placement of 1,055,000 cubic yards of sand along 4.0 miles of beach on Hutchinson Island, and Plan S-2B, the placement of 2,318,000 yards of sand along 5.6 miles of Jupiter Island.

Impact to Threatened and Endangered Species

10 In the DEIS, pg. 10, Table 2 - Comparative Impacts of Alternatives, it states that Plan S-2A and Plan S-2B would have no expected adverse impacts to threatened or endangered species and goes further to state that these plans would increase the number of potential sea turtle nesting sites. We know of no studies to substantiate these claims. In fact, several studies have been conducted that demonstrate short-term adverse impacts to nesting sea turtles and a reduction of optimal nest site selection as a result of renourishment activities. A two-year study conducted by the University of Central Florida, and funded by the COE, showed significant reduction in loggerhead nesting success and frequent aberrant nesting behavior on a 2 mile section of restored beach in South Brevard County, FL (Ehrhart and Raymond, 1983). This study concluded that the primary cause of these adverse impacts was the compaction (or cementation) of the restored beach fill material. Other renourishment projects have had similar sand conditions and sea turtle nesting results (Fletemeyer, 1979-81; Witham, 1982). These impacts should be addressed in the FEIS.

10. See Comment 1.

These potential adverse impacts to threatened and endangered species were identified in the ongoing Section 7 consultations between the COE and the USFWS and NMFS. Both agencies have notified the COE of their concern for the proposed Hutchinson Island renourishment project and have postponed the consulations pending results of further sand suitability studies. The proposed beach site currently supports in excess of 100 nests/km and has been identified in the U.S. Sea Turtle Recovery Plan as one of the most heavily utilized loggerhead nesting beaches in the Southeast.

COMMENT

2

11 We recommend that renourishment activities not be scheduled during the sea turtle nesting/hatching season (April-November) as stated in the U.S. Sea Turtle Recovery Plan (Hopkins and Richardson, 1984). Natural nest incubation should be allowed on the few remaining high density nesting beaches.

We appreciate the opportunity to provide the above comments.

Sincerely yours,

Richard J. Hoogland, Chief
Environmental Assessment Branch

RESPONSE

11. Comment noted.

COMMENT

RESPONSE

REFERENCES CITED

Ehrhart, L.M. and P.W. Raymond, 1983. The effects of beach restoration on marine turtles nesting in South Brevard County, Florida. A final report to the U.S. Army Corps of Engineers, Jacksonville District. Contract No. DA CW17-81-C-0014, 104 p.

Fletemeyer, J. 1979. Sea turtle monitoring project. Report to Broward County Environmental Quality Control Board, Ft. Lauderdale, Florida, 1-64. (Similar reports for 1980, 81, 82).

Hopkins, S.R. and Richardson, J.I. 1984. Recover plan for marine turtles. A U.S. Recovery Plan prepared by the marine turtle recovery team, 1-355.

Witham, R. 1982. Disruption of sea turtle habitat with emphasis on human influence. In Biology and conservation of sea turtles, ed. by K.A. Bjorndal, 519-522. Washington, D.C., Smithsonian Institution Press.

AUG 23 1985

4PM-EA/GM

Mr. A.J. Salem, Chief
Planning Division
U.S. Army Corps of Engineers, Jacksonville
P.O. Box 4970
Jacksonville, Florida 32232

Dear Mr. Salem:

In accordance with Section 309 of the Clean Air Act, we have reviewed the draft environmental impact statement for the beach erosion control study in Martin County, Florida. With the exception of sedimentation adversely impacting live bottoms down current of the project area, we have no pronounced environmental reservations to the immediately attributable short- or long-term environmental consequences of the proposed alternative. The adverse consequences of this sedimentation can be materially lessened through the judicious selection of borrow material. We recommend that sand pumped onto the beach be well sorted texture-wise and of similar size class to the material already present there. This will preclude unnecessary turbidity at the borrow site or the receiving beach and has the economic advantage of reducing the amount of dredging.

Comment noted.

Of course, as we have noted to you on previous occasions, pumping sand onto a retreating shoreline only postpones the inevitable; but, in candor, the document discloses the ephemeral nature of attempting to maintain a beach on a relatively high-energy shoreface. Hence, given the Corp's mandates and the absence of significant attendant environmental losses in this instance, this has effectively become a non-issue.

As a result of our review, a rating of LO-2 was assigned. That is, the environmental effects of this action are anticipated to be within acceptable limits if appropriate borrow material is used; therefore, we urge that every consideration be given to choosing locations within the borrow site which meet the above criteria.

If we can be of further assistance, please do not hesitate to call Dr. Gerald Miller (FTS 257-7901) of my staff.

Sincerely yours,

Sheppard N. Moore

Sheppard N. Moore, Chief
NEPA Review Staff
Environemental Assessment Branch

COMMENT

STATE OF FLORIDA

DEPARTMENT OF ENVIRONMENTAL REGULATION

TWIN TOWERS OFFICE BUILDING
2600 BLAIR STONE ROAD
TALLAHASSEE, FLORIDA 32301-8241

BOB GRAHAM
GOVERNOR

VICTORIA J. TSCHINKEL
SECRETARY

September 16, 1985

Mr. Walt Kolb
Senior Governmental Analyst
404 Carlton Building
Office of Planning and Budgeting
Tallahassee, Florida 32301

Dear Walt:

We have reviewed the Draft Feasibility Report and Environmental Impact Statement for the Martin County Beach Erosion Control Study. Several renourishment plans were presented in the report; only one has a ratio of benefits to costs greater than 1:0. Specifically, Plan S-2A (Hutchinson Island) has a B/C ratio of 1.2:1.0.

12 We have several concerns with this project which should be addressed in the final report. We are apprehensive about the quality of the borrow source sand, specifically the amount of fines and silts which may be released during both actual dredging and deposition (short-term) as well as long-term increased turbidity levels. Continuous sediment resuspension could, due to longshore current patterns, stress and possibly eliminate high quality sabellariid worm reef and coquina rock habitat located 400 to 5,000 feet south of the immediate project site near St. Lucie Inlet.

13 Although the patchy nearshore coquina reef habitats within the four mile project area would be eliminated or severely stressed as a consequence of the project, these sites are probably of lesser biological value than the worm reef habitat near St. Lucie Inlet. Special care should be taken to be certain the worm reefs will not be harmed.

14 We are encouraged by the number of beach access points and public beaches within the Hutchinson Island project area, although several private interests will also benefit from renourishment. Plan S-2B (Jupiter Island) has relatively poor public access and has been rejected by the Corps of Engineers due to an unacceptable benefit/cost ratio of 0.34:1.0.

15 Concern about this project has been expressed by both the U.S. Fish and Wildlife Service and the National Marine Fisheries Service regarding impacts on sea turtle nesting. Both Federal agencies have deferred Section 7 consultation for this project until the results of the Corps of Engineers' Waterways Experiment Station study concerning the effects of beach nourishment on sea

RESPONSE

12. Appendix 4 shows that the existing beach material and the fill material are very similar. There will be localized short term increases in turbidity during construction. These increases will have negligible impacts on the biota of the surf zone, which is acclimiated to turbid conditions, as are the saballeriids. The beach profiles have been designed to minimize encroachment on sabalariid reefs and coquinoid outcroppings.

13. See Comment 12.

14. Comment noted.

15. See Comment 1.

COMMENT

Mr. Walt Kolb
Page Two
September 16, 1985

turtle nesting become available. According to the U.S. Fish and Wildlife Service, Martin County has historically reported some of the highest densities of sea turtle nesting in the United States. Furthermore, the National Marine Fisheries Service reports that the Hutchinson Island project site "currently supports a high density of loggerhead turtle nesting during the late spring and summer...this beach is also a very important nesting ground for the Florida green turtle and the Florida nesting population of leatherbacks". Loggerhead turtle nests on the Hutchinson Island segment annually exceed 100 nests per kilometer. We are very concerned about potential impacts of this project on sea turtle nesting and eagerly await the study results.

While we realize the difficulties of Atlantic Coast beach renourishment outside sea turtle nesting season, adverse impacts on sea turtle nesting would be minimized by a winter project work schedule. If renourishment work must be
16 performed during sea turtle nesting season, then appropriate monitoring, transplantation and incubation of eggs by qualified personnel should by undertaken to help mitigate adverse impacts. We also advocate the use of native beach and dune grasses as well as boardwalks to help stabilize sand in the project area.

Although we find the project consistent with the state's approved coastal management program, there are several concerns that need to be addressed in the final report. To recapitulate, these are: the quality of the borrow source sand, impacts on reefs and sea turtles, the need for adequate water quality monitoring, and the need to consider re-establishment of native vegetation.

We appreciate the opportunity to comment.

Sincerely,

for Tom Swift
Randy Armstrong
Chief
Bureau of Laboratories and
Special Programs

RA/pbm

cc: Ms. Victoria J. Tschinkel
Dr. Al Devereaux
Mr. Steve Fox
Mr. Roy Duke
Mr. A. J. Salem
Mr. Joe Carroll
Mr. Lonnie Ryder

RESPONSE

16. See Comment 1 and Section 7 Biological Information.

FEASIBILITY REPORT

FOR

BEACH EROSION CONTROL

MARTIN COUNTY BEACHES, FLORIDA

APPENDIX 1

PROBLEM IDENTIFICATION

SECTION A: THE STUDY AND REPORT

SECTION B: RESOURCES AND ECONOMY OF STUDY AREA

SECTION C: PROBLEMS AND NEEDS

FEASIBILITY REPORT

FOR

BEACH EROSION CONTROL

MARTIN COUNTY BEACHES, FLORIDA

SECTION A

THE STUDY AND REPORT

SECTION A

THE STUDY AND REPORT

1. This section augments information contained in the main report with more detailed data pertinent to the study and report. Accordingly, topics presented in the main report in sufficient detail are not discussed in this appendix.

STUDY PARTICIPANTS AND COORDINATION

2. The Corps of Engineers is principally responsible for accomplishing and coordinating the study, consolidating information from other agencies, and preparing the report. The Martin County board of Commissioners--acting as the duly constituted beach and shore preservation authority for the county--is the local sponsor of the study. Other agencies or organizations assisting in the investigations and providing useful information include the following:

U.S. Naval Weather Service Command
U.S. Heritage Conservation and Recreation Service
State of Florida
Department of Natural Resources, Bureau of Beaches and Shores
State Division of Outdoor Recreation
Martin County
Treasure Coast Regional Planning Council

3. In addition, the report is being provided to other agencies for review in accordance with the policies and procedures established for coordinating civil works activities prescribed by the Office of Management and Budget (OMB) Circular A-95 and the Fish and Wildlife Coordination Act.

4. Coordination throughout the study has been maintained between representatives of the Corps of Engineers and concerned local and State officials, as well as interested citizens and groups. The coordination included correspondence, discussions, conferences, and public meetings. An initial public workshop was held on 4 May 1977 in Stuart, Florida, to inform interested parties of the study and program for public involvement. The second stage public meeting was held on 5 December 1979 in Stuart, Florida, to obtain the views of local interests and concerned local and State officials of the alternatives considered thus far in the study. The final public meeting, held on 8 September 1980, provided all interested parties with the selected plan developed and the alternatives considered in the evaluation of detailed plans in the draft feasibility report.

PRIOR STUDIES, REPORTS, AND PUBLICATIONS

5. A previous Federal beach erosion control investigation in the study area was completed in 1968. Insufficient public benefits were found at that time to warrant a Federal project for beach erosion control. A listing of prior reports concerning the study area are contained in the following section.

6. Other Corps of Engineers' studies of larger scope that include the Martin County ocean shoreline are the "National Shoreline Study," the "Survey Report, Analysis of Hurricane Problems in Coastal Areas of Florida," "Geomorphology and Sediments of the Inner Continental Shelf, Palm Beach to Cape Kennedy, Florida," and "Shallow Structural Characteristics of Florida Atlantic Shelf as Revealed by Seismic Reflection Profiles."

7. A Federal navigation project, the Intracoastal Waterway from Jacksonville to Miami traverses the study area with dimensions of 10 x 125 feet. Corps of Engineers reports which recommended construction of this waterway are published as House and Senate Documents and are listed in the following section of this appendix in table A-1.

8. A brief discussion of the shorelines of Martin County was included in the South Atlantic portion of the National Shoreline Study (1970). The study was very general in nature. Its purpose was to assess the nature and extent of erosion, develop conceptual plans for needed shore protection, develop general order-of-magnitude estimates of cost for shore protection, and identify shore owners.

9. "Survey Report, Analysis of Hurricane Problems in Coastal Areas of Florida (1961)" presents information regarding past hurricanes that have affected coastal areas within the Jacksonville District. Martin County is within this district.

10. The publications "Geomorphology and Sediments of the Inner Continental Shelf, Palm Beach to Cape Kennedy, Florida (1971)" and "Shallow Structural Characteristics of Florida Atlantic Shelf as Revealed by Seismic Reflection Profiles (1969)" are both the results of studies conducted by the U.S. Army Corps of Engineers Coastal Engineering Research Center (CERC). The first publication incorporates the latter and presents information on bottom morphology and sediments, subbottom structures, and sand deposits suitable for restoration of nearby beaches.

11. A flood insurance study for the Federal Insurance Administration on Marin County is underway at the time of this report preparation. Study findings are in a preliminary phase and coordination is continuing with local interests. The report on the study findings will provide stage frequency relationships within the tidal waters of Martin County and maps of flood zones for use in defining actuarial rates of flood insurance and in local land use planning.

PRIOR REPORTS

12. The prior reports bearing on the subject of beach erosion or including data on shore processes in the area under consideration have been made by the Corps of Engineers, by private engineering firms, and by the Coastal Engineering Laboratory of the University of Florida. Table A-1 is a listing of these reports. The reports by the Corps of Engineers relative to the

study area, except for the 1947 report on Jupiter Island and the 1960 report on Palm Beach County, were made in connection with navigation improvements of St. Lucie and Jupiter Inlets. Summaries and appropriate details of pertinent reports are presented in the following paragraphs. In addition, references incorporated in this study are listed in chronological order in the following table A-2.

TABLE A-1

PRIOR REPORTS

Name of Report	Date	Publication
St. Lucie Inlet, Fla.	1894	H.D. No. 159, 53rd Cong. 2d Sess.
Jupiter Inlet, Fla.	1897	H.D. No. 245, 54th Cong. 2d Sess.
St. Lucie Inlet, Fla.	1898	H.D. No. 548, 55th Cong. 2d Sess.
St. Lucie Inlet, Fla.	1909	H.D. No. 1312, 60th Cong. 2d Sess.
St. Lucie Inlet, Fla.	1910	S.D. No. 423, 61st Cong. 2d Sess.
Jupiter Inlet, Fla.	1910	Not published
St. Lucie Inlet, Fla.	1912	H.D. No. 471, 62d Cong. 2d Sess.
St. Lucie Inlet, Fla.	1912	H.D. No. 675, 62d Cong. 2d Sess.
St. Lucie Inlet, Fla.	1917	H.D. No. 370, 65th Cong. 1st Sess.
Jupiter Inlet, Fla.	1932	Not published
St. Lucie Inlet, Fla.	1933	Not published
Jupiter Inlet, Fla.	1936	Not published
St. Lucie Inlet, Fla.	1937	Not published
St. Lucie Inlet, Fla.	1941	H.D. No. 391, 77th Cong. 1st Sess.
Jupiter Inlet, Fla.	1946	Not published
Jupiter Inlet, Fla.	1946	Knappen Engineering Co.
Jupiter Island, Fla.	1947	H.D. No. 765, 80th Cong. 2d Sess.
Jupiter Inlet, Fla.	1949	Not published
Jupiter Island, Fla.	1957	Coastal Eng. Lab., Univ. of Florida
Palm Beach County, Fla.	1960	H.D. No. 164, 87th Cong. 1st Sess.
Jupiter Island, Fla.	1960	Coastal Eng. Lab., Univ. of Florida
Jupiter Island, Fla.	1962	Coastal Eng. Lab., Univ. of Florida
Jupiter Island, Fla.	1963	Gee and Jenson, Consulting Engineers
St. Lucie Inlet, Fla.	1966	H.D. No. 508, 89th Cong. 2d Sess.
Jupiter Island, Fla.	1967	Not published
Martin County, Fla.	1968	Not published as H.D.
Recommended Coastal Setback Line for Martin County, Fla.	1972	Dept. of Coastal & Oceanographic Engr., Univ. of Florida
Martin County, Fla.	1973	U.S. Army Corps of Engineers
St. Lucie Inlet, Fla.	1976	U.S. Army Corps of Engineers
Town of Jupiter Island, Fla.	1977	Gahagan & Bryant Assoc.
Town of Jupiter Island, Fla.	1978	Gahagan & Bryant Assoc.

H. D. indicates U.S. House of Representatives House Document
S. D. indicates U.S. Senate House Document

TABLE A-2

References

1. Flood Insurance Study, Unincorporated Areas of Martin County, Fla. Initial Review Draft, Tetra Tech. Inc., 620 North Rosemead Blvd., Pasadena, California. June 1979. U.S. Department of Housing and Urban Development, Federal Insurance Administration.

2. Research Report Sediment Transport Studies, Jupiter Inlet, Fla. Bruce R. Moore, Geology Dept. University of Kentucky. Jupiter Inlet Commission. June 1979.

3. Treasure Coast Regional Planning Council, Regional Profile. June 1979.

4. Completion Report for Beach Renourishment, Town of Jupiter Island, Gahagan and Bryant Associates, Tampa, Fla. September 1978.

5. The Economic Impact of the Coastal Construction Setback Line on Martin County, Board of Regents, State of Fla. Bureau of Beaches and Shores, Dept. of Natural Resources, State of Fla. Dr. Hulbert, C. Smith, J. D. Belliot, O. J. Snapp. September 30, 1978.

6. Phase I, General Design Memo on St. Lucie Inlet, Fla. Dept. of The Army, Jacksonville District, Corps of Engineers, Jacksonville, Fla. March 1977.

7. St. Lucie Inlet, Fla. General Design Memorandum, Phase II, Project Design, Department of the Army, Jacksonville District, Corps of Engineers, September 1977.

8. Status Report for Beach Renourishment, Town of Jupiter Island, Gahagan and Bryant Associates, Tampa, Fla. September 1977.

9. Jupiter Island Beach Renourishment Project, Gahagan and Bryant Associates, Tampa, Fla. (8 references) 1976.

10. Town of Jupiter Island, Beach Restoration Project Construction Report. Arthur V. Strock and Associates, Inc. February 1975.

11. Florida Sea Grant Program, St. Lucie Inlet. Glossary of Inlets Report #1 by Todd L. Walton. July 1974.

12. Town of Jupiter Island Beach Restoration Project. Follow-up Report No. 1. Aurthur V. Strock and Associates, Inc. October 1974.

13. Littoral Draft Computations Along the Coast of Florda by Means of Ship Wave Observations. Tech Report #15. Coastal and Oceanographic Engineering Laboratory, University of Fla., Gainesville, Fla. Walton Jr., T. L. 1973.

TABLE A-2 (Continued)

References

14. Town of Jupiter Island, Fla. Environmental Assessment. June 1973.

15. Town of Jupiter Island, Martin County, Fla. Beach Restoration Project. Arthur V. Strock and Associates, Inc. June 1973.

16. Recommended Coastal Setback Line for Martin County, Fla. Appendices, Range Monument Coordinate List and Beach and Offshore Profiles. Dept. of Natural Resources, Bureau of Beaches and Shores (submitted by) Dept. of Coastal And Oceanographic Engineering/Engineering and Industrial Experiment Station, University of Fla.

17. Cooperative Study at Jupiter Island, Fla. Engineering and Industrial Experiment Station, College of Engineering, University of Fla., at Gainesville. 1969.

18. Geomorphology and Sediments of the Nearshore Continental Shelf, Miami to Palm Beach, Fla. Tech. Memorandum No. 29. Nov. 1969. U.S. Army Corps of Engineers, Coastal Engineering Research Center.

19. Beach Erosion Control Study on Martin County, Fla. Department of the Army, Jacksonville District, Corps of Engineers. September 16, 1968.

20. Coastal Engineering Hydraulic Model Study of St. Lucie Inlet Coastal and Oceanographic Engineering, University of Florida at Gainesville. 1967.

21. Coastal Engineering Investigation at Jupiter Island Coastal and Oeanographic Engineering Laboratory, College of Engineering, University of Florida, Gainesville, Florida. 1967

22. Shore Protection Planning and Design. U.S. Army Coastal Engineering Research Center, Tech Report No. 4, 3rd Edition. 1966.

23. Survey Report on Jupiter Inlet, Fla. U.S. Army Engineer District, Jacksonville, Corps of Engineers, Jacksonville, Fla. March 11, 1966.

24. A Longnormal Size Distribution. Model for Estimating Stability of Beach Fill MaTERIAL. Tech Memo No. 16. U.S. Army Coasta Engineering Research Center. Krobine, W. C. and James, W. R. November 1965.

25. Beach Erosion Prevention, Town of Jupiter Island, Fla. Gee & Jenson, Consulting Engineering Inc., West Palm Beach, Fla. December 1963.

26. Submarine Geology. Shepard, Francis P. and Edison, Harper, & Row. N.Y. 1963. p. 557.

TABLE A-2 (Continued)

References

27. Sea-Level Rise as a Cause of Shore Erosion. Engineering Progress of the University of Florida/Fla. Engineering and Industrial Experiment Station, College of Enginering, University of Florida, Gainesville, Florida. 1962.

28. Coastal Engineering Investigation at Jupiter Island, Engineering and Industrial Experiment Station, College of Engineering, University of Florida in Gainesville, Florida. 1960.

29. Coastal Engineering Investigation at Jupiter Island, Coastal Engineering Staff, Department of Engineering Mechanics, College of Engineering, University of Florida at Gainesville, Florida. 1957.

30. A Method for Specification of Sand for Beach Fills. Tech Memo #102, Beach Erosion Board, Corps of Engineers, Krumbine, W. C. October 1957.

31. Beach Erosion Report. Jupiter Island, Fla. War Department, Beach Erosion Board, Washington, D.C. 1947.

32. Data for Jupiter Island Beach Erosion Studies. Robert M. Angas, Civil Engineer. 1946.

33. Flood Plain Information. Coastal Areas, Martin County, Fla. The Board of County Commissioners of Martin County. Corps of Engineers, U.S. Army, Jacksonville, Florida.

34. Coastal Zone Management Study of Hutchinson Island, Martin County, Florida, January-September 1982, Florida Oceanographic Society in Association with Martin County Community Development Department.

13. House Document No. 765, 80th Congress, 2d Session (1947, Jupiter Island). The report, made by the Beach Erosion Board, covers a beach erosion study of the east coast of Jupiter Island. The purpose of the study was to determine the best method of preventing further erosion on the easterly side of Jupiter Island. At that time the Beach Erosion Board found that the central developed portion of Jupiter Island was the only area for which protection was needed. The board, at that time, was of the opinion that the most effective method of preventing further erosion of the 4-mile-long shore of the developed area was the building of a continuous bulkhead fronted by a system of impermeable groins. Due to the high cost of such a comprehensive plan, the board suggested lesser measures to effect in part the desired objective. The board recommendations were: (1) establishment of a bulkhead line, (2) extension of bulkhead construction along that line in stages as required for protection, (3) construction of wingwalls to protect against flanking, and (4) positive measures to be takne to insture against interruption of the supply of littorally drifting sand reaching the shore of the developed area from the northern undeveloped portion of the island. A Federal project was not recommended as no public interest was involved.

14. Some of the board's recommendations were carried out by local interests, see appendix 1, section C. In 1953 the Beach Erosion Board informed local interests that for the whole island artificial nourishment is the most effective and economical method of protection and should be considered instead of the original report recommendation of bulkheads and groins.

15. Coastal Engineering Investigation at Jupiter Island (1957, Coastal Engineering Laboratory, University of Florida). The purpose of the report was to determine the best method of protecting Jupiter Island beaches, particularly those in front of the developed seciton. The report contains surveys and data extending those in the 1947 Beach Erosion Board report to 1956. Recommendations in the report were generally as follows:

a. If seawalls are necessary for protection of valuable property, they should be sloping, high-energy absorbing walls.

b. Certain existing seawalls, due to their location, should be destroyed.

c. About 70,000 cubic yards of suitable sand be pumped annually to beach at the 6-mile developed area.

d. Discussion be started on the establishment of a solution to the erosion problem, based principally on artifical nourishment. The discussion should also include modification of St. Lucie Inlet and possible provision of a sand-bypassing plant.

16. House Document No. 164, 87th Congress, 1st Session (1960, Palm Beach County). The report is on a cooperative beach erosion control study of Palm Beach County, including that portion of Juipter Island within Palm Beach County. The report resulted in an authorized project in 1962. The project provides for Federal contribution toward the cost of a local shore project for restoration of the reaches to a general width of 100 feet with a berm elevation 10 feet above mean low water, and periodic nourishment for 10 years. The Federal share of the Palm Beach County project portion of Jupiter Island is 4.8 percent. No work has yet been undertaken on the project.

17. Coastal Engineering Investigaiton at Jupiter Island (1960, Coastal Engineering Laboratory, University of Florida). The purpose of the investigation and report was primarily to recommend a bulkhead line. Analysis was made of the erosion and the changes that had taken place since the Coastal Engineering Laboratory's 1957 report. The report recommended constructing a protective beach by a suitable bulkhead line and sloping walls.

18. Report on Erosion Situation at Jupiter Island (1962, Coastal Engineering Laboratory, University of Florida). The report is on a survey of erosion damage on Jupiter Island with special reference to areas requiring immediate attention. The report located areas where erosion had seriously progressed and had undermined some protective structures. The report repeated previous recommendations of sloping walls and artificial fill for long-range planning and also included short-range recommendations for emergencies.

19. Beach Erosion Prevention, Town of Jupiter Island, Florida (1963, Gee and Jenson, Consulting Engineers). The report set forth a comprehensive long-range plan for stabilizing and rebuilding the eroding sections of the Jupiter Island beaches. The plan consists of nourishing the beach with sand obtained from the offshore ocean bottom by means of land-based drag-scraper equipment and the construction of long groins. The groins were considered necessary to retain the sand on the beach, reduce the effects of natural erosion, and to widen the beach. The plan was presented as a four-phase plan, shown below in the recommended order of execution.

a. Phase 1 consisted of a beach fill in the amount of 500,000 cubic yards over a 3-year period. A drag scraper was employed to excavate the require 500,000 cubic yards of sand from designated borrow areas in the ocean and place the sand on the beach for distribution by waves along the shore. The borrow areas were 1,000 feet offshore from mean high water. The drag scraper operation involved the use of a 3-cubic-yard scraper bucket, powered by a diesel engine with a three-drum hoist mounted on a stee-head tower. The drag scraper was so rigged so that the bottomless bucket fills up as it travels landward under power from the main winding drum located in the head tower. The empty bucket was returned seaward by another winding drum also powered by the same diesel engine. The drag-scraper method of beach nourishment was evaluated by a cooperative study program between the Corps of Engineers and the Coastal Engineering Laboratory of the University of Florida.

b. Phase 2 included the work of protecting and strengthening existing seawalls whose stability has become endangered by erosion.

c. Phase 3 proposed the essential minimum annual beach nourishment program necessary after completion of Phase 1.

d. Phase 4 proposed the construction of groins 100 feet long, spaced on 200-foot centers, for the purpose of stabilizing and widening the beach, after a reasonable annual supply of sand for beach nourishment has been established.

20. Recommended Coastal Setback Line for Martin County (1962, Coastal and Oceanographic Engineering Laboratory (COEL), University of Florida). Under Chapter 161.053, Florida Statutes, enacted by the 1971 session of the Florida State Legislature provided that the Department of Natural Resources shall set forth a Coastal Construction Setback Line along the gulf and Atlantic shores of the State. Subsequently, the Department of Natural Resources entered into a contract with COEL of the University of Florida for the required studies and surveys.

21. House Document No. 508, 89th Congress, 2d Session (1966, St. Lucie Inlet). The report was in response to a resolution by the Committee on Commerce of the United States Senate, with a view to determining whether improvement of the waterway is advisable. The report developed a plan of improvement for a channel, two jetties, and a jetty-weir arrangement for transfer of littoral drift across the inlet. The considered works were not economically justified and it was recommended that no improvement of Jupiter Inlet be undertaken by the United States at that time.

FEASIBILITY REPORT

FOR

BEACH EROSION CONTROL

MARTIN COUNTY BEACHES, FLORIDA

SECTION B

RESOURCES AND ECONOMY OF STUDY AREA

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MARTIN COUNTY, FLORIDA
SOCIOECONOMIC PROFILE

INTRODUCTION

Martin County is situated along what is commonly called Florida's Treasure Coast which is located in the south eastern portion of the State. Martin County was formed in 1925 from parts of Palm Beach and St. Lucie Counties. It's development has been that of a typical agricultural and fishing community. In the 1970's, the three principal employers were Grumman Aerospace Corporation, Martin Memorial Hospital, and Martin County High School. Since 1980, two more employers have been added. They are South Fork High School and Southern Eastern Training, an advertising agency.

DEMOGRAPHY

According to the 1980 census report, the rapid growth of Martin County could possibly affect the attractive, easy-going lifestyle the inhabitants have always enjoyed. The population in Martin County has increased approximately 47,000 inhabitants during 1960 to 1980. It's current level of 64,014 residents represents a 128 percent population increase during the 20-year period (see table 1). An Economic Base Study prepared for the Jacksonville Engineer District by Booz-Allen and Hamilton, Inc., lists Martin County as being among the fastest growing in Florida. According to the University of Florida's Bureau of Economic and Business Research (BEBR), 1985-2000 projections, the population growth is based on in-migrants who seek less populous coastal locations than the more heavily populated South Florida Metropolitan Areas.

The median age for Martin County in 1970 was 39.6. By 1980, the median age had increased to 43.8 years (see table 2).

More than 90 percent of the county's population lives in the eastern part of the county near the coast. The increase of persons per square mile is also due to net-migration rather than natural increases, such as births. Martin County ranks in the upper third in population density for the State of Florida (see table 3). The City of Stuart, which also happens to be the County Seat, is the most populated area with approximately 10,000 inhabitants.

Martin County's Treasure Coast Regional Planning Council indicates that the age-specific net-migration rates are highest for people age 60 years and older. This compares favorable to the 1980 census overview. It is expected that the shift towards an elderly retired population will continue. However, it is important to note that due to the significant growth rate in the region, where Martin County is located, the youth component (ages 0-14 years) had a substantial increase even though this age group's population of the total population became smaller. A new school construction program substantiates the noted increase in youths (see table 4).

TABLE B-1

POPULATION CHARACTERISTICS

	1960	1970	1980	1985 (Estimate)	1960-1970 Increase Number	1960-1970 Increase %	1970-1980 Increase Number	1970-1980 Increase %	1980-1985 (Estimate) Increase Number	1980-1985 (Estimate) Increase %
Martin County	16,932	28,035	64,014	81,822	11,103	66	35,979	128	17,808	28
State of Florida	4,951,560	6,789,443	9,746,324	13,683,883	1,837,883	37	2,956,881	44	3,937,476	40

Source: 1. U.S. Department of Commerce, Bureau of Census, Social and Economic Statistics Adminstration, 1960-1980
2. U.S. Department of Commerce, Bureau of Census, Census of Population, 1960-1980
3. Florida Statistical Abstract, 1983

TABLE B-2

MEDIAN AGE

1960	1970	1980
Not available	39.6	43.8

Source: U.S. Department of Commerce, Bureau of the Census, Census of Population, 1970-1980, Florida

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TABLE B-3

POPULATION DENSITY

PER SQUARE MILE

1960	1970	1980
30.5	50.4	115.1

Source: Bureau of Economic and Business Research Statistical Research, Florida, 1967 and 1981

TABLE B-4

POPULATION BY AGE GROUP

Age	1970	1980
0-14	5,504	10,517
15-24	3,009	9,029
25-44	4,342	13,672
45-64	5,487	15,142
65+	4,873	15,654

Table 5 depicting population by race and table 6 depicting past and future population growth are included in this report for information purposes.

TABLE B-5

POPULATION BY RACE

Group	1970	1980
White	23,705	57,895
Black	4,197	4,719
Spanish Origin	*	2,084
Native American, Eskimo, and Aleut	*	62
Asian and Pacific Islander	*	195

Source: 1. U.S. Department of Commerce, 1970 and 1980 Census of Population, General Population Characteristics (Florida)
2. Regional Growth: A 5-year outlook, 1982-87 Comprehensive Planning, Treasure Coast Regional Planning
* Statistics for these groups located in counties with less than 10,000 people were not subdivided in 1970.

TABLE B-6

HISTORICAL AND PROJECTED POPULATION
FOR MARTIN COUNTY, FLORIDA

Year	Number of Persons	10-Year Change	
		Number	Percent
1950	7,807	-	-
1960	16,932	9,125	16
1970	28,035	11,103	66
1980	64,014	35,979	24
1985	77,900	13,886	22
1990	85,833	7,933	10
1995	93,767	7,934	9
2000	101,700	7,933	8

Source: 1. Economic Base Study prepared for Jacksonville District by Booz-Allen and Hamilton, Inc. and Earth Satelite Corporation.
2. U.S. Department of Commerce, Bureau of Census, Social and Economic Statistics Administration, 1960, 1970, and 1980 (Florida).
3. U.S. Department of Commerce, Bureau of Census, Census of Population, 1950 (Florida).

HOUSING

Martin County's housing activity declined during the 1973-1974 recession. Since that time, the market rebounded and now reflect a growth rate of 38 percent for the 1980's (see tables 7 and 8). This high increase in housing units can best be attributed to the in-migration of people seeking milder climates. The trend of fewer residents per dwelling unit is occurring throughout Florida and the United States. It is believed that this is because the population is aging and because younger people now elect to have fewer children. Only 1 percent of the dwellings in Martin County lack plumbing facilities (see table 8). The value of property in Martin County (table 8) is in keeping with the increase values of real estate throughout the United States.

TABLE B-7

COMPARATIVE HOUSING DATA

1980

YEAR-ROUND HOUSING UNITS

1960	1970	1980	Percentage Increase
Not available	12,403	31,587	38

HOUSING GROWTH PERCENTAGES

1960-1970	1970-1980
83.7	135.0

RESIDENTS PER DWELLING UNIT

1960-1970	1970-1980
2.5	No change

Source: 1. Economic Base Study prepared for the Jacksonville District by Booz-Allen and Hamilton, Inc., and Earth Satelite Corporation.
2. U.S. Department of Commerce, Bureau of Census, Census of Population and Housing, 1970, 1980 (Florida).

TABLE B-8

1980 HOUSING DATA FOR MARTIN COUNTY

Owner-Occupied Units	1981-1982 Building Permits
20,109	3,792
Percent of Housing Lacking Plumbing Facilities	**1981-1982 Single Unit Permit**
1 percent	36 percent total permits
Median Value Owner Occupied Single-Family Units	**1981-1982 5 or More Unit Permits**
$55,600	64 percent total permits
Median Rent	**Renters**
$235.00	5,754

Source: 1. 1980 Florida Statistical Abstract.
2. U.S. Department of Commerce, Bureau of the Census, Census of Population and Housing.

GOVERNMENT

Martin County is governed by the county commissioner form of government. A Board of Commissioners composed of five elected officials (three commissioners, a chairman, and a vice chairman) presides over county matters. The chairman presides over each agenda item. Other elected officials include (1) the Clerk of Circuit Court, who has responsibility for the County's finances, (2) a Property Appraiser, (3) Tax Collector, (4) County Sheriff, and (5) Supervisor of Elections.

Source: Personal conversation with individual (Mr. Banti), Martin County Planning Department, Administrative Office, Stuart, Florida.

POLICE

All incorporated townships, cities, etc., in Martin County have their own police departments. Martin County Sheriff's Department provides police coverage for all other unincorporated townships. Because Indiantown is a remote city, it has a Deputy Sheriff Station in conjunction with its fire protection facilities.

Source: Personal telephone conversation with Martin County Sheriff Department

FIRE PROTECTION

All townships (cities) of Martin County have fire departments. The incorporated cities, Stuart, Sewall's Point, and Jupiter Island, have city fire departments in which personnel are paid from that city's funds. The unincorporated cities are served by the county and volunteers. The personnel are paid by the county. There are 75 fire trucks of various types located within Martin County. The number of trucks for each area are appropriated according to size and population.

Source: Personal telephone conversation with Martin County's Planning Department, Administrative Office, Office of Clerk of the Circuit Court, Office of the Disaster Preparedness Chief.

MEDICAL FACILITIES

Medical facilties located in Martin County serve a wide area. There is one hospital with 310 beds (4.2 beds per thousand people), 40 dentists, 133 physicians, and 2 nursing homes with 302 beds. The county ranks 27th in the State for medical facilities.

Source: Florida County Comparisons/1984, Division of Economic Development.

EDUCATION

Fifteen public schools serve the Martin County area (School District 43) from kindergarten through high school. There are 6 elementary schools, 3 middle schools, 2 high schools (see table 9). The 3 adult educational programs are located in the south and west portion of Martin County, the other in the city of Stuart. One exceptional Student Educational Center for the physically, hearing, and speaking impaired, which employs 5 teachers and has an enrollment of 37 students, serves the county. Some colleges or universities are located within a 30-mile radius of Stuart which is the most populated area. Table 9a depicts total enrollment and educational attainment in Martin County's public school during the 1981 and 1982 school year.

Due to the population growth from in-migration, enrollment in the aforementioned schools has increased during the period 1970 to 1980 (see table 10). According to a spokesperson from the Board of Education Office the impact on school enrollments from migrant workers and the flux of immigrants (Haitians and Cubans) have not been significant for the Martin County area in that the people moving into the county are from other areas of the State of Florida and the country. The quality of education within Martin County ranks sixth in the State.

TABLE B-9

City	Schools/Grades	Teaching Staff
Hobe Sound	2 pub.S/K-5 & 9-12	113
Jensen Beach	1 pub.S/K-5	39
Palm City	1 pub.S/K-5	36
Stuart	4 pub.S/K-5, 7-8, 9-12	219
Port Salerno	1 pub.S/7-8	49
Indiantown	1 pub.S/7-8	27

Source: 1. Personal contact with Martin County's Board of Education.
2. Personal conversation with each school office.

TABLE B-9a

MARTIN COUNTY SCHOOL YEAR
DATA FOR 1981 AND 1982

Enrollment
Public Elementary and Secondary

	Number	Pop. %
Kindergarten through Grade 3	2,529	4
Grades 4 through 9	4,144	6
Grades 10 through 12	1,587	2

Educational Attainment

	Number	Pop. %
8 years or less	6,757	11
Some high school	6,417	10
High school degree	16,224	25
Some college	7,984	12
College degree	7,096	11

TABLE B-10

SCHOOL-YEAR ENROLLMENT DATA
PUBLIC ELEMENTARY AND SECONDARY

Enrollment	1970 Number	1980 Number
Kindergarten	122	532
Elementary (1-8 years)	3,750	5,391
High School (1-4 years)	1,361	2,438

Source: U.S. Department of Commerce, Bureau of Census, General Social and Economic Statistics Administration, 1970 and 1980, Florida.

EDUCATIONAL ATTAINMENT

A comparison of the level of educational attainment for all persons 25 years old and older in 1970 in Martin County and the State of Florida is presented in table 11. Only percentages are given, as they can be easily compared. Martin County has a higher percentage of persons completing college for 1970 (8 percent) and 1980 (10 percent) than does the State of Florida for 1970 (6 percent) and 1980 (9 percent).

TABLE B-11

EDUCATIONAL ATTAINMENT

	1970		1980	
School Years Completed	County	State	County	State
8 years or less	29%	20%	15%	15%
Some high school	20%	20%	14%	15%
High school degree	32%	31%	36%	36%
Some college	11%	12%	18%	17%
College Degree	8%	6%	.10%	9%
Median school years of education	11.7	12.1	12.6	12.1

Source: U.S. Department of Commerce, Bureau of Census, General Social and Economic Characteristics, 1970-1980, Florida.

TRANSPORTATION

Martin County is supplied with rail and highway transporation facilities. The Florida East Coast and Seaboard Coastline provides rail transportation. These lines are linked to north, south, and eastern cities and towns in the State.

The County is linked north and south by Interstate Highway 95, Florida Turnpike, and U.S. Highway 1. State Roads 76, 708, and 714 are used for access to major highways and interstates for direct routes to western metropolitan areas.

The major commercial airport used by Martin County residents is in West Palm Beach which is 45 miles from the city of Stuart. There are approximately 140 airline flights scheduled per day on 10 major airlines.

Source: Florida Department of Commerce, Division of Economic Development/ Bureau of Economic Analysis, Tallahassee, Florida.

COMMUNITY DEVELOPMENT

Martin County generally provides adequate public facilities as well as land for growth. At present, the county nas adequate educational, recreational, health, and a number of employment opportunities. However, with the continued population increase, both current and projected, the County's Board of Commissioners has set goals to increase economic development and fiscal conservancy, residential quality, and natural resource conservation.

Source: 1. Martin County Comprehensive Plan, April 1, 1982.
2. Florida Department of Commerce, Division of Economic Development/Bureau of Economic Analysis, Tallahassee, Florida, 1983.

ECONOMY

The wholesales and retail trades comprises the largest industries in Martin County. The economic development agencies for the county are the Martin County Industrial Development Authority and the Stuart Chamber of Commerce. There is an estimated 399,000 square feet of office space with 33,300 square feet of it under construction. The labor drawing areas include the counties of Okeechobee, Palm Beach, and St. Lucie. Estimated labor force from these counties is 359,758.

Source: Florida Department of Commerce, Division of Economic Development/ Bureau of Economic Analysis, Tallahassee, Florida.

EMPLOYMENT

Wholesale/retail trade and services (health, education, and culture) are the main employment sectors for Martin County and employs the highest number of people (see table 12). It is expected that these services will continue to grow rapidly as the county receives its share of retirees and high technology persons. The tremendous increase in these areas since 1971 is depicted in table 12a.

The construction sector is expected to stabilize with a slight increase because of house building activities induced by population growth. The share of agriculture employment, which is mostly citrus and cattle, is expected to steadily decline. This is said to be attributed to the increased use of machines rather than manual stoop labor. As stated in aforementioned paragraph, all other sectors will show steady rate of increase.

UNEMPLOYMENT

As of 1983 all males 16 years and older in Martin County accounted for 47.9 percent of the labor force while the corresponding rate for all females was 38.3 percent. The unemployment rate for both males and females in Martin County is lower than the National Average (9.2) and the State of Florida

TABLE B-12

EMPLOYMENT BY INDUSTRY:
MARTIN COUNTY, 1983

	Number	Percent by Population
Construction	3,510	5
Manufacturing	2,663	4
Trans-Comm-Utilities	1,169	2
Wholesale and Retail Trade	5,466	9
Finance-Insur-Real Estate	1,501	2
Services (health, education, culture)	5,706	9
Government (Federal)	831	1
Agriculture, Forestry, and Fishing	1,812	3
Total	22,658	35

Source: Bureau of Business and Economic Research, Statistical Abstract, Florida, 1983.

TABLE B-12a

EMPLOYMENT BY INDUSTRY:
MARTIN COUNTY, 1971

	Number	Percent by Population (1970 Census)
Construction	920	3
Manufacturing	1,180	4
Trans-Comm-Utilities	240	1
Wholesale and Retail Trade	1,700	6
Finance-Insur-Real Estate	500	2
Services (health, education, culture)	1,280	5
Government (Federal)	980	3
Agriculture	Not Available	—
Total	5,738	22

Source: Bureau of Economic and Business Research, College of Business Administration, University of Florida.

(8.6) (see table 13). The number of unemployed people in the county is considerably lower compared to those who are employed. The number of retirees and children under the age of 16 accounts for a portion of the nonworking population (see Table 14 - Employment Trends).

Sources:
1. Study of Central and Southern Florida Project, Part III, page E-12.
2. United States Department of Commerce, Bureau of Economic Analysis.
3. Division of Economic Development, Florida County Comparison, 1984.

TABLE B-13

COMPARATIVE LABOR FORCE
AND UNEMPLOYMENT STATISTICS
MARTIN COUNTY

Males, 16 years old and over	Number and Percentage
Number in labor force	25,205
Percent of total labor force	47.9
Numbr civilian labor force	25,189
Employed	24,424
Unemployed	765
Percent civilian labor force unemployed	3.0
Not in labor force	27,370

Females, 16 years old and over	Number and Percentage
Number in labor force	10,408
Percent of total labor force	38.3
Numbr civilian labor force	10,408
Employed	10,021
Unemployed	387
Percent civilian labor force unemployed	3.7
Not in labor force	16,738

Source: U.S. Department of Commerce, Bureau of the Census, General Social and Economic Characteristics, 1980

TABLE B-14

EMPLOYMENT TRENDS

	1980	1981	1982	
Martin County				
Labor force	26,227	27,842	30,435	*
Employed	25,207	26,494	28,254	
Unemployment Rate	3.9	4.8	7.2	*
Florida				
Labor force	4,267,054	4,502,454	4,726,913	
Employed	4,016,637	4,195,404	4,340,772	*
Unemployment rate	5.9	6.8	8.2	

Source: Bureau of Business and Economic Research, Statistical Abstract, Florida, 1983.

FAMILY INCOME FOR MARTIN COUNTY

Income characteristics for families in Martin County are provided in table 15. It is expected that income for the area will continue to increase because of the rapid rate of population growth and the associated growth of commercial activity, particularly retail trade and services.

Per capita income for Martin County (table 16) increased yearly from 1975 to 1982. The county exceeded the State's per capita income for both the years 1981 ($10,362) and 1982 ($10,907). As previously stated, this trend is expected to continue because of growth of commercial activities.

TABLE B-15

FAMILY INCOME
MARTIN COUNTY
1980

Amount	Number in Families	Percent of Population
Less than $5,000	1,120	2
$5,000 - $7,499	1,427	2
$7,500 - $9,999	1,511	2
$10,000 - $14,999	3,246	5
$15,000 - $19,999	3,188	5
$20,000 - $24,999	2,569	4
$25,000 - $34,999	3,084	5
$35,000 - $49,999	1,663	3
$50,000 or more	1,234	2
Total	$19,042	30
Median Family Income	$18,311	
Percent Less than poverty level	7.3	
Percent $15,000 or more	19	

Source: U.S. Department of Commerce, Bureau of Census, General Social and Economic Characteristics, Census of Population, Florida, 1980.

TABLE B-16

PER CAPITA INCOME
MARTIN COUNTY

Year	Amount
1975	$ 5,557
1976	6,045
1977	6,775
1978	7,733
1979	8,708
1980	10,012
1981	11,587
1982	11,845

Source: 1. Bureau of Business and Economic Research, Statistical Abstract, Florida, 1983.
2. Division of Economic Development, Florida County Comparison, 1984.

