RESOLUTION NO. 38-86

A RESOLUTION OF THE TOWN COUNCIL OF THE TOWN OF PALM BEACH, PALM BEACH COUNTY, FLORIDA, RECEIVING AND ACCEPTING THE COMPREHENSIVE COASTAL MANAGEMENT PLAN, DATED AUGUST 1986, AS PREPARED WITH THE PROFESSIONAL AND TECHNICAL ASSISTANCE OF THE COASTAL ENGINEERING CONSULTANT, CUBIT ENGINEERING LIMITED.

* * *

WHEREAS, the Town Council of the Town of Palm Beach adopted Resolution No. 19-85 on April 9, 1985, authorizing the preparation and completion of a Comprehensive Coastal Management Plan (the "Plan") for the Town of Palm Beach; and

WHEREAS, the Town has held several public meetings since April 9, 1985 on the Plan; and

WHEREAS, the Town Council deems it to be in the best interests of the general welfare of the residents of the Town of Palm Beach to receive and accept said Plan and to proceed with implementation during the following years, as the Town Council may determine to be financially and technically appropriate, in view of Town's overall projects, programs, and requirements;

NOW, THEREFORE BE IT RESOLVED BY THE TOWN COUNCIL OF THE TOWN OF PALM BEACH, PALM BEACH COUNTY, FLORIDA as follows:

Section 1. The Town Council hereby acknowledges receipt and acceptance of the Comprehensive Coastal Management Plan to use as an overall guide in evaluating and implementing projects and programs which may affect the entire shoreline within the corporate limits of the Town of Palm Beach.

Section 2. The Town Council hereby directs the Town Staff to proceed with implementation of the Plan, contingent upon subsequent necessary direction and approvals by the Town Council as may be required, and as may be deemed financially and technically appropriate by the Town Council.

Section 3. All proposed beachfront projects, programs, and other related activities shall be evaluated based upon said Plan and the Town Council shall direct actions as it may deem appropriate to be consistent with overall Plan implementation.

PASSED AND ADOPTED in a regular adjourned session assembled this 9th day of September, 1986.

APPROVED:

Mayor

ATTEST:

George T. Peters

Town Clerk

Nancy S. Douthit

Richard C. Brim

Town Council

COMPREHENSIVE COASTAL MANAGEMENT PLAN

FOR

TOWN OF PALM BEACH

CUBIT ENGINEERING LIMITED

AUGUST 1986

COMPREHENSIVE COASTAL MANAGEMENT PLAN
FOR THE TOWN OF PALM BEACH

MAYOR	Yvelyne de Marcellus Marix
TOWN COUNCIL	
PRESIDENT	Richard C. Burn
PRESIDENT PRO TEM -	Paul R. Ilyinsky
MEMBER	Nancy S. Douthit
MEMBER	George G. Matthews
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August 1986

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ACKNOWLEDGEMENTS

This report was prepared for the Town of Palm Beach under the direction of Douglas C. Delano, Town Manager and Robert J. Doney, Assistant Town Manager.

Members of Town Council and Town Staff have participated in the constructive review of and input to this document. In addition, several persons and agencies have contributed data and information which was instrumental in the preparation of the Plan. The individual contributions are greatly appreciated.

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Richard C. Burn	President
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EXECUTIVE SUMMARY

COMPREHENSIVE COASTAL
MANAGEMENT PLAN
FOR
TOWN OF PALM BEACH

EXECUTIVE SUMMARY

The Town of Palm Beach authorized the preparation of a Comprehensive Coastal Management Plan by adopting Resolution No. 19-85 on April 9, 1985. The purpose of the act was to authorize the preparation of a document that would outline a strategy to effectively manage the Town's shoreline and deal with erosion on a planned basis. This report presents the Plan developed on the basis of coastal processes, historical trends, environmental considerations, financial feasibility, and need.

The Town has participated in coastal erosion management since the 1920's. After a series of hurricanes, the Town authorized a seawall and groin construction program referenced to a master plan that is considered one of the first of its kind. These seawalls have continued to provide necessary storm protection to upland property. The groins have generally deteriorated to a non-functional state and in most instances pose nuisance hazards to bathers.

The Lake Worth Inlet has played a dominant role in contributing to erosion of downcoast beaches. Since its construction in 1920 by local interests and made a Federal project in 1934, the Inlet has impounded sand on the north side contributing to erosion on the Town side. Studies by the Corps of Engineers indicate that the Inlet is responsible for only 40 percent of the erosion south of the Inlet. The remainder is the result of natural processes. The Corps has proposed to mitigate the erosion by replacing the existing sand bypass plant with a new facility capable of pumping more sand around the Inlet at greater reliability and less expense. The Town should endorse this plan and participate in seeking the appropriate local sponsor to maintain it in perpetuity.

The well being of the Town's beaches depends upon the amount of sand which is bypassed around the Lake Worth Inlet and the frequency of exposure to erosive northeasters and hurricanes. In general the Town needs to insure that sufficient sand is pumped annually to the south of the Inlet and that only beach quality material from all Federal maintenance of the navigation channel is deposited on the beach south of the South jetty. Due to the long term impacts of Lake Worth Inlet effects, beach nourishment at Mid-Town is recommended to replenish a sand starved area. This improvement to the public bathing beach will also beneficially effect beaches to the south by creating a feeder beach.

The Town's commitment to coastal structures must be maintained to protect upland property. This requires regular seawall maintenance and plans for future replacement as needed in response to age deterioration. The troublesome erosion which has continually effected the Widener's Curve to Sloan's Curve area can be mitigated by the revetment proposed by the Florida Department of Transportation. Construction of this revetment should continue to be a top Town priority to preserve upland property and infrastructure in this area. The groins can be largely abandoned except in select areas where they have shown to be effective.

The Town's shoreline has areas of rock outcrop which have historically experienced burial and uncovering. The principal environmental impact of the Town's Coastal Management Plan concerns effects to the offshore reef system and nearshore rock outcrops. Through prudent environmental baseline data collection and construction monitoring, impacts to the offshore reef system can be held to a minimum. Beach nourishment is proposed only for areas south of Lake Worth Inlet and at Mid-Town. No nearshore outcrops appear at Mid-Town; features south of Lake Worth Inlet historically cover and uncover which implies that renourishment there can be shown to be non-impacting.

The recommended plan for the Town incorporates the following elements:

1. replace the sand bypass plant at Lake Worth Inlet;
2. require all sand bypass plant discharge and beach quality maintenance dredge spoil to be placed south of Onondaga Avenue so that it will be of greatest benefit;
3. renourish the Mid-Town public beach to enhance that area and provide downcoast property protection;
4. endorse the Department of Transportation (DOT) revetment at Widener's Curve to Sloan's Curve;
5. maintain the seawalls to ensure that storm protection to upland property and infrastructure is provided;
6. maintain and/or modify only those groins which are presently effective; abandon and remove all others as may be physically and financially practical;
7. enhance the dune areas with vegetation and sand fence techniques between Sloan's Curve and Kreusler Park to take advantage of the relatively wide beach there now; and
8. monitor the Town's beach to develop a better data base of information concerning beach characteristics so that future planning decisions can be made.

The Plan recognizes that funding is a major problem in limiting the extent of improvement that can be made over a period of time. Federal participation can be obtained for replacement of the sand bypass plant at Lake Worth Inlet. Federal and State money may be available to finance renourishment of the beach at Mid-Town. To guarantee Federal participation, efforts are required to prevent the Palm Beach Island Federal project from being deauthorized as proposed in current Congressional legislation. Federal and State participation requires increases in public access and parking. These requirements should be identified and considered for consistency with Town uses.

The Town of Palm Beach can independently fund capital improvements for beach projects by creating a special independent taxing district. In so doing, the private citizenry can exercise freer control in nourishment projects or coastal structure improvements. The local residents may be polled for interest in participating in self-funding techniques. This funding mechanism needs further review by the Town's legal counsel.

It is recommended that the Town plan a 10-year forecast of expenditures. The 10-year cycle is recommended due to sensitivity to storm frequency and improved knowledge of the Town's erosion trends based on better data collection techniques. A summary of the initial ten year implementation schedule and cost is given on the table, reproduced from Chapter 10.0, at the end of this section.

As a first priority toward implementation of the Plan the Town should work closely with the Corps of Engineers to implement a sand bypass plant improvement and Federal participation at Mid-Town. Second, the Town must demonstrate to its citizens that local funding of a portion of the Plan is in the best interests of both the community and the individual taxpayers. As a minimum, the Town must upgrade the Lake Worth Inlet bypass plant, preserve its seawall system and regularly monitor the behavior and trends of its beach.

The Comprehensive Coastal Management Plan should be periodically reviewed and amended as necessary. As a minimum the Ten Year Implementation Schedule should be reviewed and revised annually during the Town's budget and capital improvement program and budgeting process. The Plan itself should be updated every five years or after the passage of a major hurricane or northeaster. This frequency is recommended to allow time for a significant beach profile database to accumulate and provide a sufficient time duration to observe shoreline changes and trends. Adjustments to beach fill operations and structural improvements can then be recommended and implemented accordingly to "fine tune" the Plan.

TEN YEAR IMPLEMENTATION SCHEDULE
COMPREHENSIVE COASTAL MANAGEMENT PLAN
TOWN OF PALM BEACH

Estimated Costs in Thousands of 1986 Dollars

	Fiscal Year (Oct.1 – Sept.30)	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
REACH 1 Lake Worth Inlet to Breakers Hotel	Replace bypass plant*			1080							
	Roadway protective seawall repair**						438				
	Groin removal								204	202	202
	Monitoring	2.4	2.4	2.4	2.4						
REACH 2 Breakers Hotel to Barton Ave.	Monitoring	1.2	1.2	1.2	1.2						
REACH 3 Barton Ave. to Banyan Road	Roadway protective seawall repair		498	498	364	364					
	Groin removal	226									
	Beach nourishment		400	3038							
	Monitoring				2.4	2.4	2.4	2.4			
REACH 4 Banyan Road to Widener's Curve	Roadway protective seawall repair	416									
	Groin maintenance and removal		2.1		164						
	Monitoring	2.4	2.4	2.4	2.4						
REACH 5 Widener's Curve to Sloan's Curve	DOT revetment ***	7480									
	Monitoring	1.2	1.2	1.2	1.2						
REACH 6 Sloan's Curve to City of Lake Worth	Dune maintenance			40							
	Monitoring	2.4	2.4	2.4	2.4						
REACH 7 City of Lake Worth to South Town Limit	Monitoring	2.4	2.4	2.4	2.4						
Roadway Protective Seawall Repairs Reaches 1, 3, and 4 (To be determined by further studies)								500	500	500	500
ESTIMATED COST SUB-TOTAL		8134	931	4668	542	366	440	502	704	702	702
ESTIMATED COSTS TO POTENTIALLY BE PAID BY OTHERS ****		7641	188	3388							
ESTIMATED COSTS TO POTENTIALLY BE PAID BY ASSESSMENT *****		208	259	249	264	182	219	250	352	351	351
ESTIMATED COST TO THE TOWN OF PALM BEACH		285	484	1030	278	184	221	252	352	351	351

* – Lake Worth Inlet bypass plant improvements by others
** – Seawall repair costs as estimated by Mock, Roos & Associates + 10% contingency
*** – Cost of revetment by DOT
**** – Assumes 75% state funding of groin removal in Reach 3, except engineering and contingencies, 75% state funding of non-federal share of beach nourishment costs (except engineering) in FY 1987 and 1988, and 28% federal funding of beach fill cost in FY 1988
*****– Assumes 50% assessment to private ownership for groin and seawall work

Note: Costs include 10% for engineering and 10% contingency.
Refer to Plan text for understanding of project limits and type of work.
This program should be reviewed and revised annually during the Town's budget and capital improvement program and budgeting process.

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CHAPTER 1.0
INTRODUCTION

COMPREHENSIVE COASTAL
MANAGEMENT PLAN
FOR
TOWN OF PALM BEACH

1.0 INTRODUCTION

1.1 Authorization

On November 13, 1984, the Town of Palm Beach considered goals and objectives for studies and reports to be prepared which would achieve operational and physical improvements for the Town. The highest ranking priority that was identified called for the development of a Comprehensive Beach Erosion Plan. By adoption of Resolution No. 19-85 on April 9, 1985, the Town Council authorized the preparation of a plan to identify structural and non-structural projects for subsequent implementation to protect and enhance the shoreline of the Town of Palm Beach and the land within the Town's corporate limits. A Plan was requested which would provide advanced planning for future beach erosion management so that emergency action requirements could be reduced and long-term stabilization of the shorefront could be realized. This document presents the selected beach management plan.

1.2 Coastal Erosion at Palm Beach

The Town of Palm Beach has experienced a gradual loss of sand from its ocean beaches over the years. The erosion has been a chronic problem since the construction and maintenance of the Lake Worth Inlet jetties and navigation channel and a series of hurricanes and storms which impacted the island in the 1920's, 1930's and 1940's. The Town has responded to the situation over the years through sponsorship and participation in beach nourishment projects, seawall and groin construction, and a sand bypass program.

The Thanksgiving holiday storm of 1984 focused attention on the current erosion situation at the Town. This northeaster affected a significant portion of the Florida east coast including Palm Beach County. At the Town of Palm Beach, dune erosion at the Sloan's to Widener's Curve area threatened State Road A-1-A; loss of sand at the Mid-Town Municipal Bathing Beach resulted in limited availability during high tide.

As a result of the concerns brought about by the Thanksgiving holiday storm, the Town of Palm Beach considered it appropriate to study its shoreline in a more comprehensive manner and determine what future planning may be necessary to better manage the shoreline. A scope of study was therefore developed to analyze the historical erosion, inventory the current situation, and predict the future trend. Based upon the anticipated erosion problems and their causes, a comprehensive plan could be adopted to protect upland property as necessary and maintain recreational beaches within feasible funding resources and environmental limits.

1.3 Purpose and Scope of the Coastal Management Plan

A comprehensive beach management plan defines a consistent and coherent approach to the management of the dynamic beach segment of the coastal zone. Recognizing the important resource characteristics of the ocean beach, this strategy attempts to fully utilize that resource with sensitivity to its dynamic characteristics. The plan is intended as a technical support document which together with appropriate political and economic considerations can be developed into an actual plan of action for managing the beach.

An effective beach management strategy provides the following advantages:

- avoidance of resource depleting trial-and-error solutions;
- identification of the range of feasible action;
- improved decisions involving recreation and storm protection uses of the beach;
- development of a community appreciation of the economic and political realities of managing the beach resource;
- encouragement of planning process before needs become critical; and
- avoidance or limitation of practices and policies which run counter to coastal physical processes and which may be difficult or impossible to reverse once begun.

The purposes of this coastal management plan are:

- perform research and analysis of previous coastal structural projects at the Town;
- review the historical shoreline location;
- evaluate the effects of the Lake Worth Inlet;
- consider the desires of the community concerning public and private beaches;
- research and evaluate state-of-the-art projects and techniques for structural and non-structural systems to enhance and protect the coastline and upland development; and

- present a comprehensive and workable plan that can be implemented by the public/private sector.

1.4 Report Organization

This Comprehensive Coastal Management Plan is divided into ten chapters. Chapter 2 discusses general coastal processes. Chapters 3 and 4 present a detailed review of the dynamic history of the area and an evaluation of the current condition of the Town's shoreline. Chapter 5 discusses the Lake Worth Inlet and recommended management action. Chapters 6 and 7 present funding options and permit issues for consideration in the implementation of a selected plan. Chapter 8 discusses erosion management alternatives and the rationale for plan selection for the Lake Worth Inlet, the public beach, and the private beach sections. Chapter 9 presents the recommended plan for the public and private beach areas and contains a discussion of the emergency contingency plan to direct actions in the event of major storm damage. Finally, Chapter 10 presents an outline of implementation to bring the plan into reality

CHAPTER 2.0
PHYSICAL PROCESSES

COMPREHENSIVE COASTAL
MANAGEMENT PLAN
FOR
TOWN OF PALM BEACH

2.0 PHYSICAL PROCESSES AND FEATURES

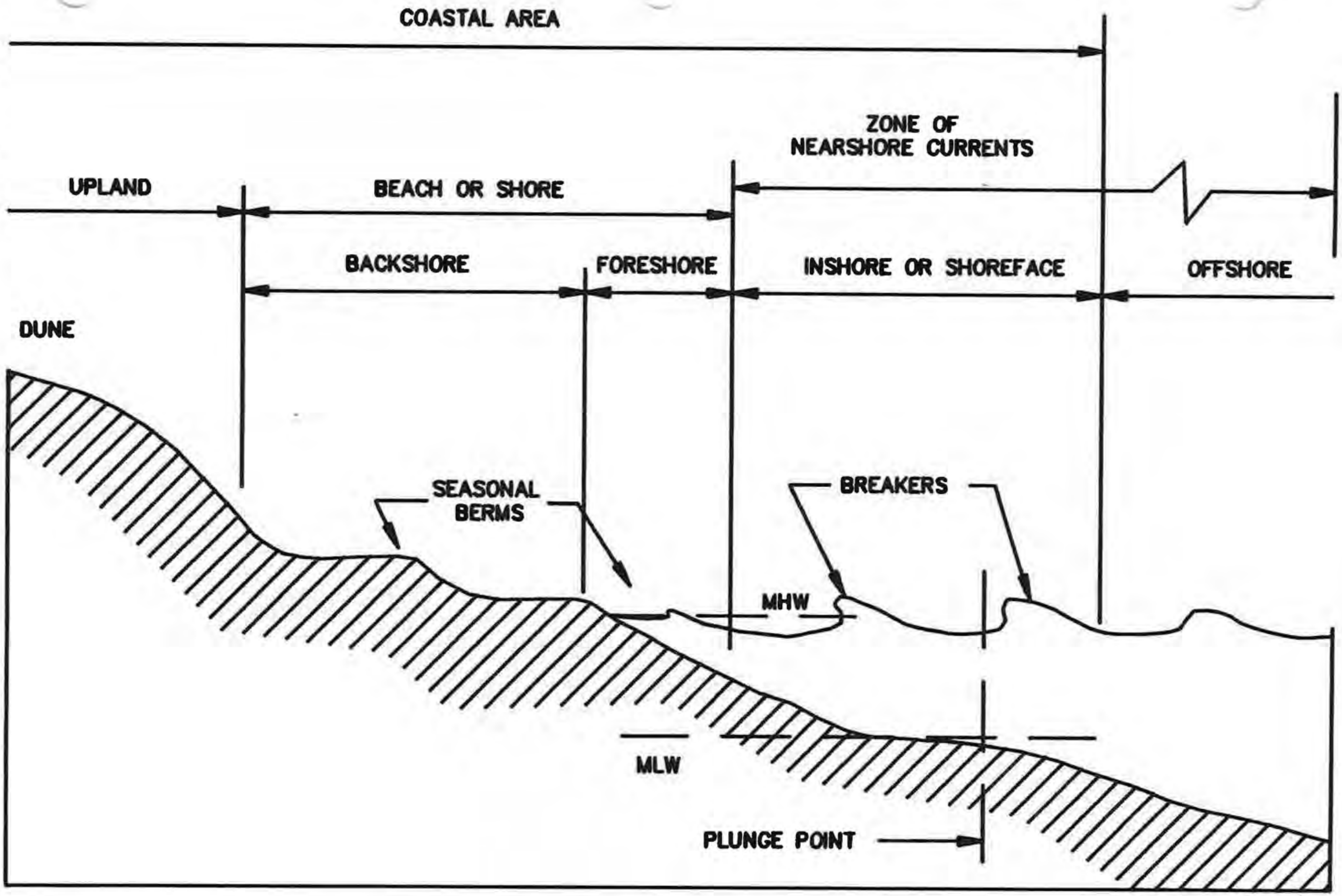
The entire length of the Town of Palm Beach shoreline is composed of sandy beach which is particularly responsive to the natural influences of wind, waves, tides, currents and other phenomena in the coastal zone. Large quantities of sand annually move along the Town's shoreline in response to these processes. The sand is carried along the shore following the predominant current direction. The rate of sand movement increases in proportion to the strength of the wind or water currents. The result is a shoreline undergoing constant change. The shores erode, accrete or remain stable depending on the rates at which sand is supplied to or removed from the beach area. Typically shoreline changes are gradual, but under the influence of high energy storms these changes can occur with dramatic swiftness.

2.1 Beach-dune System

Profiles running across a beach from dune to deep water have characteristic features which reflect the action of the physical processes in the littoral zone. Figure 2.1 represents a typical beach profile which identifies these features. At any given time an actual beach may exhibit only a few of these specific features.

A sand beach provides the shore with natural protection against attack by waves, currents and storms. The sloping nearshore bottom causes waves to break offshore, dissipating their energy over the surf zone. The formation of an offshore bar along the beach also promotes the offshore breaking of waves. If the waves break far enough offshore, they will reform as smaller waves to break again closer to the shore. The process of waves breaking and reforming may continue in this cycle until the substantially reduced wave rushes up onto the beach foreshore. A wide beach offers considerable protection to the property behind it. In other words, if the berm contains more sand than a storm erodes, then structures behind the beach will not be threatened by the receding shoreline. Alternatively, a narrow beach does not afford as much protection to the property behind it.

Beaches are shaped by wave conditions which vary with season. Figure 2.2 shows typical changes in beach profile over time. This figure illustrates how the berm built up gradually from February through August, eroded back from November through January, and then rebuilt in March through September. This process is typical of the cyclical process of storm-caused erosion in winter, followed by rebuilding in response to the lower and longer waves during the summer.



BEACH FEATURES

FIGURE 2.1

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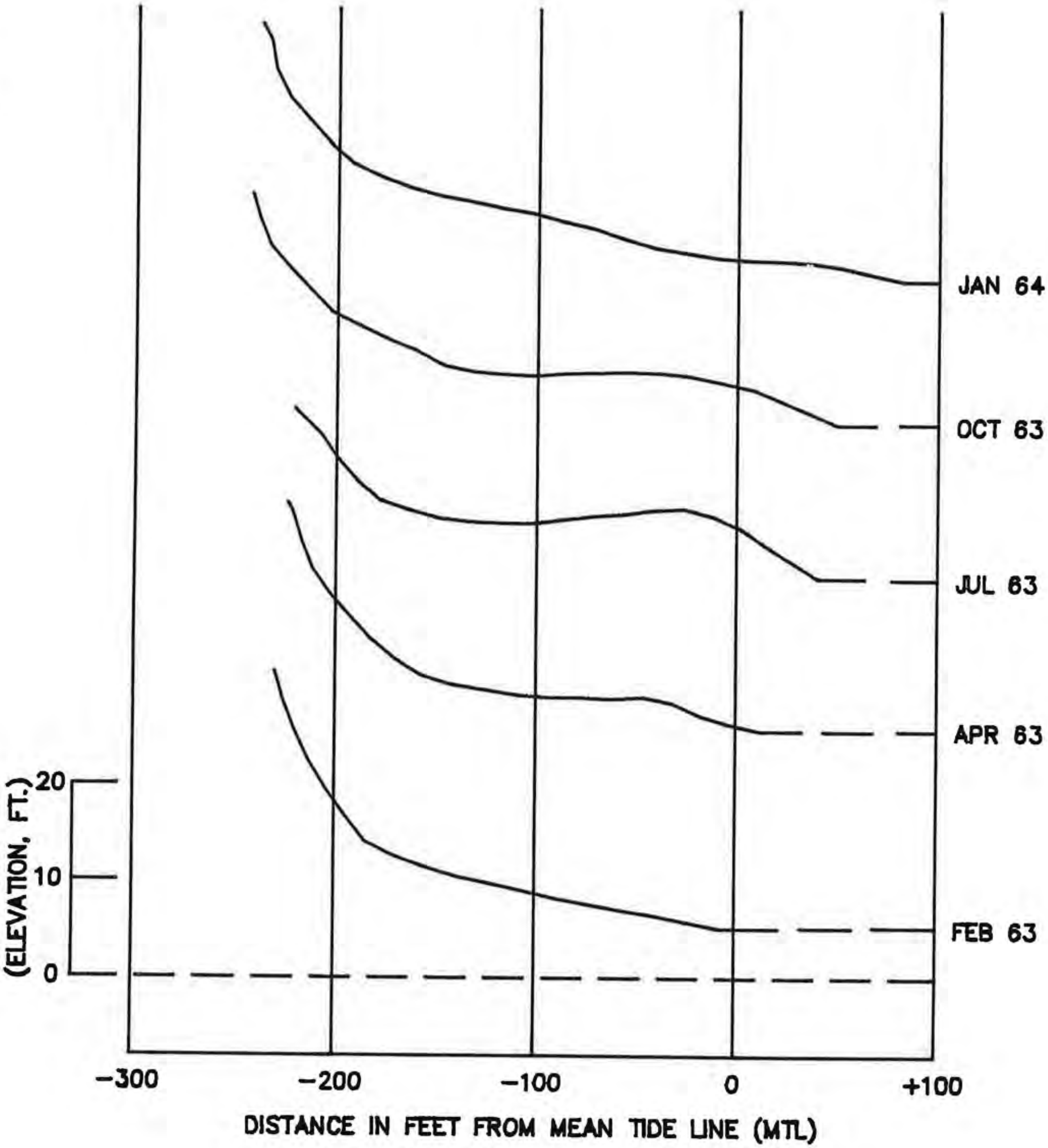


TYPICAL SEASONAL PROFILE CHANGES

SOURCE: COASTAL ENGINEERING RESEARCH CENTER, 1984

AUGUST 1986

FIGURE 2.2

Onshore winds can move sand inland from the beach. Foredunes are often created and maintained by the action of beachgrasses trapping and stabilizing sand blown from the beach. Like the beach berm, foredunes perform an important role in littoral processes. Foredunes function as a reservoir of sand to nourish eroding beaches during high water and to act as a levee to prevent wave damage to backshore areas. As such, dunes, like the beach berm are valuable non-rigid shore protection structures. The important role dunes play in protecting the landward property has been recognized by layman and expert alike. Public awareness has been responsible for the formulation of special dune ordinances to protect the foredune.

One of the major causes of damage to dune systems is pedestrian traffic (Collier, 1977). Shore visitors often opt for the shortest route between their car and the beach. Large numbers of people crossing the dunes have resulted in:

1. dissection of the dune field by formation of numerous pathways across and along the foredune;

2. development of large, barren areas (blowouts), where vegetation has been completely destroyed; and

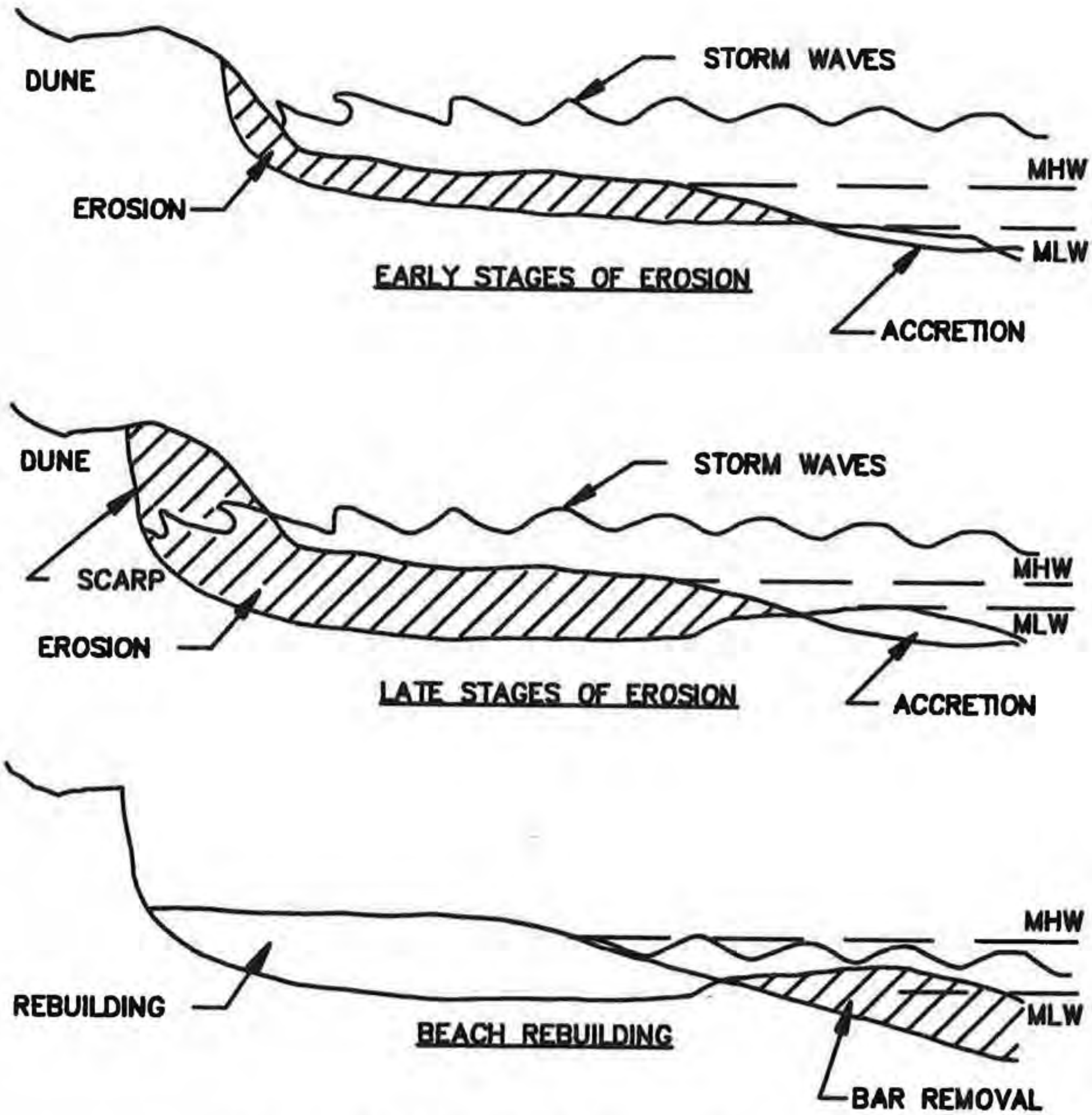
3. retardation of new dune growth and development.

With heavy and continued use initial pathways quickly become large breachways through the foredune. Field studies have shown that the loss of elevation in a devegetated pathway can amount to over 2 feet annually (Leatherman, 1979).

A discontinuous dune system is vulnerable to further erosion. In the case of a major storm gaps in the system allow water and debris to be washed inland. To preserve this natural protection, it is important to provide dune crossover structures at access points allowing the beach visitor a path to the beach and protecting the inland areas.

2.2 Wave Effects

Wind waves affect beaches in two major ways. Short, steep waves generated by nearshore storms tend to erode a sand beach as shown in Figure 2.3. Long swells generated by distant storms tend to move sand back toward shore, thereby rebuilding the beach. Typically a beach undergoes an annual erosion/accretion cycle in which winter storms erode the beach and the summer swells rebuild it. Long term erosional/accretional cycles may also develop. The intensity, duration, and direction of waves are significant factors in the orientation, slope and grain size of a beach.



BEACH EROSION AND REBUILDING SEQUENCE

FIGURE 2.3

AUGUST 1986

Hurricanes and severe storms moving near shore can produce significant changes in water levels along the coast. The term "storm surge" is used to indicate a rise in water level above normal due to the action of storms. In addition to the obvious flooding implications of storm surge, these conditions can also contribute significantly to beach erosion. The beach berms shown in Figure 2.1 are built naturally by storm waves to about the highest elevation reached by normal storm waves. The storm surge allows large, steep storm waves to act at higher beach elevations not normally subjected to wave action.

When the storm waves with high storm tides attack and erode the beach and dune system (Figure 2.3) the sand is moved seaward until the offshore beach slope becomes stabilized. An offshore bar often forms which acts to dissipate the storm wave energy further. After the storm the offshore bar material is gradually returned to the beach under favorable wave conditions.

2.3 Littoral Transport

Littoral transport is defined as the movement of sediments in the nearshore zone by waves and currents in either the longshore (shore parallel) or onshore-offshore directions. Longshore transport results from the suspension of sediment by breaking waves and the movement of this sediment by wave generated longshore currents. The direction of wave approach to the shore determines the direction of longshore transport. The quantity of material actually moved is related to the wave height, with high waves being capable of moving more material than low waves.

The rate and direction of longshore transport are variable because of the variability of wave conditions. Although rate and direction change at random, the net direction of littoral transport is seasonal. These seasonal changes in littoral transport are partially responsible for cyclic erosion/accretion patterns discussed earlier. Onshore-offshore transport is determined by wave steepness, sediment size and beach slope. The erosion characteristics of steep storm waves and the beach building characteristics of long period swell are the principal mechanisms in onshore-offshore transport.

Although a beach may be temporarily eroded by storm waves and restored by swell, and seasonal patterns of erosion and accretion may occur, the long term condition of the beach is determined by differences in rates of supply and loss of littoral material. The shore will accrete, be stable, or erode depending on the relative magnitudes of the supply and loss rates.

2.4 Inlets

Inlets may have significant effects on adjacent shores by interrupting the longshore transport and trapping the moving sand. Sands can either be transported into the inlet where a portion may be lost to inner bar deposits, or the sand may be transported by ebb tidal flows and then deposited offshore on outer bars. In this way, tidal inlets may store sand and reduce the supply to adjacent shores. The sand accumulated on the outer bar also plays an important part in the changing direction or refraction of the advancing wave crests as they approach shore. The bars built around the mouth of inlets in Florida often contain ideal sand for nourishment of the adjacent beach. Over long time periods, the natural process is to slowly move the sand along the outer bar as on a conveyer belt from the updrift shore to the downdrift shore. The highly dynamic changes of the inlet often disrupt this natural transport of sand.

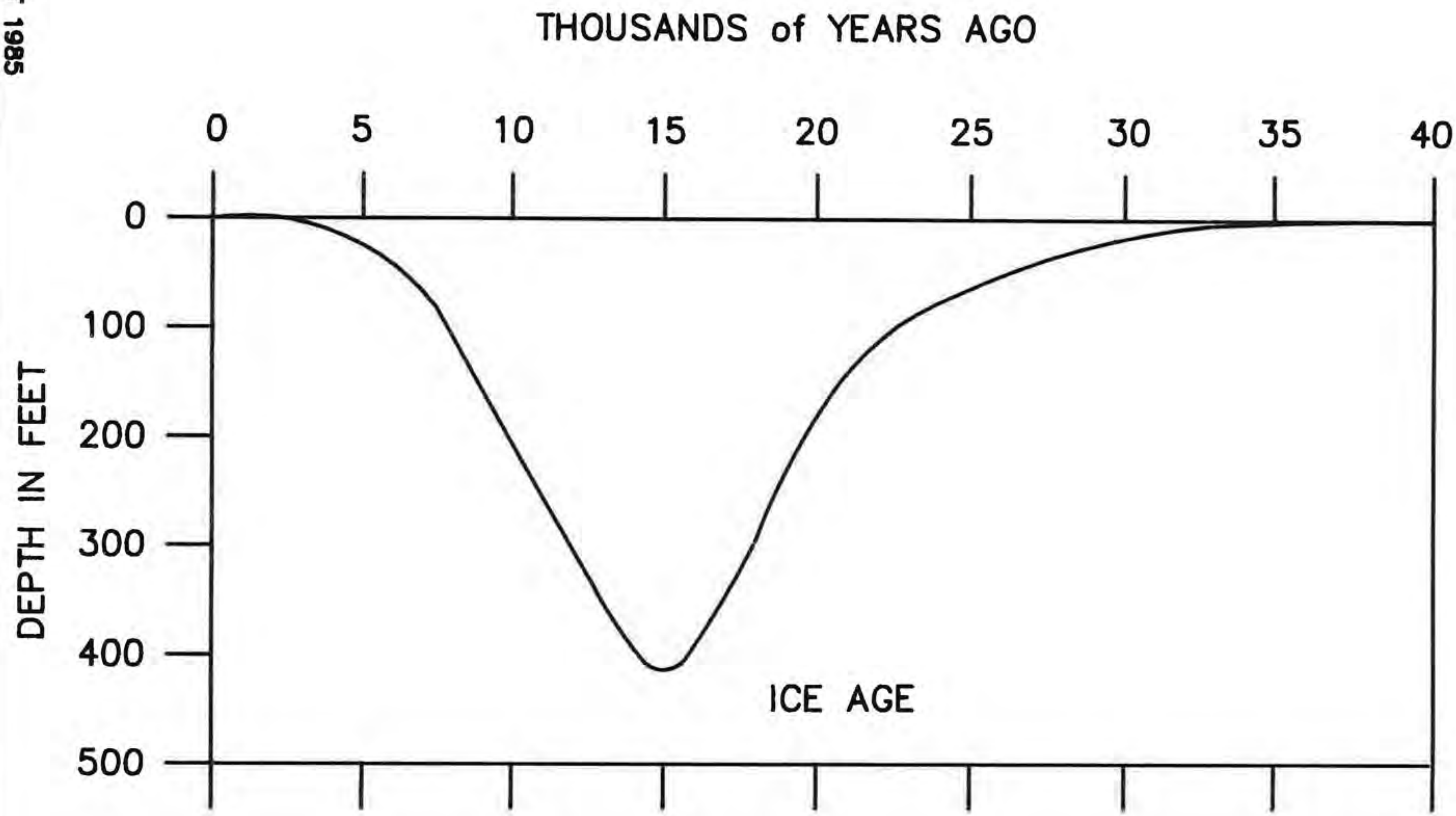
2.5 Sea Level Rise

The ocean level has never remained constant over geologic time, but has risen and fallen relative to the land surface. The last major reversal in sea level change occurred about 15,000 years ago when the Ice Age brought sea levels about 400 ft lower than its present elevation (Figure 2.4). In recent times the rate of rise has slowed to about 1 ft per century. The most recently determined rate of sea level rise along the Florida coast is about 2mm/year or about 8 in/century (Hicks et al., 1983).

The causes of relative sea level change are both global and regional. They include:

1. changes in the volume of the contained water and the volume of the ocean basins;
2. volume of ice above sea level;
3. "greenhouse" warming due to atmospheric CO_2 buildup;
4. tectonic adjustments;
5. land subsidence; and
6. long term changes in atmospheric pressure, temperature and wind patterns (Everts, 1985).

These factors account for the alongshore variations in sea level change rates shown in Figure 2.5.

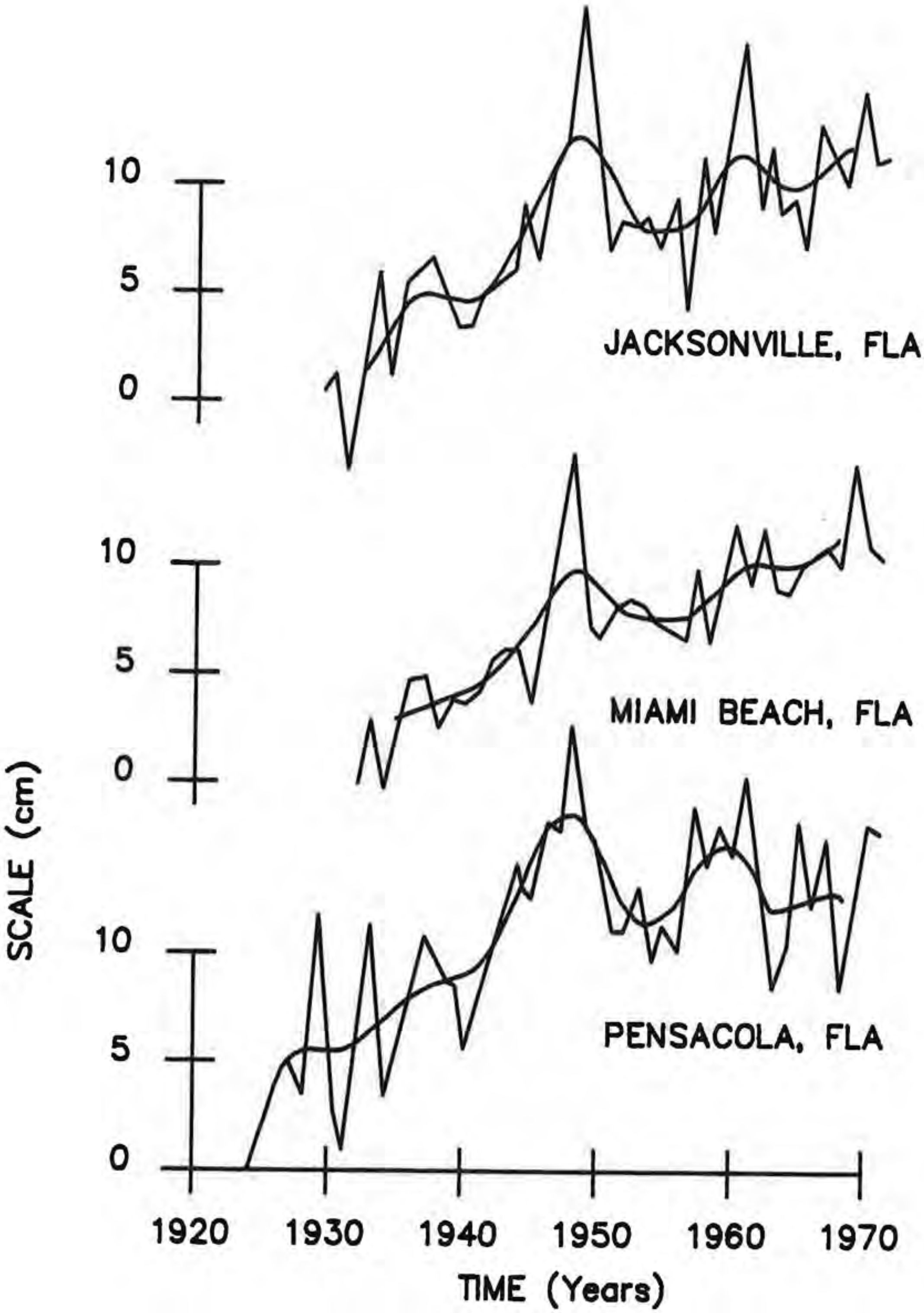


SEA LEVEL RISE

SOURCE: MILLIMAN & EMERY, 1968

FIGURE 2.4

AUGUST 1985



RELATIVE SEA LEVEL RISE IN FLORIDA

SOURCE: HICKS, 1973

FIGURE 2.5

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The general rise in sea level has been associated with the recession of shorelines. Long term monitoring (Everts, et al., 1983) shows that shoreline changes vary greatly in time and space and not sympathetically with relative sea level change. Other factors involved in shoreline erosion can obscure the sea level rise effect.

The effect of rising relative sea level on the coast is two fold:

1. a higher sea level causes a direct encroachment on the shoreline leading to an "apparent" shoreline recession which is larger on milder slopes; and

2. the volume of sand from the upper beach profile will slough off to maintain an equilibrium bottom profile (Walton, 1979).

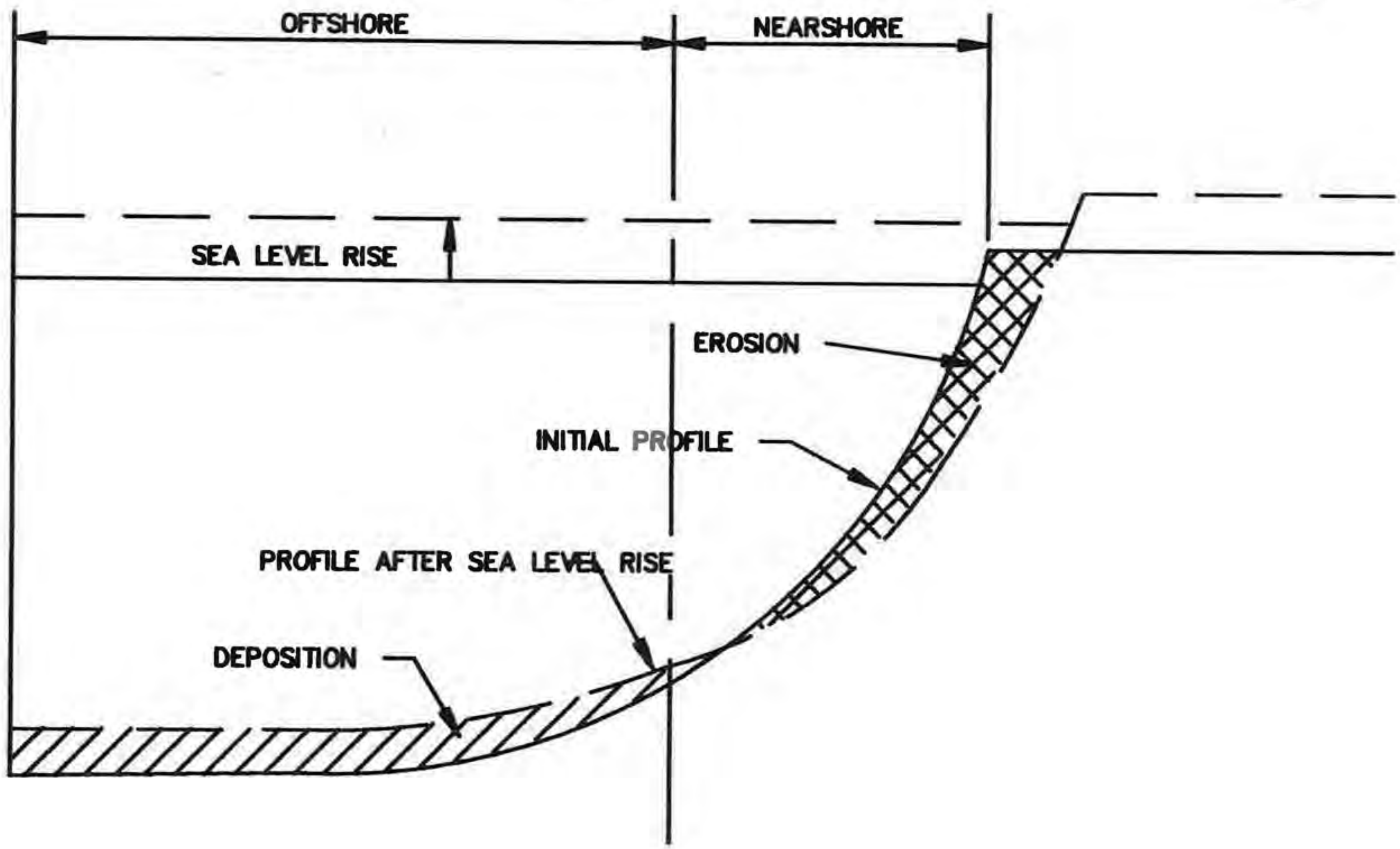
Brunn (1962) first discussed this concept and developed a model to relate the rate of shoreline retreat to the rate of relative sea level rise. He assumed that the inner continental shelf profile would maintain a constant shape and position relative to the sea surface by translating landward and up as the relative sea level rose (Figure 2.6). The beach and the upper shoreface would erode and the lower part of the shoreface profile would acquire an equal volume of sediment.

Everts (1985) further develops the analysis to account for changes in sand volume within a shoreline reach including that caused by longshore and cross-shore transport, transport into inlets, overwash, beach nourishment and other sediment losses. Field application of Evert's method shows that sea level rise accounts for about 53% of the total shore retreat of 18 ft/yr at Smith Island, Virginia and for about 88% of the 5.6 ft/yr retreat along the Outer Banks of North Carolina.

2.6 Barrier Island Features

The Town of Palm Beach may be described as a barrier island extending the full length of the Town's limits and is separated from the mainland by Lake Worth. The barrier itself is a low-relief feature with a 10 to 20 foot beach ridge protected to a large degree with seawall structures. The island extends beyond the Town limits, extending from Lake Worth Inlet at the north for nearly 16 miles to South Lake Worth Inlet.

The island is typical of Florida's east coast barriers in that it consists of beach and dune sands underlain by a rock core. The rock core is a ridge of the Anastasia Formation Coquina which is a beach rock formed from a cemented mixture of sand and shell (Cooke, 1945). The formation originated as a beach-bar complex with repeated exposure in the geologic past. Recently deposited



SHORE EROSION WITH SEA LEVEL RISE

SOURCE: BRUUN, 1983

FIGURE 2.6

AUGUST 1986

sands and shell have been draped over the formation resulting in a "perched" island (Tanner, 1960). Recent studies (Johnson, 1976) consisting of seismic surveys and borings place the coquina surface between -4 to -7 ft MSL. Typical overlying sand thicknesses are between 9 to 12 ft. The rock core serves to protect the island and slow the rate of erosion attributable to the rise in sea level.

2.7 Reefs

The sabellariid worm, Phragmatopoma lapidosa, is known as the reef builder. After an initial stage as planktonic larvae, the worms attach themselves to a site and begin their reef building process. Each worm constructs a cylindrical tube by grabbing particles suspended in the water column and cementing them together with a secreted substance. Colonies of cemented worm tubes form sabellariid worm reefs.

These worm reefs are generally found in the turbulent surf zone where wave energy suspends sand grains and shell fragments that the worms gather. The reefs are found in every major ocean on earth. The reefs grow to approximately mean sea level, oriented perpendicular to the prevailing wave energy. Many are parallel to the shoreline. The reefs act as natural breakwaters, dissipating wave energy before it reaches the shore. As a result, the shore behind the reef progrades rather than erodes (Mehta, 1973).

The honeycombed, mound shaped reefs can withstand hurricane conditions, yet can be crushed with the hand. Many studies have been conducted to determine the durability of the worm and its reef. Most were tests of the worm's ability to withstand conditions likely to occur during a beach stabilization project. The worms were tested for tolerance to sediment burial, exposure to sulfides, heavy silt loads, and oil spills. In all cases, the worms could withstand the conditions for at least 24 hours (Nelson & Main, 1985 and Mulhern, 1976). The worms were also found to be adaptable to transplantation to a new location. A study was also conducted to learn if the juvenile worms would settle on a concrete surface, such as a man made structure. The results showed that the worms will settle on a concrete surface, especially if an exterior layer of ground reef material has been applied (Kreuger, 1974).

Artificially induced reef growth may eventually become an important option of shorefront protection plans. The use of a worm reef in addition to renourishment could reduce the frequency of sand replenishment. The breakwater effect of the reef could be used to build up areas of the shore or prevent further erosion of the shore. The worms' use of fine particles in their reef building process results in a better sorted beach sand distribution. Consequently, in areas where sabellariid reefs exist, the beach contains less fine grains and therefore will not erode as easily. Cracks and crevices in the reefs also trap sediment, changing the beach sand distribution (Gram, 1968).

The sabellariid worm has been found to be a hardy, adaptable species. More study is needed to learn specifically how conditions such as water temperature, food, predation, sand supply, and turbulence affect the reef building process. With the current data though, it appears possible to artificially induce reef building. Only general predictions of variables such as growth rate and reef size are possible at present. Further research will enable the engineer to accurately estimate reef development and incorporate it into the total shore protection design.

CHAPTER 3.0
HISTORICAL PERSPECTIVE

3.0 HISTORICAL PERSPECTIVE

This chapter presents the historical background information which was researched and considered in developing the Comprehensive Coastal Management Plan. Of interest are the past experiences of sand accretion and erosion, the successes and failures of previously implemented erosion management techniques, and the influences of storms on beach condition. An understanding of these items aids in determining the dominant coastal processes along the beach, extrapolating future trends, and defining the limit of feasible techniques to stabilize the shoreline.

The Town of Palm Beach is unique in its early history of coastal study and management. The Town's awareness of shoreline processes developed in the 1920's and 1930's in response to the increase of resort visitors and permanent residents who sought to enjoy the Town's beach and recreational benefits. Concurrent with this growth in development, the Town experienced several significant hurricanes. The hurricanes of 1926 and 1928 were the most influential to the early history of the Town's coastal management practices as the resulting damages indicated a need for mitigation of erosion from future events. The construction of the Lake Worth Inlet and its subsequent channel deepening over this same time period, also created shoreline erosion problems for areas downcoast of the jetties. As a result of these two impacts the Town launched a program to study the nature of beach erosion and identify suitable methods to provide property protection and beach recreation. One result was the creation of the first example of shoreline planning on a large scale in the development of a Town-wide shore protection plan which identified predetermined locations for all existing and future seawalls and groins.

The following sections discuss the storms which have influenced the Town's beach, the documented changes in shoreline position which have occurred over the years, and the record of Town management to address the erosional and storm protection influences.

3.1 Storm History

Numerous hurricanes and northeasters have influenced the Town of Palm Beach shoreline. The intensity of these storms generates abnormally high tides which when combined with wind generated waves, erode large quantities of beach and can damage shorefront structures.

Hurricanes and tropical storms generally originate in the Caribbean Sea and tropical Atlantic Ocean. Frequently occurring between the months of September and December these storms are tropical storms in that their sustained surface wind speed reaches or exceeds 64 knots. The most damaging storms are those which landfall just south of the Town. Under this condition, the shorefront is most susceptible to damage resulting from the storms maximum onshore wind and wave attack. Less damaging hurricanes generally travel some distance offshore.

Northeasters refer to extra tropical storms associated with cold, high pressure air masses. Winds associated with a stationary high pressure system generally approach the coast from the northeast direction and occasionally reach gale force velocity (varying between 34 and 47 knots). Northeast storms generally last for 2 to 3 days and typically occur in the months of November through April. Shoreline erosion can result from wind set up and wave attack.

Storms which have passed within 50 miles of the Town's coastline are presented in Table 3.1. A brief description of some of the more significant storms which have affected the Town of Palm Beach shoreline appears below:

<u>1903 and 1926</u>

The September hurricanes of 1903 and 1926 both crossed the Florida coast approximately 50 miles south of the Town of Palm Beach. Wind speeds of eighty miles per hour were reported at Palm Beach during the 1903 storm. Although reported damages from the 1926 hurricane were limited, considerable erosion reportedly occurred along the Town's shorefront.

<u>1928</u>

The hurricane of September, 1928 was the most violent storm to strike the Town's shoreline. A storm tide of 11.2 feet, the maximum of record, was reported at Palm Beach and damage to the area was in excess of $11 million. Sections of beach were lowered two to three feet during the storm. Unprotected dunes were damaged and sections of Ocean Boulevard and State Road AlA were washed out during this severe storm.

<u>1933</u>

The hurricane of September, 1933 passed over Jupiter Island. Although wind speeds approaching 125 miles per hour were estimated, erosion of the Town's shoreline and reported damage was limited.

1947

The September and October hurricanes of 1947 crossed the Florida coastline at Fort Lauderdale. Wind velocity in excess of 100 miles per hour was reported at West Palm Beach during the September hurricane. The Town of Palm Beach reported an estimated $7 million in property damage and Ocean Boulevard was washed out at several locations. The most severe damage resulting from the October storm was caused by heavy flooding. A wind speed of 60 miles per hour was reported at West Palm Beach during this storm.

1949

The August, 1949 hurricane crossed the Florida coastline in the vicinity of the Town. Wind speeds approaching 130 miles per hour were reported at West Palm Beach and a maximum storm tide of 8.3 feet was recorded. Stretches of State Road A1A were washed out south of Lake Worth. Reported damages to the area approached $4 million and severe wind damage was reported in West Palm Beach.

1962

The March, 1962 northeaster caused long period swells and high waves along the Town's shoreline. Although the center of the storm remained offshore, severe beach erosion resulted from this northeaster.