FEASIBILITY REPORT

FOR

BEACH EROSION CONTROL

MARTIN COUNTY BEACHES, FLORIDA

SECTION C

PROBLEMS AND NEEDS

SECTION C

PROBLEMS AND NEEDS

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SECTION C

PROBLEMS AND NEEDS

WINDS

1. A study of recorded and possible wind velocities, duration, and direction is necessary to determine their effect on characteristics of waves likely to be experienced in the study area. Wind-generated waves are the primary cause of loss of material from the beaches. In addition, the design height of shore protection structures is dictated to a great degree by the height and force of the waves likely to be experienced.

2. The wind directional statistics are developed from data based on observations made by ships in passage. It should be stated that such ships tend to avoid bad weather when possible, thus biasing the data toward good weather samples. Also, the observations themselves are generally estimates based on the appearance of the waves, the drifting of smoke, or the flapping of flags, although some are anemometer measurements. In any event, the statistics are more representative of winds that can directly or indirectly affect the shoreline than shore-based inland observation facilities. The following table gives the percent of time and direction from which winds blow as indicated by shipboard meteorological records.

TABLE C-1

Yearly Average Winds

Direction	Percent of Time
North	10
Northeast	16
East	22
Southeast	13
South	13
Southwest	8
West	8
Northwest	8
Calm	2

WAVES

3. The most familiar ocean waves are wind-generated waves. They are formed by the transfer of energy from winds blowing over the water surface. They can vary in size from ripples to as large as 10 feet or more in height.

Their size and frequency of occurrence are important factors in shaping the shoreline on Florida's sandy coasts. Storm waves generated by the wind are the primary cause of losses of sand from the beaches, and the shoreline damage in the study area.

4. The wind waves that occur in the study area vicinity consists of "sea" and "swell." Seas are waves generated by local winds and are observed as traveling with the wind. Swells are waves generated from distant storms that enter the study area independent of the local wind conditions. Available data sources include records from two pier-mounted wave gages that have been operated by the Coastal Engineering Research Center (CERC) at Daytona Beach to the north and one at Palm Beach to the south of the study area.

5. The data recorded at each gage include a summary by month of the significant wave heights and periods (but not the directions), significant wave height distributions, and printed or plotted wave energy spectra. Linear interpolation of these results--derived from the two gages--provides a first approximation of typical wave conditions that exist in the study area.

6. Records of offshore wave and swell from shipboard observations are compiled by the U.S. Naval Weather Service Command. These data are available in the "Summary of Synoptic Meteorological Observations," Volume 4, hereafter referred to as SSMO. Data given in the SSMO is used to estimate the wave climate near the study area using the following accepted assumptions:

- swell waves are traveling in the same direction as sea waves, which in turn corredponds to wind direction;

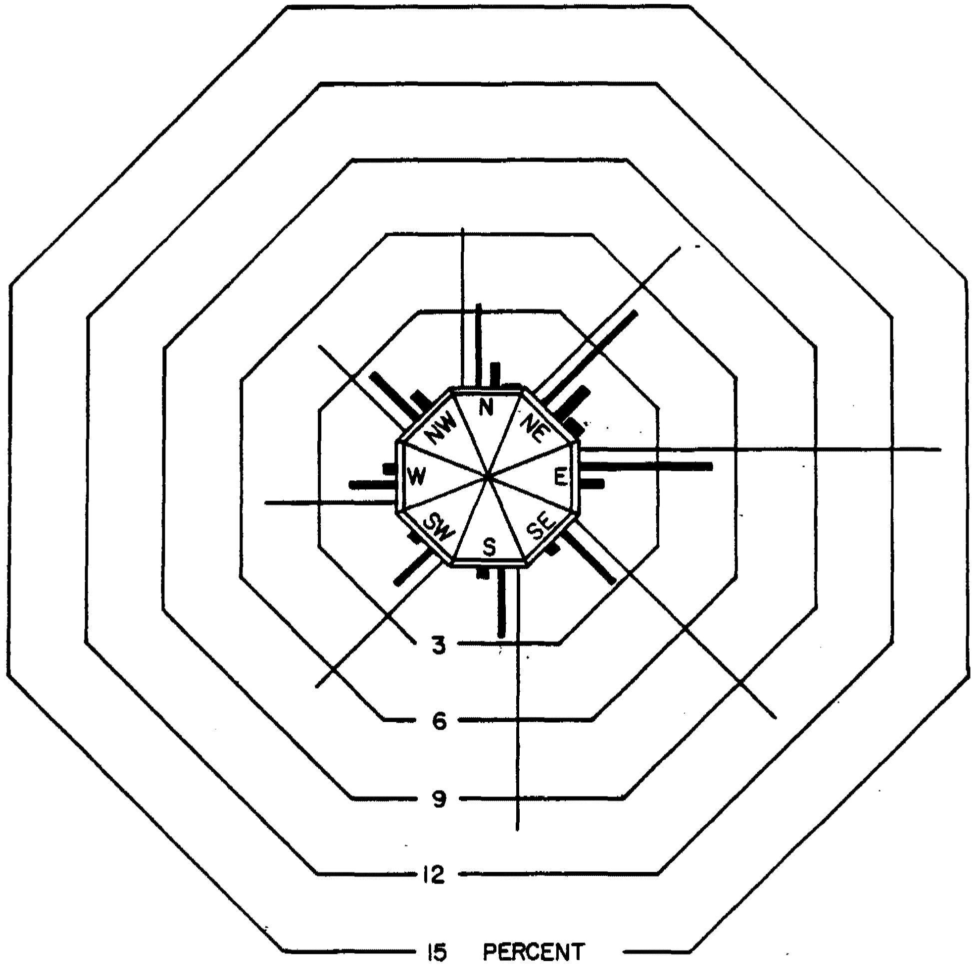
- waves are propagated in one direction only, the observed direction, in any specific time interval;

- sea and swell waves of the same period can be treated alike, and will not lose energy to the atmosphere between the point of observation and the study area;

- no other wave heights or periods are present during the observation;

- all observations were made in water deeper than 2.56 times the square of the wave period for the wave periods recorded (i.e., "deep water" or shore waves).

7. The unrefracted annual average deepwater significant wave height diagram shown in figure C-1 is derived from the SSMO data for an ocean area near the study area having an approximate boundaries of 80° W. latitude to the coast and 26° N. to 30° N. longitude. As with the wind data, it should be stated that ships tend to avoid bad weather when possible. This being the case, the data are biased toward good weather and lower wave height observations. The diagram indicates that in deep water the majority of medium waves approach from the north through eastern quadrants and most of the largest waves from the northeastern quadrant.



0 - 4 FT. (0 - 1.2M)
4 - 8 FT. (1.2 - 24M)
8 - 12 FT. (24 - 36M)
OVER 12 FT. (OVER 36 M)

THE LENGTH OF THE BAR DENOTES THE PERCENT OF TIME THAT WAVES OF EACH TYPE (SEA + SWELL) APPROACHED FROM OR NEAR THE GIVEN DIRECTION.

WAVE DATA IS BASED ON SHIPBOARD OBSERVATIONS OF EVENTS OCCURRING WITHIN A DATA SQUARE FOR A 5-YEAR PERIOD FROM 1963-1968. THE DATA SQUARES APPROXIMATE BOUNDARIES ARE 81°W ⟶ COAST AND 26° ⟶ 30°N.

BEACH EROSION CONTROL AND
SHORE PROTECTION STUDY
MARTIN COUNTY, FLORIDA

DEEP - WATER SIGNIFICANT
WAVE HEIGHTS BY DIRECTION
(UNREFRACTED ANNUAL AVERAGE)

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

FIGURE C-1

8. By correlating the SSMO data with the wave gages operated by CERC it can be found that the average annual wave periods from the northeast, east, and southeast that strike the shoreline of the study area are approximately 7.3, 6.6, and 6.2 seconds, respectively. Also, the average annual wave height to be expected just seaward of the surf zone is about 2.1 feet.

9. Water waves as they approach the shoreline are affected by the ocean's bottom. For example, in Palm Beach where deep water is relatively close to the shoreline, the average annual significant wave height just seaward of the surf zone is about 2.3 feet, with approximately 1 percent of those observed above 7 feet. At Daytona Beach, where the continental shelf slopes more gradually and more significantly affects the incoming waves, the average annual wave height is about 1.8 feet with 1 percent or more observed above about 4.8 feet.

TIDES

10. The mean range of tides in the Atlantic Ocean at Jupiter Island is 2.6 feet; the average spring range is 3.0 feet. Actual mean sea level (m.s.l.) is 1.1 feet above mean low water (m.l.w.) and 1.83 feet below mean high water (m.h.w.).

11. Storms and hurricane winds blowing from the sea can create abnormally high tides in the coastal area. Tropical storms in this vicinity occasionally increase the tide range. Storm surge data employed in this study were taken from National Oceanic and Atmospheric Administration (NOAA) return intervals. Information on extreme tides is sparse. The lowest tide to be expected is 2 feet below mean low water.

CURRENTS

12. The maximum velocity at the throat of St. Lucie Inlet was measured on 1 March 1980 at 1.9 feet per second for ebb flow and 2.5 feet per second for flood flow.

FLOOD INSURANCE STUDY

13. A Flood Plain Information report was prepared for the Board of County Commissioners of Martin County in 1973 by the Corps of Engineers. That report was prepared to provide knowledge of flood potential and flood hazards in regard to developing a basis for land use planning and management decisions affecting flood plain utilization.

14. The Federal Insurance Administration (FIA) has a study underway to provide information on the flood elevations that can be expected along the Martin County shoreline. The study findings are currently in preliminary draft status and are being coordinated with local interests.

TROPICAL STORMS

15. The study area is in a zone subjected to tropical storms of hurricane intensity. The study area is also subjected to relatively frequent coastal storms from the northeast (extra-tropical). Specific hurricanes and northeast storms that affected the beaches of Martin County are listed below. Northeast storm history will be updated when the data become available.

HURRICANES

16. The study area has experienced, within a 150-mile radius, 52 storms of hurricane intensity between 1830 and 1965, inclusive, or an average of one hurricane every 2.6 years. However, only 15 hurricanes passed within a 50-mile radius in that period, or an average of one hurricane in nine years. The effect of hurricanes on the beaches of Martin and North Palm Beach Counties has not been as severe as that of many northeast storms. The short duration of hurricane-force winds and waves in the area has usually limited the severity of erosion damage. The approximate paths of hurricanes of record that have passed through or near the study area are shown in plate 1 of the main report.

HURRICANES	NORTHEAST STORMS
August 23, 1885	November 1956
October 10-13, 1904	December 1957
July-August 1926	March 1962
September 6-22, 1926	November-December 1962
September 6-22, 1928	December 1963
August 31-September 7, 1933	January 1964
August 24-29, 1944	
August 23-31, 1949	
October 15-19, 1950	
October 16-30, 1963	
August 17-29, 1964	
October 7-14, 1964	
August 27-September 10, 1965	
September 4, 1979	

LITTORAL DRIFT

17. Analysis of the littoral movement along the southeast coast of Florida, to the extent that available data permit indicates that in the shore segment near Jupiter and Palm Beach Islands, the southerly drift is appreciable. Analysis also shows that although erosion of the foreshore prevails in much of the area, there is no significant accumulation of the eroded material in quantities comprable to the eroded quantities at any of the littoral barriers along this sector of the coast. The average annual beach erosion losses of 6.8 cubic yards per foot of shorefront per year for the 16.5 mile length of Jupiter Island indicates that the anticipated annual erosion losses for this reach total about 592,400 cubic yards. Since this annual

Since this annual loss (592,400 cubic yards) is greater than the southerly drift (230,000 cubic yards per year), and the average annual maintenance dredging of 65,300 cubic yards at St. Lucie Inlet (see following section on effect of St. Lucie Inlet). The data suggest that erosion of the shore south of St. Lucie Inlet would be inevitable even if the natural drift rate were restored south of St. Lucie Inlet. Sand bypassing across St. Lucie Inlet, even if all the littoral drift were bypassed, would be helpful but would not solve the problem.

18. An important aspect of littoral movement in the area is the degree of exposure of the coast to high- and low-steepnes waves. The Little Bahama and Great Bahama Banks are located about 60 miles to the east of the Florida coast and virtually prevent attack of the shore by long-period or swell-type waves from the east. The shoreline for some distance north of Lake Worth Inlet is oriented so it is exposed for about an 80- to 90-degree sector to the northeast between the mainland and the Bahama Banks. This means that the shore sector is subjected to some low-steepness waves (long-period swells) which would transport back to the beach zone material which has been eroded from the beach and carried to the offshore zones by high-steepness waves (storm-type waves).

THE STORM PROBLEM

19. The problem along the study area is one of erosion and lowering of the beach profile and recession of the shoreline and dunes. Hurricanes and severe northeast storms have caused considerable erosion and damage. Along parts of the shore within the study area erosion of the beach and dune has placed seawalls, buildings, and other structures in a position vulnerable to severe damage during storms.

DESCRIPTION OF HURRICANES

20. Hurricanes and severe northeast storms have caused considerable erosion and damage at Jensen Beach. Many of the major storms of record occurred prior to full development of the area. However, the storms of October 1963 and August 1965 (hurricanes), and December 1963 and January 1964 (northeasters) damaged or destroyed seawalls, retaining walls, and upland buildings and facilities, and eroded the recreational beach completely, lowering the profile as much as 6 feet. The beach and recreational areas were partially replenished by the use of bulldozers, draglines, and trucks in distributing sand gained during favorable weather. During Hurricane Betsy in September 1965, storm tides, waves, and currents completely eroded the public recreational beach area and lowered the profile 7 feet in front of the seawall. The southern end of the seawall was flanked and the washout extended about 40 feet upland. Natural partial recovery after the storm has improved conditions considerably. Both storm wave action and the mean high water erosion trend have significantly receeded the shoreline from the historical shoreline documented by 1882 surveys (see plate 3). The county beach in the city of Stuart, as is the case of Jensen Beach, has been repeatedly eroded during storms of record and was completely eroded as a result of Hurricane Betsy in September 1965. Since 1882 the high water shoreline has receeded

about 175 feet at Jensen Public Beach Park and about 200 feet at Stuart Public Beach Park. Along parts of Jupiter Island shore, erosion of the beach and dune palces seawalls, buildings, and other structures in a position vulnerable to severe damage, especially during storms. The shores of Jupiter Island have had a long history of erosion. The erosion and damage to the beach, seawalls and oceanfront property are accelerated and greatly magnified during storms of tropical and extra-tropical origin which frequent the area. As a result of several northeast storms the beach level is lowered, structures are damaged or destroyed, and valuable oceanfront property is eroded. Natural buildup of the beach during summer months generally alleviates the situation to some degree, though complete recovery seldom occurs. However, erosion during the winter months still leaves the shore vulnerable to possible severe damage from storms.

HURRICANES

21. The study area is subject to frequent visitations by tropical storms of hurricane intensity. The paths of hurricanes which have passed within 50-mile and 150-mile radii of Martin County during the period 1830-1965 are shown on plate 1. Between 1830 and 1965, 52 hurricanes passed within a radius of 150 miles of Jupiter Island, or an average of one hurricane every 2.6 years. Between 1830 and 1965, 15 hurricanes passed within a 50-mile radius, or an average of one hurricane every 9 years. Specific hurricanes and their effects on the shores of Jupiter Island and adjacent Martin County shores, to the extent of availabile data, are discussed in the following paragraphs.

August 23, 1885. The hurricane approached from the southeast and skirted the Atlantic coast of Florida. It passed about 15 miles east of Jupiter Island with full hurricane force. Winds of 40 miles an hour were recorded in Jacksonville as the storm passed 40 miles to the east. Details on storm damage at Jupiter Island and the remainder of Martin County are not available.

October 10-13, 1904. This storm approached Florida from the southeast and passed over Jupiter Island. Its intensity decreased rapidly to less than hurricane force after moving inland. Peak winds of 88 miles an hour were reported at Jupiter Island on October 17 in the second phase of the storm. The extent of storm damages is unknown.

July-August 1926. This storm moved in a northerly direction and parallel to the Atlantic coastline a short distance offshore. The storm caused an estimated $3 million property damages to the east coast of Florida.

September 6-22, 1926. The storm was one of the most severe of the present century. A minimum barometric pressure of 27.61 inches, recorded at the Miami Weather Bureau Station, was at that time the lowest corrected reading ever recorded by a regular Weather Bureau Station. A maximum 2-minute wind velocity of 132 miles an hour was recorded. Red Cross reports showed that over 350 persons lost their lives during the storm. Tidal flooding extended northward to Fort Pierce. Damages caused by the storm in south Florida were evaluated to be from $50 to $165 million.

September 6-20, 1928. This storm is also considered one of the most violent of the present century to strike Florida. The minimum barometric pressure at West Palm Beach was 27.43 inches, one of the lowest of record in the United States at that time. The storm entered Florida at West Palm Beach, causing $11.5 million damage in the Palm Beach-Lake Worth area. West Palm Beach recorded a wind velocity from the northeast of over 100 miles per hour. Moderately heavy damages were reported by areas north of West Palm Beach. Beach highways from Jupiter to Delray Beach were undermined by tide and wave action. High tides were reported along the entire east coast. At Jupiter Island, strongest winds were from the northeast and east. Waves from that storm caused considerable erosion on Jupiter Island, the principal areas affected being in the vicinity of Blowing Rocks. A short distance south of Blowing Rocks the bluff was cut back to the edge of the road. A short distance north of Blowing Rocks erosion occurred over approximately 1 mile, the greatest shore recession being about 170 feet.

August 31-September 7, 1933. This was a small severe storm that moved northwesterly from the Virgin Islands and entered the Florida coast at Jupiter Inlet. The minimum barometric pressure recorded at Jupiter Inlet was 27.98 inches. A wind velocity of 110 miles an hour was recorded at Jupiter Inlet. Storm damages were moderately severe, with the largest percentage of the damages occurring between Jupiter Island and Fort Pierce. Bridges, docks, and numerous seawalls were damaged.

August 24-29, 1944. This storm passed inland over the West Palm Beach-Delray Beach area. The strongest winds and heaviest wind damage were in the vicinity of Stuart and Jupiter. Jupiter had wind gusts of 153 miles per hour. Total losses in the State were $45 million, including $20 million crop damage and $18 million property damage. A total of 265 dwellings was destroyed and 24,000 others reported damaged. Stuart, immediately west of the study area, suffered severe damage, the worst in the history of the area, with over 500 persons homeless. A high-water mark of 8.5 feet was observed in St. Lucie River on the railroad bridge near Stuart. Sections of waterfront streets were swept by high seas and were badly eroded.

October 15-19, 1950. This was a small but violent storm. Wind gusts of 122 to 150 miles an hour were reported at Miami. Storm damages were severe along the lower east coast of Florida.

October 16-30, 1963. Hurricane Ginny was an unusual storm. It developed from an extratropical depression in the Bahamas; intensification of hurricane force occurred on the 20th when it was centered near Cape Hatteras. The center was then slowly forced southward parallel to the coast, less than 100 miles offshore, by a hig pressure area until it eached the latitude of Daytona Beach. The high pressure area then weakened and the hurricane center reversed its path. Ginny was a minor hurricane and its damaging effects were moderate. Winds along the northeast Florida coast ranged from 35 to 45 miles an hour. Tides at Daytona Beach were reported 2 to 3 feet above normal. Beach erosion was reported in some places, but was of minor nature in Florida. Total damages in Florida were estimated at $50,000.

August 17-29, 1964. Hurricane Cleo was the first full hurricane to strike directly into the metropolitan complex of southeastern Florida since the storm of October 17, 1950. It first reached hurricane force about 1,000 miles east of the Lesser Antilles on August 21. After crossing Cuba, the storm followed a track which brought the center over Miami at 2 a.m. on August 27. The storm center then followed a path some 10 to 20 miles inland, closely paralleling the coast until it passed over the ocean near Jacksonville Beach on the 28th. Maximum winds along the lower east coast were estimated at 100 to 110 miles per hour with gusts to 135. The storm center was small (10 to 16 miles in diameter) and damage was restricted to a strip 20 to 35 miles wide between Miami and Melbourne. Peak tides along the lower east coast were above 5 feet above normal; some minor beach erosion was reported there. Highest tides elsewhere along the coast were equivalent to spring tides. Overall direct and indirect damages in Florida have been estimated at $125 million. Losses were caused primarily by the wind and include minor structural damages, crop damage, uprooted trees, disrupted communication, and power failures.

October 7-14, 1964. Hurricane Isbell developed from a tropical depression in the western Caribbean on October 7 and reached hurricane intensity as it neared western Cuba on the 13th. From there it took a northwesterly course, reaching the lower coast of Florida at Everglades at 4 p.m. on the 14th. It then pursued a rapid northeasward course across the State, making its exist from Florida near Jupiter. Property damage in the State was estimated at about $5 million. A sizable portion of this was caused by tornadoes. Two persons were killed and 50 people injured. Highest winds reached in Florida were nearly 90 miles an hou along the coasts. Isbell was a small storm and damage was limited to a narrow strip across the State. Vegetable crops in the Everglades were damaged by winds and rain. Tidal damages were of a minor nature, being generally limited to smaller pier and boats.

August 27-September 10, 1965. Hurricane Betsy was an unusual storm. It developed from a tropical depression in the southwest Atlantic Ocean. Intensification to hurricane force occurred on the 29th when it was centered about 200 miles northeast of Puerto Rico, after which it followed an erratic track for the next 2 days. On 1 September a more definite west-northwestward movement began. Development of a high pressure area off the Carolina coast affected Betsy's movement at that time, forcing the storm toward the southwest. The hurricane center moved slowly southward through the northern Bahamas for the next 2 days. On 8 September the center, 40 miles in diameter, passed over extreme south Florida. The storm center then followed a path west to northwest through the Gulf of Mexico, crossed inland just west of New Orleans, and passed northward through Louisiana and into eastern Arkansas. The greatest damages in Florida occurred in the southern end of the State, where about 15,000 acres of agriculture lands and sections of Miami were inundated by rising tides in Biscayne Bay. The President of the United States declared 10 south Florida counties a disaster area because of the extent of damages resulting from the hurricane. Estimated damages in the State of Florida as a result of the hurricane were about $140 million.

This consisted of about $123 million damages to private facilities, $9 million damages to public facilities, and $7.5 million damges to the agricultural industry. Waves, currents, and tides accompanying this hurricane caused a major loss of fill along the beaches of the lower east coast of Florida where beaches had been wide and stable for many years. There was an appreciable loss of sand from the beaches throughout Martin County. The recreational beaches at Stuart and Jensen Beach were essentially completely eroded. Vertical seawalls were flanked and other development features were undermined and threatened. It appeared that sloping walls and revetments on Jupiter Island were not as adversely affected as vertical walls.

NORTHEAST STORMS

22. These seemingly periodic storms attack the Florida east coast during the fall and winter months. It is reported that northeasters cause more erosion to the beaches in 2 or 3 months than is caused by winds and swells from other directions during the rest of the year. If the northeasters occur when the moon is in perigee, they are accompanied by abnormally high tides. The combination of large waves from the northeast and high tides for several days appear to cause more sand movement than the average hurricane, probably due to the short duration of hurricanes. Detailed information on damages caused by northeast storms is generally scarce. However, loss of valuable land and recreational areas, damage to protective structures and development, and damge to shorefront highways and streets are reported annually. Specific recent northeasters and their effects on the study area, to the extent of available information, are presented in the following paragraphs.

November 1956. The damage during the November 2-5, 1956 northeast storm was caused chiefly by wave action on top of high tides generated by winds from a storm center which later developed into Hurricane Greta. The winds blew generally from the northeast at sustained velocities of 20 to 30 miles an hour for 4 days. The winds generated tides as much as 4 feet above normal, with fairly heavy seas. Heavy erosion of the beach ridge and lowering of the beach profile was observed along Jupiter Island. Erosion was particularly evident along the southerly 2 miles of the island. At Jensen Beach it was reported that the beach road leading south was damaged at several points by erosion into the edge of the roadway and that the recreational beach was essentially lost.

December 1957. That storm caused severe and lasting erosion in Palm Beach and Martin Counties. The outer end of the steel-sheet-pile jetty on the north side of Jupiter Inlet was badly deformed and bent out of line. The shore to the south of Jupiter Inlet experienced severe recession.

March 1962. The storm, a vast low pressure system centered off the middle Atlantic coast, battered installations along the coast from Florida to New England between March 5 and 9. Huge swells, building up to about 20 feet near the shore on top of abnormally high tides, caused considerable flooding and erosion. The narrow sand barrier near the north end of Jupiter

Island was breached, opening an inlet from the Atlantic Ocean into Peck Lake. Peck Lake, located about 3.5 miles south of St. Lucie Inlet, is a shallow sound about 1 mile long and 1/3 mile wide, which is traversed by the Intracoastal Waterway. Before the breakthrough the beach barrier was about 400 feet wide from the ocean to Peck Lake. The initial breach was about 350 feet wide and 5 feet deep. The inlet widened to about 700 feet and reopened to about 12 feet in 1 year. Peck Lake Inlet was closed by the Corps of Engineers in to protect traffic on the Intracoastal Waterway. Closure was by a dredged barrier beach and was completed in August 1963.

November-December 1962. A severe coastal storm with winds 60 to 70 miles an hour within 100 miles of the center remained within 300 to 500 miles of the beaches in the study area for several days. Sustained northeast winds over a fetch of several hundred miles generated large waves that pounded the shore for several days. Though erosion was extensive in Martin County, it was not as severe as in north Florida. On Jupiter Island the steep beach ridge in areas unprotected by seawalls was severely eroded. The beach infront of the vertical seawalls was eroded and lowered considerably. It was reported that wave aciton and the loss of sand endangered the stability of about 2,000 feet of seawall and caused the failure of several hundred feet of wall.

December 1963. That storm caused severe and lasting erosion at Hutchinson and Jupiter Islands. Heavy erosion of the beach ridge and lowering of the beach profile was observed along the two islands. Erosion was particularly evident at Jensen Beach because the beach dropped about 5 feet in elevation, endangering a public pavilion and other development features. The storm was accompanied by unusually high tides and large waves.

January 1964. That northeast storm caused severe erosion and destroyed the seawall and a section of the parking area at the public beach of Jensen Beach. Erosion was particularly evident just south of the Jensen Beach pavilion. Huge swells, building up to about 15 feet near the shore, on top of high tides, caused considerable flooding and erosion throughout the Martin County ocean frontage. The beach dropped about 3 feet in elevation and many of the oceanfront structures were damaged during this northeaster.

Other recent northeast storms. Many northeast storms of lesser intensity and causing less severe and widespread damage than those described above have affected the study area shores in the last few years. In September and October 1963, the study area beaches were exposed to northeasters that caused considerable erosion as in 1979 and 1981. Nearly every winter, in addition to seasonable winds and waves from the north-northeast, periods of intense storm wave activity occur, causing considerable erosion and damage. The Thanksgiving Day storm of 1984 destroyed the 254-foot-long seawall at Jensen Beach and receded the primary dune width by about 20 feet along the study area.

Summary. Much damage has been done periodically to the beaches in the study area by tropical and extratropical storms. Since only portions of the shore are highly developed and some development has been relatively recent, damage has not been readily apparent and at times was unrecorded. Much material has been lost in front of vertical seawalls and on several occasions beaches have been completely eroded. A small amount of material is occasionally returned during favorable weather. The study area is located within a close distance of highly developed beaches where period-of-record storms have frequently caused damages amounting to several million dollars. Considerable damage from such storms can generally be expected to have extended to the shores of the study area. The estimated amount of damages for the existing conditions and various beach fill design berm widths are indicated on table 24 through 28 of Appendix 5.

WATER ELEVATION FREQUENCY

23. The rise of the ocean surface above its normal high tide level during a storm is referred to as the storm surge elevation. The increased elevation is due to a variety of factors which include waves, wind shear strees, atmospheric pressure, and astronomical tides. An estimate of water-level change is essential for the design of the beach berm elevation since an increase in water depth will allow larger breakers to attack the shore.

It is possible to predict probable storm surge elevations for various storm probability periods utilizing data compiled by the University of Florida, NOAA, and others. Storm surge predictions are based on historical storm data and theoretical developments. Table C-2 shows storm surge elevations computed for various storm probability periods for Martin County. For the purpose of this report, the National Oceanic and Atmospheric Administration (NOAA) curve was used since its use would result in the most conservative estimate of bluffline recession (See Appendix 4).

Table C-2
Comparison of Storm Surge Frequencies and Elevations (MSL)

Return Period (once in)	U of F 1/ (Ft)	NOAA 2/ (Ft)	COE 3/ (Ft)	Composite Value (Ft)
10	4.7	3.6	-	4.15
20	6.4	4.2	-	5.3
50	9.1	5.3	-	6.35 4/
100	-	6.1	8.0	7.05
500	-	8.0	9.0	8.5

THE BEACH EROSION PROBLEM

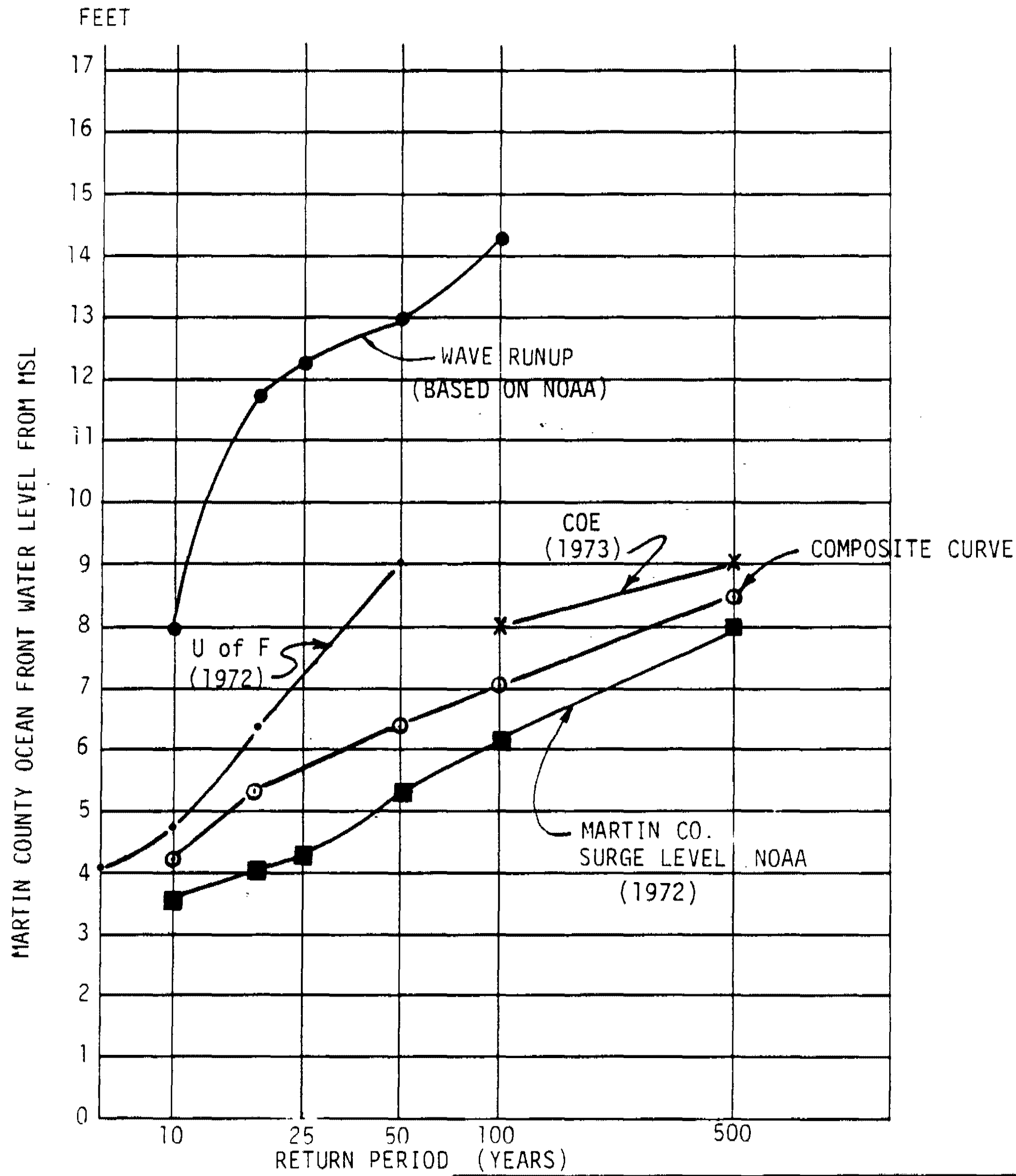
24. The long-term (1882-1976) erosion trend for the considered shorefront on Hutchinson Island indicates an average annual high water shoreline recession of about 2 feet per year from historical shoreline of 1882 on plate 3 of the main report. The recent short-term high water shoreline trend (1971-1976) is about 2.0 feet per year. The existing condition of the shorefront * in Hutchinson Island is one of reduced capacity for protection of upland

1/ Recommended Coastal Setback Line for Martin County, Florida Appendixes Range Monument Coordinate List, and Beach and Offshore Profiles, Coastal and Oceanographic Engineering Laboratory, College of Engineering, University of Florida, February 1972.

2/ Preliminary data (1972) as part of a NOAA study, for FIA.

3/ Flood Plain Information, Coastal Areas, Martin County, Florida Corps of Engineers, U.S. Army, Jacksonville, Florida, June 1973.

4/ From Fig C-2



BEACH EROSION CONTROL AND
SHORE PROTECTION STUDY
MARTIN COUNTY, FLORIDA

WATER LEVEL
FREQUENCY CURVE

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

FIGURE C-2

development and recreation needs due to long-term recession. In 1964 a 254-foot-long concrete sheet pile seawall was required at Jensen Public Beach Park to halt recession. Other more recent measures have included construction of rubble revetments for shore protection at Little Ocean Club and Suntide Condominiums.

25. The Martin County erosion problem, which has existed at Jupiter Island since 1945, has required that largest non-Federal local erosion control effort on the Florida east coast. Between 1945-1955, 8,000 feet of seawall were constructed on Jupiter Island. By 1970, 1,200 feet of this seawall was lost to erosion. In the ensuing years, 7,760 feet of sloping block revetment wwere construction in 1961 (1,700 feet lost in 1972); beach fills included 254,000 cubic yards in 1957, 366,000 cubic yards in 1961, 363,000 cubic yards between 1964-1968, 280,000 cubic yards between 1970-1972, and 2,527,300 cubic yards in 1973-1974. Later beach nourishment projects entailed placement of 488,100 cubic yards of beach fill in 1977 and 847,200 cibuc yards in 1978. Beach nourishment with 1,000,000 cubic yards of material was completed in 1983.

26. The beaches of Hutchinson Island are composed of fine sand and shell fragments, and in some locations, exposed coquina rock. The sand and shell are easily moved by wave action and littoral currents. The outcroppings of coquina found along the beach have a material effect on the shore proprocesses. In general, the effect is beneficial. The coquina outcroppings offshore form a semipermanent bar, which, together with the shifting sand bars, acts to retard the rate of erosion of the offshore area and to reduce the intensity of wave action on the shore. The slow disintegration of the coquina outcroppings along the shore has also furnished shell fragments to the beach.

27. The direction of littoral drift is reversed during the summer months when normally gentle southeasterly winds create waves which cause movement from south to north. The drift reversal is more than offset by the large and rapid movement of beach material from north to south during the fall and winter months when the more violent action of large waves from the northeast prevails. The behavior of the shore of Jupiter Island is influenced by two inlets, St. Lucie and Jupiter. The inlets are protected by jetties of varying length and effectiveness. The inlets constitute partial littoral barriers.

28. Many structures have been built along the shoreline of the area in an effort to stabilize the shore and no doubt those structures have diverted littoral drift to deeper waters and reduced the net southerly rate of drift. Wind transport of beach material to the backshore and possibly shell ground to powder or dissolved in sea water could account for some losses but these would only be a small fraction of the net residual loss. This provides evidence that material is being transported to the offshore zone where, for all practicable purposes, it is lost from the nearshore system of onshore-offshore transport.

HISTORICAL SHORELINE

29. The high water shoreline of Martin County surveyed in 1882 by the U.S. Coast and Geodetic Survey serves as the historical shoreline and provides a basis for developing the degree of Federal interest in cost-sharing for beach erosion control measures. The shorefront along the public beach parks at Jensen and Stuart have receeded about 175 and 200 feet, respectively, over the 1882-1976 time period. This long-term average trend is about 2 feet of recession per year (see plate 2 of the main text).

VOLUMETRIC CHANGES

Hutchinson Island

30. Based upon recent State of Florida, Department of Natural Resources (DNR) beach profiles, the average volumetric accretion and erosion calculated for Hutchinson Island shorefront in Martin County is presented in table C-3. This recent erosion trend is utilized in computing the erosion rate associated with this segment of the study area since it incorporates the affects of the recent trend in sea level rise and the erosion currently experienced due to ongoing losses from primary dune. Longer term erosion rates would not adequately represent the erosion trend anticipated along the study area based upon the current trend in sea level rise and the reduced capacity of the primary dune to provide material to the beach during periods of recession associated with storms.

Jupiter Island

31. Similarly, the volumetric changes for Jupiter Island and 1 mile south of Jupiter Inlet are shown in table C-4. Previous beach erosion control measures that have been implemented at Jupiter Island including beach fills along various segments of the shoreline affect the determination of the volumetric changes attributed to each reach. The segments of the study area to the south of St. Lucie Inlet to be addressed in the interest of beach erosion control have therefore been based upon ownership, existing erosion condition, and previous beach nourishment project construciton limits. As shown on plate C-1, these segments have been delineated by DNR profile line number locations as segments 1-S through 10-S. Table C-5 lists these segments and their current status and needs.

Shoreline Changes

32. Long-term shoreline changes along the county's ocean shore were determined by comparing historic surveys. Based on this data, it was determined that the long-term erosion rates for the beaches fronting Jensen Beach Public Park and Stuart Public Beach are 1.9 feet per year and 2.1 feet per year, respectively.

33. In addition, shoreline recession that would occur when the area is under the influence of storms with various frequencies of occurrence was calculated (see figure 3, appendix 4). Shoreline recession that would accompany storms with frequencies of occurrence of once every 5, 20, 59, and 100 years would be as shown on the following table. It is important to note that immediately after a storm, beach repair by bar migration begins and that this poststorm recovery of the beach is usually rapid.

BLUFFLINE RECESSION

Frequency (years)	Recession (feet)
5 15	20
20	50
59	90
100	108

TABLE C-3

Volumetric Accretion and Erosion
(Hutchinson Island)

DNR Beach Profile Lines	Distance (ft)	Volumetric Change [1/] (5/1978-5/1984) (cu yds)	Average Annual Change (cu yds/ft/yr)
3	2910	- 50,600	- 2.9
6	2780	-106,800	- 6.4
9	2760	- 39,700	- 2.4
12	2650	+ 9,500	+ .6
15	2680	- 38,600	- 2.4
18	2640	- 52,300	- 3.3
21	1790	+ 19,300	+1.8
22	1350	- 6,500	- .8
24	1560	- 52,400	- 5.6
TOTAL	21,120	-318,100[2/]	

1/ + indicates accretion, - indicates erosion.

2/ Average annual erosion is 318,100 cu. yds. ÷ 6 = 53,000 cu. yds.

TABLE C-4

Volumetric Accretion and Erosion
(Jupiter Island)

Profile Lines (Inclusive)	Segment Designation	Distance (ft)	Volumetric Change (cu yds/ft/yr) 1971-1976			Annual Erosion Rate (cu yds/ft/yr)
N. limit of development						
10S	2-S	3,000	-13.2			13.2
11S	2-S	1,700	- 8.5			8.5
12S	3-S	1,400	- 4.0			4.0
N. limit of previous beach nourishment projects						
13S	4-S	2,100	-16.0			16.0
14S	4-S	2,000	-14.0			14.0
15S	4-S	2,000	- 3.7			3.7
16S	4-S	2,100	- 7.6			7.6
17S	4-S	1,900	- 3.1			3.1
18S	4-S	2,000	- 1.3			1.3
19S	4-S	2,100	- 5.1		5.6 mi	5.1
20S	4-S	1,900	- 0.8	7.5 mi	Avg=6.5	0.8
21S	4-S	2,000	- 3.7	Avg=6.8		3.7
22S	4-S	2,300	- 9.3			9.3
23S	4-S	2,000	- 5.8			5.8
24S	4-S	3,000	- 3.1			3.1
25S	4-S	4,000	- 8.7			8.7
S. limit of previous beach nourishment projects						
26S	5-S	3,900	- 3.9			3.9
S. limit of development						
27S	6-S	3,900	-2.1			2.1
28S	6-S	5,000	-0.8		3.2 mi Avg=1.8	0.8
Martin Co./Palm Beach Co. Line						
29S	7-S	5,000	-2.4			2.4
30S	8-S	3,200	-1.8			1.8
Jupiter Inlet	9-S					
31S	10-S	2,700	- 0			0
32S	10-S	2,600	-9.9			9.9

1/ + Indicates accretion, - indicates erosion.

TABLE C-5

Current Status and Needs
Jupiter Island Shorefront

Segment	Ranging from Profile Line # to Profile Line #	Shorefront (Miles)	Current Status[1/]	Current Needs[2/]
1-S	R-44-1,150' to R-63 & 650'	(3.5)	S-PN	PFN
2-S	R-63+650' to R-76+500	(2.1)	S-NPN	DS
3-S	R-76+500 to R-82+500	(1.1)	P-NPN	ECMR
4-S	R-82+500 to R-111+500'	(4.9)	P-PN	ECMR
5-S	R112+500 to R-118+700	(1.0)	P-PN	ECMR
6-S	R-118+700 to R-126	(1.5)	P-NPN	NECMR
7-S	R-126+700 to R-127+5,700'	(1.1)	P-NPN	ECMR
8-S	R-127+5,700' to Jupiter Inlet	(0.7)	P-NPN	ECMR
9-S	North Side of Jupiter Inlet to south side of Jupiter Inlet	(0.1)		
10-S	Jupiter Inlet to 1 mile south	(1.0)	P&S-PN	PFN

[1/] Status
S-PN - indicates State owned, previously nourished
S-NPN - indicates State owned, not previously nourished
P-PN - indicates privately owned, previously nourished
P-NPN - indicates privately owned, not previously nourished

[2/] Needs
PFN - indicates provided for by nourishment from inlet maintenance
DSN - indicates downdrift shores, low degree of nourishment anticipated
ECMR - indicates erosion control measures required
NECMR - indicates no erosion control measures required

34. As indicated on plate C-1, four previous beach nourishment projects within this area have provided interim protection since 1967. The quantities indicated are averages and not necessarily the design beach fill cross section quantities placed. Larger volumes per foot of beach have been placed along the northern reaches of the construction limits in the interest of providing downdrift shores with a longer supply of material to supplement the net southerly drift. *

35. Table C-6 indicates average and maximum mean high water shoreline changes for the survey information available at the time of this study. Recession rates for the time interval of 1946 to 1964 provide a better indication of the true nature of the erosion problem along this portion of the study area since nourishment projects that took place after this time period affect the data by indicating net seaward advance of the shoreline. Therefore, the shoreline recession rates that occurred between 1946 and 1964 are considered to represent the erosion trend except for segments 6-S south. For the reach 6-S south, the more recent 1971-1976 recession rates indicate the order of magnitude of the recession rates experienced along this portion of the study area.

36. As indicated by data contained in Table C-2 for beach profiles along Jupiter Island, an average erosion rate of 6.5 cubic yards per year has occurred along 5.5 miles of shorefront within the previous beach nourishment project limits. Within the limits of development, an average erosion rate of 6.8 cubic yards per year has occurred along 7.5 miles of shorefront. The erosion rates for these areas are significant and indicate that future erosion control measures should address the need of reducing anticipated annual erosion losses. The shores along Jupiter Island to the south indicate an accretion trend in the recent past. This is attributed to the net southerly drift and previous beach nourishment projects that have added sand to the quantity of material ordinarily transported alongshore. The recent annual erosion rate along the 2.5 miles of shore south of developed property to Jupiter Inlet is 1.7 cubic yards whereas the 1946-1964 accretion rate is 8.9 cubic yards per year along the southern 2.5 miles of this reach.

EFFECT OF SEA LEVEL RISE

37. An important factor affecting the erosion situation along the shore of the State of Florida is the mean annual level of the ocean. Indications are that sea level along the Atlantic coast of the State has been rising at the rate of .006 feet per year.[1] This long-term effect can have serious detrimental effect in flat coastal regions. A rise in sea level along a typically concave beach profile causes the beach face to be readjusted by the wave to a flatter slope resulting in erosion above the waterline and some accretion offshore.

38. Per Brunn[1] proposed a formula for computing the rate of shoreline recession from the rate of sea level rise that takes into account local

[1] U.S. National Ocean Survey (1973), Trends and Variability of Yearly Sea Level (1893-1971), NOAA Technical Memorandum No. 12, Rockville, Md.

TABLE C-6

SHORELINE CHANGES

Segment Designation	Profile Line #	Average M.H.W. Shoreline Change (ft/yr) (1946-1964) 1/ Advance	(1946-1964) 1/ Recession	(1964-1968) 1/ Advance	(1964-1968) 1/ Recession	(1971-1976) 2/ Advance	(1971-1976) 2/ Recession	(1971-1976) M.H.W. Shoreline Recession Rate (ft/yr)
Hutchinson Island	DNR 2/ R-3						.7	
	R-4+174 (CE #6N)	2.2					1.0	
	R-6						3.0	
	R-9						2.0	
	R-12						.8	
	R-15						.6	
	R-18							
	R-21						2.9	
	R-22						.7	
	R-24+428 (CE #5N)		5.0					
	CE 4N	0						
	CE 3N	8.3						
	CE 2N	11.7						
	CE 1N	26.7						
Jupiter Island								
1-S	R44 to R63+650'		26		23		0 3/	0 3/
2-S	R63+650 to R76+500		15		6		0 3/	0 3/
3-S	R76+500 to R82+500		2		9	5		8
4-S	R82+500 to R111+500		3.4	4		10		0 4/
5-S	R111+500 to R118+700		2.0		1	1		
6-S	R118+700 to R126		1.1	9			4	
7-S	R126+700 to R127+5700		3.2	9			3	
8-S	R127+5700 to Jupiter Inlet		1			1	19	28
9-S	Jupiter Inlet							
10-S	Jupiter Inlet to 1 mile so.	4.2		4			7	14

[1] U.S. Army Corps of Engineers profile lines.

[2] Department of Natural Resources (DNR) profile lines.

[3] 1976 profiles not available for comparison.

[4] Accretion is indicated because of nourishment projects.

topography and bathymetry. His contention is that with a rise in sea level, the beach profile attempts to reestablish the same bottom depths relative to the surface of the sea that existed prior to the sea level rise. Assuming that the longshore littoral transport into and out of a given shoreline is equal, then the quantity of material required to reestablish the equilibrium bottom profile must be derived from erosion of the shore.