1984

The Thanksgiving holiday storm of November, 1984 affected nearly 300 miles of Florida shorefront. The southern boundary of significant damage and flooding associated with this storm included the Town of Palm Beach shoreline. This storm's duration and moderate storm tide produced coastal erosion along the Town's shorefront damaging portions of SR A1A from Sloan's to Widener's Curves.

1985

The most recent northeaster occurred during September 15-17, 1985. Waves of 8 to 10 feet were reported and storm winds varied from 15 to 25 miles per hour. Beach erosion associated with this storm was minor.

TABLE 3.1

STORM HISTORY

TOWN OF PALM BEACH

Date	Type	Name
September 10-16, 1903	Hurricane	None
October 10-23, 1904	Hurricane	None
October 11-20, 1906	Hurricane	None
July 22-August 2, 1926	Hurricane	None
September 11-22, 1926	Hurricane	None
August 7-10, 1928	Hurricane	None
September 6-20, 1928	Hurricane	None
1932	Northeaster	----
August 31-September 17, 1933	Hurricane	None
October 30-November 8, 1935	Hurricane	None
September 11-19, 1947	Hurricane	None
October 9-15, 1947	Hurricane	None
1947	Northeaster	----
October 4-8, 1948	Hurricane	None
August 24-29, 1949	Hurricane	None
October 15-19, 1950	Hurricane	King
1956	Northeaster	----
March 1962	Northeaster	----
August 20-September 5, 1964	Hurricane	Isabell
August 27-29, 1965	Hurricane	Betsy
October 1965	Northeaster	----
1969	Northeaster	----
1972	Northeaster	----
1974	Northeaster	----
August 25-September 7, 1979	Hurricane	David
December 1983	Northeaster	----
September 25-October 1, 1984	Tropical Storm	Isadore
November 21-24, 1984	Extra Tropical Storm	Thanksgiving Day
July 23, 1985	Tropical Storm	Bob
September 15-17, 1985	Northeaster	----

Source: U.S. Army Corps of Engineers, 1985
Florida Department of Natural Resources, 1985
Palm Beach Post, 1985

3.2 History of Erosion Control

Following the dredging of the Lake Worth Inlet and construction of the jetties in 1925, local interests to the south of the Inlet began fortifying their shorefront. The Inlet was causing changes in the adjacent shorelines and beaches south of the Inlet were eroding. In an effort to protect their property and control shoreline recession, residents constructed numerous shore protective and erosion control structures including bulkheads, seawalls and groins. The Town's bulkhead and groin construction program was generally completed from 1926 through 1930. The severe damage caused by the hurricanes of 1926 and 1928 served to accelerate construction of protective structures along the Town's shorefront.

In an effort to preserve and improve the beaches within their municipal limits and protect against erosion, the Town Council adopted a groin and bulkhead ordinance on February 3, 1932. This ordinance (Sections 6-1 through 6-19, Town Code of Ordinances) designates the locations, dimensions and lengths of bulkheads and groins within the corporate limits of the Town. In August 1935 the Town's Department of Public Works completed an overall plan of existing and future shore protection structures. This plan, reproduced on Plate 1, is referred to as the "Official Bulkhead and Groin Plan of the Town of Palm Beach, Florida" and was made part of the Town's 1932 Bulkhead and Groin Ordinance. Since 1935, protective structures have generally been constructed in accordance with the overall Town plan.

In August 1936 a cooperative study was completed by the U.S. Army Beach Erosion Board to address concerns of shoreline erosion south of Lake Worth Inlet and investigate deterioration of steel sheet pile groins along the Town's shoreline. As part of this study, experimental groins were installed by the Town. The Federal government provided the various groin designs and also completed periodic field observations of the experimental groins from March 1937 through July 1946.

In March 1941 the Beach Erosion Board was asked to provide comments on remedial measures for controlling the continual erosion being experienced south of the Lake Worth Inlet. The Board's views were presented in an interim report jointly issued in September, 1941, by the U.S. Army Corps of Engineers and the University of Florida. This report concluded that maintenance of the existing groins would not improve conditions but would only retard the erosion process. The report further concluded that construction of groins further north of Queens Lane would serve no useful purpose but groin construction along other unspecified sections of shorefront might be temporarily beneficial. The recommendations considered placement and monitoring of suitable material south of the Inlet. Interim results of the experimental groin program were also included in the September 1941 report. These groins had reportedly performed satisfactorily. It was further concluded that groins designed by the Town's Department of Public Works and included in their overall plan would function properly if sufficient sand supply was available for impoundment.

In August and September 1944 approximately 282,000 cubic yards of dredged material was stockpiled by the Port of Palm Beach District on the beach at Mediterranean Road. This material was moved along the beach by waves and currents associated with winter storms which occurred during and after fill placement. The movement of this material along the beachfront was further influenced by an October 1944 hurricane landfalling near Charlotte Harbor on Florida's west coast. A considerable amount of material reportedly moved onshore in the vicinity of the original stockpile under the influence of a September 1945 hurricane in Miami. Field data obtained in 1946 by the U.S. Army Corps of Engineers indicated that beach conditions were effected one quarter mile north and one and a half miles south of Mediterranean Road. Beach elevations within this area increased from two to three feet and numerous groins in the area were again functional(USACOE, 1948).

The Beach Erosion Board was petitioned by the Port of Palm Beach District in December 1945 to initiate a study of the eroding shoreline south of the Lake Worth Inlet. The Beach Erosion Board (BEB) was organized under the U.S. Army in 1930 for purposes of coordinating a Federal effort of study and research in shore processes and shore erosion. Composed of prominent coastal engineers and scientists the BEB was authorized to make general shoreline investigations at Federal expense(Quinn, 1977). The study was approved in February 1946. Its purpose was to develop a plan for the rehabilitation and future protection of the Town's shorefront extending from the inlet to a point 1.7 miles south of Southern Boulevard.

This investigation concluded that the existing groins were not effective because of a deficiency of sand available for impoundment. The study recommended against construction of new groins along unprotected shore segments and modifications to existing short groins. Although these improvements would reduce the rate of material loss and beach maintenance, the annual realized cost savings would not offset the initial construction expenditures associated with construction of new groins. The study did recommend maintaining all existing, repairable groins and maintaining bulkheads and seawalls to insure continued protection of shorefront structures. The plan of improvement outlined by the Beach Erosion Board also included stockpiling approximately 1 million cubic yards of material on the beach at 5 different locations with periodic replenishment.

Shoreline studies completed by the U.S. Army Corps of Engineers through 1946 indicated that in general, erosion had occurred along 8.5 miles of shorefront south of the Lake Worth Inlet south jetty. Prior to the stockpiling of dredged material at Mediterranean Road, shoreline erosion approaching 300 feet was observed along a stretch of shore located 1.6 miles south of the south jetty. Accretion was noted downcoast in the vicinity of Sunrise Avenue, Worth Avenue, Southern Boulevard and at a location approximately 8.5 miles south of the Lake Worth Inlet.

Between May and November 1948, approximately 2.3 million cubic yards of material were stockpiled on the beach at Mediterranean Road, Eden Road, Tangier Avenue and Banyan Road. Also in 1948, 225,000 cubic yards of material dredged from the Turning Basin of Palm Beach Harbor during new work was deposited on the beach south of the Inlet. In 1949, 100,000 cubic yards of material were stockpiled on the beach south of Sloan's Curve and in the same year 380,000 cubic yards were stockpiled at Mediterranean Road. In 1953, 463,000 cubic yards were placed on the beach south of the Lake Worth Inlet(USACOE, 1956).

In October 1954 and February 1955, Palm Beach County applied to the U.S. Army for a cooperative study to determine the most economical method of restoring the beaches on Palm Beach Island. This study was approved in May 1955 and considered alternatives to restore eroded beaches and protect shorefront property from storm related damage(USACOE, 1956). The study further included a general investigation of sand transfer at Lake Worth Inlet (as described in Chapter 5.0). From this investigation it was concluded that artificial nourishment and construction of a sand transfer facility were the most practical methods for improving the beaches along Palm Beach Island. The sand transfer facility was constructed at the north jetty of Lake Worth Inlet from 1957 through 1958. The Town financed the cost of design and construction while Palm Beach County assumed responsibility for operation and maintenance of the plant. From 1959 through 1985, approximately 2.7 million cubic yards of sand has reportedly been transferred across Lake Worth Inlet. This estimate is based upon the total hours of bypass plant operation considering an assumed pumping rate of 200 cubic yards of sand pumped each hour. It is believed that this estimate may be double that which has actually been pumped (USACOE, 1985.)

From 1970 through 1978, the U. S. Army Corps of Engineers placed approximately 450,000 cubic yards of material on the beach south of the Lake Worth Inlet. In 1976, the Town placed approximately 100,000 cubic yards along the shoreline in the vicinity of Sloan's to Widener's Curves. In September, 1977, approximately 86,000 cubic yards of sand made available from local building construction was placed on the beach near Chilean Avenue(Palm Beach Post, 1977). Most recently, the U.S. Army Corps of Engineers placed approximately 131,000 cubic yards of material in the nearshore zone south of the Inlet. This material was dredged from the outer channel of Palm Beach Harbor in February, 1985. A summary of beach fill projects is presented on Table 3.2.

TABLE 3.2

SUMMARY OF ARTIFICIAL NOURISHMENT

TOWN OF PALM BEACH

Date	Volume(yd^3)	Location	Source of Material/ Responsible agency
August-September, 1944	282,000	Mediterranean Road	A
May-November, 1948	215,700	Mediterranean Road	B
	630,600	Eden Road	B
	454,600	Tangier Avenue	B
	1,035,000	Banyan Road	B
1948	225,000	Beach south of inlet	C
1949	100,000	South of Sloan's Curve	B
	380,000	Mediterranean Road	
1953	463,000	Beach south of inlet	C
April-May, 1970	61,949	Beach south of inlet	C
April-May, 1972	131,538	Beach south of inlet	C
November-December, 1973	145,498	Beach south of inlet	C
July-August, 1975	68,090	Beach south of inlet	C
1976	100,000	Sloan's to Widener's Curve	D
September, 1977	86,000	Beach at Chilean Avenue	E
June-July, 1978	43,559	Beach south of inlet	C
1959 - 1982	2,491,281	Sand transfer across Lake Worth Inlet	F
February, 1985	131,000	Nearshore, south of inlet	C

KEY:

A) Lake Worth Inlet/Port of Palm Beach
B) Lake Worth Inlet/Town of Palm Beach
C) Lake Worth Inlet/USACOE
D) Import Fill/Town of Palm Beach
E) Onshore Excavation/Private Development
F) North of Lake Worth Inlet/Palm Beach County

An inventory of the Town's existing coastal structures was completed in June 1985 as a part of this study. Plate 2 shows the present locations of structures along the Town's shorefront.

Historically, the Town has performed repairs to the roadway protective seawalls in response to physical conditions and financial capabilities. A summary of completed repairs is provided in Table 3.3.

A plan for repairs to the roadway protective seawalls was implemented by the Town early in 1985 and improvements are scheduled during the summers of 1986 through 1990. Table 3.4 summarizes the proposed repairs. The areas scheduled for improvement span from Bahama Lane to Country Club Road, Wells Road to Grace Trail, and from Barton Avenue to Via Bellaria.

The section of State Road A1A between Sloan's Curve to Widener's Curve has been particularly prone to damages in recent years. The Department of Transportation has recently designed a stone revetment for this area to remedy the problem. This revetment is planned to be constructed at a slope of 2 horizontal to 1 vertical and consists of a filter fabric overlain by a layer of bedding material covered with a layer of boulders. The permitting and bidding processes have been initiated for the project and the Town of Palm Beach has completed negotiations to acquire the necessary property easements.

3.3 <u>Shoreline Changes</u>

The destructive hurricanes of 1926 and 1928 and the construction of the Lake Worth Inlet and jetties served as the major events which triggered an awareness of the importance of the dynamics of the Town's shoreline. The Town of Palm Beach took the initiative in addressing the coastal erosion problem by their shoreline surveys of 1931 and 1935. The Beach Erosion Board of the U.S. Army Corps of Engineers became involved at the request of the Port of Palm Beach in studying the Town's shoreline in the late 1930's when they reviewed the critical erosion conditions south of Lake Worth Inlet as previously described. This initial Federal involvement led to a Comprehensive Shoreline Inventory of the Town's beach which was conducted by the Corps in 1946. Subsequent Corps surveys were done in the mid 1950's and in the 1970's. The State of Florida began surveying beach profiles in 1974 which included the entire Town shoreline. These data have been reviewed in a comparative manner.

The information shown on Plate 4 represents a compilation of the following sources:

1931 - Mean high water line survey of November and December 1931 by the Town of Palm Beach.

TABLE 3.3

COASTAL STRUCTURE CONSTRUCTION AND REPAIRS

AUTHORIZED AND COMPLETED BY TOWN

Type	Date Authorized	Total Cost	Amount Paid by Town*
Construction of reinforced step-type seawall, Lot 41, south 25 ft. of Proximity Park	4/7/31	$ 2,750	$ 750
Construction of steel sheet pile bulkhead Everglade Ave. south 240 ft.	2/5/36	$ 5,316	$ 2,658
Groin construction at Stations 2S, 5S and 8S	2/11/37	$ 22,480	$ 11,240
Groin construction, District 1	6/24/37	$ 19,433	$ 9,716
Groin construction, District 1	9/6/38	$ 38,710	$ 19,355
Groin repair at Stations 34N, 35N, 36N, 38N, 39N, and 40N	10/25/38	$ 4,978	$ 2,488
Groin construction between Hammon Avenue and El Vedado Road	10/3/39	$ 23,142	$ 11,571
Groin construction at Stations 80N and 85N	9/7/40	unknown	unknown
Groin construction at Stations 92S and 94S	7/7/41	$ 13,510	$ 6,755
Groin construction at Stations 79N and 80N	9/17/41	$ 10,132	$ 5,066
Seawall repair and construction in the vicinity of Jungle Road, Country Club Road and Royal Palm Way	11/12/58	$ 291,156	$145,526
Seawall repair from 780 S. Ocean Blvd. to Via Vizcaya and Hammon Avenue south to El Bravo	12/9/58	$ 142,099	$ 88,397

TABLE 3.3 cont.

COASTAL STRUCTURE CONSTRUCTION AND REPAIRS

AUTHORIZED AND COMPLETED BY TOWN

Type	Date Authorized	Total Cost	Amount Paid by Town*
Seawall repair 1102 - 1230 N. Ocean Boulevard	11/11/58	$ 56,055	$ 29,206
Seawall repair; Debra Lane south for 3000 feet	11/8/60	$ 337,949	$175,731
Seawall repair; Everglade Avenue south for 800 feet	4/9/63	$ 97,826	$ 50,215
Seawall repair and groin construction Jungle Road south to Clarendon Avenue	10/30/64	$ 154,859	$ 77,429
Seawall repair Jungle Road south to Clarendon Avenue	4/13/65	$ 113,843	$ 56,921
Groin removal and repair and seawall repair; Ocean Boulevard south of lot 110	2/14/67	$ 276,248	$138,444
Seawall repair; Ocean Boulevard near Worth Avenue	4/11/72	$ 18,487	$ 9,883
Seawall repairs and toewall construction near El Bravo Way	4/13/76	$ 155,507	$ 77,754
Sloan's Curve to Widener's Curve dune replenishment	4/13/76	$ 94,667	$ 47,334
Seawall repair near Royal Palm Way and Worth Avenue	4/13/76	$ 143,789	$ 71,895
Seawall repair near Everglade Avenue and Wells Avenue	5/30/80	$ 588,185	$323,156
Seawall repairs; Gulfstream Road to Peruvian Avenue	5/14/86	$ 383,689	$383,689

* Remainder of cost paid by private property owners who were especially benefited from improvements.

Source: Town of Palm Beach

TABLE 3.4

COASTAL STRUCTURE CONSTRUCTION AND REPAIRS

PROPOSED REPAIRS 1986 to 1990**

Groin and Safety Hazard removal: Sunset Avenue to Gulfstream Road (Clarke Avenue Public Beach, Municipal Bathing Beach at Mid-Town)

Anchor repairs: Via Bellaria to Via Del Mar and Via LaSelva to Jungle Point

Gunite repair: Via Bellaria to 'S' Curve

Anchor repairs: 'S' Curve to Hammon Avenue

Gunite repairs: 'S' Curve to Hammon Avenue

Replace cap and gunite repairs to wall face: Wells Road to Grace Trail

Toewall construction: Royal Palm Way to Australian Avenue

Anchor repairs: North line of Royal Park to Australian Avenue

Gunite repairs: Hammon Avenue to Seabreeze

Anchor repairs and gunite repairs to wall face: Bahama Lane to Country Club Road

**Source: Mock, Roos & Associates, Inc., 1985

1935 - Mean high water line survey of August and September 1935 by the Town of Palm Beach.

1946 - Survey of mean high water line published in July 1946 by the US Army Corps of Engineers. The month when the survey was performed is not known.

1968 - Aerial photography of the Town published at a scale of one(1) inch equals 200 feet. Data was recorded August 1968 for Palm Beach County by an unknown source.

1985 - Aerial photography of the Town published in color 9-inch by 9-inch format at a scale of 1-in equals 600 feet. Data was recorded in February 1985 for Palm Beach County and processed by Precision Photo Laboratories of Dayton, Ohio.

The mean high water data were digitized to a common baseline to enable comparative interpretation. The 1931, 1935, and 1946 data were obtained directly from published drawings. Mean high water lines for the 1968 and 1985 data were visually estimated from the aerial photography.

In July and August 1985, seventeen beach profiles were surveyed along the Town's shorefront as a part of this study. These data were compared to the State profiles collected in 1974 to provide a current status of the Town's shoreline. These comparative profiles are presented in Appendix B, Figures B-1 through B-17, and their locations correspond to the Department of Natural Resources (DNR) reference monuments located in Plate 3. The following paragraphs summarize the historical trends observed from these data.

<u>1931 - 1935</u>

Two storms influenced the Town's shoreline during this time period: a northeaster in 1932 and a hurricane in September of 1933. No mechanical placement of fill along the Town's beach front was reported. Authorized Town expenditures were limited to seawall construction near Atlantic Avenue.

Comparison of 1931 and 1935 mean high water shorelines indicates a general trend of shoreline erosion, extending from Onondaga Avenue to the south Town limits. Isolated areas of accretion occurred along sections of shorefront which coincided with functionally effective groins and groin systems located in the vicinity of Via

Marila, Wells Road, the Breakers Hotel and south of Jungle Road. Some accretion occurred just south of the Lake Worth Inlet jetty. This is likely the result of some trapping of the littoral transport moving to the north during summer season.

1935 - 1946

During this period only one recorded hurricane passed within 50 miles of the Town's shoreline. Authorized Town repairs of structures from 1935 through 1946 involved bulkhead repairs in the vicinity of Everglades Avenue and numerous groin repairs (See Table 3.3).

Comparison of the two mean high water shorelines indicates a continued general trend of shoreline erosion. Beaches in the vicinity of Southern Boulevard and from Wells Road to the Breakers Hotel generally showed accretion directly related by the trapping effect of the groins in these areas. Shoreline accretion from Mediterranean Road to Queens Lane resulted from placement of 282,000 cy of fill at Mediterranean Road in 1944.

This time period comparison continues to demonstrate the influence of the Lake Worth Inlet jetties on the sand supply to the Town's beaches.

1946 - 1968

Seven hurricanes and four major northeasters influenced the Town shoreline from 1946 through 1968. As a direct result of this storm experience, the Town authorized bulkhead repairs in the vicinity of Banyan Road, Debra Lane and in the public beach at Mid-Town and areas south. The sand bypass plant began operation in August 1958. Beach fills were also placed at Mediterranean Road in 1948 and 1949. The contribution of about 0.5 million cy by the bypass plant from 1960 through 1968 and artificial nourishment of approximately 3.8 million cubic yards of material are evident as the shoreline segment extending from the south jetty to Onondaga Avenue accreted due to the bypass operation and fill placements.

Because of the artificial addition of sand to the beach system, the shoreline generally exhibits a moderate accretional trend during this period. Effectively functioning groins along the shoreline from Jungle Road to Widener's Curve were, however, responsible for some downdrift shoreline erosion from Widener's to Sloan's Curves during the 1946 to 1968 time period.

1968 - 1985

One hurricane, two tropical storms and four northeasters influenced the Town's shorefront from 1968 through 1985. The Town authorized repairs during this time for bulkhead repairs at the public beach at Mid-Town, near Banyan Road and in the vicinity of Wells Road. Dune replenishment from Sloan's to Widener's Curve was authorized in 1976.

Comparison of 1968 and 1985 mean high water shorelines indicates a general trend of accretion from the south jetty to Wells Road. South of this point evidence of erosion is indicated. Nominal sand bypassing operations continued through this time period. Artificial nourishment of nearly three quarters of a million yards also occurred south of the Inlet and at Chilean Avenue via maintenance dredging of Lake Worth Inlet and disposal of material excavated from a high rise building foundation at Mid-Town. Both operations have influenced the shoreline south of the south jetty to Banyan Road. By 1968, the steel sheet pile groins constructed between 1926 and 1931 had deteriorated and had become generally ineffective. Material once trapped by these structures now freely moves downcoast and is impounded by downcoast concrete groins.

1935 - 1985

Net changes in the Town's shoreline over the past 50 years can be evaluated by comparison of the mean highwater line measured in 1935 from that photographed in 1985. These changes were most influenced by the sand bypass operations, artificial nourishment and effective littoral barriers. The Town's shoreline is critically dependent on inlet sand transfer operations and other methods to compensate for the deficiency in material supply which include either artificial nourishment or onshore disposal of suitable dredged material.

Comparison of 1935 and 1985 shorelines indicate:

1) a general trend of accretion between the south jetty and near Banyan Road;

2) a general trend of shoreline erosion south of Banyan Road to the Town's Par 3 Golf Course; and

3) an apparent accreational trend from the Par 3 Golf Course to the south Town limits.

Shoreline accretion south of the Inlet is the direct result of Inlet sand transfer and artificial nourishment. Functionally ineffective groins now permit material movement up and down coast. The groins in the vicinity of El Mirasol, Widener's Curve and the Breakers Hotel are effective littoral barriers and shoreline accretion is most pronounced updrift of these structures.

Shoreline recession south of Banyan Road is the direct result of deficient supply of material in transport. The most pronounced net shoreline recession over the past fifty years is observed in the area from Sloan's to Widener's Curves and in the vicinity of Banyan Road.

The area between the Breakers Hotel and Banyan Road has been moderately stable over the past fifty years but will, however, become erosional unless material is artificially or naturally added to the littoral system updrift of the area or within the area. Functionally ineffective groins can no longer slow the rate of sand being eroded from this area.

The 50 year shoreline comparison further indicates shoreline accretion extending from the Par 3 Golf Course south to the vicinity of the south Town limits; although, shoreline erosion has occurred from the City of Lake Worth Municipal Beach to the Town's southern limits. Sand eroded from this area supplies beaches in the Towns of South Palm Beach, Lantana and Manalapan. Comparison of seventeen beach profiles completed in 1974 and 1985 indicates shoreline accretion for those profiles north of the Breakers Hotel. Beach steepening has occurred in the vicinity of the public beach at Mid-Town and at Banyan Road. From Banyan Road south, a comparison of profiles indicates a general trend of erosion and lowering of the beach profile south of Lake Worth fishing pier. A comparison of profiles completed in the vicinity of the Par 3 Golf Course and the Lake Worth fishing pier agrees with the general shoreline trends shown by the high water lines and indicates an accreting shoreline in this vicinity.

Seasonal beach changes can cloud the interpretation of shoreline change. In a 4.5 year series (from 1969 to 1973) of daily and weekly littoral environment observations and beach surveys in southeastern Florida, Dewall and Richter (1977) found seasonal changes in MSL shoreline position ranging from about 25 to 75 feet. The 1931-1935 lines could represent a winter-summer beach comparison because the data was measured in November/December 1931 and August/September 1935. Winter beaches are more eroded and summer beaches show more accretion as described in Chapter 2.1 The month of the 1946 survey is not known. The 1935-1968 comparison could represent a summer-summer comparison. The 1935-1985 comparison may also represent a summer-winter shoreline comparison. The DNR profiles of 1974 and 1985 should be considered winter and summer comparisons.

CHAPTER 4.0
THE BEACH TODAY

COMPREHENSIVE COASTAL
MANAGEMENT PLAN
FOR
TOWN OF PALM BEACH

4.0 THE BEACH TODAY

This chapter summarizes the existing conditions of the Town's shoreline which define the starting point for developing the Comprehensive Coastal Management Plan. Contained in this chapter are summaries of the beach's condition, structure condition, ownership, and usage. These data were used in extrapolating future erosion scenarios for the Town and defining the planning units or reaches along the shoreline.

4.1 Prediction of Erosion Trends

Observed changes in the Town's shoreline over the past fifty years as summarized in Section 3.3 provide a basis for predicting future shoreline performance. Shoreline changes within the Town limits are directly influenced by storms, sand transfer across Lake Worth Inlet, artificial beach nourishment and shorefront structures.

Although it is not possible to predict future storms and the erosion losses which they might cause, it is possible to evaluate shoreline trends to the extent that they are influenced by human actions. With this limitation in mind, shoreline erosion trends for the following shore protection scenarios are discussed:

1) no changes in sand bypassing operations
2) improved sand bypassing operations
3) improved sand bypassing operations and beach nourishment

4.1.1 Status Quo

Under this scenario only the current sand bypassing operations at the Inlet would contribute sand to the Town's beach. Records since the start of sand bypassing operations in 1959 indicate that the plant has delivered approximately 108,000 cubic yards of sand per year to the Town's beach. The actual sand volumes may be less than the records indicate due to inaccuracies in the volume estimation procedures. More accurate monitoring of comparable bypass plant operations suggest that the actual delivered volumes are only about one-half of the originally estimated volumes. Spoil from the Federal maintenance dredging of the outer inlet navigation channel has been placed on the beach in the past. Dredging records indicate that this amounts to about 54,000 cubic yards on an average annual basis. Collectively the two sources have historically contributed between 100,000 to 150,000 cubic yards per year.

Estimates of the net southerly longshore transport* at the Lake Worth Inlet range from 230,000 to 336,000 cubic yards per year. The University of Florida (1969) found that no natural inlet bypassing occurs. When considering the net transport rates, the lack of natural bypassing, and the dredging and bypass plant operations, there is an estimated deficiency in the littoral transport system of about 80,000 to 236,000 cubic yards. This represents a net annual erosion of 1 to 4 feet along the entire Town's shoreline.

With no changes in the bypassing operations, the beach between the jetty and the Breakers Hotel will begin to erode. The beach between the Breakers Hotel and Sloan's Curve is presently in critical condition. This condition will worsen to the point where there will be little to no sand remaining. Seawall damage will increase as the protective beaches disappear. The beach south of the proposed revetment at Sloan's Curve to Widener's Curve is generally unprotected. Erosion will worsen as the updrift sand supply decreases. Eventually new seawalls would be required to protect upland property there.

In summary, the adoption of a no change approach to beach management will lead to island wide erosion problems. Beach areas at the north and south ends of the Town will be reduced. Increased structural maintenance will be required along the central portion of the Town and new seawalls will eventually be required along the southern Town beaches.

4.1.2 Improved Sand Bypass Operations

The natural system currently supplies more sand to the Inlet area than can be handled by the sand bypassing plant. The plant's present efficiency is related to its design limitations, the seasonal wave climate, offshore bar formations, and sand discharge location. Productivity of the plant is highest during the months of October through March and lowest during the April to September period when the prevailing southeasterly wave climate generates northerly drift. The northeasterly waves of the Fall and Winter months are responsible for delivering most of the sand to the plant which can be pumped across the Inlet. However, the littoral transport rate increases to the point which exceeds the plant's capacity. This fact, together with the natural bypassing which occurs around the plant contributes to significant quantities of sand that are not pumped, but rather are deposited in the navigation channel and offshore areas.

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* Net longshore transport is defined as the difference between the northerly volume of sand transport and the southerly volume of sand transport which is moved alongshore by waves and currents.

Recommended modifications to the bypass plant are discussed in Chapter 5.0. These improvements would allow greater quantities of sand to be bypassed around the Inlet. It appears that a fully improved bypass operation may be able to provide sufficient sand to maintain the beach between the jetty and the Breakers Hotel in a generally stable condition. The improved bypass operation would not however provide enough sand to the system to significantly improve the conditions south of the Breakers Hotel. The added sand in transport would be expected to be carried around the groins at the Breakers Hotel to the downdrift beaches. No significant accretion of protective and recreational beach south of the Breakers Hotel would be expected as a result of the increased bypassing.

With sand bypassing alone, shoreline recession is expected to continue south of the Breakers to Gulfstream Road until beaches to the north recover to the point where greater volumes of sand are able to pass around the Breakers Hotel area. Barring artificial nourishment to speed recovery, recession of this shoreline will continue as the Mid-Town beach area remains a source of material to nourish beaches downdrift. At some point, however, the material will begin to pass the Breakers at the same rate as it is transferred across the Inlet. When this occurs the beaches to the south will stabilize but not widen.

4.1.3 Sand Bypassing and Beach Nourishment

Because the Mid-Town beach can no longer provide a source of supply little sand is available now from the Mid-Town beach, additional erosional stress will be placed on beaches south of Southern Boulevard. The proposed shore hardening of the Sloan's to Widener's Curve area will shift erosion further south resulting in the onset of noticeable erosion immediately south of Sloan's Curve and more serious erosion at the south end of the Town limit. Renourishment at Mid-Town and near the south limit of the Town at the City of Lake Worth Municipal Beach will help to prevent continuous shoreline recession until such time as the effects of the Lake Worth Inlet sand bypassing improvements can be observed downdrift. A discussion of these proposed renourishment projects is given in Chapter 9.0.

The beaches in the vicinity of the Lake Worth fishing pier, and those south of Sloan's Curve including Phipps Ocean Park were significantly lowered during the past Thanksgiving Day 1984 storm. Comparative beach profiles indicate that these areas are presently undergoing erosion, a situation which is expected to continue without an available supply of adequate material for nourishment.

4.2 Recreational Beach and Dune Preserve Areas

Four shorefront recreational areas exist within the municipal limits of the Town of Palm Beach. Three facilities, Phipps Ocean Park, Municipal Beach at Mid-Town and Clarke Beach, are under the full jurisdiction of the Town. Kreusler Park is under County jurisdiction although the Town provides parking meters and police enforcement. The locations of these recreational areas are shown in Figure 4.1. A description of each facility is described below.

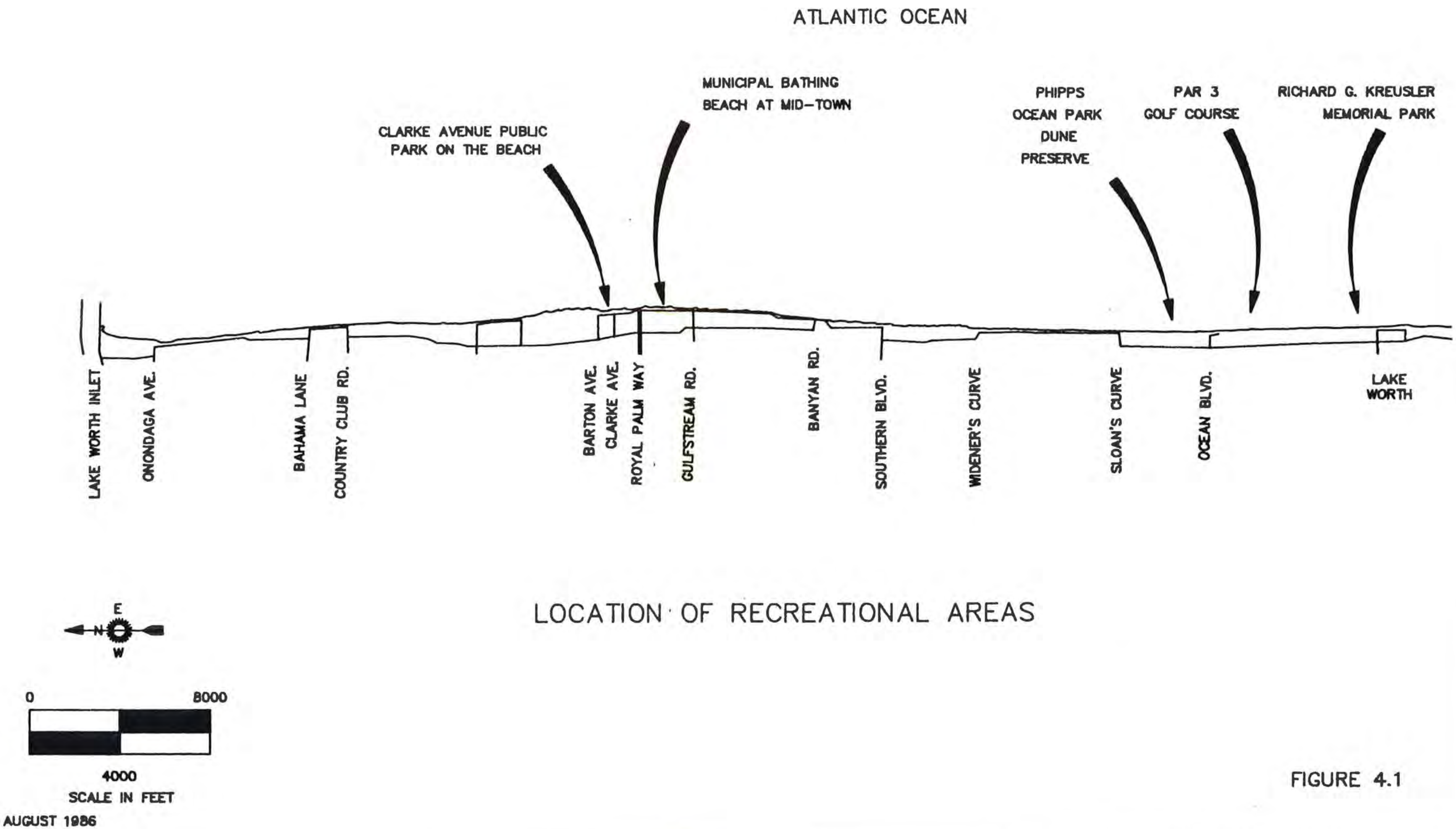
4.2.1 Clarke Avenue Public Park on the Beach

Clarke Avenue Beach is not considered as a major recreational facility within the Town. Instead, this area is classified as a neighborhood recreational beach and therefore the Town does not provide beach patrol at this location. This pocket beach, comprised of approximately three acres, contains 610 feet of shorefront nestled between two concrete stepped curved-face seawalls located at its north and south extremities. The 610 feet of shorefront does not include an AT & T cable right-of-way which accounts for approximately 56 feet of shore. Public beach access is provided by a dune crossover structure at Clarke Avenue. Numerous discharge and/or intake piping and pipe support structures are located at the north and south beach boundaries. These above ground structures generally extend from the surf zone to wading depth and beyond.

4.2.2 Municipal Bathing Beach at Mid-Town

The Mid-Town Public Beach is considered a major recreational facility within the Town and is under Town jurisdiction. The 2,435 foot long beach consists of approximately 5.6 acres located east of South Ocean Boulevard. It is bounded to the north by Royal Palm Way and to the south by Gulf Stream Road. Six groins exist within the limits of the beach area and penetrate the surf zone. These groins are generally ineffective and are considered a hazard to bathers and swimmers. Within the areas for which lifeguard services are provided by the Town, the groins are identified with signs, including ropes and buoys, and are noted as non-bathing areas. The State and Town are proceeding with a groin removal program in this area during the summer of 1986.

Public access to the Municipal Beach at Mid-Town is by stairways provided at Brazilian, Australian, and Chilean Avenues. Beach stairs are proposed to be installed at Gulfstream Road. A total of 150 metered street parking spaces exist along Ocean Boulevard. Additional timed, permitted, and metered parking spaces are available within a 1/4 mile radius of the municipal bathing beach.



LOCATION OF RECREATIONAL AREAS

FIGURE 4.1

4.2.3 Phipps Ocean Park

Phipps Ocean Park is considered a major recreational area within the Town of Palm Beach and is completely under Town jurisdiction. The Park consists of approximately 24 acres, which extends from Lake Worth on the West to the Atlantic Ocean on the east. The majority of land is located east of State Road A1A. Phipps Ocean Park contains 1200 feet of Atlantic shorefront encompassing approximately 21 beachfront acres. The Park is bordered on the north by the Sloan's Curve Condominium and on the south by the Reef Condominium.

This park is heavily used on weekends and holidays. The Town has provided approximately 300 metered parking spaces within the park. Beach access is provided by four dune cross-over structures. The dune within the park is well vegetated and six tropical beach huts overlook the Ocean from the crest of the dune.

4.2.4 Par 3 Golf Course Dune

The Palm Beach Par 3 Golf Course, including shorefront dune, comprises approximately 37 acres bounded by Lake Worth and the Atlantic Ocean. The dune is completely under Town jurisdiction and consists of approximately 2115 feet of naturally vegetated shorefront bounded by condominiums to the north and south. Public beach access is not provided over the dune to enhance preservation; parking is available only to those using the golf facility.

4.2.5 Richard G. Kreusler Memorial Park

Richard G. Kreusler Memorial Park is under the jurisdiction of Palm Beach County. The County provides lifeguards and park administration while the Town of Palm Beach supplies law enforcement and parking meters. Kreusler Park consists of approximately 3.8 acres bounded by the City of Lake Worth (Casino Complex) to the south, Palm Worth apartments to the north and commercial properties to the west. The east boundary consists of approximately 500 feet of Atlantic Ocean shorefront. This park is heavily used and approximately 153 metered parking spaces are available. Restroom facilities are also provided. Public beach access is provided by three stairways over the sparsely vegetated dune and revetment.

4.3 <u>Coastal Structure Conditions</u>

An inventory of coastal structures along the shorefront of the Town of Palm Beach was completed as part of the Comprehensive Coastal Management Plan. The field reconnaissance was conducted from May 31 to June 1, continuing from June 3 through completion on June 5, 1985. The study area extended from Lake Worth Inlet to the southern limit of the Town and included approximately 1400 feet of coastline outside the municipal limits of the Town of Palm Beach in the City of Lake Worth.

The field reconnaissance verified the location and type of existing coastal structures, assessed the general condition of coastal structures and identified existing beach conditions. Inventoried structures included seawalls, groins, revetments, breakwaters, armor stone, various methods of dune toe protection and miscellaneous drain and intake piping. The evaluation of groins was concerned solely with identifying those structures which may contribute to localized erosion or which are no longer performing as intended. Identification of existing beach conditions included field estimation of berm width and beach slope along the Town's shorefront.

The results of the field program are presented in part on Plates 1 and 2 entitled Beach Characteristics and Structures Inventory respectively. The position of the 1974 Florida Department of National Resources (FDNR) coastal construction control line (CCCL), FDNR reference monuments and the location of existing coastal structures are presented on Plate 2 and in Appendix C. Field observations are further described for various coastal structures in subsequent sections below.

All locations presented in the tables are referenced to existing FDNR reference coastal construction control line monuments. These locations are described by an FDNR monument number followed by an offset distance measured in feet south of the reference monument. For example, Station 77 + 1120 to 80 + 590 identifies the location of a structure which begins 1120 feet south of FDNR reference monument 77 and continues to a location 590 feet south of FDNR monument 80.

4.3.1 Seawalls

In general the first seawalls along the Town's shorefront were constructed of wood, steel sheet pile, or stepped concrete revetments. Repairs and replacement projects were initiated in the late fifties through the mid-sixties and consisted of replacing wood walls with steel or precast concrete sheet piles. Also reinforced gunite repairs of steel sections were completed during this time. The next period of seawall maintenance occurred in the mid-seventies when more wood walls were replaced and toewall construction and gunite repairs were authorized.

The location of seawalls observed during the field survey along the open coast of the Town of Palm Beach are shown on Plate 2. Approximately 6.8 miles of seawalls were observed along the open coast from Lake Worth Inlet to the southerly Town limits during the field reconnaissance. Numerous seawalls constructed behind the dune below grade south of Sloan's Curve along the west roadway right-of-way could not be observed during the field program. The existence of these seawalls was verified through discussions with Town personnel.

Data relative to the extent of each seawall type are presented in Table 4.1 below.

TABLE 4.1

OBSERVED OPEN COAST SEAWALLS[1]

Type	Extent (Ft)[2]
Vertical reinforced gunite concrete	23,420
Prestressed concrete sheet piling	5,080
Sloped or curved-face concrete	4,230
Steel sheet pile with concrete cap	1,960
Timber	850
Undetermined (wall cap visible only)	530

NOTES: 1) Does not include buried walls built south of Sloan's Curve to South Town limit

2) Total length as measured along FDNR Coastal Construction Control Line

Seawall elevations were determined using 1974 FDNR beach profiles. These data indicate a range in seawall elevations from 11.4 to approximately 25 feet National Geodetic Vertical Datum (NGVD)* and average on the order of 15 to 17 feet NGVD.

Previous studies of seawall conditions in the Town of Palm Beach were conducted by Smith & Gillespie Engineers, Inc. (1977) and by Mock, Roos and Associates, Inc. (1984). The Smith & Gillespie study presented the results of a 1974 conditions survey of the roadway protective seawalls in the following locations:

- Onondaga Road to Queens Lane
- Bahama Lane to County Club Road
- Wells Road to Sunrise Avenue
- Barton Avenue to Southern Boulevard

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* Commonly referred to as the mean sea level of 1929

The results of this survey, reproduced in Table 4.2 indicated that roadway protective seawall conditions varied from a need for immediate repair to an estimated useful life of 15 years. Methods used to estimate the useful life of roadway protective seawalls were not referenced in the report. It is believed that professional opinion and judgment were used to determine remaining usefulness.

TABLE 4.2

ANALYSIS OF EXISTING ROADWAY

PROTECTIVE SEAWALLS

Location	Adjacent Road	Approx. Length(ft)	Seawalls General Condition	Seawalls Estimated Useful Life
Onondaga Avenue to Queens Lane	North Ocean Blvd.	3960	Fair	6-9 years
Bahama Lane to Country Club Road	North Ocean Blvd.	1320	Fair	6-9 years
Wells Road to Sunrise Avenue	North Ocean Blvd.	2640	1/4 Poor 3/4 Good	0-4 years 9-15 years
Barton Avenue to Via Vizcaya	South Ocean Blvd.	9240	1/2 Poor 1/4 Fair 1/4 Good	0-4 years 6-9 years 9-15 years
Via Vizcaya to Southern Blvd.	SR A1A	2640	1/2 Poor 1/4 Fair 1/4 Good	0-4 years 6-9 years 9-15 years
Widener's Curve to Sloan's Curve	SR A1A	7920	Seawalls Not Generally Present	----------

Source: Smith and Gillespie Engineers, Inc., 1977.

The May 1974 on-site inspection of roadway protection seawalls was limited to visual above-ground observations. No observations relative to foundation conditions and tie back systems were made.

The Smith & Gillespie study recommended a 20 year phased approach of restoration and/or replacement of the roadway protective seawalls at the end of the useful lives. The study also recommended constructing a seawall between Sloan's and Widener's Curves and beach nourishment from Lake Worth Inlet to the Lake Worth Pier including a 10-year maintenance nourishment program. As an alternative, the report proposed that a rubble mound revetment could be used in lieu of seawall repair or replacement. The results of the Smith & Gillespie study were incorporated into the Town of Palm Beach Long Range Public Works Plan, Part V in 1977. As a result of this study seawall repairs were performed on 3889 feet of seawall located between Royal Palm Way and Worth Avenue, near El Bravo Way and later between Wells Road and Everglade Avenue.

In December 1984, Mock, Roos & Associates, Inc. completed a detailed inspection of the same roadway protective seawalls surveyed in 1974. The purpose of this investigation was to evaluate existing conditions and re-evaluate the plan for repair and replacement. Field studies included limited excavations and inspections of the tieback systems at various locations along the seawall.

This study developed a phased 3-year plan of repair and replacement. Recommendations for repairs consisted primarily of anchor repairs, toewall construction, gunite repairs, and cap replacement. Their prioritized recommendations are reproduced in Table 4.3 The revised recommendations approved by Town Council in 1985 are also given in the table. On an annual basis, it is recommended that these roadway protective seawall repairs be field inspected and repairs re-evaluated as necessary, for recommended changes in priorities.

Observations completed during the May 31 through June 5, 1985, field reconnaissance by Cubit Engineering Limited, Inc. are presented in Appendix D. Observations tabulated include seawall type and structure alignment relative to an adjacent structure or a predominant beach feature. Shore parallel offsets were typically on the order of 30 feet but varied from a minimum offset of 5 to 100 feet. These larger offsets occur at pocket beaches located at breaks in continuous seawall sections.

One objective of the field reconnaissance was to note deterioration of seawalls beyond those observed during the 1977 and 1984 field surveys. The level of deterioration of the roadway protective structures had not significantly changed from that documented in the 1984 Mock, Roos and Associates, Inc. survey.

TABLE 4.3

RECOMMENDED ROADWAY PROTECTIVE SEAWALL REPAIRS

FOR EACH AREA IN ORDER OF PRIORITY

Location	Total Repairs Recommended in 1984	Repair Schedule Recommended to Town Council 1985
Onondaga Avenue to Queens Lane	None	
Bahama Lane to 1987 Country Club Road	1. Repairs to gunite facing.	
	2. Repairs to anchor rods.	1987
	3. Repairs to cap and parapet.	N.S.
	4. Should additional erosion occur exposing the steel sheet piling below the gunite for an extended period, a toe reinforcement program must be added to the proposed work.	N.S.
Wells Road to Grace Trail	1. Replacement of concrete wall cap.	1986
	2. Repairs to vertical sheet piling.	N.S.
	3. Addition of rubble to revetment area.	N.S.
	4. Should additional erosion occur N.S. exposing the concrete sheet piling below Elevation 1.0 for a sustained period, a toe reinforcement program or a rock revetment must be added to the proposed work.	
Seabreeze Avenue to Via Bellaria	1. Toewall construction from Gulfstream Road to Peruvian Avenue.	1985
	2. Anchor repairs - Via Bellaria to Via Del Mar - Via La Selva to "S" curve	1985

TABLE 4.3 cont.

RECOMMENDED ROADWAY PROTECTIVE SEAWALL REPAIRS

FOR EACH AREA IN ORDER OF PRIORITY

Location	Total Repairs Recommended in 1984	Repair Program Recommended to Town Council 1985
Seabreeze Avenue to Via Bellaria	3. Toewall construction from Royal Palm Way to Australian Avenue.	1987
	4. Anchor repairs "S" curve to Hammon Avenue.	1986
	5. Gunite repairs Via Bellaria to Worth Avenue.	1985/ 1986/ 1987*
	6. Anchor repairs north line Royal Palm to Australian Avenue.	1987
	7. Anchor repairs Australian Avenue to Hammon Avenue.	N.S.
	8. Toewall construction from Australian Avenue to Peruvian Avenue.	N.S.
	9. Toewall construction from Gulfstream Road to Via Marina.	N.S.
	10. Should additional erosion expose any portions of the seawall in this area below Elevation +1.0 for a sustained period, either a toewall or a revetment must be added to the proposed work.	N.S.

Source: Mock, Roos & Associates, Inc., 1984,1985.

* Via Bellaria to "S" Curve, "S" Curve to Hammon Avenue, Hammon Avenue to Seabreeze

N.S. = not scheduled as of 1985

4.3.2 Groins

Groins are shore protection structures built usually perpendicular to the shoreline to trap littoral drift or retard erosion of the shore(USACOE, 1984).

The relative positions of groins located along the open coast of the Town of Palm Beach are shown on Plate 2. Aerial photographs of the Palm Beach shoreline taken in February, May 16 and June 15, 1985, were used to further locate additional groins not observed during the course of the field survey.

The majority of observed groins are of steel sheet piling construction. This type of groin also accounts for nearly all of the existing groin remnants. The Florida Department of Natural Resources(Balsillie, 1978) reported inshore-end groin elevations generally average 7.5 feet MLW and vary between 4 to 17 feet. Groin lengths vary between 50 and 300 feet and generally average 150 feet.

Field observations identified numerous groins and groin remnants that are functionally ineffective and hazards to bathing and beach walking. The complete tabulation of observations completed during field reconnaissance are presented in Appendix D.

Changes in beach elevation due to functionally effective groins were typically on the order of one to two feet. However, changes in elevations on the order of 3 to 6 feet were observed at several groins. Individually effective groins and functionally effective groin systems are identified in Appendix D. Of the groins inventoried, 45 were concluded to be ineffective and a bathing hazard. These structures should be scheduled for removal at some time in the future as funding and related considerations will allow. Beginning in summer 1986, 8 groins are scheduled for removal by the State and the Town from the public bathing beach at Mid-Town.

4.3.3 Piping and Support Structure

Numerous discharge pipes, and pipe support structures were observed. Table 4.6 presents the locations of 28 discharge and/or intake pipes and associated support structures. This Table includes only that piping which was observed to discharge directly onto the beach, or that which was visible in the surf zone.

Numerous discharge pipes were observed at the base of seawalls. These drains are included in Appendix D only if localized beach erosion attributable to the drain was observed at the time of the field reconnaissance. Localized erosion from discharging directly onto the beach typically produced a trough extending from the drain to the surf zone which varied in depth from one to three feet.

4.3.4 Miscellaneous Shore and Dune Protective Structures

Miscellaneous structures identified during the field investigation are presented in Appendix D. These structures include concrete revetments, breakwaters, armor stone slope protection, snow fencing and toe protection. This appendix also includes information on the protective foredune which was intermittently observed along the shoreline at the time of the field survey.

4.3.5 Maintenance Requirements

The 1984 Mock, Roos report has recommended a comprehensive seawall maintenance program for the roadway protective structures. The Town should encourage private beachfront owners to participate in a voluntary program of seawall inspection and maintenance. This is particularly important along the stretch of seawall extending from Via Bellaria to Southern Boulevard. It should be recognized that the seawall repair program outlined by Mock, Roos and Associates, Inc. will perpetuate unless protective beaches are re-established adjacent to them. The generally infrequent maintenance required from Onondaga to Queens Lane compared to the frequent repairs required at seawalls near Banyan Road clearly demonstrates the advantages of beach maintenance.

Maintenance and removal of groins can be considered as a lessor priority until the sand bypassing system at the Lake Worth Inlet is improved. In the absence of sand supply, groins are not effective and can be destructive.

Once a littoral sand supply is re-established and the effects of increased pumping are observed at Sunrise Avenue, modifications to downstream groins should be accomplished. The recommendation is made to guarantee natural renourishment of beaches from Mid-Town and south.

Modifications to those select groin fields identified in Appendix D will be necessary once the sand supply from Lake Worth Inlet is increased. Removal of groins which are ineffective and hazardous to bathers should be initiated at some time in the future. The State and the Town has taken the initiative in this regard and has scheduled removal of eight groins at Mid-Town and Sunrise Avenue during summer 1986.

The miscellaneous drain and drain pipe structures inventoried must be further evaluated by the Town as to their overall use. The Town should encourage the removal or acceptable replacement of those structures which are no longer in use, deteriorated, and hazardous to bathers. Direct discharge of drain effluent on the beach should be discouraged to prevent localized scour of sand.

4.3.6 Improvements at Littoral Barriers

Presently, there are several structures which contribute to the interruption of littoral transport. These structures include the groins between Sunset and Barton Avenues, private seawalls in the Widener's to Sloan's Curve area, and three groins north of Widener's Curve. These groins should be scheduled for modification in the future when improvements to the Lake Worth Inlet are made.

4.4 Definition of Planning Reaches

The natural dynamics of the coastal system must be evaluated in any study of shoreline erosion if a realistic evaluation of the potential hazards and the possible mitigation measures is desired. Therefore the coastal processes which effect the entire Palm Beach Island system are the background for all the coastal analysis, planning, and design in this study.

The importance of these coastal processes does not however preclude examination of erosion problems on a scale smaller than the island. The "reach concept" is an approach whereby consistent shore protection engineering plans are developed within areas affected by similar coastal processes. The reach concept in the engineering design process endeavors to reduce the potential for any one shore erosion control program to produce adverse effects in adjacent areas. Shore protection is thereby provided for an entire coastal compartment, irrespective of political subdivision boundaries and individual property lines. This approach is the opposite of the as-needed piecemeal solutions which often tend to aggravate the problems in adjacent downdrift shore areas.

The Town of Palm Beach shoreline has been divided into seven planning reaches on the basis of physical characteristics. These reaches are defined and characterized as follows:

Reach 1	Location
1	Lake Worth Inlet to Breakers Hotel
2	Breakers Hotel to Barton Avenue
3	Barton Avenue to Banyan Road
4	Banyan Road to Widener's Curve
5	Widener's Curve to Sloan's Curve
6	Sloan's Curve to the point south of the Lake Worth Municipal Beachfront Park
7	South Boundary of Lake Worth Municipal Beachfront Park to southern limit of Town

Reach 1 is characterized by a relatively wide beach at Lake Worth Inlet which gradually diminishes to no beach at the Breakers Hotel. Upland property and infrastructure are almost entirely protected with seawalls and groins. Groins are generally in a state of advanced deterioration.

Reach 2 is a littoral barrier formed by the presence of the Breakers Hotel and private seawalls and groins from Via Bethesda to Barton Avenue. These structures restrict the amount of sediment which can be transported by wave action from Reach 1 to Reach 3. The structures and beach areas which exist within this short stretch of shoreline are privately owned and maintained.

Reach 3, which extends from Barton Avenue to Banyan Road, contains the section of public beach at Mid-Town. The beach is diminishing and backed by a high seawall. The area offshore of Banyan Road is characterized by a reef outcrop which tends to deflect sediment away from the wall at that point. It is unclear if the diverted sediment continues to move along shore in deeper water south of this point or merely bypasses the reef and re-attaches to the beach near Via Del Mar.

Reach 4 extends from Banyan Road to just north of Widener's Curve. This area is characterized by a narrow beach increasing in width to a terminal groin. The beach between Banyan Road and Southern Boulevard is backed by seawalls. The beach from Southern Boulevard to just north of Widener's Curve contains a well developed groin field that is effective.

Reach 5 extends from Widener's Curve to Sloan's Curve. This area is in the shadow of the terminal groin just north of Widener's Curve. The area is characterized by a low flat beach, reef outcrop, and unprotected bluff which fronts State Road A1A. A series of Tee-groins are filled to capacity in the summer and are generally empty in the winter.

Reach 6 extends from Sloan's Curve to a point south of Lake Worth. This area is characterized by moderate beach width, a high, well vegetated bluff, and few exposed protective structures. However, seawalls are generally buried along most of the developed portions of the shoreline to protect highrise structures.

Reach 7, which extends to the southern Town limits, is characterized by a reef outcrop close to shore, a diminishing beach and active dune erosion. Development has located very close to the edge of bluff in this reach. Seawalls are generally buried along most of the developed portions of this reach as well.

CHAPTER 5.0
LAKE WORTH INLET

COMPREHENSIVE COASTAL
MANAGEMENT PLAN
FOR
TOWN OF PALM BEACH

5.0 LAKE WORTH INLET

This chapter discusses the history and impact of Lake Worth Inlet on the Town's shoreline. Since the Inlet's construction in the 1920's, it has played a prominent role in erosion of the areas downcoast of the south jetty. The following sections summarize the Inlet's history, effects, and improvements.

5.1 History

5.1.1 Inlet Construction

Lake Worth Inlet was originally constructed in its present location between 1918 and 1925 by the Lake Worth Inlet District as part of the Port of Palm Beach development. Initially the Inlet was 750 feet wide with a 300 foot wide dredged channel and a project depth of 15 to 18 feet MLW. Two rubble mound jetties 750 feet apart were constructed and extended to the 21-foot depth contour as it existed at that time. The North and South jetties were 1700 and 2150 feet long, respectively. A recent aerial photograph of the Inlet is shown in Figure 5.1

In 1934, the Federal government authorized funds to maintain a 16 foot inlet channel. The Corps of Engineers assumed responsibility for maintenance of the inlet under authorization of the River and Harbor Act of August 30, 1935. Subsequent improvements to the Inlet under Federal auspices are summarized in Table 5.1.

TABLE 5.1

HISTORY OF LAKE WORTH INLET IMPROVEMENTS

Improvement	Authority	Year Completed
Construct Inlet and jetties	Lake Worth Inlet District	1925
Maintain a 16 ft channel	Public Works Administration	1934
Deepen channel to 20 feet	Public Works Administration	1937
Provide 2-foot overdepth	River and Harbor Act	1941
Deepen entrance to 27 feet	River and Harbor Act	1948
Deepen entrance to 35 feet	River and Harbor Act	1967

FIGURE 5.1 AERIAL VIEW OF LAKE WORTH INLET

MAY 1985

Source: Cubit Engineering Limited

The jetties have undergone periodic maintenance since their initial construction in 1925. In 1937 and 1939 a concrete cap was added to each jetty. Repairs generally consisted of stone replacement. In 1985, the South jetty was repaired with grout to make the structure impermeable and minimize sand migration from the south beach area into the channel. In their present form, the North and South jetties are about 2000 feet and 1900 feet long, respectively. Crest elevation is approximately seven feet above mean low water (MLW). A plan of the Inlet is shown in Figure 5.2.

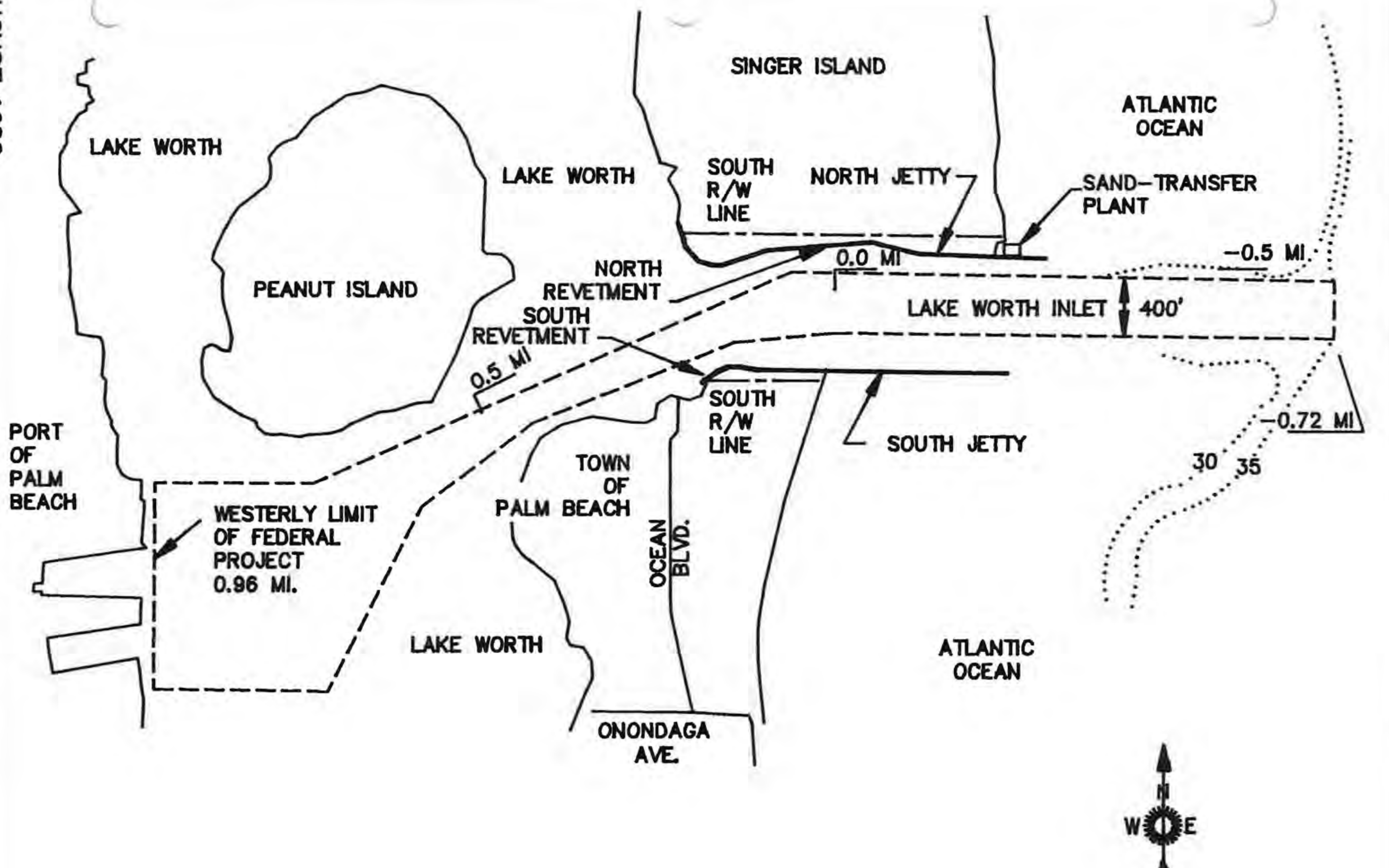
After completion of the jetties in 1925, southward littoral drift was intercepted and beaches south of the jetty receded from the cutoff of this supply. Sand that was accumulating at the North jetty resulted in beach growth north of the Inlet. Figure 5.3 shows the historical shoreline behavior since Inlet construction. The U.S. Army Beach Erosion Board and the U.S. Army Corps of Engineers conducted several studies of the situation. It was concluded that by 1948 the beach upcoast of the North jetty had accreted to the point where sand began to move around the jetty to shoal the navigation channel. As a result, the Corps of Engineers periodically removed accumulated sand from the Inlet by hopper dredges. Dredge spoil was typically deposited offshore and away from the Palm Beach shoreline. Table 5.2 summarizes the record of maintenance dredging since 1949. Inspection of this table shows that 1,902,051 cubic yards of sand were removed from the Inlet and deposited offshore in deep water. This translates to an average volume of 54,344 cubic yards per year.

The erosion condition downcoast of the South jetty prompted local action to investigate feasible means to mitigate the problem in the early 1950's.

5.1.2 Sand Transfer Plant

In 1954, the Florida State Board of Conservation, Palm Beach County, and Town of Palm Beach jointly contracted a private consultant to determine the feasibility of transferring sand across Lake Worth Inlet. The study considered alternatives and concluded that a fixed sand bypassing plant was the preferred solution to transport sand around the Inlet on a more or less continuous basis. Design drawings were prepared in 1955 and the plant was installed in 1957 and 1958 at a total cost of $544,539. Figure 5.4 shows the details of the facility as originally designed. Its basic components were:

- 12-inch suction line;
- 400 horsepower electrically driven motor and pump combination;
- 17,000 gallon emergency flushing tank; and
- 1700 feet of steel and rubber discharge line.



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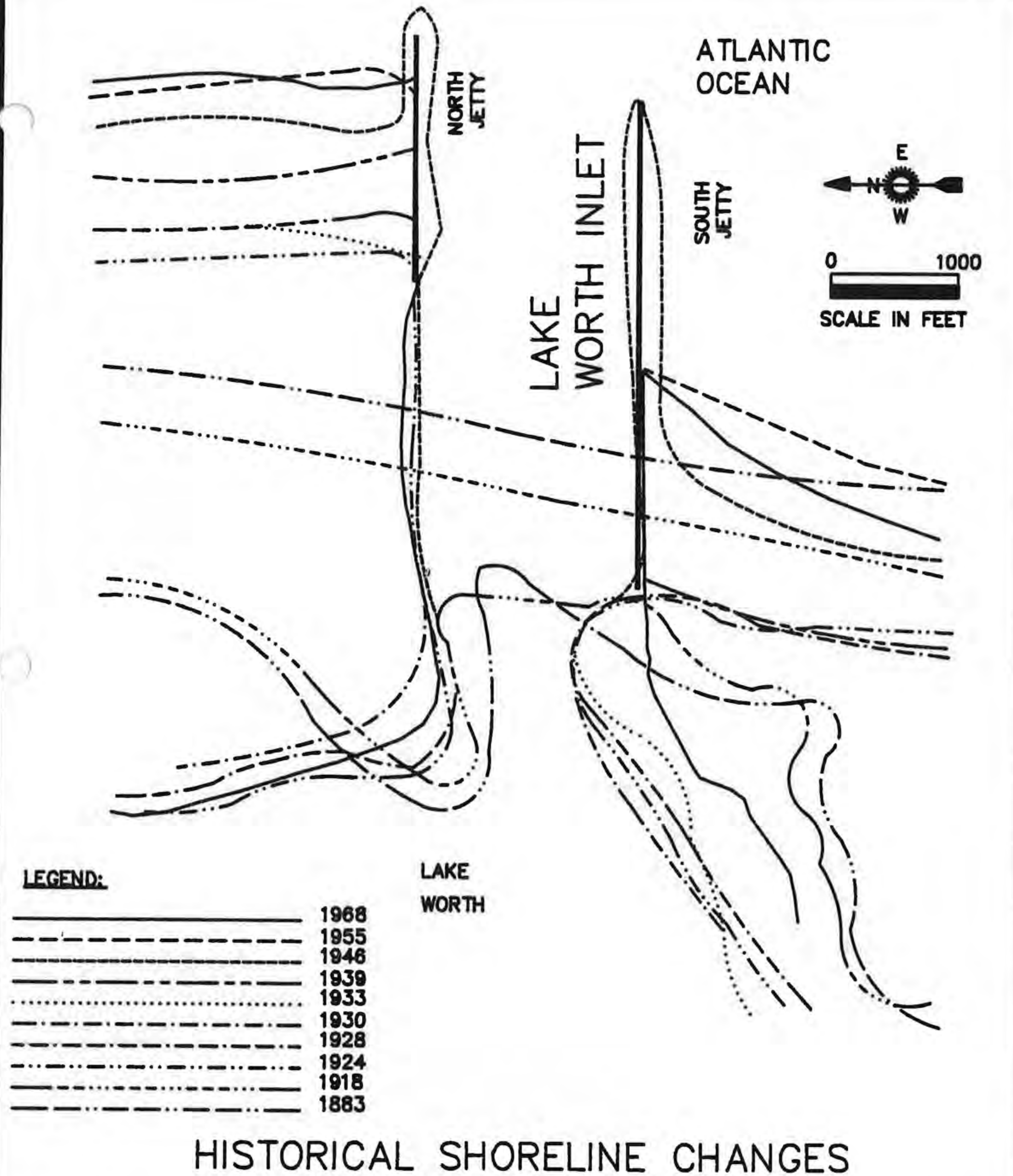
LAKE WORTH INLET

NOTE: DEPTHS IN FEET BELOW MLW

SOURCE: US ARMY CORPS OF ENGINEERS, 1985

FIGURE 5.2



HISTORICAL SHORELINE CHANGES
AT LAKE WORTH INLET

SOURCE: UNIVERSITY OF FLORIDA, 1969

FIGURE 5.3

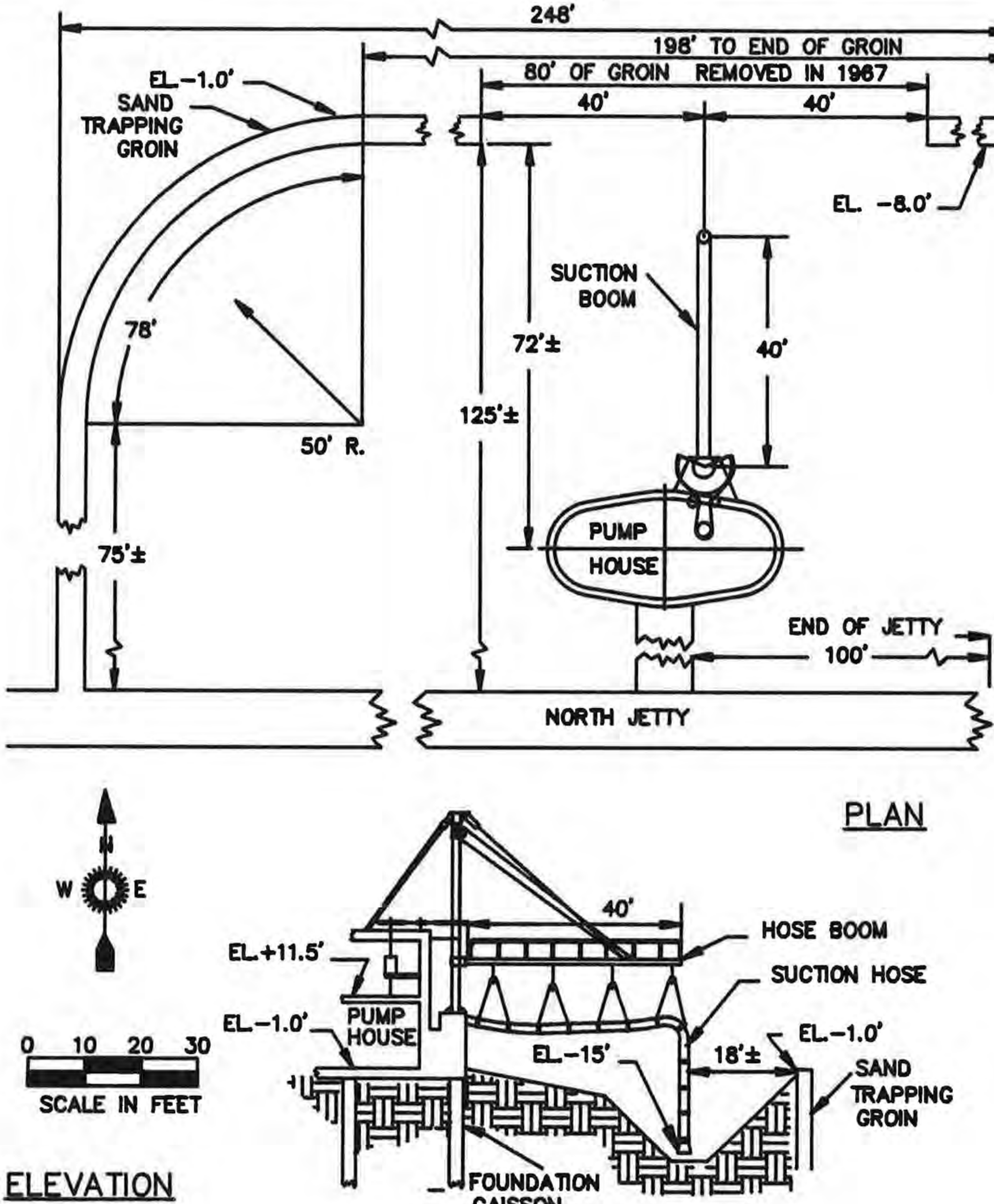
AUGUST 1986

TABLE 5.2

SUMMARY OF INLET MAINTENANCE DREDGING SINCE 1949

Year	Volume (cy)	Disposition
1949	45,410	At sea
1951	122,928	At sea
1952	19,070	At sea
1953	46,037	At sea
1955	53,744	At sea
1956	81,551	At sea
1957	59,355	At sea
1958	98,537	At sea and Lake Worth
1959	34,312	At sea
1961	47,139	At sea
1962	128,830	At sea
1963	44,588	At sea
1965	122,857	At sea
1966	16,191	At sea
1968	16,080	At sea
1970	61,949	Beach south of Inlet
1972	131,538	Beach south of Inlet
1973	85,119	Beach south of Inlet
1975	57,090	Beach south of Inlet
1978	43,559	Beach south of Inlet
1979	48,080	At sea
1980	208,378	At sea
1981	153,568	At sea
1983	176,141	At sea
1985	131,000	Beach south of Inlet

Source: Corps of Engineers, 1985



NOTE: ELEVATIONS IN FEET MLW

SOURCE: PALM BEACH COUNTY ENGINEERING AND PUBLIC WORKS

AUGUST 1986

LAKE WORTH INLET
SAND BYPASS PLANT

FIGURE 5.4

The plant's design was compromised by two major modifications:

1. installation of a sheet pile trapping groin to limit the volume of sand which the plant could pump; and

2. termination of the discharge line immediately south of the South jetty.

The trapping groin was constructed by the Town at the same time as the bypass plant as a concession to upcoast residents who were fearful of losing beach due to the sand pumping operation. The design engineer originally recommended in 1954 that the discharge line terminate 1500 feet downcoast of the South jetty to avoid recycling of sand back into the Inlet. This recommendation was endorsed by the Corps of Engineers in 1956. The Town of Palm Beach preferred the discharge line ending in the shadow of the South jetty because of cost savings and an opinion of satisfactory performance based on observations of a previous fill.

The Town of Palm Beach and Palm Beach County entered into an agreement dated July 12, 1955 to finance the plant. The Town, being a major beneficiary of the operation would finance the cost of design and construction. The County agreed to bear the continuous operation and maintenance costs. The plant became operational in August 1958.

The Corps of Engineers included the sand bypass plant as part of their recommended beach erosion control project for Palm Beach Island as authorized by the River and Harbor Act of 1958. Policy for Federal aid in financial participation was set forth in Public Law 826, 84th Congress. As a result the Federal share was apportioned at 19.3 percent for sand bypass plant construction. Annual operation cost sharing was limited to a period of 10 years also at 19.3 percent. Furthermore, the Corps stipulated in the 1958 authorization that before Federal monies could be dispensed, the design must be modified to extend the discharge pipe to a point 1000 to 2000 feet downcoast of the South jetty.

The County continued to operate the plant solely at its expense since the overall beach erosion control plan into which the bypass plant was incorporated did not receive local funding participation. Therefore the Corps again evaluated the sand bypass plant in 1974 for purposes of extending the period for considering Federal participation in the annual operation and maintenance costs. The Corps concluded that Federal aid should not be extended for the following reasons:

1. the Federal beach erosion control project as authorized by the River and Harbor Act of 1958 did not receive local sponsorship; and

2. the plant was concluded to be ineffective with respect to reducing Inlet shoaling and therefore was of little benefit to the Federal navigation project at Palm Beach.

The Corps again considered improvements to the sand bypass plant in 1985 as part of the Section 111 study of Lake Worth Inlet to ascertain shore damage attributable to the Inlet. Alternatives considered were:

1. assume operation of the existing plant;

2. construct a new sand transfer system; or

3. rehabilitate the existing plant.

The first alternative was rejected because the existing plant does not meet the Federal design standards of the 1958 River and Harbor Act. The other alternatives were rejected on the basis of unfavorable benefit/cost ratios (0.76 and 0.48 respectively) when considered in conjunction with initial beach fill requirements. This view was re-evaluated in 1986 as discussed at the end of this Chapter.

5.2 Sand Transfer Plant Performance

5.2.1 Pumping Records

Palm Beach County has maintained records of sand pumped across Lake Worth Inlet since July 1959. Table 5.3 summarizes these data on an annual basis. These data indicate that for the period of 1959 through 1985, a total of 2,714,781 cubic yards was delivered across the Inlet. This translates to an average annual volume of 108,316 cubic yards per year.

The data in Table 5.3 are based upon the number of hours of pump operation and assuming a solids transport rate of 200 cubic yards per hour. This assumption of pumping has been subject to question by the Corps of Engineers and the Town of Palm Beach because of hydraulic design limitations and inefficiencies of the plant to pump sand year round. Recently, Palm Beach County installed a nuclear density gage on the South Lake Worth Inlet plant for purposes of measuring solids transport. Measurements to date indicate that the plant may be pumping at about one-half its assumed rate. These preliminary findings were instrumental in reducing the estimated solids transport rate at Lake Worth Inlet to 150 cubic yards per hour in November 1985. Data presented in Table 5.3 for that year reflect this estimated rate change. The Lake Worth plant was scheduled for installation of a similar gage in the fall of 1985. Better records of the actual pumping rate should be available in 1986.

TABLE 5.3

RECORD OF SAND TRANSFER AT LAKE WORTH INLET PLANT

Year	Vol of saturated sand cubic yds
1960	77,175
1961	41,890
1962	99,225
1963	79,626
1964	60,200
1965	33,600
1966	19,950*
1967	27,915*
1968	85,925
1969	92,325
1970	160,800
1971	141,100
1972	177,900
1973	143,800
1974	71,400
1975	137,000
1976	167,800
1977	155,400
1978	156,800
1979	60,600
1980	167,350
1981	178,200
1982	155,300
1983	101,500
1984	65,200
1985	56,800

*The plant operated for only a portion of the year.

Source: Gee & Jensen, 1983
Palm Beach County Engineering and Public Works, 1985
U.S. Army Corps of Engineers, 1985

5.2.2 Inlet Dynamics

The Lake Worth Inlet acts as a littoral barrier by intercepting littoral drift from the north and south as transported by the seasonal wave action. Once deposited in the entrance channel, material can be carried further into the Inlet by flood currents.

Studies of Lake Worth Inlet were conducted by the University of Florida in 1969 under sponsorship of the Florida Bureau of Beaches and Shores and Palm Beach County. A series of field investigations were conducted to ascertain the behavior of the Inlet. The principal findings were:

1. No natural bypassing occurs as there is no offshore bar formation;

2. Sediment has accumulated offshore of the North jetty and is entrained by northeast waves and carried into the Inlet;

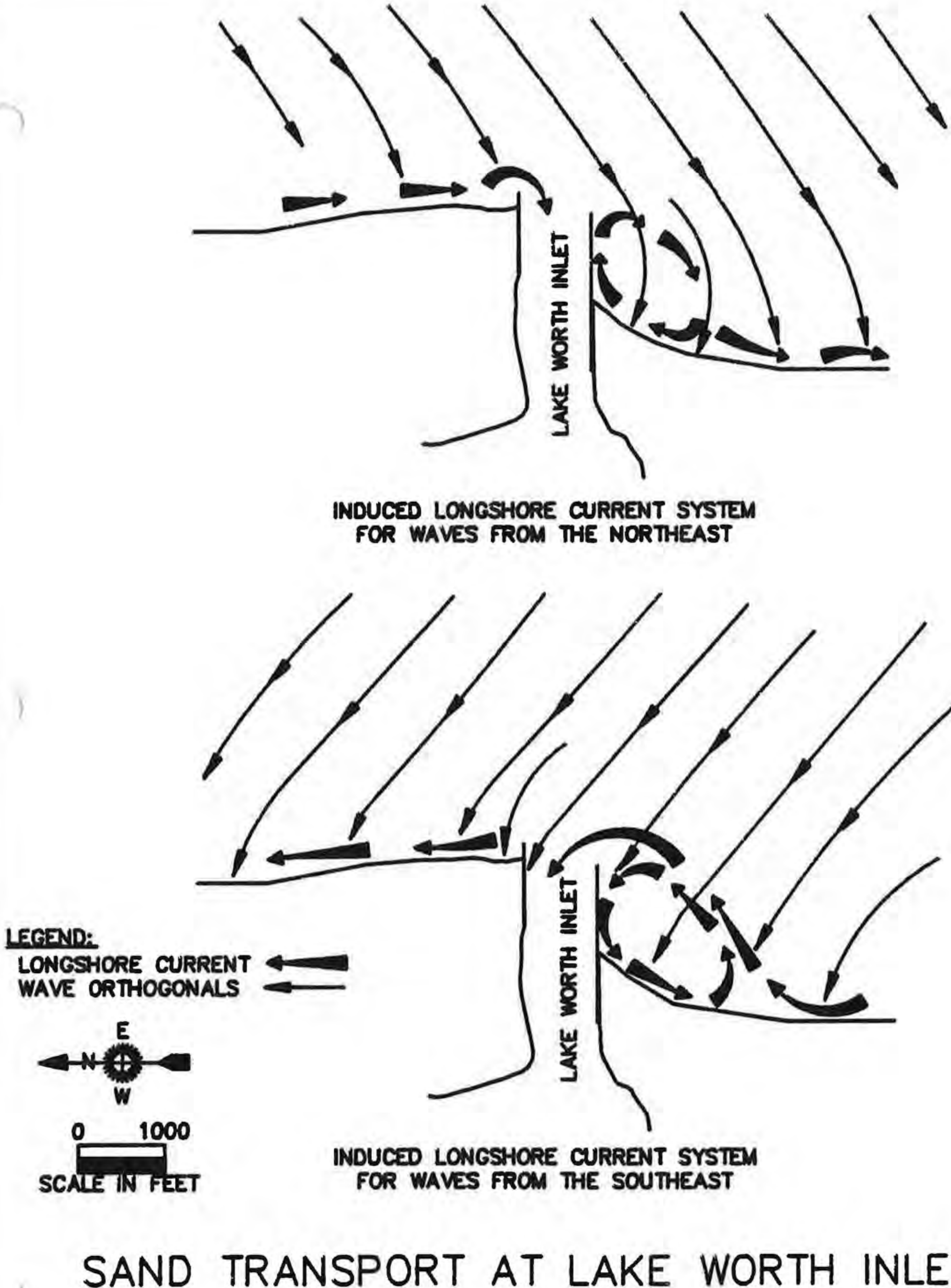
3. A nodal point about 2500 ft downcoast of the South jetty appears during northeast wave conditions. Material south of this point is transported south; material north of this point is moved northward and probably carried offshore and into the Inlet once it reaches the South jetty;

4. Easterly waves result in the condition of least sand transport, but the mechanism for transport into the Inlet can be greatest;

5. Southeast waves set up a counterclockwise eddy downcoast of the South jetty and a similar and smaller gyre north of the North jetty. Material enters the Inlet from both directions simultaneously; and

6. Inlet currents average from 2.5 to 4.0 feet per second. Ebb tide currents exceeds flood currents which may imply that the inlet tends to favor deposition of material at the entrance as opposed to back bay shoals.

Figure 5.5 illustrates the principal mechanism of sand transport determined by the University of Florida studies.



SAND TRANSPORT AT LAKE WORTH INLET

SOURCE: UNIVERSITY OF FLORIDA, 1969

FIGURE 5.5

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5.2.3 Sand Bypassing Efficiency

The University of Florida studies have indicated that the locations of both the plant's intake and discharge line are inefficient. In 1969, an underwater shoal or spit was observed to extend about 700 feet beyond the end of the North jetty and into the navigation channel. As a result, a considerable amount of material is believed to be bypassing the present intake.

The location of the discharge at the South jetty exposes sand to recycling offshore and back into the Inlet via the counterclockwise circulation as described above. Therefore sand that is presently discharged by the plant at the South jetty does not renourish the southern beaches of the Town. In summary, the sand bypass plant requires improvements to restore its efficiency in delivering sand around Lake Worth Inlet.

5.3 Inlet Effects

5.3.1 Background

The effects of Lake Worth Inlet on the beaches of the Town of Palm Beach have been studied by several agencies since the late 1930's. Most recently, the Town of Palm Beach and the Palm Beach County Board of County Commissioners requested in 1969 that the Corps of Engineers study the effects of the Lake Worth Inlet on the adjacent shoreline. Under authority provided by Section 111 of the River and Harbor Act of 1968 (Public Law 90-483), the U.S. Army Corps of Engineers is empowered to investigate, study, and construct projects for the prevention or mitigation of shore damage attributable to Federal navigation projects. Furthermore, the cost of installing, operating, and maintaining such projects may be borne in whole or in part by the United States Government.

The jetties are believed to contribute to erosion damages to the Town of Palm Beach as a result of their interruption of the natural littoral processes. Studies have been performed by the Jacksonville District Corps of Engineers and a summary of their findings follows.

5.3.2 Section 111 Report

A comprehensive study to identify the nature, extent, and fiscal responsibility of erosion damages attributable to the Lake Worth Inlet jetties was published as part of the Corps Draft General Design Memorandum of Beach Erosion Control Projects for Palm Beach County dated March 1985. The Corps described the historical events of Inlet construction and maintenance, summarized the meteorological and oceanographical parameters of records, and documented shoreline erosion/accretion, Inlet dredging, and sand bypassing performed over the life of the project.

Principal data used in the analysis consisted of the following:

1. littoral drift annual volume hindcast computed for the years 1956 through 1975;

2. beach profiles recorded in 1955/57, 1974/75 and 1979;

3. maintenance dredging records of sand removed from the Lake Worth Inlet by hydraulic dredge and pumped south of the Inlet via the sand bypass plant; and

4. wave climatology for the area.

In the opinion of the Corps of Engineers, the survey data of 1955 through 1979 provided the only data base devoid of hurricane effects which could be used to investigate the natural erosion rate of the island, estimate the effects on erosion caused by the Inlet, and determine the percentage of historical erosion attributable to the Inlet. A summary of the results of the Corps analysis follows. The summary is excerpted from the Corps Section 111 Report (USACOE,1985).

1. Historical beach surveys are available for the periods 1883 to 1979. Data recorded from 1883 to 1955 were considered invalid due to questionable accuracy and the impacts of 7 hurricanes which affected the Palm Beach area between 1929 and 1955. Therefore only surveys from 1955 to 1979 were consulted.

2. Profiles of 1955 and 1975 surveyed by the Corps were reduced as follows together with Inlet dredging and sand bypass records

R-76 to R-80*	831,000cy accretion
R-80 to R-93	531,000cy erosion
Net Result R-76 to R-93	300,000cy accretion
Sand placed on beach from inlet maintenance	339,000cy
Sand placed on beach by Lake Worth Inlet bypass plant	1,570,000cy
Total Erosion 1955-1975	1,609,000cy

* R-76 refers to DNR reference monument.
cy = cubic yards

3. Consider the stretch of shoreline from R-102 to R-113 (3.5 miles long)

   This stretch eroded 500,000cy from 1955 to 1975. Assume this represents an ambient erosion over the entire island not influenced by Lake Worth Inlet.

4. Erosion due to Inlet improvement from 1955-1975:

1,609,000cy	(from Item 2 above)
500,000cy	(from Item 3 above)
1,109,000cy	

5. Consider the DNR profiles of 1974 and compare with Corps data of 1979

R-76 to R-93	209,000cy	accretion
	236,000cy	erosion
Net results R-76 to R-93	27,000cy	erosion
Sand placed on beach from inlet maintenance	137,000cy	
Sand placed on beach by Lake Worth Inlet bypass plant	725,000cy	
Total erosion 1974-1979	889,000cy	

   Convert this from 1974-1979 to 1975-1979
   4/5 (889,000) = 711,000cy

6. Consider the stretch of shoreline from R-93 to R-106 (2.9 miles long)

R-93 to R-106	67,000cy	accretion
	300,000cy	erosion
Net results R-93 to R-106	233,000cy	erosion

   Convert this value from 1974-1979 (5 year) to 1975-1979 (4 year) value. Also convert this 2.9 mile long stretch to comparable 3.5 mile long stretch for consistency with item 3.

   4/5 (3.5/2.9) (233,000) = 225,000cy

   Assume this value represents the natural erosion of Palm Beach Island not influenced by Lake Worth Inlet.

7. Erosion due to Inlet improvement from 1975 to 1979

$$\begin{array}{r} 711{,}000\text{cy} \\ - \underline{225{,}000\text{cy}} \\ 486{,}000\text{cy} \end{array}$$

8. Erosion due to Inlet improvement from 1955 to 1979

$$\begin{array}{r} 1{,}109{,}000\text{cy} \\ \underline{486{,}000\text{cy}} \\ 1{,}595{,}000\text{cy} \end{array}$$

9. Compute Corps responsibility

Total erosion 1955 to 1975	1,610,000cy	
Total erosion 1975 to 1979	711,000cy	(not 889,000)*
	2,321,000cy	

$$\% \text{ Responsibility} = \frac{1{,}595{,}000}{2{,}321{,}000} = 68.7\% \text{ (not } 63.8\%)^*$$

10. Corps estimates that the sand bypass plant is only 10 to 21.5% efficient. Erosion attributable to the inlet is reduced to 521,000cy. Assume that plant volumes are reduced by 50%.

$$\text{Responsibility} = \frac{521{,}000}{2{,}321{,}000} = 22.4\% \text{ (not } 20.8\%)^*$$

Take the average of items 9 and 10:

$$\frac{22.4 + 68.7}{2} = 45.6\% \text{ (not } 45\%)^*$$

The Corps has recommended the following measures to mitigate shoreline damages attributable to Lake Worth Inlet:

1. construct an initial beach fill for 1.9 miles downcoast of the South jetty; and

2. renourish the downcoast periodically from Lake Worth Inlet maintenance dredging.

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*Value reported by U. S. Corps of Engineers in the Section 111 Report (1985).

Total cost allocation of the project is based upon a determination of the percentage of beach erosion attributable to the Inlet. The Corps has concluded that the Inlet is responsible for 45% of the erosion. The remaining 55% is felt to be naturally occurring and is therefore eligible for funding under standard beach erosion control project guidelines. The 45% figure is fully reimbursed by the Corps. The remaining 55% is cost shared on the basis of percentage of public shorefrontage. The Corps will pay for fifty per cent of the project which is considered public shorefront. The Corps has determined that the 1.9 stretch of beach contains about 17.7% public shorefront. Therefore the Corps would pay for half or 8.8% for a total of 49.8%*. Periodic maintenance would be a 100% Federally funded item.

5.4 Recommended Actions

The Town's objective with respect to the Lake Worth Inlet is twofold. First, maintenance of the Inlet's navigation channel should be guaranteed to preserve the commercial and recreational boating interests of the area. Second, the natural littoral transport of sand around the inlet should be maintained to provide a continuous source of sand to renourish the Town's beaches and beaches of communities to the south thereby helping to stabilize their recreational and storm protection functions. Reasonable alternatives to meet these objectives are:

1. Improvements to the sand bypassing operation; and

2. Consideration of Section 111 Authorization.

A discussion of these alternatives is provided below.

5.4.1 Improvements to the sand bypassing operation

Estimates of longshore transport at the Lake Worth Inlet have been made by the U.S. Army Corps of Engineers and the University of Florida. Predicted volumes range from 230,000 to 336,000 cubic yards per year net to the south. Gross sand transport volume, which includes northerly and southerly rates, have been estimated at 440,000 to 762,000 cubic yards per year. The fixed bypass plant was originally designed to discharge from 170 to 178 cubic yards of sand per hour. When the plant was converted to diesel power in 1977, the discharge output changed to 140 to 200 cubic yards of saturated sand per hour.

As previously presented in Table 5.3, the plant has delivered approximately 108,000 cubic yards of sand per year to the beachfront within the Town. Because of the inaccuracies of volume measurements, it is probable that less sand has actually been pumped. Estimates of one-half the published volumes have been

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*45% + (8.8% of remaining 55%) = 49.8%

suggested by the U.S. Army Corps of Engineers and others. Federal dredging records indicate that about 54,000 cubic yards are removed on an annual average basis from the outer navigation channel. Collectively the two sources have historically added to 100,000 to 150,000 cubic yards per year. When compared against the above estimates of littoral transport, a deficiency in bypassing amounting to 80,000 to 236,000 cubic yards presently exists. This shortfall must be provided for in improvements to the existing bypass plant.

The plant's present efficiency is related to the seasonal wave climate, offshore bar formations, and sand discharge location. Productivity of the plant is highest during the months of October through March and lowest during the April to September period when the prevailing southeasterly wave climate generates northerly drift. The northeasterly waves of the Fall and Winter months are responsible for delivering most of the sand to the plant which can be pumped across the Inlet. However, the littoral transport rate is highly variable. During the stronger northeasters, alongshore drift increases to the point which exceeds the plant's capacity. This fact, together with the natural bypassing which occurs around the plant contributes to significant quantities of sand that are not pumped, but rather are deposited in the navigation channel and offshore areas.

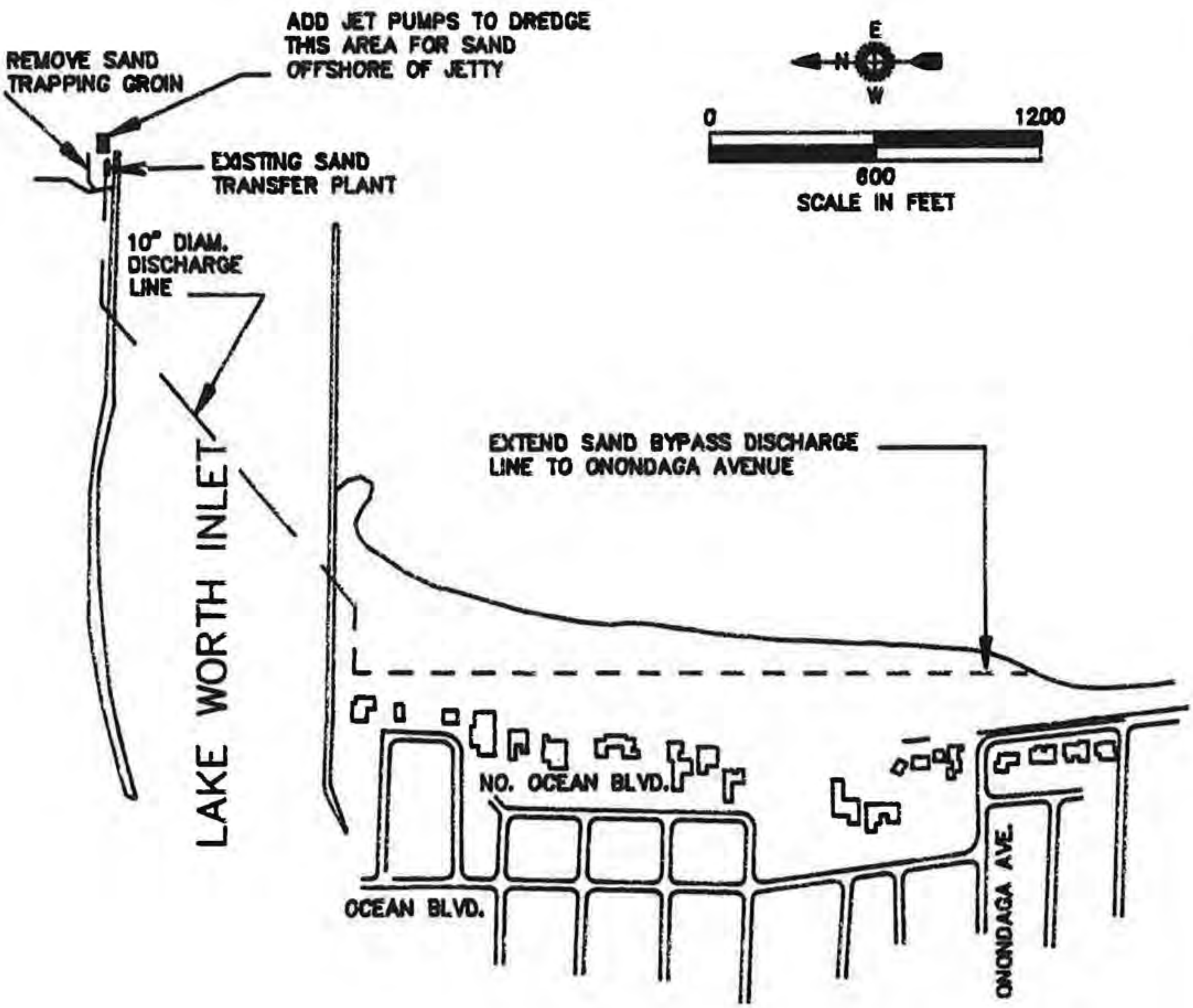
As a minimum improvement, the existing bypass plant should incorporate the following modifications:

1. provide for Summer bypassing by installing one or more jet pump dredges further offshore;

2. extend the discharge pipe downcoast; and

3. remove the sand trapping groin that protects the intake.

During the calmer Spring and Summer months, portable jet pump dredges can be deployed from the existing plant to pump sand from the offshore shoals. Through judicious management, the portable system could also be operated during selected intervals during the fall and winter months as required. The discharge pipe needs to be extended approximately 2500 feet downcoast to minimize recirculation of sediment back into the Inlet. Lastly, the sand trapping groin should be completely removed. Partial removal of this structure in 1967 realized increases in plant output. Complete removal of the structure will further increase the plant's efficiency. Figure 5.6 shows these improvements. These improvements would cost approximately $490,000.



RECOMMENDED IMPROVEMENTS TO BYPASS PLANT

FIGURE 5.6

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5.4.2 Consideration of Section 111 Authorization

The Town of Palm Beach has several alternatives concerning the proposed Corps of Engineers Section 111 plan to mitigate the beach erosion attributable to the Lake Worth Inlet jetties. These alternatives are:

1. Endorse the plan as currently proposed by the Corps of Engineers;

2. Propose that the plan be substantially redone because of the questionable conclusion that the jetties only contribute to 45 per cent of the overall erosion problem with the Town and areas to the south and validate other statistical information in the plan; and

3. Propose that the plan be modified so that the beach nourishment component will be of a greater overall benefit to the Town.

The first alternative simply accepts the Corps of Engineers' appraisal of the the problem, and thus seeks to have it implemented as soon as possible. To do so requires a letter of intent to participate from a local sponsor and congressional authorization since the proposed improvements exceed $1,000,000 in Federal cost. The non-Federal costs for this plan are approximately $1,600,000, presumably to be shared by the Town, County, and/or State.

The second alternative involves the gathering of evidence to submit for Corps consideration which may show that the jetties have caused more that 45 percent of the erosion problems within the Town of Palm Beach. This alternative would probably result in a delay in the implementation of the Section 111. In addition, it is possible that a new study would indicate that the jetties have caused less erosion than the level presently suggested by the Corps. However, it is likely that the 45 percent erosion is a minimum value, and that a more definitive study using 1985 data would indicate that the jetties have had a greater impact than what the present Corps study concludes.

In 1976, Moffatt & Nichol, a private consultant, (under contract to the Corps) prepared a draft assessment of Lake Worth Inlet impacts on the adjacent shoreline (USACOE, 1976). This report concluded that:

1. The construction of shore protection works prevented a determination of the direct impact of the jetties;

2. The Corps is responsible for the annual bypassing of 300,000 cubic yards in order to mitigate the sand trapping effect of the jetties; and

3. The shoreline erosion due to the jetties extends along the seven mile stretch of shoreline just south of the jetties, and that if left uncorrected, the next nine miles of shoreline would be threatened.

This latter conclusion is in sharp contradiction to the 1985 Corps study which states that the impact of the jetties is limited to the first 1.9 miles of shoreline south of the Inlet.

The 1985 Corps Section 111 analysis is affected by several limiting assumptions due to the relatively sparse data available to document the historical changes in the shoreline. These assumptions are:

1. The 1955 to 1979 beach profiles constitute the only valid data because of the absence of significant hurricanes during this period;

2. The island is experiencing natural erosion, regardless of the construction of the jetties; and

3. The 1974 to 1979 beach surveys indicate that only the first 1.9 miles south of the jetties are eroding because of these jetties.

Based upon the limited data base, these assumptions are subject to reconsideration. The Corps has limited their review to data taken in 1955, 1974, and 1979. Although these assumptions can be challenged, engineering judgment and opinion were required to make conclusions.

If the Town elects to proceed with this alternative, an in-depth study of the erosion history will be required. This study will need to incorporate the proposed 1985 update of the FDNR beach profiles, extensive re-analysis of the earlier Corps reports, and recent developments in the understanding of longterm changes in coastal wave climates and beach processes. This study should be undertaken with the cooperation and input of the Corps of Engineers, although their funding participation in such a study appears unlikely.

The third alternative, a modification of the present Section 111 plan, would relocate the proposed initial beach fill to the public beach area at Midtown as shown in Figure 5.7. Rationale behind this alternative consider that:

1. By placing the beach nourishment in this more centralized location (the present Corps plan has the fill located just south of the jetties) it will serve as a feeder beach for both the north and south adjacent beaches. This will substantially reduce the amount of sand which would otherwise be lost to the Inlet and offshore bar during periods of southeasterly waves;

2. With the fill in the public beach area, there is considerably more direct public benefit from the project;

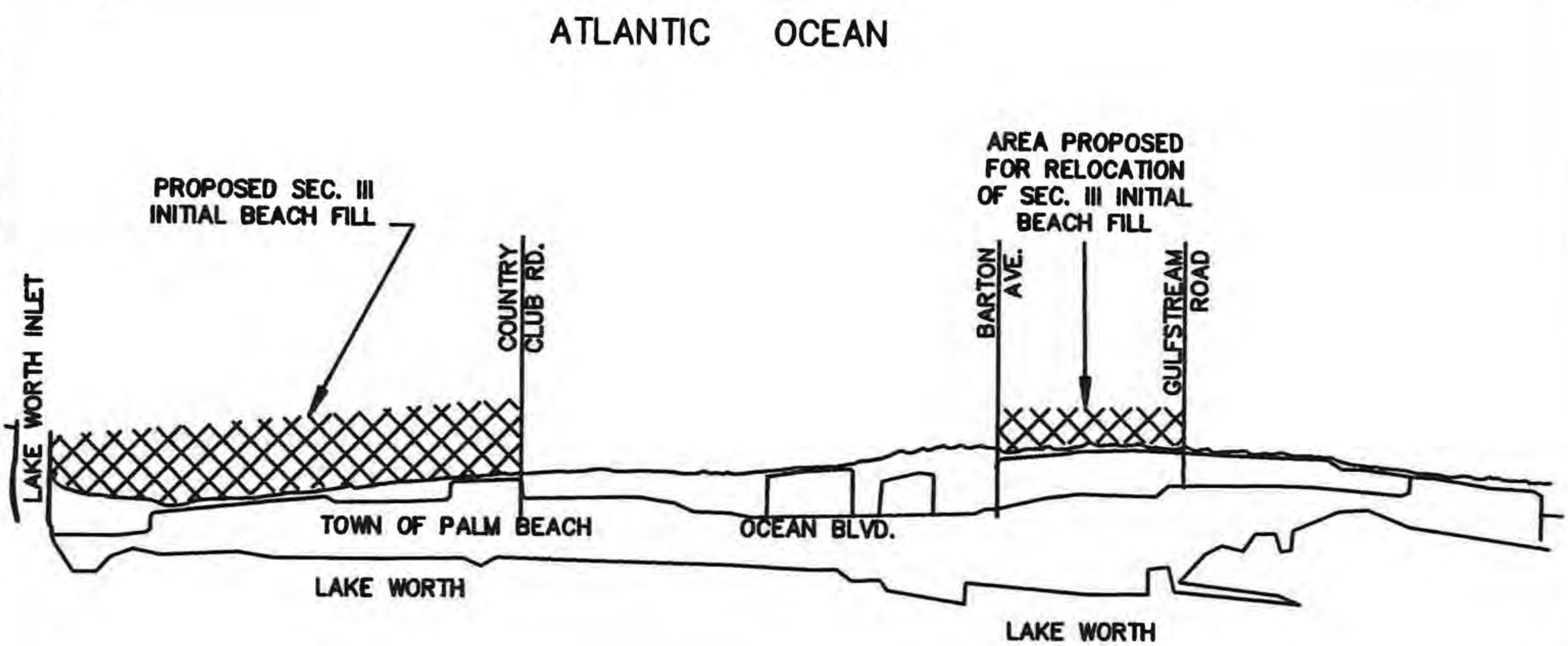
3. Because of the absence of the nearshore reef in the Midtown area, there will be less opportunity for any adverse environmental impacts from the project; and

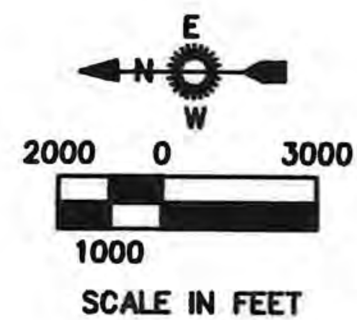
4. The Midtown area is presently one of the more severely eroded sections of the Town's shoreline, and thus in greater need of this beach nourishment.

The selection of this third alternative would require that the Corps delay the implementation of the Section 111 as presently proposed. The changes outlined above would have to be negotiated between the Town, the County, and the Corps. Some additional analysis may be required to provide that these changes are consistent with the overall objectives of the Section 111 study.

The Corps of Engineers has considered the Town's position of fill relocation and has reevaluated its Section 111 findings. At a Workshop Meeting on March 17, 1986, between Town Council and the Corps, the most recent proposal was presented.

The Corps does not support the alternative of fill relocation to Mid-Town on the basis of unfavorable benefit/cost ratio and their contention that the Mid-Town beach lies outside of the Inlet effect area. The Corps has however, proposed to mitigate Lake Worth Inlet damages by construction of a new sand bypass plant which would be designed to replace the existing structure.





PROPOSED MODIFICATION TO
CORPS OF ENGINEERS
SECTION III MITIGATION

NOTE: SEAWARD EXTENT OF BEACH FILL NOT TO SCALE

FIGURE 5.7

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In the COE's conceptual plan, the replacement facility would bypass approximately 215,000 cubic yards of sand per year. Combined with the Inlet maintenance dredging program, an estimated 250,000 cubic yards of sand would be deposited south of the Inlet. Discharge from the bypass plant would terminate 2500 feet downcoast of the south jetty. The replacement cost is estimated at $900,000 which implies that Congressional authorization would not be required to implement the improvement. An average annual operations and maintenance cost of $100,000 has been estimated by the Corps at this time.

This proposal by the Corps represents a significant departure from previous policy with respect to their participation in improvements to the sand bypass plant. It is recommended that their proposal be carefully reviewed and endorsed as appropriate, and that the Town coordinate with the County and Port of Palm Beach to obtain appropriate sponsorship and interlocal agreements.

CHAPTER 6.0
FUNDING SOURCES AND FINANCING

COMPREHENSIVE COASTAL
MANAGEMENT PLAN
FOR
TOWN OF PALM BEACH

6.0 FUNDING OPTIONS FOR BEACH IMPROVEMENTS

The extent to which a beach management plan can be implemented depends upon the available source of funds to underwrite the program. Therefore, an analysis of available monies is an important factor to enable proper scaling and timing of a possible plan. Four potential sources of financing may be available to the Town:

1. Federal participation;
2. State participation;
3. County participation; and
4. Town participation.

6.1 Federal Funding Programs

Prior to 1930, Federal interest in shore problems was limited to the protection of Federal property and navigation improvements. Beginning in that year, a series of laws were passed by Congress which gave Federal agencies a broader roll in studying and mitigating shore problems. The shore protection program of the US Army Corps of Engineers is the most important of these programs. The Corps of Engineers currently researches the causes of beach erosion, investigates and studies specific shore erosion problems, and constructs - or in certain cases, reimburses local and state governments for construction of - shore protection and beach restoration projects.

The US Army Corps of Engineers Shore Protection Program relates Federal participation to public benefit and requires the active participation of the sponsoring local interests. Under this concept, Federal participation is greatest where the protected shore areas are publicly owned and appropriate facilities to encourage full public use are provided. As much as 70 percent of the construction cost can be borne by the Federal government in such cases. At the opposite end of the scale, no Federal funds can be provided where the protected shore area is privately owned and public access is restricted. Federal participation in providing shore protection is proportional to public use and benefit. Other legislation provides that the Federal Government bear the entire cost of protecting Federally owned shore areas and of mitigating or preventing shore damages attributable to Federal navigational works. Any remaining costs are borne by the sponsoring local interests. Additionally, local interests are normally required to provide all necessary lands, easements, and rights-of-way, hold and save the United States free from claims for damages, prevent water pollution which would affect the health of the bathers, maintain the completed works, and assure continued public use of the protected area.

The Federal Government is not normally held responsible for damages incidental to shore protection works or activities. Usually, as a precondition of project authorization, local interests are required to hold and save the United States free from damages due to construction, operation, and maintenance of the project works. The Chief of Engineers does, however, have discretionary authority under certain conditions to provide remedial work to correct certain adverse conditions resulting directly from a shore protection project.

The Corps is authorized (River and Harbor Act of 1968 P.L. 90-483 Section 111) to investigate and construct, operate, and maintain projects, at full Federal expense, for the prevention or mitigation of shore damages attributable to Federal navigation works. The authority to provide mitigation at Federal expense is not mandatory, however. Where such projects are undertaken, the degree of mitigation is normally dependent on a reduction of erosion or accretion only to the level which would be attained without the influence of the navigation works at the time the works were accepted as a Federal responsibility. The damaged shorelines need not be restored to historic dimensions; rather, the work is usually performed to lessen the existing damage or prevent subsequent damage. Federal shore erosion control legislation does not authorize:

1. restoration of damaged beaches by extension beyond their historic shoreline unless required for protection of upland areas; or

2. funding of shore protection devices for limitation of use to specific segments of the population, such as local residents, or similar restrictions on outside visitors, directly or indirectly.

In addition to the shore erosion control program described above, the Corps also provides programs for hurricane and emergency coastal storm and flood protection. The Federal interest in shore projects to protect against hurricanes or abnormal tidal damage from coastal storms is not well defined by legislation. Congressional authorization for Corps construction of such projects on a case-by-case basis has essentially established the Federal policy. Hurricane-related projects generally provide the same kind of protection in the same areas as erosion control projects - differing primarily in the degree of protection. In addition, new protection of areas that have generally not been protected under shore erosion control programs is often provided. Both programs benefit public recreation and protect against storms, but hurricane protection offers a greater degree of safety.

Emergency shore protection under The Flood Control Act of 1955 (PL 84-99) involves restoration and repair of existing Federally authorized shore protection structures, whereas shore erosion control and hurricane programs are for new work. Emergency restoration of hurricane or shore erosion protection structures, under P.L. 84-99, is not a program under which non-Federal interests can substitute shore erosion control or hurricane protection programs.

Under P.L. 84-99, as amended, the Corps does not have any authority for the emergency protection of non-Federal works being threatened or the repair or restoration of such works damaged by a storm. This does not, however, preclude the Corps from furnishing emergency flood-fighting assistance during a storm, including strengthening project features where preservation of a Federally constructed project is threatened. Emergency shore protection is usually for the rehabilitation or restoration of damaged Federal projects already constructed under one of the other two shore protection programs.

Under authority provided by the Disaster Relief Acts of 1970 and 1974 (P.L. 91-606 and P.L. 93-288), the Corps can provide shore restoration where there has been no Federally authorized project if the President has declared the damaging storm event a major disaster.

6.1.1 Program Requirements and Cost Sharing

All shore protection projects must demonstrate positive net benefits to be eligible for Federal assistance. A summary of existing cost-sharing rules and program requirements for shore erosion control hurricane, emergency coastal storm and flood protection are provided below.

The Corps' participation in shore protection and beach restoration projects can be basically categorized into two programs(33CFR.282). The first includes those projects for which individual authorization by Congress is not required. This category of projects is limited to those for which the Federal share of construction cost will not exceed $1 million. If the project is proposed to control erosion attributable to Federal navigation works, mitigating measures costing not more than $1 million can be constructed entirely with Federal funds. The second category of projects includes those for which the Federal share of construction cost will exceed $1 million. These projects require individual authorization by Congress.