39. Considering a sea level rise of .006 feet per year, the erosion rate attributable to sea level rise along the shore of the study area would be computed in accordance with Dr. Brunn's equation as follows:

$$X\ (e + d) = (ab)$$

X = shoreline recession

e = elevation of shoreline

d = 30-foot depth

b = distance to 30-foot isobath

a = rate of sea level rise

EFFECT OF ST. LUCIE AND JUPITER INLETS

St. Lucie Inlet

40. St. Lucie Inlet is located in Martin County on the east coast of Florida near the town of Stuart, about midway between Cape Canaveral and Miami. St. Lucie Inlet is bordered on the north by the southern tip of Hutchinson Island and on the south by the narrow northern extension of Jupiter Island and a small number of mangrove islands. The northernmost 6.1 miles of Jupiter Island controlled is managed by the Federal government and the State of Florida. The State is planning to develop a State park along the 2.7-mile shorefront immediately south of the inlet while the remaining 3.4 miles is managed by the U.S. Fish and Wildlife Service as a wildlife refuge. The inlet and adjacent areas are shown on figure C-2 and on U.S. Department of Commerce, National Ocean Survey Charts No. 11474.

41. St. Lucie Inlet was created by an artificial cut into the barrier 30 feet wide and 5 feet deep by local interests in 1892. By 1898 the inlet widened to 1,700 feet and by 1922 to 2,600 feet. Between 1926 and 1929 the St. Lucie Inlet District and Port Authority constructed a stone jetty 3,325 feet long on the north side of the inlet.

42. Before construction of the north jetty, St. Lucie Inlet was typical of all unprotected inlets across a sandy beach with an alongshore movement of drift material. The inlet acted as a barrier in itself by trapping littoral-drift material in a middle-ground shoal and in a bar across the mouth of the

inlet. Littoral drift across the inlet was irregular. The current estimate of littoral drift is 230,000 cubic yards to the south annually. The inlet and adjacent shores both to the north and south were unstable. Historic surveys show that between 1882 and 1928 the shoreline for about 1.5 miles north of the inlet receded considerably.

43. When the north jetty was constructed at St. Lucie Inlet, the north side of the inlet was stabilized and accretion on the north side of the jetty took place, moving the shoreline back seaward to a position in 1946 that approximately conincides with the 1882 position. However, the jetty effected the inlet as a littoral barrier and the shore to the south continued to recede. Shoreline recession south of the inlet has continued since 1882. Between 1882 and 1946 the shoreline receded a maximum of about 2,500 feet at the inlet with a gradual decrease southward. Between 1946 and 1964 shoreline recession south of the inlet continued, with the most severe being immediately south of the inlet along the ocean frontage of St. Lucie Inlet State Park and Reed Wilderness National Wildlife Sanctuary. The mean high water shoreline at the north jetty advanced an average of 10 feet per year between 1946 and 1964, while the 4-mile reach south of the inlet receded an average of 27 feet annually. A comparison of the 1964 and 1976 beach profiles again indicates that the shoreline south of the inlet continues to recede at an average annual rate of 27 feet. This reach includes the shore area of the St. Luce Inlet State Park and part of the Reed Wilderness National Wildlife Sanctuary. Plate 2 shows the shoreline changes in the immediate vicinity of the inlet for the periods 1882-1976.

44. Maintenance dredging records from January 1965 to September 1979 indicate that a total quantity of 914,431 cubic yards have been dredged from St. Lucie Inlet. The average annual quantity removed is about 61,000 cubic yards. A listing of previous maintenance dredging at St. Lucie Inlet is shown in table C-7.

Jupiter Inlet

45. Jupiter Inlet is in northern Palm Beach County on the southeast coast of Florida. It is about 16 miles south of St. Lucie Inlet and 14 miles north of Lake Worth Inlet near West Palm Beach. The inlet is a natural waterway connecting the Atlantic Ocean with Loxahatchee River. According to historical accounts, Jupiter Inlet, when open, has been used for navigation for about 300 years. Severe storms often close the inlet. Between 1896 and 1909, under special emergency authority, the Federal government reopened Jupiter Inlet three times. Local interests also reopened the inlet several times between 1896 and 1922. The Jupiter Inlet District, created in 1921 by special act of the Florida Legislature, spent in excess of $400,000 improving and maintaining the inlet between 1922 and 1960. In 1922 the Inlet District built parallel jetties about 350 feet apart. Subsequently, the jetties were extended and strengthened. In 1940 the Inlet District built an angular groin at the seaward end of the south jetty. The intended purpose was to increase current velocities and induce scouring between the jetties where closure of the inlet had recurred. However, the inlet again closed in

TABLE C-7

Dredging Volumes - St. Lucie Inlet

Period	Nature of Work	Total Quantity Removed C.Y.	Disposal Area[1]
1 Jan-29 Jan 65	Section 3	8,300	
3 Dec-20 Dec 66	Maintenance	37,960	SC
24 Mar-16 Apr 67	Maintenance	26,750	SC
1 Mar-8 Mar 68	Maintenance	100,102	B
18 Nov-8 Dec 68	Maintenance	42,420	B
1 Dec-8 Dec 68	Maintenance	8,773	SC
5 Nov-29 Nov 69	Maintenance	18,456	SC
10 Nov-12 Dec 71	Maintenance	18,829	SC
5 Nov-12 Dec 72	Maintenance	30,864	SC
2 Sep-6 Oct 73	Maintenance	53,298	SC
25 Sep-16 Oct 74	Maintenance	26,940	SC
1 Sep-21 Sep 74	Maintenance	77,369	B
16 Jul-16 Aug 75	Maintenance	40,201	SC
20 Jun-10 Jul 76	Maintenance	36,684	SC
31 Oct-20 Nov 76	Maintenance	41,118	SC
27 May-15 Jun 77	Maintenance	55,414	SC
24 Mar-31 Mar 78	Maintenance	178,437	B
5 Nov-5 Dec 78	Maintenance	55,270	SC
19 Aug-23 Sep 79	Maintenance	57,246	SC

[1]B = Beach disposal
SC - Sidecast along the south side of the channel.

1942 and remained closed until 1947. Since 1947 biannual maintenance dredging, by the Inlet District, has kept the inlet open for small craft navigation. Palm Beach County contributes funds to the Inlet District periodically for fill placed on the south beach.

46. The shoreline, for a distance of about 2,000 feet, north of Jupiter Inlet receded about 40 feet over the time period of 1882-1930. The shoreline then accreted to the 1882 shoreline by 1946 due to the jetty construction in 1922. By 1964 the shore north of the north jetty accreted to about 100 feet seaward of the 1882 shoreline. The present location of the new shoreline indicated by 1978 beach profiles, is that of recession to the 1882 shoreline for a distance of 2,000 feet north of the north jetty.

47. When Jupiter Inlet was stabilized in relation to its north-south position by jetty constrution in 1922, the entrance had been shifted about 1,500 feet north of the 1882 location. Approximately 200 feet of recession occurred along a 1,500-foot reach south of the inlet between 1882 and 1930. By 1946, this reach had accreted approximately 200 feet seaward of the 1930 position. The high water shoreline of 1964 had acreted an additional 30 feet seaward from the 1946 location. Surveys conducted in 1978 for this 1,500-foot reach indicate a current recession of about 100 feet from the 1964 position.

THE NEED FOR BEACH

48. Martin County is experiencing a sustained growth rate and development trend because of a favorable location and subtropical climate. Corresponding with progressive development, the recreational need for sufficient beach area is increasing. Long-term storm damage to the area beaches has resulted in reduced beach widths, thereby diminishing the shoreline's natural protection and leaving the backshore and primary dune susceptible to further damages.

49. Within Martin County, 70 percent of the publicly owned shorefront is provided by the two county beach parks at Stuart and Jensen Beach. These county parks provide 72 percent of the available recreational shorefront (excluding the beaches where recreation is limited by rock outcroppings) in public ownership on Hutchinson Island. On the north shoreline of Jupiter Island, the St. Lucie Inlet State Park provides 39 percent of all publicly owned shorefront in Martin County and Reed Wilderness National Wildlife Sanctuary provides 47 percent of all publicly owned shorefront in Martin County. These areas on Jupiter Island are currently undeveloped and have limited access. They constitute 98 percent of the publicly owned shorefront at Jupiter Island. Thus, the following discussion of beach needs within the county is restricted to the two public beach parks at Hutchinson Island.

50. Jensen Beach Public Park fronts 1,450 feet of the Atlantic shoreline in north Martin County. The beach thus is subjected to not only a large average annual erosion rate, but sustains periodic storm damage as well. The mean

high water shoreline receeds about 2.0 feet on an average each year and the dune receeds about 1.5 feet per year. Local interests constructed about 250 feet of concrete sheet pile seawall to halt this erosion trend. The reduced capacity of the existing beach to protect upland development eventually resulted in loss of the seawall in 1984.

51. Stuart Beach Public Park fronts 1,150 feet of the Atlantic shoreline in northern Martin County. The existing beach width, reduced by erosion, has left backshore susceptible to significant losses from storm damage. The dune exhibits a recession trend of about 1.4 feet per year. The mean high water shoreline has shown advance during the 1971-1976 time period due to sand lost from the face of the dune and the use of earth-moving equipment to adjust the beach profile for the benefit of visitors. Based on beach profiles to the north and south, the current recession trend for this area is about 2.0 feet per year.

52. Continuation of the present erosion trends at both Jensen and Stuart Beach Public Parks, without remedial measures, will eventually result in loss of the existing dune and subsequent loss of valuable development and recreational area. The current trend, if left unattended, will result in degredation of the shorefront and insufficient beach area to meet the anticipated recreational needs of the study area.

STATUS OF PLANS AND IMPROVEMENTS

53. Local interests have attempted to protect the shoreline from erosion and storm damages. They have built bulkheads, revetments, and attempted to restore the eroded shoreline by scraping sand material from the beach using a bulldozer. The beach along some reaches of Stuart Beach have at times been in such a deteriorated condition that beach use became dangerous due to obstacles such as emergent coquina blocks lying on the beach. There is no record of any major joint project undertaken to protect the public beach parks on Hutchinson Island.

54. Considerable public expenditures have been made to develop and upgrade the public shorefront parks as shown in the above picture of Jensen Beach Public Park shorefront and the following picture of Stuart Public Beach Park, which were taken in 22 January 1984. The 250-foot-long seawall shown in the background of the above photograph of Jensen Beach was destroyed by the Thanksgiving Day storm in 1984.

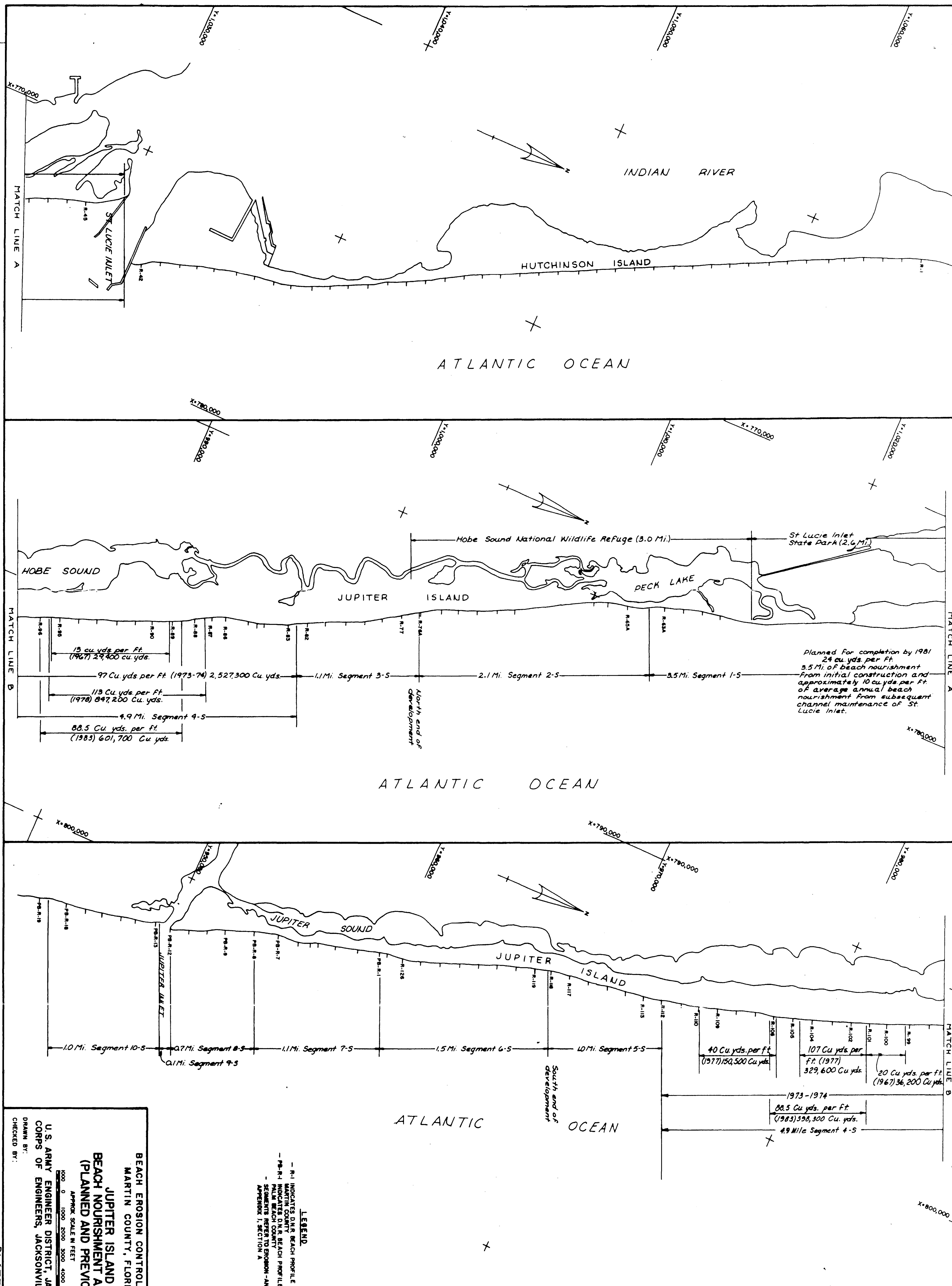

INDIAN RIVER
ST LUCIE INLET
HUTCHINSON ISLAND
MATCH LINE A
ATLANTIC OCEAN
Hobe Sound National Wildlife Refuge (3.0 Mi.)
St Lucie Inlet State Park (2.6 Mi.)
HOBE SOUND
JUPITER ISLAND
PECK LAKE
MATCH LINE B
13 cu. yds. per ft. (1967) 29,400 cu. yds.
97 Cu. yds per Ft. (1973-74) 2,527,300 Cu. yds.
1.1 Mi. Segment 3-S
2.1 Mi. Segment 2-S
3.5 Mi. Segment 1-S
113 Cu. yds. per ft. (1978) 847,200 Cu. yds.
4.9 Mi. Segment 4-S
88.5 Cu. yds. per ft. (1983) 601,700 Cu. yds.
North end of development
Planned for completion by 1981 24 cu. yds. per ft. 3.5 Mi. of beach nourishment from initial construction and approximately 10 cu. yds. per ft. of average annual beach nourishment from subsequent channel maintenance of St. Lucie Inlet.
JUPITER SOUND
JUPITER INLET
1.0 Mi. Segment 10-S
0.7 Mi. Segment 8-S
0.1 Mi. Segment 9-S
1.1 Mi. Segment 7-S
1.5 Mi. Segment 6-S
1.0 Mi. Segment 5-S
South end of development
40 Cu. yds. per ft. (1977) 150,500 Cu. yds.
107 Cu. yds. per ft. (1977) 329,600 Cu. yds.
20 Cu. yds. per ft. (1967) 36,200 Cu. yds.
1973-1974
88.5 Cu. yds. per ft. (1983) 398,300 Cu. yds.
4.9 Mile Segment 4-S
LEGEND
- R-1 INDICATES D.N.R. BEACH PROFILE LINES FOR MARTIN COUNTY
- PB-R-1 INDICATES D.N.R. BEACH PROFILE LINES FOR PALM BEACH COUNTY
- SEGMENTS REFER TO EROSION-ANALYSIS IN APPENDIX I, SECTION A
BEACH EROSION CONTROL STUDY
MARTIN COUNTY, FLORIDA
JUPITER ISLAND
BEACH NOURISHMENT AREAS
(PLANNED AND PREVIOUS)
1000 0 1000 2000 3000 4000 5000
APPROX. SCALE IN FEET
U.S. ARMY ENGINEER DISTRICT, JACKSONVILLE
CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA
DRAWN BY:
CHECKED BY:
D.O. FILE NO.
24-33,359

PLATE C-1

APPENDIX 2

FORMULATION ASSESSMENT AND EVALUATION

APPENDIX 2

FORMULATION ASSESSMENT AND EVALUATION

TABLE OF CONTENTS

LIST OF TABLES

APPENDIX 2

FORMULATION, ASSESSMENT
AND
EVALUATION

1. The formulation of alternatives for providing shore protection for Martin County is mostly presented in the main text of the report. Accordingly, the information presented in this appendix only augments the discussion of the formulation and evaluation processes in the main report.

EFFECT ASSESSMENT

2. An effect assessment carried out in terms of the considered plan's contribution to the four accounts of NED, EQ, RD, and OSE was made. Also, a system of accounts displaying the results of the assessment of the alternatives considered in detail was prepared and is shown in tables 1a through 1c. Additionally, the 17 areas of concern specifically mentioned in Section 122 of Public Law 91-611 as being of critical concern are numerated on these tables.

Table 1a. - System of Accounts

NO-ACTION ALTERNATIVE

ACCOUNTS	LOCATION OF IMPACTS			
	Project Area	Adjacent Counties	Southeastern U. S.	Rest of Nation
1. National Economic Development	(Not displayed. A no-action alternative would require no direct commitment of national resources and would forego any benefits attributable to other projects considered. Therefore, no reasonable display can be made.)			
2. Environmental Quality				
a. EQ Degraded				
*Natural Resources	Erosion will continue with resultant loss of beaches (2,5)	None	Minimal	Negligible
*Manmade Resources	As beach erodes, shore structures become more vulnerable to flood and wave damage (2,5)	None	Minimal	Negligible
	Increase in unsightly scars caused by excessive erosion (2,5)	None	Minimal	Negligible
3. Social Well-Being				
a. Beneficial Impacts				
*Tax Changes	Decline in tax base as property values decrease (2,5)	None	Minimal	Negligible
b. Adverse Impacts				
*Community Cohesion	Patterns of social and economic cohesion will be altered by continued erosion (2,5)	None	Minimal	Negligible
*Public Facilities	Continued erosion eventually affects available facilities (2,5)	None	Minimal	Negligible

Index of footnotes:

Timing

1. Impact is expected to occur prior to or during implementation of the plan.
2. Impact is expected within 15 years following plan implementation.
3. Impact is expected in a longer time frame (15 or more years following implementation).

Uncertainty

4. The uncertainty associated with the impact is 50% or more.
5. The uncertainty is between 10% and 50%.
6. The uncertainty is less than 10%.

Exclusivity

7. Overlapping entry; fully monetized in NED account.
8. Overlapping entry; not fully monetized in NED account.

Actuality

9. Impact will occur with implementation.
10. Impact will occur only when specific additional actions are carried out during implementation.
11. Impact will not occur because necessary additional actions are lacking.

Section 122

*. Items specifically required in Section 122 and ER 1105-2-240.

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Table 1a. - System of Accounts (continued)

NO-ACTION ALTERNATIVE

ACCOUNTS	LOCATION OF IMPACTS			
	Project Area	Adjacent Counties	Southeastern U. S.	Rest of Nation
Security of Life, Health and Safety	Continued erosion will increase threat to health and safety from flood and wave damage (2,5)	None	Minimal	Negligible
*Property Values	Decrease as erosion continues (2,5)	None	Minimal	Negligible
*Displacement of People	Some will be forced to move as erosion continues (2,5)	None	Minimal	Negligible
*Community Growth	Loss of beach will retard growth trends (2,5)	None	Minimal	Negligible
4. Regional Development				
a. Beneficial Impact	None	None	None	None
b. Adverse Impacts				
*Business Activity	Continued erosion could force some establishments to move (2,5)	None	Minimal	Negligible
*Regional Growth		Loss of beach opportunity will affect growth trends (2,5)	Minimal	Negligible

Index of footnotes:

Timing

1. Impact is expected to occur prior to or during implementation of the plan.
2. Impact is expected within 15 years following plan implementation.
3. Impact is expected in a longer time frame (15 or more years following implementation).

Uncertainty

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5. The uncertainty is between 10% and 50%.
6. The uncertainty is less than 10%.

Exclusivity

7. Overlapping entry; fully monetized in NED account.
8. Overlapping entry; not fully monetized in NED account.

Actuality

9. Impact will occur with implementation.
10. Impact will occur only when specific additional actions are carried out during implementation.
11. Impact will not occur because necessary additional actions are lacking.

Section 122

*. Items specifically required in Section 122 and ER 1105-2-240.

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Table 1b. - System of Accounts

BEACH FILL WITH PERIODIC NOURISHMENT
(4.0 miles at Hutchinson Island)
(Values x 1,000)

ACCOUNTS	LOCATION OF IMPACTS			
	Project Area	Adjacent Counties	Southeastern U. S.	Rest of Nation
1. National Economic Development	Figures are average annual equivalent values in $1,000.			
a. Beneficial Impacts	Beneficial impacts are distributed between the 4 areas in an undetermined ratio.			
Recreation	$1,144.2			
Loss of Land	$208.6			
Prevention of: damages to development	$858.4			
Damages to Erosion Control Structures	$13.8			
TOTAL	Total = $2,225.0			
b. Adverse Impacts				
Project Cost	$1,340.3 (1,6,7,9)			
c. Net NED Benefits	Net benefits equal $884.7			
2. Environmental Quality				
a. EQ Enhanced *Natural Resources	Create additional recreational beaches and storm protection (1,6,7,9)	Create additional recreational beaches and storm protection	Create additional recreational beaches and storm protection	Negligible
*Manmade Resources	Help protect structures from flooding and wave run-up damage (1,5,7,9)	Negligible	None	None
*Esthetic Values	Beautify beaches by reducing erosion (1,5,8,9)	Not quantifiable	Minimal	Negligible

Index of footnotes:

Timing

1. Impact is expected to occur prior to or during implementation of the plan.
2. Impact is expected within 15 years following plan implementation.
3. Impact is expected in a longer time frame (15 or more years following implementation).

Uncertainty

4. The uncertainty associated with the impact is 50% or more.
5. The uncertainty is between 10% and 50%.
6. The uncertainty is less than 10%.

Exclusivity

7. Overlapping entry; fully monetized in NED account.
8. Overlapping entry; not fully monetized in NED account.

Actuality

9. Impact will occur with implementation.
10. Impact will occur only when specific additional actions are carried out during implementation.
11. Impact will not occur because necessary additional actions are lacking.

Section 122

*. Items specifically required in Section 122 and ER 1105-2-240.

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Table 1b. - System of Accounts (continued)

BEACH FILL WITH PERIODIC NOURISHMENT
4.0 miles at Hutchinson Island

ACCOUNTS	LOCATION OF IMPACTS			
	Project Area	Adjacent Counties	Southeastern U. S.	Rest of Nation
b. EQ Degraded				
*Air Quality	Some decrease as number of visitors increase (3,5)	Minimal	Negligible	Negligible
*Water Quality	Temporary turbidity during construction and maintenance (1,6,9)	None	None	None
*Natural Resources	Temporary disruption of beach during construction and maintenance (1,6,9)	None	None	None
*Noise Level Changes	Temporary increase during construction (1,6,9) Increase as crowds and traffic increase (2,5)	None	None	None
*Biological Resources	Loss of benthic invertebrates on beach and in offshore borrow area and disruption of fishing during construction (1,6,9)	None	Negligible	Negligible
*Esthetic Values	Disruption of scenic value of beaches during construction and maintenance (1,6,9)	None	None	None
c. EQ Destroyed				
*Irreversible Effects	Loss of fuel used in project (1,6,9)	None	Impacts national energy program	Impacts national energy program

Index of footnotes:

Timing

1. Impact is expected to occur prior to or during implementation of the plan.
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Uncertainty

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5. The uncertainty is between 10% and 50%.
6. The uncertainty is less than 10%.

Exclusivity

7. Overlapping entry; fully monetized in NED account.
8. Overlapping entry; not fully monetized in NED account.

Actuality

9. Impact will occur with implementation.
10. Impact will occur only when specific additional actions are carried out during implementation.
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Section 122

*. Items specifically required in Section 122 and ER 1105-2-240.

SAJ FORM 975

Table 1b. - System of Accounts (continued)

BEACH FILL WITH PERIODIC NOURISHMENT
(4.0 miles at Hutchinson Island)

ACCOUNTS	LOCATION OF IMPACTS			
	Project Area	Adjacent Counties	Southeastern U. S.	Rest of Nation
*Biological Resources	Destruction of benthic biota in construction area and offshore borrow area (1,6,9)	None	Negligible	Negligible
3. Social Well-Being				
a. Beneficial Impacts				
*Community Cohesion	Increase leisure opportunity (1,5,8,9)	Not quantifiable	Minimal	Negligible
Security of Life, Health, and Safety	Reduce threat to health and safety from storms (1,5,9)	None	Minimal	Negligible
*Public Facilities	Local interests provide parking facilities, comfort stations, and beach access (1,5,8,9)	None	Minimal	Negligible
*Community Growth	Growth trends would be enhanced (2,5)	Marginal growth impact	Minimal	Negligible
b. Adverse Impacts				
*Community Cohesion	Crowding as demand on beach increases (2,5)	None	None	None
*Displacement People	Commercial demand on property could cause residents to move away from beach (2,4)	None	None	None
*Public Services	Increase need for water supply, sewer service, and other utilities as area develops (2,5)	None	None	None

Index of footnotes:

Timing

1. Impact is expected to occur prior to or during implementation of the plan.
2. Impact is expected within 15 years following plan implementation.
3. Impact is expected in a longer time frame (15 or more years following implementation).

Uncertainty

4. The uncertainty associated with the impact is 50% or more.
5. The uncertainty is between 10% and 50%.
6. The uncertainty is less than 10%.

Exclusivity

7. Overlapping entry; fully monetized in NED account.
8. Overlapping entry; not fully monetized in NED account.

Actuality

9. Impact will occur with implementation.
10. Impact will occur only when specific additional actions are carried out during implementation.
11. Impact will not occur because necessary additional actions are lacking.

Section 122

*. Items specifically required in Section 122 and ER 1105-2-240.

SAJ FORM 975
23 May 77

Table 1b. - System of Accounts (continued)

BEACH FILL WITH PERIODIC NOURISHMENT
(4.0 miles at Hutchinson Island)

ACCOUNTS	LOCATION OF IMPACTS: Project Area	Adjacent Counties	Southeastern U. S.	Rest of Nation
*Tax Changes	Expenditure for project construction and maintenance	None	None	None
	Increase expenditures for public facilities and services as area develops (2,5)			
	Increase in tax base as area develops (2,5)	Increase in tax base as area develops (2,5)	Minimal	Negligible
4. Regional Development				
a. Beneficial Impacts				
*Employment	Some local opportunity during construction and maintenance (1,5,9)	Minimal	Spinoff labor benefits	Spinoff labor benefits
	Job opportunity increases as area develops (2,5)	Minimal	Minimal	Minimal
*Business Activity	Additional business to cater to increased beach use visitors (2,5)	Enhance business along highways leading to beaches (2,5)	None	Minimal
*Regional Growth		Growth trends enhanced as project area develops (2,5)	None	Minimal

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Section 122

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SAJ FORM 975
23 May 77

Table 1c. - System of Accounts

BEACH FILL WITH PERIODIC NOURISHMENT
(5.6 miles at Jupiter Island)
(values x 1,000)

ACCOUNTS	LOCATION OF IMPACTS			
	Project Area	Adjacent Counties	Southeastern U. S.	Rest of Nation
1. National Economic Development	Figures are average annual equivalent values in $1,000.			
a. Beneficial Impacts	Beneficial impacts are distributed between the 4 areas in an undetermined ratio.			
Recreation	$103.4			
Loss of Land	$798.3			
Prevention of: damages to development	$84.2			
Damages to Erosion Control Structures	$92.5			
TOTAL	$1,078.4			
b. Adverse Impacts	Adverse impacts are distributed between the 4 areas in an undetermined ratio.			
Project Cost	$18,688.0 (First Cost) $3,349.4 (Annual Cost)			
c. Net NED Benefits	NONE			
2. Environmental Quality				
a. EQ Enhanced				
*Natural Resources	Create additional recreational beaches and storm protection (1,6,7,9)	Create additional recreational beaches and storm protection	Create additional recreational beaches and storm protection	Negligible
*Manmade Resources	Help protect structures from flooding and wave run-up damage (1,5,7,9)	Negligible	None	None
*Esthetic Values	Beautify beaches by reducing erosion (1,5,8,9)	Not quantifiable	Minimal	Negligible
b. EQ Degraded				
*Air Quality	Some decrease as number of visitors increase (3,5)	Minimal	Negligible	Negligible

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SAJ FORM 975
23 May 77

Table 1c. - System of Accounts (Continued)

BEACH FILL WITH PERIODIC NOURISHMENT
(5.6 miles at Jupiter Island)

ACCOUNTS	LOCATION OF IMPACTS			
	Project Area	Adjacent Counties	Southeastern U. S.	Rest of Nation
*Water Quality	Temporary turbidity during construction and maintenance (1,6,9)	None	None	None
*Natural Resources	Temporary disruption of beach during construction and maintenance (1,6,9)	None	None	None
*Noise Level Changes	Temporary increase during construction (1,6,9) Increase as crowds and traffic increase (2,5)	None	None	None
*Biological Resources	Loss of benthic invertebrates on beach and in offshore borrow area and disruption of fishing during construction (1,6,9)	None	Negligible	Negligible
*Esthetic Values	Disruption of scenic value of beaches during construction and maintenance (1,6,9)	None	None	None
c. EQ Destroyed				
*Irreversible Effects	Loss of fuel used in project (1,6,9)	None	Impacts national energy program	Impacts national energy program
*Biological Resources	Destruction of benthic biota in construction area and offshore borrow area (1,6,9)	None	Negligible	Negligible
3. Social Well-Being				

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23 May 77

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BEACH FILL WITH PERIODIC NOURISHMENT
(5.6 miles at Jupiter Island)

ACCOUNTS	LOCATION OF IMPACTS			
	Project Area	Adjacent Counties	Southeastern U. S.	Rest of Nation
a. Beneficial Impacts				
*Community Cohesion	Increase leisure opportunity (1,5,8,9)	Not quantifiable	Minimal	Negligible
Security of Life, Health, and Safety	Reduce threat to health and safety from storms (1,5,9)	None	Minimal	Negligible
*Public Facilities	Local interests provide parking facilities, comfort stations, and beach access (1,5,8,9)	None	Minimal	Negligible
*Community Growth	Growth trends would be enhanced (2,5)	Marginal growth impact	Minimal	Negligible
b. Adverse Impacts				
*Community Cohesion	Crowding as demand on beach increases (2,5)	None	None	None
*Displacement People	Commercial demand on property could cause residents to move away from beach (2,4)	None	None	None
*Public Services	Increase need for water supply, sewer service, and other utilities as area develops (2,5)	None	None	None
*Tax Changes	Expenditure for project construction and maintenance	None	None	None
	Increase expenditures for public facilities and services as area develops (2,5)			

SAJ FORM 975
23 May 77

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Table 1c. - System of Accounts (Continued)

BEACH FILL WITH PERIODIC NOURISHMENT
(5.6 miles at Jupiter Island)

ACCOUNTS	LOCATION OF IMPACTS			
	Project Area	Adjacent Counties	Southeastern U. S.	Rest of Nation
	Increase in tax base as area develops (2,5)	Increase in tax base as area develops (2,5)	Minimal	Negligible
4. Regional Development				
a. Beneficial Impacts				
*Employment	Some local opportunity during construction and maintenance (1,5,9)	Minimal	Spinoff labor benefits	Spinoff labor benefits
	Job opportunity increases as area develops (2,5)	Minimal	Minimal	Minimal
*Business Activity	Additional business to cater to increased beach use visitors (2,5)	Enhance business along highways leading to beaches (2,5)	None	Minimal
*Regional Growth		Growth trends enhanced as project area develops (2,5)	None	Minimal

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SAJ FORM 975
23 May 77

APPENDIX 3

PUBLIC VIEWS AND RESPONSES

APPENDIX 3

PUBLIC VIEWS AND RESPONSES

TABLE OF CONTENTS

SECTION 1

CORRESPONDENCE FROM LOCAL SPONSOR

FRANK A. WACHA
District 1

Chairman
TOM HIGGINS
District 2

Vice-Chairman
THOMAS G. KENNY, III
District 3

MAGGY HURCHALLA
District 4

JOHN W. HOLT, JR.
District 5

BOARD OF COUNTY COMMISSIONERS
50 Kindred Street • Stuart, Florida 33497

ROBERT H. OLDLAND • County Administrator

PHONE (305) 283-6760

COUNTY OF MARTIN STATE OF FLORIDA

CO-85-TJH-2
October 2, 1985

Colonel Charles T. Myers,III
District Engineer
U.S. Army Corps of Engineers
400 W. Bay Street
Jacksonville, FL 32232-0019

Dear Colonel Myers;

This is in reference to the draft feasibility report and environmental impact statement for beach erosion control in Martin County, Florida as provided for review by letter dated July 17, 1985 and as presented by the Corps of Engineers to the Martin County Commission at Public Meeting on August 27, 1985.

At this meeting the Commission authorized this letter of intent to comply with the items of local cooperation listed in the referenced report and presentation, following a presentation by our Staff on the report recommendations.

It is understood that the items of local cooperation will be specifically set forth with mutual accord in an agreement to be executed at a future date by the U.S. Army Corps of Engineers and Martin County. Such agreement shall be made contingent upon Congressional authorization and subject to the availability of funds for Martin County.

Sincerely,

Thomas J. Higgins
Chairman

TJH:RHO/kl

cc: A.J.Salem, Chief, Planning Division, Corps of Engineers
Board of County Commissioners
County Administrator
County Attorney
Public Works Director

FRANK A. WACHA
District 1

Chairman
TOM HIGGINS
District 2

Vice-Chairman
THOMAS G. KENNY, III
District 3

MAGGY HURCHALLA
District 4

JOHN W. HOLT, JR.
District 5

BOARD OF COUNTY COMMISSIONERS
50 Kindred Street • Stuart, Florida 33497

ROBERT H. OLDLAND • County Administrator

PHONE (305) 283-6760

COUNTY OF MARTIN STATE OF FLORIDA

September 13, 1985

CO-85-TJH-582

Department of the Army
Jacksonville District, Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

ATTENTION: A.J. Salem
Charlie Stevens

Gentlemen:

We wish to take this opportunity to thank you gentlemen for the presentation on August 27, 1985 concerning the Beach Erosion Control proposed project here in Martin County.

We in Martin County of course, as in all of Florida, are worried about being able to maintain our beaches. The Commission has authorized me by motion to indicate their desire to continue this study. We understand that this continuation does not commit the Board of County Commissioners to the expenditure of any funds until such time as the Corps has reached a final decision and has requested permission from Congress for their portion of the funds. We therefore reserve the right to reject this project, if at some date in the future, the funds are not available for our local contribution.

Respectfully submitted,

Thomas J. Higgins

Thomas J. Higgins, Chairman
Martin County Board of County Commissioners

TJH/JBW/tld

cc: Robert H. Oldland, County Administrator
James B. Winn, P.E., Public Works Director
Board of County Commissioners

BOARD OF COUNTY COMMISSIONERS
P. O. Box 626 • Stuart, Florida 33495

COUNTY OF MARTIN — STATE OF FLORIDA

May 29, 1985

Corps of Engineers, U.S. Army
Jacksonville District
400 West Bay Street
P.O. Box 4970
Jacksonville, Florida 32232

Attention: SAJPD-C

Per our conversation on May 24, 1985, and your request for an updated Hutchinson Island public parking inventory, the following is an accurate total of existing and proposed spaces. The inventory includes only those spaces that are, or will be, designated, paved stalls. Obvious overflow grass parking will occur at some sites that cannot be quantified at this time.

		Existing	Proposed
1.	Access strip #1	33	0
2.	North Jensen Beach	0	250
3.	Jensen Beach	240	0
4.	Bob Graham Beach	32	148
5.	Alex's Beach	23	22
6.	Virginia Forrest Strip	22	0
7.	Stuart Beach	145	205
8.	Tiger Shores strip	30	0
9.	Fletcher strip	8	0
10.	Chastain strip	30	0
11.	House of Refuge	32	0
12.	Bathtub Reef Park	88	57
	Total for Hutchinson Island	538	477

Additional public beach parking, on Jupiter Island, includes 88 spaces at Hobe Sound Wildlife Refuge, 95 spaces at Hobe Sound Beach and 18 spaces at Blowing Rocks Beach.

We in Martin County will make every effort to cooperate with the Corps of Engineers and other agencies to develop a workable solution on adequate parking to satisfy the project requirements. We are committed to improvements that will increase public useage of our shorefront so that the beach fill proposal will without a doubt meet the cost-benefit criteria being reviewed.

With the current eroded state of our beaches and dunes, we look forward with great anticipation to the progress of the Corps plan toward mitigating and managing coastal erosion through sand nourishment and continued maintenance.

If you have any questions or comments, please contact this office.

Sincerely,

Greg Boggs

Greg Boggs
County Landscape Architect

GB:cw

cc: Robert H. Oldland
County Administrator

SECTION 2

CORRESPONDENCE FROM STATE AGENCIES
AND THE
TREASURE COAST REGIONAL PLANNING COUNCIL

STATE OF FLORIDA

Office of the Governor

THE CAPITOL
TALLAHASSEE 32301

BOB GRAHAM
GOVERNOR

October 15, 1985

Mr. A. J. Salem
Chief, Planning Division
Department of the Army
Jacksonville District
Post Office Box 4970
Jacksonville, Florida 32232

Dear Mr. Salem:

With reference to our October 11, 1985 letter responding to your Draft Feasibility Report with Environmental Impact Statement for a Martin County Beach Erosion Control project, we are forwarding for your additional consideration comments submitted by the Department of Community Affairs. This Department was the state's lead agency that guided the preparation of the Hutchinson Island Management Plan. The Plan was adopted in October 1983 by a Governor appointed Resource Management Committee.

The Department of Community Affairs finds that beach renourishment activities do not conflict with the Plan, however, the importance and protection of worm reefs is recognized. Any extensive change to the reefs would violate the Management Plan. Another resource that could be affected by the proposed beach project are sea turtles. To assure consistency with the Management Plan requires that beach renourishment activities be confined to a period when turtles or turtle nesting would not be endangered.

We appreciate you extending your comment period and accepting these additional comments from the Department of Community Affairs. Thank you for your cooperation.

Sincerely,

Walt

Walter O. Kolb
Sr. Governmental Analyst

WOK/nk

cc: Attachments on following page

cc: Pam Davis
Dr. Elton J. Gissendanner
Randy Armstrong
Dennis Harmon
Brad Hartman
Jim Murley
George W. Percy
Sam Shannon

STATE OF FLORIDA

Office of the Governor

THE CAPITOL

TALLAHASSEE 32301

BOB GRAHAM
GOVERNOR

October 11, 1985

Mr. A. J. Salem
Chief, Planning Division
Department of the Army
Jacksonville District
Post Office Box 4970
Jacksonville, Florida 32232

Dear Mr. Salem:

In response to your request, this Office reviewed and coordinated a state review of the Draft Feasibility Report with Environmental Impact Statement for Beach Erosion Control Martin County Florida. Copies of the draft document were distributed to state and regional agencies for comment. Attached for your consideration are comments from the Departments of Environmental Regulation, Natural Resources, State, and Treasure Coast Regional Planning Council. The Departments of Commerce, Transportation, Game and Fresh Water Fish Commission had no comments. The Department of Community Affairs has indicated that it will submit comments later.

The draft reports and statement describe a beach erosion control project S-2A for Hutchinson Island. A proposed project for Jupiter Island was evaluated, however, the economic justifications for federal participation were inadequate. Plan S-2A, suggests renourishing about four miles of shorefront by placing 1,055,000 cubic yards of sand on the beach. Initial construction costs are estimated at $8,368,000. The annual benefits and costs are $1.3 million and $1.1 million, resulting in a B/C ratio of 1.2 to 1. If the selected plan is implemented, the federal government may cost share 55 percent of the project, leaving the state and local governments to pay $3.7 million. The anticipated adverse impacts associated with the selected plan would be the temporary disturbance of biotic habitat in the sand borrow and near shore areas. Water quality probably will be adversely affected during construction.

The Department of Environmental Regulation (DER) has expressed several concerns about this project. Specifically, they question the quality of the sand that will be taken from the borrow area. Fines and silts that would be released during dredging and deposition would increase turbidity. Continuous sediment resuspension would stress the sabellariid worm reef and coquina rock habitat located 400 to 5000 feet south of the project site near St. Lucie Inlet. Another concern is the impact of the project on nesting of sea turtles. This long-standing concern may be resolved when the results of the Corps of Engineers Waterways Experiment Station study on the effects of beach renourishment on sea turtle nesting is completed.

The Department of Natural Resources (DNR) has identified ten miles of critically eroding beaches on Martin County. Renourishing four miles of beach as suggested in plan S-2A would reduce this problem. The DNR while recognizing probable impacts on rock outcroppings or hardbottom habitat notes that these features are routinely covered and uncovered through natural processes. Species that are in the nearshore environment have the ability to migrate and will return, recolonizing the area after the dredging has been completed.

The Department of State, Division of Archives and History and Records Management, finds that the proposed offshore borrow areas A and B probably contain resources eligible for listing in the National Register of Historic Places. They suggest a magnetometer survey be conducted in these areas to locate any anomalies. If surveys of the areas have been completed, the information should be sent to the Department for review. They also report that borrow area B contains a freighter sunk in 1943. This shipwreck site 8Mt22 should be temporarily marked with buoys when dredging near the site.

The Treasure Coast Regional Planning Council has completed an extensive analysis of the documents. They recommend implementation of plan S-2A with certain conditions. These conditions and their support for the project are based on the Council's interim Coastal Zone Management Policy. Two conditions are directed to the local project sponsor, Martin County. The other conditions 1, 2, 4 and 5 (see attachment) must be incorporated into the project design.

Based on our review and agency comments we find that selected plan S-2A for Hutchinson Island should be considered for further detailed evaluation and refinement.

When all of our concerns are addressed and an agreeable federal, state, and local government cost-sharing arrangement is developed, a beach renourishment project for the Hutchinson Island area in Martin County will comply with State plans, goals, and objectives.

We appreciate the opportunity to comment on these documents and look forward to reviewing the Corps final report on this project.

Sincerely,

Glenn W. Robertson, Jr., Director
Office of Planning & Budgeting

GWR/jkc

Attachment

cc: Dr. Elton J. Gissendanner
Randy Armstrong
Dennis Harmon
Brad Hartman
Jim Murley
George W. Percy
Sam Shannon

STATE OF FLORIDA
DEPARTMENT OF COMMUNITY AFFAIRS

BOB GRAHAM
Governor

TOM LEWIS, JR.
Secretary

October 3, 1985

M E M O R A N D U M

TO: Walter O. Kolb, Senior Governmental Analyst
Governor's Office of Planning and Budgeting

FROM: Pam Davis, Assistant Secretary
Department of Community Affairs

SUBJECT: Martin County Beach Erosion Control Study Draft
Feasibility Report with Environmental Impact Statement

The Department of Community Affairs monitors development in the Hutchinson Island area, including Martin County, for compliance with the Hutchinson Island Management Plan. The Management Plan was developed pursuant to Section 380.045, Florida Statutes, and was adopted in October 1983 by the Governor-appointed Hutchinson Island Resource Planning and Management Committee.

I have reviewed the Martin County Beach Erosion Study and have two areas of concern. One is the threat posed to the worm reefs by beach renourishment activities. Although the study indicates that the reefs which exist in the area are few and the damage expected to be temporary, nevertheless permanent or extensive damage to the reefs would violate the Management Plan. My other concern pertains to sea turtle nests. The study states that "provisions will be required for relocation of turtle nests should the construction occur during the nesting season of May through October" (p.52). Consistency with the Management Plan requires that beach renourishment be limited to that period during which turtles will not be endangered, that is, from November to April.

I hope these comments are useful to you in formulating the State's response to the Erosion Control Study. If I can be of further assistance please call me at (904) 488-8466.

PD/mmi

STATE OF FLORIDA

DEPARTMENT OF ENVIRONMENTAL REGULATION

TWIN TOWERS OFFICE BUILDING
2600 BLAIR STONE ROAD
TALLAHASSEE, FLORIDA 32301-8241

BOB GRAHAM
GOVERNOR

VICTORIA J. TSCHINKEL
SECRETARY

September 16, 1985

SEP 1985

Mr. Walt Kolb
Senior Governmental Analyst
404 Carlton Building
Office of Planning and Budgeting
Tallahassee, Florida 32301

Dear Walt:

We have reviewed the Draft Feasibility Report and Environmental Impact Statement for the Martin County Beach Erosion Control Study. Several renourishment plans were presented in the report; only one has a ratio of benefits to costs greater than 1:0. Specifically, Plan S-2A (Hutchinson Island) has a B/C ratio of 1.2:1.0.

We have several concerns with this project which should be addressed in the final report. We are apprehensive about the quality of the borrow source sand, specifically the amount of fines and silts which may be released during both actual dredging and deposition (short-term) as well as long-term increased turbidity levels. Continuous sediment resuspension could, due to longshore current patterns, stress and possibly eliminate high quality sabellariid worm reef and coquina rock habitat located 400 to 5,000 feet south of the immediate project site near St. Lucie Inlet.

Although the patchy nearshore coquina reef habitats within the four mile project area would be eliminated or severely stressed as a consequence of the project, these sites are probably of lesser biological value than the worm reef habitat near St. Lucie Inlet. Special care should be taken to be certain the worm reefs will not be harmed.

We are encouraged by the number of beach access points and public beaches within the Hutchinson Island project area, although several private interests will also benefit from renourishment. Plan S-2B (Jupiter Island) has relatively poor public access and has been rejected by the Corps of Engineers due to an unacceptable benefit/cost ratio of 0.34:1.0.

Concern about this project has been expressed by both the U.S. Fish and Wildlife Service and the National Marine Fisheries Service regarding impacts on sea turtle nesting. Both Federal agencies have deferred Section 7 consultation for this project until the results of the Corps of Engineers' Waterways Experiment Station study concerning the effects of beach nourishment on sea turtle nesting become available. According to the U.S. Fish and Wildlife Service, Martin County has historically reported some of the highest densities of sea turtle nesting in the United States. Furthermore, the National Marine Fisheries Service reports that the Hutchinson Island project site "currently supports a high density of loggerhead turtle nesting during the late spring and summer...this beach is also a very important nesting ground for the Florida green turtle and the Florida nesting population of leatherbacks". Loggerhead turtle nests on the Hutchinson Island segment annually exceed 100 nests per kilometer. We are very concerned about potential impacts of this project on sea turtle nesting and eagerly await the study results.

While we realize the difficulties of Atlantic Coast beach renourishment outside sea turtle nesting season, adverse impacts on sea turtle nesting would be minimized by a winter project work schedule. If renourishment work must be performed during sea turtle nesting season, then appropriate monitoring, transplantation and incubation of eggs by qualified personnel should by undertaken to help mitigate adverse impacts. We also advocate the use of native beach and dune grasses as well as boardwalks to help stabilize sand in the project area.

Although we find the project consistent with the state's approved coastal management program, there are several concerns that need to be addressed in the final report. To recapitulate, these are: the quality of the borrow source sand, impacts on reefs and sea turtles, the need for adequate water quality monitoring, and the need to consider re-establishment of native vegetation.

We appreciate the opportunity to comment.

Sincerely,

Tom Swift
for Randy Armstrong
Chief
Bureau of Laboratories and
Special Programs

RA/pbm

cc: Ms. Victoria J. Tschinkel
Dr. Al Devereaux
Mr. Steve Fox
Mr. Roy Duke
Mr. A. J. Salem
Mr. Joe Carroll
Mr. Lonnie Ryder

State of Florida
DEPARTMENT OF NATURAL RESOURCES

DR. ELTON J. GISSENDANNER
Executive Director
Marjory Stoneman Douglas Building
3900 Commonwealth Boulevard, Tallahassee, Florida 32303

September 30, 1985

Mr. Walter O. Kolb
Senior Governmental Analyst
404 Carlton Building
Office of Planning and Budgeting
Tallahassee, Florida 32301

Dear Mr. Kolb:

SUBJECT: Beach Erosion Control Projects for Palm Beach County, Draft General Design Memorandum with Palm Beach Harbor Section III Report and Environmental Impact Statement;

Beach Erosion Control Study, Martin County Feasibility Report with Environmental Impact Statement

The Department staff has reviewed the two above referenced projects and offer the following comments:

Palm Beach County

The Department concurs with the recommendations contained in the March, 1985 Draft General Design Memorandum, specifically the selected plan of improvement which provides for a protective and recreational beach along 11.3 miles of badly eroded shoreline. Project lengths and typical sections of restored beach are shown on plates 1 through 6 of the Draft General Design Memorandum.

The Department has identified 15.1 miles of critically eroding beaches located in Palm Beach County in our report titled Beach Restoration: A State Initiative, April, 1985. This figure does not include segments contained in the 11.3 miles as outlined in the Design Memorandum which have been previously nourished under the federal program.

Generally, areas undergoing significant erosion are categorized as critical by the Department if the rate of erosion, considered in conjunction with economic, industrial, recreational, demograpic, ecological and other relevant factors indicate that action to halt erosion is deemed necessary.

Martin County

The Department agrees with the selection of plan S-2A which provides for restoration of the primary dune to a 20-foot width and a protective beach with a 35-foot design berm width along 4.0 miles of the ocean shore of Hutchinson Island from the north county line south to 1/4 mile south of the southern limit of Stuart Public Beach with periodic nourishment at 8-year intervals as shown on plate 3.

The Department has identified 6 miles of critically eroding beaches located in Martin County. This figure is in addition to the 4 mile reach contained in Plan S-2A.

It should be noted that the Coastal Construction Control Line for Martin County was reestablished July 9, 1985.

The Department shares the concerns expressed by the Department of Environmental Regulation with reference to the impact to the hardbottom or rock outcrops. However, because the hardbottom habitat is routinely covered and uncovered through natural erosion and accretion the areas are considered a highly stressed nearshore environment. Many of the species which flourish in this zone have the ability to migrate and repopulate adjacent areas and will return and recolonize the area following dredge fill placement.

Through the use of environmentally sensitive dredging techniques it is felt that environmental hazards, such as turbidity, can be held to a minimum. Also, it should be recognized that the availability of renourished beaches for sea turtle nesting provides environmental benefits beyond recreational and storm protection.

The Department of Natural Resources appreciates the opportunity to comment on these two viable and desperately needed projects and we look forward to project implementation as soon as possible.

Sincerely,

Elton

Elton J. Gissendanner
Executive Director

EJG/PEW/sp
cc: Mr. Lonnie L. Ryder
Mr. Ralph R. Clark
Mr. Dale Adams

FLORIDA DEPARTMENT OF STATE
George Firestone
Secretary of State

DIVISION OF ARCHIVES,
HISTORY AND RECORDS MANAGEMENT
The Capitol, Tallahassee, Florida 32301-8020
(904) 488-1480

August 16, 1985

In Reply Refer to:

Mike Wisenbaker
Historic Sites Specialist
(904) 487-2333

Mr. Walter O. Kolb
Division of State Planning
Department of Administration
Office of the Governor
The Capitol
Tallahassee, Florida 32301

RE: Your Letter and Attachment of July 23, 1985
Cultural Resource Assessment Request
Beach Erosion Control Feasibility Report with Environmental Impact Statement, Martin County, Florida

Dear Mr. Kolb:

In accordance with the procedures contained in 36 C.F.R., Part 800 ("Procedures for the Protection of Historic and Cultural Properties"), we have reviewed the above referenced project for possible impact to archaeological and historical sites and properties listed, or eligible for listing in the National Register of Historic Places. The authorities for these procedures are the National Historic Preservation Act of 1966 (Public Law 89-665) as amended by P.L. 91-243, P.L. 93-54, P.L. 94-422, P.L. 94-458 and P.L. 96-515, and Presidential Executive Order 11593 ("Protection and Enhancement of the Cultural Environment").

After carefully reviewing the above cited document, it is the opinion of this office that the renourishment of beaches in Martin County will have no adverse impact on cultural resources since these activities involve depositing rather than excavating soils. On the other hand, the proposed offshore A & B borrow areas probably contain resources potentially eligible for listing in the National Register of Historic Places.

Much of borrow area A falls within the same tract on which a treasure salvor holds an exploration lease with the State of Florida. According to information provided by the Bureau of Archaeological Research, the salvor claims to have located three shipwrecks in this vicinity. Therefore, it is our recommendation that the area be subjected to a magnetometer survey to locate any anomalies within this area; or if such a survey has already been conducted, to provide us with this information in order for us to complete our review. Copies of the strip charts, logs, and information on the type equipment used, line spacing, and tourspeeds should be included with this information.

As for borrow pit site B, we have included a map showing (according to our files) an area previously cleared by this office and labeled "previous borrow area." If the area is correctly delineated, no additional survey work is necessary within this previously borrowed tract. However, portion of borrow area B located outside of this previously disturbed tract should be subjected to a magnetometer survey (unless this information is already available in which case it should be forwarded to this office) in order to complete our review of this project. In addition, according to the Florida Master Site File, site 8Mt22 (please see map enclosure) is located in the southeastern portion of the proposed borrow area B. This wreck is a freighter which was built in 1919 and sank when it collided with a tanker in 1943.

It is our recommendation that wreck site 8Mt22, and any identified anomalies representing potential wreck sites, plus a suitable buffer of at least 50m from the edge of such anomalies and the wreck remain undisturbed by proposed borrow activities. Temporary Bouys should be placed around the edge and at the corners of the buffer areas surrounding the wreck and anomalies. These bouys are to prevent dredge crews from accidentally disturbing the identified areas. Following completion of dredging in the area of these features, the bouys should be removed.

Additionally, the southwest coast of Florida has been the scene of many shipwrecks over the past several centuries. These wrecks are valuable repositories of Florida's maritime history. Moreover, they are primarily clustered within ½ mile of the existing shoreline. In the future, therefore, it would be best from the standpoint of Cultural Resource Management to conduct offshore borrowing activities for beach renourishment projects in this area from no closer than ½ (nautical) mile offshore seaward.

Mr. Walter O. Kolb
August 16, 1985
Page Three

If you have any questions concerning our comments, please do not hesitate to contact us.

Your interest and cooperation in helping to protect Florida's archaeological and historical resources are appreciated.

Sincerely,

Louis E. Tesar

for George W. Percy
State Historic
Preservation Officer

GWP/Wkp

FLORIDA DEPARTMENT OF STATE
George Firestone
Secretary of State
Ron Levitt
Assistant Secretary of State

March 27, 1980

In reply refer to:

Mr. Louis Tesar
Historic Sites Specialist
(904) 487-2333

Mr. James L. Garland
Chief, Engineering Division
Jacksonville District
Corps of Engineers
Post Office Box 4970
Jacksonville, Florida 32201

Re: February 5, 1980 Letter and Map
Cultural Resource Assessment Request
SAJEN-EE Proposed Beach Nourishment at
Jensen and Stuart Public Beaches and
3500'X3500' Borrow Area near Stuart Public
Beach, Martin County, Florida

Dear Sir:

In accordance with the procedures contained in 36 C.F.R., Part 800 ("Procedures for the Protection of Historic and Cultural Properties"), we have reviewed the above referenced project for possible impact to archaeological and historical sites or properties listed, or eligible for listing, in the National Register of Historic Places. The authorities for these procedures are the National Historic Preservation Act of 1966 (Public Law 89-665) as amended by P.L. 91-243, P.L. 93-54, P.L. 94-422, and P.L. 94-458, and Presidential Executive Order 11593 ("Protection and Enhancement of the Cultural Environment").

A review of the Florida Master Site File indicates that no archaeological or historical sites are recorded for the project area. Furthermore, because of the location of the project, it is considered high unlikely that any significant, unrecorded sites exist in the vicinity. Therefore, it is the opinion of this office that the proposed project will not adversely impact any sites listed, or eligible for listing, in the National Register of Historic Places, or otherwise of national, state, or local significance.

Mr. James L. Garland
March 27, 1980
Page Two

On behalf of the Secretary of State, George Firestone, and his staff at the Bureau of Historic Sites and Properties, I would like to thank you for your interest and cooperation in the protection of Florida's irreplaceable historic resources.

Sincerely,

L. Ross Morrell,
Deputy State Historic
Preservation Officer

LRM:Teh

indian river
st. lucie
martin
palm beach

treasure coast regional planning council

September 30, 1985

Mr. A. J. Salem, Chief
Planning Division
U.S. Army Corps of Engineers
Jacksonville District
Post Office Box 4970
Jacksonville, FL 32232

Subject: Martin County, Florida - Erosion Control Study SAJPD-C

Dear Mr. Salem:

Attached is an analysis of the Draft Feasibility Report and Draft Environmental Impact Statement of the subject study. Based upon this analysis and testimony received by Council on September 20, 1985, Council adopted the following comment and directed that it be transmitted to your office.

> Council recommends the selection of Alternative Plan S-2A provided that the renourishment project design incorporates the following conditions for consistency with the Council's adopted interim Coastal Zone Management Policy.

1. Avoid areas of active worm reefs;
2. ensure that the proposed fill material is compatible with existing beach sand and provides a suitable substrate for recolonization of indigenous, benthic, intertidal organisms;
3. require the local sponsor, Martin County, to implement nonstructural measures (zoning restrictions, setback lines, etc.) and prohibit the construction of seawalls, jetties, groins and other beach-destroying structures in this and other areas of the beach within Martin County;
4. include a program of planting beach vegetation;
5. time the construction so that it does not interfere with turtle nesting season; and
6. require the local sponsor, Martin County, to implement a cost-sharing formula which assigns funding responsibility to those who benefit from the erosion control effort.

620 s. dixie highway
p.o. drawer 396
stuart, florida, 33495-0396
phone (305) 286-3313

thomas d. mccloskey, jr.
chairman

a.a. hendry, III
vice chairman

margaret c. bowman
secretary/treasurer

sam shannon
executive director

Mr. A. J. Salem, Chief
Planning Division
U.S. Army Corps of Engineers
September 30, 1985
Page Two

If you have any questions, please contact me or Andrew Feinstein of this office.

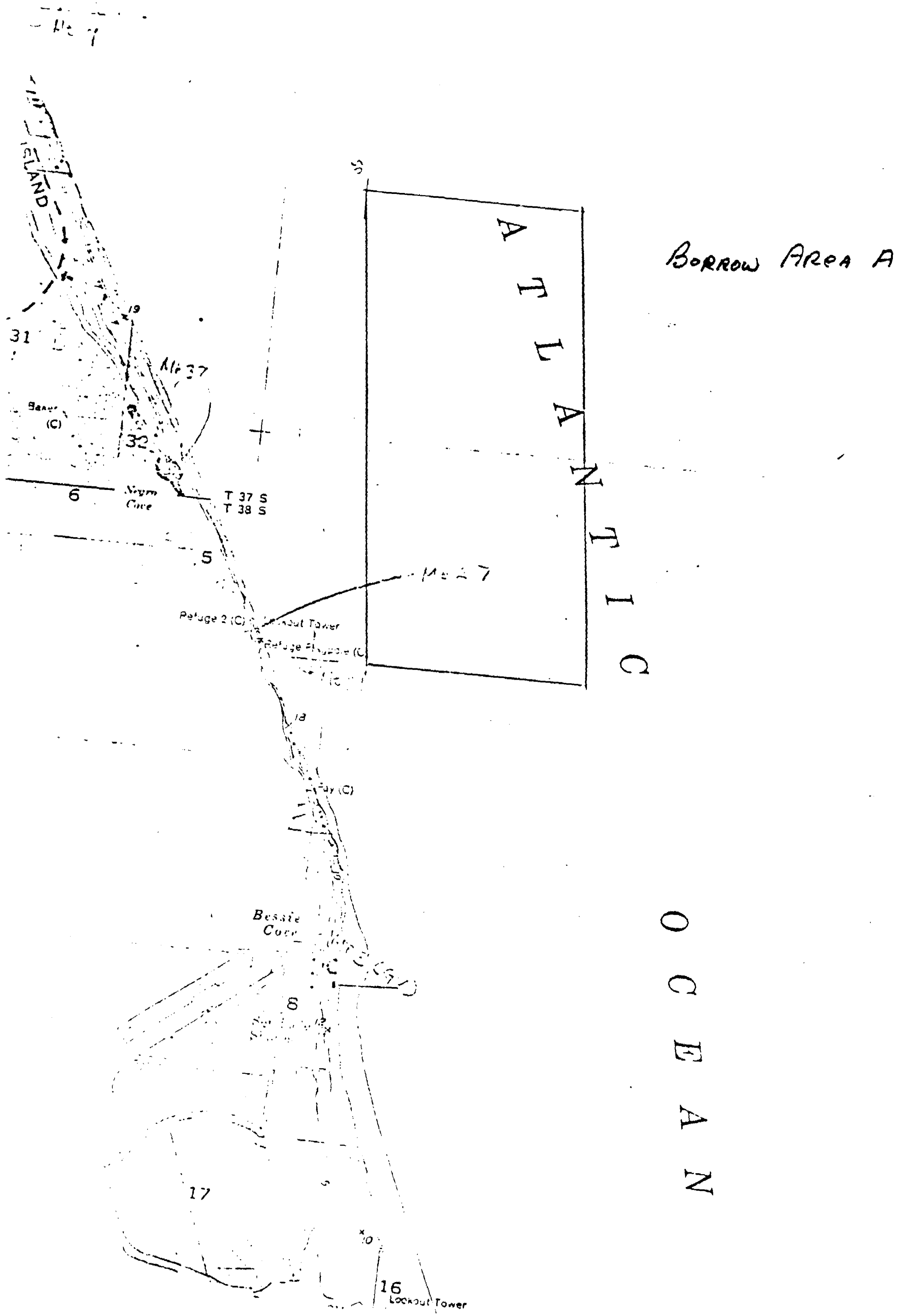
Yours truly,

Sam Shannon
Executive Director

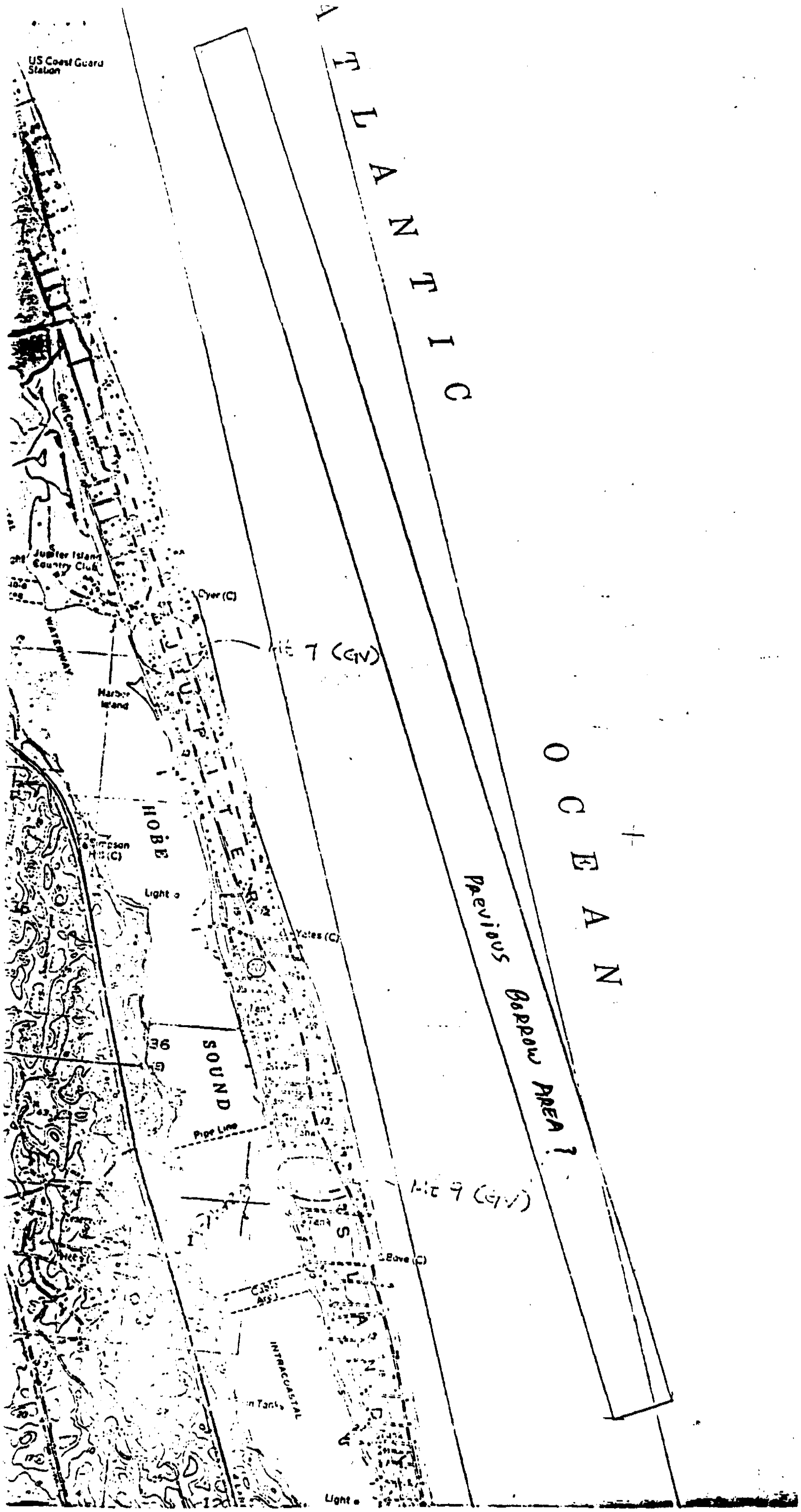
SS/RA:pk

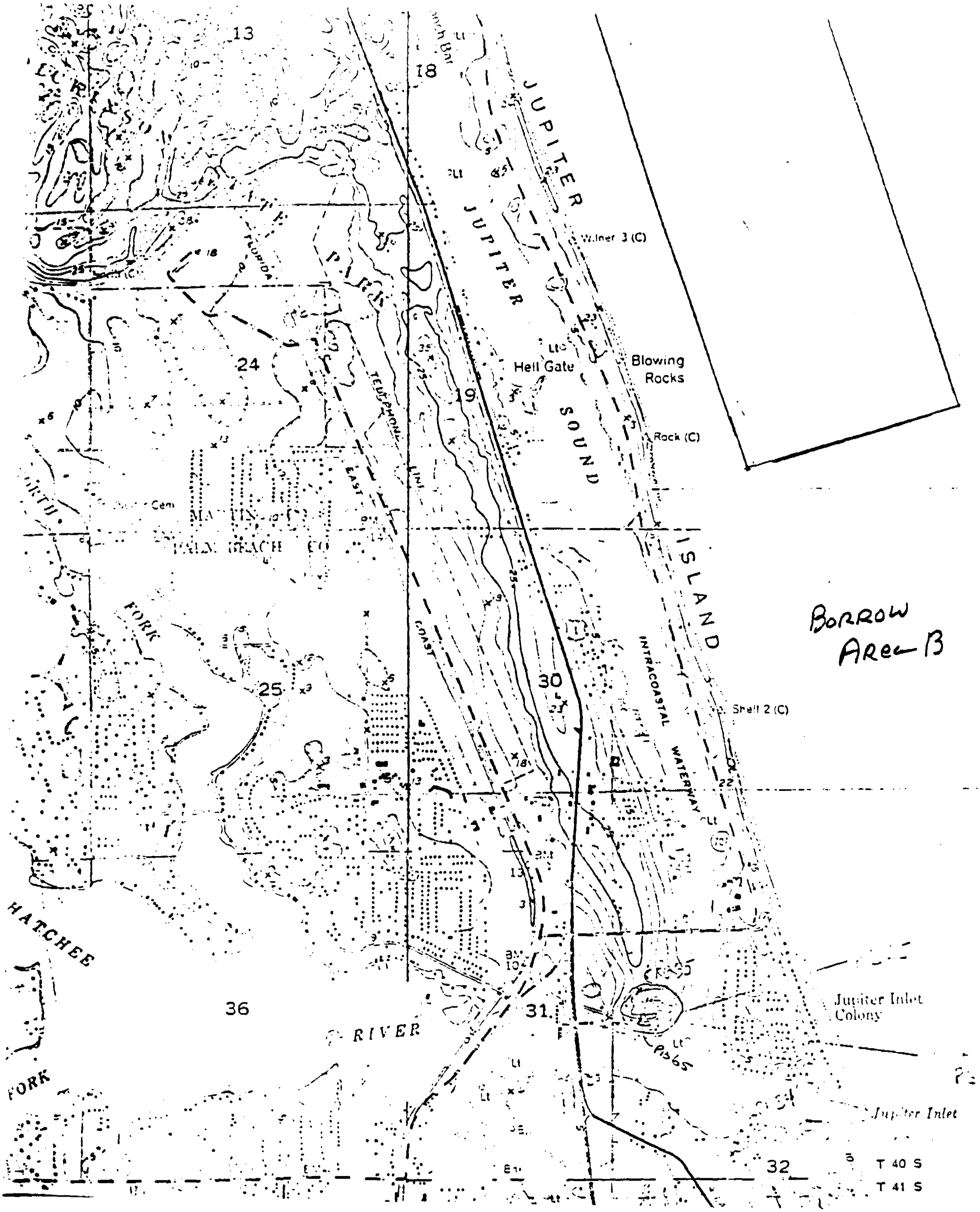
Attachment

cc: Walt Kolb



Borrow Area A
ATLANTIC
OCEAN
ISLAND
31
32
6
5
T 37 S
T 38 S
Refuge 2 (C)
Lookout Tower
18
19
Bessie
Cove
8
17
16
Lookout Tower


US Coast Guard Station
ATLANTIC
OCEAN
Jupiter Island Country Club
WATERWAY
Cyer (C)
Harbor Island
JUPITER ISLAND
HOBE SOUND
Simpson Hill (C)
Light
Yates (C)
Previous Borrow Area ?
Pipe Line
Bove (C)
INTRACOASTAL
Light



13
18
JUPITER
JUPITER
Wilner 3 (C)
FLORIDA
PARK
Hell Gate
Blowing
Rocks
24
19
SOUND
Rock (C)
TELEPHONE
EAST
COAST
MARTIN CO
PALM BEACH CO
ISLAND
FORK
INTRACOASTAL
WATERWAY
30
25
Shell 2 (C)
HATCHEE
36
31
RIVER
Jupiter Inlet
Colony
FORK
Jupiter Inlet
32
T 40 S
T 41 S
Borrow
Area B

SECTION 3

CORRESPONDENCE FROM FEDERAL AGENCIES

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IV
345 COURTLAND STREET
ATLANTA, GEORGIA 30365

AUG 23 1985

4PM-EA/GM

Mr. A.J. Salem, Chief
Planning Division
U.S. Army Corps of Engineers, Jacksonville
P.O. Box 4970
Jacksonville, Florida 32232

Dear Mr. Salem:

In accordance with Section 309 of the Clean Air Act, we have reviewed the draft environmental impact statement for the beach erosion control study in Martin County, Florida. With the exception of sedimentation adversely impacting live bottoms down current of the project area, we have no pronounced environmental reservations to the immediately attributable short- or long-term environmental consequences of the proposed alternative. The adverse consequences of this sedimentation can be materially lessened through the judicious selection of borrow material. We recommend that sand pumped onto the beach be well sorted texture-wise and of similar size class to the material already present there. This will preclude unnecessary turbidity at the borrow site or the receiving beach and has the economic advantage of reducing the amount of dredging.

Of course, as we have noted to you on previous occasions, pumping sand onto a retreating shoreline only postpones the inevitable; but, in candor, the document discloses the ephemeral nature of attempting to maintain a beach on a relatively high-energy shoreface. Hence, given the Corp's mandates and the absence of significant attendant environmental losses in this instance, this has effectively become a non-issue.

As a result of our review, a rating of LO-2 was assigned. That is, the environmental effects of this action are anticipated to be within acceptable limits if appropriate borrow material is used; therefore, we urge that every consideration be given to choosing locations within the borrow site which meet the above criteria.

If we can be of further assistance, please do not hesitate to call Dr. Gerald Miller (FTS 257-7901) of my staff.

Sincerely yours,

Sheppard N. Moore

Sheppard N. Moore, Chief
NEPA Review Staff
Environemental Assessment Branch

United States Department of the Interior

OFFICE OF ENVIRONMENTAL PROJECT REVIEW

Southeast Region / Suite 1360
Richard B. Russell Federal Building
75 Spring Street, S.W. / Atlanta, Ga. 30303

Telephone 404/221-4524 - FTS: 242-4524

AUG 30 1985

ER-85/1153

Colonel Charles T. Myers, III
District Engineer
U.S. Army Corps of Engineers
Post Office Box 4970
Jacksonville, Florida 32232-0019

Dear Colonel Myers:

The Department of the Interior has reviewed the Draft Environmental Statement and Feasibility Report, Beach Erosion Control Study, Martin County, Florida, and has the following comments.

General Comments

The Fish and Wildlife Service (FWS) recommends that Section 7 consultation for this project be postponed until the results of the Corps of Engineers, Coastal Ecology Group, Waterway Experiment station studies on the effects of beach nourishment on nesting sea turtles is completed. We remain concerned with the potential long-term adverse impacts of beach nourishment projects on sea turtle nesting. Statements made in these reports which indicate there will be no unacceptable environmental impacts on the aquatic system, and that sea turtle nesting will be enhanced, are premature and possibly incorrect.

The draft environmental statement does not discuss mineral resources or mineral related facilities. There has been no recorded mineral production in Martin County since 1975, however, and none of the alternate plans discussed in the documents would produce adverse effects on mineral resources or related activities. For completeness, a statement to the effect, that mineral resources would not be impacted, should be included in subsequent versions of the document.

Specific Comments - Feasibility Report

Page 8, paragraph 30. The only major "water courses" in the project area are the Indian and the St. Lucie Rivers, neither of which can be characterized by the description in this paragraph. Most of the Indian River is bordered by a fringe of mangroves of varying width most of which have been impounded for mosquito control. A similar description should also be corrected on page 9, paragraph 4.04 of the EIS.

Page 10, paragraph 41. The Indian River is a narrow estuarine lagoon whose only water movement is the result of the influence of tidal exchange through six inlets, wind-driven tides and fresh water inflow. Thus, the Indian River is not a river in the traditional sense and does not flow in any direction.

Page 52, paragraph 208; page 57, Table 6. The FWS cannot concur with your assessment that no rare or endangered species will be adversely affected by this beach nourishment project. In the FWS letter from the Jacksonville Endangered Species office, dated June 6, 1985, concern was expressed for the project's impacts on loggerhead and green sea turtle nesting. Compaction of beach sediments and concurrent reduction of nesting density after nourishment projects have been documented in several cases (Ehrhart and Raymond, 1983; Fletemeyer, 1978-81; Witham, 1982). The technology to predict these impacts is not currently available, thus, making your conclusions premature and possibly inaccurate. Acquisition of the above referenced studies would add considerable information to the final EIS.

Specific Comments - Environmental Impact Statement

Page 3, Table 1. This table should include the Coastal Barrier Resources Act of 1982 since Unit P-12 in Martin County is presently in the system.

Page 11, paragraph 4.08. This paragraph and Appendix C fail to discuss the fishery value of the coquinoid reef outcroppings which are not encrusted with sabellariid worms. These coquinoid reefs provide habitat diversity in the nearshore for a large number of benthic invertebrates, algae, and numerous fish species. Covering of any of these reef areas would represent loss of a significant habitat.

We appreciate the opportunity to comment on these documents.

Sincerely yours,

James H. Lee

James H. Lee
Regional Environmental Officer

Attachment

Literature Cited

Ehrhart, L.M. and T.W. Raymond, 1983. The Effects of Beach Restoration on Marine Turtles Nesting in South Brevard County, Florida. A final report to the U.S. Army Corps of Engineers, Jacksonville District Contract No. DA CW17-81-C-0014, 104 P.

Fletemeyer, J. 1979. Sea Turtle Monitoring Project Report to Broward County Environmental Quality Control Board, Ft. Lauderdale, Florida, 1-64.

Witham, R. 1982. Description of Sea Turtle Habitat with Emphasis on Human Influences in Biology and Conservation of Sea Turtles, ed. by K.A. Bjorndal, 519-522. Washington, D.C., Smithsonian Institution Press.

APPENDIX 4

ENGINEERING, DESIGN, AND COST ESTIMATES

APPENDIX 4

ENGINEERING, DESIGN, AND COST ESTIMATES

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APPENDIX 4

ENGINEERING, DESIGN, AND COST ESTIMATES

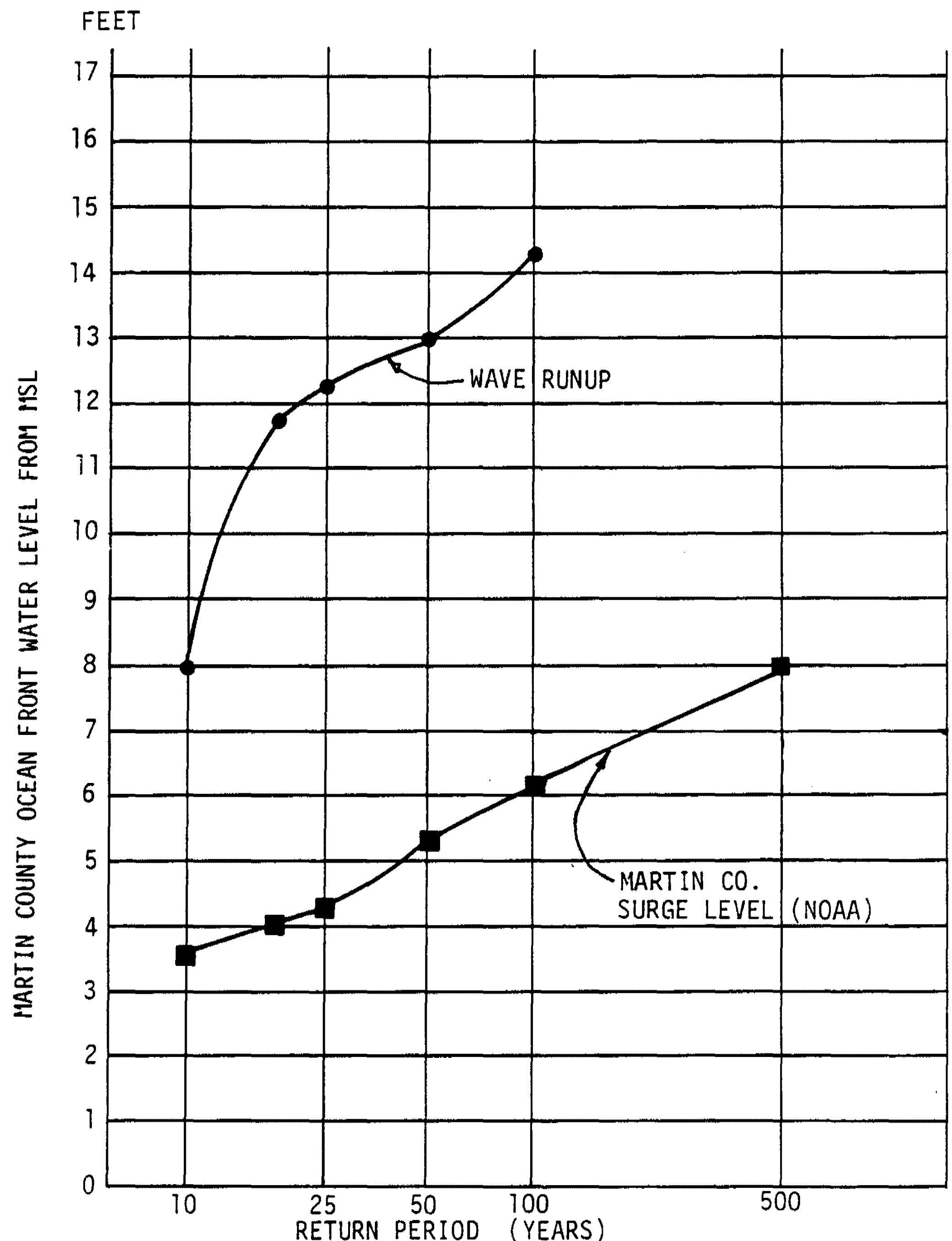
INTRODUCTION

1. This appendix presents the design aspects of the considered alternatives and their respective cost. The rationale for the selection of each design parameter is also discussed. The location of the considered problem area is shown on plate 4. Guidelines and techniques for functional and structural design for shore protection works considered herein were primarily obtained from the U.S. Army Coastal Engineering Research Center "Shore Protection Manual (SPM)." Considerable information such as shoreline change, erosion, and storm damage which is pertinent to the design is contained in appendix 1, and will not be repeated here. Design parameters are described in the following paragraphs.

DESIGN FEATURES - PROTECTIVE BEACH

2. Surge Levels. NOAA surge levels, shown in figure 1, were used in engineering design. These surge levels take in account wind setup, but do not include the wave setup and wave runup elevations. These surge levels were based on historic tropical storms and hurricanes on the east coast of Florida.

3. Wave Runup. Wave runup calculations, the results of which are shown in figure 1, were made using procedures in the "Shore Protection Manual" and CERC publication TP 78-2, "Reanalysis of Wave Runup on Structures and Beaches." The breaking wave depth (ds) was determined by examination of the beach profiles. The depth corresponds with the top of the nearshore bar or the plateau immediately at the foreshore toe. The breaking wave height for each considered surge level and the averaged beach parameters were then used in conjunction with TP 78-2 to calculate the wave runup heights. These calculations were made for an average composite beach profile in the Martin County study area. Besides calculation of bluffline recession, the major use of the runup levels is to estimate the height above the natural elevation that a dune can be built to maximize protection from overwash. The average dune height in the Jensen Beach area is 14.1 feet relative to m.s.l., which corresponds to a 90-year return period storm. The average dune height in the Stuart area is 19.3 feet, which exceeds the 14.3 foot elevation for a 100-year event by a considerable margin.



FREQUENCY AS DEVELOPED BY NOAA

BEACH EROSION CONTROL AND SHORE PROTECTION STUDY
MARTIN COUNTY, FLORIDA

WATER LEVEL FREQUENCY CURVE

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

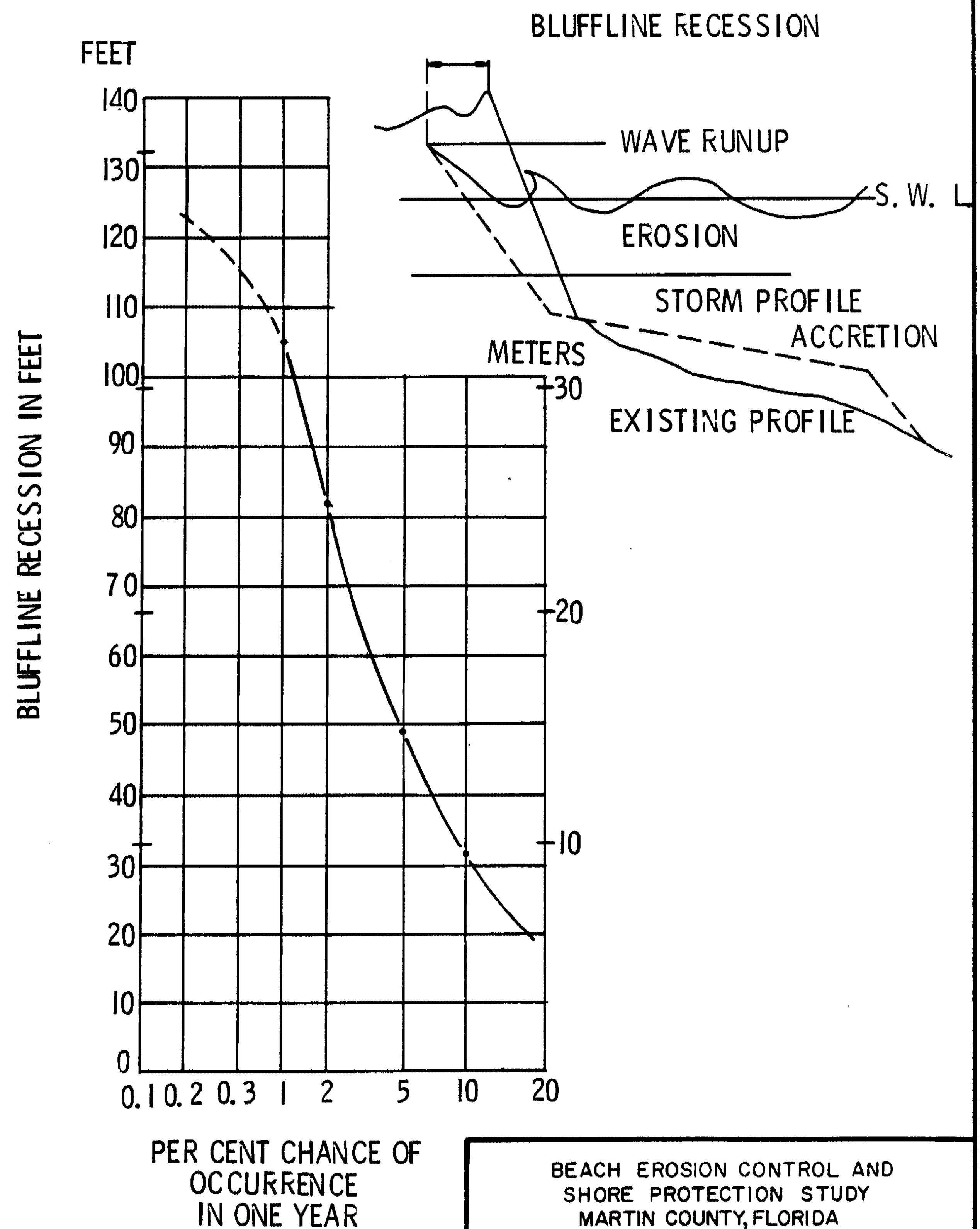
FIGURE 1

4. Bluffline Recession. During a storm, waves gouge tremendous quantities of sand from the upland beach and dunes, and then deposit most of it offshore forming a sand bar. Given enough time, before the next severe storm, much of the material in the bar will return to the upland beach primarily by wave action. There are no known specific data relating shore erosion to storm surge levels and waves for the beaches in the study area. With knowledge of the frequency of surge and wave runup levels, the expected frequency of bluffline recession can be estimated. The bluffline recession curve shown in figure 2 was calculated using the method suggested by T. Edelman, Jr., and presented in chapter 46 of the proceedings of the 1968 Coastal Engineering Conference. This method states that high storm surge and runup levels will erode a volume of material from the upshore dunes equal to the amount of material it can accrete offshore under a storm profile, as illustrated in the upper right hand corner of figure 2. The frequency curve shown in figure 2 will be used to calculate damage prevention benefits.

5. Three fundamental assumptions were made in the determination of shore recession attendant with a specific storm-tide level; first, during the storm, the alongshore transport of littoral materials is uniform, thus obviating alongshore deficits. Secondly, the duration of any given storm condition is sufficiently long to create the equilibrium profile associated with that condition. Thirdly, the toe of the storm escarpment occurs at that point along the beach profile of maximum storm wave runup.

6. Using the water level frequency relationship shown in figure 1, a bluffline recession frequency curve was developed for the Hutchinson problem area. This is the curve shown on figure 2. The volumetric erosion associated with a particular storm is independent of the shape of the fill or beach. Since a greater amount of material is stored in large or high dunes, the volumetric erosion requirements of a given storm are satisfied with smaller amounts of recession with high dunes than in the case of relatively lower or smaller dunes. An example of the computations used to develop this curve is given on figure 3. In this example, the average beach profile cross section was subjected to a 50-year storm. The NOAA surge level of the 50-year storm is about 5.3 feet above mean sea level. The predicted amount of bluffline erosion for a 50-year storm acting on the section was calculated to be about 82 feet. The construction set-back line, established by the Florida Department of Natural Resources, is based on a modified Edelman model, and is based on a 100-year storm event. The average distance from mean-sea-level to the set-back line on Hutchinson Island, based on the 1971 DNR survey, is 130 feet. This is greater than the value of 106 feet derived from figure 2. Therefore, figure 2, the bluffline recession frequency curve is considered to give a conservative estamate of bluffline recession.

7. The wave runup and bluffline recession calculations are based on an assumption of no significant overtopping. When the wave runup elevation reaches an elevation higher than the natural dune elevation, the curves for runup in figure 1 should be stopped. Due to the great variation of dune heights along the county shoreline, this has not been shown in figure 1. The degree which the Edelman method is valid when wave overtopping begins has not been determined, but is assumed to continue for sometime after overtopping starts. This transition region is marked by dashed lines in figure 2.

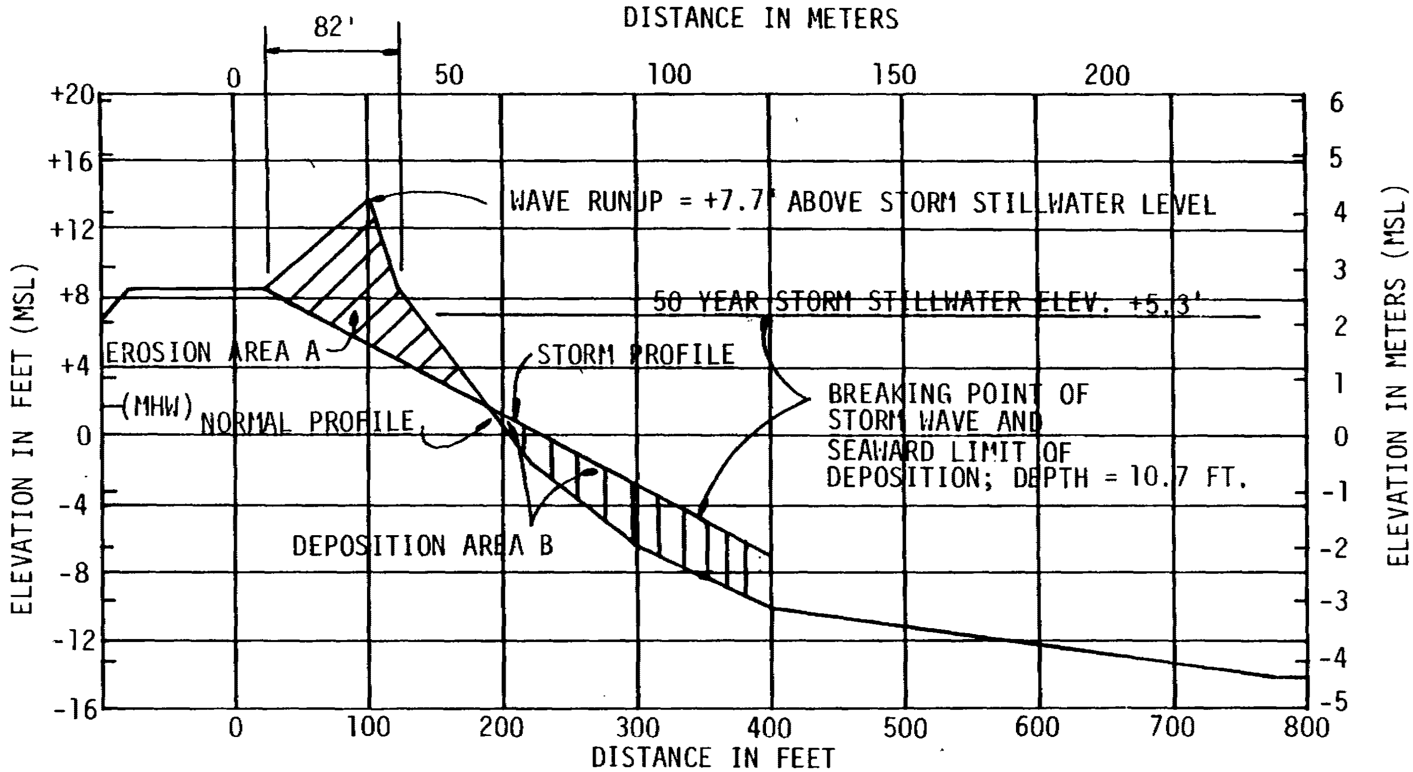


BEACH EROSION CONTROL AND SHORE PROTECTION STUDY
MARTIN COUNTY, FLORIDA

BLUFFLINE RECESSION FREQUENCY

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

FIGURE 2



EXAMPLE OF BLUFFLINE RECESSION COMPUTATION PROCEDURE FOR THE 50 YEAR STORM ACTING ON THE SHORELINE OF THE MARTIN COUNTY AREA.

EXAMPLE CALCULATION

1. STORM STILLWATER LEVEL S= +5.3 FT. MSL
2. STORM WAVE HEIGHT H_b = 1.55(S)= 8.2 FT.
3. DEPTH OF WATER IN WHICH WAVE H_b WOULD BREAK = 1.3 H_b = 10.7 FT.
4. BREAKING DEPTH OF WAVE RELATIVE TO MSL AND NORMAL PROFILE = 10.7 FT. MSL
5. AREA A = AREA B
6. RECESSION OF BLUFF = 82 FT.

FIGURE 3

8. Dune and Berm Elevations and Widths. Due to engineering economics and constructability constraints, the minimum amount of protection desired of a protective beach would be protection from a 5-year storm, or a beach with a 8.0 m.s.l., height and a 20-foot width (from figures 1 and 2). Beach fills, that provide 3.3, 10, 40, and 59 year protection were also considered, in order to find the optimum beach width under NED Standards for both damage prevention and recreation benefit analysis. There are three major considerations for the selection of a design berm and dune height. The first is the natural berm and dune elevations. Construction of a berm or dune substantially higher than this may obstruct the view of shoreline residents or cause increased erosion due to wind blown sand or drainage/passenger routes cut through the dune. Protective dunes built too low may offer little protection to upland development or existing dunes. In addition, a protective berm constructed too low may leave areas along the coast that could be eroded faster during lesser storms. Secondly, the protective berm and/or dune can be built up to protect against the design surge and runup. A dune of sufficient height can protect lower areas to the rear of the dune line from overtopping and flooding. Lastly, the dune elevation should not be higher than the runup elevation associated with a surge to the level of the natural elevation back of the dune. A higher dune would not stop back island flooding caused by the rise of estuary levels during storms.