The Federal law places limitations on the Corps' financial participation in a project depending on whether it is for beach erosion control, hurricane and flood protection, or emergency protection. The Corps' financial participation in shoreline protection projects, where the Federal cost share exceeds $1 million, is presented in Table 6.1 which shows the maximum Federal

TABLE 6.1

LEVELS OF FEDERAL AID FOR SHORE, HURRICANE

AND ABNORMAL TIDE PROTECTION PROGRAMS

Program/ Ownership and Use Category	Construction[(a)] Maximum Federal Cost Shares	Construction[(a)] Non-Federal Shares	Percentage of Costs: Lands, Easements, and Rights-of-Way	Percentage of Costs: Operation and Maintenance	Percentage of Costs: Pre-authorization Surveys
Shore Erosion Control					
I Federally owned[(b)]	100	0	100	100	100
II Publicly owned, non-Federal parks and conservation areas	70	30	0	0[(c)]	100
III Publicly owned, non-Federal shores other than parks and conservation areas	50	50	0	0[(c)]	100
IV Privately owned-publicly used will result in public benefits	50[(d)]	50[(d)]	0	0[(c)]	100
V Privately owned; protection will not result in public benefits susceptible of evaluation	0	100	0	0	0

TABLE 6.1 (cont.)

LEVELS OF FEDERAL AID FOR SHORE, HURRICANE AND ABNORMAL TIDE PROTECTION PROGRAMS

Program/ Ownership and Use Category	Construction[a] Maximum Federal Cost Shares	Construction[a] Non-Federal Shares	Percentage of Costs Lands, Easements, and Rights-of-Way	Percentage of Costs Operation and Maintenance	Percentage of Costs Pre-authorization Surveys
Hurricane and Abnormal Tidal Protection					
Single purpose	70	30[e]	0[e]	0[f]	100
Combined with beach erosion control	70[f]	30[f]	0	0[c]	100
Emergency Protection	100	0[g]	0[g]	0[g]	100
Mitigation of damages caused by navigation projects	100	0	100	100	100
Mitigation of damages caused by shore protection projects	(h)	(h)	(h)	(h)	(h)

Notes:

(a) Construction costs include post-authorization engineering and design and interest costs during construction.

(b) Costs or work specifically to protect lands controlled by a Federal agency other than the Corps are borne by the agency concerned.

(c) Where periodic beach nourishment is a principal technique used in a shoreline protection project, the costs of periodic nourishment can be federally shared, for a specified period, usually 10 years. This nourishment is defined as construction by law, with cost sharing the same as with construction.

TABLE 6.1 (cont.)

LEVELS OF FEDERAL AID FOR SHORE, HURRICANE AND ABNORMAL TIDE PROTECTION PROGRAMS

Notes: cont.

(d) The cost share varies directly with the degree of public ownership and public use. The 50 percent Federal share is multiplied by the ratio of public benefits to total benefits along the subject private shore. The local share includes the cost allocated to private benefits.

(e) Costs for determination of local share include costs of lands, easements, right-of-way, and relocation.

(f) Corps has discretionary authority for 70 percent participation of construction cost of shore projects which include hurricane protection as well as beach erosion control. Normally combination project costs area allocated among the various purposes so that cost shares can be determined by purpose according to the prescribed rules for that purpose.

(g) Under certain circumstances the true costs of operation and maintenance to local interests may be altered or eliminated by the Federal government.

(h) Cost sharing is the same as for the purposes causing the damages (causative purposes). The entire costs of mitigation including construction, lands required for mitigation, and computed present worth of further operation and maintenance are cost shared on the same basis as for the purpose causing the damage. Responsibility for actual performance of operation and maintenance is normally assigned to non-Federal interests.

Source: 33 CFR Part 282, 1985

shares to be paid under different programs and for different categories of shore-front ownership, with varying degrees of public benefits or use. Under the same participation terms, the Chief of Engineers, in conjunction with the Secretary of the Army, can also approve Corps participation in authorized beach erosion control projects when the total cost of a project does not exceed $1 million. Traditional Federal cost-sharing programs are described as follows.

6.1.2 Shore Erosion Control

Federal participation in any shore erosion control project is based on shore ownership, use, and type of benefits. An applicant for aid must demonstrate public ownership or public use to be eligible for assistance. As indicated in Table 6.1, the maximum Federal share of construction costs varies from 0 to 70 percent for shore erosion control projects depending on the category of ownership of shore frontage and the degrees of public benefits and use.

Prior to Corps of Engineers participation in funding construction of any authorized erosion control project, the project cosponsor (Town of Palm Beach) must also agree to the following terms:

1. contribute in cash the non-Federal share of the first cost of any construction, maintenance of jetties and groins, and periodic nourishment to be accomplished by the Corps of Engineers;

2. provide without cost to the United States all lands, easements, right-of-way, and relocation required for construction of the project, including that required for periodic nourishment;

3. hold and save the United States free from all claims for damage that may arise before, during, or after prosecution of the work, except damages due to the fault or negligence of the United States or its contractors;

4. prior to the commencement of any work, obtain approval of the Chief of Engineers for detailed plans and specifications for the project or suitable sections thereof and also for the arrangements for completing the work;

5. ensure continued public ownership of public and private shores upon which the amount of Federal participation is based and their administration for public use during the economic life of the project;

6. ensure the maintenance and repair of structures and the local share of periodic nourishment, where appropriate, as required to serve the project's intended purpose during the useful life of the work; and

7. provide and maintain necessary roads, parking areas, and other public use facilities open and available to all on equal terms.

Specific cases may also warrant assigning additional responsibilities such as providing minimum land use controls or appurtenant facilities required for realization of recreational benefits.

No Federal contribution toward operation and maintenance of a complete shore erosion control project is authorized unless such a program (e.g., periodic beach renourishment) is found to include a more suitable and economical remedial measure for beach erosion control than other construction. If beach nourishment is considered the most suitable method for shore protection, the Chief of Engineers may recommend Federal aid for the life of a project.

6.1.3 Hurricane and Emergency Storm Protection

It is Corps policy to limit the Federal share of project cost to a maximum of 70 percent including the cost of lands, easements, rights-of-way, and relocation and alteration of utilities. Operation and maintenance cost for the life of the project is generally a non-Federal responsibility. Public shore ownership and use are not normally required for hurricane or emergency protection programs.

For emergency protection, the maximum Federal cost share is 100 percent for existing Federal projects. Local interests are usually required to bear the costs of lands, easements, rights-of-way, operation and maintenance, and relocation and alteration of utilities. Under certain circumstances, the Chief of Engineers can eliminate any of the local cooperation requirements upon adequate justification. Under authorizing legislation (P.L. 84-99 and P.L. 87-874), emergency assistance by the Corps is intended to supplement state and local interests and does not provide explicit cost-sharing rules.

6.1.4 Combination Projects

Some shore protection projects provide beach erosion control as well as hurricane protection. For these multi-purpose combination projects, total costs are normally allocated among the various purposes so that cost shares and benefits can be determined by purpose according to the prescribed appropriation rules. For multiple-purpose hurricane protection and beach erosion control projects, the Flood Control Act of 1970 provides discretionary power to the Secretary of the Army, acting through the Chief of Engineers, to authorize a Federal share up to 70 percent of the project cost (exclusive of land cost).

Federal project participation is restricted to public lands. This restriction is satisfied by corresponding Florida law, specifically Chapter 161, Florida Statutes (F.S.), which requires pre-project establishment of an Erosion Control Line. This line delineates private upland from sovereign beach. An Erosion Control Line is generally established at the line of mean high water existing prior to the project. In turn, it does not alter private upland, while assuring that the "new" or restored beach which is publicly financed is available to all users. Like the State, the Federal government also requires upland access to the restored beach through legal requirements for adequate access and parking. The adequacy of access has customarily been determined to be at half mile intervals.

Florida receives $40 to 80 million annually for construction of Federally-authorized public works projects. Included within this program is a category for beach erosion control activities. Uniquely, Florida has established a corresponding public works program within the Department of Environmental Regulation (DER) to establish and set forth State priorities for subsequent consideration by the Federal Office of Management and Budget (OMB) for the President, and Congress. Authorization of such projects is a time-consuming process and funding is contingent upon passage of the Federal budget. Competition between states and internally between competing state priorities is extreme. Nevertheless, Florida has been the past recipient of numerous Federally-authorized beach restoration and erosion control projects. In all such cases to date, the State of Florida, pursuant to Chapter 161, F.S., has financially participated in satisfying the non-federal share of total project costs, resulting in a Federal-State-local partnership for beach restoration and subsequent nourishment.

6.1.5 Funding Timetable

Actual funding for a federal beach restoration or other erosion control project is relatively straight-forward; it is considered as part of the Federal budget process. However, getting to that point in the process can, in some cases, take 8 to 12 years. First, study funding must be congressionally appropriated, then there is an extensive study phase, and finally Congress must authorize the project. At this point, no construction money, just authority is provided. To put this in proper perspective, there has not been an authorizing resolution passed since 1975. If a study is funded, its development must proceed through various stages within the Army Corps of Engineers. Once completed, a study sign-off must occur at various levels within the Corps, go through Florida's various agencies A-95 review process, and be reviewed by other Federal agencies. If the study concludes beach restoration or another identified erosion control alternative is viable in terms of cost-benefit, the Corps may submit the study for congressional consideration. If Congress accepts the study, the project is authorized. At this point, an actual request for construction funding can be submitted to the State-Federal public works appropriations process discussed in detail later in this section.

6.1.6 Funding Application Procedures

Just before the first of every calendar year, the Department of Environmental Regulation (DER) mails all local Florida governments a notice of intent to initiate the next cycle of Federal public works project proposals. Interested local governments may submit to DER "Requests for State Support". This is a project description which will determine whether the State of Florida will include a given local government request in the State's overall request to the President and Congress. An annual conference is held in mid-February to give local governments the opportunity to present their project proposals to various representatives of State agencies.

By the following August, DER presents an overall public works priority list to the Governor for his consideration. Applicants are then notified of their proposal status.

In January of the following year, the Secretary of DER presents the State's public works priorities to OMB to be considered for inclusion in the President's Budget. In April, the Secretary of DER also presents the State request to both Senate and House Public Works Appropriations Committees. State priority revisions may be made at this time as a result of the President's budget recommendations. Historically, appropriations bills, when passed, have been acted upon in late summer or early fall for the fiscal year beginning on October 1. If a proposal for study, construction, or maintenance funding is fortunate enough to be included in the appropriations act, funds generally reach the Corps by the first of the calendar year, or two years after the process began. Generally, for a beach erosion control project, this process must be repeated for the study and construction phases as well as for funding requests for subsequent maintenance or renourishment.

6.1.7 Importance of Federal Funding

Few major beach restoration or other erosion control projects have been undertaken in Florida without substantial Federal financial participation. Without Federal tax dollars, State and local governments have simply not pursued the costly beach restoration alternative. This is particularly relevant, given the reality that no new beach restoration projects have been Federally-authorized in the last ten years. Therefore, Federal expenditures for Florida's beaches have been limited to renourishment of previously-authorized project areas and "small project" grants with a $1 million cap. In turn, there has recently been considerable discussion among State and local officials concerning alternative funding formulas which involve substantial private sector participation. This discussion has been fueled by recent instances where beach restoration projects have been pursued with totally private funding, thus pre-empting the necessity to satisfy Federal and State access requirements. In such cases, the hurricane protection afforded and recreational benefits have been considered to be cost-effective by the private upland owners when compared with other shore-protective alternatives.

The Corps public works funding program described herein can also be avoided for small beach restoration projects or projects with other primary funding sources. The Federal government, through the Army Corps of Engineers, can participate in a beach restoration or other beach erosion control project in an amount up to $1 million under the "Small Projects Program". There is $10 to 12 million available annually for this program and Federal funding is at the discretion of the Chief of Engineers -- an 18 month to 2 year process without necessity for Congressional authorization and financial consideration. Recent Federal participation in Florida's Key Biscayne Beach Restoration Project was pursuant to this authority.

6.1.8 Existing Federal Projects

There are two authorized Federal projects within the municipal limits of the Town of Palm Beach. Details of these projects are provided in the March, 1985 Corps Draft, "Beach Erosion Control Projects for Palm Beach County Florida, General Design Memorandum with Palm Beach Harbor Section 111 Report and Environmental Impact Statement". These are:

1. combination shore erosion control and emergency protection (Section 111) consisting of 1.9 miles of protective and recreational beach between Lake Worth Inlet and Palm Beach County Country Club; and

2. shore erosion control consisting of 1.0 miles of protective and recreational beach between Kreusler Park and Lake Worth Park..

The details of these projects are provided in Table 6.2.

TABLE 6.2

AUTHORIZED ACTIVE FEDERAL PROJECTS
(Funding not yet authorized)

I. DESCRIPTION

The project provides for a protective and recreational beach along 1.9 miles of shoreline located within the Town of Palm Beach; Northern Boundary - 400 feet south of Lake Worth Inlet; Southern Boundary - southern end, Palm Beach County Country Club.

COSTS

Initial Cost.................................$	3,190,000
Annual Cost..................................$	265,000

BENEFITS

Prevention of damages........................$	447,000
Recreation benefits..........................$	0
Total benefits...............................$	447,000
Benefit/Cost Ratio............................	1.7

Physical Features	
Length of Project (miles)......................	1.9
Berm elevation (ft MSL)........................	9.0
Added beach width (feet).......................	50.0
Fill material source...........................	Initial fill + 2 years advance nourishment - offshore; periodic nourishment-Lake Worth Inlet

Quantity	
Initial fill (cu. yd.).........................	371,000
Advance nourishment (cu. yd.)..................	184,000
Total..	555,000

CONSTRUCTION

Method Initial construction 27-inch hydraulic dredge
Periodic nourishment pipeline dredge - 2-year intervals
Construction time.............................. 6 months

COST SHARING

	Beach Erosion Control	Section 111	Total
Federal	8.8%	100%	49.8%
Non-Federal	91.2%	0%	50.2%

TABLE 6.2(cont.)

AUTHORIZED ACTIVE FEDERAL PROJECTS
(Funding not yet authorized)

II. DESCRIPTION

The project provides for a 1.0 mile protective and recreational beach located within the Town of Palm Beach and the City of Lake Worth; Northern Boundary - 1/4 mile north of Kreusler Park; Southern Boundary - 1/4 mile south of Lake Worth Park.

COSTS

Initial Cost....................................$	2,425,000
Annual Cost.....................................$	396,000

BENEFITS

Prevention of damages...........................$	49,000
Recreation benefits.............................$	450,000
Total benefits..................................$	499,000
Benefit/Cost Ratio..............................	1.3

Physical Features	
Length of Project (miles)......................	1.0
Berm elevation (ft MSL)........................	9.0
Added beach width (feet).......................	50.0
Fill material source...........................	Offshore

Quantity	
Initial fill (cu. yd.).........................	158,000
Advance nourishment (cu. yd.)..................	217,000
Total..	375,000

CONSTRUCTION

Method...	27-inch hydraulic dredge
Construction time..............................	6 months

COST SHARING

Federal	50.0%
Non-Federal	50.0%

SOURCE: U.S. Army Corps of Engineers, 1985.

6.2 Beach Management Programs Administered by the State of Florida

Pursuant to the Beach and Shore Preservation Act, specifically Sec. 161.091, F.S., Florida, through the Department of Natural Resources, administers a local government grants-in-aid program for the purpose of assisting local governments in alleviating serious beach erosion problems and for protection and preservation of the State's sandy beaches fronting the Atlantic or Gulf of Mexico.

6.2.1 Project Eligibility

Program funding may be provided in support of the following beach preservation and erosion control activities:

a) beach restoration or nourishment
b) sand transfer, stockpiling
c) jetties, groins, breakwaters, revetments
d) bypass plant construction and maintenance
e) dune construction and revegetation
f) beach-dune overwalks
g) dune protective walkways or other measures of dune protection or preservation
h) sand fencing
i) biological and hydrological monitoring studies
j) sand source studies
k) educational signs
(Source: Section 16B - 36.04, Florida Administrative Code)

6.2.2 State Funding Participation

Up to 75% of the total project cost (or up to 75% of the non-Federal share of a Federal aid project) may be provided by the State under this Beach Erosion Control Assistance Program. The State is authorized to pay according to the following schedule of items:

a) project design engineering and construction supervision and inspection;

b) biological monitoring;

c) dune revegetation and stabilization;

d) construction easements, rights-of-way, public access easements, and vehicle parking spaces;

e) obtaining required permits;

f) establishing erosion control lines; and

g) enhancement of marine turtle propagation.

In addition to 25% of the total contracted project cost, the local government sponsor must assume full responsibility for all project costs in excess of the State cost limitation. The State may pay up to 100% of the cost of sand-source data collection.

There are no statutory limitations on the amount of money a local government may request under Florida's Beach Erosion Control Assistance Program. Discretionary funding is provided annually by the legislature through individual line-item appropriations to designated local governments. It should be noted, however, that current Statewide program funding has been reduced to approximately $3 million annually.

6.2.3 Program Policy and Requirements

Beach preservation and erosion control must be the primary purpose of a project receiving a program grant, pursuant to Section 161.091, F.S. For a project to qualify for State funding under this program, the local government applicant must provide permanent public access to project areas at approximately one-half mile intervals; including adequate vehicle parking spaces. The adequacy of the provision of parking is determined on a case by case basis by the Department of Natural Resources with regard to the public interest. Past Department actions have allowed for partial substitution of on-site parking requirements with off-site/mass transit alternatives. Exceptions to the public access and parking requirements may be made for emergency removal of coastal protection structures which are a hazard to public safety and cause beach erosion, and for sand transfer and placement associated with Federal or Non-Federal inlet navigation channel construction or maintenance.

6.2.4 Application Procedures

All requests for financial assistance under this program must be made on forms provided by the Department of Natural Resources. Applications are accepted between April 1 and July 1, although the Department has the discretion to extend this submission period. While the Department routinely mails application packages to eligible local governments, applications may be requested in writing at any time.

Application requirements include: designation of agents; a resolution in support of the requested project, approved by the local governing body; a map illustrating type of upland ownership within the project area; a project description including a site plan, access and parking designations, legal descriptions, and locational references to DNR permanent monuments; estimated project costs and breakdowns; and estimated design life and maintenance costs.

After application submission, the Department staff transmits those applications determined to be eligible for funding to the Governor and Cabinet, the Governor's Office, and subsequently to the Legislature for consideration. If funding is provided by the Legislature for a given project, it becomes available for contracting on July 1, the beginning of the next State fiscal year.

The likelihood of receiving a grant cannot be specified. It is a function of Legislative priorities, total dollars earmarked for this program, and comparative assessment of need among local governments requesting erosion control project funding.

6.2.5 Florida's Coastal Management Program

The Department of Environmental Regulation administers Florida's Coastal Management Program pursuant to the Federal Coastal Zone Management Act. This program recognizes that coastal areas play a critical role in providing for the public's health, safety and welfare, and that these zones are subject to increasing growth pressures. Florida's Coastal Management Program far transcends a beach erosion control perspective. It is instead a coordinative effort to integrate various Federal and State substantive program areas to assure consistency and effectiveness in managing coastal development and providing environmental protection. This is, for the most part, a federally-funded program in which Florida has elected to pass-thru a proportion of dollars to local governments for coastal "studies". Study topics may relate to marine habitat protection, hazard mitigation, hurricane evacuation, waterfront development, port planning, beach access inventories, etc. It is the intent of the CZM program to fill in voids in existing State and local programmatic areas rather than to supplant or supplement existing efforts. To date a small proportion of total funding has been provided to local governments for beach access and erosion control studies, preparation of beach management plans, and biological monitoring.

Florida's annual Federal program allocation pursuant to Section 306 generally falls between $1.75 and $2 million. Historically, approximately $500,000 annually has been contracted for local or regional studies. Local government grants have been limited to $50,000 and require a 25% local match. Grants under Sec. 306 can not be used for land acquisition or construction activities.

The Department of Environmental Regulation calls for applications in the beginning of the calendar year by letter and by publication in the Florida Administrative Weekly. Applications must be received by the Department by March 1. Notice of whether or not a specific grant request is included in the State's grant submission to the Federal Office of Coastal Zone Management (OCZM) is given all applicants in the beginning of May. A Federal response to this state submission is usually provided in early

August. Individual project grants may be awarded on or after October 1, the beginning of the federal fiscal year. and are usually of a one-year duration.

6.3 County Government Activities in Support of Beach Erosion Control

In terms of general application, Part II of Chapter 161,F.S., provides the Board of County Commissioners with the power to act as the beach and shore preservation authority for a given county, and to create beach and shore preservation districts. Further, it authorizes uses of an available County funds for beach erosion control, including authority to levy a uniform ad valorem tax and issue bonds.

Additionally, Section 120.0104, F.S., the Tourist Development Tax, was amended this past legislative session. Beginning October 1, 1985, the use of such tax revenue has been expanded to include financing beach improvements, maintenance, renourishment, restoration and erosion control. Specifically, up to 50% of the revenues to be derived from the Tourist Development Tax may be pledged to secure and liquidate revenue bonds issued by a County for the aforementioned beach management purposes.

6.3.1 Palm Beach County Policy and Requirements

Funding participation by Palm Beach County requires that the project cosponsor (Town of Palm Beach) must agree to Federal and State requirements including requirements on parking and access. The County will further require that all available parking be equally available to all County residents. Additionally, the Town of Palm Beach is required to enter into an intergovernmental agreement with Palm Beach County. This agreement requires that the Town finance all construction costs and all other 'first time' costs which are not reimbursed through Federal or State financial participation. The agreement provides that Palm Beach County maintain the project over the life of the agreement assuming continued Federal and State reimbursement. Maintenance costs beyond those originally estimated at the time of the intergovernmental agreement are the financial responsibility of the Town.

6.4 Town Activities in Support of Beach Erosion Control

6.4.1 Example Programs

Under the Municipal Service Improvement District legislation as established by Florida, a municipality may elect to create a tax assessment district to fund the selected beach maintenance program. The system is extremely flexible and can be set up to weight assessment on the basis of proximity to the improvement. The creation of special taxing districts and the use of special assessments have been employed by various local governments for financing major beach erosion control projects (specifically beach restoration and nourishment).

Special tax districts have financed beach nourishment projects on Captiva Island and at Jupiter Island, Florida. The proposed North Boca Raton beach nourishment project may also be funded through an independent special tax district. Details of funding for these examples are briefly provided below.

The Town of Jupiter Island established a special erosion district nearly twenty years ago. This special district has funded three major beach erosion control projects along private Atlantic Ocean shorefront. The district currently assesses an ad valorem tax of 4 mills on all taxable property in the district. Tax generated revenues are placed into a beach erosion project fund isolated from the Town's general fund. The district has specific guidelines for disbursement of these funds for any erosion control program.

The Captiva Erosion Prevention District was formed in 1959. (59-1496,Laws of Florida 1959). The district is responsible for beach and shore preservation programs on Captiva Island and has completed several projects concerning erosion control structures along the Gulf of Mexico shorefront.

The Army Corps of Engineers completed a study of erosion control for Lee County which recommended a federal beach erosion control project at Captiva Island. The project was authorized by Congress in 1970 but because of funding problems was never constructed. Subsequent studies have further recommended beach nourishment along Captive Islands eroding shorefront.

The Captiva Erosion Prevention District now proposes to nourish three miles of Gulf of Mexico shorefront. Financing is necessary for $5.6 of the 6 million dollars in estimated project costs. In 1979, the District surveyed local residents for their input on project financing. The results of the survey indicated that the residents favored a locally financed project since local public financing would limit stipulations on public access, parking and use inherent to Federal participation. An economic apportionment plan was developed by the District to finance the project. The basis of the plan is that the apportioned cost should reflect the benefits received by each property owner. The plan followed assessment procedures outlined in 81-413 laws of Florida and identified cost apportionment by zone, land use and property location relative to the proposed project. The District Board of Commissioners plans to conduct a socio-economic study to further evaluate the determination of benefits as required by the districts enabling legislation. The economic costs apportionment plan has been indefinitely tabled pending the results of this future study.

In 1978, property owners of South Seas Plantation initiated a petition to Lee County for establishing a special tax district to fund a $3.6 million beach nourishment project. This project (known as the South Seas Plantation Beach Improvement Project) provided for placement of beach fill along nearly two miles of private Gulf of Mexico shorefront. The special tax district, called a municipal services taxing unit (170 F.S.) as adopted included a cost share arrangement which weighted the expected individual benefits derived from its project. The project was completed in 1981.

The City of Boca Raton owns and administers several beach front parks. Funding for property acquisition and park development is generally through the Greater Boca Raton Beach Tax District. The District was established by legislature (74-423 Laws of Florida) in 1974 and amended in 1976 (76-323, H.B. 3624, Laws of Florida). It is an independent special tax district with two mills taxing authority. Presently, the levied district millage is approximately 0.9 mills.

An estimated 4.8 million dollar beach nourishment project is proposed along municipal and private Atlantic Ocean shorefront in Boca Raton. This project is included in the Army Corps of Engineers Study of Beach Erosion Control Projects in Palm Beach County. Although the City is actively seeking federal and state funding assistance, the project may be initiated before federal or state funds are committed. The City is presently considering a general obligation bond issue to finance the project. Thereafter, if congressionally authorized finances become available, those funds reimbursed to the City would be placed in a sinking fund to finance future beach projects in Boca Raton.

The Greater Boca Raton Beach Tax District boundaries exceed the municipal limits of the the City and include the reserve areas to the west. The district may participate in funding the City's proposed nourishment project. District participation would, however, require a change in the City beach use policies as presently enforced. Stipulations attached to Beach District funds may require that the beachfront parks be open to all who reside within the district boundaries and not solely to those residing within the municipal boundaries of Boca Raton. This issue is further complicated by the fact that nearly 75% of the assessed project costs available through the tax district will be generated from within the municipal limits of the City. Consequently, it is necessary for the City to weigh the benefits of "out of City" contributions against the impacts associated with increased park usage and facility stress which may result from less restrictive use policies.

6.4.2 Town of Palm Beach Funding Alternatives

Public funding of beach erosion control projects places new demands on already limited municipal finances. Local governments cannot use Home Rule Authority to levy taxes for special purposes. The Florida Constitution requires that municipalities levy ad valorem taxes on a uniform basis and enabling legislation giving municipalities authority to provide improvements like beach nourishment through special assessments is poorly defined.

Article III, Chapter 19, Sections 43 through 45, Town Code of Ordinances provides the Town with the authority to protect Ocean Boulevard from erosion and outlines provisions to assess the cost or a portion of the cost of improvements against especially benefiting and or affected property. This assessment is based primarily upon property frontage along Ocean Boulevard or on a square foot basis against the lands affected. The assessment is made in the same manner now provided in the Town Charter and Code for other special assessments.

Chapter 170, Florida Statutes provides authority for municipalities to make public improvements and defray the whole or any part of the expense by special assessments. This legislation enables the establishment of a special assessment district to provide for payment of all or any portion of the cost of the improvements by levying and collecting special assessments on the abutting, adjoining, contiguous or specially benefited property. Special assessments may be levied only for the purposes outlined in Chapter 170, F.S. which does include "stabilization of .... water bodies". The context of this construction may, however, be solely related to stormwater management and requires further legal research by the Town's attorney to clarify the Town's authority in establishing a special assessment district for the beach erosion control projects.

The formation of local governments act (Chapter 165 F.S.) provides standards, directions and procedures for the formation of local government units including the special district (165.031(s)F.S.). The special district is created for the purpose of performing prescribed specialized functions within limited boundaries. An independent special district is created by a special act of the legislature. The independent special district has the authority to levy ad valorem taxes to finance specific projects. The millage cannot be levied in excess of that amount authorized by general law and approved by vote of the electors (200.001 F.S.). Special districts can successfully finance beach erosion control projects.

Generally, funding assistance involving Federal, State, and County participation require that the Town provide at a minimum: public access, adequate public parking and provide facilities which encourage public use. These requirements could involve substantial construction and alteration of public access and parking in order to obtain funding assistance. Federal, State and County funding assistance may therefore prove an unpopular alternative with local residents.

Under the present legislation, considering the stipulations inherent to Federal, State and County participation the alternatives for local financing of beach erosion control projects for the Town of Palm Beach include underwriting the program with ad valorem taxes, special assessments (Sect. 19-43 through 19-45 Town Code of Ordinances), creating a special assessment district (170 F.S.) and creating an independent special taxing district (165 F.S.).

These alternatives have been initially reviewed by the Town's Attorney. Additional research will be required to evaluate the legal complexities and ramifications involved with implementation of each alternative before formal policy considerations by the Town Council.

It is recommended that the Town further research the legality of each funding alternative. It is further recommended, that the Town consider the merits of creating an independent special district within the Town's corporate limits for purposes of maintaining the Town's shorefront.

CHAPTER 7.0
PERMIT FEASIBILITY

COMPREHENSIVE COASTAL
MANAGEMENT PLAN
FOR
TOWN OF PALM BEACH

7.0 PERMITABILITY OF BEACH IMPROVEMENTS

Since the late 1960's, increasing public awareness of the coastal environment, has mandated that environmental concerns regarding beach restoration and beach erosion control be addressed prior to approval of proposed improvements. Essentially this means that any proposed improvements must be consistent with all local codes and satisfy State and Federal criteria.

Before beach improvements can be initiated, permits are required from Federal and State agencies which include the U.S. Army Corps of Engineers (ACOE), Florida Department of Environmental Regulation (FDER), and Florida Department of Natural Resources (FDNR), Palm Beach County Health Department and the Town. Federal, State and County agencies solicit and review comments especially regarding environmental impacts from other agencies and groups in consideration of issuing a permit. From the perspective of these agencies, the major concerns regarding re-establishment of beaches are environmental, that is, successful permitting of the proposed improvement is dependent upon controlling and minimizing environmental impacts.

7.1 Federal Permit Requirements

Federal laws prohibit certain activities in navigable waters unless authorized by permit. Agencies involved in regulating improvements below mean high water (MHW) or in navigable waters include the ACOE, Environmental Protection Agency (EPA), U.S. Coast Guard and the U.S. Fish and Wildlife Service. Federal laws regulating improvements in these waters include the following:

- River and Harbor Act of 1899
- Federal Water Pollution Control Act of 1972 as amended by the Clean Water Act of 1977
- Fish and Wildlife Coordination Act of 1958
- The National Environmental Policy Act of 1969
- Title 33,s209.120 Code of Federal Regulations
- Title 32,s209.320 and s209.330 Code of Federal Regulations
- Marine Protection, Research and Sanctuaries Act of 1972

Permits from both the U.S. Coast Guard and EPA are not required for improvements addressed in this beach management plan. These agencies regulate bridge, causeway or pipeline construction in and material discharge (other than dredge and fill material) to navigable waters.

The ACOE has statutory responsibility for the control of works or improvements below MHW, in navigable waters and work relating to discharge of dredge and fill material into navigable waters. The primary purposes of the ACOE permitting program are to restore and maintain the integrity of natural waters, maintain waterway navigability and protect the oceans from pollutant dumping. In issuing a permit, the ACOE evaluates the probable impact of the improvement on public interest with consideration to protecting and utilizing important resources. Factors considered during review of a proposed improvement include aesthetics, environmental concerns, historic resources, fish and wildlife values, flood damage prevention, land use classification, navigation, recreation, water quality and supply, and public benefit and welfare. Under Federal permitting jurisdiction, the ACOE must further consult with the U.S. Fish and Wildlife Service to assess project impact and consider methods to mitigate the predicted damages from proposed improvements in navigable waters.

7.2 State Permit Requirements

Beach erosion control improvements are regulated on a State level by the FDER and FDNR. Each agency has its specific authority in relevant sections of the following Florida Statutes and Rules contained in the Florida Administrative Code. These include:

- Chapters 120, 161, 253, 258 and 403, Florida Statutes
- Rules 17-3, 17-4, 17-12 and 17-45 Florida Administrative Code
- Rules 16B-24, 16B-26 and 16B-33 Florida Administrative Code
- Rules 16Q-18, 16Q-20 and 16Q-21 Florida Administrative Code

The State is particularly interested in protection of its offshore resources. Unless specifically exempted (Chapter 403 F.S.) all dredge and fill activities conducted in waters of the State require a State permit.

The purpose of the FDER permitting program is to maintain and improve water quality and preserve and protect wetlands and fish and wildlife which use these areas. The FDER will evaluate the impacts of the proposed improvements on water quality and will determine if reasonable assurances are provided to insure that State water quality standards will not be violated. The State further evaluates if the improvement is in the public interest and considers such factors as public health, safety and welfare, erosion and shoaling, recreational values and the current condition and relative value of the affected area.

The FDNR permitting program is designed to manage and protect State lands as well as control beach erosion. The FDNR will authorize permits when improvements involve State owned lands and evaluates the proposed improvement in terms of policy consistency, standards and criteria set forth in the Florida Administrative Code. Further, FDNR evaluation considers the functional and compatibility of the proposed improvement to local coastal processes, the impacts of the proposed improvements on adjacent riparian properties, storm and erosion protection provided by the proposed improvements, and public response (in terms of access, historical value and turtle nesting sites) when authorizing permits. If the proposed improvement further requires a coastal construction permit, FDNR may require an easement, submerged land lease, dedication or other form of consent of use for applications involving State owned lands.

The Florida Department of State, Division of Archives, History and Records Management evaluates the impacts of the beach erosion improvements to historical and archaeological sites of value or of public interest. Protection of historic sites and properties are authorized in the following Florida Statute and Rules of the Florida Administrative Code:

- Chapter 267, Florida Statutes
- Rules 1A-31, 1A-32 and 1A-35 Florida Administrative Code

Authority and procedures for Federal agency responsibility are outlined in 36 CFR 800, the National Historic Act of 1966 (and subsequent amendments) and related Presidential Executive Order 11593.

The Office of Planning and Budgeting administers the States program of environmental impact analysis review. Chapter 23, Florida Statutes requires the Governor's office to act as the State Clearinghouse and coordinate intergovernmental planning. Subject to the National Environmental Policy Act of 1969, this review is intended to insure that all pertinent project data is available to all agencies to insure that agencies understand the issues, consequences of the proposed action and impact of their decision. The intent of agency (Federal, State and local) review is to insure that the proposed improvement is consistent with State law, policy, plans, programs and objectives.

7.3 County Requirements

Palm Beach County laws and ordinances prohibit construction of beach erosion control improvements unless these activities are permitted or granted a variance or waiver by the County Commission. Permitting, coastal protection and flood damage prevention are discussed in the sections of the Codes of Laws and Ordinances of Palm Beach County. A summary of the relevant sections is provided below.

The Palm Beach County Environmental Control Ordinance, (Ord. No. 78-5), requires approval of the Palm Beach County Health Department for any activity requiring a State permit through the Department of Environmental Regulation (Sect. 7.2). The County Health Department is by agreement, the local authority of the State's Department of Environmental Regulation. As such, the Department will evaluate the impacts of the proposed improvement on water quality and consider if reasonable assurances are provided to protect water quality. County Health Department evaluation criteria is similar to that used by the State agency to review a project for permit. The permit is issued by the State and is approved by the County when signed or cosigned by the County Health Department Director or authorized agent. This Ordinance further provides details on Environmental Control Board hearings, judicial review, inspections and administration and permit fee schedules.

The Flood Damage Prevention Ordinance (Ord. No. 70-1, Art. 1 and Ord. No. 82-25, Art. 1) provides Palm Beach County with the authority to establish and administer a program of flood control under Chapter 125 F.S. This ordinance requires a development permit for construction within areas of special flood hazard, and prohibits flood protection techniques which increase erosion, flood heights of flood water velocity.

The Palm Beach County Coastal Protection Ordinance (Ord. No. 72-12 and Ord. No. 78-20) establishes a setback line relative to the existing dune crest and prohibits material excavation or removal or alteration of existing ground elevation seaward of the designated setback line. Beach erosion control projects which alter existing ground elevation and which are located seaward of the setback would require a waiver or variance authorized by the Palm Beach County Commission.

The Palm Beach County Mangrove Protection Ordinance (Ord. No. 81-18) prohibits destruction, removal or maintenance of mangroves on land or in water without a permit. Permit application is through the Palm Beach County Health Department.

7.4 Town Requirements

Shorefront construction of bulkheads, seawalls and groins, alteration of dunes and dune vegetation and flood damage prevention are activities which require permits authorized by the Town of Palm Beach. Permit requirements are presented in the Town Code of Ordinances of the Town of Palm Beach and include:

- Chapter 5, Article VII "Flood Damage Prevention", Sections 5-198. thru 5-237. Town Code of Ordinances
- Chapter 6 "Bulkheads, Pierheads and Groins", Sections 6-1 thru 6-19. Town Code of Ordinances
- Chapter 13 "Beaches", Sections 13-9 thru 13-11. Town Code of Ordinances

Chapter 6 of the Town Code of Ordinance, requires that bulkheads, seawalls and groins be constructed or platted in accordance with the "Official Bulkhead and Groin Plat of the Town of Palm Beach, Fl." (adopted Feb. 3, 1932) detailed in Chapter 6, Section 16 and amended by Ord. No. 25-82. The aforementioned structures must also comply with criteria and general specifications established and setforth in Sections 6-17 and 6-18. Permits for construction are authorized by the Town Manager and are issued through the Building Department.

Section 13-10, Code of Ordinances (amended by Ord. No. 10-85) provides for dune and dune vegetation protection. A permit is required for any alteration of a dune or dune vegetation. This Ordinance further authorizes the Town to approve the construction of bulkheads for those cases where dunes are completely removed or lowered to an elevation below that specified in the Ordinance. Section 13-9, Town Code of Ordinances provides the Town Manager with the authority to permit deposition of material on the ocean beach.

Flood damage prevention is provided by Chapter 5, Article VII of the Town Code of Ordinances. This article applies to all areas of special flood hazard within the jurisdiction of the Town and is administered by the Building Department. A development permit is required for construction in special flood hazard areas and permit requirements are provided in this article of Chapter 5 of the Town Code of Ordinances.

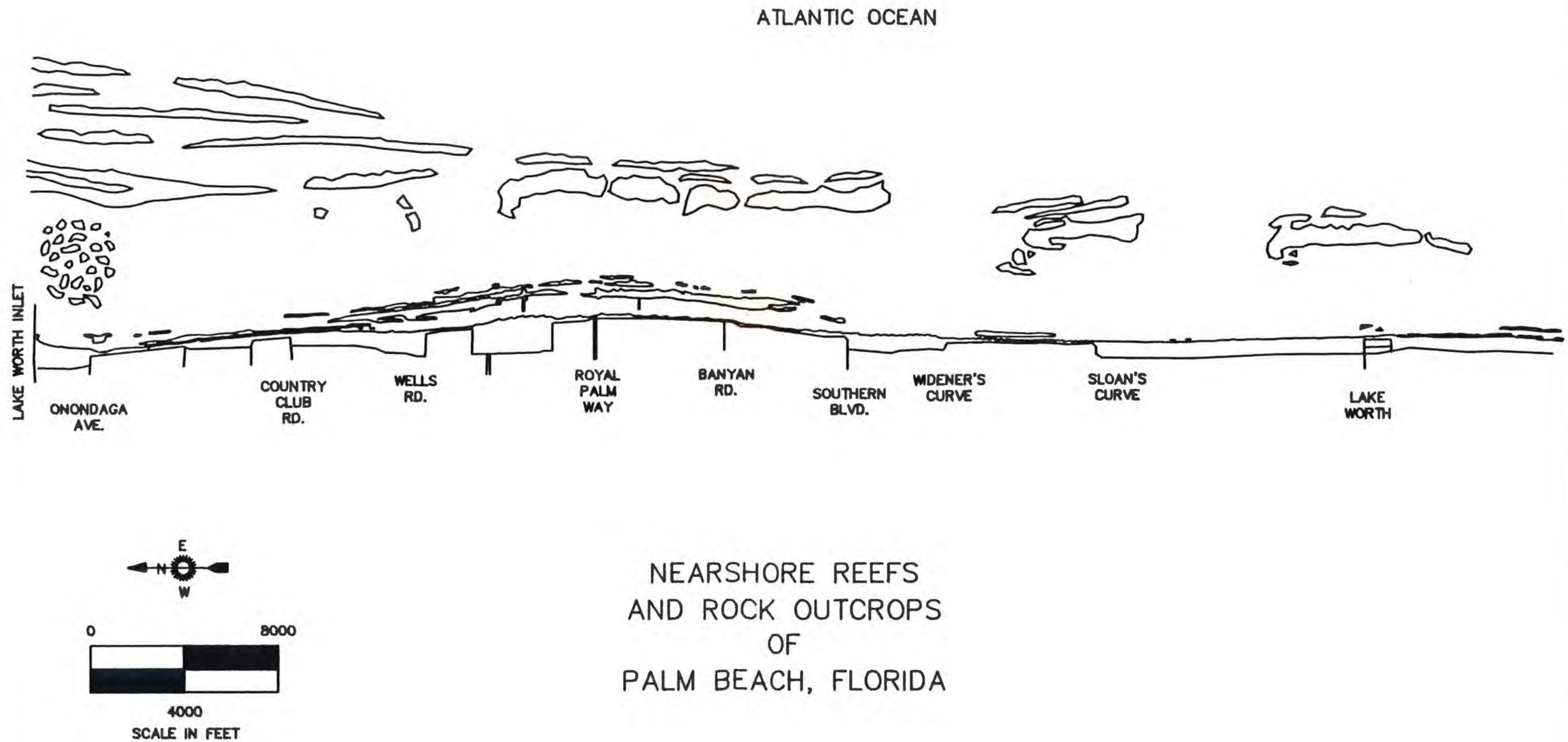
7.5 Permit Feasibility

7.5.1 Physical Environment

The Town of Palm Beach is underlain by several limestone formations along the coastline. Limestone is exposed in various locations as reef formations. Where exposed in the marine environment, limestone provides habitat for highly diverse and productive communities. The limestone provides a solid substrate for attachment of various organisms especially algae and soft and hard corals which provide food and additional habitat for other organisms. The concentration of life on these outcrops, especially in comparison to surrounding sandy bottom, represents an important natural resource.

Three essentially linear limestone outcrops comprise the reef systems which parallel the coastline of the Town of Palm Beach. These formations are shown in Figure 7.1. The outcrops vary in location and diversity and consequently have been categorized as the surf zone outcrop and the second, and third terraces.

The surf zone outcrop is a fractured extension of the Anastasia formation which underlies most of the island. It is composed of relatively flat limestone terraces and occurs from the shoreline seaward approximately 200 feet. Although this formation



NEARSHORE REEFS
AND ROCK OUTCROPS
OF
PALM BEACH, FLORIDA

SOURCE: CZR,INCORPORATED

FIGURE 7.1

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is not continually visible, it is however expected to exist along the entire coast. Maximum vertical relief of about two feet occurs along the seaward edge of these platforms; however, up to one foot of vertical relief may occur along the shoreward edge. Much of this outcrop is broken or cracked allowing sand to fill or vacate the fissures. Several of these inner outcrops support colonies of the sabellariid worm (Phragmatopoma lapidosa) which, when conditions are right, can add considerable surface area and relief to the outcrops. The surf zone outcrop probably is exposed during periods of erosion and covered by sand during accretion.

The second terrace is a coquina rock outcrop composed mainly of rock with smooth or flat surfaces which underlie and/or are exposed above the nearshore sand basin. This reef occurs from approximately 400 feet to 1600 feet from shore in water depths of from 6 to 20 feet. Sink holes or solution features up to 60 feet in diameter occur sporadically in this terrace especially offshore of the Breakers Hotel. Maximum vertical relief of the exposed rock is 3 feet or less except within the solution cavities where up to 6 feet of relief may occur. In some places, regular fissures in the outcrop yield a resemblance of the "Bimini Road" of the Bahama Islands. These reefs, especially the nearshore portions, are subject to sand inundation caused by littoral drift and major storms. Review of historical aerial photographs reveals that such outcrops recently have been covered and/or exposed. The most extensive of these outcrops occurs offshore paralleling the Town's shoreline extending from the Palm Beach Country Club south to the vicinity of the Everglades Golf Course.

The third terrace is composed of coral rock originally deposited by the growth of hard corals. This is the terminal reef system of the local continental shelf. From the seaward edge of this reef, the seafloor slopes steeply toward the channel of the Florida Current. This terrace is composed of patches of rock which protrude above the sand to a maximum height of 20 feet at the top of the reef. The patches occur 4000-6000 feet from shore in water depths of 40-90 feet. Typically, the seaward edges of these reefs slope gently into the sand, and a series of finger-like projections are observed that extend seaward for distances up to 100 feet. Maximum vertical relief is usually found along the shoreward edge of the patches especially at their northernmost ends. Bioerosion (the dissolution of rock by living organisms) is primarily responsible for the "caves" and "cliffs" along the nearshore edges of these reefs as well as the numerous potholes, nooks, and crevices found throughout the reef. The third terrace occurs most extensively offshore and generally parallels the Town's shoreline extending from the Breakers Hotel southward to the Bath and Tennis Club in 45-80 feet of water .

Sand composed primarily of quartz with some calcium carbonate, covers most of the underlying rock from the coastline seaward to the continental slope. These particles occupy the low areas between the outcrops as well as being moved along the beach by littoral processes. Depth of sand varies with location but generally increases with distance from shore to a maximum depth of 40-50 feet of sand between the second and third outcrops.

7.5.2 Biotic Communities

Biological inventories or studies of the Palm Beach reefs and rock outcroppings have not been completed. Existing literature contains such works for the reefs both north (Jupiter northward: Nelson, et al. 1983; Harbor Branch Consortium Annual Reports 1974 and 1975) and south (Ocean Ridge-Briney Breezes southward: Marszalek 1983; Goldberg 1970, 1973, 1982; A. V. Strock and Associates, Inc. 1981; Turbeville 1981; Raymond 1978; Iverson and Corcoran 1976; Courtenay, et al. 1974). Consequently, information presented here was derived from the above publications, personal communications with Norine Rouse, Jim Barry, and other local divers, and personal knowledge and experience of CZR, Inc. All organisms discussed herein are listed by group or common names; a more comprehensive list of species names is contained in Appendix E.

The surf zone outcrop supports an assemblage of plants and animals adapted to a high energy environment. Dominant macrophytic plants include species of green and red algae. Attached invertebrate animals include sponges, anemones, bryozoans, barnacles, tube-building worms, chitons, sea squirts, and limpets. Mobile invertebrates include crabs, snails, shrimps, and sea urchins. Transient vertebrate animals associated with these outcrops include fishes and marine turtles. Fishes typical of the surf zone and high energy inlet environments frequent the outcrops during periods of tidal inundations. Young fishes that use the outcrops during at least part of the tide cycle include permit, pompano, jacks, Atlantic threadfin, kingfish, spadefish, and stargazers. More or less permanent residents include blennies, gobies, clinids, and damsel fishes. Transient adult fishes include many of those found on reefs further offshore as well as pelagic predators such as bluefish, jacks, and sharks.

The coquina rock of the second terrace further supports two different biotic communities of marine life. The first occurs on the shallower portions of the outcrop closest to shore (approximately 400'-1200' east of the shoreline). This community is similar to that of the surf zone outcrops, although less diverse because of the low, flat nature of these deeper outcrops which allow periodic covering by sand. This community type is found closer to shore than the second type and differs from the surf zone community by the lack of or lesser abundance of many of the attached invertebrates and the lack of young permit, pompano, jacks, Atlantic threadfin, kingfish, and stargazers. It differs also by possessing several species of brown algae, juveniles of many reef fishes (angelfishes, surgeonfishes, sciaenids, parrotfishes, wrasses, and cardinalfishes) and larger individuals of mobile invertebrates (snails, crabs, sea urchins, and lobsters).

The second type of community supported by the second terrace is characterized by the occurrence of several species of gorgonians (octocorals) and occurs on the deeper, more seaward portions about 1200-1600 feet from shore. Species diversity is greater here primarily because of slightly greater relief and distance from shore which probably prevents periodic total inundation by sand. The plants and animals of this community closely resemble those of the deeper reefs located 4000 feet offshore. Various brown and red algae dominate the macroscopic plant life occurring on the rock itself and within surface breaks and fissures. Attached macroinvertebrate animals include sponges, hydroids, anemones, corals, bryozoans, tube-building worms, oysters, clams, and sea squirts. These animals, together with the algae, cover almost every available hard surface and commonly grow attached to one another. Mobile macroinvertebrates include worms, snails, shrimps, crabs, lobsters, starfish, sea urchins, and sea cucumbers. Vertebrate animals associated with these outcrops include marine turtles and fishes. Hawksbill, loggerhead, and green turtles traverse this outcrop during nesting seasons and occasionally are sighted in the vicinity at other times of the year. Fishes utilizing the outcrop are primarily coral reef fishes typical of Florida Keys coral reefs. They include but are not limited to eels, barracuda, filefishes, triggerfishes, trunkfishes, puffers, porcupinefishes, frogfish, batfish, gobies, blennies, clinids, wrasses, parrotfishes, surgeonfishes, damselfishes, angelfishes, jacks, sciaenids, snappers, grunts, groupers, porgies, sharks, and rays. These fishes can be found in the water column above the outcrop, among the gorgorians, in the cracks and crevices, or in the deep fissures and solution features.

The third terrace or reef system supports the most diverse assemblage of marine organisms. The greater vertical relief coupled with active bioerosion have created considerable surface area, and this accounts for much of the diversity and abundance of life on this reef. The macroscopic plant component of this community is much the same as that of the second terrace comprised mainly of red and brown algae. Algal production on these 40-90 foot deep reefs is less per unit area than in the inshore outcrops due to light attenuation. Most of the terrace is covered with attached invertebrate animals including all of those listed above for the middle outcrop as well as numerous small colonies of hard corals. Mobile macroinvertebrates found on the terrace are very similar to those on the deeper community associated with the second terrace (listed above). Because of its greater surface area and relief, this terrace supports far more species of animals than the inshore terraces. The vertebrate component of this outcrop community is represented mainly by marine turtles and fishes. Hawksbill, loggerhead, and green turtles seasonally reside on the reef and can be located in the same area year after year (Norine Rouse, personal communication). Occasionally, leatherback and ridley turtles visit the reef or water column over it. Fishes of this terrace include all species mentioned earlier as inhabiting the offshore portions of the second outcrop with the addition of the following : sweepers, bigeyes, scorpionfishes, hawkfish, jawfishes, butterflyfishes, flounders, goatfishes, hamlets, squirrelfishes, lizardfish, trumpetfishes, and tarpon. Pelagic fishes known to school and/or feed over the reef include jacks, bluefish, sharks, cobia, sailfish, tunas, mackerels, halfbeaks, and flyingfish.

The sandy bottom supports a different biotic community. The sand provides habitat for many small to microscopic organisms which reside between and among the sand grains. These include many species of diatoms, crustaceans and mollusks. A few species of larger animals reside in or on the sand such as, sting rays, tilefish, garden eels, sea urchins, sand dollars, snails, shrimps, and worms. Many of the larger organisms can either escape or tolerate temporarily adverse conditions associated with beach nourishment. Generally, sand bottom flora and fauna are considered depauperate when compared to those adjacent live bottom outcrops. Consequently, agencies express less concern for sand bottom communities because of less impact on flora and fauna and documented quick recovery of benthic infauna.

Although technically not considered "living coral reefs", the three limestone terrace outcrops offshore the Town of Palm Beach shoreline are hard bottom covered with live organisms. Generally, the species diversity and abundance of plants an animals associated with the terraces is greater with increasing depth of water and distance from shore. The random and periodic covering and uncovering of the surf zone terrace coupled with the harsh environment of the surf zone prohibit establishment of substantial hard bottom plant and/or animal communities. Therefore, the biological viability of the surf zone terrace depend upon coast and future events regarding littoral sand transport and storm related sand movement. Recently uncovered outcrops will display a relatively sparse and young biotic community; whereas, those exposed for long periods support a rather lush growth of marine life and attract many transient organisms as well. The offshore edge of the second terrace and the entire third terrace have remained relatively unaffected by shore zone sand movement and support stable assemblages of marine organisms.

7.6 Environmental Concerns of Beach Management Alternatives

During processing of permit applications, public interest aspects and environmental impacts of the proposed improvement are thoroughly reviewed by regulatory agencies. Successful acquisition of permits requires that impacts to the marine environment be minimized. The following discussion of environmental concerns associated with various beach erosion control techniques resulted in part from review of those issues with the Palm Beach County Division of Environmental Sciences and Engineering, Florida Department of Environmental Regulation, Florida Department of Natural Resources, U.S. Army Corps of Engineers, National Marine Fisheries Service, U.S. Fish and Wildlife Service, and other knowledgeable individuals. The environmental concerns for the major beach management alternatives are described in Table 7.1 and presented below.

7.6.1 Coastal Structures

From an environmental standpoint vertical bulkheads are not recommended as beach erosion control structures. These structures drastically reduce substrate surface area, thereby limiting habitat for organisms that would otherwise occupy the spaces between particles of a natural dune or beach, jetty or rock groin. Bulkheads placed at or below the mean high water (MHW) line reflect wave energy which serves to maintain suspended solids or cause additional sediment suspension. The suspended material not only decreases light penetration but also inhibits efficient filter feeding of organisms especially if the suspended material is of an inorganic nature. Vertical bulkheads usually replace a more natural sloped environment and are typically backfilled with non-native material, inhibiting organisms such as sea turtles from using the area.

Revetments cause environmental problems similar to vertical bulkheads, if little seaward surface area exists and the structure is placed at or below MHW. If revetments are made of sandbags, stone, or other coarse materials which furnish greater surface area and are placed above MHW, the environmental impact is reduced provided they do not occupy the majority of the former beach.

When constructed with sufficient surface area, groins, jetties and breakwaters can actually enhance species habitat and diversity. Care must be taken to ensure that local live-bottom outcrops are not damaged during installation. Depending upon local conditions, fully functional groins may cause inundation of updrift surf zone outcrops. Removal of ineffective structures should be done with the same caution regarding protection of the live-bottom outcrops. In addition, construction and removal should be accomplished between the months of October to April in order to avoid the possibility of heavy equipment damage to incubating eggs or hatchlings of endangered sea turtles. If done during May to September, turtle nests will have to be identified and moved.

7.6.2 Beach Nourishment

Traditionally, beach nourishment has been accomplished using sand dredged from the nearshore ocean environment, nearby navigation channels (use of sand from maintenance dredging), or from upland areas. Three major areas of environmental concern are associated with beach nourishment within the Town of Palm Beach.

TABLE 7.1

POSSIBLE ENVIRONMENTAL CONCERNS REGARDING POTENTIAL IMPACTS OF POSSIBLE IMPROVEMENTS

FOR THE TOWN OF PALM BEACH COMPREHENSIVE COASTAL MANAGEMENT PLAN

Activity ================ Potential Impact	Seawall & groin maint.	Groin removal	Beach fill	Increase sand bypassing	Dune enhancmnt.	Revetment construction
DAMAGE/DESTRUCTION OF LIVE BOTTOM OUTCROPS						
Offshore (Borrow Activity)						
Adverse Sedimentation			X			
Physical Damage			X			
Invertebrate			X			
Nearshore/Surfzone						
Adverse Sedimentation			X			
Inundation			X			
Physical Damage		X		X		
WATER QUALITY DEGRADATION						
Adverse turbidity nearshore due to filling operations			X			X
Adverse turbidity nearshore due to structure removal		X		X		
Adverse turbidity offshore due to borrow operations			X			
SEA TURTLE IMPACT			X			X
NO SIGNIFICANT IMPACT	X				X	X

Source: CZR, Inc. 1985

These include: 1) inundation or sedimentation of live-bottom rock outcrops, 2) loss of endangered sea turtle nests and/or nesting sites, and 3) local water quality degradation. These concerns are described in greater detail below.