9. The dune and berm elevations selected for design are as shown in table 1. These elevations were selected as a compromise between the natural elevations and the wave runup elevation for the 3.3-, 10-, 40-, and 59-year storms.

10. Beach Slopes. The initial slope of any beach fill will naturally be steeper than that of the natural profile over which it is placed. Subsequent behavior of the slope depends upon the charateristics of the fill material and the nature of wave climate. In practice, the initial fill slope is designed parallel to the local or comparable natural beach slope above low-water datum. The design of the offshore slope is determined after careful investigation of all pertinent data from low-water datum to about the 18-foot depth. The design slope is derived through synthesis and averaging of existing data within and adjacent to the problem area, and is usually significantly flatter than the foreshore slope. It is unnecessary and usually impracticable to grade beach slopes artificially below the berm crest since they will be shaped naturally by wave action. Fills placed to a desired berm width but with steep initial slopes will quickly adjust to a natural slope, narrowing the berm and leaving the impression that much of the fill has been lost, although it has only moved to establish the natural slope.

11. The design beach slopes shown in table 1 were selected to conform to the natural beach slopes for volume computation. The constructed profiles may be more or less steep; however, natural wave action will adjust the slopes to those naturally found in the area.

12. Advanced Nourishment. The selection of the advanced nourishment quantity was based on the long-term erosion rates as reflected through profile analysis discussed in appendix 1, section 2. An annual erosion rate of

<u>TABLE 1</u>

<u>ENGINEERING SUMMARY - BEACH FILL ALTERNATIVE</u>

DESIGN LEVEL (YR)	NOURISHMENT INTERVAL (YR)	BERM 1/ ELEVATION (FT M.S.L.)	BERM WIDTH (FT)	CREST ELEV. 2/ DUNE (FT M.S.L.)	CREST WIDTH DUNE (FT)	BEACH FILL QUANTITY (CU. YD.)	ADVANCE 3/ NOURISHMENT (CU. YD.)	OVERFILL 4/ (CU. YD.)	TOTAL INITIAL FILL QUANTITY (CU. YD.)
3.3	2	5	0	-	-	90,000	106,000	16,000	212,000
	5	5	0	-	-	90,000	265,000	40,000	395,000
	8	5	0	-	-	90,000	424,000	64,000	578,000
	15	5	0	-	-	90,000	795,000	119,000	1,004,000
10	2	8	20	-	-	244,000	106,000	16,000	366,000
	5	8	20	-	-	244,000	265,000	40,000	549,000
	8	8	20	-	-	244,000	424,000	64,000	732,000
	15	8	20	-	-	244,000	795,000	119,000	1,158,000
40	2	8	35	12.5	20	454,000	106,000	16,000	576,000
	5	8	35	12.5	20	454,000	265,000	40,000	759,000
	8	8	35	12.5	20	454,000	424,000	64,000	942,000
	15	8	35	12.5	20	454,000	795,000	119,000	1,368,000
59	2	8	60	13.1	35	608,000	106,000	16,000	730,000
	5	8	60	13.1	35	608,000	265,000	40,000	913,000
	8	8	60	13.1	35	608,000	424,000	64,000	1,096,000
	15	8	60	13.1	35	608,000	795,000	119,000	1,522,000

1/Four mile fill length, slopes 1 on 8.5 from berm elevation to M.L.W., thence 1 on 20 to existing bottom.
2/Slopes 1 on 5 from crest elevation to +8.0 M.S.L.
3/Annual nourishment rate of 53,000 cubic yards times the nourishment interval shown.
4/Overfill factor of 1.15 applied to advance nourishment only.

53,000 cubic yards per year, (or 2.5 cubic yards/year/linear foot) was estimated based on recent surveys. This erosion will probably continue, but at a somewhat lower than current rate if the project is constructed. If a project is constructed, performance monitoring would be required to determine, with greater assurance, the renourishment rate. Advanced nourishment quantities used in design are shown in table 1.

13. Volumes of Material. The initial volumes of material required to build the considered beaches without advanced nourishment are shown in table 1. These volumes were calculated by superimposing sketches of the considered design sections (figure 4) on plots of existing beach profiles. The sketches used were developed using the berm widths, heights, and slopes displayed in table 1.

14. The design beach profiles shown in figure 4 are representative of the level of protection they provide. The lower fore berm shown (for placement of advance nourishment) will have a height of 5 feet m.s.l. and its purpose is two fold. First, it will prevent an abrupt and high scarp from forming from storm attack after construction. Secondly, it will increase the distance between the ocean and the major berm, thus delaying major damage to this berm. The fore berm's size (width) will be determined by the amount of advanced nourishment and overfill required.

Geotechnical Summary

15. Native Beach Material. Surface sand samples were collected along 11 of the Corps of Engineers profile lines (1N, 3-N, 6-N, 1-S, 2-S, 6-S, 10-S, 16-S, 22-S, 28-S, and 32-S shown on plate 3 of the main report) surveyed in 1965. The samples were collected from the dry beach, at mean high water, at mean low water, and at elevations -3, -6, -12 and -18 feet. Grain size analyses of the beach samples were performed at the Corps of Engineers, South Atlantic Division Laboratory. Gradation curves of each sample are available for inspection at the Jacksonville District Corps of Engineers.

16. Grain size curves of material from the beach show very little material of a size smaller than 0.125 mm. exists above mean high water, although finer grained material occurs in the zone from the shoreline to a water depth of 6 to 12 feet. The largest grain sized material on the beach occurs at the shoreline. Shell fragments comprise a considerable part of the beach material.

17. Borrow Area. Geophysical surveys for beach fill material were conducted offshore of Martin County in reconnaissance scope by the U.S. Army Coastal Engineering Research Center and detail investigation by the Jacksonville District. As a result of these investigations, suitable quantities of sand material are known to exist offshore. For this study, an offshore borrow area was considered to be the most environmentally acceptable source of sand. Detailed sampling was confined to areas known to contain suitable beach fill (see plate 1 and figure 5).

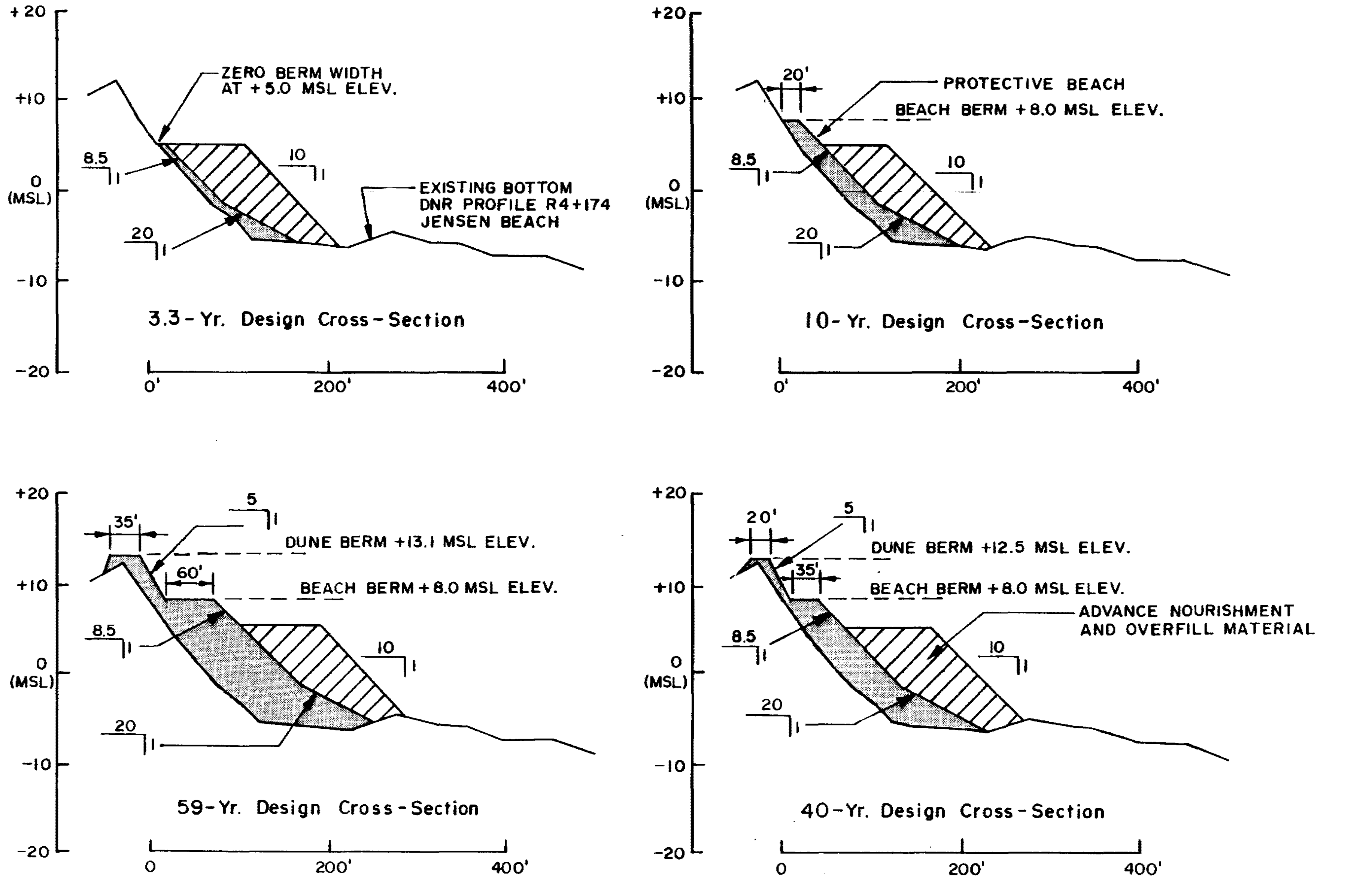


FIGURE 4: DESIGN BEACH PROFILES

FIGURE 4

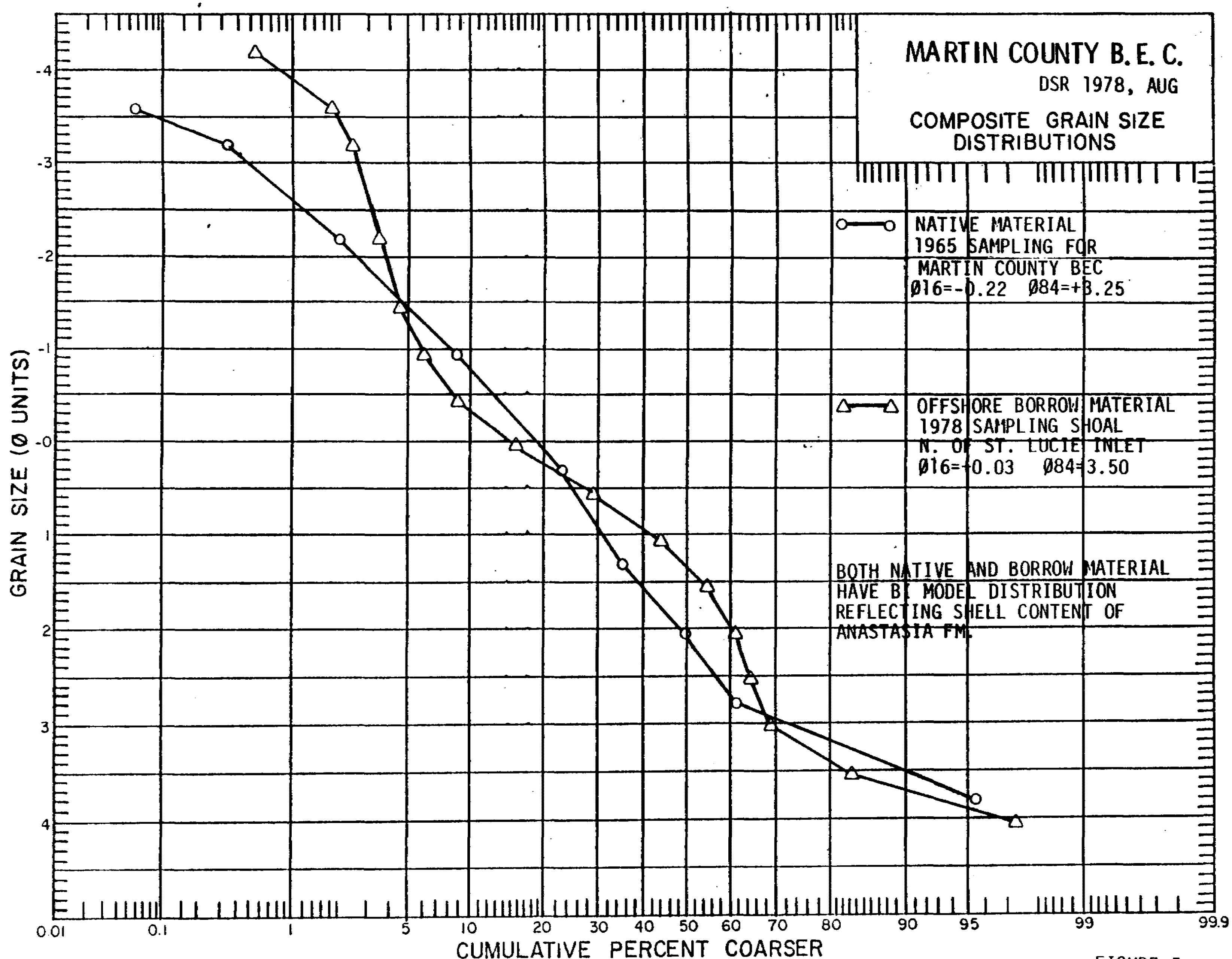

MARTIN COUNTY B. E. C.
DSR 1978, AUG
COMPOSITE GRAIN SIZE DISTRIBUTIONS
NATIVE MATERIAL
1965 SAMPLING FOR
MARTIN COUNTY BEC
Ø16=-0.22 Ø84=+3.25
OFFSHORE BORROW MATERIAL
1978 SAMPLING SHOAL
N. OF ST. LUCIE INLET
Ø16=+0.03 Ø84=3.50
BOTH NATIVE AND BORROW MATERIAL
HAVE BI MODEL DISTRIBUTION
REFLECTING SHELL CONTENT OF
ANASTASIA FM.
GRAIN SIZE (Ø UNITS)
-4
-3
-2
-1
-0
1
2
3
4
0.01
0.1
1
5
10
20
30
40
50
60
70
80
90
95
99
99.9
CUMULATIVE PERCENT COARSER

FIGURE 5

18. Thirty-nine exploratory borings were drilled along the Martin County coast in 1978. These borings were located approximately 1/2 to 2 miles offshore. The boring locations were chosen to cover the coast and sample sand deposits. Utilizing vibracore drilling methods, borings were drilled to a depth of 20 feet wherever possible. Boring locations were determined by electronic positioning equipment. Boring locations are shown on plate 1. Representative gradation curves are presented in subappendix A at the end of this appendix. Additional boring logs are available for inspection at the Jacksonville District, Corps of Engineers.

19. The bulk of the material encountered in the borings was sand, though limestone beds were also encountered. For the most part the sands were clean, although lesser amounts of silty sand and some clayey sands were encountered. The sand is a mixture of fine to medium grain quartz and fragments of shell with shell composing 50 percent or more of the material in many areas. Gravel sized shell fragments are common throughout much of the material encountered.

20. Based on the boring and laboratory data two offshore borrow areas were examined and are shown on plate 1 of this appendix. The northernmost borrow area is located 3,000 feet offshore about 3 miles northeast of St. Lucie Inlet. This borrow area contains approximately 8.0 million cubic yards of material. The other potential borrow area is located 3,000 feet offshore, about 5.5 miles and contains approximately 77.0 million cubic yards of material. Prior to dredging operations, these borrow areas would need no further geophysical subbottom profiles or additional core borings.

21. <u>Comparison of Material</u>. The stability and compatibility of the borrow material was evaluated the methods presented and discussed by William R. James in the Coastal Engineering Research Center Technical Memorandum Number 60, "Techniques in Evaluating Suitability of Borrow Material for Beach Nourishment." The composite grain size distribution for the native beach material and for the material from the borrow areas were computed using the data discussed in the previous paragraphs. These composite grain size distributions are shown on figure 5. Typical drilling logs of classifications of materials encountered in the borrow area and typical gradation curves from sand samples are shown in subappendix A.

22. The results of the evaluation of the suitability of the proposed borrow materials for beach nourishment are summarized in table 2. An overfill factor of 1.15 was determined to be appropriate. The purpose of overfill is to compensate for the difference in gradation between natural beach sand and borrow source sand. In this case, the borrow source sand has a greater percentage of fine material which will erode from the new beach faster than the natural erosion rate, due to sorting action of the waves. By increasing the amount of fill material by the overfill factor, the new beach should perform as designed. These factors are applied to the entire advanced and renourished quantities, but not to the initial or core fill. It would be inappropriate to aply the overfill factor to the entire fill, since most of the design berm should never be subject to direct wave attack, except under extreme conditions.

TABLE 2

EVALUATION OF THE SUITABILITY OF THE PROPOSED BORROW MATERIALS FOR BEACH NOURISHMENT -

Material	Mean Diameter MM	Sorting	Fill Factor
Native Beach Material	0.35	1.74	
Offshore Borrow Material	0.29	1.74	1.15

23. In addition to the previously discussed borrow areas it may be feasible to, on occassion, use material dredged as part of the maintenance program for the Intracoastal Waterway to nourish the beach fill. However, since the maintenance of the waterway may not coinside with required nourishment of the beach fill and the quality and quantity of material to be dredged are not known at this time, detailed investigations of this source of material are not warranted at this time. However, the waterway is considered as a possible sand source and will be investigated further if future data indicate the advisability of using the Intracoastal Waterway as a sand source.

24. Limiting Depth. The limiting depth defines the oceanward extent of significant sediment movement. The location of this zone is important in the considerations of borrow sources or site selection of offshore structures such as breakwaters and perched beaches. The time frame of analysis is important when defining the limiting depth. Hallermeier in the Coastal Engineering Research Center (CERC) publication TP 77-9 defines a process to calculate the yearly limiting depth. This depth in Martin County is 19.8 feet and considers sediment motion due to normal waves and does not consider motion due to major nonannual storms. Two other methods were used to define limiting depth. The first is to find the depth at which the offshore contours first become shore parallel. From recent charts, the 12-foot contour is somewhat irregular and the 18-foot contour is substantially shore parallel. Therefore, the 18-foot contour is the first one that is substantially shore parallel. A second method is to find the depth where beach profiles intersect offshore, when examining successive surveyed profiles. In the Martin County study area, this depth varies between 10 to 15 feet of water where the profile lines extend seaward enough to make this determination. These last two results define the long term limiting depth. This would be the depth at which waves, currents, and storms could cause substantial sediment movement in a 10- to 100-year time frame. The findings of this analysis provides guidance to select borrow sites in at least 20.0 feet of water, but consideration must be also given to selecting deeper depths to decrease long-term effects due to borrow sites acting as sand traps. This limiting depth does not apply to the use of shallow shoals around inlets for borrow sources since the inlet process itself is a sink.

The borrow site selected in this report for Hutchinson Island is in waters generally deeper than 23 feet. The selection of a limit depth precludes effecting the longshore littoral drift with a sink and creating a zone whereby waves or currents can increase local erosion rates.

COST ESTIMATES

25. Cost estimates for the considered beach fill alternatives are based on June 1985 price levels. Each estimate includes 25 percent for project contingencies and 15 percent for engineering and design, supervision and administration of the project. The beach fill material would be moved from the borrow area to the project area by a hydraulic dredge, either pipeline or hopper type. The estimated time from the start of engineering and design to construction completion is estimated at 18 months, except for those beach fill requiring two mobilization/demobilization for construction. A network diagram showing details of engineering, design, and construction is included in this appendix as plate 2.

26. Both pipeline and hopper type dredges were considered to be feasible methods of construction. With estimated mobilization costs of $1 million and a price per cubic yard of $5.80, the hopper dredge (or hopper barge) was determined to be more economical than the mobilization costs of $1.3 million * and the $6.20 per cubic yard costs of the pipeline dredge. Therefore, the use of a pipeline dredge was not considered further. The cost estimates for construction of various size beach fills utilizing a hopper barge are based on (a) use of a monobuoy located 3,000 feet offshore of the fill area; (b) no booster pumps; (c) average travel distance from borrow area to buoy of 2.5 miles; (d) maximum pipeline length of 18,000 feet; (e) hopper barge with an average load of 8,350 cubic yards. Costs for the various beach fills included the cost of fill placement and monitoring. Table 3 summarizes the estimated first and annual costs for the 3.3-, 10-, 40-, and 59-year level of protection beach fill plans.

27. The costs in table 3 were determined for comparison and evaluation and are based upon mobilization/demobilization costs of $1.0 million plus $12,000 for monitoring and $5.80 per cubic yard of fill placed. Contingency costs (25%) and engineering, design, supervision, and administration costs (15%) are also added. The total cost for placement of a given fill would be computed as follows:

Total initial cost of construction = ($5.80 Q + $12,000 + $1,000,000 + $20,000 + $28,800 + $27,500)(1.25)(1.15), where Q is the quantity of fill placed. A sample calculation of the first and annual cost of the 40-year, 4-mile beach fill with 8-year nourishment is displayed in table 4. As indicated by the foot note to table 4, additional costs for establishment of the * Erosion Control Line, relocating turtle eggs and for land easements and rights-of-way, would be added to all alternatives for total costs.

TABLE 3

SUMMARY - COST ESTIMATES
4-MILE BEACH FILL ALTERNATIVE (X 1000)

DESIGN LEVEL (YR)	NOURISHMENT INTERVAL (YR)	INITIAL 1/ VOLUME (CU.YD.)	RENOURISHMENT 1/ VOLUME (CU. YD.)	INITIAL COST ($)	RENOURISHMENT COST ($)	ANNUAL COST ($)	
						8 3/8%	8 5/8%
3.3	2	212	122	3,223	2,472	1,461	1,467
	5	395	305	4,749	3,999	1,075	1,089
	8	578	488	6,275	5,525	1,046	1,056
	15	1,004	914	9,828	9,078	1,159	1,177
10	2	366	122	4,507	2,472	1,570	1,580
	5	549	305	6,033	3,999	1,184	1,202
	8	732	488	7,560	5,525	1,156	1,169
	15	1,158	914	11,113	9,078	1,269	1,290
40	2	576	122	6,259	2,472	1,720	1,734
	5	759	305	7,785	3,999	1,334	1,355
	8	942	488	9,311	5,525	1,305	1,322
	15	1,368	914	12,864	9,078	1,418	1,444
59	2	730	122	7,453	2,472	1,829	1,838
	5	913	305	9,069	3,999	1,443	1,468
	8	1,096	488	10,595	5,525	1,415	1,435
	15	1,522	914	14,148	9,078	1,528	1,556

1/From table 2, appendix 4.

TABLE 4
ESTIMATED COSTS
RECOMMENDED PLAN (PLAN S-2A)
40-YEAR DESIGN
JUNE 1985 PRICE LEVELS

Item	Quanity & Unit	Unit Cost	Total
Mobilization & Demobilization	Lump Sum		$1,000,000
Beach Fill (includes advance nourishment)	942,000 cu. yds.	5.80 per cu. yd.	5,464,000
Establish the ECL	Lump Sum		20,000*
Monitoring	Lump sum		12,000
Relocation of Turtle Eggs	Lump sum		28,800*
Lands, Easements and Rights-of-way	Lump sum		27,500*
SUBTOTAL			$6,552,300
Contingencies	25%		1,638,100
SUBTOTAL			$8,190,400
Engineering & Design Supervision & Administration	15%		1,228,600
TOTAL FIRST COST			$ 9,419,000 1/
Interest During Construction			102,000*
TOTAL INVESTMENT			$ 9,521,000

ESTIMATED ANNUAL COST 2/

Item	Annual Cost
Interest and Amorization ($9,521,000 @ 8 5/8%)	$834,500
Periodic Nourishment (488,000 cy @ 8-yr interval)	505,800
Project Monitoring (included in above)	-
TOTAL	$1,340,300

1/ The difference in first costs (versus that shown on page 14, table 3) is due to the additional costs for: establishment of the Erosion Control Line, relocating turtle eggs, and land costs. Table 3 compares alternatives on an equal basis without these additional costs, which would increase the costs for all alternatives equally.

2/ Annual operation and maintenance costs for recreation, of $60,500, are not shown because they were netted out in calculation of recreation benefits.

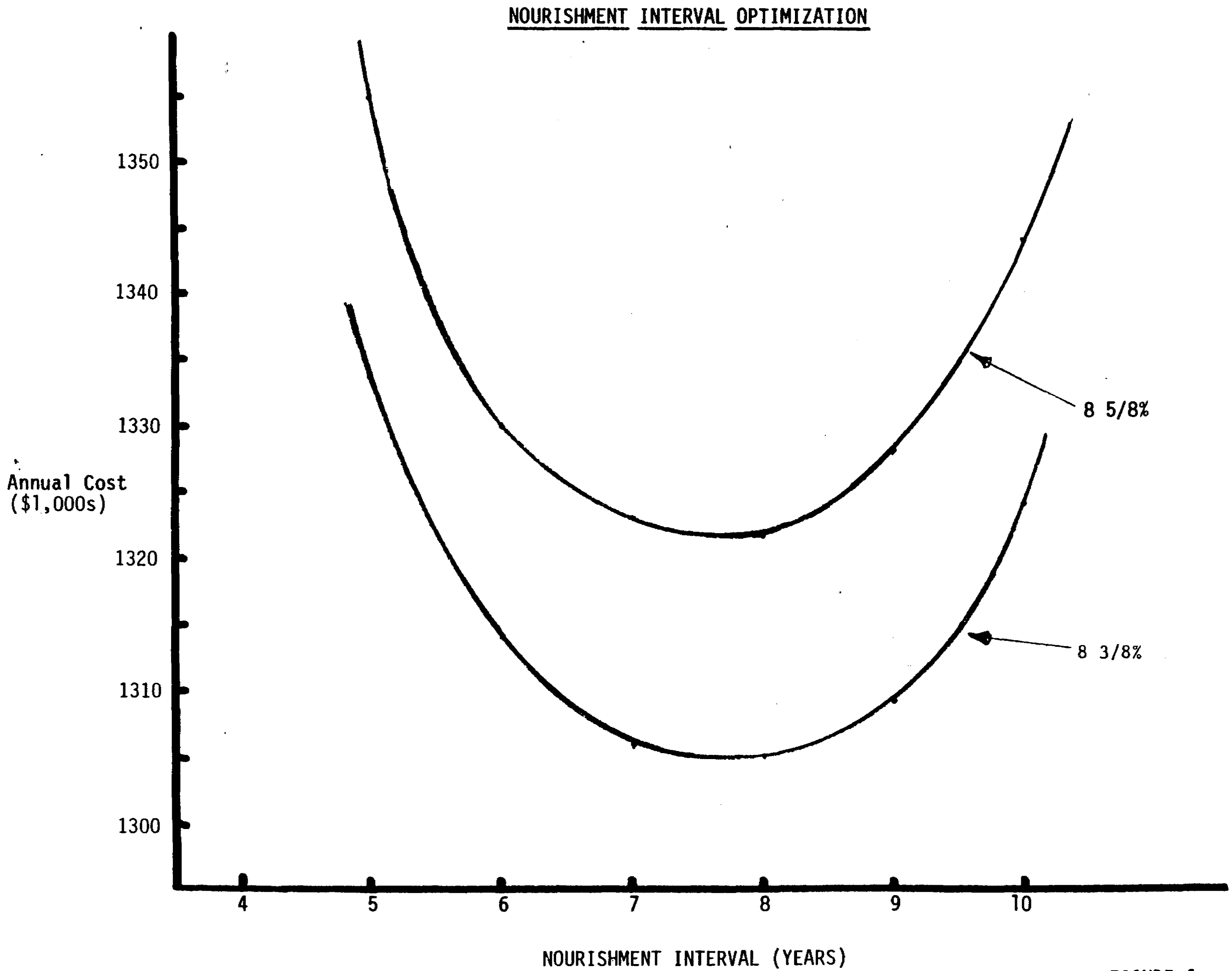
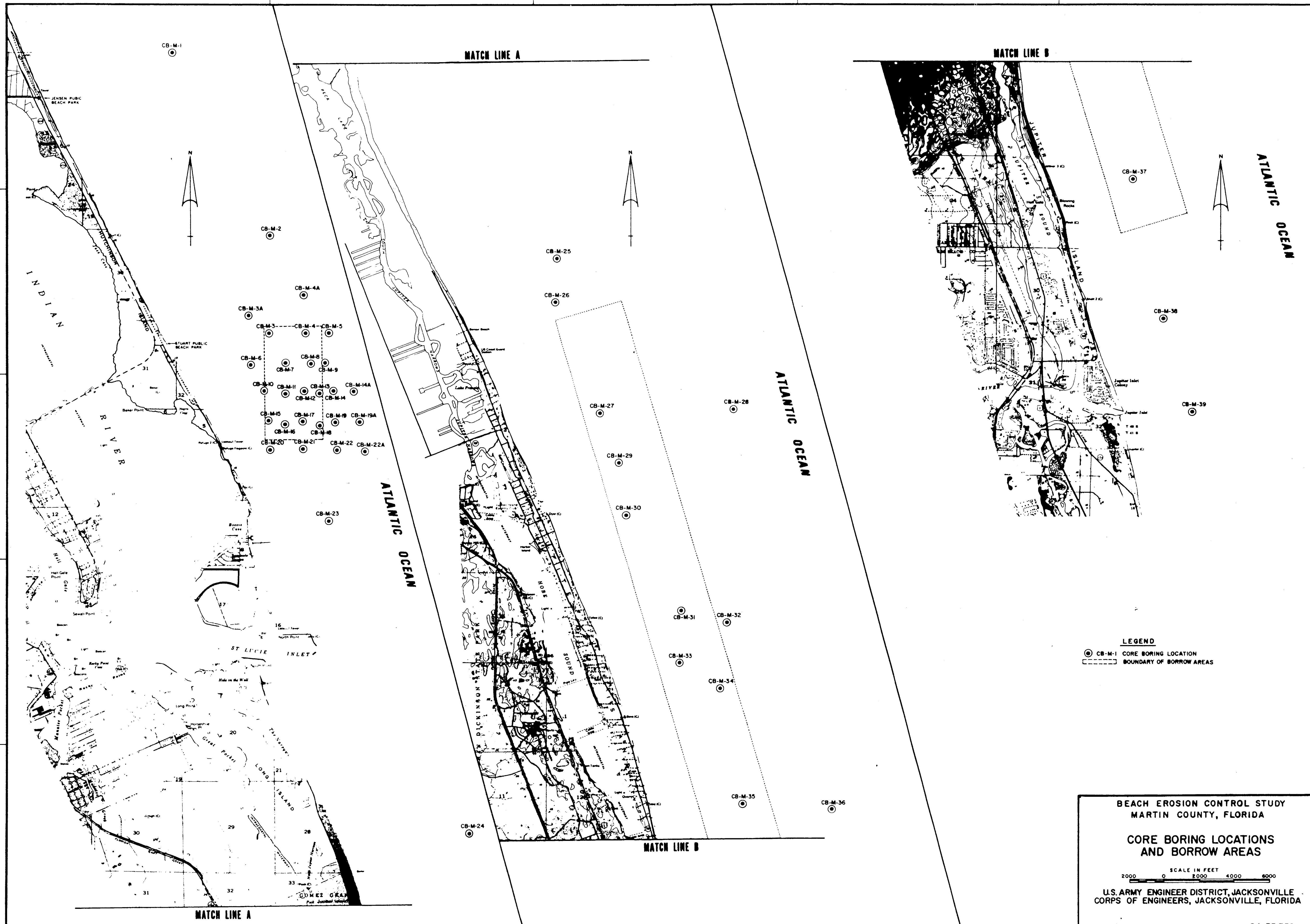

NOURISHMENT INTERVAL OPTIMIZATION
Annual Cost ($1,000s)
1350
1340
1330
1320
1310
1300
4
5
6
7
8
9
10
NOURISHMENT INTERVAL (YEARS)
8 5/8%
8 3/8%

FIGURE 6

28. The nourishment material was optimized to reduce annual costs. Cost estimates for nourishment rates from 2 to 15 years are displayed in table 3. As an example, the nourishment interval optimization for the 40-year protection beach fill plan is graphically displayed in figure 6, for 8 3/8% and 8 5/8% interest rates. The difference between the annual costs for nourishment material from 7 to 9 years is negligible. The 8-year nourishment interval was selected for use in determining the plan which generates the maximum amount of NED benefits (see economics appendix).

29. Project Monitoring. The project performance will be monitored following construction to collect design data for improving the economic and engineering efficiency of future nourishment operations. Monitoring will consist of surveys of the beach profiles and other engineering and environmental data collection. The cost of monitoring is included as part of project cost as shown in table 3.



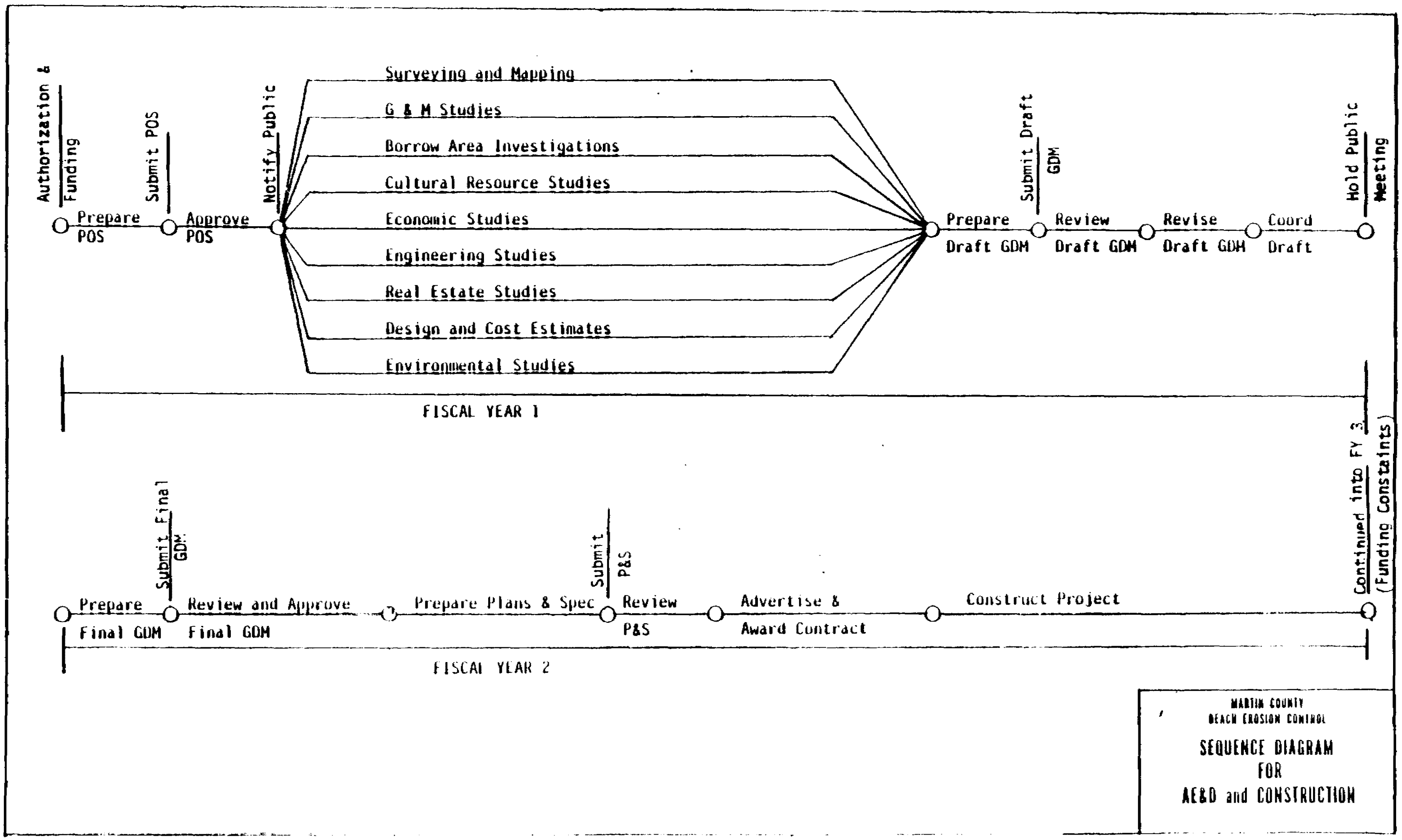
BEACH EROSION CONTROL STUDY
MARTIN COUNTY, FLORIDA

CORE BORING LOCATIONS
AND BORROW AREAS

SCALE IN FEET
2000 0 2000 4000 6000

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

24-33,359



MARTIN COUNTY
BEACH EROSION CONTROL

SEQUENCE DIAGRAM
FOR
AE&D and CONSTRUCTION

PLATE 2

APPENDIX 4

SUBAPPENDIX A

Records of Subsurface Investigations for
Offshore Borrow Areas and Grain Size Analysis

Hole No. CB-M-7

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Jacksonville District	SHEET 1 OF 1 SHEETS

1. PROJECT Martin County Beach Erosion Control	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station) X=774,957 Y=1,047,266	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY Corps of Engineers	12. MANUFACTURER'S DESIGNATION OF DRILL Vibracore
4. HOLE NO. (As shown on drawing title and file number) CB-M-7	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN DISTURBED UNDISTURBED
5. NAME OF DRILLER R. Gordon	14. TOTAL NUMBER CORE BOXES 1
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER Tidal
7. THICKNESS OF OVERBURDEN	16. DATE HOLE STARTED 2 Jun 78 COMPLETED 2 Jun 78
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE -23.0
9. TOTAL DEPTH OF HOLE 19.9'	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR Geologist: D. Rosen

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
-23.0	0.0					-23.0
			SAND, medium to coarse, shell. (SP)		1	BIT OR BARREL VIBRACORE
-32.6	9.6		SAND, very fine to medium, slightly shelly, slightly silty. (SP-SM)		2	
-37.5	14.5		SAND, medium to coarse, shell. (SP)		3	
-42.9	19.9					-42.9

Hole No. CB-M-8

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Jacksonville District	SHEET 1 OF 1 SHEETS

1. PROJECT Martin County Beach Erosion Control	10. SIZE AND TYPE OF BIT NA
2. LOCATION (Coordinates or Station) X=776,474 Y=1,047,154	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY Corps of Engineers	12. MANUFACTURER'S DESIGNATION OF DRILL Vibracore
4. HOLE NO. (As shown on drawing title and file number) CB-M-8	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER R. Gordon	14. TOTAL NUMBER CORE BOXES 1
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER Tidal
	16. DATE HOLE STARTED 7 Jun 78 COMPLETED 7 Jun 78
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE -36.0
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 9.8'	19. SIGNATURE OF INSPECTOR Geologist: D. Rosen

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
						BIT OR BARREL
-36.0	0.0		SAND, fine to medium sand, shelly, slightly silty. (SP-SM)		1	-36.0 VIBRACORE
-45.6	9.6		LIMESTONE, medium, sandy.			
-45.8	9.8					-45.8

Hole No. CB-M-16

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Jacksonville District	SHEET OF 1 SHEETS

1. PROJECT Martin County Beach Erosion Control	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station) X=774,914 Y=1,043,630	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY Corps of Engineers	12. MANUFACTURER'S DESIGNATION OF DRILL Vibracore
4. HOLE NO. (As shown on drawing title and file number) CB-M-16	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER R. Gordon	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER Tidal
	16. DATE HOLE — STARTED 6 Jun 78 — COMPLETED 6 Jun 78
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE -36.5
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING
9. TOTAL DEPTH OF HOLE 6.1'	19. SIGNATURE OF INSPECTOR Geologist: D. Rosen

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
						BIT OR BARREL
-36.5	0.0					-36.5
-38.2	1.7		SAND, coarse, shell, slightly silty, sandy, light gray. (SP)		1	VIBRACORE
-39.9	3.4		SAND, very fine to medium, SAND, very fine to medium, shelly, gray. (SM)		2	
-41.2	4.7		SHELL, Limestone, pebbles, silty, sandy (SP)			
-41.3	4.8		LIMESTONE, pebbles, silty, sandy, ferous.			
-42.6	6.1		LIMESTONE, very sandy, silty, friable with hard LIMESTONE, pebbles.			-42.6

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT Martin County Beach Erosion Control — HOLE NO. CB-M-16

Hole No. CB-M-17

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Jacksonville District	SHEET 1 OF 1 SHEETS
1. PROJECT Martin County Beach Erosion Control		10. SIZE AND TYPE OF BIT 3"	
2. LOCATION (Coordinates or Station) X=775,370 Y=1,043,347		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL	
3. DRILLING AGENCY Corps of Engineers		12. MANUFACTURER'S DESIGNATION OF DRILL Vibracore	
4. HOLE NO. (As shown on drawing title and file number) CB-M-17		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER R. Gordon		14. TOTAL NUMBER CORE BOXES 1	
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.		15. ELEVATION GROUND WATER Tidal	
		16. DATE HOLE	STARTED 3 Jun 78 / COMPLETED 3 Jun 78
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE -28.0	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE 16.3'		19. SIGNATURE OF INSPECTOR Geologist: D. Rosen	

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
-28.0	0.0					BIT OR BARREL -28.0
			SAND, alternate between medium to coarse shell and fine to medium sand. (SP-(SP)		1	VIBRACORE
-42.1	14.1					
-42.8	14.8		SAND, medium coarse shell, (SM), gray.		2	
-44.3	16.3		SAND, fine to medium, tan, slightly shelly. (SP-SM)			-44.3

Hole No. CB-M-27

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Jacksonville District	SHEET 1 OF 1 SHEETS

1. PROJECT Martin County Beach Erosion Control	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station) X=793,220 Y=995,047	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY Corps of Engineers	12. MANUFACTURER'S DESIGNATION OF DRILL Vibracore
4. HOLE NO. (As shown on drawing title and file number) CB-M-27	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED / UNDISTURBED
5. NAME OF DRILLER R. Gordon	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER Tidal
	16. DATE HOLE — STARTED 4 Jun 78 — COMPLETED 4 Jun 78
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE -30.0
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 11.9'	19. SIGNATURE OF INSPECTOR Geologist: J. Rosen

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
						BIT OR BARREL
-30.0	0.0					-30.0
			SAND, gray, fine, slightly silty. (SP-SM)			VIBRACORE
					1	
			Shelly below depth 7.5'.			
					2	
-41.9	11.9					-41.9

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PROJECT Martin County Beach Erosion Control HOLE NO. CB-M-27

Hole No. CB-M-31

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET 1 OF 1 SHEETS

1. PROJECT: Martin County Beach Erosion Control	10. SIZE AND TYPE OF BIT: NA
2. LOCATION (Coordinates or Station): X=797,921 Y=963,497	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
3. DRILLING AGENCY: Corps of Engineers	12. MANUFACTURER'S DESIGNATION OF DRILL: Vibracore
4. HOLE NO. (As shown on drawing title and file number): CB-M-31	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER: R. Gordon	14. TOTAL NUMBER CORE BOXES: 1
6. DIRECTION OF HOLE: [x] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER: Tidal
	16. DATE HOLE: STARTED 5 Jun 78; COMPLETED 5 Jun 78
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE: -29.9
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING: %
9. TOTAL DEPTH OF HOLE: 9.8'	19. SIGNATURE OF INSPECTOR: Geologist: D. Rosen

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
						BIT OR BARREL
-29.9	0.0					-29.9
			SAND, gray, fine, quartz. (SP) - (SM)			
-39.7	9.8					-39.7

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: Martin County Beach Erosion Control | HOLE NO. CB-M-31

Hole No. CB-M-38

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET 1 OF 1 SHEETS

1. PROJECT: Martin County Beach Erosion Control
2. LOCATION (Coordinates or Station): Y=904,050 Y=955,300
3. DRILLING AGENCY: Corps of Engineers
4. HOLE NO. (As shown on drawing title and file number): CB-M-38
5. NAME OF DRILLER: R. Gordon
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE: 10.9'
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Vibracore
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER: Tidal
16. DATE HOLE: STARTED 7 Jun 78 / COMPLETED 7 Jun 78
17. ELEVATION TOP OF HOLE: -33.0
18. TOTAL CORE RECOVERY FOR BORING
19. SIGNATURE OF INSPECTOR: Geologist: D. Rosen

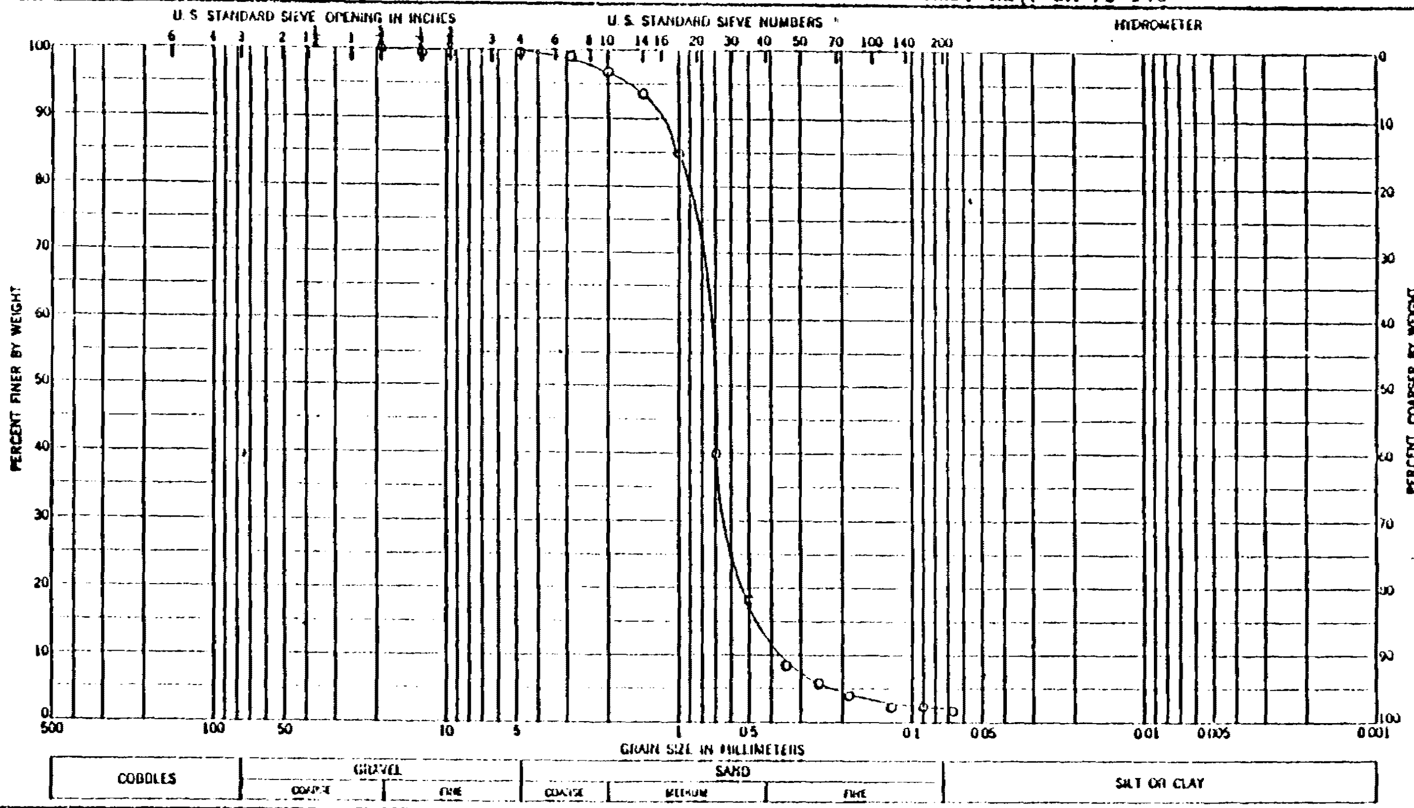
ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
						BIT OR BARREL
-33.0	0.0					-33.0
			SAND, gray, fine, quartz. (SP) - (SM)		1	VIBRACORE
-43.9	10.9					-43.9

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: Martin County Beach Erosion Control | HOLE NO. CB-M-38

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

Req. No. 08-123-ENG-149-78
REF. REQ. GH-78-140



Sample No.	Depth	Visual Classification	Nat w %	LL	PL	PI
1	0.0-9.6'	Gray poorly graded sandy shell (SP). Approximately 60% shell	-	-	-	-

Project: Jacksonville District
Martin County B.E.C.
Lab No. 73/8718

Area: --

Boring No. CB-M-7, Sample No. 1

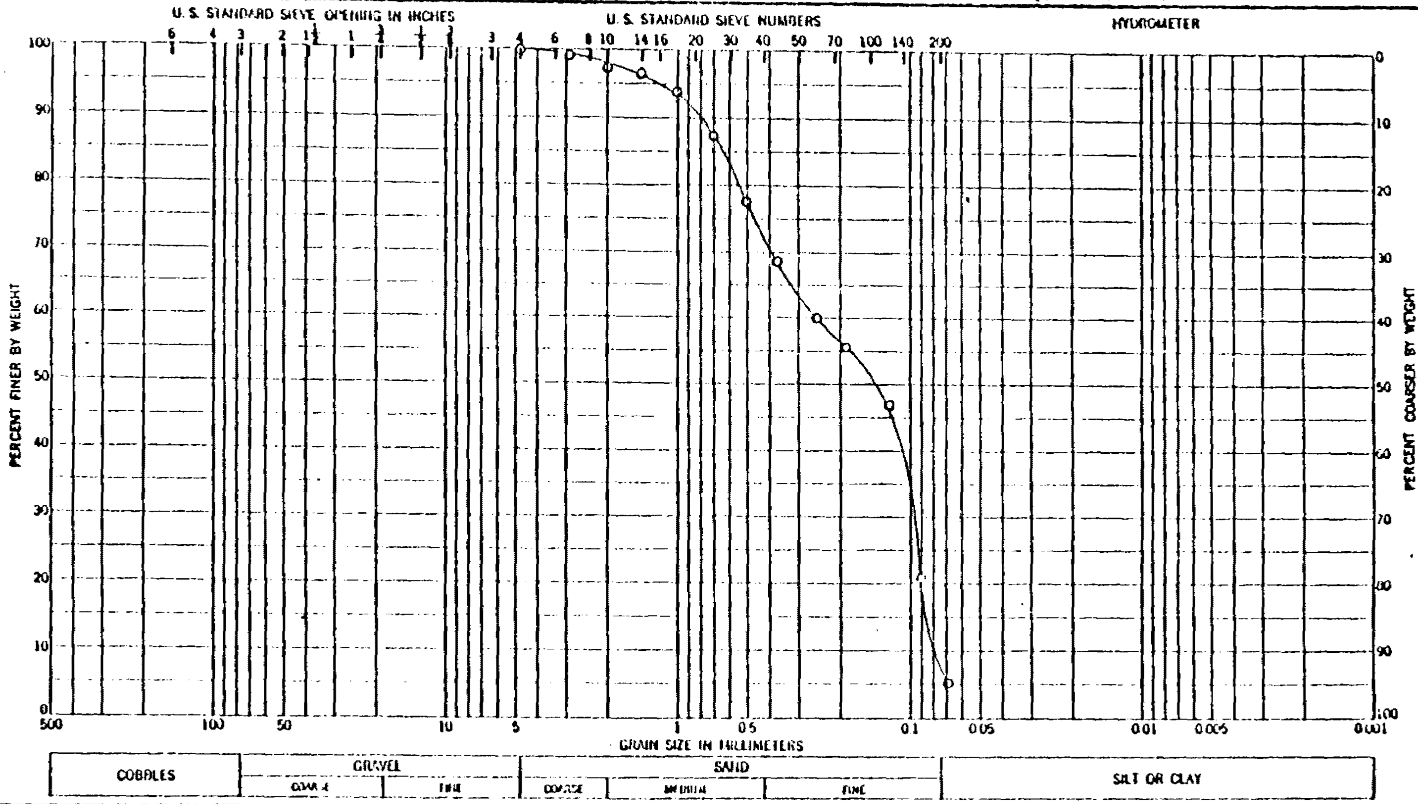
Date: 1 August 1978

GRADATION CURVES

ENG FORM 1 MAY 63 2087

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

Req. No. 08-123-ENG-149-78
REF. REQ. GM-78-140



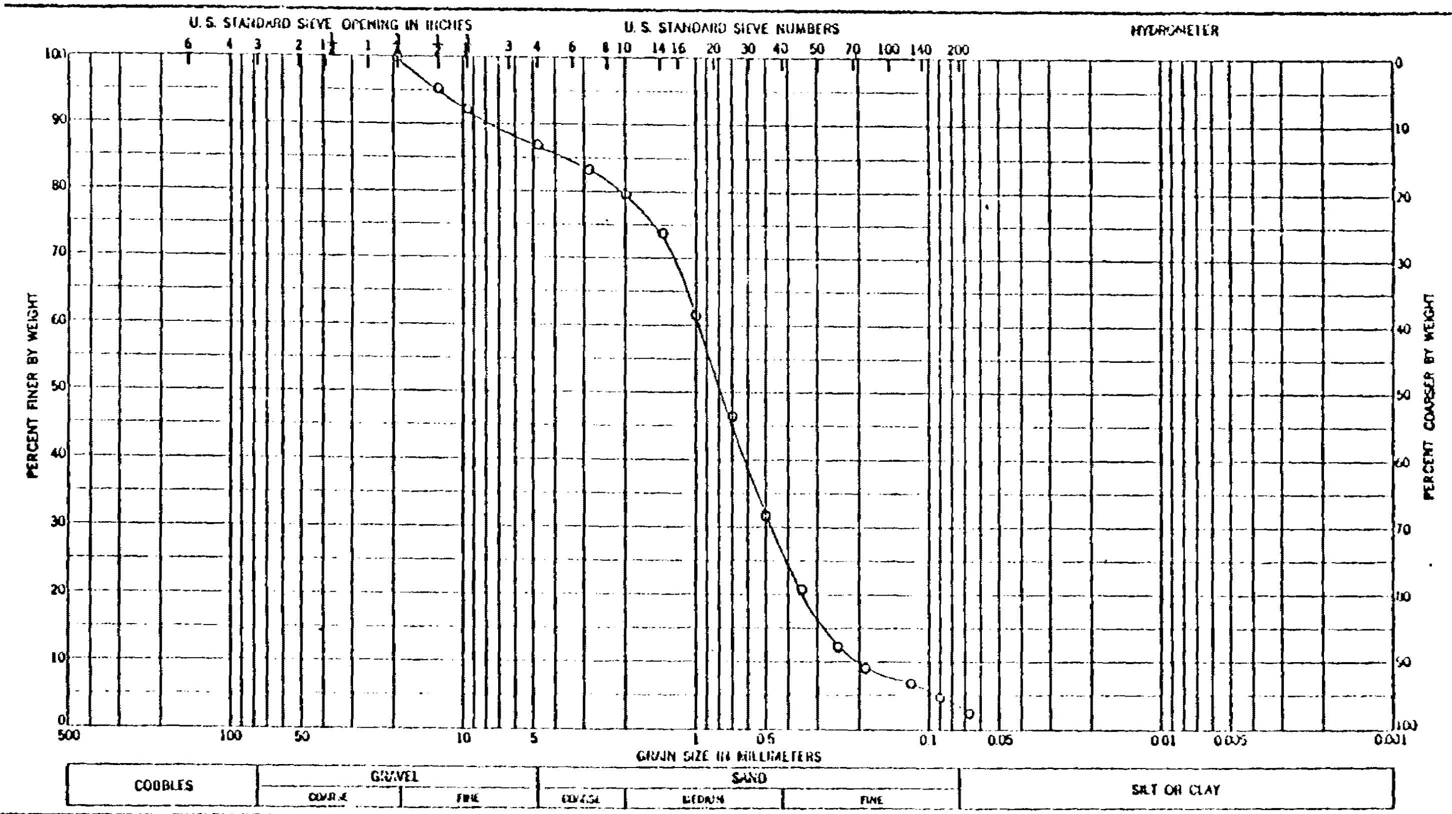
Sample No.	Boring Depth	Visual Classification	Nat w %	LL	PL	PI
1	0.0-9.8'	Gray poorly graded silty sand (SP-SM) with a trace of shell. Approximately 10% shell.	-	-	-	-

Jacksonville District
Project Martin County B.E.C.
Lab No. 73/8721
Area --
Boring No. CB-M-8, Sample No. 1
Date 1 August 1978

GRADATION CURVES

ENG FORM 1 MAY 63 2087

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061 Req. No. 08-123-ENG-149-78



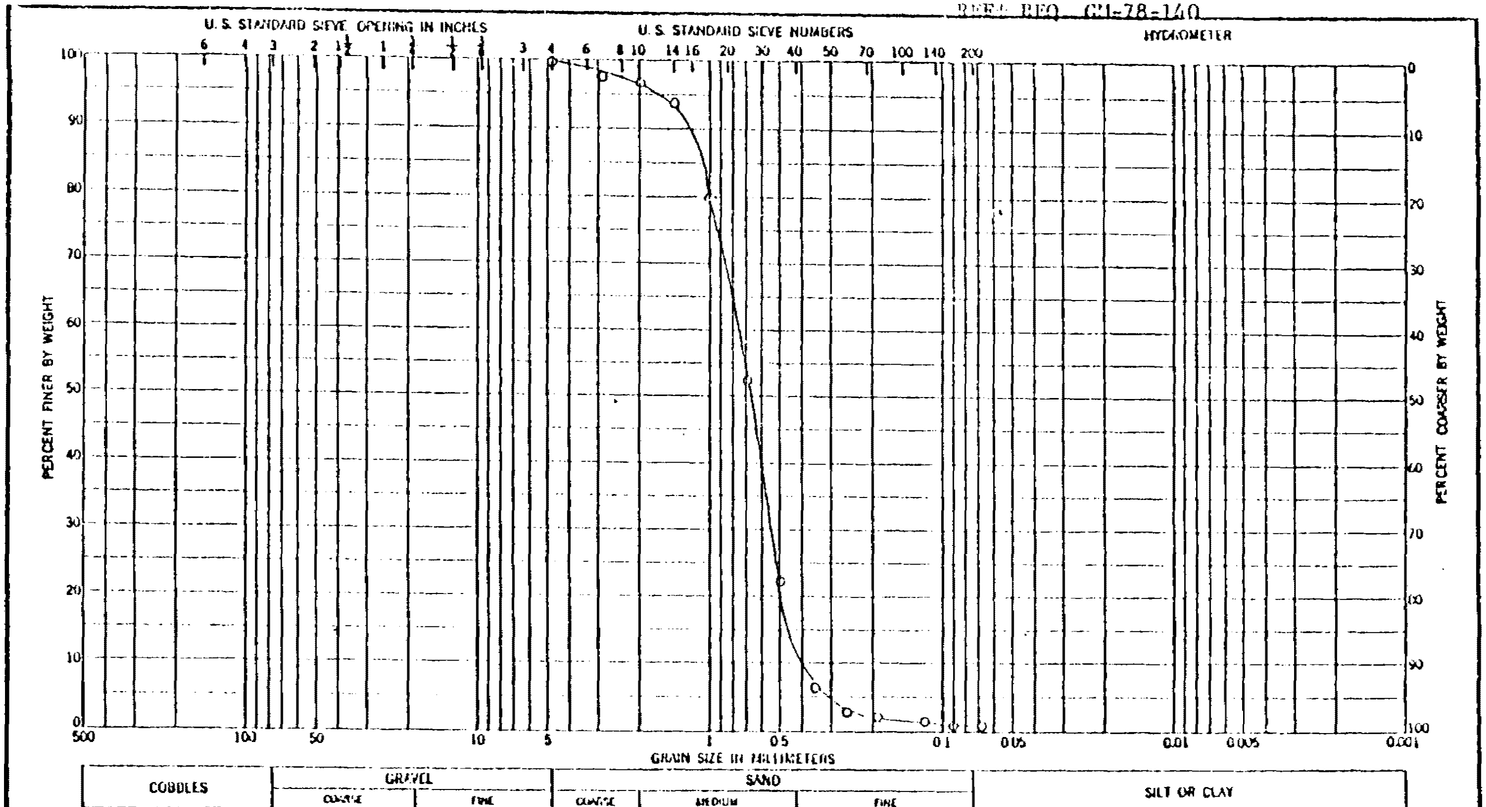
Sample No.	XXXX or Depth	Visual Classification	Nat w %	LL	PL	PI
1	0.0-1.7 '	Gray poorly graded shelly sand (SP). Approximately 40% shell	-	-	-	-

Jacksonville District
Project Martin County B.E.C.
Lab No. 73/8731
Area --
Boring No. CB-M-16-, Sample No. 1
Date 1 August 1978

GRADATION CURVES

ENG FORM 1 MAY 63 2087

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION ENGINEERS
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30061 Req. No. 08-123-ENG-149-78
REF: REQ. CM-78-140



Sample No.	Depth	Visual Classification	Nat w %	LL	PL	PI
1	0.0-14.1'	Gray poorly graded shelly sand (SP). Approximately 40% shell.	-	-	-	-

Project: Jacksonville District
Martin County B.E.C.
Lab No. 73/8733

Area: --

Boring No. CB-M-17, Sample No. 1

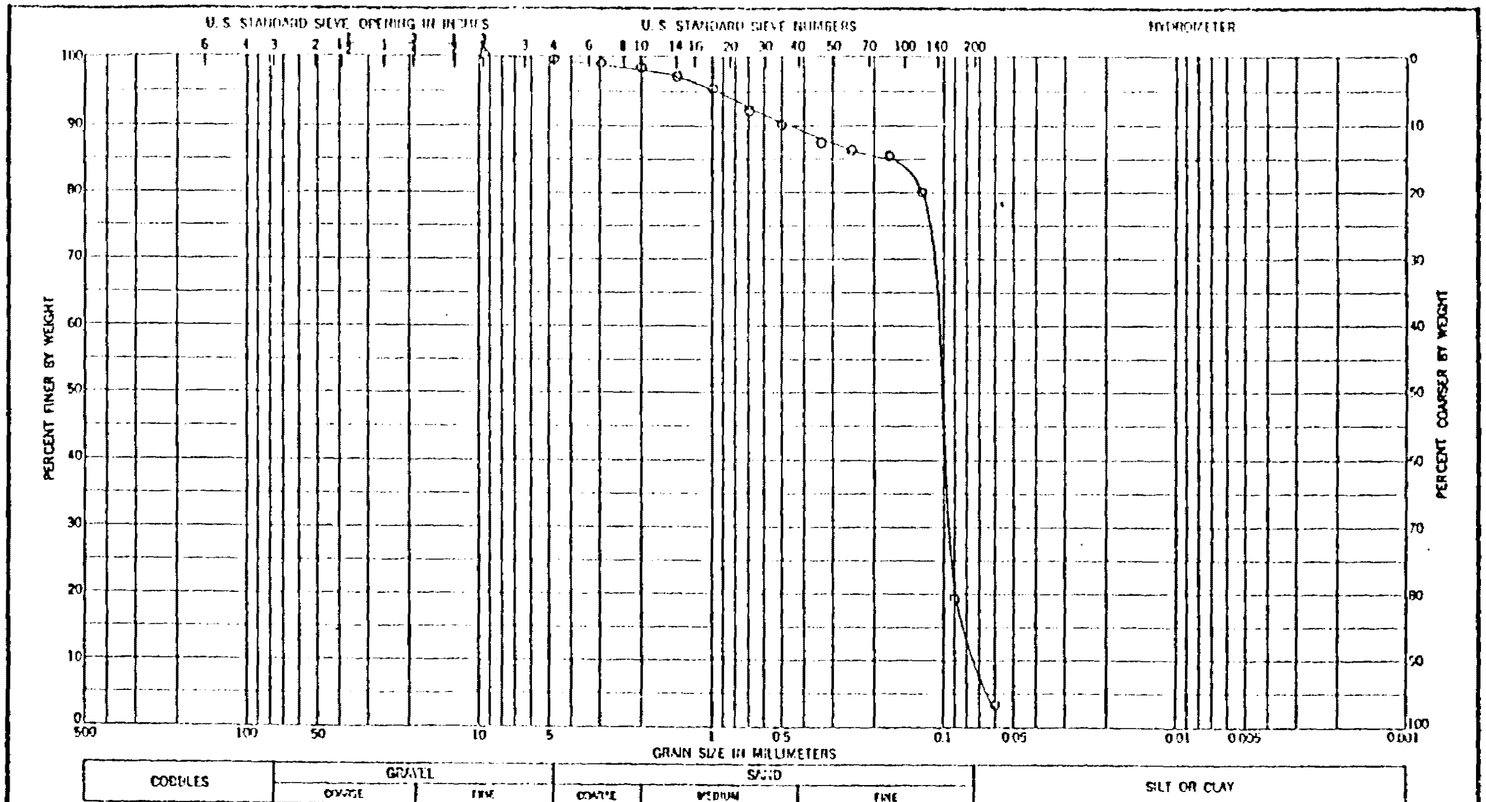
Date: 1 August 1978

GRADATION CURVES

ENG FORM 1 MAY 63 2087

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

WORK ORDER NO. 1384
Req. No. 08-123-ENG-143-78



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
1	0.0-7.5	Gray poorly graded silty sand (SP-SM) with a little shell fragments Shell approximately 13%.	-	-	-	-

Project: Jacksonville District
Martin County, FLA.
Lab No. 73/8658

Area: --

Boring No. CB-M-27, Sample No. 1

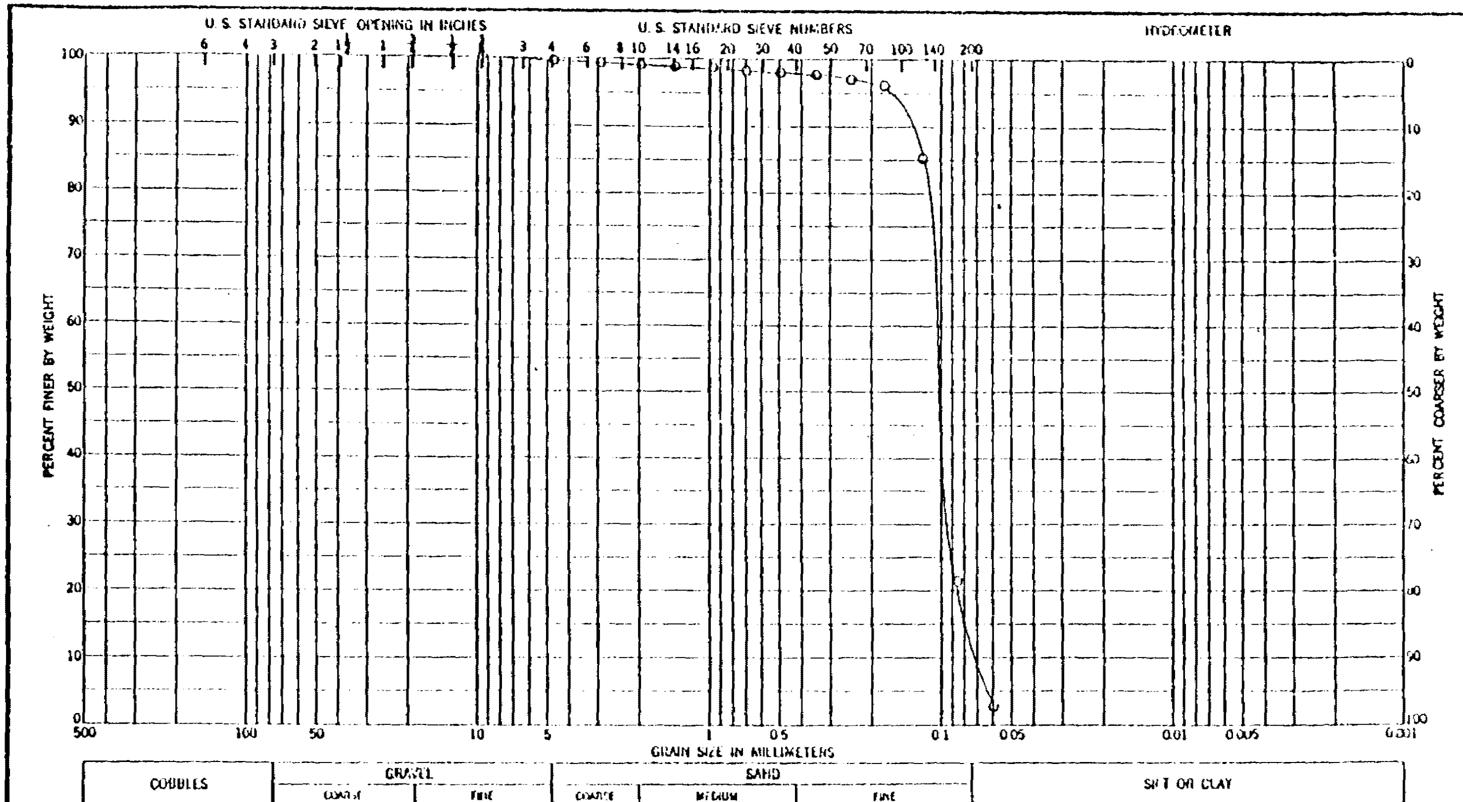
Date: 31 July 1978

GRADATION CURVES

ENG FORM 1 MAY 63 2087

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

WORK ORDER NO. 1314
Req. No. 08-123-ENG-143-78



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
1	0.0-9.8'	Gray poorly graded silty sand (SP-SM) with a trace of shell fragments. Shell approximately 2%.	-	-	-	-

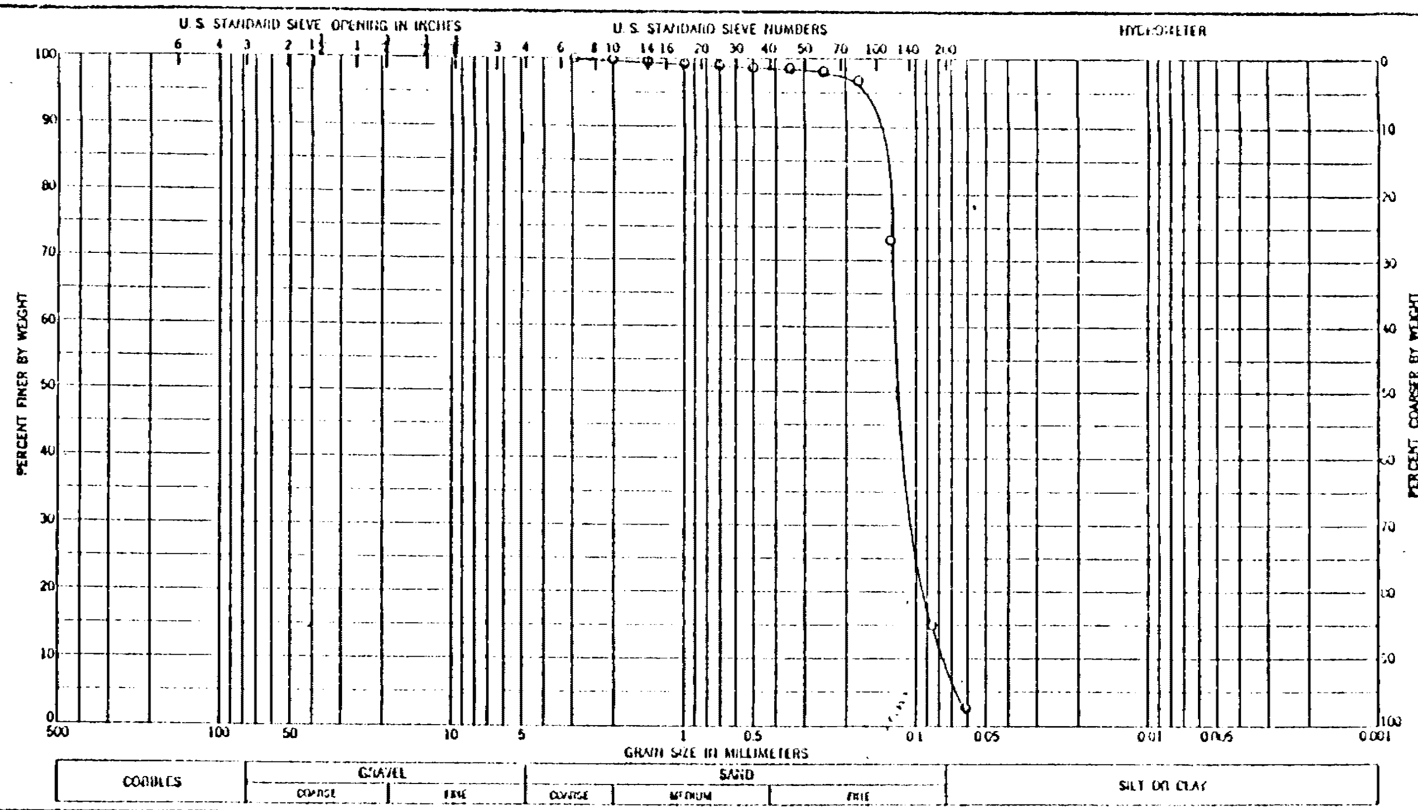
Jacksonville District
Project Martin County, FLA.
Lab No. 73/8663
Area --
Boring No. CB-M-31, Sample No. 1
Date 31 July 1978

GRADATION CURVES

ENG FORM 1 MAY 63 2087

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

Work Order No. [illegible]
Req. No. 08-123-ENG-143-78



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
1	0.0-10.9	Gray poorly graded silty sand (SP-SM) with a trace of shell fragments. Shell approximately 2%.	-	-	-	-

Project Jacksonville DIvision
Martin County, FLA.
Lab No. 73/8669

Area --

Boring No. CB-M-38, Sample No. 1

Date 31 July 1978

GRADATION CURVES

ENG FORM 1 MAY 63 2087

APPENDIX 5

ECONOMICS

APPENDIX 5

ECONOMICS

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MARTIN COUNTY, FLORIDA
BEACH EROSION CONTROL STUDY

APPENDIX 5

ECONOMICS

1. GENERAL. The tangible economic justification of the considered plan for beach fill can be ascertained by comparing the equivalent average annual charges (i.e., interest and amortization on initial costs, and maintenance costs) with an estimate of the equivalent average annual benefits which would be realized over the 50-year period of analysis. Computed damages and costs are based on June 1985 price levels. *

2. The value given to benefits and costs at their time of accrual are comparable by conversion to an equivalent time basis using an appropriate interest rate. A directed rate of 8 5/8 percent applicable to public projects was used for the economic analyses of plans presented in this report. It was necessary to evaluate the existing conditions as well as the considered project conditions with respect to carrying capacity for recreational use and erosion damage prevention.

3. The development of costs and benefits follows standard Corps of Engineers practice. The value of all goods and services used in the project is estimated on the cost side. On the benefit side, storm damages prevented and recreational values created are estimated. The development of damages prevented is based on the frequency of anticipated erosion damage that would occur with and without the project implemented. Modifications in this data, introduced by project effects, permit the computation of annual benefits.

BENEFITS

4. General. The average annual economic benefits derived for the project are based upon restoration and preservation of the recreational resource provided by the carrying capacity of the beach fill and protection of the existing structures and upland development. Estimates of recreational benefits are based upon the analysis of the demand for beach use along the project area through the travel cost methodology presented in the following section of this appendix. Benefits attributed to the considered plans are based upon the evaluation of the projected carrying capacity during project life and that of the existing conditions utilizing the current erosion rate. The estimates of damage prevention benefits are based upon an August 1984 real estate appraisal of property and development values by the Jacksonville District.

RECREATION BENEFITS

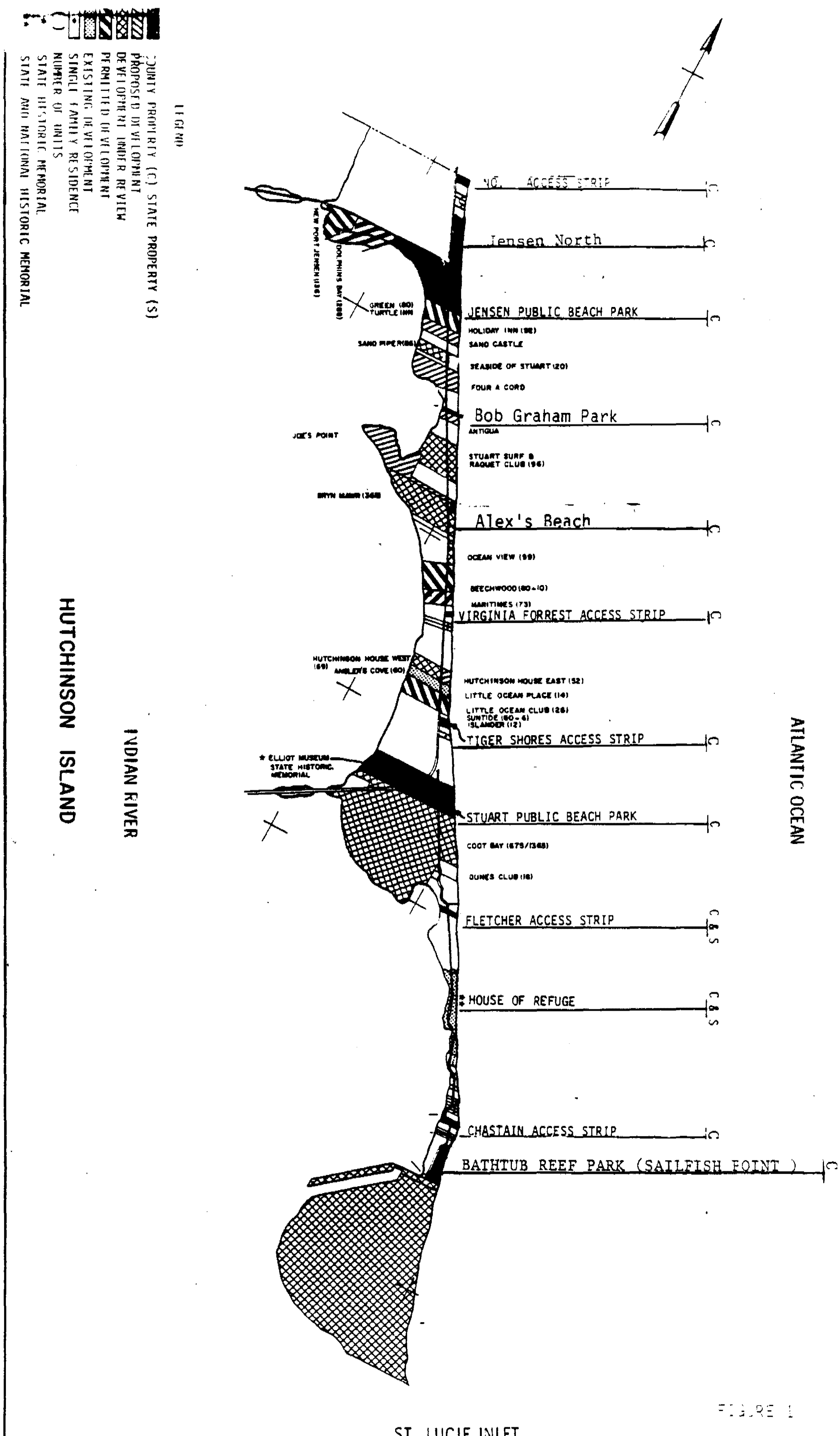
5. INTRODUCTION. The estimated recreational benefits attributable to the project were determined using procedures based on those prescribed in the Principals and Guidelines developed by the Water Resources Council and published 10 March 1983.

6. The methodology used in estimating recreation benefits entails determining the total beach visits to Martin County beaches under two different conditions, "With and Without" the project (selected plan) implemented. The difference of the results of the two analyses establishes beach visitors attributable to the considered works. The with-project condition is determined for the final array of alternative plans to determine the National Economic Development (NED) Plan. The without-project condition is determined from surveyed conditions and modified to reflect what would likely happen in the absence of a project. The without project is compared to the with project condition in the analysis of benefits for the selected plan. Recreation benefits attributable to the considered works were determined by applying a value determined by the travel cost method to the visits attributable to the new beach.

7. STUDY AREA. As related to analysis of recreation benefits the principal study area is Martin County; however, visitors from Port St. Lucie in St. Lucie County are included as are vistiors from other counties in Florida and out of state that recreate in Martin County. Out-of-state visitors to the county beaches are generally from the eastern and central parts of the United States and other countries. The specific study area extends south along the Atlantic coast of Martin County from the St. Lucie/Martin county line, to the Martin/Palm Beach County line. Plate 2 of the Main Report illustrates the study area.

8. RECREATIONAL RESOURCE. The beaches of Martin County are an important recreational resource to Florida. All recreational beach area in Martin County was included to determine the interactive influence of the total county demand for beach use on the project area. Accessibility to the project area beach is based on location of designated access points, available public parking, available facilities to accommodate walk-on visitors, and the distance a beach visitor could be expected to walk to enjoy an uncrowded area of beach. Public accesss to the project shorefront is designated on Figure 1. It is assumed that visitors arriving by car are willing to walk up to 1/4 mile from an access point to recreate at the beach.

9. Public Access to the Shorefront. Access to the shorefront south of the St. Lucie/Martin County line is predominately by car. The major routes to the shorefront are State Highways 707 and 1 from Port St. Lucie and State Road A1A from the north and west to the Jensen Beach Causeway and Stuart Causeway which run west to east. There are twelve designated access points that consist of land parcels purchased by Martin County along the shorefront from the north county line south to St. Lucie Inlet as indicated on figure 1. The average spacing of access points along the shorefront is .55 mile north of Stuart Public Beach. Access to the public access south of St. Lucie Inlet on Jupiter Island at Jupiter Beach is via Route 707.



LEGEND
COUNTY PROPERTY (C) STATE PROPERTY (S)
PROPOSED DEVELOPMENT
DEVELOPMENT UNDER REVIEW
PERMITTED DEVELOPMENT
EXISTING DEVELOPMENT
SINGLE FAMILY RESIDENCE
NUMBER OF UNITS
STATE HISTORIC MEMORIAL
STATE AND NATIONAL HISTORIC MEMORIAL
HUTCHINSON ISLAND
INDIAN RIVER
ATLANTIC OCEAN
NO. ACCESS STRIP
Jensen North
JENSEN PUBLIC BEACH PARK
HOLIDAY INN (92)
SAND CASTLE
SEASIDE OF STUART (20)
FOUR A CORD
Bob Graham Park
ANTIGUA
STUART SURF & RAQUET CLUB (96)
JOE'S POINT
Alex's Beach
OCEAN VIEW (99)
BEECHWOOD (80+10)
MARITIMES (73)
VIRGINIA FORREST ACCESS STRIP
HUTCHINSON HOUSE WEST (69)
ANGLER'S COVE (60)
HUTCHINSON HOUSE EAST (52)
LITTLE OCEAN PLACE (14)
LITTLE OCEAN CLUB (26)
SUNTIDE (60+6)
ISLANDER (12)
TIGER SHORES ACCESS STRIP
ELLIOT MUSEUM STATE HISTORIC MEMORIAL
STUART PUBLIC BEACH PARK
COOT BAY
DUNES CLUB (18)
FLETCHER ACCESS STRIP
HOUSE OF REFUGE
CHASTAIN ACCESS STRIP
BATHTUB REEF PARK (SAILFISH POINT)
ST. LUCIE INLET

FIGURE 1

10. Available Parking. Total available public parking within the limits of the selected plan is sufficient for 1,205 cars, considering a parking space to be 10 feet wide by 20 feet in length. Assuming a daily turnover rate of two with four persons per car, the available parking would provide for 9,640 visitors. Total public parking is sufficient for 1,579 cars along the entire study area, and would provide for 12,632 visitors per day.

11. Tourist Facilities. The shorefront along the limits of the selected plan has been developed to accommodate residential housing and hotel/motel facilities. The 1983 Florida Statistical Abstract indicates the following: As of July 1982 there were 30 hotels and motels in Martin County providing 1,158 living units. Data indicates that 64.1 percent of tourists arriving in Florida by air stay in hotel/motel units, while 45.5 percent of tourists arriving in Florida by automobile stay in hotel/motel units. Due to the limited number of hotel/motel units available at the shorefront the walk-on beach demand associated with these tourist facilities is not included in the assessment of public access. An analysis of walk-on use of the estimated * without project private beach carrying capacity indicated that sufficient surface area would exist to meet the anticipated demand over 50 years. Based upon existing and projected tourist development, it is reasonable to assume that tourists would have about the same travel distance and costs as local residents to make a beach visit due to the small amount of tourist accommodations that could be built on the barrier island over and above the development that is already planned for the undeveloped property on the island.

VALUE OF BEACH VISIT

12. The travel cost method was used to determine the value of a beach visit. The basic premise of the travel cost method (TCM) is that the per capita use of a recreation site will decrease as the out-of-pocket and time cost of traveling from place of origin to site increases. The value of a beach visit would be determined by dividing the area under the Cost of Travel versus Beach Activity Demand Curve by the total annual demand. The procedures which comprise the analysis are listed below and discussed in the following paragraphs.

a. Considering the Martin County ocean coast as mile 0, establish 6-mile-wide origin zones that lie equal distance to the coast.

b. Establish population of each zone.

c. Establish beach-use demand in each zone.

d. Establish per capita beach-use rate in each zone.

e. Establish mean round trip distance for each zone and establish a per capita use relationship (per capita participation rate versus mean round trip travel distance).

f. Compute travel and opportunity costs per person for each zone for a given trip.

g. Adjust travel and opportunity costs for round trip distance and compute "f" on a per mile basis for each zone.

h. Average values in each zone computed in "g" and equate to a price per person per mile.

i. Calculate total demand from all zones as point on price - demand curve where price equals 0.0.

j. Simulate moving the Martin County ocean coast seaward by calculating the anticipated reduction in demand for the three zones that would be associated with increments in travel costs. *

k. For each simulation estimate per capita participation from the per capita use relationship and compute estimated demand for each zone.

l. For each simulation plot price vs. demand on a composite demand curve.

m. Estimate value of a beach visit by dividing the area under the curve developed by step i, j, k, and l by the total demand.

Origin Zones

13. Selection of the origin zones was based on the unique geography of Martin and St. Lucie Counties. An area with radius of 40 miles was selected to keep the one-way travel time within 1 hour in keeping with day users within Martin and St. Lucie Counties that would recreate along the study area beach.

14. Considering the shorefront as mile 0, four 6-mile-wide origin zones lying equidistant to the nearest beach area were plotted on a 1980 census tract county map. The equidistance of the zones was maintained by drawing circles whose radius increased by 6-mile increments. The circles originate from the ocean beach area fronting the most direct access route from the mainland to the barrier island beaches. These access routes consists of the State highways from north in St. Lucie County and west in Martin County that tie into the Jensen Beach and Stuart Causeways.

15. For a better population grouping definition each of the four zones were subdivided into 2.0-mile-wide subzones which correspond to the Inner (I), Middle (M), and Outer (O) with respect to location within the zone.

Population Distribution

16. The population in each zone was established by using block statistics derived from the U.S. Department of Commerce 1980 Census of Housing for Martin and St. Lucie Counties, Florida. The methodology used to establish population groupings was as follows:

a. The tract numbers were identified and located on the master 1980 census tract maps for Martin and St. Lucie Counties. The dividing line for visitors from the Port St. Lucie area in St. Lucie County that would recreate at Martin County Beaches was taken as that distance that was equal to or less than the distance to the only southernmost causeway to the shorefront at Fort Pierce in St. Lucie County.

b. The zone and zip codes in which these tracts were located and noted along with the population from each tract. *

c. A compilation was made for each major 6-mile zone by subzone. The tract population for each subzone per zip code was established. The compilation is summarized in table 1.

Zone Per Capita Use Rate

17. The participation rates for beach visitations in Martin County were obtained from a statistical survey made by the State of Florida. The total number of beach visitations or demand from each zone was calculated by multiplying the zip code participation rates by the number of people residing in that zip code within a given zone. The number of visitations per zip code were summated to obtain the total zone visitation. The total zone visitation when divided by the zone population gives the average zone participation rate shown on table 2.

Travel Distance Computation

18. Travel distance is of paramount importance when using the travel cost method as a proxy for willingness to pay for a beach visit. The utilization of subzones allows the determination of a mean weighted average travel distance (MWATD) for each zone. The MWATD for each zone was calculated by first taking the distance from the centroid of each 2-mile-wide subzone and multiplying it by the subzone population. The number thus obtained for each subzone was summated for each zone (3 subzones) and this cumulative value was divided by the total zone population to obtain the MWATD for these distances in miles shown on table 3.

Cost of Travel

19. The cost of travel is comprised of the out-of-pocket travel cost and the opportunity cost of time. The travel cost per mile is determined as an average variable cost per mile. These costs, which were extracted from U.S. Department of Transportation, Federal Highway Administration Phamplet "Cost of Owning and Operating Automobiles and Vans, 1984," are summarized in table 4. As indicated, this cost was updated to reflect 1985 price levels since this was the most recent data available at the time of this analysis. *

TABLE 1

POPULATION BY SUBZONE

Subzone	1980 Population (1980 Census)
1 Inner	3,985
1 Middle	18,573
1 Outer	25,427

TABLE 1 (Cont)

POPULATION BY SUBZONE

Subzone	1980 Population (1980 Census)
2 Inner	8,436
2 Middle	6,973
2 Outer	4,057
3 Inner	1,074
3 Middle	2,785
3 Outer	2,676
4 Inner	0
4 Middle	245
4 Outer	0
Total	74,231

TABLE 2

AVERAGE PARTICIPATION RATE

Distances (mi)	Subzone	Participation Rate 1/	1980 Population	1980 Participation
2	1 Inner	5.06	3,985	20,173
4	1 Middle	5.00	18,573	93,120
6	1 Outer	4.03	25,427	102,408
8	2 Inner	2.56	8,436	21,610
10	2 Middle	2.98	6,973	20,758
12	2 Outer	3.80	4,057	15,397
14	3 Inner	4.20	1,074	4,495
16	3 Middle	4.20	2,785	11,677
18	3 Outer	4.20	2,676	11,204
22	4 Middle	2.24	245	549
		Total	74,231	301,391

1/ Rounded to the nearest hundreth.

*

TABLE 3
MARTIN COUNTY BEC
TRAVEL COST METHOD DATA
(POPULATION, PARTICIPATION, AND TRAVEL DISTANCES)

Zone No.	Subzone No.	Subzone Population 1/	Zone Population	Subzone Partic	Zone Partic	Distance One-Way	Roundtrip MWATD 2/
	1.I	3,985		5.06		1.0	8.3
A	1.M	18,573	22,558	5.00	5.02	3.0	
B	1.0	25,427	25,427	4.03	4.03	6.0	13.0
	2.I	8,436		2.56		7.3	
	2.M	6,973		2.98		9.4	
C	2.0	4,057		3.80		11.2	
	3.I	1,074		4.20		13.0	
	3.M	2,785		4.20		15.0	
	3.0	2,676		4.20		17.0	
	4.M	245	26,246	2.24	3.25	21.0	23.8

1/ Data from 1980 Census
2/ Mean weighted average travel distance

TABLE 4

AVERAGE VARIABLE COST TO OPERATE AN AUTOMOBILE
(Cents per Mile)

	Intermediate	Compact	Subcompact	Average
1984 Variable Cost 1/	13.6	11.7	11.8	12.4
(1984 to 1985 Consumer price index) 2/	13.5	11.6	11.7	12.3

1/ Includes maintenance, gas and oil, parking and tolls, and Federal and State taxes.
2/ U.S. Department of Commerce, "Survey of Current Business." (February 1985 Vol. 65, No. 2) indicates consumer price index ratio for commodities of .995 based on 2 May 1984 CPI-U of 311.5 and January 1985 CPI-U of 309.8.

---

20. The opportunity cost of time is valued as one-third of the average hourly wage rate for adults and one-twelfth of the adult wage rate for children. The 1985 average wage rate for Martin County was derived from data obtained from the U.S. Department of Labor Bureau of Labor Statistics which indicates the average hourly wage rate of $7.76. The wage rate available for the closest metropolitan area was $8.44 for West Palm Beach and Boca Raton. The state-wide rate of $7.76 was utilized as a more representative value. Using the formula shown in the Principals and Guidelines

(effective July 1983), the adult's opportunity cost of time is \$2.59 (\$7.76 ÷ 3) and the children's opportunity cost of time is \$.65 (\$7.76 ÷ 12). In this report, each automobile is considered to be occupied by four persons with a representative population comprised of 25.7 percent children and 74.3 percent adults, based upon data contained in the 1981 Florida Statistical Abstract. The average occupancy of each automobile would be comprised of 2.97 adults and 1.03 children. The weighted opportunity cost of time per hour per visitor would be \$2.09 and would be computed as follows:

$$\frac{(1.03 \times \$.65) + (2.97 \times \$2.59)}{4} = \$2.09$$

21. Based on the previous discussion the total cost required to access the beach and return is given on table 5. Notice that 1 mile has been added to the commuting distance to allow for parking. The total cost of travel per beach visitor from the previously established origin zones is summarized by the following equation:

Total Cost of Travel = Out-of-Pocket Cost + Opportunity Cost of Time

where,

$$\text{Out-of-Pocket Cost} = \frac{D \times CM}{4};$$

$$\text{Opportunity Cost of Time} = \frac{D \times CH}{V}; \text{ and}$$

D = total distance
CM = cost per mile
CH = cost per hour
V = velocity
4 = number of persons per vehicle

Average Value of Travel

22. Values utilized for the overall trip cost, which include travel cost and opportunity cost of time were converted to a price per person per mile for each zone by dividing the trip cost per person by the mean weighted average round trip distance in that zone. Table 5 illustrates the data utilized to determine the average cost (value) of travel. Price per person per mile computed for the three zones shown in table 5 are: \$.09, \$.09, and \$.09. Therefore, an average value of \$.09 was calculated for the three zones from table 5. *

It can be shown that; $\begin{pmatrix} a \\ b \end{pmatrix} = \begin{pmatrix} 12.31 \\ -3.91 \end{pmatrix}$ and, *

The number of visits from the least squares fit of these data from the travel costs and participation rates from table 3, were similarily determined for increments in travel costs as shown in table 6.