- Rock Outcrops - Placement of beach fill over live-bottom outcrops would be difficult to permit. County, State and Federal agency biologists have provided a unified response - small, isolated outcrops may be filled if the applicant has a comprehensive management plan, but continuous outcrops must not be harmed. This means that the toe of any beach fill must remain sufficiently shoreward of the continuous outcrops to prevent inundation both during and following initial fill placement.

- Sea Turtles - Placement of fill on beaches between May and September may cover subsurface nests of incubating sea turtle eggs. The additional fill may cause the death of the young turtles by prevention of essential gas exchange or because of the mass and/or compaction of fill which either crushes the eggs initially or prevents escape of the hatchlings. If the fill material is not compatible with the native sands, turtle nesting behavior may be altered so that females preferring native sands may nest either shoreward or seaward of the beach fill in less than optimal nesting sites. In addition, nests made in incompatible fill may cause the female to spend too much time digging in compacted sediment and result in either a shallow nest or in no nest at all. The U.S. Fish and Wildlife Service, which is the principal agency responsible for endangered species, usually will not oppose beach nourishment plans from an endangered species standpoint if an acceptable monitoring plan is incorporated into the dredge and fill permit application.

- Water Quality - Degradation of local water quality (turbidity) and sedimentation of the nearshore rock outcrops results primarily from fine particles in the fill material being carried downdrift or offshore of the fill site before settling out of suspension. Fine particles can also cause turbidity when resuspended by rough seas or strong currents. Eventually they will be carried by currents to deeper waters where they will no longer be subject to resuspension in surface waters. State law prohibits turbidity to exceed 29 NTU's (Nephelometric turbidity units) above background. Ideal beach fill should be closely compatible with native beach sands.

Conventional beach nourishment techniques do cause increased turbidity. The State permit agencies tolerate a small localized downdrift plume (mixing zone). Palm Beach County has indicated that it will not hesitate to cite violations of state water quality standards or sedimentation of nearshore outcrops. These concerns behoove the beach nourishment applicant to ascertain the grain diameters and percent fines of the proposed borrow material, propose a rigorous water quality monitoring program, and provide for frequent monitoring of nearby downdrift outcrops to prevent significant sedimentation.

7.6.3 Offshore Borrow Areas

In southeastern Florida, the traditional location for obtaining sand for beach nourishment fill is between offshore reefs. Two major environmental concerns arise when beach fill is borrowed from between offshore outcrops:

1) mechanical damage or destruction of live-bottom reefs; and

2) sedimentation or turbidity on the live- bottom outcrops near the dredging activity.

Mechanical damage or destruction of live-bottom outcrops can result from the dredge cutterhead contacting the reef, the anchors being placed upon or moving about the outcrop, and/or anchor cables moving across the outcrop as the dredge repositions itself. All of these problems may be avoided by locating the borrow area and anchor site sufficiently distant from the outcrops. Suggested minimum distances between the borrow area and closest outcrops vary from 400 to 800 feet depending upon the individual project characteristics. It is recommended that offshore borrow areas be located at a minimum distance of 600 feet from the closest outcrop. This suggestion allows a potential borrow area corridor of approximately 1000 feet between the second and third outcrops off Palm Beach. Effective monitoring (discussed below) should be conducted to assure that dredging activities remain confined within the proposed areas.

7.6.4 Alternate Borrow Material Sources

Several alternate sources of borrow material are available, including upland sources, Lake Worth, and Bahamian aragonite. From an environmental perspective, material from upland or Lake Worth sources must be tested to insure biologically/chemically compatibility. In addition, transportation of these materials to the fill site is costly and increases the chances of further environmental problems. From the same perspective, aragonite material, although more expensive, may provide the least environmental problems and monitoring costs. The main impediment to use of this material has been the Buy American Act which prohibits federal funding of projects if the U.S. Army Corps of Engineers is involved in purchasing. Use of aragonite would however eliminate the need for an offshore borrow site and consequently environmental monitoring requirements would be reduced.

7.7 Environmental Monitoring

Complete permit applications, timely attainment of permits, and completion of a successful improvement project require that effective environmental planning and monitoring be an integral part of the erosion control plans. Beach nourishment projects necessitate environmental planning/monitoring in the following areas.

7.7.1 Endangered Sea Turtles

Impacts on sea turtle nesting can be avoided by nourishing the beach with compatible material during October to April; however, June and July are months suggested for nourishment because of the calmer sea conditions and fair weather during this period. Nourishment can usually be accomplished during June and July if the applicant provides and executes a comprehensive monitoring plan. This plan should provide the following:

a) a minimum of 2 months prenourishment beach monitoring to identify and relocate turtle nests;

b) ongoing nesting surveys and relocation during nourishment operations;

c) ongoing nesting/crawl surveys (May-October) for the design life of the initial fill; and

d) personnel to accomplish the monitoring approved and permitted by the Florida Department of Natural Resources.

7.7.2 Nearshore Outcrops

Because permitting agencies will allow only isolated outcrops to be covered, all nearshore outcrops need to be identified, quantified, and categorized as to extent of life supported. Sampling stations should be established and baseline data should be gathered as near predredging/filling operations as possible. Data should be gathered from the same stations during nourishment activities, immediately after such activities have ceased, and periodically for up to two years thereafter. Comparison of these data will allow conclusions to be made as to the effectiveness of the project and its impact, if any, on the local live-bottom communities. Data to be gathered should include 1) water quality parameters such as temperature, turbidity, pH, alkalinity, and dissolved oxygen; 2) species inventory and relative abundance; 3) physical data such as depth of water, height of vertical relief, relative amount of sedimentation, and depth to rock or adjacent sand bottom; and 4) photographic or video documentation.

7.7.3 Offshore Borrow Area

Monitoring for excessive turbidity and adverse sedimentation of outcrops near the offshore borrow area will help prevent damage to adjacent live-bottom outcrops. This necessitates the use of divers equipped with SCUBA (self contained underwater breathing apparatus) to visually observe the location of the dredge and the amount of sediment, if any, on adjacent outcrops. Well in advance of the project (at least 6 months before start-up and prior to permit application) the potential offshore borrow areas need to be surveyed for material compatibility. The general area should be delineated on a map and east-west transects designated at reasonable intervals should be plotted. There are no established rules regarding this methodology; therefore it should be closely coordinated with Palm Beach County Division of Environmental Sciences and Engineering, West Palm Beach Office of the Florida DER, and the Miami Office of the Corps of Engineers. Once agreed upon as to ample location and number, vibracore samples should be taken to a depth of at least 20 feet. Analysis of mean grain size, percent fines, and percent rock should be obtained from each of these samples. These data will indicate whether or not the material in the area of the sample is compatible with requirements of acceptable beach fill.

7.7.4 Offshore Dredging Activities

Divers should monitor the positions of the dredge during dredging operations. If it has approached to within less than 600 feet of an outcrop the operator should be instructed to move the dredge back into the designated borrow area. Close cooperation of the divers and dredge crew will facilitate dredging operations and help prevent environmental damage.

Because field work was not included as part of this study, this report is based entirely upon local knowledge of and published references defining location of the Palm Beach reefs and their biological character. Appendix E provides an inventory of biota found on the reefs as identified in the draft report Detailed Project Report on Palm Beach Erosion, Palm Beach County, Florida, (Section 111, Appendix III) prepared by Jacksonville District, U.S. Army Corps of Engineers (September 1976).

Chapter Note: Sections 7.5, 7.6, and 7.7 of this chapter were written from material prepared by CZR, Incorporated especially for the Comprehensive Coastal Management Plan.

CHAPTER 8.0
MANAGEMENT ALTERNATIVES

COMPREHENSIVE COASTAL
MANAGEMENT PLAN
FOR
TOWN OF PALM BEACH

8.0 SHORE EROSION MANAGEMENT ALTERNATIVES

A wide range of techniques have been implemented at various levels of government, and by individual and private shorefront property owners to adjust to coastal erosion processes. There are two basic approaches to shore protection. First are the engineering techniques and concepts (structural and non-structural), designed primarily to reduce the direct adverse effects of erosion on shorefront property by controlling or mitigating the natural forces that cause the erosion. Second, are the non-engineering approaches which seek to either avoid future erosion losses through land management programs, or to lessen or eliminate the direct social and economic costs and hardships incurred by shorefront property owners where erosion is occurring.

Sorensen and Mitchell (1975) have classified the alternative adjustments to coastal erosion into four major categories:

1. control and protection works (engineering alternatives);
2. land use management;
3. warning systems; and
4. public relief, rehabilitation, and insurance means.

In addition to the above listed alternatives there is the "no action" alternative. This policy is simply as stated. No mitigation of shore erosion or storm protection is adopted. The community accepts the natural course of events, and no attempt is made to control, maintain, or prepare for future scenarios. Clearly, the no-action policy is not advisable in lieu of minimal procedures which could be developed.

In the remaining sections of this chapter, the objectives of erosion management are discussed along with various alternative techniques and concepts under each of the major approaches mentioned above.

8.1 Objectives of Erosion Protection

The objectives of erosion protection may be classified into two general categories:

1. storm protection;
2. recreation enhancement.

Storm protection may be specified for hurricanes or moderate northeasters. Recreation can be specified to maintain a narrow strand for private use or wide beach to accommodate a larger public demand. The stated objective desired for a particular reach will determine the alternatives available to achieve it.

8.2 Engineering Techniques for Shore Protection

This section discusses engineering techniques for shore protection. These techniques are classified into two major categories - structural methods including breakwaters, seawalls, revetments, groins, and bulkheads; and non-structural methods such as beach nourishment, intertidal vegetation, and dune stabilization. The application of any specific engineering technique to mitigate an erosion problem normally requires systematic and thorough study. In particular, the selection of a technique for a given environment and location requires detailed site-specific consideration of needs, cause-effect dynamics, and cost and cost-benefit relationships. Detailed summaries of engineering methods, techniques, and data pertinent to the control of shore erosion problems are included in the Army Corps of Engineers Shore Protection Manual (USACOE, CERC, 1984), as well as other Corps publications. A detailed bibliographical listing of research related to many of the engineering alternatives referred to here has been published by Sperling and Edge (November 1978).

Properly applied, the methods summarized in this chapter can aid in controlling erosion of the Palm Beach shores; but improperly used, the methods may accelerate or aggravate existing erosion conditions and increase the short-term erosion damage associated with storms. Some general comments regarding various traditional shore protection methods are provided below.

8.2.1 Seawalls, Bulkheads, and Revetments

Seawalls, bulkheads, and revetments are structures placed parallel to the shoreline to separate a land area from a water area. The distinction among these structures is mainly a matter of purpose. In general, seawalls are built as a last resort and are the most massive because they are intended to resist the full force of the waves. Bulkheads are next in size; their function is to retain fill, and they are generally not designed for direct exposure to severe wave action. On the oceanfront, bulkheads are normally located above the ordinary water level so that they are not brought under direct wave attack except during storms or at times of very high water levels. Revetments are flexible structures designed to protect shorelines against erosion by currents or wave action. The degree of protection afforded depends on the materials used and the method of construction.

Seawalls, bulkheads, or revetments protect only the land immediately behind them. These structures provide no protection to either upcoast or downcoast areas and have no effect on shoreline erosion updrift. Also, as erosion of the beach proceeds, wave forces will be directly acting on these structures during storm events. In these instances, erosion is likely to be intensified in the downcoast areas.

Seawalls, bulkheads, and revetments can also have an effect on seaward beach profiles. Scour can be anticipated at the toe of the structure as an initial short-term effect. Scour will form a trough with dimensions governed by the type of structure face, the nature of the wave attack, and resistance of the seabed material. At a rubble-mound seawall, scour may undermine the toe stone, causing it to collapse or sink to a lower stable position. It is safe to assume that these structures would not be effective in reducing loss of the seaward beach.

8.2.2 Groins

Groins are shore erosion control structures designed to retard erosion of existing or restored beaches. Groins are generally narrow structures placed perpendicular to the shore. They are designed to extend from a point landward of the predicted recession shoreline to an offshore point sufficient to trap the portion of littoral drift required by their design. Since most of the littoral drift moves in a zone landward of the normal breaker depth (about the 6-foot depth contour), extension of groins beyond that depth is generally unnecessary and uneconomical (USACOE, CERC, 1984).

The groin acts as a partial dam intercepting a portion of the normal longshore transport (Figure 8.1). As material accumulates on the updrift side, supply to the downdrift side is reduced, and the downdrift shore recedes. Accretion on the updrift side continues in accordance with the grain size characteristic of the sand and the height of the groin. At some point accretion stops, and all littoral drift passes the groin. If a groin is high enough to prevent the passage of sediment, then the littoral drift is diverted around the seaward end of the groin. Material in transport around a groin does not move directly shoreward after passing the groin. In fact, groins affect the normal movement of beach sands for some distance downdrift. Thus, a system of groins (or groin field) too closely spaced would tend to divert sediment offshore rather than create a widened beach, and the loss of sediment would worsen erosion problems on downdrift beaches.

Groins are usually considered for application in areas where the supply of littoral drift is less than the capacity of the littoral transport forces. In these areas, a shoreline adjustment resulting from the installation of groin or a groin system may not reduce the actual transport rate, but result only in a reduction of the expected additional losses from beach fills within the groin system. However, for this to occur, the groins must extend to the surf zone.* In the case of high profile groins some of the littoral material can be thereby diverted to the offshore zone, resulting in adverse erosion effects to downdrift beaches.

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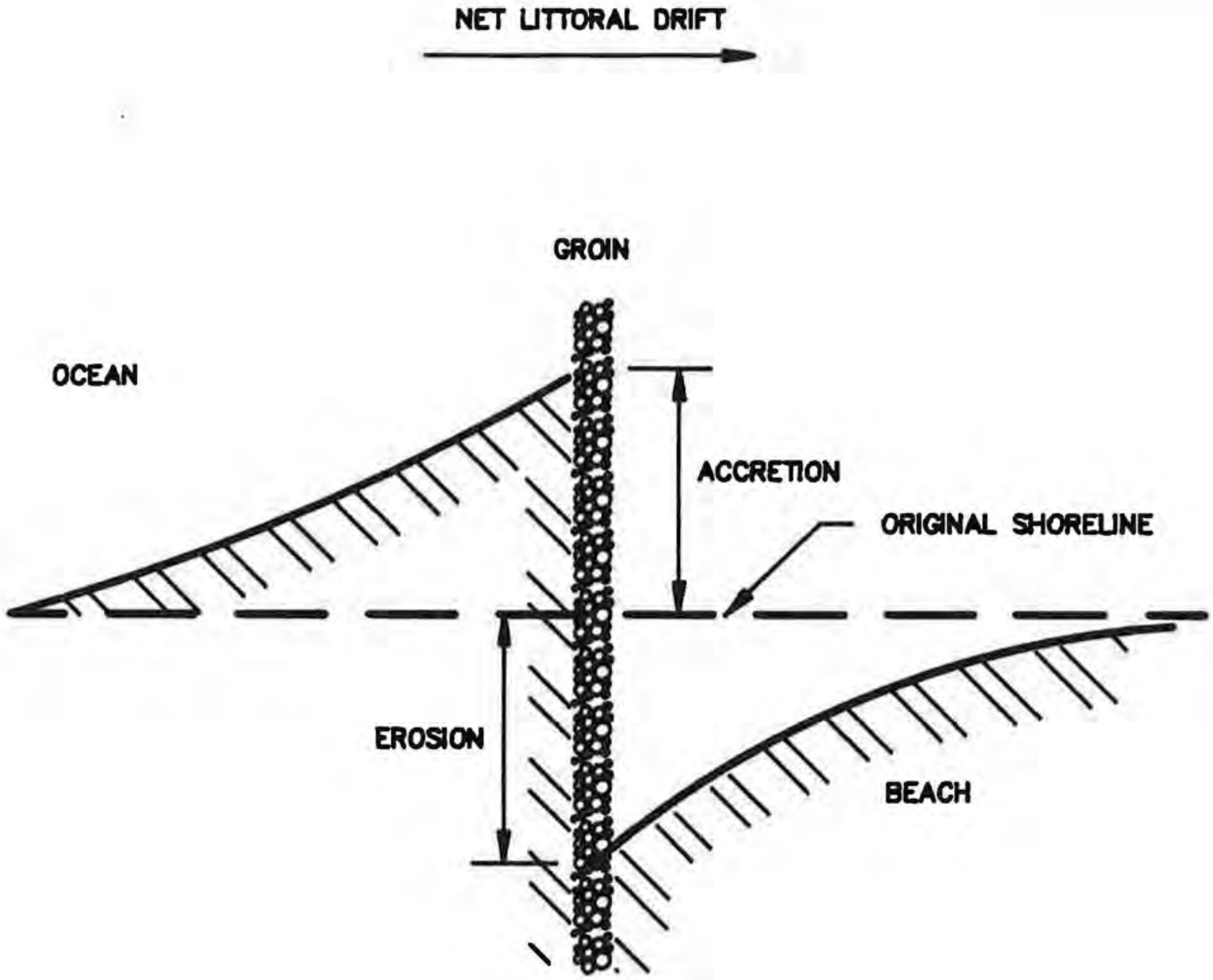
* Surf zone is defined as the area between the outermost breaker and the limit of wave uprush (Corps of Engineers, 1984).



GROIN INFLUENCED SHORELINE

FIGURE 8.1

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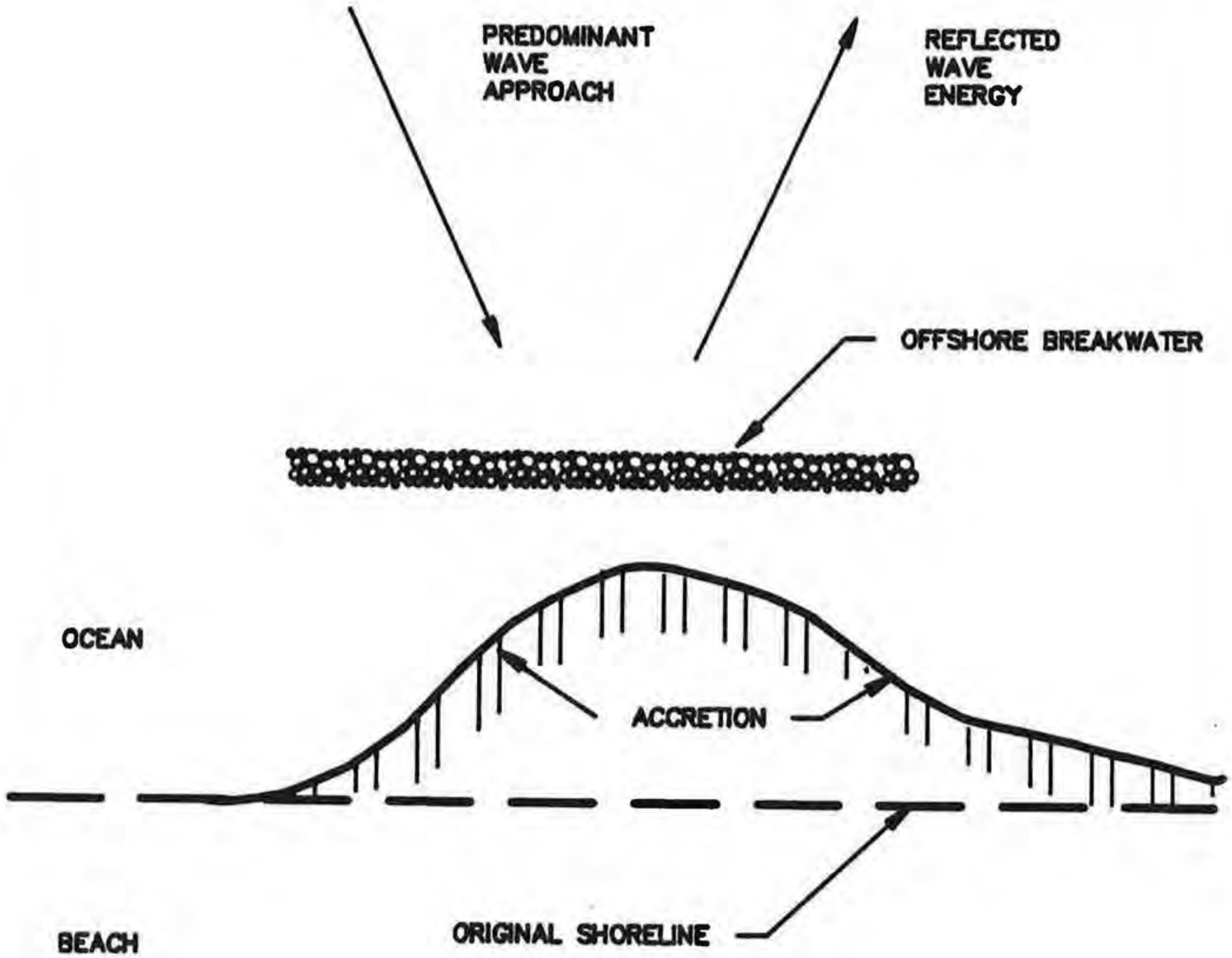
Where the littoral drift supply satisfies the capacity of the transporting forces, the adjustment in the shore alignment from a groin system may reduce the capacity of longshore transport forces at the groin site. Thus, less material is transported longshore than prior to the construction of the groins, and a permanent adverse effect to the downdrift shore would occur. Adverse effects on adjacent shores described above are not necessarily a measure of the effectiveness of the groin or groin system since these groins might well have diverted some of the longshore transport to deep water depriving the downdrift beaches from receiving a full amount of longshore transport(USACOE, CERC, 1984).

The construction sequence for groin fields, which depends on littoral drift material for filling, is important in minimizing the detrimental effects on downdrift areas. Any natural filling after construction tends to reduce the supply of sediment to downdrift beaches (littoral starvation). The time required for an entire system to fill and for the littoral drift to resume its downdrift movement may be so extensive that downdrift beach areas will be severely damaged. To reduce such effects, construction should begin at the downdrift end of the planned system. Construction of subsequent groins is not recommended until the first groin has filled and sand passing around or over the groin has again stabilized the downdrift beach. As an alternative, the groin field should be artificially filled as they are constructed. Such an operation minimizes the disruption of littoral transport to downdrift beaches.

Groins are structurally and functionally different from jetties, which are larger structures with more massive components and are used primarily to confine the tidal flow at an inlet and to prevent littoral drift from shoaling the channel. The jetties and inlet stabilization at Lake Worth Inlet are directly considered in the planning efforts of this study.

8.2.3 Offshore Breakwaters

Offshore breakwaters are structures designed to protect shore areas from direct wave action. Breakwaters function by dissipating and reflecting incident wave energy. Some wave energy finds its way into the lee or geometric shadow of the breakwater through diffraction around the ends of the breakwater. This wave energy generally represents a small percentage of the incident wave energy. The lack of wave energy which drives the littoral transport system results in a deposition of sediment behind the breakwater (Figure 8.2). As sand is deposited, a seaward projection of the shore is formed in the still water behind the breakwater. This projecting shore alignment in turn acts as a groin, which causes the updrift shoreline to advance. As the projection enlarges and the zone of longshore transport moves closer to the breakwater, it becomes increasingly efficient as a littoral barrier. In this situation there generally is accretion



OFFSHORE BREAKWATER INFLUENCED SHORELINE

FIGURE 8.2

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updrift of the breakwater and erosion downdrift (USACOE, CERC, 1984).

The effectiveness of an offshore breakwater as a sand trap and in providing a protected area is dependent on its height in relation to the wave action. To avoid the problems associated with a breakwater which acts as a complete littoral barrier, it may be desirable to design the breakwater so that a degree of wave overtopping is allowed. Such partial barriers need not extend above low water. Adequate markings are required, however, so as not to cause a navigation hazard.

8.2.4 Beach Nourishment

Beach nourishment can range from the periodic replacement of sand lost by erosion to the extensive placement of sand to construct large new beach areas suitable for recreation. Beach nourishment represents the replacement of a resource, but in and of itself does little to avoid the need for subsequent renourishment. In addition, beach nourishment costs have escalated rapidly in recent years. Continuation of this trend could result in more projects becoming uneconomical, even in high recreational demand areas. Thus, the use of nourishment as an erosion control technique requires a continuous financial commitment.

The Federal beach erosion and hurricane protection project in Dade County, Florida, is an example of a recent beachfill operation. The project consists of placing 13.5 million cubic yards of sand on the shore along about 9 miles of Miami Beach. This plan provides dry beach berms between 130 and 250 feet in width, together with a dune system for hurricane protection. The 10-year program provides periodic nourishment to make up for erosion losses at an estimated rate of 211,000 cubic yards per year. The present estimated project cost, including the beach nourishment, is $56 million. The Federal share of the cost, as determined by ownership of adjacent land and public access to the beach, is 55 percent or about $31 million.

Physical effects of beach nourishment operations are most evident in the sand source or borrow areas. Sand dredging in backbay areas is generally avoided because of the potential for disturbance of sensitive productive biological assemblages. The loss of such sand source areas is not particularly significant because the fine sands typically found in such areas are generally not suitable for ocean beach nourishment.

The exploitation of offshore sand resources is not without potential problems, which can include:

1. increasing the offshore transport of sand during storms and limiting its return as a result of excavations near enough to the shore to upset the

beach dynamic equilibrium;

2. interruption of the supply of sediment to the shore due to the depression left from nearshore dredging which may trap a portion of the dredged material - if a beach is being fed from offshore by currents and wave action; and

3. changes in offshore bathymetry by excavating sand from protective offshore banks or bars, which can result in changes in the refraction of incident waves and therefore changes in the next angle of wave attack (such changes may affect the rate of littoral drift along the shoreline, which can change erosion or accretion patterns).

A detailed study of each proposed dredging operation is required to estimate its actual effect on the beaches and the environment.

Beach nourishment and erosion control projects can be undertaken in conjunction with DNR and the federal government (Florida Statutes 161.141 through 161.45). There are several ways in which such projects can be implemented (see Chapter 6). Florida's support Coastal Barrier Resources System (CBRS) (Coastal Barrier Resources Act of 1982, Public Law 97-348) and Florida Executive Order 81-105 tend to discourage such activities in the CBRS units (see Section 8.3.11 for a discussion of CBRS and E.O.81-105).

There are legal implications related to the natural or artificial changes in shoreline position. Florida recognizes the line of mean high water as the legal boundary between privately owned uplands and adjoining sovereign lands. The Florida Coastal Mapping Act of 1974 (Florida Statutes 177.25 et seq.) defines the mean high water (MHW) line as the intersection of the tidal plane of MHW with the shore as consistent with National Ocean Service practice which is the average of all low water heights observed over the 19 year National Tidal Datum Epoch (Hicks, 1984).

The law recognizes that physical processes can change the location of the shoreline over time and distinguishes between the types of changes which may occur. The legal terminology used by the statutes and courts to describe the various shoreline changes are:

1. Accretion - the gradual, imperceptible addition to littoral land of solid material by water. The legal test of "imperceptibility" was set by the United States Supreme Court in 1874 as "that though the witnesses may see from time to time what progress has been made, they could not perceive it while the progress was going on."

2. Erosion - the gradual, imperceptible wearing away of littoral land.

3. Reliction (Dereliction) - the gradual recession of water formerly covering land, leaving dry land. The practical effect is the same as in accretion.

4. Submergence - the gradual disappearance of land under water and the formation of a navigable body of water over it. The practical effect is the same as erosion.

5. Avulsion - the sudden perceptible changes in the shoreline. Physically avulsive changes may result in either gain or loss of littoral land as may occur as a result of artificial filling or in response to severe natural phenomena such as earthquakes or hurricanes (Graber, 1982).

The law generally treats avulsive changes differently from the slower processes of accretion, erosion, reliction and submergence. The property boundary is generally frozen at its location before the avulsion. In the slower shoreline changes the property boundaries shift with the process and the upland property owners gain or lose title to the affected lands.

In Florida, the avulsion concept is further detailed in the case of artificial filling or beach nourishment. The Beach and Shore Preservation Act (Florida Statutes, 161.011 et seq.) provides for the establishment of an erosion control line (ECL) in such cases. The ECL permanently fixes the boundary of private and sovereign lands at the old or prerestored beach. The law requires that an ECL must be recorded prior to the beach restoration. Approval for establishment of the line is granted by the State after the need for beach restoration is demonstrated and approval from at least 50 percent of the property owners fronting the project is obtained.

8.2.5 Sand Scraping

Beach scraping is the removal of material from the lower part of the beach for deposition on the higher part of the beach or at the dune toe. Beach scraping is usually performed by a scraper pan which removes or skims the uppermost layer of the beach. Bulldozers are used on narrow beaches which do not provide sufficient maneuvering room for a scraper.

Beach scraping is different from artificial nourishment. Artificial nourishment is replacement of eroded material by new material. Scraping is the distribution of the available beach material in a manner which improves the coastal protection capabilities of the overall beach profile without providing any new beach material.

Bruun (1983) examines the advisability of beach scraping. He concludes that:

1. beach scraping by skimming thin surface layers where surplus material is available in the profile is beneficial as protection for eroding dunes;

2. technically responsible beach scraping does not have an adverse effect on adjacent beaches; and

3. beach scraping is a method of arranging the available beach material in a more sensible manner on a short term basis. It is a temporary procedure which does not replace artificial nourishment.

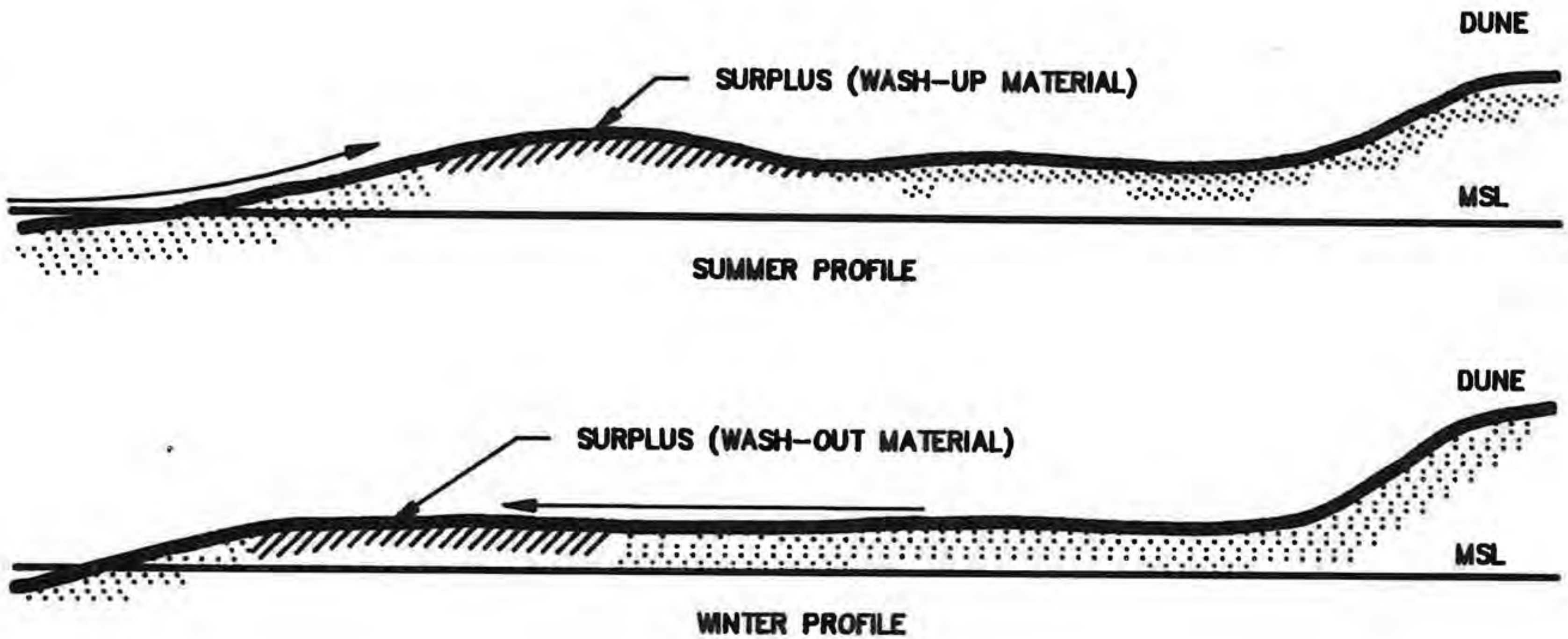
Bruun (1983) states that beach scraping should only be done where beach material is available in relative surplus in the profile. This is the area of active fluctuation of the profile where ridges build up by swell activity following a storm or during the spring and summer seasons. Figure 8.3 shows the location of suitable source material in a typical profile. The material which comprises the beach ridge comes from the near shore bottom. The scraped beach material should be used to protect the dune by placing it at the dune toe. A reasonable scraping program will skim no more that about one foot of the upper surface of the beach.

Present indications are that the Florida Department of Natural Resources is generally in favor of the beach scraping concept. Proposals for scraping projects may receive approvals conditioned with mitigation and monitoring requirements. Beach scraping projects could lose a good deal of their attractiveness depending on the specific conditions which are imposed.

8.2.6 Sand Bypassing

Sand bypassing involves the mechanical transfer of sand around littoral barriers such as jetties and breakwaters. The basic methods of sand bypassing are by means of permanent bypassing plants, floating bypassing plants, and land-based mobile equipment.

Sand bypassing schemes are designed to relieve the erosion conditions which occur downdrift of littoral barriers. Sand from the accretion area updrift of the barrier is used to nourish the eroded downdrift beaches. In other situations, sand traps are excavated in inlet areas. These traps are periodically dredged to remove the sand which is deposited there by the tidal currents in the inlet. Effective bypassing can be accomplished when the dredged sands are deposited on the downdrift beaches. This has been done at Lake Worth Inlet. A fixed sand transfer plant was constructed at Lake Worth Inlet in 1957-1958. A complete



SOURCE AREAS FOR BEACH SCRAPING

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FIGURE 8.3

discussion of the system's history, performance and recommendations for improvement is provided in Chapter 5.

8.2.7 Dune Stabilization

Dunes that form just behind the beach perform an important role in littoral processes. The foredunes' function as reservoirs of sand to nourish eroding beaches during high water conditions and as levees to prevent wave damage to backshore areas. As such, they are valuable non-rigid, natural shore protection features. Well-stabilized inland dune ridges are a second line of defense against erosion if the foredunes are destroyed by storms. Use of native vegetation will stabilize dune sands that might otherwise migrate over adjacent areas and damage property by sand burial. The vegetation helps to trap and hold sand on the dunes and therefore contributes to their growth and repair. Table 8.1 lists plant species identified in Soil Conservation Service (SCS) Field Studies as having good potential for dune revegetation. The species are selected because of their favorable characteristics for erosion control, their frequency of occurrence, and their dominance in the natural ecosystem.

For more rapid accumulation of sand, construction of dunes through use of sand fencing is recommended. Relatively inexpensive, slat-type snow fencing is used extensively in artificial dune construction.

8.3 Land Management

The land management alternative involves the use of a variety of regulatory tools by local, State and the Federal governments for controlling development in erosion hazard areas. The land management alternatives generally flow from a government's authority under its police power to promote the public's health, safety and welfare by controlling or regulating the activities of individuals. Specifically, it enables governments to place limits on individual's uses of their own property (i.e., zoning). With regard to erosion processes, it enables governments to control and limit the amount of private and public investment in erosion hazard areas so as to limit or avoid future losses.

Land management alternatives are constrained by constitutional limits on how far private rights may be limited. Shorefront property is a scarce, and thereby a very valuable economic resource. Government imposed limitations on the use of this resource must be careful not to run afoul of the "taking" issue; that is, denying an individual reasonable use of his property. A range of land management techniques and concepts that have been, or could be utilized as shore protection techniques, are presented below.

TABLE 8.1

OCCURRENCE OF PLANTS ON COASTAL DUNES

Plant Name	Most likely in Frontal Zone	Most likely in Backdune Zone	Frequency on study sites[1] SE
Grasses:			
bitter panicum	x		57
coastal panicgrass	x		23
common bermudagrass		x	3
crowfoot grass		x	11
saltmeadow cordgrass	x		31
sandbur		x	31
seaoats	x		97
seashore dropseed	x		6
seashore paspalum	x		23
seashore saltgrass		x	12
St. Augustine grass		x	9
stiffleaf eustachys		x	17
Other herbaceous plants:			
beach bean	x		40
beach morningglory	x		71
blanket flower		x	6
burrowing four o'clock		x	9
cucumberleaf sunflower	x		80
fiddle-leaf morningglory	x		3
largeleaf pennywort		x	2
partridge pea		x	21
sea purslane	x		17
Trees:			
baycedar		x	14
buttonwood		x	17
cabbage palm		x	9
coconut palm	x		12
cocoplum		x	14
seagrape	x		49
Spanish-bayonet	x		40
Shrubs:			
beach creeper		x	9
cactus		x	14
coin vine	x		14
inkberry	x		26
lantana		x	23
saw-palmetto		x	17
sea lavender	x		14
seashore elder	x		80
silverleaf croton		x	23

1) SE - Atlantic coast of Florida from Indian River County south to the Florida Keys, 50 sites. Source: Craig, 1984

8.3.1 Zoning

Zoning involves limiting land use type, intensity, and structural configuration within a clearly defined mapped area such as an erosion or flood hazard area. This limitation on, or prohibition of, development within an area must be designed to protect the public health, safety and welfare (e.g., prevent erosion-related losses), and/or promote the public welfare (preserve beach and dune areas, provide additional open space). Zoning is generally implemented at the local government level. The extent of the regulated area can be tied to an observed erosion rate and its boundary can be periodically readjusted to account for continuing erosion.

An example of zoning would be the establishment of a dune and beach preservation district. This would involve the establishment of a regulatory zone that forbids further development or other specified activities in dune and beach districts. Such a program recognizes the natural protective function of the dunes and beaches in attenuating storm and long-term erosional forces. It would enable a maintenance or reestablishment of the natural integrity of the shore ecosystems.

8.3.2 Shifting or Rolling Easement

This alternative involves the maintenance of a public easement (either acquired or prescriptive) at a beach during periods of erosion or accretion. Under erosion, the easement would move inland preceding the advance of the mean high water line. Thus, private shorefront property would revert to public use.

8.3.3 Building Codes

The promulgation of design standards and materials specifications could be applied to structures located in erosion hazard areas. These regulations are designed to limit the probability of, or amount of property damage that would accompany continuing erosion or a major storm. Common specifications include: 1) deep foundation standards, 2) minimum floor elevations, and 3) design standards for parts and columns.

The Coastal Zone Protection Act of 1985 (Florida Statutes 161.52 -161.58) requires that all local governments with jurisdictions fronting on the Gulf of Mexico, Atlantic Ocean, Florida Bay, or Straits of Florida to establish a "coastal building zone." Increased minimum standards for construction of major habitable structures will apply within this designated zone.

The legislation gives the local governments two basic responsibilities which are:

1. implement new building code requirements for the coastal building zone; and

2. delineate the geographic boundary of the coastal building zone for their respective jurisdictions.

Amendments to the State Minimum Building Codes have been prepared and approved by the Board of Building Codes and Standards. Adoption of these building code standards will minimize the necessity for each local government to revise their individual codes. The Town has adopted a building code pursuant to the requirements of the Florida Department of Community Affairs.

That portion of the Town of Palm Beach 5000 feet west of the Coastal Construction Control Line (CCCL) is considered to be in the "Coastal Building Zone" according to the definitions contained in Florida Statutes 161.54-55. This Coastal Building Zone comprises the entire Town corporate limits.

8.3.4 Building Setbacks

Building setbacks entail the establishment of a line seaward of which new construction, excavation and other activities would be regulated or prohibited. Thus, additional construction in erosion hazard areas, or in areas which would preclude the maintenance or reestablishment of the natural beach and dune profile would be prevented. Setback lines have been in employed at the state level by Florida, Delaware, and Michigan. The extent of a regulated area can be based on historical erosion rates. In addition, its boundary can also be regularly adjusted to account for continuing erosion or changes in erosion trends.

In Florida, setback requirements are delineated by the coastal construction setback line (SBL) (Purpura and Sensabaugh, and University of Florida, 1974) which has evolved into the Coastal Construction Control Line (CCCL). This is administered by the Division of Beaches and Shores (DNR).

8.3.5 Acquisition

Acquisition may be described as the purchase of shorefront areas by state, federal or local governments through the exercise of the eminent domain power. The acquisition must be for a valid public purpose (e.g., recreation) or promote the public's health, safety and welfare (e.g., prevent future erosion or storm related losses in hazard areas). Purchases may be on a pre- or post-storm basis. Purchases may be on a fee-simple basis or involve the purchase of easements. An easement involves the purchase, at less than fee-simple, of a portion of the total rights in a shorefront parcel. Provision for continued public access or limitations on future development rights can be obtained in this manner.

Properties may also be obtained through private donation whereby individuals give title to their shorefront properties to a state or local government. This is usually coupled with a provision allowing the donor to receive some kind of benefit, such as a tax deduction.

In addition to fee simple acquisition and easement purchase, mentioned above, the other methods of land acquisition are:

1. dedication;
2. eminent domain; and
3. monetary payments "in lieu" of mandatory dedication.

Dedication can be voluntary with provision of land for public walkways and recreation use being common. The parcels are recorded in the County public records for the perpetual use of the public. Mandatory dedication is used to provide development areas with necessary services or access to individual lots. Utility rights-of-way and street dedications are examples of mandatory dedication. Street dedications can provide beach access as a secondary purpose. Subdivision extraction is another form of mandatory dedication where local governments secure land for public use as a part of a development. Subdivision extraction is used where projects are of a size or location are significant enough to justify a public interest in maintaining lands for public use.

An alternative to mandatory dedication is the concept of monetary payments "in-lieu" of dedication. The payments by a developer are used toward the purchase cost of land being developed for public uses such as parks and recreational facilities. Such payments are required when the size or location of a development make actual dedication a problem.

8.3.6 Preferential Taxation

This is the application of lower tax rates or assessed values to land which is kept in a natural, or in its existing condition (i.e., less than its best and highest use). Taxes are then based on the value-in-use of the land, and not on its development potential. Lower tax burdens serve as incentives to keep shorefront parcels from being further developed, or as compensation for value reductions caused by other regulatory programs (i.e., zoning).

Presently there are no state taxation policies which support or encourage development in Florida (U.S. Dept. of the Interior, 1985). There are some state taxation incentives which encourage non-development of barrier properties. The best example is the conservation easement (704.06/193.50 Florida Statutes) which allows a property owner to surrender development rights for a 10-year period. It is renewable at the option of the property owner. During this time no property taxes are levied on the land and it is categorized as a nature preserve. Because of the potential loss of large amounts of revenue, this is not a widely used program.

8.3.7 Building Moratoriums

These involve the prohibition of any additional development in erosion hazard areas. Ohio has adopted such a program along the shore of Lake Erie.

8.3.8 Transfer of Development Rights

Development rights (land use type, building height, bulk, lot coverage, etc.) are defined for shorefront parcels by applicable zoning laws. Shorefront property owners would be permitted to sell some or all of the development rights of their parcels to owners of properties not located in shorefront or erosion hazard areas. This would generate declines in shorefront development intensity and still permit shorefront property owners to capture some of the economic value of their holdings. Transfer of development rights would usually be administered at the municipal and county level.

8.3.9 Compensable Regulations

Under this scheme the government would compensate shorefront property owners for the decline in the value of their holdings caused by the imposition of a regulation effecting that property. This allows the promulgation of restrictive regulations limiting shorefront development without encountering the "taking" issue. There is no known use of this method as yet.

8.3.10 Permitting

The permitting alternative involves the establishment of a regulatory framework whereby the undertaking of certain activities in a defined area is contingent upon obtaining a governmental permit by meeting certain terms and conditions. These can include compatibility of the proposed activity in its desired location with established land use, environmental, and socioeconomic policies. In addition, they can also include site-specific design and engineering standards intended to minimize potential adverse economic, social, fiscal, and environmental impacts.

The Town of Palm Beach has ordinances dealing with storm management, flood protection, residential construction, and construction and maintenance of erosion protection structures. These provisions are listed in the Town Code.

8.3.11 Discontinuation of Growth and Development Subsidies

The Coastal Barrier Resources Act (16 U.S. Code 3509) enacted in 1982, established the Coastal Barrier Resources System (CBRS) within which most Federal expenditures are no longer available to promote economic growth or development on specified undeveloped coastal barriers. With certain exceptions, the act prohibits new Federal expenditures and financial assistance for development within the units of the CBRS. Section 3(3) of the Act defines "financial assistance" as "any form of loan, grant, guarantee, insurance payment, rebate, subsidy, or any form of direct or indirect Federal assistance" other than certain specified exceptions.

Section 5(a)of the Act states that the limitation on new expenditures of new financial assistance includes, but is no limited to:

1. construction or purchase of any structure, appurtenence, facility or related infrastructure;

2. construction or purchase of any road, airport, boat landing facility on, or bridge or causeway to, any System unit; and

3. assistance for erosion control or other stabilization of any inlet, shoreline, or inshore area except in certain emergencies.

Section 5(a)(3) states that, in general, erosion control or stabilization projects are prohibited except "in cases where as emergency threatens life, land, and property immediately adjacent to that unit." This means a stabilization project in a CBRS unit is permissible only if an emergency threatens a non-system coastal barrier or mainland area and only if the area to be protected is "immediately adjacent" to the coastal barrier landform and associated aquatic habitats which comprise the CBRS unit (U.S. Dept. of the Interior,1985).

There are no CBRS units located within the Town's limits. However, two "protected areas" have been identified in the Department of Interior's inventory. The areas are Mar-A-Lago and Kreusler Park.

8.3.12 Intergovernment Cooperative Groups

A unique intergovernmental unit is developing as a means to address the regional extent of beach erosion and the coastal processes which cause it (Coastline Quarterly, 1985).

Five coastal cities and two counties plan to join forces against beach erosion along 55 miles of southern California coastline stretching from Dana Point to La Jolla.

The Beach Erosion Action Committee (BEACh) is being formed in recognition of the fact that individual shoreline programs ultimately affect more than one area. The group will consist of representatives from the cities of San Clemente, Oceanside, Carlsbad, Del Mar, and San Diego; the Counties of Orange and San Diego; and Camp Pendleton. Ex-officio members will include the Army Corps of Engineers, California Department of Boating and Waterways, California State Parks and Recreation Department, California Coastal Commission, California Coastal Conservancy, San Diego Association of Governments, Scripps Institution of Oceanography, and State and Federal elected officials from districts within the littoral sand cell.

BEACh will be unique because its membership is based on a littoral cell rather than political boundaries. "Littoral cells" are defined by patterns of nearshore currents that transport sand and distribute it along beaches. River dams, artificial harbors, and underwater breakwaters, all of which serve useful purposes in or around the area they are constructed, interrupt the natural flow and have the potential to cause damage to coastal regions miles away. Sometimes even methods aimed at preventing beach and bluff erosion have the effect of replenishing sand at one beach while accelerating erosion at another.

The Oceanside cell is one of the largest known to exist and travels along property owned primarily by government agencies. In this sense, BEACH members literally share sand as well as shoreline erosion problems. They also share a degree of control over the implementation of proposed solutions. To coordinate and strengthen that control, a Joint Powers Agreement has been drafted and circulated to each affected jurisdiction for approval. Once approved, the JPA will empower BEACh to review shoreline projects proposed by member agencies and to serve as an advisory body.

BEACh's main objectives will be to facilitate communication among agencies, prepare contingency plans for emergency situations, act as an agent for shoreline project applications, coordinate governments involved in projects, and develop a citizen information group.

Initial funding will be provided by BEACh members, and State and Federal funds will be sought for long-term projects. The analogous organization from the Town's perspective would be a similar body composed of all municipalities from Lake Worth Inlet to South Lake Worth Inlet.

8.4 Warning Systems

This group of techniques primarily involves governmental agencies at various levels providing the public with information concerning the projected short-term and long-term risks associated with development in erosion hazard areas. The activities can range from ongoing, year round educational programs to broadcast warnings immediately before major storm events. A range of different programs and activities that serve as warning systems are described below.

8.4.1 Public Education

This would encompass a range of programs and activities sponsored by local, State and Federal government agencies. These could include periodic workshops in major shore communities, dissemination of maps and pamphlets detailing erosion hazard areas and erosion probabilities, and speakers programs.

8.4.2 Deed Disclosure

This would require the inclusion of a statement on all deeds of properties located in defined erosion hazard areas that such properties are subject to probable, erosion-related impacts. This would warn potential purchasers of shorefront properties of the erosion risk. The definition of the erosion hazard area would likely be done at the state level, and the primary recordkeeping responsibility would reside at the local or county government level (e.g. county clerk or county recorder's office). Florida Statute 161.57 provides that the seller of a parcel of land must convey the buyer the location of the CCCL across the property.

8.4.3 Real Estate Disclosure

This is similar to the deed disclosure program above. In this instance, local real estate agents would be required to warn potential buyers of shorefront properties located in erosion hazard areas, that these properties face the probability of future erosion-related losses.

8.4.4 Erosion Forecasts

The National Weather Service currently issues estimates of short-term erosion expected to accompany the occurrence of coastal storms. This service usually provides advance notice only for the occurrence of major storms. The erosion forecasts could be supplemented with information on yearly recession rates and how these are being influenced by seasonal weather trends (e.g. prolonged winds). However, long range beach monitoring is better managed at the Town level.

8.4.5 Disaster Preparedness

State and local emergency planning officials would develop contingency plans for the evacuation of shorefront areas situated in critical erosion and flood hazard areas. In addition, evacuation plans would be developed for barrier islands with limited links to the mainland. The National Weather Service storm warning would be quickly relayed to local emergency planning officials. State and local officials would inform shorefront residents residing in hazard areas that they face the high probability of severe erosion losses during major storms. Timely evacuation of erosion hazard areas would lessen human suffering associated with short-term erosion accompanying severe storms. This effort could be coordinated with the various public education and civil defense efforts. The Town has developed a storm preparedness plan which outlines a plan to safeguard its population in the event of a hurricane. The plan was last revised June 1986.

8.5 Relief, Rehabilitation, and Insurance

In contrast to warning systems, this group of techniques deals directly with location of structures and public facilities in erosion hazard areas. These measures either offer aid to replace erosion-related losses of property, or create incentives and performance standards for avoiding or minimizing future erosion losses. Some of the important methods are noted below.

8.5.1 Insurance

The National Flood Insurance Program(NFIP) is a federally sponsored and operated program which currently provides shorefront property owners subsidized insurance protection against erosion-related losses and undermining caused by waves or currents exceeding specific levels. Thus, it applies only to short-term, erosion-related losses accompanying major storms. Local communities participating in either the emergency or regular programs of the NFIP must adopt minimum building codes and planning programs. The Town participates in the program.

8.5.2 Relief and Rehabilitation

Existing rehabilitation and post-disaster assistance is generally not available to cover erosion-related property losses. Aid is generally only available where erosion-related losses have occurred as the result of a major storm. It generally requires a Presidential declaration of a "major disaster" or of an "emergency" for post disaster assistance to be made available. The available aid is generally targeted toward the reconstruction of public facilities, utilities and infrastructure. Low interest loans can be made available to private citizens. Rehabilitation and post-disaster assistance originate at the Federal level through the Federal Emergency Management Agency (FEMA).

8.5.3 Relocation Incentives

Economic incentives could be offered by governments to shorefront property owners to relocate out of erosion hazard areas. These could be implemented on a pre-or post-storm basis. Incentives could include outright grants or low interest loans covering moving or reconstruction expenses. Reconstruction grants or loans could be made contingent upon relocation out of a coastal hazard area. Similarly, tax abatements could be granted on new construction located out of an erosion hazard area. Finally, government(s) could supply assistance in locating and purchasing suitable areas for relocation. These programs would likely be implemented at the State and Federal levels. In the opinion of Cubit Engineering Limited, relocation programs are not realistic for the Town of Palm Beach due to property values.

8.6 Alternative Selection Process

The selection and implementation of any one (or several) of the alternatives discussed above will typically produce both positive and negative impacts on the community. These impacts can be realized by different segments of the population in widely varying ways. As an example, upgrading the groins at Palm Beach could provide homeowners in the center portion of the island with additional beach and storm protection but penalize property owners on the southern portion of the island by restricting the sand supply and increasing erosion rates. More prudently, several of the above alternatives may be utilized simultaneously for the best overall results.

The strategic objectives of this Coastal Management Plan are defined by the Town of Palm Beach Study Authorization to be:

1. upland property protection; and
2. recreational beach enhancement.

These objectives have been expanded into a list of four plan alternatives for possible implementation in each of the reaches of the Town. These plan alternatives are:

1. full hurricane protection;
2. moderate storm protection;
3. wide recreational beach; and
4. narrow recreational beach.

These plan alternatives provide a sufficient level of plan distinctions to realistically consider the overall objectives of the Coastal Management Plan, the operative coastal processes, the shoreline condition, the character of the upland development as well as the dictates and opportunities of the Town, State and Federal shore protection programs on a reach-by-reach basis.

The shore protection techniques and concepts discussed earlier in this chapter provide the physical and institutional means to attain the objectives of the various plan alternatives. Two of the four approaches for shore erosion mitigation considered for evaluation and potential application were engineering and land management techniques. Warning systems and relief, rehabilitation, and insurance measures are incorporated to varying degrees by the Town already. Table 8.2 lists the plan objectives together with those specific engineering and land management techniques which are judged to be most appropriate for the Town of Palm Beach shore for each individual reach of the Town's shoreline. The definition of the Town's planning reaches is given in Chapter 4.

TABLE 8.2

COMPREHENSIVE COASTAL MANAGEMENT PLAN

ALTERNATIVE OBJECTIVES

Objective	Alternatives to Achieve Objectives
1. Full Hurricane Protection	Seawalls Wide Beach and Dune
2. Moderate Storm Protection	Beach and Dune Seawalls/Revetments Offshore Breakwaters Setback Lines/Dune Stabilization
3. Wide* Recreational Beach	Beach Nourishment Nourishment with Structures
4. Narrow* Recreational Beach	Beach Nourishment Nourishment with Structures Maintenance of Structures Benefit from Upstream Fill

* NARROW <= 50' berm
WIDE >= 50' berm

CHAPTER 9.0
THE RECOMMENDED PLAN

COMPREHENSIVE COASTAL
MANAGEMENT PLAN
FOR
TOWN OF PALM BEACH

9.0 THE RECOMMENDED PLAN

The evaluation and selection process for shore protection alternatives for the Town of Palm Beach considered all of the available shore protection techniques and concepts identified in Chapter 8.0. The comparative evaluation of practical engineering and land management alternatives included consideration of the Coastal Management Plan objectives, Town, State and Federal shore protection policies, operative coastal processes, shoreline conditions and density of development along the shore.

The Plan seeks to satisfy two main erosion control objectives. These objectives together with their respective alternative improvement strategies are listed below:

1. Upland Property Protection
   a. Hurricane erosion protection;
   b. Moderate storm erosion protection;

2. Recreational Beach Enhancement
   a. Wide recreational beach;
   b. Narrow recreational beach.

This section develops the design criteria associated with the accomplishment of each of the above objectives, presents the recommended Plan and provides the estimated costs of implementing the Plan.