23. A per capita utilization curve which relates per capita participation and travel costs was derived by drawing a smooth curve through the data for the average participation rate computed for the three zones and the respective travel cost per person. A straight line fit by the method of least squares was utilized to represent the travel cost per person (x) and the participation rate (y) based upon the assumption that the x's are fixed variables and the y's are independent random variables having normal distributions. Figure 2 illustrates these data, which are plotted as a straight line which can be represented by the equation for the participation rate, $y = a + b\ (\text{Cost}) + e$ where, cost = $\log_{10}$ cents/trip/person. From the equation of the form $y = ax_1 + bx_2 + e$ the data in the following table for cost (x_2) were determined as shown when $y = 12.31 - 3.91(x_i)$. *

ZONE	x_1	x_2 (COST)	y PARTICIPATION RATE
A	1	1.875	5.02
B	1	2.071	4.03
C	1	2.333	3.25

$$\begin{pmatrix} a \\ b \end{pmatrix} = (x'x)^{-1}x'y$$ *

$$\text{where, } x = \begin{matrix} 1 & 1.875 \\ 1 & 2.071 \\ 1 & 2.333 \end{matrix}$$

Value of Recreation

24. The travel cost method utilizes the analysis of small incremental increases in the price of participation to measure the quantity of use that would be demanded given these changes. This is equivalent to moving the project further and further from the potential users, requiring them to pay more and more in travel costs (An example of the calculations involved in this process is shown in table 6).

25. A demand curve which relates the expected visitation at varying price levels was plotted as figure 3. The area under the curve represents the average value of visits to the entire county beaches. The computed value of these visits is $1,100,000. The average value per visit is computed by dividing this value by the total number of visits in the analysis (301,011). The average value per visit is $3.65. Therefore, a value of $3.65 was used in the analysis of recreation benefits. *

TABLE 5

PER TRIP COSTS

Zone	Round Trip MWATD (MI)	Variable Auto 1/ ($)	Time 2/ (Hrs)	Time Value 3/ ($)	Total ($)	Trip cost Per Person ($)	Log 10 Cents Per Person
A	8.3	1.02	.237	1.98	3.00	0.75	1.875
B	13.0	1.60	.371	3.11	4.71	1.18	2.071
C	23.8	2.93	.68	5.68	8.61	2.15	2.333

1/ $0.123/mile
2/ 35 mph Average.
3/ 4 x $2.09 x hrs.

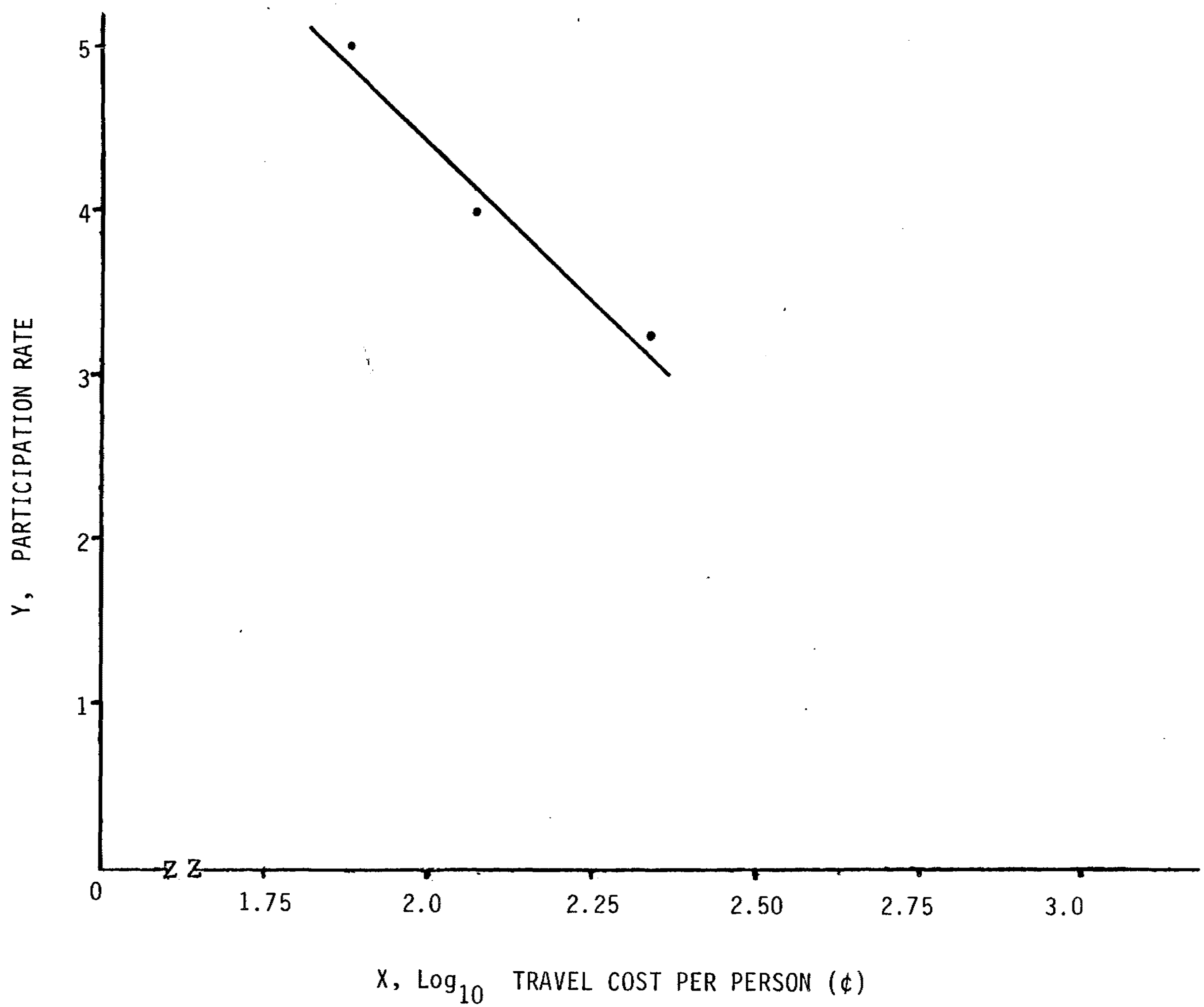

Y, PARTICIPATION RATE
5
4
3
2
1
0
1.75
2.0
2.25
2.50
2.75
3.0
X, Log10 TRAVEL COST PER PERSON (¢)

FIGURE 2

TABLE 6
DEMAND CURVE RELATIONSHIP-CALCULATIONS
OF PRICE AND VISITATION

COST INCREASE	X_1 (COST)	Y EST. PARTICIPATION RATE	VISITS Y (EST.) X POPULATION
$0.00			
ZONE A	1.875	5.02	113,241
ZONE B	2.071	4.03	102,471
ZONE C	2.333	3.25	85,300
			301,011
$.50			
ZONE A	2.10	4.13	93,165
ZONE B	2.23	3.63	92,300
ZONE C	2.42	2.87	75,326
			260,791
$1.00			
ZONE A	2.24	3.56	80,307
ZONE B	2.34	3.20	81,366
ZONE C	2.50	2.58	67,715
			229,388
$2.00			
ZONE A	2.44	2.81	63,388
ZONE B	2.50	2.57	65,347
ZONE C	2.62	2.12	55,642
			184,377
$3.00			
ZONE A	2.57	2.29	51,658
ZONE B	2.62	2.11	53,651
ZONE C	2.71	1.76	46,193
			151,502
$4.00			
ZONE A	2.68	1.89	42,635
ZONE B	2.71	1.75	44,497
ZONE C	2.79	1.46	38,319
			125,451
$6.00			
ZONE A	2.83	1.31	29,551
ZONE B	2.86	1.20	30,512
ZONE C	2.91	0.99	25,984
			86,047

*

TABLE 6 (continued)
DEMAND CURVE RELATIONSHIP-CALCULATIONS
OF PRICE AND VISITATION

COST INCREASE	X_1 (COST)	Y EST. PARTICIPATION RATE	VISITS Y (EST.) X POPULATION
$8.00			
ZONE A	2.94	0.87	19,626
ZONE B	2.96	0.79	20,087
ZONE C	3.01	0.63	16,535
			56,248
$10.00			
ZONE A	3.03	0.53	11,956
ZONE B	3.05	0.45	11,442
ZONE C	3.09	0.32	8,399
			31,797
$12.00			
ZONE A	3.11	0.24	5,414
ZONE B	3.12	0.19	4,831
ZONE C	3.15	0.07	1,837
			12,082

AVERAGE VALUE PER VISIT

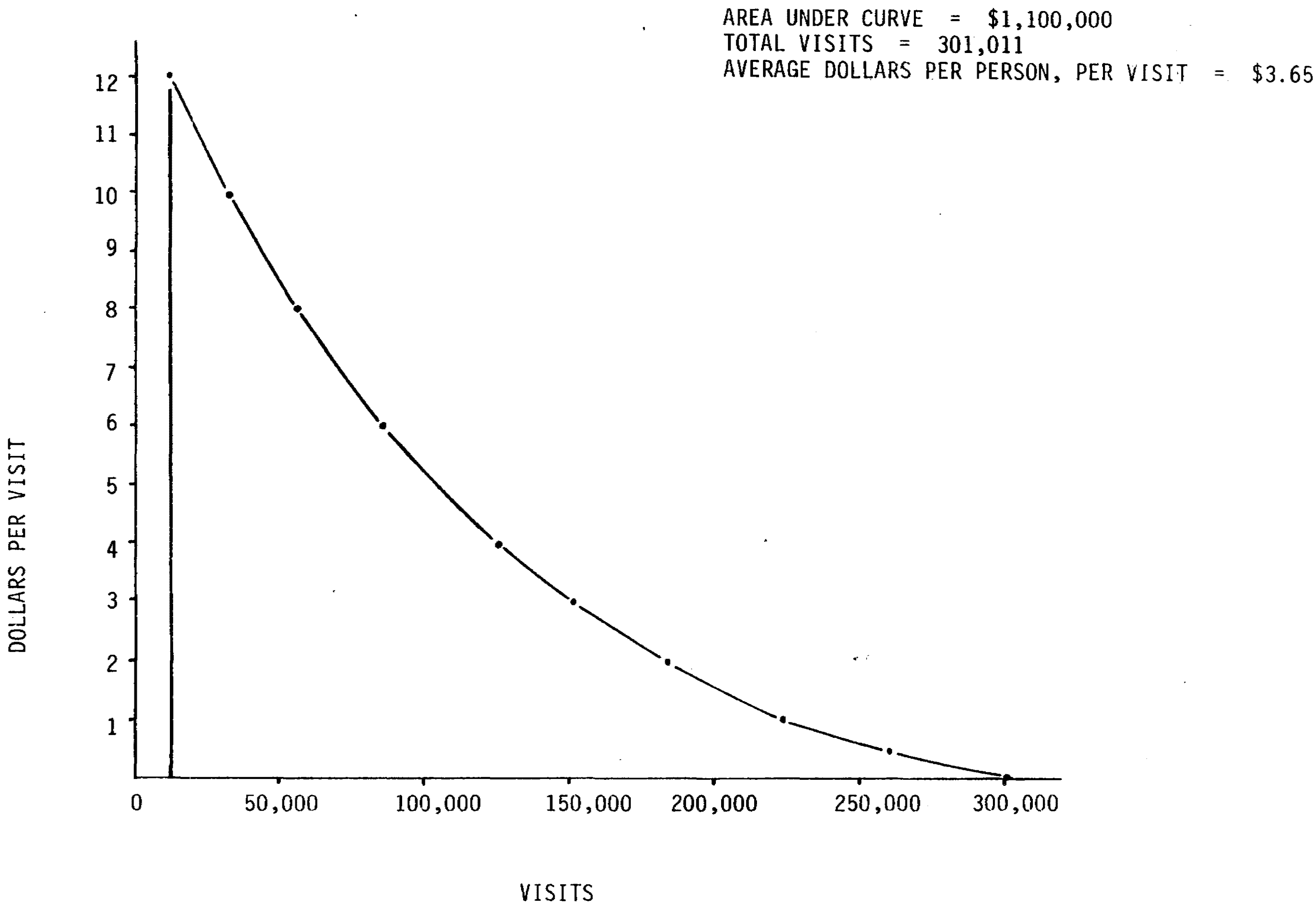


FIGURE 3

26. Corps of Engineers Beach Counts. Total daily attendance estimates are made by life guards at Jensen and Stuart public beaches. This data for Jensen Beach in 1984 is displayed in figure 4. As part of the overall recreation benefit analysis, District personnel conducted hourly visitor counts at the designated public access locations along the study area on Hutchinson Island on 23 and 24 March 1985. This data is compared with the attendance estimates in the following table. A factor of .7 is obtained by averaging the ratios of counts to estimates.

	23 March (SAT.)	24 March (SUN.)
C.E. counts 1/	1,245	1,855
Lifeguard estimates	1,600	3,000

1/Consist of adding the number of visitors for two peak periods; one in the morning (11:00 a.m.), and afternoon (1:00 p.m.).

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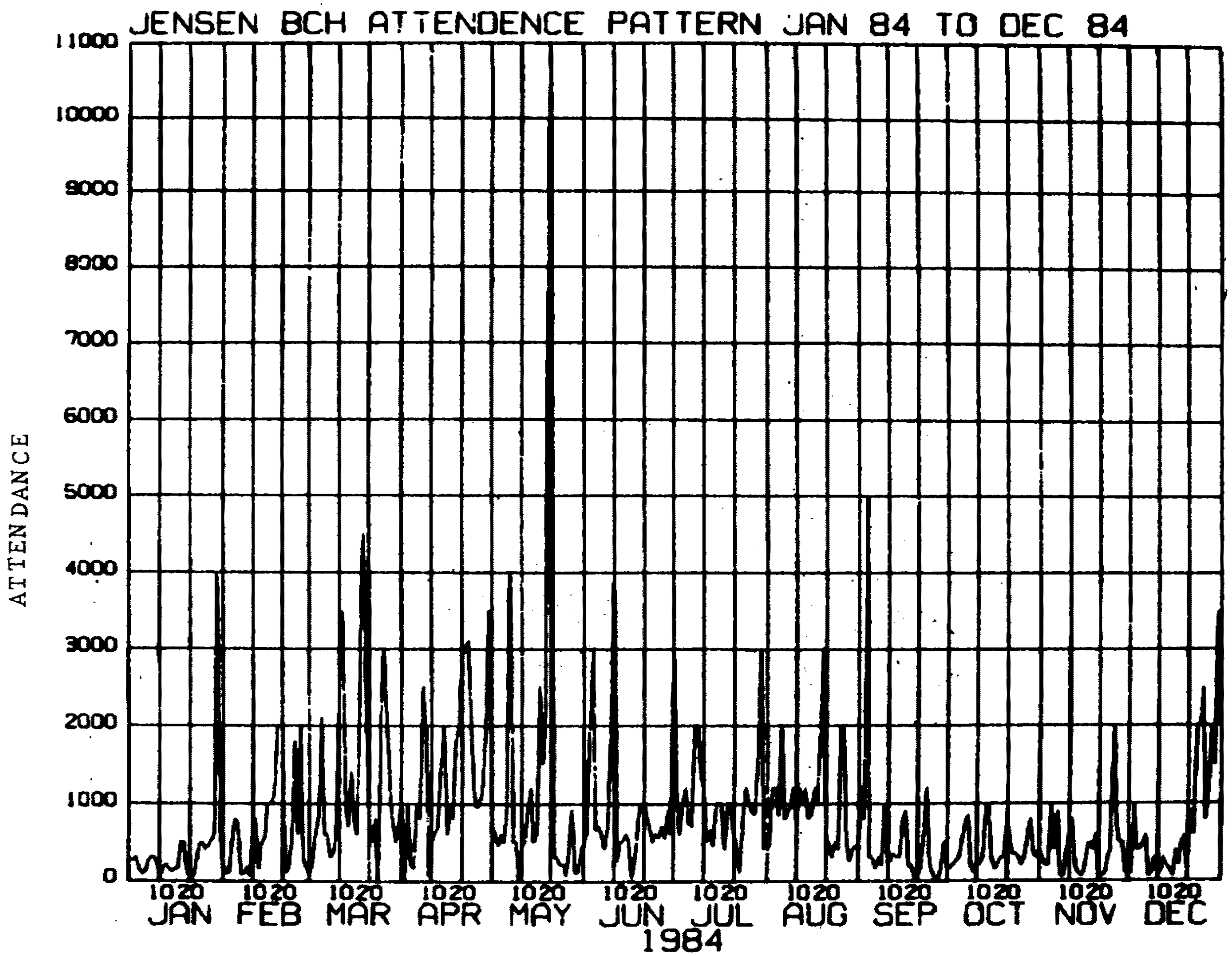
27. Daily Beach Use Demand. Historical patterns of beach use along the Atlantic coast of Florida can be characterized by user groups. These groups define how annual participation occurs within a given year. Daily attendance within the year reflects the climate or season which affects monthly participation. Daily attendance is also influenced by weekdays and weekends. Daily attendance records for 1 year at Jensen Beach public beach were selected for an analysis of the patterns of beach use. User groups were derived by ranking attendance records in descending order. Each day's attendance was divided by the attendance for the year to determine the percentage of yearly participation attributable to that day. To reduce the number of groups and simplify the computational process, groups with similar percentages were averaged. The net result was 19 user groups representing 365 days in the year. These user groups are shown in table 7.

28. Table 7 indicates the attendance categories associated with a 2 percent difference in visitor estimates at Jensen Beach in 1984. By table 7, estimated attendance for 49 days would exceed available parking constraints. Adjusting the estimates by a factor of .7 results in 19 days exceeding constraints. Based upon visitor counts 24 March 1985, parking was not exceeded. However, additional notional parking area is open to the public at Jensen Beach Park but is not included in this analysis to be consistent with county plans for 240 designated parking spaces at Jensen Beach in 1990.

29. Annual Beach Use Demand. The annual beach activity demand for the study area project area at Martin County was determined from data contained in the 1980 Census for population and the 1983 SCORP, which is a statistical analysis by the State of Florida for participation rates and projected per capita use rates for Florida residents and tourists. Census data from 1980 was utilized in conjunction with data provided by a statistical report by the State of Florida based on information obtained from about 11,000 questionaires on outdoor recreation to evaluate per capita use rates and



JENSEN BCH ATTENDENCE PATTERN JAN 84 TO DEC 84
ATTENDANCE
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
10 20
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1984

Figure 4

TABLE 7

JENSEN BEACH ATTENDANCE PATTERN
(JAN 84 TO DEC 84)

ATTENDANCE CATEGORIES (RANK)	NO. DAYS IN GROUP	AVERAGE DAILY ATTENDANCE	AVERAGE DAILY % OF TOTAL (IN %)	%
1	1	11,000.00	3.544	3.5
2	1	9,500.00	3.061	3.1
3	1	5,000.00	1.611	1.6
4	1	4,500.00	1.450	1.5
5	3	4,000.00	1.289	3.9
6	3	3,500.00	1.128	3.4
7	1	3,100.00	0.999	1.0
8	8	2,993.75	0.965	7.7
9	4	2,500.00	0.806	3.2
10	1	2,250.00	0.725	0.7
Subtotal	(24 1/)			
11	25	2,004.00	0.646	16.2
12	3	1,800.00	0.580	1.7
13	6	1,466.67	0.473	2.8
14	18	1,194.44	0.385	6.9
15	35	975.71	0.314	11.0
16	40	771.25	0.249	10.0
17	71	539.08	0.174	12.4
18	58	330.17	0.106	6.2
19	85	121.35	0.039	3.3
TOTAL	365		TOTAL	100.1

1/ The 24 days including those groups marked 1 through 10 represent peak daily demand for beach use.

---

the user day value by the travel cost method. Attendance estimates for 1 year at Jensen Beach Park were analyzed to determine attendance patterns at the project area. The demand for beach use was distributed by the percentage of parking spaces available to the southern end of Stuart Public Beach based upon the total number of parking spaces available county wide due to environmental consideration along the shorefront south of Stuart Public Beach. Paragrahs 47 and 48 provide additional information regarding the allocation of demand along the shorefront. Based upon these data, the annual beach activity demand was determined utilizing the following relationships:

$$CD = (PcNc + PsNs + PtNt)\ K$$

CD = County beach activity demand
Pc = Constant from State survey = participation rate by county residents
Ps = Constant from State survey = Participation rate of residents from other Florida counties who recreate on Martin County beaches
Pt = Constant from State survey = Participation rate tourist to Martin County.
Nc = County resident population
Ns = State population
Nt = County tourist population
K = Constant for adjusting calculated demand to reflect actual counted beach visits = Actual county demand

30. Data from the visitor counts at the access points by District personnel on 23 and 24 March 1985 do not provide a representative k factor for adjusting demand. A k factor of 1.0 is considered applicable for use based upon the information available from the State survey. Table 8 indicates the data utilized in computing the annual demand at 10-year intervals.

31. A comparison of county population projections from State of Florida and Bureau of Economic Analysis (BEA) data is provided in the following table. Florida Statistical Abstract data were utilized for all components of the beach activity demand to ensure that the data base was consistent with that used by the State in developing the comprehensive outdoor recreation plan. This data is universally applied in recreational planning by the State of Florida.

Year	Florida Statistical Abstract 1/	BEA Projections
1990	99,700	86,643
2000	130,100	101,382
2010	148,600	113,528
2020	165,200	126,302
2030	183,700 2/	137,626
2040	204,200 2/	149,965

1/Medium projection utilized; low projection would maximize at 98,900 in 2000; high projection would maximize at 357,900 in 2040.

2/Extrapolated from 2010 to 2020 trend.

---

32. Carrying Capacity. Following the discussion in the main report the analysis of recreational benefits is developed for two alternative plans: construction of a project to 5- and 10-year storm protection from the north county line south to the south limit at Stuart Beach Park (Plan S-2). The beach carrying capacities of these alternative plans are compared with the existing beach carrying capacity in the following analysis.

TABLE 8

ANNUAL BEACH ACTIVITY DEMAND (X 1,000)

Year	County Resident Participation Rate	County Residents	State Resident Participation Rate	State 1/ Residents	State Tourist Participation Rate	County Tourists	Total Annual County-Wide Demand	Unconstrained 4/5/ Annual Demand	Distrubuted 6/ Annual Demand for Project Area
1990	3.418	99.7	.004	12,478.7	3.875	375.2	1,844.6	1,244.6	949.8
2000	3.418	130.1	.004	14,820.7	3.875	518.9 3/	2,514.7	1,914.7	1,461.1
2010	3.418	148.6	.004	16,815.5 2/	3.875	717.8 3/	3,356.7	2,756.7	2,103.6
2020	3.418	165.2	.004	18,810.2	3.875	992.8 3/	4,487.0	3,887.0	2,966.2
2030	3.418	183.7 1/	.004	21,041.5 2/	3.875	1,373.2 3/	6,033.2	5,433.2	4,146.1
2040	3.418	204.2 1/	.004	23,537.5 2/	3.875	1,899.4 3/	8,152.3	7,552.3	5,763.2

1/ Based upon 1.12 percent annual growth rate in 1983 Florida Statistical Abstract.

2/ Based upon 1.186 percent annual growth rate in 1983 Florida Statistical Abstract between 2000 and 2020.

3/ Based upon 3.832 percent annual growth rate from State of Florida DNR data for 1985, 1990, and 1995.

4/ Demand reduced by 600,000 average annual visits distributed to St. Lucie Inlet State Park.

5/ Demand for county wide public beaches is not constrained by available public parking. Carrying capacity along the study area is constrained to 12,632 visitors daily, or 4,610,700 visitors yearly by available public parking in 2030 and 2040.

6/ As discussed in the Distribution of Demand for Beach Use section of this appendix, 23.69 percent of parking is outside of the limits of the selected plan, therefore, the distributed demand indicated represents 76.31 percent of the unconstrained annual demand.

Beach Area

33. Under existing conditions, about 682,400 square feet of recreational beach were available to the public in Martin County in 1985 on Hutchinson Island and Jupiter Island excluding St. Lucie Inlet State Park. A breakdown of this beach area according to location is given in table 9. In addition, table 10 estimates the future beach area based on current erosion rates from 1971 to 1978 and 1978 to 1984, and thereafter in 10-year increments including the public shorefront south of St. Lucie Inlet in Martin County. Authorized improvements for St. Lucie Inlet provide for nourishing the shorefront along the northern reach of Jupiter Island. Therefore, the available beach area along this northern reach of Jupiter Island is considered to remain constant over the 50-year period of economic analysis.

34. The St. Lucie Inlet State Park is expected to be fully operational by the beginning of the project life. The beaches adjacent to the St. Lucie Inlet are a major resource and represent valuable potential recreation areas for permanent residents of the region as well as for tourists visiting the area. Present plans are for the State of Florida to develop approximately 2.7 miles of shoreline as a State park with complete recreational facilities for camping, swimming, and picnicking. In the St. Lucie Inlet Survey Review Report for Navigation Improvements, submitted by the Jacksonville District in 1973, the capacity of the entire park and the State's desire to prevent overuse and crowding determines the estimate of beach visits and benefits. In accordance with this report, yearly participation estimates were assumed to peak in 1985 and remain constant throughout the project life. Estimated participation in this report is 600,000 user visits per year. Therefore, this part of the total county demand is allocated to this park. Martin County total demand allocated to the remaining county publically accessible beaches is shown in table 8.

35. Data provided in 1984 and 1985 by the county and from field investigations were analyzed to identify all designated physical access points to Martin County. It is assumed the average beach visitor would be willing to walk up to 1/4 mile from an access point to enjoy an uncrowded beach area. Therefore, public beach areas on each side of an access point were included in the total available recreational beach area shown in table 10.

36. It was assumed in the "without project" or existing condition that all beach area in public ownership would be available for public use if accessible. Use of the beach area above MHW is strictly at the private property owner's perogative. Therefore, the actual beach area available to the public was calculated as the existing beach surface area fronting public lands which are currently improved or adjacent to improved lands and have development plans prepared by Martin County which include public access. Past accomplishments of Martin County in securing and developing public shorefront areas, access strips, and parking plans indicate continued

expansion of public access and facilities along county-owned shorefront at the Jensen Beach north and Bob Graham accesses. Therefore, additional public shorefront and beach areas are included in the analysis of available public beach area during project life to be consistent with development plans underway. This method of determining available public beach area under existing conditions results in a more conservative estimate of beach use for the "with project" condition.

37. Available Public Beach. The amount of beach surface area over a 50-year period of analysis without the proposed project is dependent upon mean high water recession rates. Currently, storm wave runup in Martin County is generally at an escarpment which is essentially vertical and any erosion of that escarpment will cause the top of the escarpment to collapse with resulting loss of land. Table 9 indicates public beach areas and accretion/recession rates.

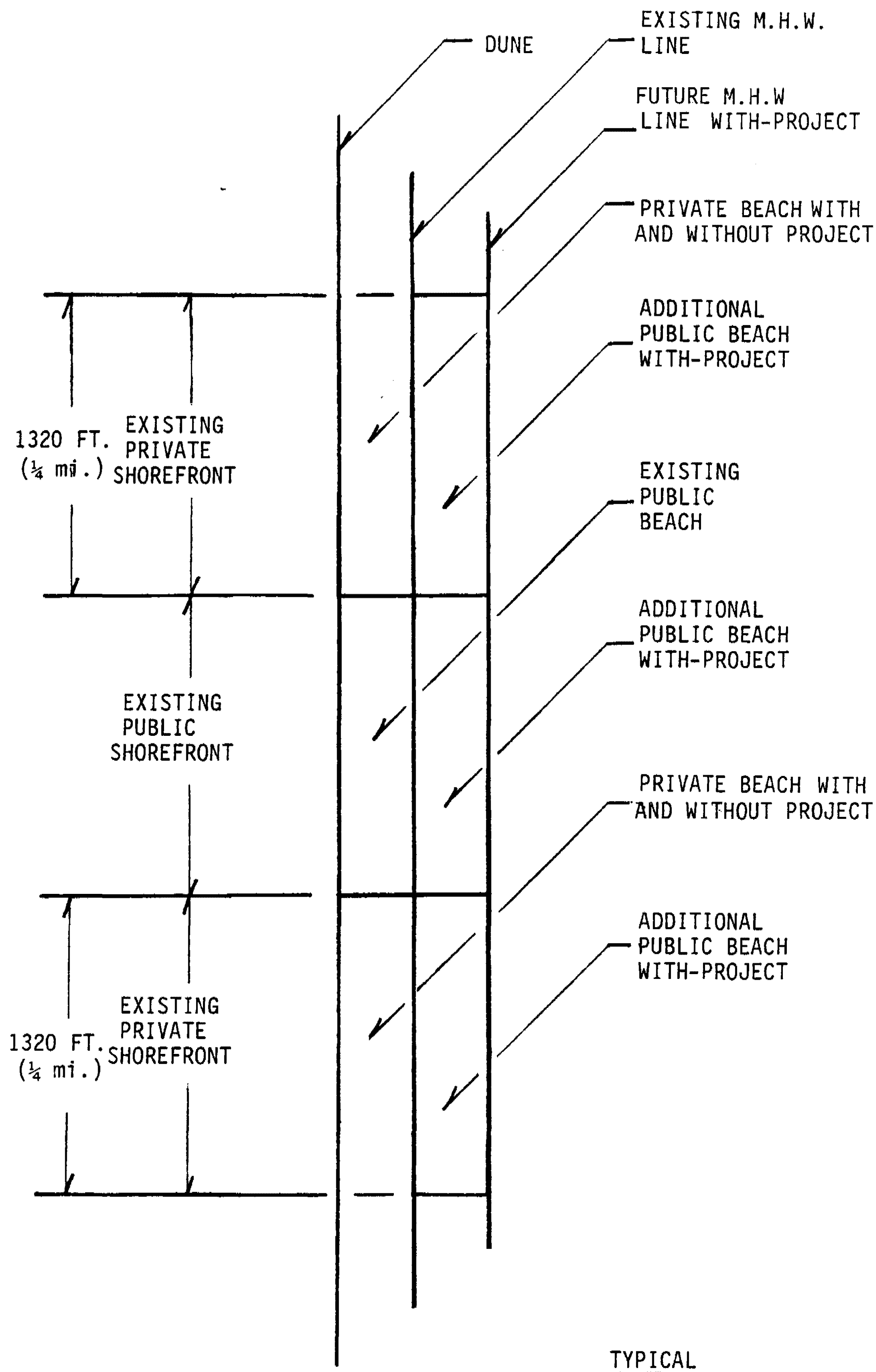
38. The procedure used to calcuate remaining public beach is to multiply the annual mean high water erosion rate by the front footage of the park by the time increment. The area computed is subtracted from the remaining area in the preceding time increment if the beach is receding or added if the beach is accreting. The House of Refuge is a national historical site visited for reasons other than beach participation. A natural reef denies access to all but about 200 linear front feet of beach. Therefore, usable beach areas are calculated using this front footage at this site.

39. Information defining existing usable public beach is based upon 1984 aerial photographs, a 1984 beach profile survey, and 1985 field inspections. On Hutchinson Island, public areas are eroded from 1990 in 10-year increments throughout a 50-year project life. On Jupiter Island, an erosion control project was completed in 1983. It is assumed that local interests will not continue to provide renourishment. Therefore, mean high water recession rate was utilized to recede the available beach width over a 50-year interval. The estimated public beach surface areas for a 50-year interval shown in table 10 are based upon data from table 9.

40. Public Beach Area With the Selected Plan. The total capacity of usable public beach with the selected plan includes the project public area and all public beaches without the plan of improvement inside the study area but outside the area of improvement. A diagram indicating the typical public beach areas that are used in the calculation of the capacity of a project is * shown on the following page. An estimate of the amount of public beach with the selected plan requires the following computations:

a. Compute the total area of the renourished beaches. This is dependent upon average project width.

b. Subtract out all privately owned land in the renourishment area above preproject mean high water.



TYPICAL
PUBLIC AND PRIVATE
BEACH SURFACE AREAS
WITH IMPLEMENTATION
OF A BEACH FILL PROJECT

TABLE 9

BEACH SURFACE AREA
(WITHOUT PROJECT)

ACCESS LOCATION/NAME	PUBLIC SHOREFRONT DISTANCE ALONGSHORE (FT)	M.H.W. SHOREFRONT WIDTH (FT.)	1971-1976 AVERAGE M.H.W. RECESSION RATE 1/ (FT. PER YR.)	1985 BEACH SURFACE AREA TO M.H.W. (SQ. FT.)
Hutchinson Island				
North County Access	100	75	-.7	7,500
Jensen Beach North	1,600	75	-1.0	120,000
Jensen Beach Park	1,450	70	-3.0	101,500
Bob Graham Beach	1,990	70	-2.0	139,300
Alex's Beach	565	70	-.8	39,550
Virginia Forest Beach	100	80	-.6	8,000
Tiger Shores	100	75	-2.9	7,500
Stuart Beach	1,150	50	-.7	57,500
Subtotal	7,055			480,850
Fletcher Access	100	20	-1.0	2,000
House of Refuge	200	20	+2.1	4,000
Chastain Access	100	50	0	5,000
Bathtub Reef Park	950	20	-7.0	19,000
Sailfish Point	150	20	-17.1	3,000
Subtotal	1,500			33,000
Jupiter Island				
Hobe Sound National Wildlife Refuge	2,470	50	-4.0	123,500
Hobe Sound County Beach	200	156	-3.4	31,200
Subtotal	2,670			154,700
TOTAL	11,225		TOTAL	668,550

1/ + indicates accretion, - indicates recession.

TABLE 10

WITHOUT PROJECT - CHANGING BEACH SURFACE AREA (SQ. FT.) 1/
(UNCONSTRAINED PARKING)

Access Location/Name	YEAR 1/					
	1990	2000	2010	2020	2030	2040
Hutchinson Island						
North County Access	7,150	6,450	5,750	4,350	3,650	2,950
Jensen Beach North	112,000	96,000	80,000	69,400	48,000	26,600
Jensen Beach Park	79,750	36,250	0	0	0	0
Bob Graham Park	119,400	79,600	39,800	0	0	0
Alex's Beach	37,290	32,770	28,250	23,730	19,210	14,690
Virginia Forest	7,700	7,100	6,500	5,900	5,600	5,300
Tiger Shores	6,050	3,150	250	0	0	0
Stuart Beach Park	53,475	45,425	37,375	29,325	21,275	13,225
Subtotal	422,825	306,745	158,125	132,705	97,735	62,765
Fletcher Access	1,500	500	0	0	0	0
House of Refuge	6,100	10,300	14,500	18,700	22,900	27,100
Chastain Access	5,000	5,000	5,000	5,000	5,000	5,000
Bathtub Reef Park 2/	61,750	0	0	0	0	0
Sailfish Point 3/	0	0	0	0	0	0
Subtotal	74,350	15,800	19,500	23,700	27,900	32,100
Jupiter Island						
Hobe Sound National Wildlife Refuge	74,100	0	0	0	0	0
Hobe Sound County Beach	27,800	21,000	14,200	7,400	600	0
Subtotal	101,900	21,000	14,200	7,400	600	0
Total	599,075	343,545	191,825	163,805	126,235	94,865

1/First year of project life is estimated to be 1990.
2/Redistribution of sand by county provided a parking lot and widened beach to approximately 100 feet in 1985. Surveys conducted in 1984 and erosion rate indicate that there would not be any beach width in1990 otherwise.
3/Minimal beach width and large recession rate indicate no available beach in 1990.

c. Limit usable beach to 1/4 of a mile in either direction from the nearest access point. The 1/4 mile limit is measured from the outlying boundaries of access strips or existing public parks.

d. Include all public beach not renourished in the study area. The areas of these beaches are adjusted for erosion/accretion changes throughout the project life. Parking constraints also limit the accessibility of a beach and impact the usable public beach area. Tables 11 and 12 compare the available public beach capacities for the without project conditions. Capacity was determined by dividing surface area by 100 square feet per visitor and multiplying by a factor of 2 for the turnover ratio.

41. Data from the following tables indicate the public beach area estimated to be available by 1990. Generally, erosion will cause available beach area to diminish along the public shorefront except at the House of Refuge where accretion is indicated and at Chastain Access where natural rock outcroppings act as groins to hold a consistent beach width.

42. Constraints on Beach Visits. According to current guidelines for determining the number of visitors that could recreate on an existing or improved public beach, available parking spaces or the beach surface area may impose a constraint on carrying capacity (i.e., the number of visitors that would be accommodated on a daily basis). Each parking space, measuring 10 feet by 20 feet, provides for 8 people per day based upon 4 people per car and a turnover rate of 2. The daily carrying capacity of the beach is calculated by dividing the available surface area by 100 square feet per person and multiplying by a turnover rate of 2. Therefore, to determine the number of visitors that could be accommodated when beach capacity exceeds parking capacity, both measured in people per day, parking capacity is substituted for beach capacity. This is done for each park in 10-year increments with and without the project. The number of visitors that would be accommodated by the available parking in 1985 and 1990 are listed in table 13.

43. The data is segmented to indicate public parking on Hutchinson Island from the north county access south to Stuart public beach, and from Fletcher Access to Bathtub Reef Park and along Jupiter Island. This is done to address potential limits of alternative plans for the length of beach fill. A letter was requested from Martin County in May 1985 regarding a public parking inventory and is contained in Appendix 6. As indicated by the 29 May 1985 letter, total existing and proposed parking spaces on Hutchinson Island are 683 and 682, respectively, for a total of 1,365. For the purposes of this study, the estimate, based upon aerial photography and site visits, is 692 and 728, respectively, for a total of 1,420. However, the beach fill alternative plans consider public parking available along the northernmost 4 miles of the county from the North County Access to Stuart Beach Park. Along this reach the county indicates existing and proposed parking of 525 and 625, respectively, where the estimates are 568 and 637, respectively. The difference of 55 parking spaces

TABLE 11

WITHOUT PROJECT - DAILY CAPACITY 1/
(UNCONSTRAINED PARKING)

	Access Location/Name	1990	2000	2010	2020	2030	2040
		YEAR					
	Hutchinson Island						
*	North County Access	143	129	115	87	73	59
	Jensen Beach North	2,240	1,920	1,600	1,388	960	532
	Jensen Beach Park	1,595	725	0	0	0	0
	Bob Graham Park	2,388	1,592	796	0	0	0
	Alex's Beach	746	655	565	475	384	294
	Virginia Forrest	154	142	130	118	112	106
	Tiger Shores	121	63	5	0	0	0
	Stuart Beach Park	1,070	909	748	586	426	265
*	Subtotal	8,457	6,135	3,959	2,654	1,955	1,256
	Fletcher Access	30	10	0	0	0	0
	House of Refuge	122	206	290	374	458	542
	Chastain Access	100	100	100	100	100	100
	Bathtub Reef Park	1,235	0	0	0	0	0
	Sailfish Point	0	0	0	0	0	0
	Subtotal	1,487	316	390	474	558	642
	Jupiter Island						
	Hobe Sound National Wildlife Refuge	1,482	0	0	0	0	0
	Hobe Sound County Beach	556	420	284	148	12	0
	Subtotal	2,038	420	284	148	12	0
*	Total	11,982	6,871	4,633	3,276	2,525	1,898

1/Visitors per day for the year indicated.

(Rev. March 86)

TABLE 12

WITHOUT PROJECT - YEARLY CAPACITY 1/
(UNCONSTRAINED PARKING)
(X 1000)

Access Location/Name	YEAR 1990	2000	2010	2020	2030	2040
Hutchinson Island						
North County Access	52.2	47.1	42.0	31.8	26.6	21.5
Jensen Beach North	817.6	700.8	584.0	506.6	350.4	194.2
Jensen Beach Park	582.2	264.6	0	0	0	0
Bob Graham Park	871.6	581.1	290.5	0	0	0
Alex's Beach	272.3	239.1	206.2	173.4	140.2	107.3
Virginia Forrest	56.2	51.8	47.5	43.1	40.9	38.7
Tiger Shores	44.2	23.0	1.8	0	0	0
Stuart Beach Park	390.6	331.8	273.0	213.8	155.5	96.7
Subtotal	3,086.9	2,239.3	1,445.0	968.7	713.6	458.4
Fletcher Access	11.0	3.7	0	0	0	
House of Refuge	44.5	75.2	105.9	136.5	167.2	197.8
Chastain Access	36.5	36.5	36.5	36.5	36.5	36.5
Bathtub Reef Park	450.8	0	0	0	0	0
Sailfish Point	0	0	0	0	0	0
Subtotal	542.8	115.4	142.4	173.0	203.7	234.3
Jupiter Island						
Hobe Sound National Wildlife Refuge	540.9	0	0	0	0	0
Hobe Sound County Beach	202.9	153.0	103.7	54.0	4.4	0
Subtotal	743.8	153.0	103.7	54.0	4.4	0
Total	4,373.5	2,507.7	1,691.1	1,195.7	921.7	692.7

1/ Based upon surface area only.

TABLE 13

EXISTING PARKING INVENTORY

LOCATION/ACCESS (PUBLIC PARKING)	EXISTING PARKING SPACES	ADDITIONAL SPACES TO BE PROVIDED BY 1990	TOTAL PARKING SPACES	VISITORS ACCOMMODATED PER DAY (YR.)	% OF TOTAL PARKING
Hutchinson Island					
North County Access	30	0	30	240 (87,000)	1.90
Jensen North	0	250	250	2,000 (730,000)	15.83
Jensen Beach Park	240	0	240	1,920 (700,800)	15.20
Bob Graham Park	32	150	182	1,456 (531,440)	11.53
Alex's Beach	23	32	55	440 (160,600)	3.48
Virginia Forrest	22	0	22	176 (64,240)	1.39
Tiger Shores	26	0	26	208 (75,920)	1.65
Stuart Beach Park	195	205	400	3,200(1,168,000)	25.33
Subtotal	568	637	1,205	9,640(3,518,600)	76.31
Fletcher Access	8	0	8	64	0.51
House of Refuge	32	0	32	256	2.03
Chastain Access	30	0	30	240	1.90
Bathtub Reef Park 1/	54	91	145	1,160	9.18
Subtotal	124	91	215	1,720	13.62
Jupiter Island					
Hobe Sound National Wildlife Refuge	87	0	87	696	5.51
Hobe Sound County Beach	72	0	72	576	4.56
Subtotal	159	0	159	1,272	10.07
Total	851	728	1,579	12,632	100.00

1/Bathtub Reef Park and Sailfish Point will be combined into one park by 1990.

along this reach is due for the most part to 50 additional parking spaces allocated at the southeast part of Stuart Park that are provided in an open parking area adjacent to the paved parking lot and directly alongshore from the paved parking area which is county property that is used for parking.

44. Average Peak Hour Parking Requirements. Available parking can limit the number of visitors that may recreate along public beaches over a 50-year period of economic analysis. Usually, constraints are imposed by the existing beach capacity due to loss of beach width from erosion in the without project condition. However, the number of visitors that can be allocated to the public beaches in the with-project condition can be limited by parking. Formulation of alternative plans for beach fill is subject to the analysis of constraints imposed by available parking when the surface area of the alternative plan is calculated to provide for large seasonal demands. In addition, maximization of benefits, including damage prevention and loss of land, is included in the overall analysis to determine the National Economic Development alternative. Therefore, maximization of benefits includes the evaluation of limitations imposed by parking on the allocation of demand for beach use.

45. To provide a rational methodology for determining parking needed to support public use of accessible beach areas, the average peak hour parking requirements are computed. The average number of parking spaces needed on an hourly basis for an average of peak days is used as the number of parking spaces required to accommodate beach visitors. Only the number of visitors that can be attributed to the available parking are included in the analysis of beach use when demand for beach use exceeds this constraint. The average peak day is computed using average of peak daily demand constrained by beach capacity (number of visitors accommodated) for 49 days rather than for a single peak day. These 49 days generally represent holiday and peak weekend demand.

46. Summary of Peak Hour Parking Requirements. The average peak hour parking requirements are calculated from the maximum unconstrained demand as displayed in table 14. Based upon the attendance categories determined for recreational beach use in Martin County 49 peak days are considered to represent peak day demand over the entire year. In order to determine the required number of parking spaces needed to satisfy requirements; peak hour parking or beach carrying capacity (whichever is less), the maximum unconstrained demand was evaluated (from table 16) as shown in table 14. As shown for the first 40 years of project life (1990 to 2030), the maximum number of parking spaces required to meet the average peak hour parking demand is 1211 in 2030, which approximates the 1205 parking spaces that are proposed by Martin County by 1990. Along the northernmost 4 miles of Hutchinson Island in Martin County, there are 568 parking spaces currently available. The county has planned for an additional 637 spaces for a total of 1,205 by 1990. Based upon the data for unconstrained demand, 1685 parking spaces are estimated to be needed to meet the projected demand in 2040, which represents 480 more parking spaces then are planned by Martin County in 1990. Considering that Martin County has planned a 12 percent increase in parking from 1985 to 1990 along the proposed project area, it is assumed that the 39.8 percent increase (480 divided by 1205) in parking spaces required to meet average hourly demands in 2040 would most probably be met. In addition, the largest part of the 8,152,300 demand in 2040 (reduced to 7,552,300) is 7,360,000 visits by county tourists which is based upon State of Florida data for 1985, 1990, and 1995 that is extrapolated to 2040 by an annual growth rate (as indicated by table 8).

Based upon the maximum without project carrying capacity in table 15 for 2000, the capacity, constrained only by surface area, would indicate 582,998

TABLE 14

UNCONSTRAINED DEMAND
(VALUES X 1,000)

	YEAR					
	1990	2000	2010	2020	2030	2040
Total Demand (49 peak days)	435.0	669.2	963.4	1358.7	1898.9	2641.5
Average Hourly Demand $\frac{\text{total demand}}{\text{49 days x 8 hours}}$	1.110	1.707	2.458	3.467	4.844	6.739
Parking Spaces Required on an Hourly Basis $\frac{\text{average hourly demand}}{\text{4 people per car}}$	.278	.427	.614	.867	1.211	1.685

TABLE 15

DEMAND BASED ON WITHOUT PROJECT YEARLY CAPACITY [1/]
(DISTRIBUTED BY PARKING)

(VISITS X 1000)

	PERCENTAGE OF PARKING	YEAR 1990	2000	2010	2020	2030	2040
Hutchinson Island							
N. County Access	1.90	23.6	36.4	42.0*	31.8*	26.6*	21.5*
Jensen Beach North	15.83	197.0	303.1	436.4	506.6	350.4*	194.2*
Jensen Beach Park	15.20	189.2	264.6*	0 *	0 *	0 *	0 *
Bob Graham Park	11.53	143.5	220.8	290.5*	0 *	0 *	0 *
Alex's Beach	3.48	43.3	66.6	95.9	135.3	140.2*	107.3*
Virginia Forrest	1.39	17.3	26.6	38.3	43.1*	40.9*	38.7*
Tiger Shores	1.65	20.5*	23.0*	1.8*	0 *	0 *	0 *
Stuart Beach Park	25.33	315.2	331.8*	273.0*	213.8*	155.5*	96.7*
	76.31%						
Distributed Demand Total		949.6	1,272.9	1177.9	930.6	713.6	458.4
Capacity[2/] Unconstrained by Parking (Table 12)		3,086.9	2,239.3	1,445.0	968.7	713.6	458.4
Distributed Annual Demand for Project Area from Table 8		949.8	1,461.1	2,103.6	2,966.2	4,146.1	5,763.2
Unconstrained Annual Demand From Table 8		1,244.6	1,914.7	2,756.7	3,887.0	5,433.2	7,552.3

[1/]Visitors per year for the year indicated.

[2/]Constrained by surface area for project area.

*Constrained only by beach surface area from Table 12.

visits (45.8% of total demand from table 15) over 49 peak days, or 372 parking spaces required on an hourly basis. Similarly for beach fill alternatives maximum parking requirements would be 1,455 and 1,579 spaces in 2040 for the 5- and 10-year designs, respectively, based upon the annual demand constrained by surface area only. In order to meet the demand constrained by surface area for 2030 and the 5- and 10-year beachfill designs, the parking requirements are 1,179 and 1,205 spaces, respectively. Therefore, the 1,205 parking spaces to be provided by 1990 are considered to satisfy the requirement for adequate public parking.

47. <u>Distribution of Demand for Beach Use</u>. Distribution of demand to the project area is based upon the percentage of parking spaces as shown in table 15. This insures that a participant will find usable beach if it is available somewhere in the county. It is assumed that the lack of transportation access between Hutchinson and Jupiter Island will not inhibit the distribution. The 1976 SCORP report states that each participant seeks at least 100 square feet of beach space for minimum comfort. No attractiveness indexes are used to distribute demand. While it is true that participants may exhibit a preference for a given park because of differences in access and beach facilities available and the more desirable beaches will be occupied first, it is assumed the avoidance of overcrowding will be the dominant concern. *

48. The demand for beach use at each access point was calculated as a percentage of the total county demand by the percentage of parking at each access to total parking county wide. Coordination with Martin County regarding current development plans for improvements to the public shorefront for additional parking indicated the number of parking spaces shown in table 13. Based upon these data for 1990, these percentages were used to allocate county demand among the access points as indicated by table 15. Projected unconstrained demand by user group for the county beaches is summarized in table 16. The values shown in this table were computed by applying the adjusted annual demands shown at the bottom of table 15 to the percentages listed in table 7. This computation distributes the total annual demand associated with the northern 4 miles of county shorefront into use patterns based on attendance data for the study area. This is for the purpose of illustrating the effects of surface area and parking constraints for the without project condition as shown by table 17.

49. <u>Visitation Attributed to Considered Alternative Plans</u>. Beach visitors that would be attributed to the 5-year and 10-year beach fill plans were computed as the differences between the attendance with the beach fills in place and the existing (without project) conditions over a 50-year interval. These results are summarized in tables 18 through 20. *

TABLE 16

ANNUAL BEACH VISITS (X 1,000)

MAXIMUM ASSOCIATED DEMAND FOR PROJECT AREA WITHOUT CONSTRAINTS DUE TO SURFACE AREA OR PARKING

ATTENDANCE CATEGORIES	DAYS	1990	2000	2010	2020	2030	2040
1	1	33.2	51.1	73.6	103.8	145.1	201.7
2	1	29.4	45.3	65.2	92.0	128.5	178.6
3	1	15.2	23.4	33.7	47.5	66.3	92.2
4	1	14.3	21.9	31.6	44.5	62.2	86.5
5	3	37.0	57.0	82.0	115.7	161.7	224.8
6	3	32.3	49.7	71.5	100.9	141.0	198.0
7	1	9.5	14.6	21.0	29.7	41.5	57.6
8	8	73.1	112.5	162.0	228.4	319.2	443.8
9	4	30.4	46.8	67.3	94.9	132.7	184.4
10	1	6.7	10.2	14.7	20.8	29.0	40.3
11	25	153.9	236.7	340.8	480.5	671.7	933.6
12	3	16.2	24.8	35.8	50.4	70.5	98.0
13	6	26.6	40.9	58.9	83.1	116.1	161.4
14	18	65.5	100.8	145.2	204.7	286.1	397.7
15	35	104.5	160.7	231.4	326.3	456.1	634.0
16	40	95.0	146.1	210.4	296.6	414.6	576.3
17	71	117.8	181.2	260.9	367.8	514.1	714.6
18	58	58.9	90.6	130.4	183.9	257.1	357.3
19	85	31.3	48.2	69.4	97.9	136.8	190.2
Distributed Demand from Table 8		949.8	1,461.1	2,103.6	2,966.2	4,146.1	5,763.2
Capacity Constrained by Surface Area and Unconstrained by Parking from Table 12 (for the Project Area Only).		3086.9	2,239.3	1,445.0	968.7	713.6	458.4 *

TABLE 17

ANNUAL BEACH VISITS (X 1,000)

WITHOUT PROJECT CAPACITY
FROM DEMAND CONSTRAINED BY SURFACE AREA AND PARKING

ATTENDANCE CATEGORIES	DAYS	% OF TOTAL	1990	2000	2010	2020	2030	2040
1	1	3.4	8.5*	6.1*	4.0*	2.7*	2.0*	1.3*
2	1	3.1	8.5*	6.1*	4.0*	2.7*	2.0*	1.3*
3	1	1.6	8.5*	6.1*	4.0*	2.7*	2.0*	1.3*
4	1	1.5	8.5*	6.1*	4.0*	2.7*	2.0*	1.3*
5	3	3.9	25.4*	18.4*	12.0*	8.0*	5.9*	4.7*
6	3	3.4	25.4*	18.4*	12.0*	8.0*	5.9*	4.7*
7	1	1.0	8.5*	6.1*	4.0*	2.7*	2.0*	1.3*
8	8	7.7	67.7*	49.1*	32.0*	21.2*	15.6*	10.1*
9	4	3.2	30.4	24.5*	16.0*	10.6*	7.8*	5.0*
10	1	0.7	6.7	6.1*	4.0*	2.7*	2.0*	1.3*
11	25	16.2	153.8	153.4*	100.0*	66.4*	48.9*	31.4*
12	3	1.7	16.1	18.4*	12.0*	8.0*	5.9*	3.8*
13	6	2.8	26.6	36.8**	24.0*	15.9*	11.7*	7.5*
14	18	6.9	65.5	100.8**	72.0*	47.8*	35.2*	22.6*
15	35	11.0	104.5	160.7**	140.0*	92.9*	68.4*	44.4*
16	40	10.0	95.0	146.1**	160.0*	106.2**	78.2**	50.2**
17	71	12.4	117.8	181.2**	260.9**	188.4**	138.8**	89.2**
18	58	6.2	58.9	90.6**	130.4**	153.9**	113.4**	72.9**
19	85	3.3	31.3	48.2**	69.4**	97.9**	136.8**	106.8**
TOTAL 1/		(100.0)	867.6	1083.2	1064.7	841.4	684.5	458.4***
(Maximum capacity Distributed by parking and constrained by surface area from Table 15)			949.6	1,272.9	1,445.0	930.6	713.6	458.4

* Constrained by surface area (refer to Table 11).

** Visits indicated are the lesser of the surface area carrying capacity or the maximum associated demand from table 16.

*** Visits limited to those indicated in table 15. This total would have been 460.7 otherwise.

1/Total existing carrying capacity considering surface area and parking constraints.

TABLE 18A
BEACH FILL SURFACE AREA

0 FOOT-WIDE BERM WIDTH ALTERNATIVE BEACH FILL PLAN

Location/Access	Existing Public Shorefront MHW Bch. Width (1990)			Additional Public Beach Width To MHW (Not Incl. Existing Width) 1/				Overall Combined Total With-Project Public Beach	
	Distance (Ft.)	Width (Ft.)	Area (Sq. Ft.)	Distance (Ft.)	Additional Width (Ft.)	Area (Sq. Ft.)	Subtotal	Area (Sq. Ft.)	
N. Co. Access	(100)	71.5	7,150	100	48	4,800			
				1155	48	55,440	60,200	67,350	*
				1255					
Jensen Beach N.	(1,600)	70.	112,000	1600	38	60,800	60,800	172,800	
Jensen Beach Park	(1,450)	55	79,750	1450	33	47,850			
				1320	33	43,560	91,410	171,160	
				2770					
Bob Graham Beach	(1,990)	60	119,400	445	38	16,910			
				1990	38	75,620			
				745	38	28,310	120,840	240,240	
				3180					
Alex's Beach	(565)	66	37,290	745	38	28,310			
				565	38	21,470			
				1420	38	53,960	103,740	141,030	
				2730					
Virginia Forest	(100)	77	7,700	1320	43	56,760			
				100	43	4,300			
				1320	43	56,760	117,820	125,520	
				2740					
Tiger Shores	(100)	60.5	6,050	1320	53	69,960			
				100	53	5,300			
				1025	53	54,325	129,585	135,635	
				2445					
Stuart Beach	(1,150)	46.5	53,475	1025	53	54,325			
				1150	53	60,950			
				1320	53	69,960	185,235	238,710	
				3495					
		Totals	422,815	20,215			869,630	1,292,445	*

1/ One half of the advanced nourishment M.H.W. width is included.

TABLE 18B

WITH PROJECT CAPACITY
0 FOOT WIDE BERM WIDTH ALTERNATIVE BEACH FILL
(DISTRIBUTED BY PARKING)

SURFACE AREA SQ. FT. (X 1,000)	LOCATION/ACCESS	PARKING (%)	(VISITS X 1000) YEAR 1990	2000	2010	2020	2030	2040
	Hutchinson Island							
67.4	North County Access	(1.9)	23.6	36.4	52.4	73.9	103.2	143.5
172.8	Jensen Beach North	(15.83)	197.0	303.1	436.4	615.3	860.1	1,195.5
171.2	Jensen Beach Park	(15.20)	189.2	291.0	419.0	590.8	825.8	1,148.0
240.2	Bob Graham Park	(11.53)	143.5	220.8	317.9	448.2	626.5	870.8
141.0	Alex's Beach	(3.48)	43.3	66.6	95.9	135.3	189.1	262.8
125.5	Virginia Forrest	(1.39)	17.3	26.6	38.3	54.0	75.5	105.0
135.6	Tiger Shores	(1.65)	20.5	31.6	45.5	64.1	89.7	124.6
238.7	Stuart Beach Park	(25.33)	315.2	485.0	698.3	984.5	1,376.2	1,742.5*
Total 1,292.4		(76.31)	949.6	1,416.1	2,103.6	2,966.1	4,146.1	5,592.7
	Distributed Demand for Project Area from Table 8		949.8	1,461.1	2,103.6	2,966.2	4,146.1	5,763.2
	Unconstrained Annual Demand from Table 8		1,244.6	1,914.7	2,756.7	3,887.0	5,433.2	7,552.3

*Constrained by surface area only.

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TABLE 18C

ANNUAL BEACH VISITS (X 1,000)

WITH PROJECT CAPACITY
0 FOOT WIDE BERM WIDTH DESIGN BEACH FILL
(CONSTRAINED BY PARKING)

ATTENDANCE CATEGORIES	DAYS	% OF TOTAL	1990	2000	2010	2020	2030	2040
1	1	3.5	9.6*	9.6*	9.6*	9.6*	9.6*	9.6*
2	1	3.1	9.6*	9.6*	9.6*	9.6*	9.6*	9.6*
3	1	1.6	9.6*	9.6*	9.6*	9.6*	9.6*	9.6*
4	1	1.5	9.6*	9.6*	9.6*	9.6*	9.6*	9.6*
5	3	3.9	28.9*	28.9*	28.9*	28.9*	28.9*	28.9*
6	3	3.4	28.9*	28.9*	28.9*	28.9*	28.9*	28.9*
7	1	1.0	9.5	9.6*	9.6*	9.6*	9.6*	9.6*
8	8	7.7	73.1	77.1*	77.1*	77.1*	77.1*	77.1*
9	4	3.2	30.4	38.6*	38.6*	38.6*	38.6*	38.6*
10	1	0.7	6.7	9.6*	9.6*	9.6*	9.6*	9.6*
11	25	16.2	153.8	229.4	241.0*	241.0*	241.0*	241.0*
12	3	1.7	16.1	24.1	28.9*	28.9*	28.9*	28.9*
13	6	2.8	26.6	39.7	57.8*	57.8*	57.8*	57.8*
14	18	6.9	65.5	97.7	145.2	173.5*	173.5*	173.5*
15	35	11.0	104.5	155.8	231.4	326.3	337.4*	337.4*
16	40	10.0	95.0	141.6	210.4	296.6	385.6*	385.6*
17	71	12.4	117.8	175.6	260.9	367.8	514.2	684.4*
18	58	6.2	58.9	87.8	130.4	183.9	257.1	346.8
19	85	3.3	31.3	46.7	69.4	97.9	136.8	184.6
TOTAL 1/			885.2	1,229.5	1,606.5	2,004.8	2,363.4	2,671.1
(Adjusted annual demand distributed by parking limited constraint by surface area in 2040 from Table 18B.) *			949.6	1,416.1	2,103.6	2,966.1	4,146.1	5,592.7

*Constrained by parking (9,640 people per day accommodated).

1/ Total capacity considering constraints.

TABLE 19A
BEACH FILL SURFACE AREA

20 FOOT-WIDE BERM WIDTH ALTERNATIVE BEACH FILL PLAN

Location/Access	Existing Public Shorefront MHW Bch. Width (1990) Distance (Ft.)	Width (Ft.)	Area (Sq. Ft.)	Additional Public Beach Width 1/ To MHW (Not Incl. Existing Width) Distance (Ft.)	Additional Width (Ft.)	Area (Sq. Ft.)	Subtotal	Overall Combined Total With-Project Public Beach Area (Sq. Ft.)
N. Co. Access	(100)	71.5	7,150	100	68	6,800		
				1155	68	78,540	85,340	92,490 *
				1255				
Jensen Beach N.	(1,600)	70.	112,000	1600	63	100,800	100,800	212,800
Jensen Beach Park	(1,450)	55	79,750	1450	51	73,950		
				1320	51	67,320	141, 270	221,020
				2770				
Bob Graham Beach	(1,990)	60	119,400	445	54	24,030		
				1990	54	107,460		
				745	54	40,230	171,720	291,120
				3180				
Alex's Beach	(565)	66	37,290	745	55	40,975		
				565	55	31,075		
				1420	55	78,100	150,150	187,440
				2730				
Virginia forest	(100)	77	7,700	1320	63	83,160		
				100	63	6,300		
				1320	63	83,160	172,620	180,320
				2740				
Tiger Shores	(100)	60.5	6,050	1320	72	95,040		
				100	72	7,200		
				1025	72	73,800	175,740	181,790
				2445				
Stuart Beach	(1,150)	46.5	53,475	1025	73	74,825		
				1150	73	83,950		
				1320	73	96,360	255,135	308,610
				3495				
		Totals	422,815	20,215			1,252,775	1,675,590

1/ One half of the advanced nourishment M.H.W. width is included.

TABLE 19B

WITH PROJECT CAPACITY*
20 FOOT WIDE BERM WIDTH ALTERNATIVE BEACH FILL
(DISTRIBUTED BY PARKING)

	SURFACE AREA SQ. FT. (X 1,000)	LOCATION/ACCESS	PARKING (%)	(VISITS X 1000) YEAR 1990	2000	2010	2020	2030	2040	
		Hutchinson Island								
	92.5	North County Access	(1.9)	23.6	36.4	52.4	73.9	103.2	143.5	*
	212.8	Jensen Beach North	(15.83)	197.0	303.1	436.4	615.3	860.1	1,195.5	
	221.0	Jensen Beach Park	(15.20)	189.2	291.0	419.0	590.8	825.8	1,148.0	
	291.1	Bob Graham Park	(11.53)	143.5	220.8	317.9	448.2	626.5	870.8	
	187.4	Alex's Beach	(3.48)	43.3	66.6	95.9	135.3	189.1	262.8	
	180.3	Virginia Forrest	(1.39)	17.3	26.6	38.3	54.0	75.5	105.0	
	181.8	Tiger Shores	(1.65)	20.5	31.6	45.5	64.1	89.7	124.6	
	308.6	Stuart Beach Park	(25.33)	315.2	485.0	698.3	984.5	1,376.2	1,913.0	
Total	1,675.5		(76.31)	949.6	1,416.1	2,103.6	2,966.1	4,146.1	5,763.2	
		Distributed Demand for Project Area from Table 8		949.8	1,461.1	2,103.6	2,966.2	4,146.1	5,763.2	
		Unconstrained Annual Demand from Table 8		1,244.6	1,914.7	2,756.7	3,887.0	5,433.2	7,552.3	

*Not Constrained by surface area.

TABLE 19C

ANNUAL BEACH VISITS (X 1,000)

WITH PROJECT CAPACITY
20 FOOT WIDE BERM WIDTH ALTERNATIVE BEACH FILL
(CONSTRAINED BY PARKING)

ATTENDANCE CATEGORIES	DAYS	% OF TOTAL	1990	2000	2010	2020	2030	2040
1	1	3.5	9.6*	9.6*	9.6*	9.6*	9.6*	9.6*
2	1	3.1	9.6*	9.6*	9.6*	9.6*	9.6*	9.6*
3	1	1.6	9.6*	9.6*	9.6*	9.6*	9.6*	9.6*
4	1	1.5	9.6*	9.6*	9.6*	9.6*	9.6*	9.6*
5	3	3.9	28.9*	28.9*	28.9*	28.9*	28.9*	28.9*
6	3	3.4	28.9*	28.9*	28.9*	28.9*	28.9*	28.9*
7	1	1.0	9.5	9.6*	9.6*	9.6*	9.6*	9.6*
8	8	7.7	73.1	77.1*	77.1*	77.1*	77.1*	77.1*
9	4	3.2	30.4	38.6*	38.6*	38.6*	38.6*	38.6*
10	1	0.7	6.7	9.6*	9.6*	9.6*	9.6*	9.6*
11	25	16.2	153.8	229.4	241.0*	241.0*	241.0*	241.0*
12	3	1.7	16.1	24.1	28.9*	28.9*	28.9*	28.9*
13	6	2.8	26.6	39.7	57.8*	57.8*	57.8*	57.8*
14	18	6.9	65.5	97.7	145.2	173.5*	173.5*	173.5*
15	35	11.0	104.5	155.8	231.4	326.3	337.4*	337.4*
16	40	10.0	95.0	141.6	210.4	296.6	385.6*	385.6*
17	71	12.4	117.8	175.6	260.9	367.8	514.2	684.4*
18	58	6.2	58.9	87.8	130.4	183.9	257.1	357.3
19	85	3.3	31.3	46.7	69.4	97.9	136.8	190.2
TOTAL 1/			885.2	1,229.5	1,606.5	2,004.8	2,363.4	2,687.2
(Adjusted annual demand distributed by parking from Table 19B.)			949.6	1,416.1	2,103.6	2,966.1	4,146.1	5,763.2

*Constrained by parking (9,640 people per day accommodated).

1/ Total capacity considering constraints.

TABLE 20A
BEACH FILL SURFACE AREA

(35 FOOT-WIDE BERM WIDTH ALTERNATIVE BEACH FILL PLAN)

Location/Access	Existing Public Shorefront MHW Bch. Width (1990) Distance (Ft.)	Width (Ft.)	Area (Sq. Ft.)	Additional Public Beach Width 1/ To MHW (Not Incl. Existing Width) Distance (Ft.)	Additional Width (Ft.)	Area (Sq. Ft.)	Subtotal	Overall Combined Total With-Project Public Beach Area (Sq. Ft.)
N. Co. Access	(100)	71.5	7,150	100	83	8,300		
				1155	83	95,865	104,165	111,315 *
				1255				
Jensen Beach N.	(1,600)	70.	112,000	1600	78	124,800	124,800	236,800
Jensen Beach Park	(1,450)	55	79,750	1450	73	105,850		
				1320	73	96,360	202,210	281,960
				2770				
Bob Graham Beach	(1,990)	60	119,400	445	75	33,375		
				1990	75	149,250		
				745	75	55,875	238,500	357,900
				3180				
Alex's Beach	(565)	66	37,290	745	73	54,385		
				565	73	41,245		
				1420	73	103,660	199,290	236,580
				2730				
Virginia forest	(100)	77	7,700	1320	85	112,200		
				100	85	8,500		
				1320	85	112,200	232,900	240,600
				2740				
Tiger Shores	(100)	60.5	6,050	1320	86	113,520		
				100	86	8,600		
				1025	86	88,150	210,270	216,320
				2445				
Stuart Beach	(1,150)	46.5	53,475	1025	90	92,250		
				1150	90	103,500		
				1320	90	118,800	314,550	368,025
				3495				
		Totals	422,815	20,215			1,626,685	2,049,500

1/ One half of the advanced nourishment M.H.W. width is included.

TABLE 20B
WITH PROJECT CAPACITY*
35 FOOT WIDE BERM WIDTH ALTERNATIVE BEACH FILL
(DISTRIBUTED BY PARKING)

Public Beach SURFACE AREA SQ. FT. (X 1,000)	LOCATION/ACCESS	PARKING (%)	(VISITS X 1000) YEAR 1990	2000	2010	2020	2030	2040
	Hutchinson Island							
111.3	North County Access	(1.9)	23.6	36.4	52.4	73.9	103.2	143.5 *
236.8	Jensen Beach North	(15.83)	197.0	303.1	436.4	615.3	860.1	1,195.5
282.0	Jensen Beach Park	(15.20)	189.2	291.0	419.0	590.8	825.9	1,148.0
357.9	Bob Graham Park	(11.53)	143.5	220.8	317.9	448.2	626.5	870.8
236.6	Alex's Beach	(3.48)	43.3	66.6	95.9	135.3	189.1	262.8
240.6	Virginia Forrest	(1.39)	17.3	26.6	38.3	54.0	75.5	105.0
216.3	Tiger Shores	(1.65)	20.5	31.6	45.5	64.1	89.7	124.6
368.0	Stuart Beach Park	(25.33)	315.2	485.0	698.3	984.5	1,376.2	1,913.0
Total 2,049.5		(76.31)	949.6	1,416.1	2,103.6	2,966.1	4,146.2	5,763.2
	Distributed Demand for Project Area from Table 8		949.8	1,461.1	2,103.6	2,966.2	4,146.1	5,763.2
	Unconstrained Annual Demand from Table 8		1,244.6	1,914.7	2,756.7	3,887.0	5,433.2	7,552.3

*Not Constrained by surface area only.

TABLE 20C

ANNUAL BEACH VISITS (X 1,000)

WITH PROJECT CAPACITY
35 FOOT WIDE BERM WIDTH ALTERNATIVE BEACH FILL

(CONSTRAINED BY PARKING)

ATTENDANCE CATEGORIES	DAYS	% OF TOTAL	1990	2000	2010	2020	2030	2040
1	1	3.5	9.6*	9.6*	9.6*	9.6*	9.6*	9.6*
2	1	3.1	9.6*	9.6*	9.6*	9.6*	9.6*	9.6*
3	1	1.6	9.6*	9.6*	9.6*	9.6*	9.6*	9.6*
4	1	1.5	9.6*	9.6*	9.6*	9.6*	9.6*	9.6*
5	3	3.9	28.9*	28.9*	28.9*	28.9*	28.9*	28.9*
6	3	3.4	28.9*	28.9*	28.9*	28.9*	28.9*	28.9*
7	1	1.0	9.5	9.6*	9.6*	9.6*	9.6*	9.6*
8	8	7.7	73.1	77.1*	77.1*	77.1*	77.1*	77.1*
9	4	3.2	30.4	38.6*	38.6*	38.6*	38.6*	38.6*
10	1	0.7	6.7	9.6*	9.6*	9.6*	9.6*	9.6*
11	25	16.2	153.8	229.4	241.0*	241.0*	241.0*	241.0*
12	3	1.7	16.1	24.1	28.9*	28.9*	28.9*	28.9*
13	6	2.8	26.6	39.7	57.8*	57.8*	57.8*	57.8*
14	18	6.9	65.5	97.7	145.2	173.5*	173.5*	173.5*
15	35	11.0	104.5	155.8	231.4	326.3	337.4*	337.4*
16	40	10.0	95.0	141.6	210.4	296.6	385.6*	385.6*
17	71	12.4	117.8	175.6	260.9	367.8	514.1	684.4*
18	58	6.2	58.9	87.8	130.4	183.9	257.1	357.3
19	85	3.3	31.3	46.7	69.4	97.9	136.8	190.2
TOTAL 1/			885.2	1,229.5	1,606.5	2,004.8	2,363.3	2,687.2
(Adjusted annual demand distributed by parking from Table 20B.)			949.6	1,416.1	2,103.6	2,966.1	4,146.2	5,763.2

*Constrained by parking (9,640 people per day accommodated).

1/ Total capacity considering constraints.

50. Average Annual Recreation Benefits. The total annual visits allocated to the 4-mile beach fill alternatives were determined considering the carrying capacity of the existing or without project conditions. Various (return interval storm) design beach fills were evaluated considering the previously discussed constraints. The with project recreational benefits for these alternative includes reductions in visits attributed to the existing conditions. The average annual benefits indicated in table 21 are based upon user day value of $3.65 determined in the previous section of this appendix. As indicated, the constraints imposed by parking limit any further significant increases in recreational benefits that would be associated with alternative plans for larger beach surface areas. *

TABLE 21
HUTCHINSON ISLAND
AVERAGE ANNUAL RECREATIONAL BENEFITS (X 1,000)
PLAN (S-2A) 4-MILE BEACH FILL ALTERNATIVE COMPARED TO WITHOUT PROJECT CONDITIONS

	YEAR					
	1990	2000	2010	2020	2030	2040
Visits attributed to existing conditions (from Table 17)	867.6	1,083.2	1,064.7	841.4	684.5	458.4
Visits attributed to a 0-foot-wide berm width reduced to account for existing conditions	17.6	146.3	541.8	1,163.4	1,659.3	2,135.7
Visits attributed to a 20-foot-wide berm width reduced to account for existing conditions	17.6	146.3	541.8	1,163.4	1,678.8	2,228.6
Visits attributed to a 35-foot-wide berm width (4-mi. beach fill) reduced to account for existing conditions	17.6	146.3	541.8	1,163.4	1,678.8	2,228.8
Benefits attributed to a 0-foot-wide berm width vs. existing conditions	$64.2	$534.0	$1,977.6	$4,246.4	$6,056.4	$7,795.3
Benefits attributed to a 20-foot-wide berm width vs. existing conditions	$64.2	$534.0	$1,977.6	$4,246.4	$6,127.6	$8,135.1
Benefits attributed to a 35-foot-wide berm width vs. existing conditions	$64.2	$534.0	$1,977.6	$4,246.4	$6,127.6	$8,135.1

*

		TOTAL	Total Reduced to Account for Operation and Maintenance Costs 1/
Average Annual Recreation Benefits:	0 Foot Berm Width Design	$1,198,800	$1,138,300
At 8 5/8% Interest Rate	20 Foot Berm Width Design	$1,204,700	$1,144,200
	35 Foot Berm Width Design	$1,204,700	$1,144,200

1/ Increased operation and maintenance costs for implementation of Plan S-2A are estimated at $60,500.

OTHER ASSOCIATED BENEFITS

BENEFITS FROM PREVENTION OF STORM DAMAGE AND LOSS OF LAND
HUTCHINSON ISLAND SEGMENT (4-MILE BEACH FILL ALTERNATIVE S-2A)

51. Benefits from prevention of damages or losses due to shore erosion include loss of or damage to development features such as roads, buildings, and other structures. Benefits from the reduction or elimination of maintenance to existing erosion control structures are not included in this analysis, but are discussed later in this appendix. For the purpose of analysis, storm damage to this property is defined as the damage incurred by the temporary loss of a given amount of shoreline as a direct result of wave attack caused by a storm of a given magnitude and frequency. The amount of damage to development was determined by drawing on maps and aerial photographs and the expected bluffline recession for various storms. The structures that would be affected by a storm of a certain frequency of occurrence were identified on the aerial photographs. These damages were then computed and are displayed on tables 23 through 27. *

52. Assumptions made during computation of storm damage were as follows:

a. Frequency of occurrence of shoreline recession wil remain constant with time.

b. When the bluffline recedes halfway through a structure, the structure is considered a total loss.

c. Seawalls and other shoreline protection structures were assumed lost when the volume loss of a given bluffline recession equaled the volume required to scour in front of a structure to the point where it would fail.

d. Although the shorefront areas continue to develop, only prevention of damages to existing developments were claimed.

53. The assessment of damages to existing development considered the protection afforded by existing widths of beach and dunes in otherwise unprotected areas. However, it is important to note that the results of continued long-term erosion will allow future damages to shore structures to be more severe with a given storm. This is due to the fact that the amount of bluff protection between a structure and the shoreline will decrease with time. In the computation of damage prevention benefits, this change was not considered.

54. As determined from a real estate study conducted as part of the overall study, the development within the study area consists of both residential houses and commercial hotels and condominiums. Property values vary from the tens of thousands for residential housing to the millions for some of the larger condominiums. Below is a detailed description of the analysis performed for both Hutchinson and Jupiter Islands. *

55. For the purpose of this analysis, storm damage was defined as the damage incurred by the temporary loss of a given amount of shoreline as a direct result of wave attack caused by a storm of a given magnitude and frequency. It is assumed that as the shoreline erodes to a building, structural damage will occur. Once the erosion is halfway through a structure, the entire building is destroyed and repair costs equal reconstruction costs. The levels of protection provided by various beach berm widths for storm return intervals are indicated on table 22B. *

56. Benefits are computed by calculating the damage between with and without project conditions. The without project conditions for both Hutchinson Island and Jupiter Island, are based on 1984 aerial photos and the bluffline recession values in table 23. With project conditions assume the design berm width increases, by the same width, the distance the shoreline must erode before coming in contact with a structure. Values for without and with project damages for Hutchinson Island are shown on tables 23, 24, 25, 26, and 27, respectively. Benefits are shown on table 33.

TABLE 22A *

STORM FREQUENCY VS. BLUFFLINE RECESSION

STORM FREQUENCY	RETURN INTERVAL(YRS)	BLUFFLINE RECESSION (FT.)
0.30	3.3	0
0.20	5	20
0.05	20	50
0.025	40	65
0.017	59	90
0.013	75	100
0.010	100	108 1/

TABLE 22B

Approximate Level of Protection

Plan	Level of Protection for Storm Return Interval in years
Existing Conditions	0
5 Foot Berm	5
20 Foot Berm	10
35 Foot Berm	40
65 Foot Berm	59

*

1/ Eight feet is not accurately resolvable on a 1" = 200' aerial; therefore, analysis ended at a storm return interval of 75 years.

TABLE 23

HUTCHINSON ISLAND
DAMAGES UNDER EXISTING CONDITIONS

Maximum Recession	Probable Occurrence	Increment of Probability	Damages (x $1,000)			
			Total	Average	Annual	Cumulative Total
0	0.30		0			
		0.10		750	75.0	75.0
20	0.20		1,500			
		0.175		3,850	674.0	749.0
65	0.025		6,200			
		0.008		7,100	56.8	805.8
90	0.017		8,000			
		0.004		8,000	32.0	837.8
100	0.013		8,000			
		0.003		8,000	24.0	861.8
107	0.010		8,000			

TABLE 24

HUTCHINSON ISLAND (PLAN S-2A)
5-FOOT BERM

Maximum Recession	Probable Occurrence	Increment of Probability	Damages (x $1,000)			
			Total	Average	Annual	Cumulative Total
0	0.30		0			
		0.10		0	0	0
20	0.20		0			
		0.175		1,250	219.0	219.0
65	0.025		2,500			
		0.008		2,850	22.8	241.6
90	0.017		4,200			
		0.004		4,950	19.8	261.4
100	0.013		5,700			
		0.003		5,850	17.6	278.9
107	0.010		6,000			

TABLE 25
HUTCHINSON ISLAND (PLAN S-2A)
20-FOOT BERM

Maximum Recession	Probable Occurrence	Increment of Probability	Damages (x $1,000) Total	Average	Annual	Cumulative Total
0	0.30		0			
		0.10		0	0	0
20	0.20		0			
		0.175		750	131.3	131.3
65	0.025		1,500			
		0.008		1,250	10.0	141.3
90	0.017		2,000			
		0.004		2,050	8.2	149.5
100	0.013		2,600			
		0.003		3,050	9.2	158.7
107	0.010		3,500			

TABLE 26
HUTCHINSON ISLAND
35-FOOT BERM

Maximum Recession	Probable Occurrence	Increment of Probability	Damages (x $1,000) Total	Average	Annual	Cumulative Total
0	0.30		0			
		0.10		0	0	0
20	0.20		0			
		0.175		0	0	0
65	0.025		0			
		0.015		0	0	0
90	0.017		0			
		0.008		250	1.0	1.0
100	0.013		500			
		0.004		800	2.4	3.4
107	0.010		1,100			

TABLE 27
HUTCHINSON ISLAND (PLAN S-2A)
55-FOOT BERM

Maximum Recession	Probable Occurrence	Increment of Probability	Damages (x $1,000) Total	Average	Annual	Cumulative Total
0	0.30		0			
		0.10		0	0	0
20	0.20		0			
		0.175		0	0	0
65	0.025		0			
		0.008		0	0	0
90	0.017		0			
		0.004		0	0	0
100	0.013		0			
		0.003		0	0	0
107	0.010		0			

LOSS OF LAND BENEFITS

57. Prevention of loss of land benefits for Hutchinson and Jupiter Islands was based on the historic erosion rates of 1.5 feet per year and 3.4 feet per year, respectively. Loss of land occurs over the project life at the historic rate unless the mean high water line recedes to an existing erosion control structure such as a revetment or sea wall. It is assumed that once the high water line has receded to a structure, the structure haults the landward migration of the water line and the structure is maintained throughout the remainder of the project life. To calculate benefits, it is assumed the project mitigates the erosion effects and thus, they are based on with and without project conditions. Without project conditions were based on 1984 aerial photos. With project conditions, assume the project's protective berm erodes, however, never landward of the estimated 1990 mean high water line. Benefit calculations were quite volumous and thus are only summarized on table 33.

As shown in table 28, the number of visitors that can be attributed to the project beach are constrained by parking to 4820 per half day. Table 28 also indicates that 482,000 sq. ft. of surface area required along the public shorefront to accommodate these visitors considering 100 square feet * per person.

Table 29 is provided to determine the distances along the public shorefront (at each access) that would be required to provide the 482,000 square feet of surface area needed to accomodate 4820 visitors per half day. Column C indicates the without (existing) and with-project surface areas at each access. Column D provides the total with-project surface area and average beach width fronting only existing public shorefront. Column E lists the surface area required to meet the demand constrained by parking from table 28. Column F subtracts Column E from Column D to determine excess surface area along only existing public shorefront. Column G shows the excess shorefront distance not needed to meet the constrained recreational demand. This is determined by dividing the excess surface area from Column F by the average beach width from Column D. The purpose of these calculations is to illustrate that since 482,000 sq. ft. of plan S-2A's 2,049,500 sq. ft. (23.5 percent) is needed to meet the constrained demand, there would be an excess surface area available that will provide loss of land benefits. Approximately 972,900 sq. ft. of the 2,049,500 sq. ft. would front existing public shorefront with implementation of Plan S-2A. Therefore, since 482,000 of the 972,900 sq. ft. (50 percent) of surface area is needed to meet the constrained recreational use, there is an excess amount of shorefront that will supply a protective beach that should be associated with benefits for prevention of loss of land along the public shorefront. Column G determines that 3556 feet along existing public shorefront are not needed for recreational use. Therefore, prevention of loss of land benefits were determined as shown in table 30, for 3556 feet of public shorefront and 10,090 feet (14,065 - 3,975) of private shorefront that is without existing protective structures.

(Rev. March 86)

Prevention of the loss of 20,864 square feet of land each year as determined in table 30 provides an average annual benefit of $208,600 considering the appraised land value of $10 per square foot from the real estate study, conducted as part of the study. Of this 20,864 square feet of land, 6,362 square feet (30.5 percent) would be existing public land. Prevention of loss of land benefits for this public property are considered appropriate since Martin County has historically experienced land loss due to erosion. An example of Martin County's willingness to prevent excessive loss of land at the public shorefront parks occurred in November 1984, when the Thanksgiving day storm overtopped the existing dune and deposited large quantities of sand along the backshore. The county utilized two large dumptrucks and a front end loader to reshape the foredune at Jensen Beach Park, Bob Graham Beach, and Bathtub Beach Park. In addition, the county placed sand fences and vegetation at these sites to help stabilize and protect the foredune to help prevent the accelerated loss of land that would have occurred otherwise. At Bob Graham Beach, the county placed sand fences along the landward side of the reconstructed foredune to alleviate pedestrian damages to the dune and replaced the dune cross over that had been destroyed by the storm. It is considered that such maintenance would be continued by the county in the without project condition. Under the with project condition, these costs would be avoided. Rather than trying to estimate the maintenance costs avoided, benefits for prevention of loss of land along the public shorefront were determined by the same method as the private benefits for consistency.

TABLE 28
REQUIRED BEACH SURFACE AREA TO
TO MEET CONSTRAINED DEMAND

	Visitors Accommodated per Half day by Parking in 1990 1/	Required Surface Area to accommodate Visitors 2/ (Sq.FT.)
North County Access	120	12,000
Jensen Beach North	1000	100,000
Jensen Beach Park	960	96,000
Bob Graham Park	728	72,800
Alex's Beach	220	22,000
Virginia Forest	88	8,800
Tiger Shores	104	10,400
Stuart Public Beach	1600	160,000
Total	4,820	482,000

1/ as determined from table 13

2/ considering 100 sq. ft. per person per half day.

TABLE 29
RECREATIONAL SURFACE AREA (PLAN S-2A)

Location/Access	A Existing Public Beach (1990 M.H.W. Beach Width) Distance (ft.)	A Width (ft.)	A Area (sq. ft.)	B Additional Public Beach to M.H.W. (Not including existing width)1/ Distance (ft.)	B Additional Width (ft.)	B Area (sq. ft.)	C With Project Total Public Beach Surface Area (sq. ft.) (A + B)	D With Project Public Beach Surface Area Along Public Shorefront Only (sq. ft.)	D Avg. Width (ft.)	E Required Beach Surface Area to Meet Demand2/ (sq. ft.)	F Excess Beach Surface Area (D - E) (sq. ft.)	G Existing Public Shorefront Distance (Alongshore) Associated With Excess Beach Surface Area Area (Ft.)	G F/D
North County Access	100	71.5	7150				7150					22	3,450
				100	83	8,300	8,300	15,450	(154.5)	12,000	3,450		154.5
				1,155	83	95,865	95,865						
Jensen Beach North	1,600	70	112,000				112,000					924	136,800
				1,600	78	124,800	124,800	236,800	(148)	100,000	136,800		148
Jensen Beach Park	1,450	55	79,750				79,750					700	89,600
				1,450	73	105,850	105,850	185,600	(128)	96,000	89,600		128
				1,320	73	96,360	96,360						
				445	75	33,375	33,375						
Bob Graham Beach	1,990	60	119,400				119,400					1450	195,850
				1,990	75	149,250	149,250	268,650	(135)	72,800	195,850		135
				745	75	55,875	55,875						
				745	73	54,385	54,385						
Alex's Beach	565	66	37,290				37,290					407	56,535
				565	73	41,245	41,245	78,535	(139)	22,000	56,535		139
				1,420	73	103,660	103,660						
				1,320	85	112,200	112,200						
Virginia Forest	100	77	7,700				7,700					46	7,400
				100	85	8,500	8,500	16,200	(162)	8,800	7,400		162
				1,320	85	112,200	112,200						
				1,320	86	113,520	113,520						
Tiger Shores	100	60.5	6,050				6,050					29	4,250
				100	86	8,600	8,600	14,650	(146.5)	10,400	4,250		146.5
				1,025	86	88,150	88,150						
				1,025	90	92,250	92,250						
Stuart Beach Park	1150	46.5	53,475				53,475						
				1,150	90	103,500	103,500	156,975	(136.5)	160,000	-3,025	-22	-3,025
				1,320	90	118,800	118,800						136.5
Total	7,055		422,815				2,049,500	972,860				3,556	

1/ Includes one-half of the advanced nourishment MHW width.
2/ As constrained by parking and as indicated in Table 21.

TABLE 30
LOSS OF LAND PREVENTED

Location/Access	Shorefront Ownership	Distance (ft.)	Erosion Rate (ft. per yr.)	Surface Area Area (sq. ft.)
North County Access	private	1155	0.7	809
Jensen Beach North	public	924	1.0	924
Jensen Beach Park	public	700	3.0	2100
	private	820*	3.0	2460
	private	268*	2.0	536
Bob Graham Beach	public	1450	2.0	2900
	private	745	2.0	1490
	private	745	0.8	596
Alex's Beach	public	407	0.8	326
	private	1420	0.8	1136
	private	50*	0.8	40
Virginia Forest	public	46	0.6	28
	private	1320	0.6	792
	private	347	0.6	208
Tiger Shores	public	29	2.9	84
	private	875*	2.9	2538
	private	1025	2.9	2973
Stuart Beach Park	private	1320	.7	924
	Total	13,646		20,864

*Reduced distance to account for
existing shorefront protective structures.

JUPITER ISLAND SEGMENT (5.6-MILE BEACH FILL ALTERNATIVE S-2B)

58. Benefits from the prevention of damage to development were calculated similarily to those for Hutchinson Island, by use of aerial photographs to establish before and after storm conditions. The existing bluffline was established and damages were then based on storm frequency versus bluffline recession values listed on table 23. Approximately one half of the project reach is revetted and assumed capable of withstanding up to a 10-year design storm. In the event a larger storm strikes the area, the revetments are expected to reduce the damage by reducing the bluffline recession by that associated with a 10-year unrevetted shotefront. Benefits are summarized on table 32.

59. Prevention of loss of land benefits for Jupiter Island were based on the historic erosion rate. Loss of land occurs over the project life unless the mean high waterline receeds to an existing erosion control structure. The erosion control structure is assumed to halt further erosion throughout the remainder of the project life. Detailed results are not presented because this segment was found unfavorable for Federal participation in construction of the 5.6-mile beach fill alternative.

BENEFITS FROM PREVENTION OF DAMAGE TO EXISTING PROTECTIVE STRUCTURES

60. Benefits from the prevention of damage to existing protective structures are considered equivalent to the costs required to maintain the existing structures under existing conditions. For analysis it is assumed that the shoreline continues to erode at the historic rate of 1.5 feet per year on Hutchinson Island and 3.4 feet per year on Jupiter Island. Once the mean high waterline has receeded to the toe of the existing protective structure, 10 year design storm. The cost of reconstruction was estimated to be $618 per foot for a 1V:2H slope revetment with 2.2 ton armor stone.

61. Once the revetment has been reconstructed it is maintained throughout the remainder of the project life. Annual maintenance costs are estimated by amortization of costs to rehabilitate the reconstructed revetment once every 10 years after reconstruction. The cost per foot for rehabilitation is estimated to be $325, based on reconstruction of a 1V:2H slope revetment with 2.2-ton stone. The difference in construction and rehabilitation costs are due to half the amount of armor stone necessary for rehabilitation and no need for bedding stone. The benefits are presented on tables 31 and 32 *
for Hutchinson Island and Jupiter Island, respectively. Benefits are summarized on table 33.

TABLE 31

HUTCHINSON ISLAND
VALUE OF EXISTING SHOREFRONT PROTECTIVE STRUCTURES
(8 5/8% interest, June 1985 price levels)

Investments	
Present worth of replacing 3,475 feet of revetment	$126,200
Present worth of replacing 500-foot dura-bag revetment	5,800
Total	$132,000
Annual Cost	
Interest and Amortization	$11,600
Maintenance	2,200
Total	$13,800

TABLE 32

JUPITER ISLAND
VALUE OF EXISTING SHOREFRONT PROTECTIVE STRUCTURES
(8 5/8% INTEREST, June 1985 price levels)

Investments	
Present worth of replacing 12,115 feet of revetment	$818,550
Annual Cost	
Interest and Amortization	$71,700
Maintenance	20,800
Total	$92,500

FLOOD DAMAGES

62. Benefits from the prevention of flood damages are negligible. Flood prevention benefits are realized by the reduction or elimination of still water flooding caused when dunes are overtopped by storm surge and wave runup. This type of still water flooding damages both the structure and the contents of the structure. For damage evaluation, the still water level is related to storm frequency.

63. Evaluation of existing conditions on Hutchinson Island show dune elevations along the Atlantic shoreline ranging from +12 feet to +18 feet, mean sea level. For the evaluation of damages it is assumed the contents of a structure would not begin to be damaged until the still water level reached +1 foot above the dune elevation. In other words, it must be 1 foot deep outside before anything inside begins to get wet. Structural damage begins to occur when flooding begins.

64. The NOAA storm curves show a 25-year storm event has a +12.2-foot m.s.l., elevation which would only begin to flood a small portion of the study area. The 100-year storm event has a +14.2-foot elevation. It appears, based on existing conditions and the NOAA curves, there would be only isolated flooding along the study reach caused by even a 100-year storm. The figure below relates the storm frequency to the storm surge along Hutchinson Island. The average dune height along the island is 15.4 feet m.s.l. which is 1.2 feet above the 100-year storm surge.

+8	+12.2	+13	+14.2	storm surge
0.10	0.04	0.05	0.01	storm frequency

BENEFITS FROM LOSS OF LAND PREVENTION AND RECREATION COMBINED

65. The recreation analysis for the proposed plan (S-2A) for Hutchinson Island indicates that a large portion of the beach fill surface area would not be required to satisfy the demand because of parking constraints. Loss of land benefits are not claimed along the shorefront where recreation benefits are computed. Recreation benefits are claimed along 16.6% of the shorefront for the proposed plan. Loss of land benefits are claimed along 64.6% of this shoreline. The remaining 18.8% of shorefront has benefits attributed to prevention of damages to existing erosion control structures. There are no overlapping benefits. *

66. At Jupiter Island limited public access and parking restrict recreation benefits to about $107,000 on an average annual basis. A similar analysis was made to determine the length of the considered plan's (S-2B) shorefront that would be required to provide sufficient beach surface area to attain recreational benefits. Approximately 253 feet of the 29,568 (5.6 miles) shorefront would be required. This amounts to about 1 percent of the total length of the plan's shorefront. Therefore, the loss of land benefits are reduced accordingly to address the inclusion of recreation benefits for this limited reach as shown on tables 28, 29, and 30.