9.1 Design Criteria

A uniform set of design criteria and assumptions applies to the reach engineering designs which are presented in Section 9.2. The design methodology for engineering protection of the Town of Palm Beach shoreline is based on four fundamental assumptions:

1. the overall coastal processes of the Town of Palm Beach should not be altered such that accelerated or new erosion is created;

2. the "reach" concept should be used in the application of engineering concepts whenever appropriate;

3. the design efforts are directed toward erosion control and recreational beach development. Flood control measures are not explicitly addressed since these are substantially different from erosion control measures; and

4. plans should be in accordance with the State's policies for shore protection as set forth in Chapter 161 Florida Statutes, Rule 16B.33 Florida Administrative Code, the Town Code and Federal laws and regulations.

Specific criteria have been developed to provide the necessary parameters for engineering planning and analysis. The criteria which apply to each of the plan objectives are discussed in the following sections.

9.1.1 Hurricane Erosion Protection

Hurricane erosion protection includes shore protection methods for both the elevated water levels of the associated storm surge and the erosive force of the large storm waves acting at the higher water levels. Traditionally hurricane protection has consisted of massive seawalls capable of withstanding the direct impact of storm waves. More recently wide beaches such as the Miami beachfill have been used. Such beaches serve as buffers by providing large enough sand volumes to safely endure large storm erosion losses and still maintain a residual protective beach berm. For the purposes of the Plan, the following hurricane conditions are adopted as design criteria for the hurricane protection objective:

1. maximum wave runup elevation of 10.1 feet MSL;
2. maximum waterlevel of 7.6 feet MSL.

These levels are approximately equal to the 100-year flood levels with added wave height effects (Corps of Engineers, 1985).

Functional and structurally sound seawalls with good toe protection in the form of adequate embedment and a sufficiently wide fronting beach are considered capable of providing hurricane protection. Plate 5 shows the elevations of existing seawalls along the Town's ocean front. In general the seawalls in Reaches 1 through 4 have sufficient height to satisfy the wave elevation criteria. If these walls are maintained and protection in the form of dunes and/or a narrow beach berm is maintained, then the seawalls can be considered as functionally sufficient to satisfy the hurricane protection objective.

Sufficiently wide beaches with dune systems are also capable of providing hurricane erosion protection. Beach profiles change frequently in response to winds, waves and tides. The most dramatic beach profile changes are the result of storm wave action, especially when accompanied by storm surge which enables waves to attack higher elevations on the beach, It is important to know the magnitude of beach erosion to be expected during storms when planning and designing a beach fill section.

The Coastal Engineering Research Center (USACOE, CERC, 1984) has compiled some limited storm erosion profile change data. They suggest that the average volumes of sand eroded from above MSL for beaches with lengths comparable to that of Palm Beach Island have a limited range of values. A moderate storm may remove 4 to 10 cubic yards per foot of beach front above MSL. An extreme storm or a moderate storm which persists for many hours or days may remove 10 to 20 cubic yards per foot. Rare storms that are most erosive due to a combination of intensity, duration, and orientation may remove 20 to 50 cubic yards per foot. For comparison, a typical berm 50 feet wide and +9 feet MSL contains 118 cubic yards per foot of beachfront.

9.1.2 Moderate Storm Erosion Protection

Moderate storm erosion protection includes shore protection methods resistant to the erosive force of moderate storm waves. Significant storm surge influences are not included in this level of erosion protection.

A moderate storm is one which would produce the following conditions:

1. wave runup up to 6.3 feet MSL;
2. water levels up to 3.8 foot MSL.

These values are representative of 10 year storm conditions (Corps of Engineers, 1985). For the purposes of this plan the following coastal structures or shoreline conditions should generally be able to resist moderate storm criteria conditions without an immediate risk of damage to upland property:

1. all hurricane protective structures discussed previously;

2. appropriately designed revetment sections;

3. beaches with narrow berm widths and continuous dunes; and

4. beaches with narrow berm widths and elevated uplands.

9.1.3 Wide Recreational Beach

A wide recreational beach may be appropriate where there is adequate parking and public access to justify the full recreational utilization of the beach. The following assumptions apply to the estimation of the required beach area:

1. 75 square feet of beach area is required per person per day;

2. only parking areas within 1/4 mile of the beach area will normally be used by beach users; and

3. an average of 2.5 persons will occupy each car.

For example the recreational beach area between Barton Avenue and Gulfstream Road. The following parking facilities are available within the specified analysis limits as of July 1986:

metered spaces	= 150
timed spaces	= 458
permitted spaces for resident parking	= 212
TOTAL SPACES	= 820

Based on these parking facilities and the earlier stated beach utilization assumptions a nominal dry beach width of 50 feet is required. This would give at this site the following requirements:

berm width	= 50 feet;
berm elevation	= + 9 feet MSL; and
beach slope	= 1:10 Maximum

Additional beach fill requirements to account for long term erosion losses as well as short term losses during beach fill placement are discussed in Section 9.1.5, Additional Beach Fill Requirements.

9.1.4 Narrow Recreational Beach

A narrow public beach is one which can support the recreational requirements of local residents. The berm width is large enough to provide a winter beach width sufficient for some limited protection for upland structures and toe protection for dunes, seawalls or bulkheads. Based on the storm erosion data contained in Section 9.1.2, a long duration moderate storm of the northeaster type can remove about 20 cubic yards of sand per foot of beachfront. A 25 foot berm contains about 60 cubic yards per foot. Such a berm could withstand the erosion loss of a moderate storm and still provide some residual dry beach area for recreational use by the residential community. The criteria for the narrow recreational beach are defined as:

berm width	= 25 feet;
berm elevation	= +9 feet MSL; and
beach slope	= 1:10 Maximum.

Additional beach fill requirements to account for long term erosion losses as well as short term losses during beach fill placement are discussed in the following section.

9.1.5 Additional Beach Fill Requirements

Sand volumes in excess of the requirements of the planned beach fill cross-section are often necessary. Additional beach fill may be required to :

1. compensate for loss of fine sand from the fill during the placement operations;

2. provide an additional volume of sand to account for the projected erosion losses until the next planned renourishment cycle;

3. accommodate the seasonal beach width changes;

4. compensate for differences in borrow material and the native beach sand.

<u>Beach Replenishment</u> - The amount of borrow sand which must be placed on a beach depends on the textural similarity of the borrow sand to the beach sand. Sorting and winnowing action by waves, tides, and currents will tend to generally transport finer sizes seaward, leave the coarsest sizes slightly shoreward of the breaker line and cover the beach face and remaining offshore areas with the more medium sand sizes.

Some sediment sizes that are in borrow sands and not in the native beach sand may not be stable in the beach environment. Extremely fine particle sizes are expected ultimately to be moved offshore and lost from the active littoral zone. Fragile grains, such as some shells, will be broken, abraded and possibly lost. These kinds of changes to the borrow sediment will make the texture of the beach fill more like the original native beach sand. These processes will reduce the original volume of fill placed on the beach.

Currently there is no proven method for computing the amount of overfill required to satisfy project requirements but reasonable estimates can be made. Techniques for the development of criteria to indicate probable behavior of borrow sand on the beach are reviewed in the Shore Protection Manual (USACOE, CERC, 1984). These procedures provide a general indication of possible beach-fill behavior. Additional data based on observations of actual beachfills are presented by Stauble (1985).

The Corps of Engineers (1985) have evaluated samples of both the native beach sands and possible borrow sand deposits in the project area. No borings have been drilled offshore of the Town. However, material offshore and south of Palm Beach Island is suitable for use as a beachfill which indicates that material resources closer to the Town may be similar and therefore also suitable for fill. All materials offshore are classified as fine sand. The sands range from fine to medium, very clean sand with trace amounts of coarse sand and fine gravel-sized shell. Suitability analyses both with and without carbonates were made to determine the relative importance of the shell material in determining the overfill requirements. The presence of the less durable carbonate material was found to inflate the overfill requirement. The Corps of Engineers analysis shows that an overfill factor of 1.35 is representative for the offshore deposits south of Palm Beach Island. The Corps of Engineers (1985) reports that a reconnaissance survey including the area offshore of Palm Beach Island was completed. The limited sampling and analysis indicate borrow area potential with quality of material equaling that found elsewhere in the County. Additional analysis of the areas offshore of Palm Beach Island will therefore be required to fully evaluate these potential borrow areas.

The Corps of Engineers overfill estimate is adopted for the preliminary engineering contained in this study. The overfill factor of 1.35 means that planned fill volumes must be increased by 35% to account for winnowing and sorting losses. This overfill factor is adopted for estimating purposes of this Plan.

Advance Nourishment - Placing an additional beach fill volume is often done to provide an allowance for erosion until the next nourishment operation is planned. The desired profile therefore is the planned minimum residual beach profile after erosion losses are considered. The Corps of Engineers have analyzed data from two beach profile surveys conducted in the years of 1955 and 1975. Based upon analysis of these data, the Corps has estimated that the Town's beaches are eroding at a rate of approximately 4 to 7 cubic yards per year per linear foot of beach. If these estimates are correct, the Town's beaches would require renourishment at a rate of 264,000 to 462,000 cubic yards per year over the entire length of the Town.

In the absence of any improvements to the Lake Worth Inlet bypassing program, these estimates may reflect realistic depletion rates along the Town shoreline. As a part of the initial fill program, the advance nourishment component should be incorporated for at least 10 years or until such a time as the proposed Lake Worth Inlet improvements are implemented and begin to influence the reaches south of the Breakers Hotel.

9.2 Overall Plan

The Town's Comprehensive Coastal Management Plan is based upon the following:

1. evaluation of the relevant coastal processes which govern the transport of sand along the shoreline;

2. requirements for upland property protection and recreation;

3. past erosion management techniques;

4. environmental and economic considerations;

5. historical and projected shoreline trends;

6. Town, County, State and Federal shore protection programs and funding; and

7. objectives of the Town of Palm Beach with respect to beach use and preservation.

The overall Plan recommended for the Town of Palm Beach is shown on Plate 6. The Plan consists of the following elements:

1. upgrade the Lake Worth Inlet sand transfer plant to increase sand pumping to restore and approximate the littoral flow at its natural rate;

2. require all beach quality spoil from Lake Worth Inlet maintenance dredgings to be placed on the beaches south of the Inlet;

3. renourish the Mid-Town public beach;

4. plan for renourishment of the Town's shoreline south of Sloan's Curve on an as-needed basis;

5. remove derelict groins which are safety hazards to beach users;

6. encourage dune growth at appropriate areas south of Southern Boulevard;

7. repair and maintain public seawalls; and

8. encourage inspection and maintenance of private seawalls.

The Plan recognizes and maintains that the negative impact of the Lake Worth Inlet jetties must be mitigated. Long term starvation of littoral transport by the Inlet has contributed in large measure to the deteriorated state of the Palm Beach shoreline. The key element of the Plan is the improvement of the sand bypassing operations at Lake Worth Inlet. If the effects of these improvements are not felt at the central and southern portions of the Town, remedial beach nourishment will be required. Details of each reach are given below. Appendix C contains details of the recommended Plan for each reach.

9.2.1 Lake Worth Inlet Bypassing Operations

The Town's objective with respect to the Lake Worth Inlet

Management Plan is twofold. First, maintenance of the Inlet's navigation channel should be guaranteed to preserve the commercial and recreational boating interests of the area. Second, the natural littoral transport of sand across the Inlet should be maintained to provide a continuous source of sand to renourish the Town's beaches thereby helping to stabilize their recreational and storm protection functions. The recommended approach to meet these objectives is to improve the sand bypassing operation at the Inlet. Specific engineering recommendations are contained in Chapter 5.0.

9.2.2 Reach 1: Lake Worth Inlet to Breakers Hotel

The upland property protection objective for this reach is to provide hurricane erosion protection. The existing roadway protective and private seawalls in this reach generally satisfy this protection objective. Plate 5 shows that the seawall crest elevations in this reach range from 12 to 25.5 feet MSL and are therefore above the elevation criteria of 10.1 feet MSL discussed in Section 9.1.1.

A commitment to repair and maintain the seawalls is essential if these structures are to be relied upon for hurricane erosion protection. Recommendations for the repair of the roadway protective seawall segments are listed in Table 9.1.

The Plan also recommends the development of a program to encourage inspection and maintenance of private seawalls. The Town should coordinate a public awareness program to demonstrate the benefits and necessity of keeping the private seawalls functional.

The recreational objective for this reach is to maintain a narrow beach. The Plan recommends improvements to the Lake Worth Inlet sand bypassing operations as the critical element in the attainment of this objective. The additional sand from the bypass plant and beach quality materials from Lake Worth Inlet dredgings must be placed directly on the beaches in this reach.

There are 27 groins (See Table 9.1) which are no longer functional as shore protection structures. In their deteriorated condition they represent safety hazards to beach users. The plan recommends removal of those groins, as may be financially and physically attainable by the Town.

9.2.3 Reach 2: Breakers Hotel to Barton Avenue

The upland property protection objective is to provide hurricane erosion protection. The existing seawalls in the reach satisfy this protection objective. All shore protection structures are privately maintained in this reach. Just as in Reach 1, the Town should encourage periodic inspection and reporting of the private shore protection structure conditions.

TABLE 9.1

RECOMMENDATIONS FOR STRUCTURAL MAINTENANCE AND BEACH FILL IN REACH 1

Roadway Protective Seawall Maintenance

Location	Description
Bahama Lane to Country Club Rd.	Repair anchors and gunite
Wells Road to Sunrise Avenue	Replace cap and repair gunite

Private Seawall Inspection and Maintenance

Encourage private ownership to periodically inspect and maintain structures.

Beach Fill

Schedule	Action
Biannual	Renourishment from Lake Worth Inlet maintenance dredgings of beach quality materials
Continuous	Sand bypassing from Lake Worth Inlet sand bypassing plant to restore and maintain littoral flow at its natural rate

Groin Modification

Remove deteriorated groins that are safety hazards:

135N	131N	124N	121N	79N
58N	56N	50N	49N	48N
47N	46N	43N	42N	41N
40N	39N	38N	37N	36N
35N	34N	93+000	90+800	90+1060
89+110	89+210			

NOTES: 1. Locations of groins are shown in Appendix C.

2. Groin 93+000 identified for removal under the May 1985 Town Groin Removal Program.

This reach is dominated by the Breakers Hotel which has demonstrated a commitment to maintenance of its shorefront which includes protective seawalls and groins. This maintenance action is conditionally consistent with the objectives of this Plan in view of the existing development. The structures are currently providing the only means of protection for the Breakers Hotel, because of the long term impacts of beach starvation caused by Lake Worth Inlet.

The long range commitment of the Plan is to restore sand transfer Town-wide. At present the groins at the Breakers Hotel restrict sand transport to the south. Once the beach conditions improve in Reach 1 due to sand bypass and Inlet dredging sand transfers, Reach 2 conditions must be investigated to determine whether they should be modified to allow the benefits to continue downcoast.

The objective would be to accommodate a transport of sand through the reach as closely equivalent to that bypassing the Inlet as possible without reducing the protection of the Breakers Hotel.

9.2.4 Reach 3: Barton Avenue to Banyan Road

The upland property protection objective for this reach is hurricane erosion protection. The roadway protective seawalls in this reach satisfy this objective. Plate 5 shows that the seawall crest elevations in this reach range from 13 to 18 feet MSL and are therefore above the elevation criteria of 10.1 feet MSL as discussed in Section 9.1.1.

A commitment to repair and maintain the seawalls is essential if these structures are to be relied upon for hurricane erosion protection. Recommendations for the repairs to the roadway protective seawalls are listed in Table 9.2. The recommended voluntary private seawall maintenance program as discussed for Reach 1 should also apply in this reach.

The recreational objective for this reach is to maintain a wide public beach and a narrow private beach. The public beach needs to be restored with a placement of about 500,000 cubic yards. This will provide a 50 foot berm including allowances for 10 years of advance nourishment. A cross-section of this proposed fill is shown in Figure 9.1. This fill would also serve as a feeder beach for the remainder of Reach 3 which is privately owned. Reach 4 would also benefit from this project.

Groins listed in Table 9.2 represent safety hazards. Several groins have been proposed by the State and the Town for removal in the summer of 1986 under a joint program.

TABLE 9.2

RECOMMENDATIONS FOR STRUCTURAL MAINTENANCE AND BEACH FILL IN REACH 3

Roadway Protective Seawall Maintenance

Location	Action
Royal Palm Way to Via Marina	toewall construction
North Line Royal Palm Way to Hammon Avenue	anchor repairs
Banyan Road to Worth Avenue	anchor repairs and gunite repairs

Private Seawall Inspection and Maintenance

Encourage private ownership to periodically inspect and maintain structures.

Beach Fill

An initial beach fill is required to provide an all season recreational beach between Barton and Gulfstream Avenues. Details of the recommended fill are shown in Figure 9.1.

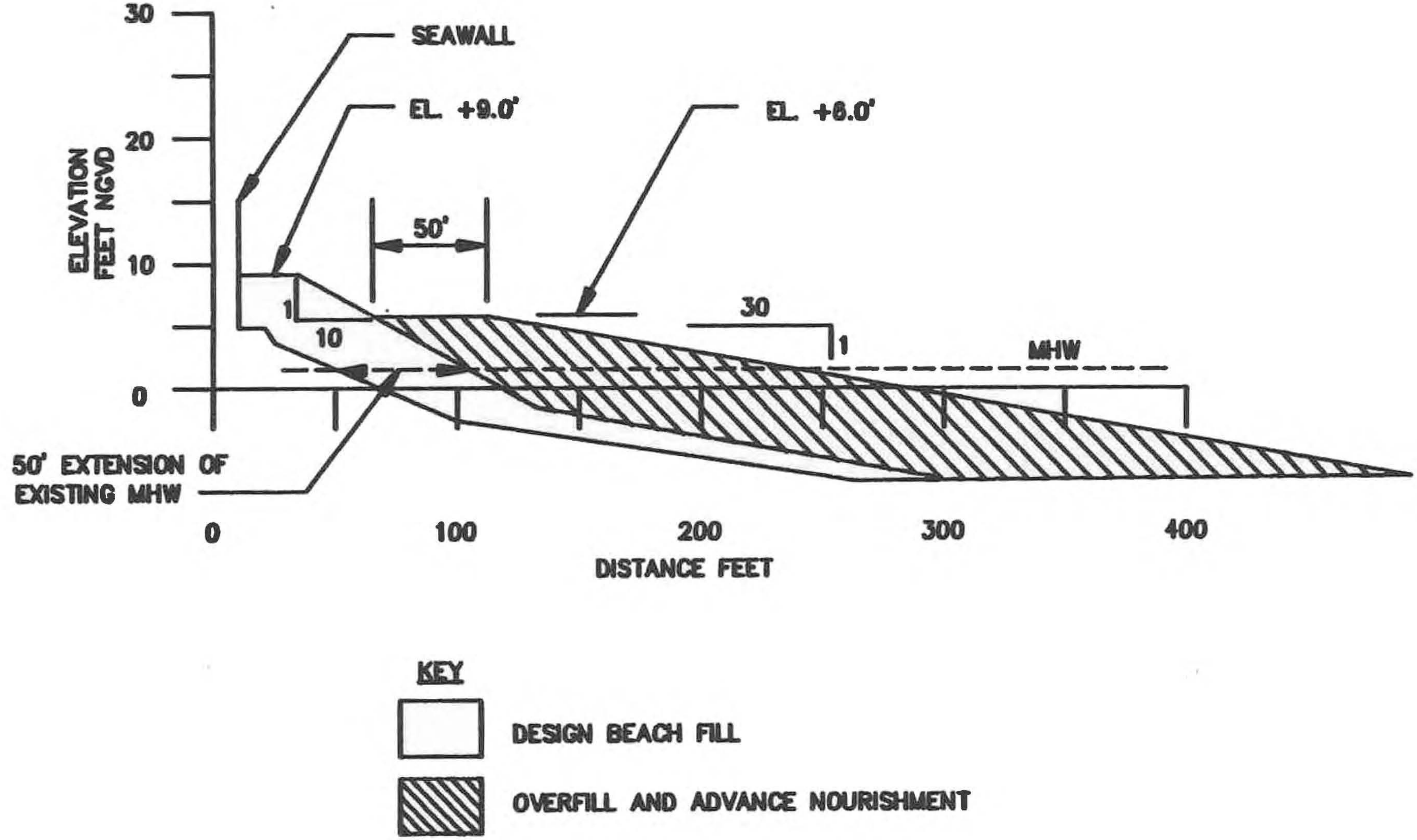
Groin Modification

Remove deteriorated groins that are safety hazards:

1N	3N	96+700	98+1050	99+340
2N	4N	14N	98+1270	98+800

NOTES: 1. Locations of groins are shown in Appendix C.

2. Groins 2N, 3N, 4N, 98+1050 identified for removal under the May 1985 Town and State Groin Removal Program; commenced during summer 1986.



TYPICAL SECTION PROPOSED BEACH FILL
REACH 3

AUGUST 1986

FIGURE 9.1

9.2.5 Reach 4: Banyan Road to Widener's Curve

The upland property protection objective for this reach is to provide hurricane erosion protection. The roadway protective and private seawalls in this reach generally satisfy this objective. Plate 5 shows that the seawall crest elevations in this reach range from 13 to 14 feet MSL and are therefore above the elevation criteria of 10.1 feet MSL as discussed in Section 9.1.1.

A commitment to repair and maintain the seawalls is essential if these structures are to be relied upon for storm erosion protection. Recommendations for the repair of the public seawall segment of this reach are listed in Table 9.3. The recommended program for maintenance of private seawalls as discussed for Reach 1 also applies here.

The recreational objective for this reach is to maintain a narrow beach. The beachfill and the periodic renourishment which is recommended for the adjacent Reach 3 will contribute as a sand source for this reach as the littoral drift system gradually carries the sand downdrift to this reach. The improvement of the Inlet bypassing operations will also have a positive contribution to the sand supply reaching the beaches in this reach provided the modifications to Reach 2 are made.

Deteriorated groins are located between Banyan Road and Woodbridge Road. These structures are no longer functional and their deteriorated condition makes them a safety hazard to the beach users. The Plan therefore recommends the removal of these eight groins. Table 9.3 lists the groins which should be removed.

The functional groins in this reach should be maintained. These groins are located between Southern Blvd. and Widener's Curve. Table 9.3 lists the groins to be maintained. Groin numbers 109 + 950, 65S and 66S should be shortened to allow downdrift sand transport improvement comparable to the improvement in Inlet bypassing at Lake Worth Inlet.

9.2.6 Reach 5: Widener's Curve to Sloan's Curve

The upland property protection objective for this reach is to provide moderate storm erosion protection. The reach has been the site of critical erosion problems in the recent past. The revetment section which the Florida Department of Transportation has proposed will provide vital protection for State Road A1A and the utilities within its right-of-way. The Plan recommends that the Department of Transportation plans be endorsed by the Town of Palm Beach. No additional shore protection actions are recommended for this reach. The Plan also recommends that no efforts be made to enhance the recreational beach resources located within this reach. The beach fill proposed for Reach 3 would help to maintain a narrow beach.

TABLE 9.3

RECOMMENDATIONS FOR STRUCTURAL MAINTENANCE FOR REACH 4

Seawall Maintenance

Location	Description
Via Bellaria to Via Del Mar	anchor repairs
Via La Selva to Hammon Ave.	anchor repairs
Via Bellaria to Banyan Road	gunite repairs

Private Seawall Inspection and Maintenance

Encourage private ownership to periodically inspect and maintain structures.

Groin Modifications

Remove deteriorated groins that are safety hazards:

9S	102+990	12S	103+350
15S	103+830	20S	103+1090

Modify Groins

109+950, 65S and 66S

Maintain Groins

40S to 109+690

NOTES: 1. Locations of Groins are shown in Appendix C.

9.2.7 Reach 6: Sloan's Curve to south limits of Lake Worth Municipal Beachfront Park

The upland property protection objective for this reach is to provide full hurricane protection. The protection is in place in the form of buried seawalls fronting highrise development. Moderate storm protection is afforded by the beach and dune system at the Par 3 Golf Course and Phipps Ocean Park. A proposed Federal shore protection project consists of the placement of 375,000 cy of beach restoration fill to provide a 50 foot wide berm along the southern end of the reach. The plan is for a one mile long beach restoration project centered around Lake Worth Park. This fill would extend about 2500 feet into the southend of Reach 6. The Federal program also includes a periodic maintenance beachfill of 217,000 cubic yards to be placed at 7 year intervals by the local sponsor, which has not been determined as of this time.

The Federal beachfill would adequately protect the southern portion of the reach. Beach maintenance would also be required along the remainder of the reach to the north. This area is showing evidence of erosion which may be accelerated once the proposed revetment in Reach 5 is installed. Therefore the Plan recommends that this area be monitored as a site for potential beach nourishment or other protective scheme. It is possible that no nourishment would be required if the Lake Worth Inlet improvements and modifications to structures in updrift reaches are completed in a timely manner.

Low dunes exist in this reach. These dunes provide some storm erosion protection by providing stockpiles of sand which can become part of the beach system during storm attack. To preserve the protection benefits of this dune system, the Plan recommends that a dune enhancement program be implemented for this reach. The modest program would include installation of sand fencing to gradually develop the dunes and dune plantings to promote stabilization and long term dune growth. The Plan also recommends that requirements for dune crossover structures and standards for their construction be established. Reports prepared by the Florida Sea Grant Extension program serve as excellent standards for a dune stabilization and walkover structure programs. These reports are:

1. Dune Restoration and Revegetation Manual, Report No. SGR-48; and

2. Beach Dune Walkover Structures, Report No. MAP-18.

The recreational objective for this reach is to maintain a narrow beach. This objective is satisfied by the beach and dune maintenance elements of the property protection program.

9.2.8 Reach 7: South limits of Lake Worth Municipal Beachfront Park to south Town limits

The upland property protection objective for this reach is to provide full hurricane protection. The protection will be in the form of existing seawalls which are buried in front of the highrise structures. A proposed Federal shore protection project consists of the placement of 375,000 cubic yards of beach restoration fill to provide a 50 foot wide berm along the northern end of the reach as described above. This fill will extend approximately 2000 feet into the north end of the reach.

The Federal beachfill would adequately protect the northern portion of the reach. This reach is being adversely affected by the beach scraping activities (see Section 8.2.5) which have occurred at the Lake Worth Municipal Beachfront Park. The Town should obtain assurances from the City of Lake Worth and the State that this activity will not be continued.

This reach is eroding to the point where a moderate storm could pose a major threat to the recreational beach. The erosion of the shoreline should be monitored by profiles taken at quarterly intervals. If the Federal project is not built and erosion persists, beachfill may be required to maintain a recreational beach. It should be recognized that the placement of any fill is contingent upon the DER and County giving consent to bury a nearshore rock outcrop. The possibility that such permits may not be obtained would indicate that the buried seawall may be called into service during the next severe storm occurrence.

9.3 Estimate Plan Costs

The estimated costs of the plan elements as described above are summarized in Table 9.4. The costs identified in this Table are based on the assumption that sand bypassing at Lake Worth Inlet will be initiated and maintained at a rate of 250,000 cubic yards. Rates for materials and construction are based upon Corps of Engineers cost estimates and construction data, interviews with contractors and evaluation of cost reports from similar projects. Another important assumption is that the proposed Corps project at the City of Lake Worth will be implemented and will provide some sediment to Reaches 6 and 7.

TABLE 9.4

ESTIMATED COSTS OF TOTAL PLAN IMPROVEMENTS

Reach	Action	Costs
1	Lake Worth Inlet Bypass Plant Improvements	$ 900,000*
Lake Worth Inlet	Groin removal	507,000
to	Roadway protective seawall	365,000
Breakers Hotel	maintenance and repair	
	Monitoring	8,000
	SUB-TOTAL	$ 1,780,000
	ENGINEERING @ 10%	178,000
	CONTINGENCIES @ 10%	178,000
	REACH TOTAL	$ 2,136,000
2	Monitoring	$ 4,000
Breakers Hotel	ENGINEERING @ 10%	400
to	CONTINGENCIES @ 10%	400
Barton Avenue	REACH TOTAL	$ 4,800
3	Groin removal	$ 215,000
Barton Avenue	Roadway protective seawall	1,436,000
to	maintenance and repair	
Banyan Road	Beach nourishment	2,762,000
	Monitoring	8,000
	SUB-TOTAL[1]	$ 4,421,000
	ENGINEERING @ 10%[1]	404,800
	CONTINGENCIES @ 10%	420,800
	ENVIRONMENTAL	150,000
	REACH TOTAL	$ 5,396,600
4	Groin maintenance and removal	$ 154,000
Banyan Road	Roadway protective seawall	362,000
to	maintenance and repair	
Widener's Curve	Monitoring	8,000
	SUB-TOTAL[2]	$ 524,000
	ENGINEERING @ 10%[2]	34,300
	CONTINGENCIES @ 10%	52,400
	REACH TOTAL	$ 610,700

TABLE 9.4 CONT.

ESTIMATED COSTS OF TOTAL PLAN IMPROVEMENTS

Reach	Action		Costs
5	Revetment by DOT		$ 7,480,000
Widener's Curve	Monitoring		4,000
to		SUB-TOTAL	$ 7,484,000
Sloan's Curve		ENGINEERING @ 10%	400
		CONTINGENCIES @ 10%	400
		REACH TOTAL	$ 7,484,800
6	Dune maintenance		$ 33,000
Sloan's Curve	Monitoring		8,000
to limit of		SUB-TOTAL	$ 41,000
City of Lake Worth		ENGINEERING @ 10%	4,100
		CONTINGENCIES @ 10%	4,100
		REACH TOTAL	$ 49,200
7	Monitoring		$ 8,000
Southern Limit of		ENGINEERING @ 10%	800
City of Lake Worth to		CONTINGENCIES @ 10%	800
Southern Limit of Town		REACH TOTAL	$ 9,600

SUMMARY OF TOTAL PLAN COSTS

Improvements	$ 14,214,000
Engineering	622,800
Environmental	150,000
Contingencies	656,900
Monitoring	48,000
TOTAL	$ 15,691,700***

NOTE:
* * - Cost of bypass plant improvements to be done by others
* ** - Estimate and improvement by DOT
* *** - Includes $2,498,000 for seawall repair and maintenance as identified by Mock, Roos & Associates 1/15/85.

1 - Groin removal engineering @ 5% since design engineering completed.
Beach nourishment engineering @ $250,000

2 - Seawall engineering @ 5% since design engineering completed

9.4 Emergency Response Plan

This section discusses an emergency response plan for the Town of Palm Beach. The purpose of an emergency response plan is preparedness for emergency beach erosion situations. The intent is to limit damage during low intensity storms and prevent futile expense combatting hopeless emergencies under more severe conditions. An organized and preplanned response with as many decisions as possible thought out ahead of time promotes an appropriate action whereas the no-plan condition leads to delay, confusion, and emotional panic.

9.4.1 Plan Contents

A contingency plan needs to address the following items:

1. Development of a suitable forecast system to provide sufficient warning of erosion trouble.

2. Anticipation of possible erosion damage scenarios and the degree of damage severity corresponding to mild, severe, and extreme storm conditions.

3. Adoption of approved responses to each type of damage event; including decisions upon issues of cost sharing, permit problems, and legal and contractual technicalities.

4. Preparation of an implementation schedule in detail which identifies material and equipment for mobilization on immediate notice or which instigates evacuation and clean-up operations or prohibits futile emergency repair action during severe events.

9.4.2 Damage Scenarios

Storm Definition The severity of a storm may be classified into three general magnitude classes of mild, severe, and extreme. A mild storm is a typical winter northeaster which generates high tides and wave action causing wave runup that extends to dune toe areas normally dry all year. A severe storm is defined in this report as a storm at least on the order of a once in 10-year event which generates tides several feet above normal and storm waves which impact structures and backshore dunes. An extreme storm is a hurricane or intense northeaster which has a return probability on the order of a 100-year event or worse. Under such conditions, storm tides and waves approach an elevation of 10 feet above mean low water datum whereupon substantial erosion, flooding, and structure damage can occur.

Probable Damage by Reach Damage scenarios for each reach have been projected for the three levels of storm intensity described above. Because of the seawalls which extend from Onondaga Avenue to Southern Boulevard, damage at the northern sections of the Town would be limited. The unprotected beaches south of Southern Boulevard (except for the proposed revetment area from Widener's to Sloan's Curve) would be more erosion-prone during lesser events.

Probable damage scenarios for the Town of Palm Beach are described below for each class of storm. Damages are described for the various reaches as described in Table 9.5 which is reproduced from Chapter 4.0.

1. Mild Storm - Dune scarping in Reaches 4 (south of Southern Boulevard), 6, and 7. No effect to Reaches 1, 2, 3, 4 (to Southern Boulevard), and 5 (with DOT Revetment).

2. Severe Storm - Some flooding at roadway protective seawalls at Reaches 1 and part of 4. Possible seawall toe scour and damage. Loss of dune material in Reaches 4, 6, and 7. Possible seawall flanking and revetment damage.

3. Extreme Storm - hurricane or severe northeaster. Extreme water level and strong wave attack. Possible seawall failure and revetment damage within Reaches 1 to 7. Significant dune loss at Reaches 4, 6, and 7. Dune loss with overwashing at low points could occur at the north end of Town near Lake Worth Inlet.

9.4.3 Response Alternatives

Response Timing The decision on when to respond to an erosion emergency depends upon the severity of the storm, the degree and extent of damages, and the consequences to upland areas if the erosion damage is not mitigated. In general, the following list summarizes the range of responses which the Town can implement:

1. pre-storm response;

2. emergency action during storm;

3. immediate post-storm response; and

4. post-storm evaluation and repair.

TABLE 9.5

REACHES OF THE TOWN OF PALM BEACH

Reach 1	Lake Worth Inlet to Breakers Hotel
Reach 2	Breakers Hotel to Barton Avenue
Reach 3	Barton Avenue to Banyan Road
Reach 4	Banyan Road to Widener's Curve
Reach 5	Widener's Curve to Sloan's Curve
Reach 6	Sloan's Curve to southern limit of City of Lake Worth
Reach 7	Southern limit of City of Lake Worth to south limit of Town

A pre-storm response implies that one can accurately forecast the occurrence, intensity and impact of a storm such that contingency measures to bolster weak areas can be enacted. However, the inability to accurately predict the occurrence of storm events and their effects is limited such that this response level is uneconomical and impractical.

Emergency response during storm activity involves stopgap measures at areas where easy access is available to construction equipment and the structure in distress or in need of repair is vital to protect upland property or infrastructure. Historically, this response has been authorized by the Town at the Sloan's to Widener's Curve area where the threat of roadway loss and utilities damage to storm erosion dictated emergency fill placement to maintain the highway corridor. Other areas where this response might be warranted in the future are the roadway protective seawall areas in Reach 1. The seawall extending from Onondaga Avenue to Queens Lane would be the most likely area requiring future emergency response since vehicular access elsewhere within this reach can be detoured to westward streets. With the construction of the DOT revetment at Sloan's to Widener's Curve the need for emergency response to protect roadways during the storm will diminish.

An immediate post-storm response is warranted where a structure is in eminent danger of failure or has weakened to the point where less intense storms will worsen the damage and affect property loss. For non-protected portions of shoreline, this response would apply when dune erosion has progressed to the Town's Bulkhead Line and/or the point when upland structures are immediately exposed to damage from continued advance of the erosion. In these instances temporary measures to provide interim protection are warranted so that time is bought between successive storms, property damage is prevented, and more permanent repairs can be made at a later date.

The last response involves damage evaluation and action on a more relaxed basis. In this case the likelihood for further damage is not probable or the immediate threat to property has diminished so that appropriate design alternatives to mitigate the problem can be prepared. The Town's history of seawall repairs and maintenance may be thought of as responding to storm damage in this manner.

<u>Response Methodology</u> Procedural methods to mitigate erosion damage at distressed areas are best handled in an emergency situation by placement of stone riprap or sand fill because of their relative ease of installation, speed of placement, and tolerance forgiveness. Other methods such as construction of temporary timber bulkheads or other rigid structures require longer periods of calm between successive storms to permit installation and lend themselves to final repair measures as opposed to temporary fixes. Sandbags are typically used in

desperation to deal with emergency erosion events. However their effectiveness is limited to mild storm conditions. Because their placement is very labor intensive and not durable, their use is not recommended for the Town.

Emergency action during a storm event itself is further limited to placement of riprap and/or sand at effected areas which are readily accessible to delivery trucks. Furthermore, the ability to respond is limited to mild to severe storm events where wave action, wind velocity, and flooding do not expose the construction crew to unworkable or hazardous conditions. Unless equipment and material is stockpiled nearby, the response to the erosion emergency is limited to what can be dispatched from available material sources on short notice. For example, assume that a 1500 ft section of beach is being severely scarped during a moderate to severe storm such that damage to upland property is eminent. In this scenario, quarry stone would be dispatched from neighboring quarries to bolster the weakened areas. If 40 trucks were dispatached, approximately 2400 tons of stone could be delivered each day assuming three trips per each truck. The steep beach profile at Reach 7, for example, may require protection of a 10-ft high dune scarp which would need about 4 tons of stone per foot of beach. This implies that 2400 tons will armor 600 ft of dune leaving the last remaining 800 ft of the 1500 ft section 1 to 2 days from safety. All this assumes that access is available for placement of the material. Cost of such an operation would approach $72,000 considering that overtime labor rates may be imposed and mobilizing of extra construction equipment to place the stone as quickly as possible would be necessary. Clearly, the cost and logistics of emergency erosion responses need to be thought out well ahead of actual situations.

The Town of Palm Beach has limited physical equipment resources to respond with the level of effort and material as indicated by the above example. Therefore, the Town has historically relied upon outside contractors to furnish the necessary labor, equipment, and materials on an as-needed basis. Ranger Construction has been contracted in the past to furnish riprap and sand fill from their quarries located at Highway 441 and Lantana Road and 10 miles west of the Town at Okeechobee Road. The Company maintains over 600 pieces of equipment in West Palm Beach and has demonstrated rapid mobilization to erosion emergencies at the Sloan's to Widener's Curve area. The advantage to the Town in this arrangement is unique in that the contractor controls both the materials pit and equipment thereby circumventing the time consuming logistics of obtaining riprap or fill from independently owned quarries on holidays, weekends, or off-hours.

9.4.4 Permit Requirements

The Town of Palm Beach is authorized to provide emergency construction when bulkheads, groins and seawalls along Ocean Boulevard are threatened by action of the sea. This authority is provided in Section 19-45, Code of Ordinances, Town of Palm Beach.

Permits for emergency construction activities are authorized by both the Department of Environmental Regulation (DER) and the Department of Natural Resources (DNR). Each agency has it's specific authority in relevant sections of the Florida Statutes and rules contained in the Florida Administrative Code. These include:

- Chapters 161, 370 and 403 Florida Statutes
- Rules 16B-33 and 17-4 Florida Administrative Code

The Florida Department of Environmental Regulation outlines emergency permit procedures in 17-4.28(5) FAC. Emergencies are classified as either those which involve loss of life or property due to a natural calamity (Class A emergency) or those emergencies which do not threaten the immediate loss of life or property but which require immediate action for relief (Class B emergency). Temporary measures to provide relief during either class of emergency do not require a permit. Temporary measures are herein defined as minimum works required to protect life or property from loss. Although these measures do not require a permit, the procedures outlined in the FAC require that the Department be notified of emergency situations. The district office must receive notice of a Class A emergency immediately after the occurrence and within 24 hours after the occurrence of a Class B emergency. Following notification, a report must be submitted to the district office with 14 days detailing the temporary measures utilized to provide relief from the emergency. This report must provide a detailed description of the work performed and measures used to protect waters of the State from pollution while implementing temporary measures.

The Florida Department of Natural Resources outlines emergency permitting procedures in 16B-33.14 FAC. The Executive Director of the Department may authorize emergency permitting procedures in the event of an emergency resulting from critical erosion, beach, coastal or upland damage or damage to shore protection structures. Emergency permits are issued by the Department for the following:

- prevent imminent collapse of a structure;
- placement of sand fill or sand fill bags;
- repair or maintenance to an existing structure; and
- repair or construction of beach access stairs.

Following authorization of emergency permit procedures, the Division Director or designated staff can issue emergency permits after on-site inspection and evaluation of the emergency by department staff. Emergency permits will not be issued for the creation of new lands or for construction of structures which did not exist prior to the emergency. Further conditions on these permits require that FDNR form 73-116 be completed and submitted to the Department following completion of the temporary measures and provisions and conditions outlined in subsections 16B-33(2), (3), (6) and (7) of the FAC further apply to the issue of the emergency permits.

Palm Beach County Environmental Control Ordinance (No. 78-5 Code of Laws and Ordinances of Palm Beach County) adopts by reference in Chapters 161 and 403 Florida Statutes. Section 4 of the Environmental Control Ordinance requires Palm Beach Health Department approval for any activity requiring a FDER permit. This approval may be given by the County Health Director or his designated agent.

9.4.5 Recommendations

The Town should declare an erosion emergency when the existing Town Bulkhead Line is threatened with encroachment. In most instances this translates to distress at roadway protective seawalls.

Response methodology should be limited to placement of sand fill and/or stone riprap. Riprap is the most effective means to arrest erosion and protect structures weakened by storm damage. Sand fill is the second best defense against temporary erosion problems until more lasting repairs can be constructed.

Permitting of State approved emergency action is in conflict with practices to provide upland property protection. The DNR has indicated that riprap is an unacceptable alternative for beach erosion mitigation. Furthermore, inspection of the area in need of repair is required by a DNR official before approval of any action. This stipulation restricts the Town from responding to emergencies in a timely manner.

It is recommended that riprap be limited to placement:

1. behind failed or flanked seawalls; and

2. adjacent to erosion scarps behind the Town Bulkhead Line.

In both instances stone could be covered at a later date with sand or a rebuilt or new seawall. Further discussions with DNR are recommended to negotiate a variance to this policy which is consistent with the Town's need to maintain its existing and planned coastal protection system. Until such time as DNR amends its policy, sand fill should be solely used for emergency response.

It is recommended that the Town continue its present policy of contracting outside services to perform emergency erosion response work. The close proximity of experienced contractors and materials to the Town makes it more economical and efficient to utilize their services particularly since the need will be relatively infrequent.

The Town should stockpile concrete rubble it collects over the years for use during moderate erosion mitigation. This material could supplement the more costly riprap available from local quarries. Use of concrete rubble will require negotiation with DNR to the extent that rubble placement can be approved in advance of or during an actual emergency.

It is impossible to accurately forecast erosion events. However, the Town should conduct periodic pre- and post-storm beach surveys to make brief visual condition assessments of beach and structure conditions. Areas of distress or vulnerability should be noted for monitoring should a storm attack occur. In keeping with the Town's Hurricane Plan, storm monitoring and response should be limited to events of wind velocity less than 60 mph.

CHAPTER 10.0
IMPLEMENTATION

COMPREHENSIVE COASTAL
MANAGEMENT PLAN
FOR
TOWN OF PALM BEACH

10.0 IMPLEMENTATION

The basic components of the Comprehensive Coastal Management Plan consist of the following elements:

1. improvements to Lake Worth Inlet sand bypass plant;
2. seawall repair and maintenance in Reaches 1, 3 and 4;
3. beach nourishment in Reach 3;
4. dune maintenance in Reach 6; and
5. beach monitoring Townwide.

The implementation of a coastal management plan depends upon satisfaction of technical, environmental, financial, and political criteria. Each item is discussed below in more detail.

10.1 Technical Criteria

The Comprehensive Management Plan has been developed from information summarized in Chapters 3, 5, and 9. The Plan recognizes that improvements to the sand transfer operation at Lake Worth Inlet are critical to the well being of the Town's beaches. As discussed in Chapter 5 the volume of sand which has been retained at the north jetty has contributed to an aggravated condition which will become more serious unless mitigated. Mitigation of this deficiency should be a high priority. Because the Town's beaches are believed by Cubit Engineering to be so starved, interim nourishment is required. A feeder beach at Mid-Town is proposed because of the need for renourishment of the public bathing beach and the potential for the site to also serve to stabilize downcoast areas.

The Town has established a long commitment to coastal structures by the historical construction of seawalls and groins. The seawalls are an integral defense to upland property and infrastructure in the event of storms. Many of the groins have generally deteriorated to a non-functional state and those that pose hazards to bathers should be scheduled for removal as financial capabilities may allow. Maintenance of seawalls should continue to be a top priority. Reach 6 contains some of the widest beach in the Town, and the dunes which exist there should be enhanced using vegetation and sand fencing techniques.

Lastly, the technical aspects of the Plan recognize that the data base discussed in Chapters 3.3 and 5.3.2 and used to predict future shoreline trends in the Town is deficient. Therefore the Plan recommends that a beach monitoring program be initiated so that the Plan can be adjusted in the future to address additional needs for nourishment and structure modifications.

10.2 Environmental Criteria

This Plan has been developed to be the least disruptive to the nearshore and offshore environmental resources of the Town. Chapter 7 provides a detailed background of the resources and the potential impacts that can be associated with beach nourishment and coastal structure improvements in the Town. The critical items that can cause problems in implementing the Plan relate to burial of nearshore and offshore rock and reef outcrops, damage to worm reef habitat, reef damage caused by dredge operations and disruption to sea turtle habitat.

The proposed nourishment at Mid-Town is located in an area presently free of nearshore anastasia rock outcrops. The proposed sand bypass improvements at Lake Worth Inlet would extend the point of sand discharge to nearshore rock areas. However, historical data indicate that this reef is buried and exposed periodically. By implementing an adequate environmental monitoring program, dredge operations can be specified to limit reef damages from direct contact and turbidity. The Town as part of its proposal to nourish Mid-Town should provide more detailed documentation of the offshore reef resources, character of borrow sands, onshore habitat, and turtle mitigation plans to verify for the regulatory agencies that no impacts would occur.

The removal of derelict groins will have minimal environmental impacts. The proposed groin removal program at Mid-Town by the Town and State has established precedent for the necessary permit approvals associated with future groin demolition.

Dune enhancement clearly is an environmental benefit as habitat is increased and shifting sands are more stabilized. Dune stabilization techniques are discussed in Chapter 8.2.7.

10.3 Financial Considerations

The total cost of the proposed Plan dictates that the components be prioritized and scheduled over a period of time to enable the Town to develop a suitable funding strategy. Table 10.1 presents a prioritization program which may be approved by Town Council and amended from time to time. Certain tasks within the Plan can be performed immediately and relate to seeking resolution on the extent of participation on projects by other governmental agencies. The first four items are study and administrative tasks which seek to resolve outside funding participation. The remaining items require capital expenses to construct or implement the components of the Plan.

Table 10.2 suggests a timetable to pay for the various aspects of the Plan. With the exception of the roadway protective seawall repairs recommended by the Town Engineer for the summer of 1986, the first year should be devoted to adoption of the

Comprehensive Plan, developing funding commitments and strategies, and seeking to resolve the Section 111 plan proposed by the Corps of Engineers. In terms of the major Plan elements, the following actions are recommended.

TABLE 10.1

COMPREHENSIVE PLAN TASK PRIORITIZATION

1. Negotiate Section 111 Plan with Corps of Engineers
2. Revise benefit/cost analysis at Mid-Town beach area
3. Seek early implementation of revisions to Lake Worth Inlet bypass plant
4. Finalize funding strategy to cover costs of beach projects
5. Monitor all reaches
6. Repair and maintain roadway protective seawalls at regular intervals
7. Nourish beach at Mid-Town
8. Modify groins in Reach 4
9. Remove derelict groins
10. Encourage dune enhancement in Reach 6
11. Encourage private ownership to periodically inspect and maintain seawalls and other structures

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10.3.1 Improvements to Lake Worth Inlet Bypass Plant

The Corps of Engineers has proposed in their Draft GDM (Corps of Engineers, 1985) that the damages attributable to Lake Worth Inlet are a 50 percent Corps funding responsibility. The Corps would therefore pay approximately 50 percent of an initial beach fill placed from the south jetty to Country Club Road. Maintenance of the area would be provided by Corps dredging of the Inlet on a biannual basis and at their expense. The County would continue to operate the sand bypass plant presumably with the same inefficiencies as presently exist.

The Corps is currently considering modifying its Section 111 plan by proposing to construct a new sand transfer plant at Lake Worth Inlet. This action is being considered as an alternative means of constructing the initial beach fill south of the Inlet. The Corps would operate the plant for up to 10 years and then turn it over to local interests (presumably Palm Beach County) for perpetual operation. The Corps would propose to substitute this new plant for the alternative presented in the GDM. It is assumed that the same cost sharing formula discussed in Chapter 5.3.2 would apply, but the initial cost would be targeted for under 1 million dollars so that the need for Congressional authorization would not be required.

TABLE 10.2
TEN YEAR IMPLEMENTATION SCHEDULE
COMPREHENSIVE COASTAL MANAGEMENT PLAN
TOWN OF PALM BEACH

Estimated Costs In Thousands of 1986 Dollars

	Fiscal Year (Oct.1 – Sept.30)	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
REACH 1 Lake Worth Inlet to Breakers Hotel	Replace bypass plant*			1080							
	Roadway protective seawall repair**						438				
	Groin removal								204	202	202
	Monitoring	2.4	2.4	2.4	2.4						
REACH 2 Breakers Hotel to Barton Ave.	Monitoring	1.2	1.2	1.2	1.2						
REACH 3 Barton Ave. to Banyan Road	Roadway protective seawall repair		498	498	364	364					
	Groin removal	226									
	Beach nourishment		400	3038							
	Monitoring				2.4	2.4	2.4	2.4			
REACH 4 Banyan Road to Widener's Curve	Roadway protective seawall repair	416									
	Groin maintenance and removal		2.1		164						
	Monitoring	2.4	2.4	2.4	2.4						
REACH 5 Widener's Curve to Sloan's Curve	DOT revetment ***	7480									
	Monitoring	1.2	1.2	1.2	1.2						
REACH 6 Sloan's Curve to City of Lake Worth	Dune maintenance			40							
	Monitoring	2.4	2.4	2.4	2.4						
REACH 7 City of Lake Worth to South Town Limit	Monitoring	2.4	2.4	2.4	2.4						
Roadway Protective Seawall Repairs Reaches 1, 3, and 4 (To be determined by further studies)								500	500	500	500
ESTIMATED COST SUB-TOTAL		8134	931	4668	542	366	440	502	704	702	702
ESTIMATED COSTS TO POTENTIALLY BE PAID BY OTHERS ****		7641	188	3388							
ESTIMATED COSTS TO POTENTIALLY BE PAID BY ASSESSMENT *****		208	259	249	264	182	219	250	352	351	351
ESTIMATED COST TO THE TOWN OF PALM BEACH		285	484	1030	278	184	221	252	352	351	351

* – Lake Worth Inlet bypass plant improvements by others
** – Seawall repair costs as estimated by Mock, Roos & Associates + 10% contingency
*** – Cost of revetment by DOT
**** – Assumes 75% state funding of groin removal in Reach 3, except engineering and contingencies, 75% state funding of non-federal share of beach nourishment costs (except engineering) in FY 1987 and 1988, and 28% federal funding of beach fill cost in FY 1988
*****– Assumes 50% assessment to private ownership for groin and seawall work

Note: Costs include 10% for engineering and 10% contingency.
Refer to Plan text for understanding of project limits and type of work.
This program should be reviewed and revised annually during the Town's budget and capital improvement program and budgeting process.

TABLE 10.2 (cont.)
TEN YEAR IMPLEMENTATION SCHEDULE
Estimated Cost Breakdown

Roadway Protective Seawall Repair Cost Delineation *

Fiscal Year	Reach	Repair & Location	Estimated Cost
1986	4	Anchor repairs Via Bellaria to 'S' Curve	270,000 **
		Gunite repairs Via Bellaria to 'S' Curve	92,000
			362,000
		+5% engineering ①	18,100
		+10% contingencies	36,200
			$416,300
1987/88	3	Anchor repairs 'S' Curve to Hammon Ave.	695,000
		Gunite repairs 'S' Curve to Hammon Ave.	135,000
			830,000
		+10% engineering	83,000
		+10% contingencies	83,000
			$996,000
		Schedule repairs over FY 1987 and 1988 @$498,000 each	
1989/90	3	Anchor repairs Royal Palm Way to Australian Ave.	176,000
		Gunite repairs Hammon Ave. to Seabreeze Ave.	120,000
		Toewall construction Australian Ave. to Peruvian Ave.	310,000
			606,000
		+10% engineering	60,600
		+10% contingencies	60,600
			$727,200
		Schedule repair over FY 1989 and 1990 @$364,000 each	
1991	1	Anchor repairs Bahama Lane to Country Club Road	155,000
		Gunite repairs Bahama Lane to Country Club Road	100,000
		Replace concrete wall cap Wells Road to Grace Trail	110,000
			365,000
		+10% engineering	36,500
		+10% contingencies	36,500
			$438,000

Groin Removal and Modification Cost Delineation ***

Fiscal Year	Reach	Action	Estimated Cost
1986	3	Remove groins 96+700 to 100+1160 2140 LF	215,000
		+5% engineering ①	10,750
			$225,750
1987	4	Remove 25' of groin 109+750 Remove 50' of groin 65S Remove 100' of groin 66S 175 LF @$100/LF	17,500
		+10% engineering	1750
		+10% contingencies	1750
			$21,000
1989	4	Remove groins 9S to 20S 1370 LF @$100/LF	137,000
		+10% engineering	13,700
		+10% contingencies	13,700
			$164,400
1993/94/95	1	Remove groins 135N to 34N 5070 LF @$100/LF	507,000
		+10% engineering	50,700
		+10% contingencies	50,700
			$608,400
		Schedule removal over FY 1993,1994,1995 @$202,000 each	

Beach Nourishment Cost Delineation

Fiscal Year	Reach	Action	Estimated Cost
1987	3	Preliminary engineering	$50,000
		Detailed engineering	100,000
		Environmental studies	150,000
		Sand source study	100,000
			$400,000
1988	3	Beach nourishment Barton Ave. to Gulfstream Road (503,000 CY)	2,762,000 ****
		+10% contingencies	276,000
			$3,038,000

Lake Worth Inlet Bypass Plant Replacement (Reach 1) *****

Estimated construction cost	900,000
+10% engineering	90,000
+10% contingencies	90,000
	$1,080,000

Dune Maintenance @Phipps Ocean Park (Reach 6)

1200 LF sand fence @15/LF	18,000
24,000 SF vegetation @$0.25/SF	6,000
2 dune walkovers @$4,500 each	9,000
	33,000
+10% engineering	3,300
+10% contingencies	3,300
	$39,600

Beach Monitoring (Townwide)

Assume 17 profiles @$600 EA/YR	10,200
+10% engineering	1,020
+10% contingencies	1,020
	$12,240

NOTES:

① – Reduced engineering cost since design engineering previously completed

* – Roadway protective seawall repair costs from Mock, Roos, & Associates, 1985 three year plan; repairs were rescheduled over longer time period in this table on basis of geographic location and repair priority originally recommended (see Table 4.3 in Chapter 4.0)

** – Repair cost in 1986 for Via Bellaria to 'S' Curve adjusted to reflect possible cost savings from alternative anchor repair method

*** – Cost based on unit removal price of $100/linear foot of groin. Method assumes cut-off below sand line. For complete removal of groin sheet piles, costs may be higher

**** – Assumes unit price of $4/CY and mob-demob cost of $750,000; combining project with other work (e.g. City of Lake Worth federal beach nourishment project) can reduce total cost

***** – Construction cost estimate by Corps of Engineers

The Town is not bound to participate in funding of the plant improvements. However, unless matching funds can be generated, it is not likely that the Section 111 mitigation will be constructed. It is recommended that the Town coordinate with the Palm Beach County, Port of Palm Beach and the Florida Inland Navigation District (FIND) to develop a local sponsor. Grant monies from FIND might be made available to reimburse some of the construction costs. Because the FIND program is new it is unclear even to FIND how their grants will be dispersed.

If the Corps reverts to its earlier Section 111 plan presented in the GDM, the Town has two options. First it may try to seek matching funds from elsewhere or, second, it could challenge the finding of the Corps. In the opinion of Cubit Engineering the latter approach may not be fruitful. Political negotiation will be required to alter the financial responsibility as determined by the Corps.

10.3.2 Beach Nourishment at Mid-Town

Funding for the Mid-Town beach nourishment project can come from three sources. The Town can provide 100 percent of monies required, State and Federal participation can be requested, or the Section 111 project can be challenged to move the initial fill from the south jetty to Mid-Town. Political negotiation will be required to shift the Section 111 project to include Mid-Town. Successful cost sharing by State and Federal agencies will depend on revising Corps of Engineers cost/benefit analysis for the North Palm Reach 5b (defined in Draft GDM as Mid-Town to the mid point of Reach 6). Presently the cost/benefit ratio calculated by the Corps for this reach is 0.63.

The Corps has recently revised its analysis of the Mid-Town area and has determined that a Federal project is feasible from Barton Avenue to Southern Boulevard. Preliminary estimates indicate that the 2.1 mile stretch of beach can be renourished at an approximate cost of $3 million. Federal cost sharing would range from 28 to 41 percent depending on the amount of public access and parking provided past Mid-Town. It is recommended that this project be explored further in terms of financial details and necessary Town commitments.

Creation of a new special independent taxing district as discussed in Chapter 6 is one method for the Town to independently provide 100 percent of construction and maintenance monies. In this regard, it is recommended that the Town give further consideration to having the private sector surveyed to determine the level of interest in providing funds for beach nourishment.

10.3.3 Seawall Repair

Table 10.2 summarizes the projected costs for roadway protective seawall maintenance and repair identified by the Town Engineer. Approximately $2.6 million of projected repair costs were distributed over a 6 year period to reduce the annual capital expenditures. Table 10.2 lists the estimated seawall repair schedule which was developed from Table 4.3 in Chapter 4.0. Other seawall repairs that have been itemized in Table 4.3 as non-scheduled have not been budgeted for repair as yet. Therefore it is recommended that the Ten Year Implementation Schedule budget approximately $500,000 annually beyond 1991 to address these and other future maintenance requirements, and these amounts be refined based upon further research and definition of necessary scopes of work.

A study was recently completed to determine the structural capacity of the roadway protective seawalls between Banyan Road and Clarendon Avenue (Cubit Engineering Limited, 1986). The results of the study indicated that consideration should be given to a long range need for repair and/or replacement of the vertical wall segments of the original 1929 steel sheet pile designs. These structures may have satisfied their expected service life and may be deteriorated to the point where more substantial structural repairs might be necessary. It is recommended that the Town evaluate the remaining service life and prepare a more detailed capital improvement schedule for roadway protective seawall repair that further considers existing structural conditions.

Chapter 6 of the Town Building Code does not address maintenance of privately owned seawalls. It is recommended that the Town consider amending the Code to require maintenance provisions and repair when necessary to ensure that adjoining properties are not subject to erosion damage and to preserve the overall seawall system Town-wide.

Roadway seawall repair costs in Reaches 3 and 4 can be deferred until subsequent years if the Mid-Town beach renourishment project is implemented and maintained. The beach fill is designed to last for a minimum of 7 years barring the occurrence of severe hurricanes during that period. Therefore the $1.7 million seawall repairs identified for Reach 3 may be able to be deferred since the restored beach elevation would provide adequate protection and wall stability; if deferred, the scope of work and estimated costs for roadway seawall repairs should be reviewed for revisions as costs may be able to be reduced.

10.3.4 Groin Removal

Approximately $868,000 has been identified for the removal or modification of groins in Reaches 1 through 4. These groins were originally constructed on a 50/50 cost sharing basis between the

Town and those property owners who benefited from the structures. Therefore it is suggested that the cost of groin removal be at least a 50 percent responsibility of the affected private land owners. This item should be considered for Ordinance definition.

10.3.5 Dune Enhancement and Beach Monitoring

These costs are relatively minor in comparison to the other elements of the Plan. Funds could be provided from ad valorem tax revenue or creation of a special tax district as discussed below. Phipps Ocean Park and the Par 3 Golf Course are the most appropriate areas for dune enhancement. It is recommended that a pilot demonstration project be initiated at Phipps Ocean Park. Because it is a public facility, State funding may be available to provide sand fencing, vegetation and new beach dune walkover structures.

The Town should periodically monitor its beaches via measurement of existing DNR profile lines. As a minimum a survey of the 17 profiles summarized in Appendix B should be performed at least once per year and preferably twice per year to measure seasonal variation. The 17 profiles listed in Appendix B reflect DNR monumentation which presently exists. Once the DNR re-establishes destroyed monuments, additional or alternate profile measurement may be appropriate. The survey party should record beach elevation from the monuments to at least wading depth. Using float boards, the profile may be extended to the -18'MLW depth contour which is more desirable.

10.3.6 Special Taxing District

As discussed in Chapter 6 the Town can assure itself of control over its shoreline management via the creation of an independent special taxing district. In this manner a trust fund can be set up to pay for those capital expenditures that make up the Comprehensive Plan. It is recommended that this mechanism be pursued and investigated even if it is only used to fund nominal items such as beach monitoring costs. Creation of a district will require State legislative consent and therefore the action will require political action to implement it.

10.4 Political Considerations

The implementation of the Town's Comprehensive Coastal Management Plan will require political negotiation to develop a workable program. The principal areas of political effort concern negotiation of the Section 111 proposal, creation of a Federal project at Mid-Town, and if the Town elects, the creation of a new independent special taxing district to pay for beach related construction and maintenance costs. Koppelman (1978) has found that it is the political aspect of erosion control that is the deciding factor in the implementation of a program. Implementation does not occur solely on the basis of technical rationality. When viewed from the standpoint that mediation and compromise are part of such a process, erosion control plans can be successfully enacted.

Three items are recommended for Ordinance consideration. First, maintenance and repair of non-roadway privately-owned protective seawalls should be addressed in the Town Code to prevent damages to adjacent properties due to failed sections. Second, cost sharing of groin removal on a joint private ownership and Town participation should be established. Third, it is recommended that a 30-year erosion line deed disclosure provision be required in the sale of oceanfront property to inform future property owners of their exposure to erosion impacts.

The non-roadway protective seawall maintenance and repair ordinance for private properties should address the following:

1. the type of inspection and definition of responsibility to check for structural problems;

2. a requirement to repair failed or storm damaged sections on an as-observed basis by the Town; and

3. the procedures for Town approval and enforcement of private structure inspection and repair.

The groin removal ordinance should contain language which defines the responsibility for groin removal and maintenance Town-wide. A formula for cost sharing between the Town and affected private property should be specified. Finally, the ordinance should delegate the authority for managing groin improvements to the Town.

The 30-year erosion line deed disclosure ordinance should outline the requirement of disclosure at the time of property sale. The ordinance should cite the provisions of Rule 16B-33.24 of the Florida Administrative Code (Thirty-Year Erosion Projection Procedures) and require the property seller to retain a Florida Registered Professional Engineer to calculate and certify the 30-year line. Finally, the Town should define the reporting procedure to enforce disclosure and specify that copies of the calculated data also be submitted to the Town for data reference purposes.

APPENDIX A

COMPREHENSIVE COASTAL
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APPENDIX A

LIST OF REFERENCES

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APPENDIX B

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APPENDIX B

COMPARATIVE BEACH PROFILES

AUGUST 1986

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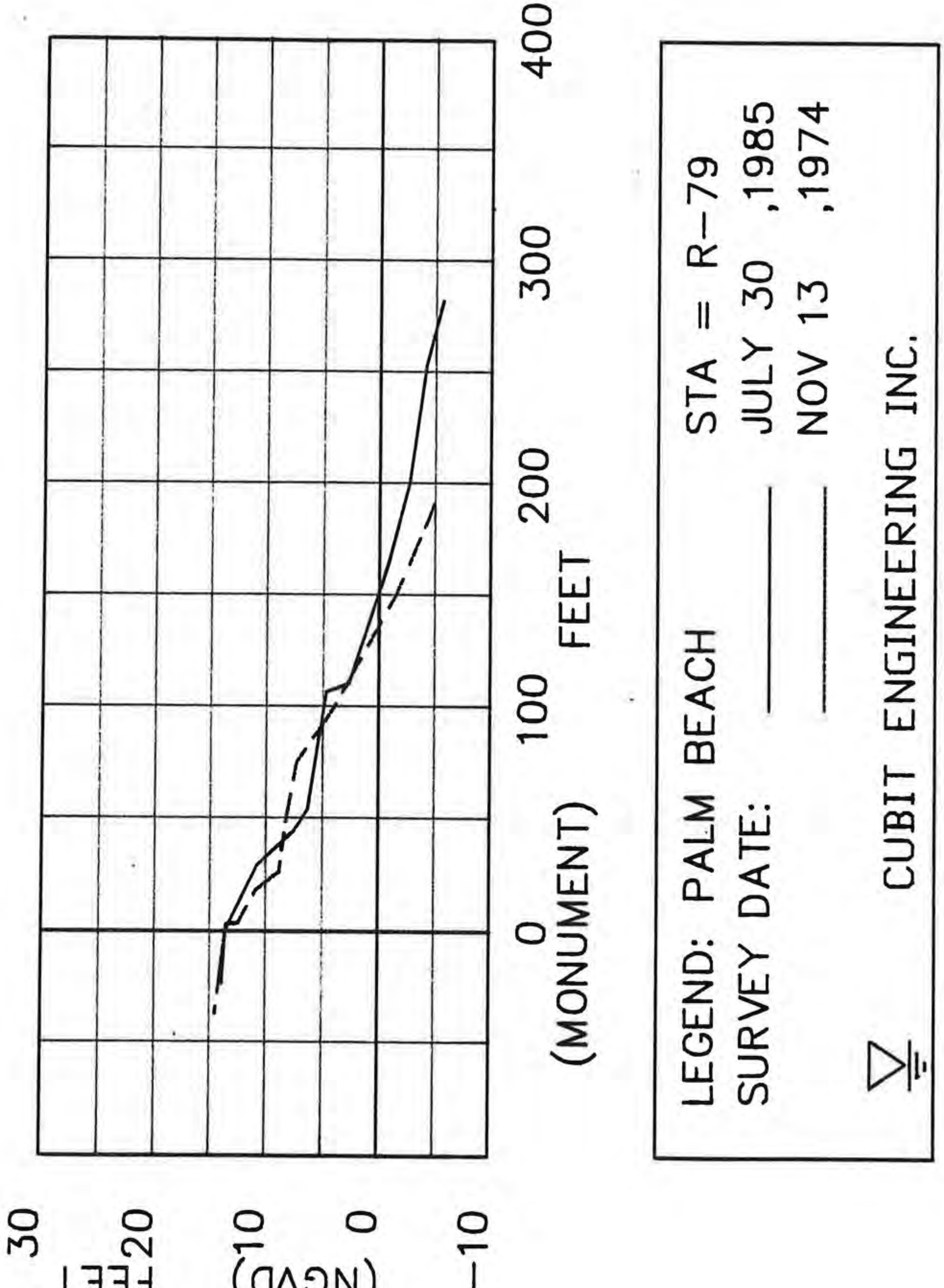
Note: 1985 data surveyed by Hutcheon Engineers



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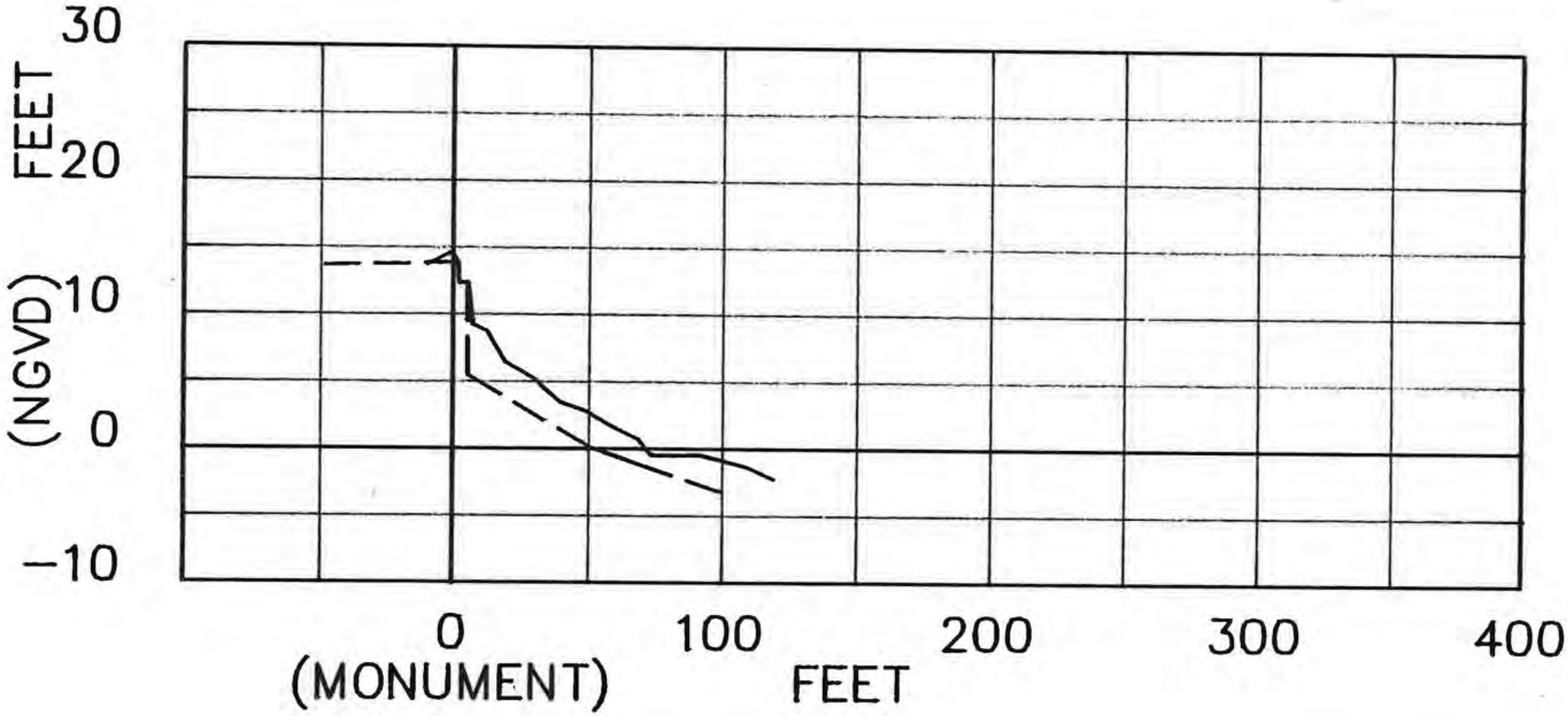

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CUBIT ENGINEERING INC.

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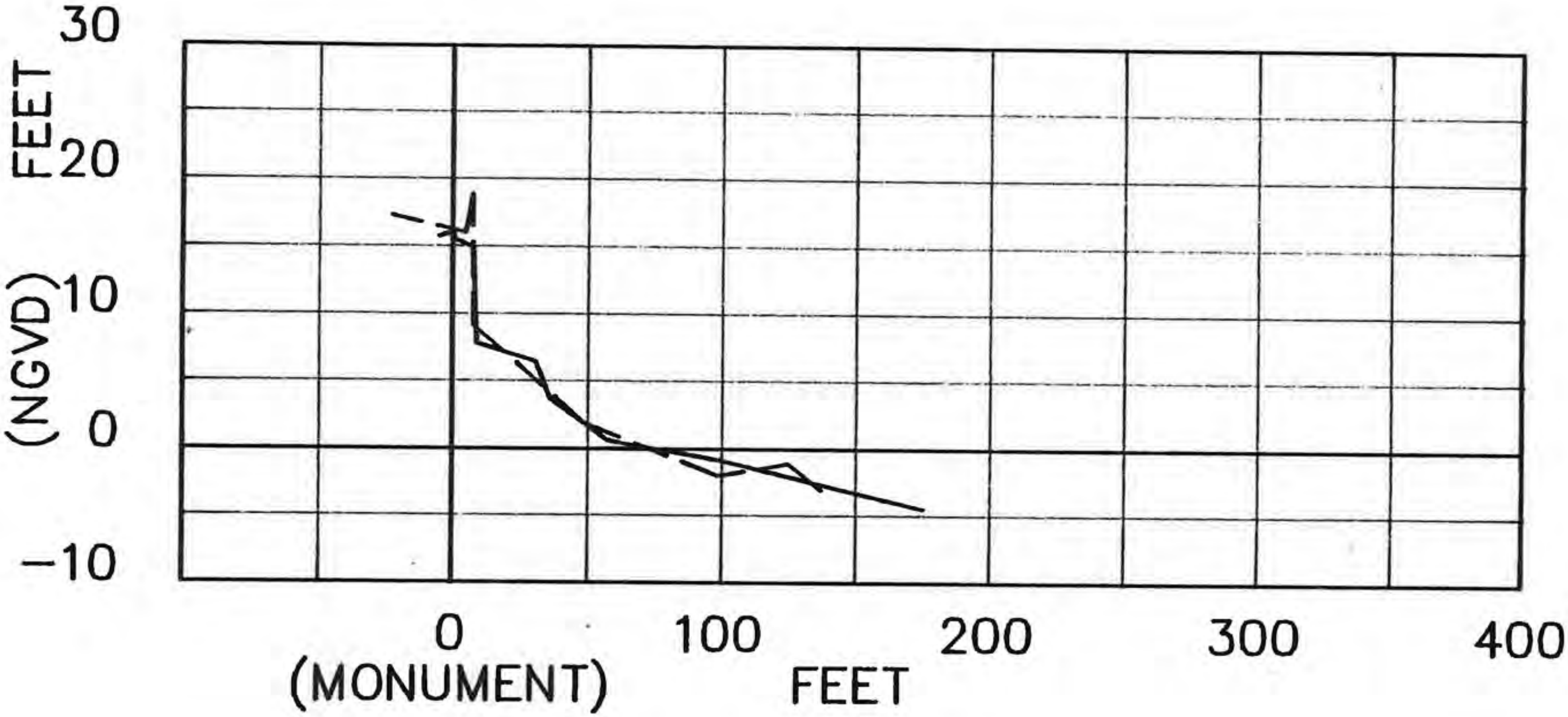

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CUBIT ENGINEERING INC.

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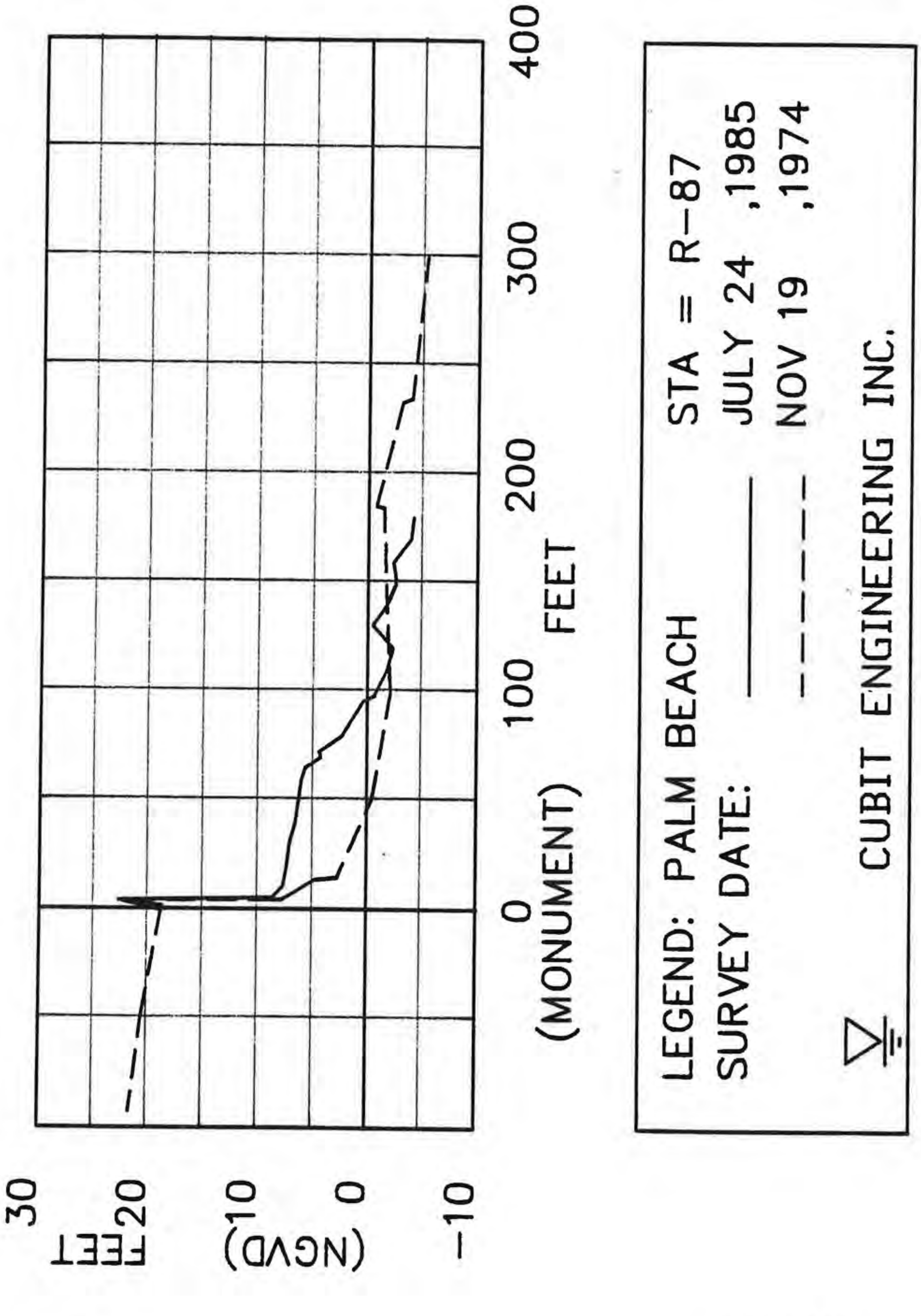
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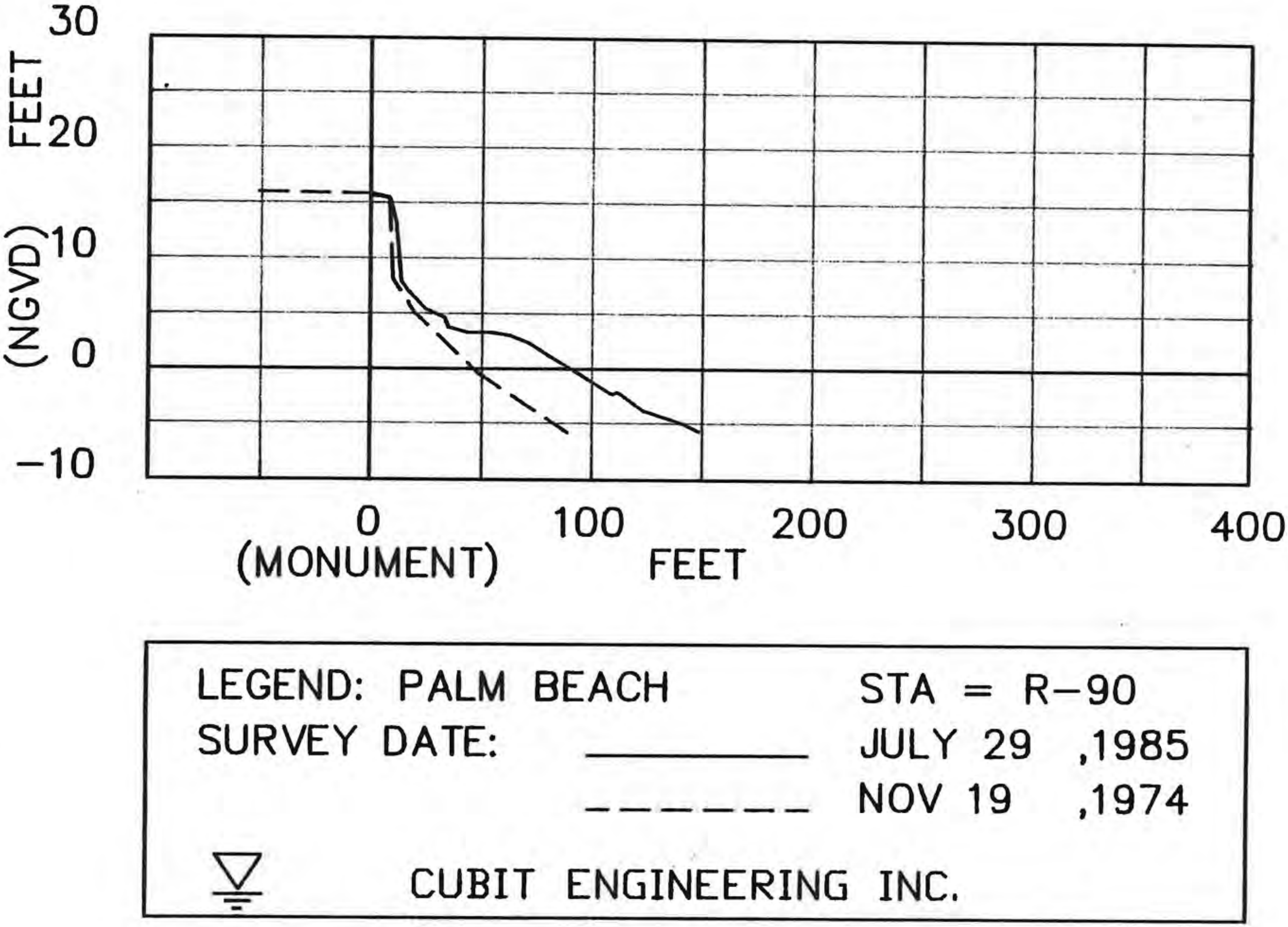
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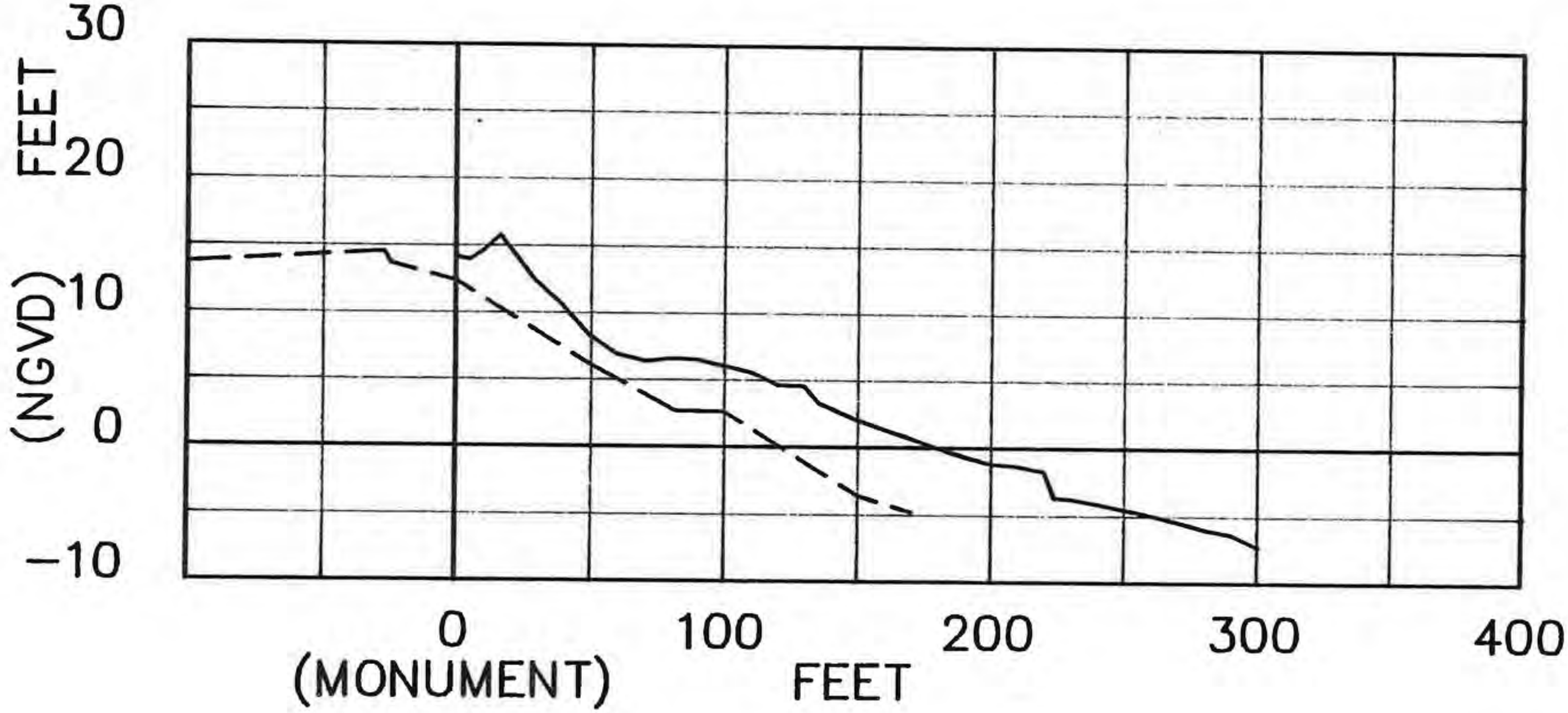

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CUBIT ENGINEERING INC.

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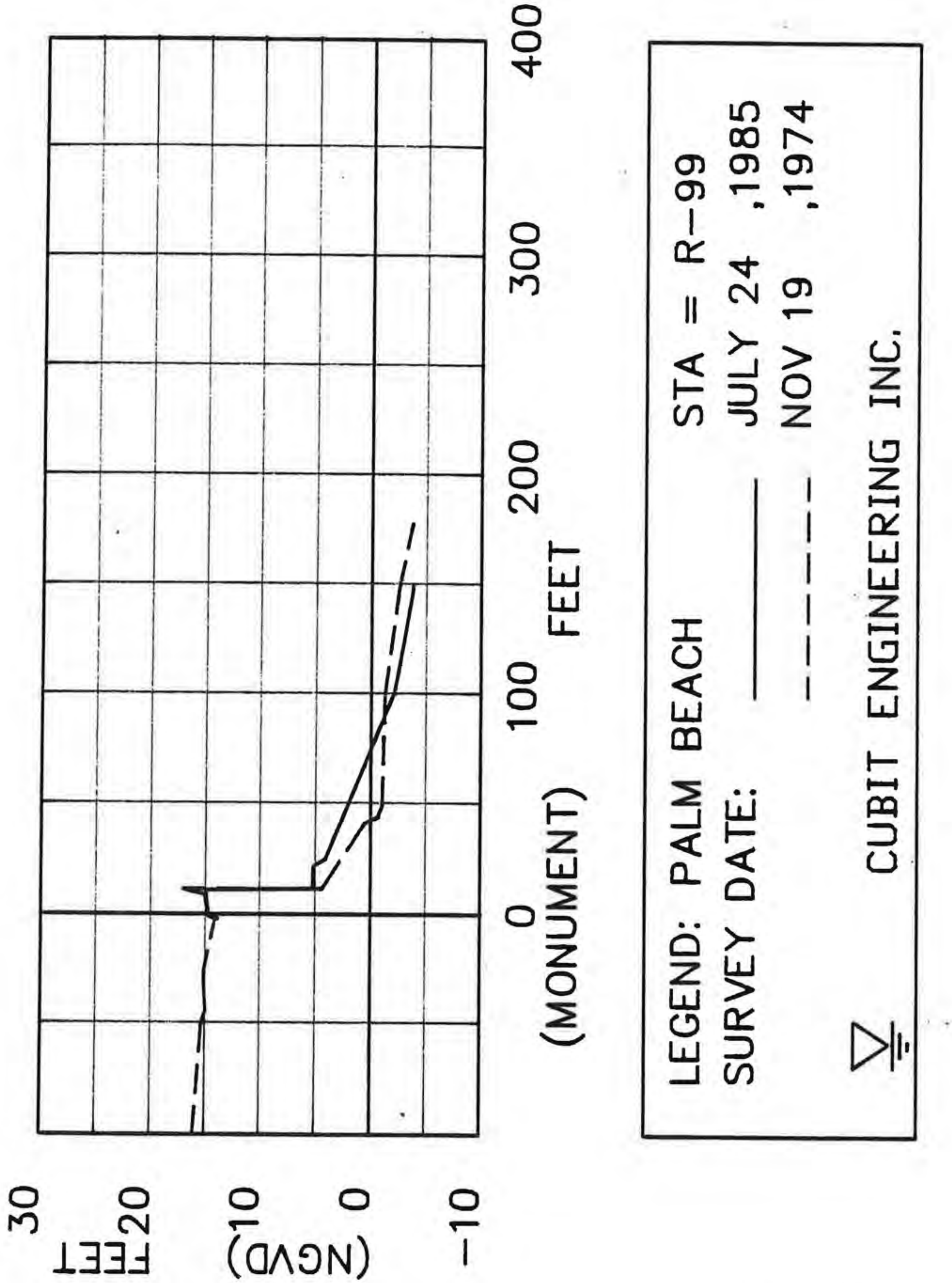

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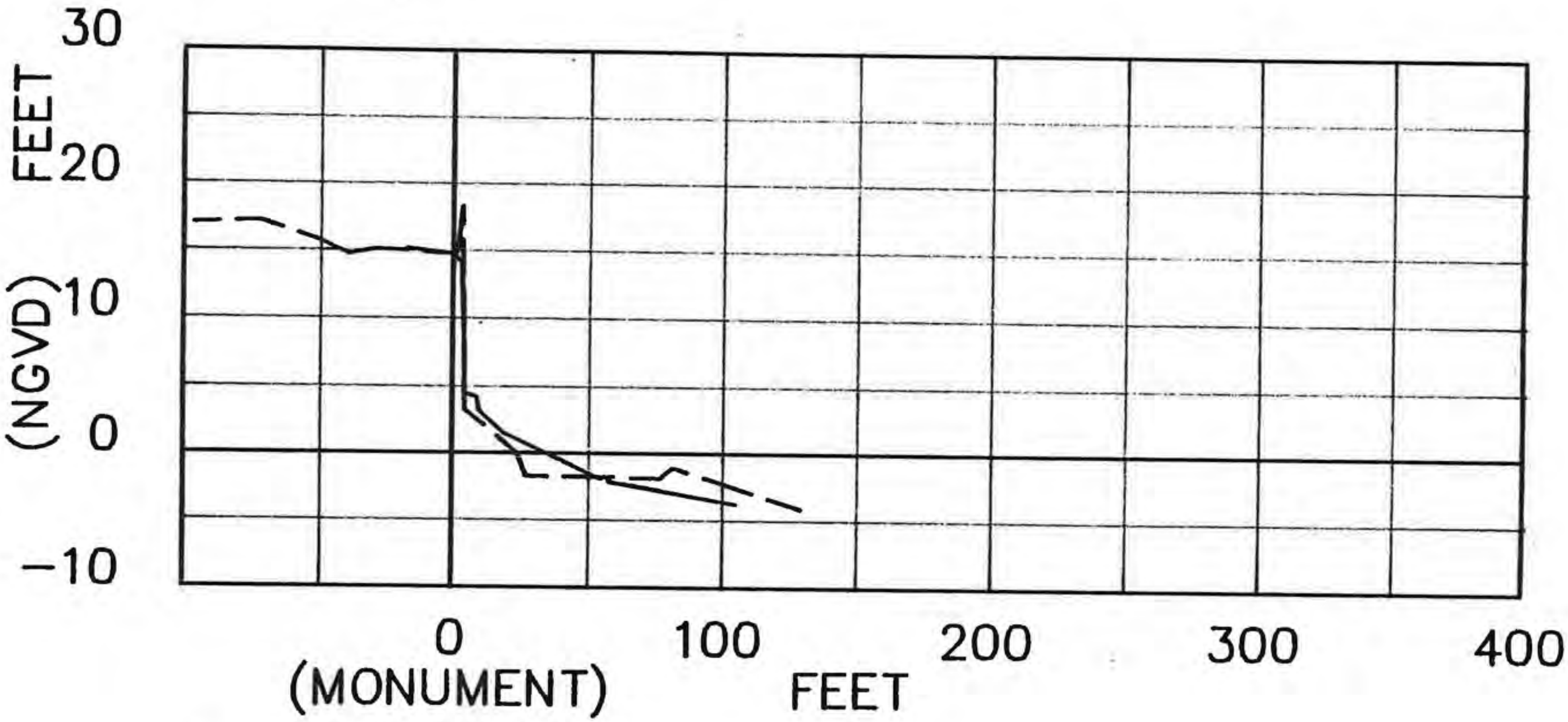
AUGUST 1986



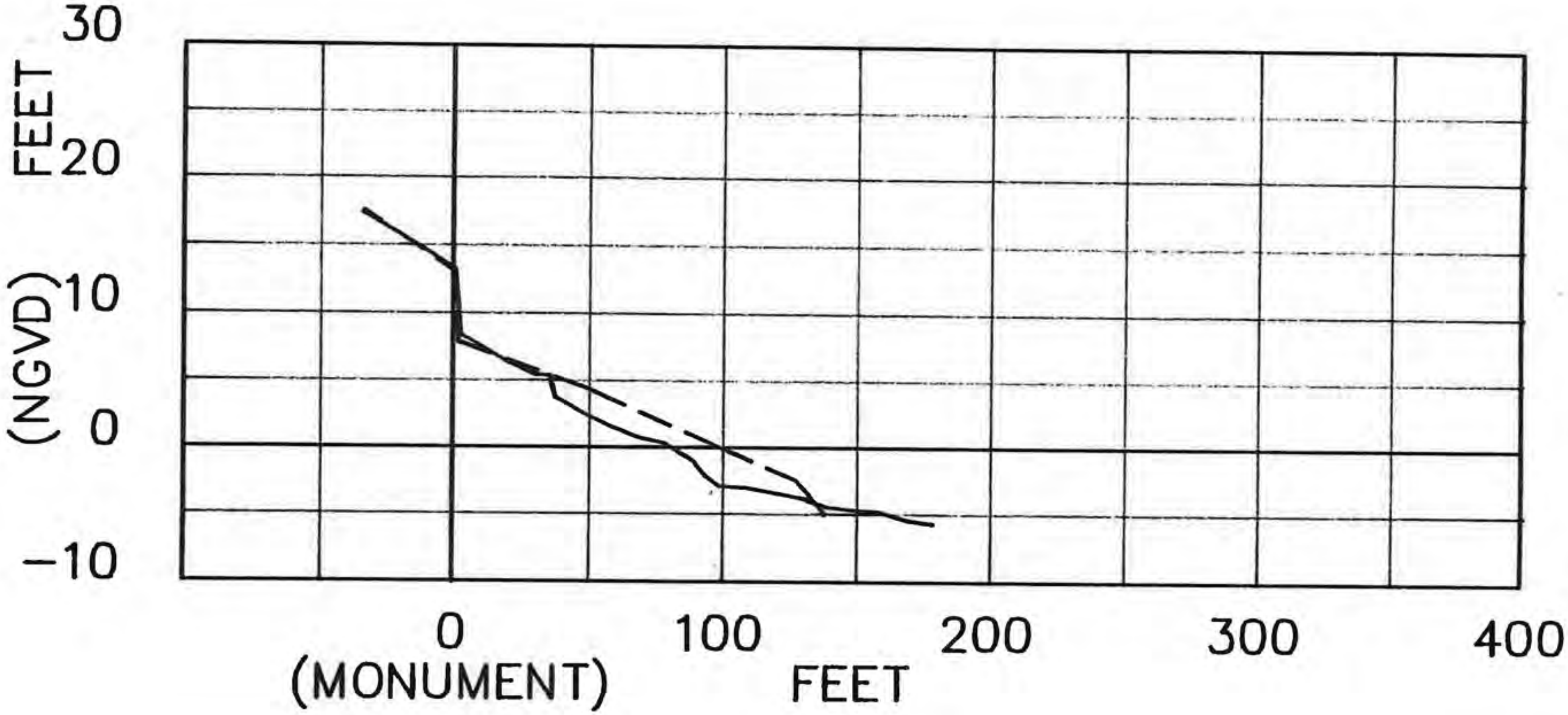
LEGEND: PALM BEACH STA = R−102

SURVEY DATE: ———— JULY 24 ,1985

- - - - - - - NOV 19 ,1974

CUBIT ENGINEERING INC.

Figure B8



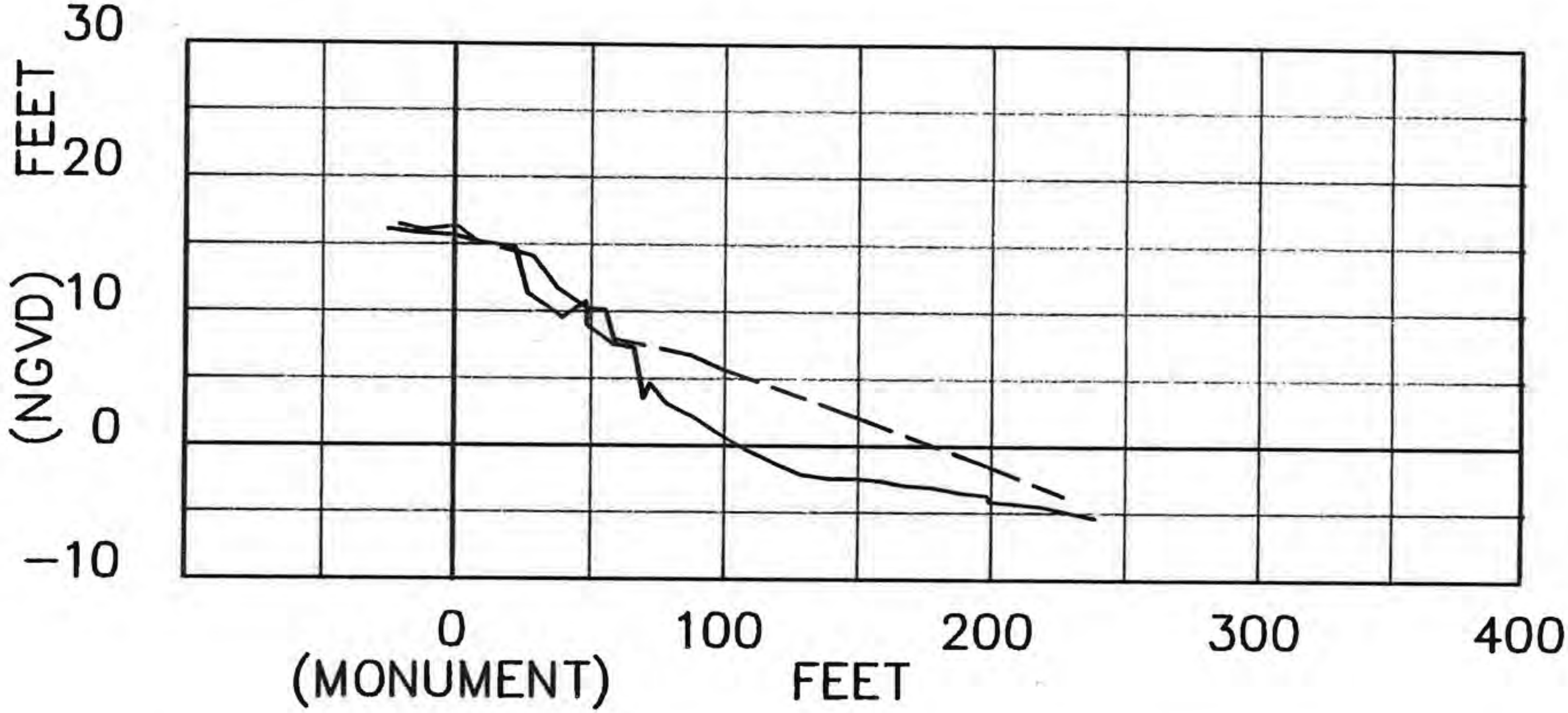
LEGEND: PALM BEACH STA = R-106

SURVEY DATE: ———— JULY 31 ,1985

– – – – – – NOV 19 ,1974

CUBIT ENGINEERING INC.

Figure B9



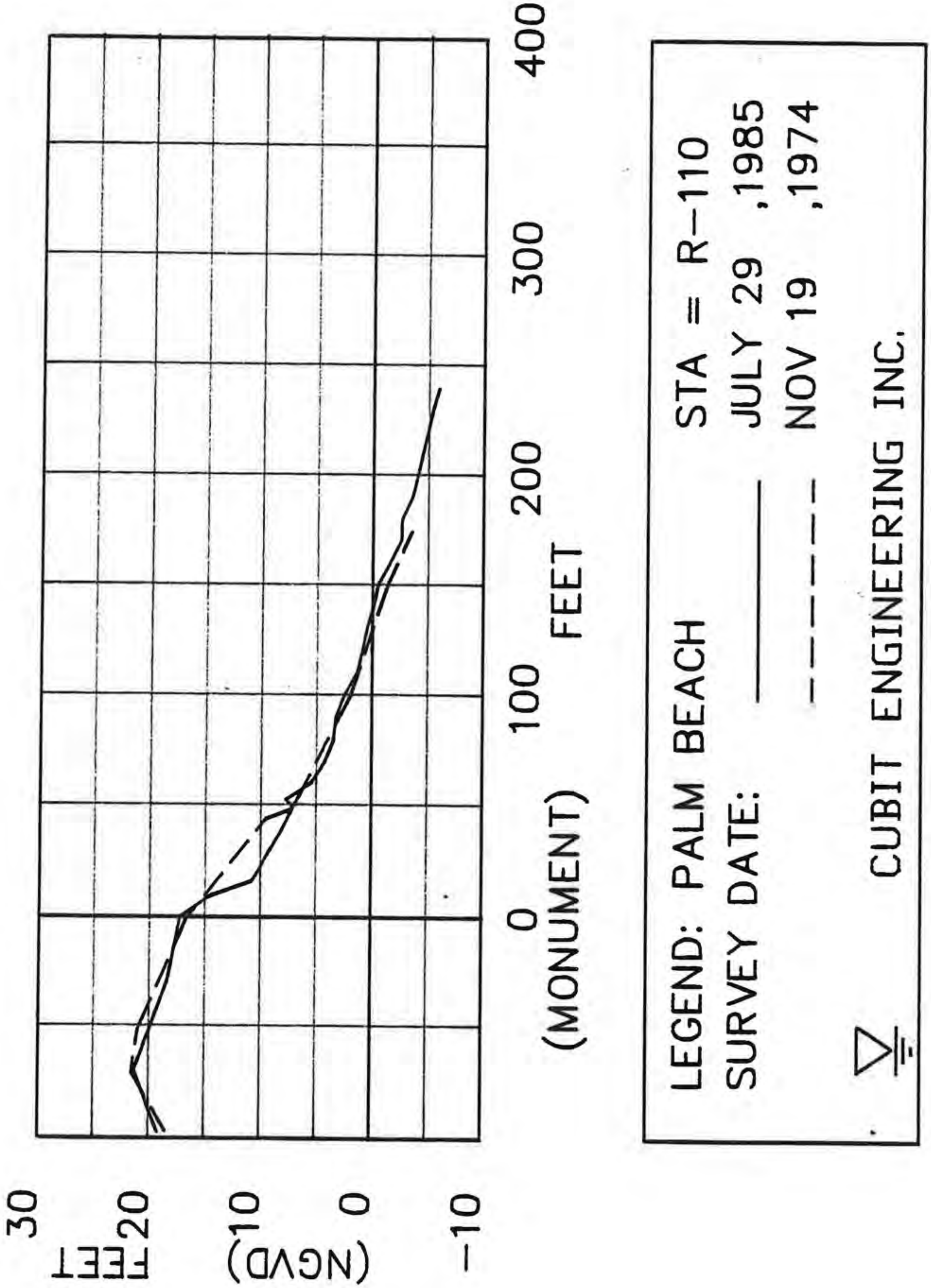
LEGEND: PALM BEACH STA = R–108

SURVEY DATE: ________ JULY 29 ,1985

\- - - - - - - NOV 19 ,1974

CUBIT ENGINEERING INC.

Figure B10



FEET (NGVD)
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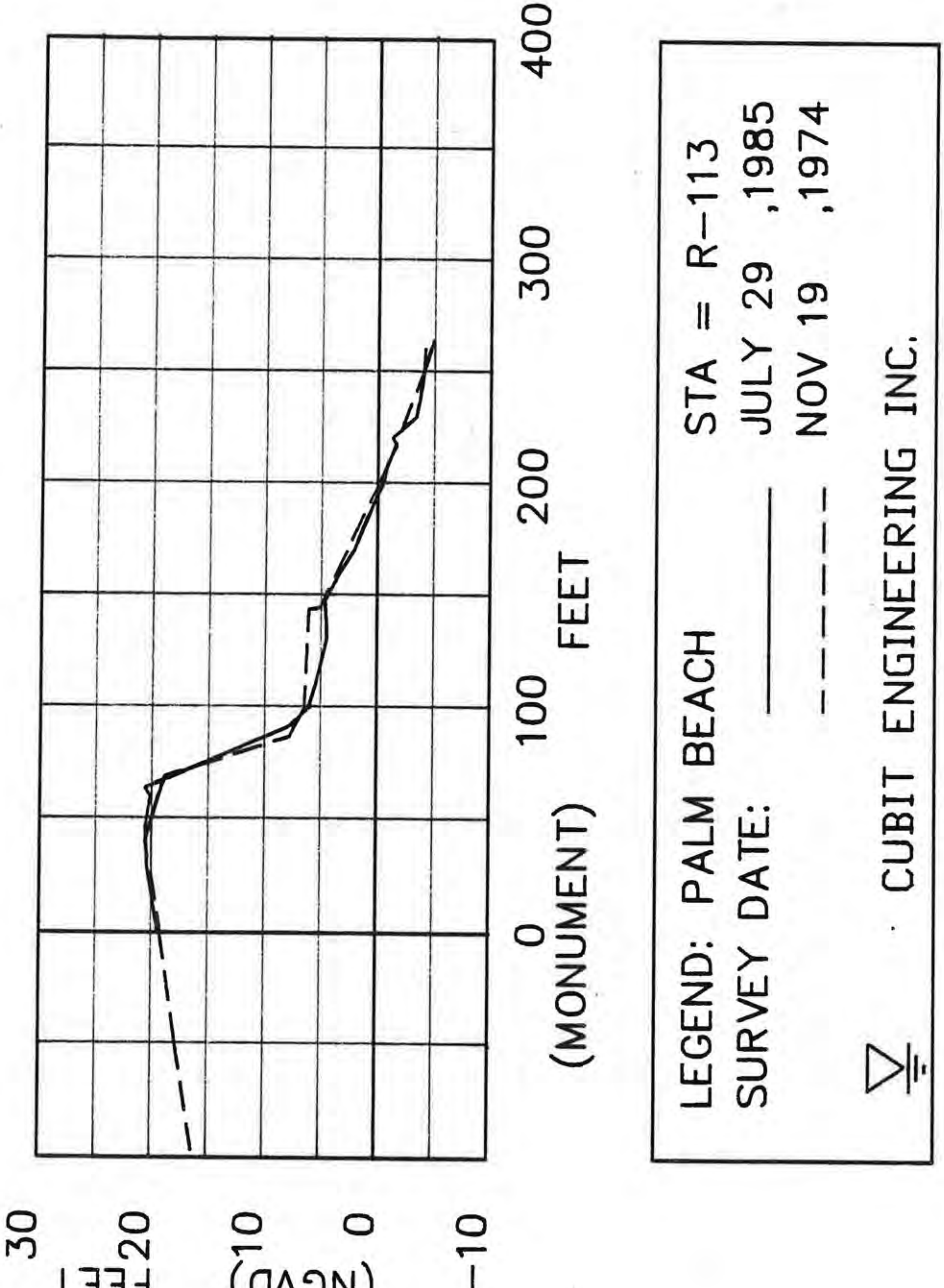
20
10
0
-10
0 (MONUMENT)
100
200
300
400
FEET
LEGEND: PALM BEACH
STA = R-110
SURVEY DATE:
JULY 29 ,1985
NOV 19 ,1974
CUBIT ENGINEERING INC.

Figure B11



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-10
FEET (NGVD)
0 (MONUMENT)
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FEET
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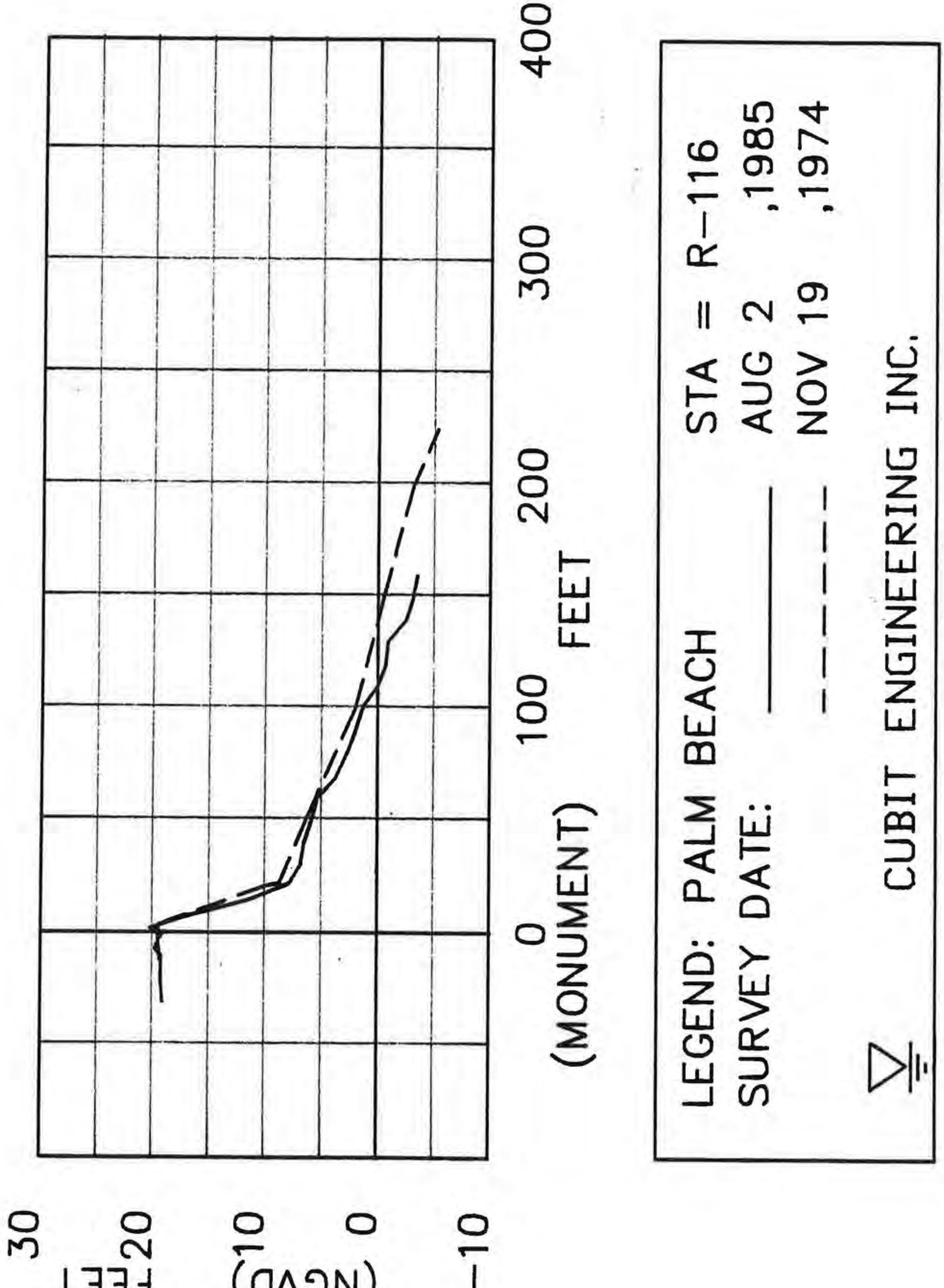
300
400
LEGEND: PALM BEACH STA = R-113
SURVEY DATE: ——— JULY 29 ,1985
- - - - - NOV 19 ,1974
CUBIT ENGINEERING INC.

Figure B12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-10
FEET
(NGVD)
0
(MONUMENT)
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FEET
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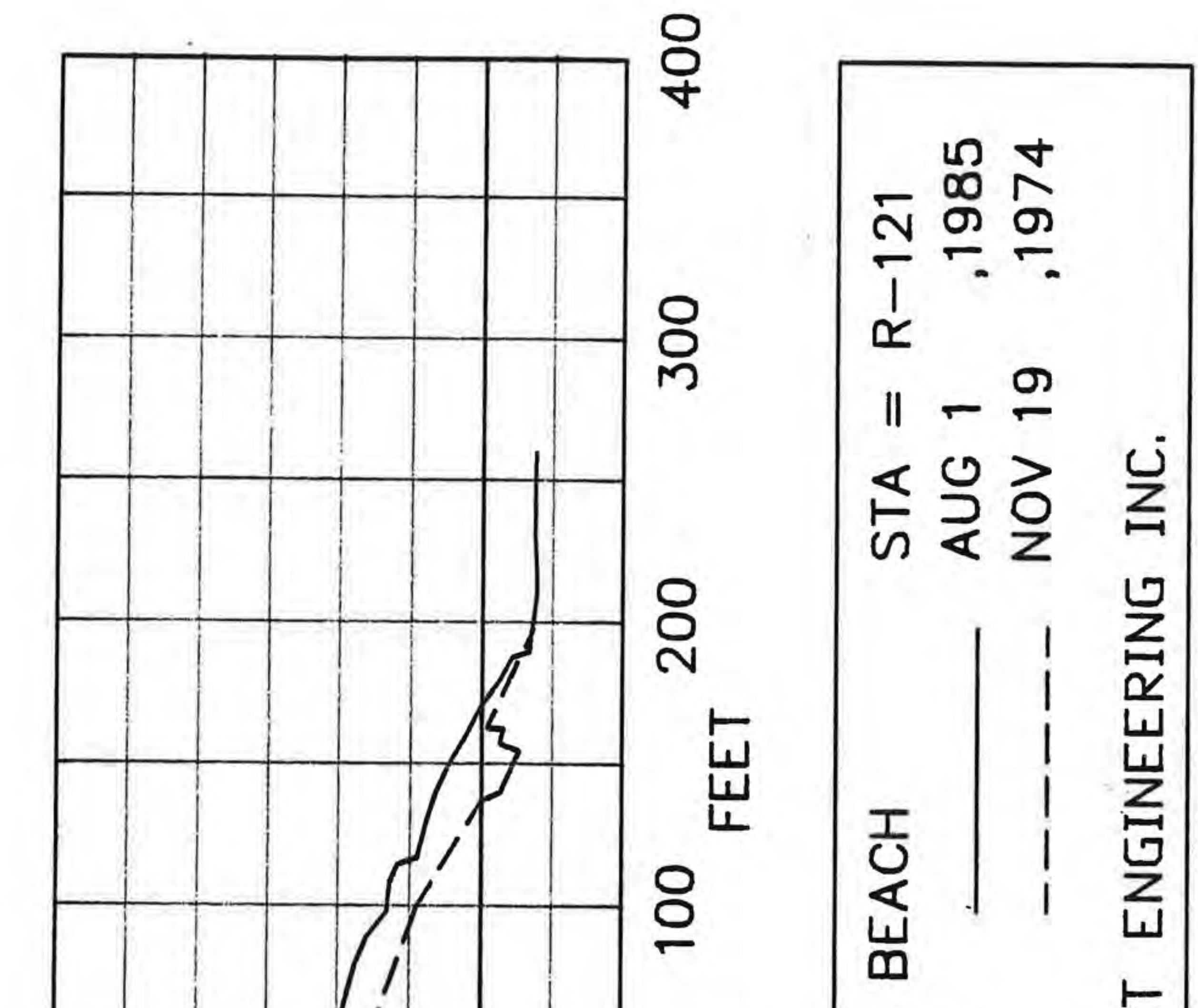
300
400
LEGEND: PALM BEACH STA = R-116
SURVEY DATE: AUG 2 ,1985
NOV 19 ,1974
CUBIT ENGINEERING INC.

Figure B13


LEGEND: PALM BEACH STA = R-121
SURVEY DATE: AUG 1 ,1985
NOV 19 ,1974
CUBIT ENGINEERING INC.
FEET
(MONUMENT)
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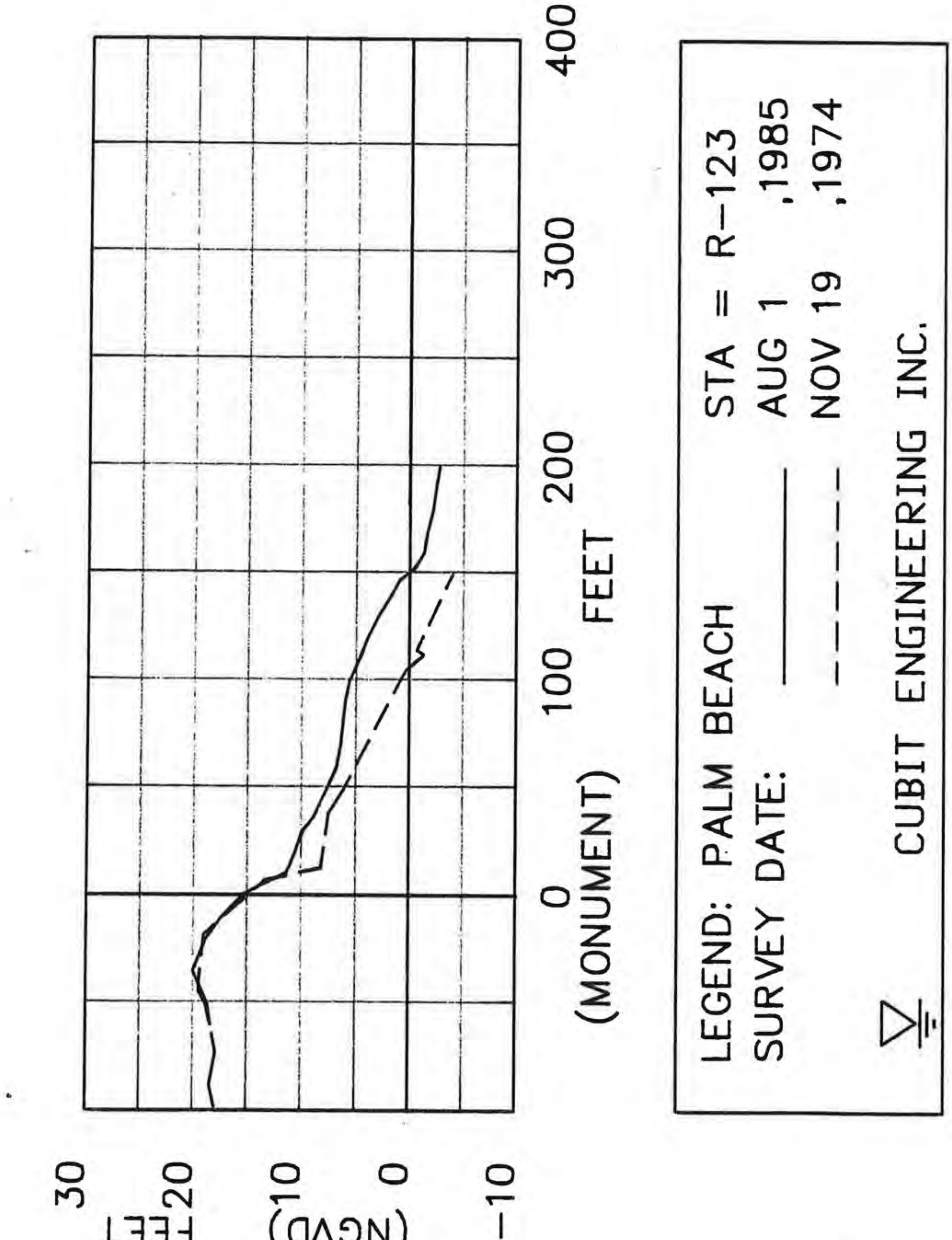
200
300
400
FEET
(NGVD)
30
20
10
0
-10

Figure B14



30
20
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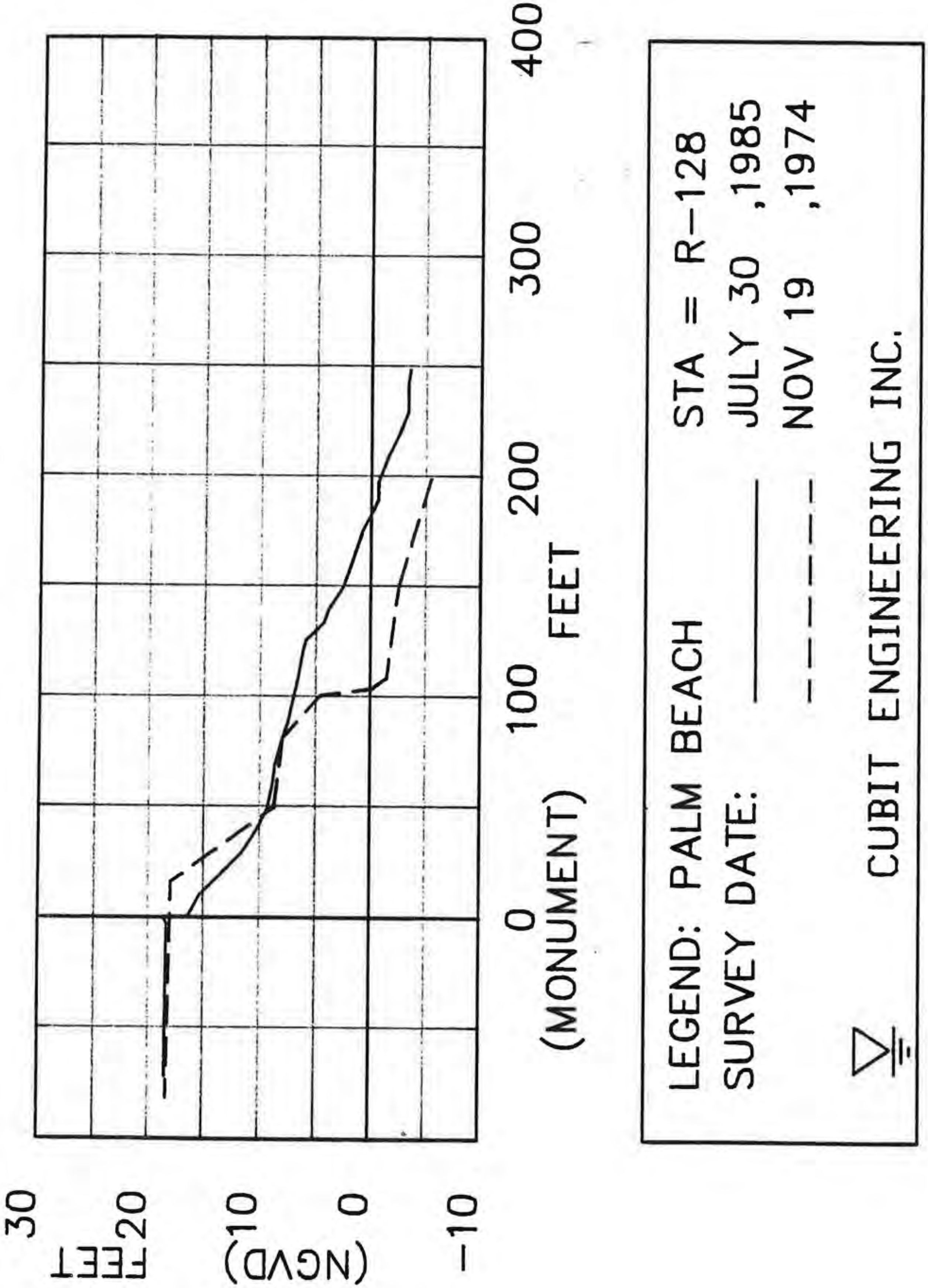
0
-10
FEET
(NGVD)
0
100
200
300
400
FEET
(MONUMENT)
LEGEND: PALM BEACH
STA = R-123
SURVEY DATE:
AUG 1 ,1985
NOV 19 ,1974
CUBIT ENGINEERING INC.

Figure B15


FEET (NGVD)
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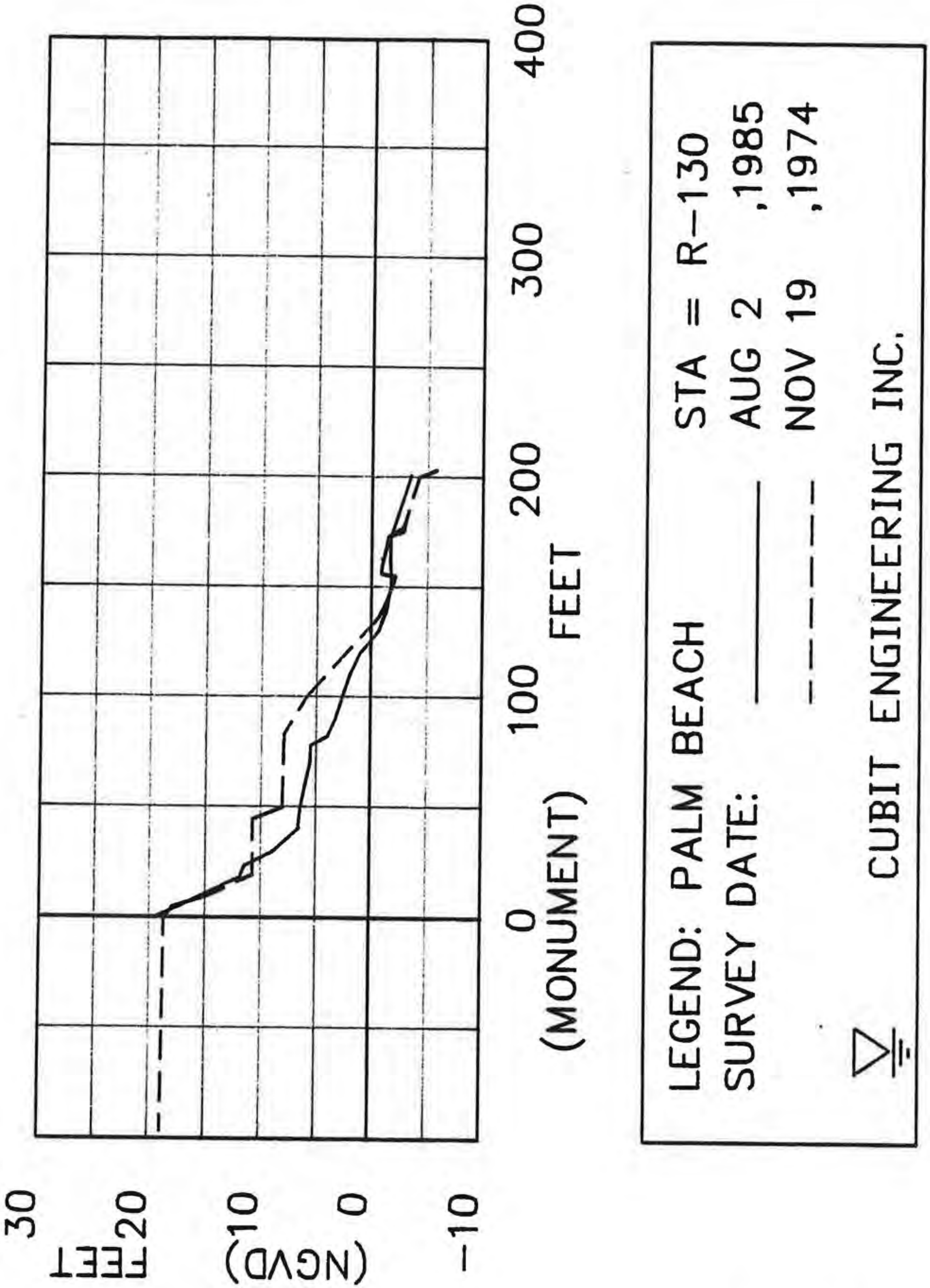
10
0
-10
0
(MONUMENT)
100
200
300
400
FEET
LEGEND: PALM BEACH STA = R-128
SURVEY DATE: JULY 30 ,1985
NOV 19 ,1974
CUBIT ENGINEERING INC.

Figure B16



30
20
10
0
-10
FEET
(NGVD)
0
(MONUMENT)
100
FEET
200
300
400
LEGEND: PALM BEACH
STA = R-130
SURVEY DATE:
AUG 2 ,1985
NOV 19 ,1974
CUBIT ENGINEERING INC.

Figure B17

APPENDIX C

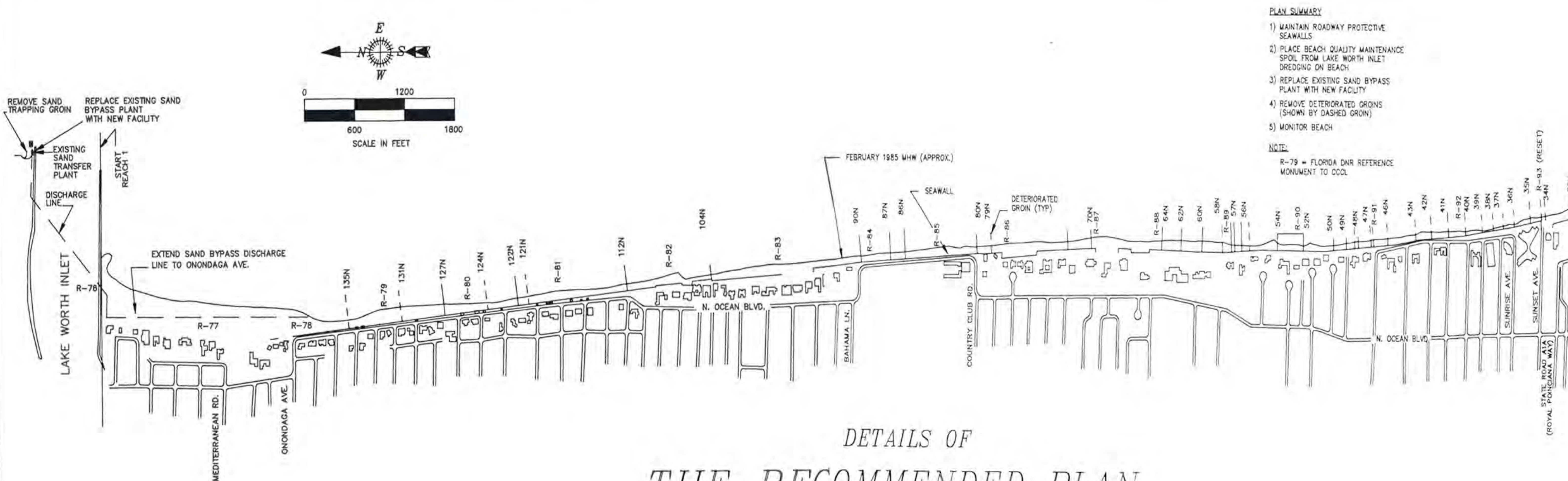
COMPREHENSIVE COASTAL
MANAGEMENT PLAN
FOR
TOWN OF PALM BEACH

APPENDIX C

THE RECOMMENDED PLAN BY REACH

AUGUST 1986

APPENDIX C
TABLE OF CONTENTS



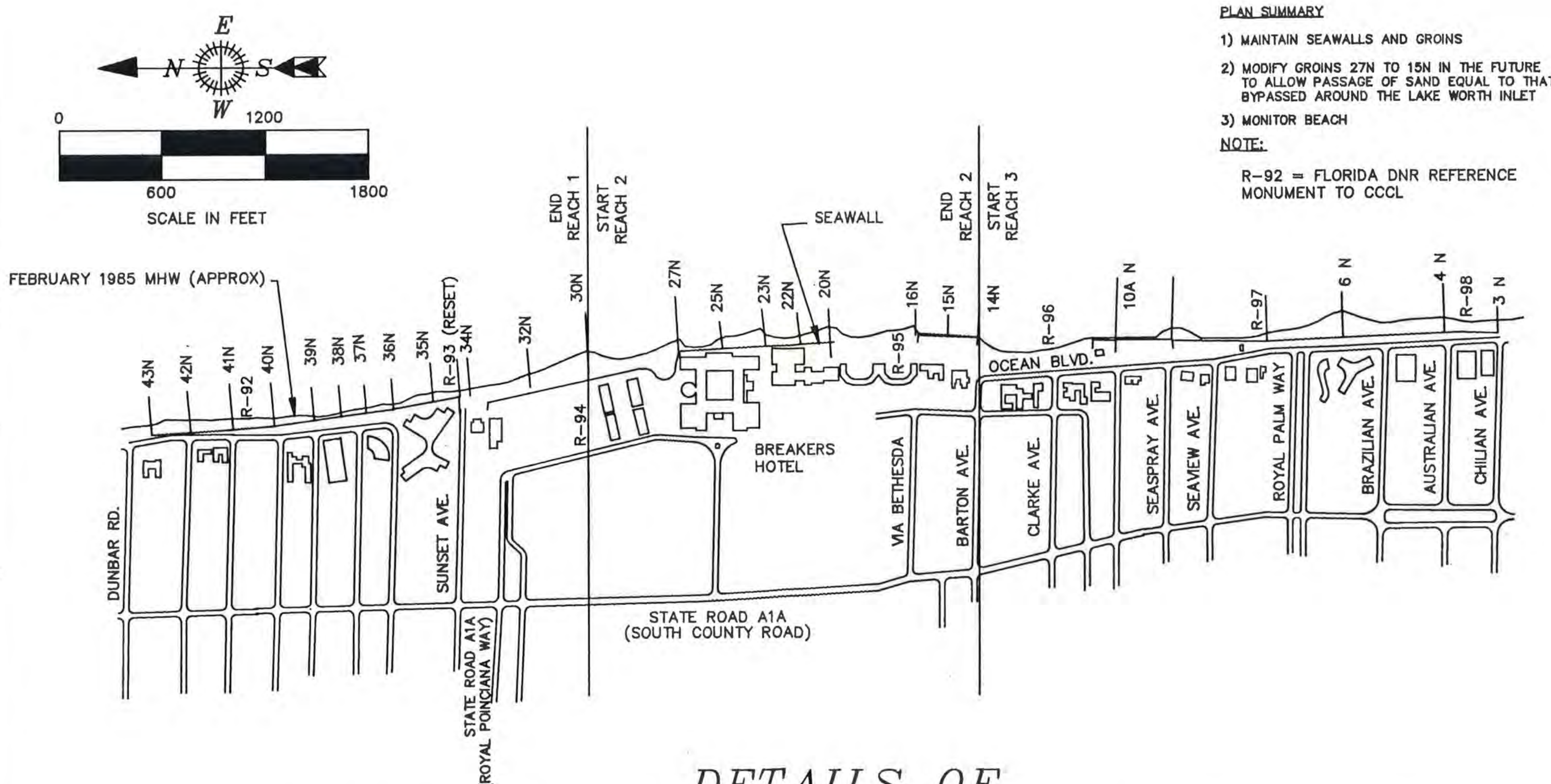
DETAILS OF THE RECOMMENDED PLAN

REACH 1

FIGURE C.1

PREPARED BY: CUBIT ENGINEERING LTD.

AUGUST 1986

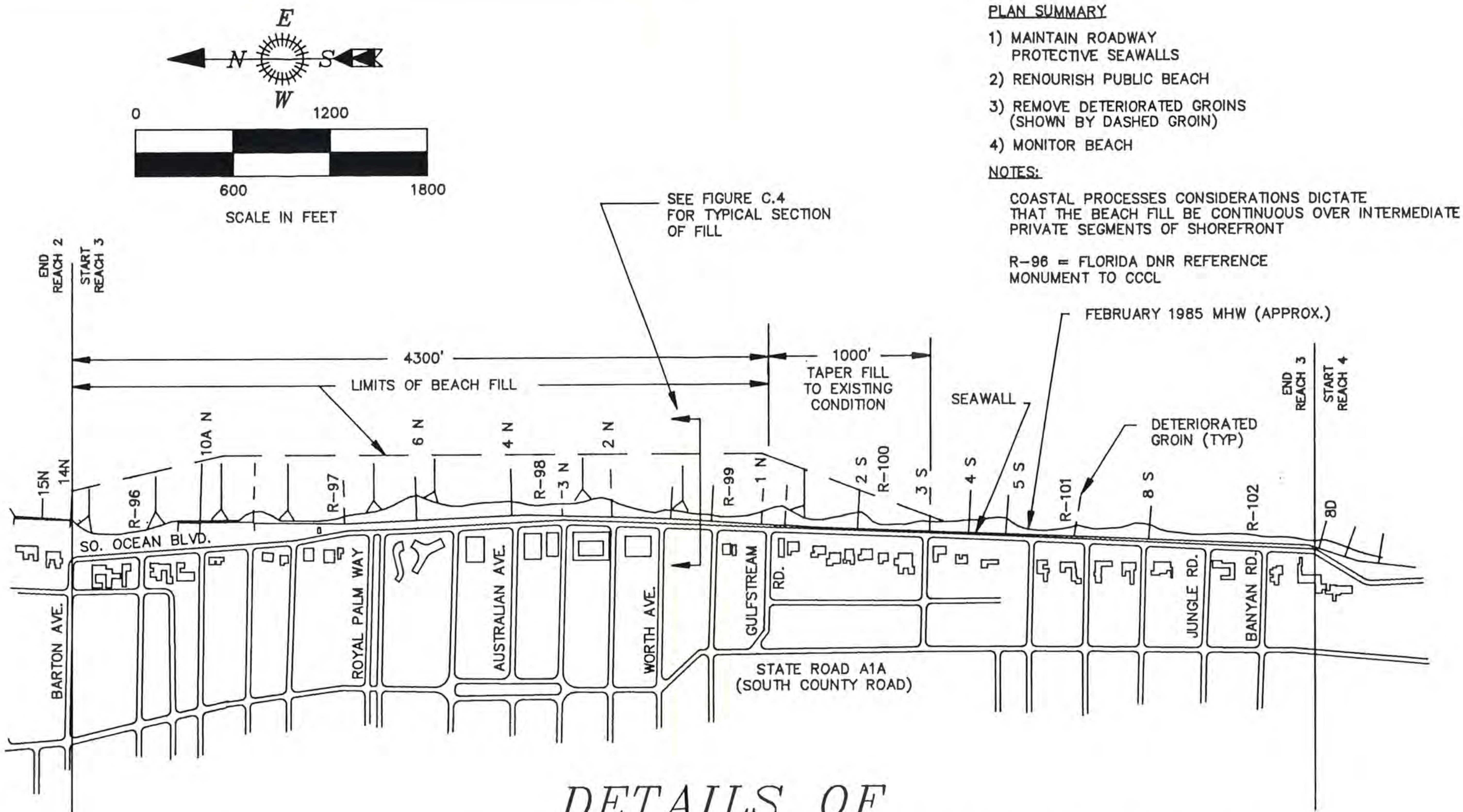


DETAILS OF THE RECOMMENDED PLAN
REACH 2

FIGURE C.2

PREPARED BY: CUBIT ENGINEERING LTD.

AUGUST 1986

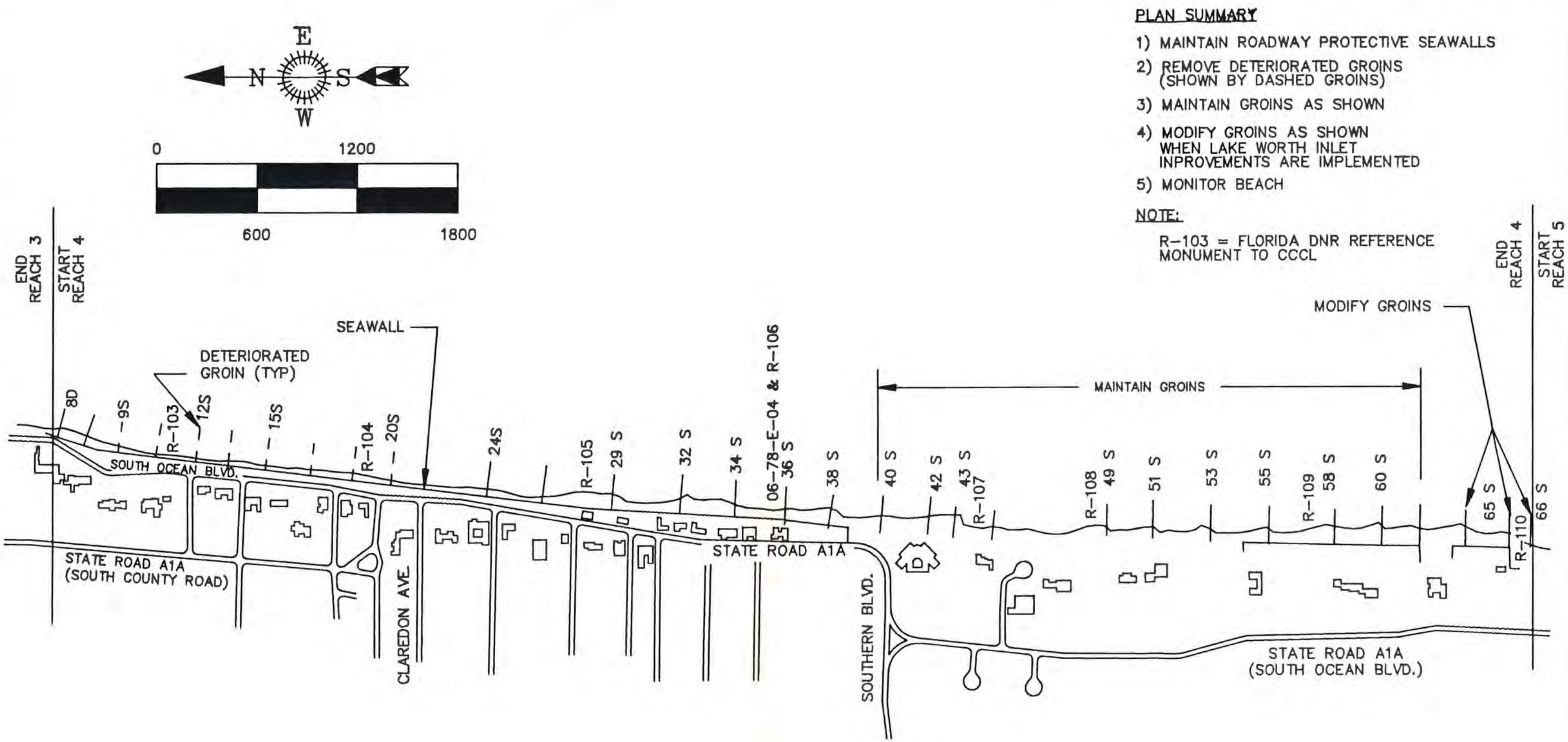


DETAILS OF
THE RECOMMENDED PLAN
REACH 3

PREPARED BY: CUBIT ENGINEERING LTD.

AUGUST 1986

FIGURE C.3



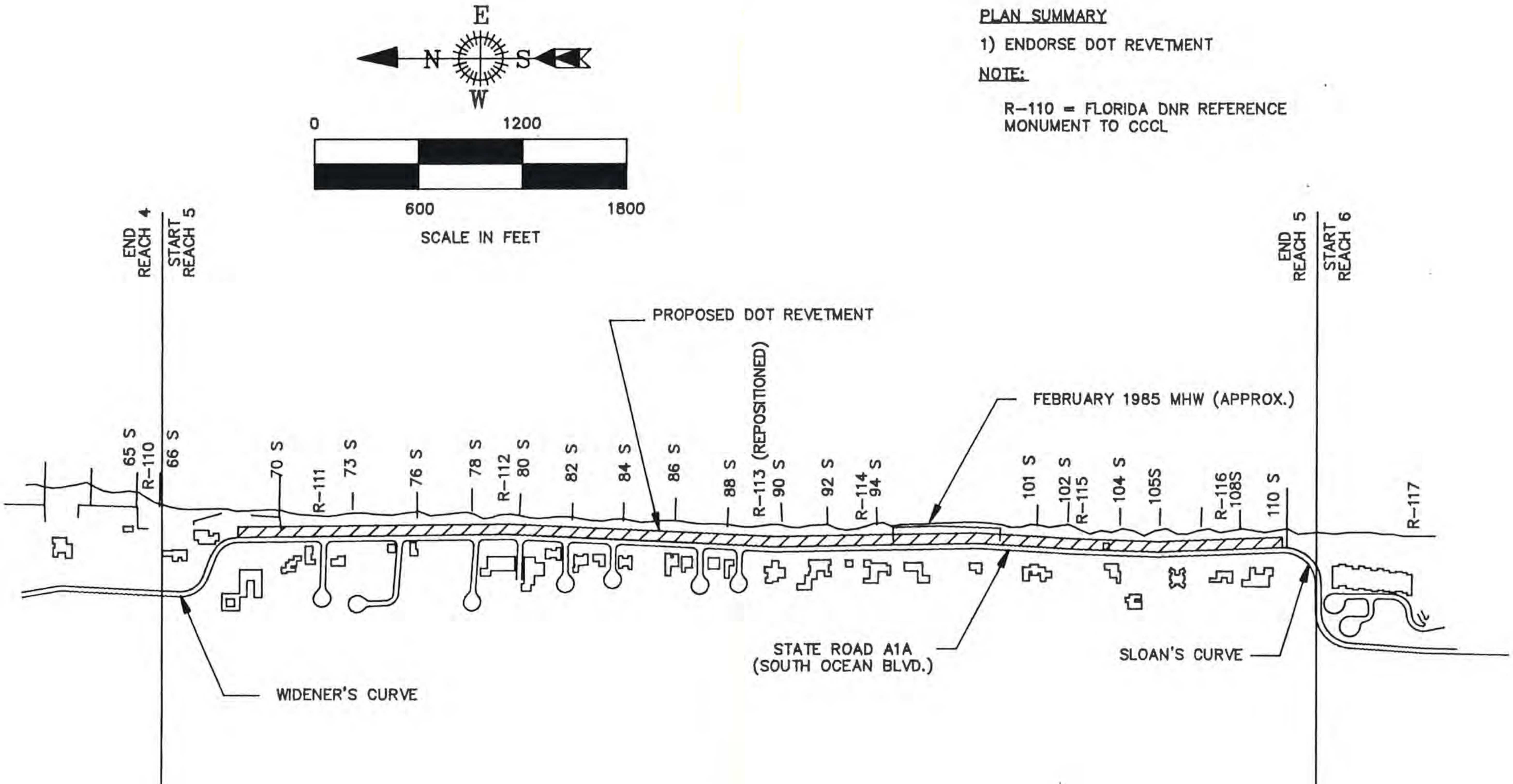
DETAILS OF THE RECOMMENDED PLAN

REACH 4

FIGURE C.4

PREPARED BY: CUBIT ENGINEERING LTD.

AUGUST 1986



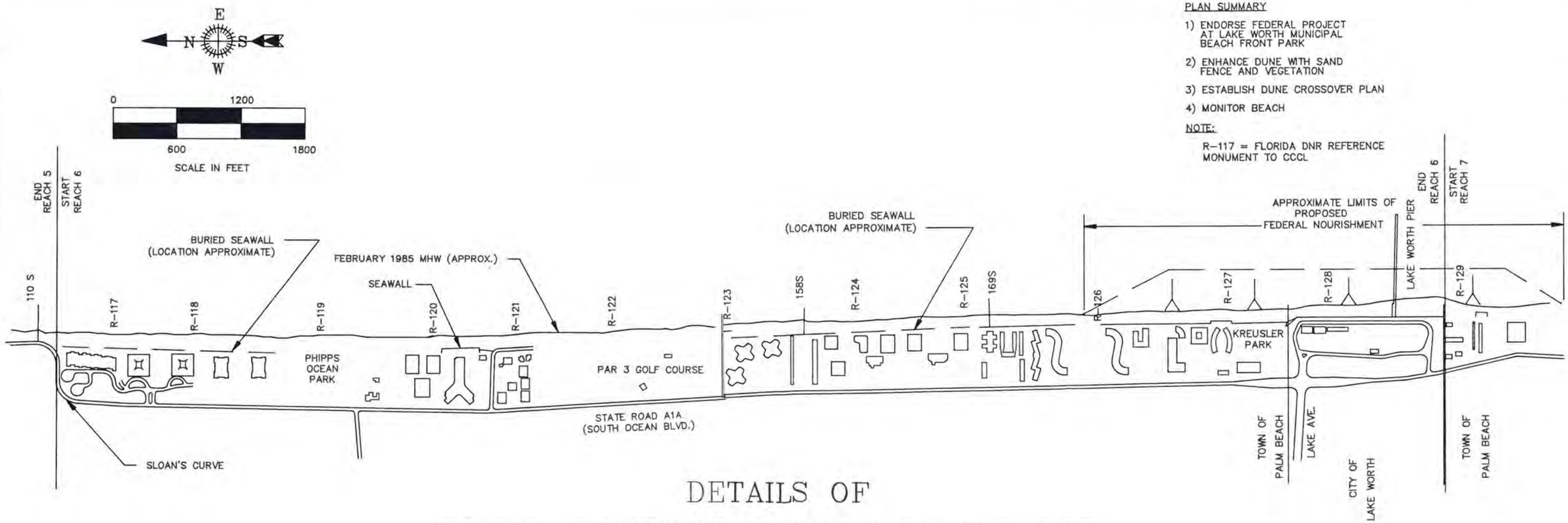
DETAILS OF THE RECOMMENDED PLAN

REACH 5

FIGURE C.5

PREPARED BY: CUBIT ENGINEERING LTD.

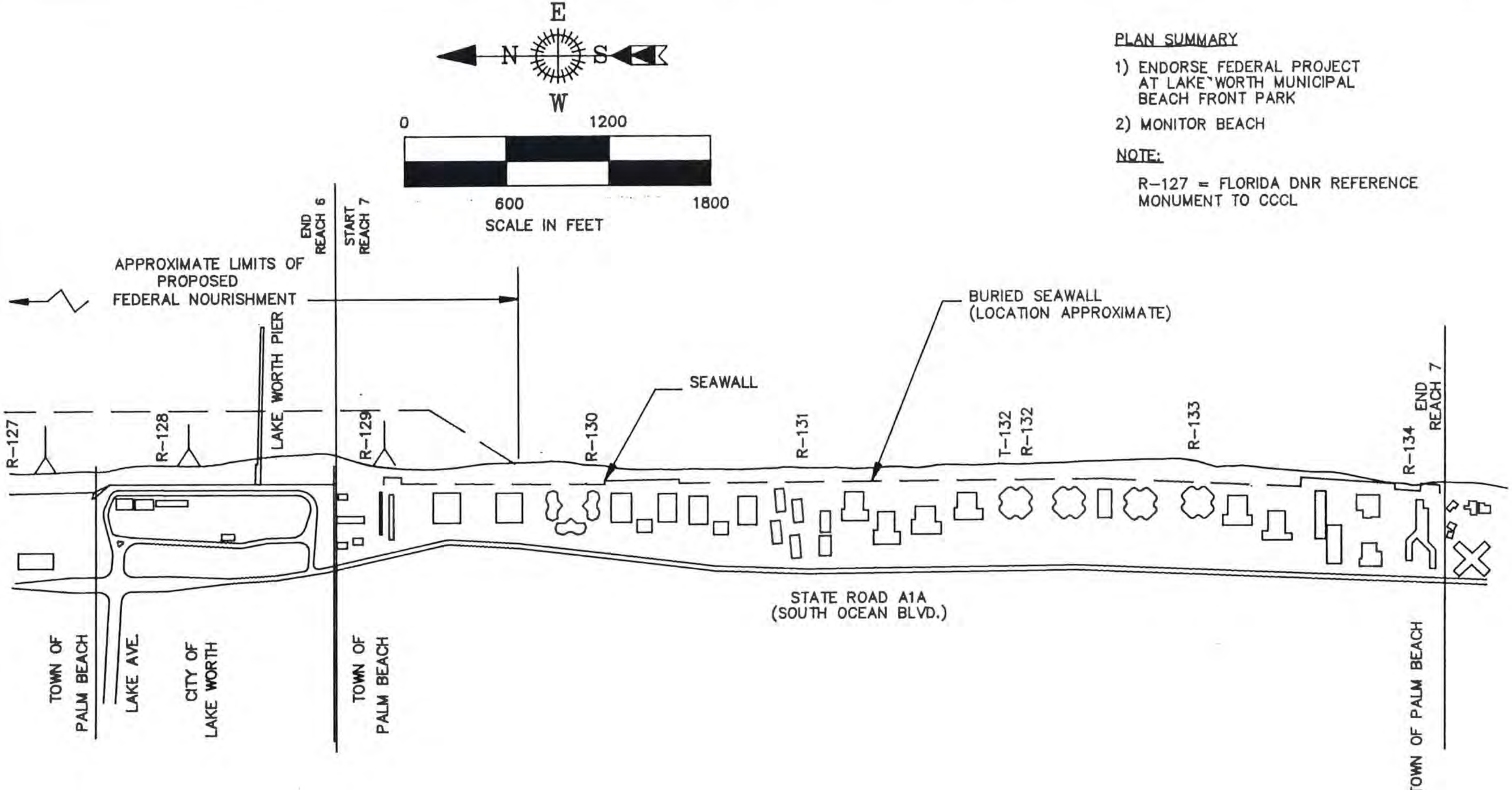
AUGUST 1986



DETAILS OF THE RECOMMENDED PLAN
REACH 6

PREPARED BY: CUBIT ENGINEERING LTD.
AUGUST 1986

FIGURE C.6



DETAILS OF THE RECOMMENDED PLAN REACH 7

FIGURE C.7

PREPARED BY: CUBIT ENGINEERING LTD.

AUGUST 1986

APPENDIX D

COMPREHENSIVE COASTAL
MANAGEMENT PLAN
FOR
TOWN OF PALM BEACH

APPENDIX D

COASTAL STRUCTURE INVENTORY

AUGUST 1986

APPENDIX D
TABLE OF CONTENTS

Note: This appendix was compiled from field observations made May 31 to June 5, 1985 by Cubit Engineering Limited.

TABLE D4 CONT'D

DUNES AND MISCELLANEOUS PROTECTIVE STRUCTURES

LOCATION	TYPE	OBSERVATION
132 + 450 to 132 + 720	5	Evident erosion of dune toe. Dune height approximately 20 feet. Dune crest vegetated.
132 + 720 to 132 + 1060	6	Dune toe protection consisting of stacked railroad ties placed along eroding dune toe. Evident dune toe erosion. Dune height approximately 2 feet.
132 + 1060 to 133 + 520	5	Dune height approximately 20 feet. Dune crest vegetated. Evident dune toe erosion.

Key:

1 Concrete-block Revetment
2 Breakwater
3 Armor Stone
4 Snow fence
5 Protective Foredune
6 Timber Dune Toe Protection

78-2, March 1978, Bureau of Beaches and Shores.

APPENDIX D
TABLE OF CONTENTS

TABLE D1

EXISTING SEAWALLS

TOWN OF PALM BEACH

Location	Type	Observations
77 + 865 to 77 + 945	N.A.	Dune adjacent to wall, unable to distinguish wall type.
77 + 1120 to 80 + 590	1	Dune adjacent to seawall from Station 77 + 1120 to Station 80 + 140.
80 + 590 to 81 + 1140	2	-
81 + 1140 to 81 + 1340	3	Wall toe extends approximately 30 feet seaward of north wall.
81 + 1340 to 82 + 110	4	-
82 + 110 to 82 + 230	2	Wall toe located approximately 20 feet landward of north wall.
82 + 230 to 82 + 465	2	North return timber, south return gunite. Wall toe extends approximately 40 feet seaward of north wall.
82 + 465 to 82 + 660	2	Wall toe located approximately 20 feet landward of north wall.
82 + 660 to 83 + 000	1	Curved concrete cap. Dune adjacent to wall.
83 + 390 to 83 + 1060	2	Wall toe extends approximately 30 feet seaward of north dune toe.
83 + 1060 to 86 + 000	2	Wall height decreasing to south, South return wall timber.
86 + 000 to 86 + 300	N.A.	Concrete wall cap. Dune adjacent to wall unable to distinguish wall type. Wall located approximately 60 feet landward of north wall.

(TABLE D1 CONT'D)

EXISTING SEAWALLS

TOWN OF PALM BEACH

Location	Type	Observations
86 + 300 to 86 + 500	3	-
86 + 500 to 86 + 750	3	Wall toe extends approximately 40 feet seaward of north wall toe.
86 + 750 to 87 + 030	3	Wall type 3 with stepped toe. South return wall type 2.
87 + 350 to 87 + 540	2	Wall toe extends approximately 40 feet seaward of north dune toe.
87 + 540 to 87 + 650	1	Curved wall cap. Wall toe located approximately 30 feet landward of north wall toe.
87 + 650 to 87 + 800	N.A.	Dune adjacent to wall. Unable to distinguish wall type.
87 + 800 to 88 + 430	1	Curved wall cap. Wall toe extends approximately 30 feet seaward of north wall toe.
88 + 430 to 89 + 350	5	Wall toe located approximately 5 feet landward of toe of north wall.
89 + 350 to 89 + 530	2	Wall toe extends approximately 5 feet seaward of north wall.
89 + 530 to 89 + 740	4	Concrete cap. Wall toe located approximately 5 feet landward of north wall.
89 + 740 to 91 + 120	3	Stepped toe. Rubble toe protection from Stations 89 + 740 to approximately 90 + 060. Stepped toe extends approximately 10 feet seaward of toe of north wall.
91 + 120 to 91 + 250	2	-
91 + 250 to 91 + 1020	3	-

(TABLE D1 CONT'D)

EXISTING SEAWALLS

TOWN OF PALM BEACH

Location	Type	Observations
91 + 1020 to 92 + 790	1	Curved concrete cap. Toe of wall located approximately 5 feet seaward or toe of north wall.
92 + 790 to 93 + 000	2	Steel sheet visible along bottom of south return wall.
93 + 170 to 94 + 1550	2	Wall height increases to south. Wall located approximately 25 feet seaward of dune toe at Sunset Avenue. Difficult to determine wall type from Stations 93 + 170 to 94 + 620 due to adjacent dune and walkway. Wall toe 90 feet seaward of toe of north dune.
95 + 015 to 95 + 360	3	Curved face wall with stepped toe. Wall toe extends approximately 100 feet seaward of toe of north and south dunes. Steel sheet exposed at sand line along south return wall.
96 + 240 to 96 + 370	3	Curved face wall with stepped toe. Wall toe extends approximately 70 feet seaward of north dune. Steel sheet visible at sand line along north return wall.
96 + 370 to 96 + 700	3	Sloped - stepped wall. Loss of material noted landward of north section of wall.
96 + 700 to 106 + 430	2	Various wall heights and design. Wall height decreasing to south.
108 + 870 to 109 + 690	2	Toe of wall extends approximately 30 feet seaward of toe of north dune.

(TABLE D1 CONT'D)

EXISTING SEAWALLS

TOWN OF PALM BEACH

Location	Type	Observations
109 + 875 to 109 + 1220	2	-
109 + 1220 to 109 + 1280	2	Wall located approximately 140 feet landward of north wall.
110 + 225 to 110 + 380	3	Sloped stepped - toe gunite wall. Wall extends approximately 30 feet seaward of north dune. Steel sheet visible along south return wall.
110 + 570 to 110 + 730	2	Exposed steel sheet. Wall remnant. Wall extends approximately 90 feet seaward from toe of south dune.
114 + 075 to 114 + 710	2	Wall extends approximately 90 feet seaward of north dune. North return wall undermined. Loss of material noted landward of wall; tie rods and anchors exposed. Steel sheet exposed along south return. Wall extends approximately 80 feet seaward of south dune.
120 + 000 to 120 + 350	4	Wall extends approximately 5 feet seaward of north dune.
120 + 350 to 120 + 450	2	-
123 + 080 to 123 + 130	2	-
123 + 730 to 123 + 960	2	Wall located approximately 40 feet landward of south dune toe.
126 + 920 to 127 + 100	-	Wall extends approximately 32 feet seaward of toe of north revetment.

(TABLE D1 CONT'D)

EXISTING SEAWALLS

TOWN OF PALM BEACH

Location	Type	Observations
127 + 610 to 128 + 970	2	127 + 610 to 128 + 860 - City of Lake Worth Municipal limits.
129 + 090 to 129 + 200	4	Wall extends approximately 5 feet seaward of north dune.
130 + 060 to 130 + 500	4	Wall extends approximately 10 feet seaward of south dune. Concrete stairway extends approximately 25 feet seaward of wall.
133 + 520 to 134 + 140	4	Wall extends approximately 35 ft. from toe seaward of north dune.

KEY:

1 - Vertical prestressed concrete sheet pile

2 - Vertical gunite concrete seawall

3 - Sloped or curved face concrete

4 - Vertical steel sheet piling with concrete cap

5 - Vertical timber

N.A. - Data not available

TABLE D2: GROIN INDEX TOWN OF PALM BEACH

Groin Number	Location	Type	Condition: Remnant	Condition: Derelict	Condition: Complete	Function: Effective	Function: Ineffective	Incrustation	Safety Hazard	Remarks/Observations
135N	78+625	1	X				X		X	
131N	79+175	1		X			X		X	
127N	79+705	N.A.		X			X			Observed in January, 1985 aerial photography only.
124N	80+215	1		X			X		X	
122N	80+590	N.A.		X			X			Observed in January, 1985 aerial photography only.
121N	80+740	1		X			X	X	X	Timber waler protruding seaward from berm. Offshore end of groin terminates at nearshore rock outcrop.
112N	81+790	N.A.		X			X			Observed in January, 1985 aerial photography only.
104N	82+465	N.A.		X			X			Observed in January, 1985 aerial photography only.
90N	84+145						X			Not observed during field reconnaissance.

TABLE CONT'D.

Groin Number	Location	Type	Condition: Remnant	Condition: Derelict	Condition: Complete	Function: Effective	Function: Ineffective	Incrustation	Safety Hazard	Remarks/Observations
87N	84+275						X			Not observed during field reconnaissance.
86N	84+490						X			Not observed during field reconnaissance.
80N	85+548						X			Not observed during field reconnaissance.
79N	85+770	1		X			X		X	Offshore segment penetrates and extends seaward of nearshore rock outcrop.
-	86+950									Not observed during field reconnaissance.
70N	86+1310	2		X			X			Seaward end of stone rubble at nearshore rock outcrop.
64N	88+000	1			X	X				Hole in steel sheet piling in surf zone. Seaward end of groin terminates at nearshore rock outcrop.
62N	88+280	3			X	X		X		Rock ourcrop in vicinity of seaward seaward end of groin.
60N	88+580	3			X	X		X		Groin extends seaward to isolated nearshore rock outcrop.

TABLE D2 CONT'D.

Groin Number	Location	Type	Condition: Remnant	Condition: Derelict	Condition: Complete	Function: Effective	Function: Ineffective	Function: Incrustation	Function: SafetyHazard	Remarks/Observations
58N	88+870	3			X	X		X		Offshore end of groin in vicinity of nearshore rock outcrop. Loss of steel plate and infill concrete along south face.
57N	89+075	1		X			X		X	Stone rubble adjacent to groin.
-	89+110	4	X				X		X	Numerous isolated members composed primarily of timber pilings and scattered steel sheet pilings.
-	89+210	1		X			X		X	
56N	89+340	1		X			X	X	X	
54N	89+740	3			X	X		X		Offshore section of groin discontinuous.Stone rubble adjacent to groin in surf zone. Loss of steel plate and infill concrete along south face. Offshore end of groin terminates at north end of derelict breakwater. Inshore end concrete and terminates at stepped-toe curved face seawall.

TABLE 2 CONT'D.

Groin Number	Location	Type	Condition: Remnant	Condition: Derelict	Condition: Complete	Function: Effective	Function: Ineffective	Incrustation	SafetyHazard	Remarks/Observations
52N	90+050	2			X	X				Unable to confirm existence of structure below stone rubble.Off-shore end of groin terminates near south end of derelict breakwater. Groin does not extend seaward to breakwater. Inshore end of groin concrete and terminates at stepped-toe curved face seawall.
-	90+170	N.A.		X			X			Buried, only concrete surface visible, inshore end of stepped-toe curved face wall. Offshore end does not extend through surf zone.
51N	90+270	N.A.		X			X			Buried, only concrete surface visible. Offshore end does not extend through surf zone.
50N	90+490	N.A.	X				X		X	Submerged at time of observation. Probable incrustation.
49N	90+680	N.A.	X				X		X	Submerged at time of observation. Probable incrustation.
-	90+800	N.A.		X			X	X	X	Submerged at time of observation.
48N	90+850	N.A.	X				X		X	Submerged at time of observation.
47N	90+1040	N.A.	X				X		X	Submerged at time of observation.

TABLE CONT'D.

Groin Number	Location	Type	Condition: Remnant	Condition: Derelict	Condition: Complete	Function: Effective	Function: Ineffective	Incrustation	Safety Hazard	Remarks/Observations
-	90+1060	1		X			X	X	X	
46N	91+120	N.A.	X				X		X	Submerged at time of observation.
43N	91+550	N.A.	X				X		X	Submerged at time of observation.
42N	91+760	1		X			X		X	Inshore end appears in surf zone. Generally sumerged at time of observation. Possible incrustation.
41N	91+1020	N.A.	X				X		X	Submerged at time of observation. Possible incrustation.
40N	92+090	N.A.	X				X		X	Submerged at time of observation.
39N	92+330	N.A.	X				X		X	Submerged at time of observation.
38N	92+490	N.A.	X				X		X	Submerged at time of observation.
37N	92+620	1		X			X		X	Not continuous through surf zone. Offshore segment submerged at time of observation.
36N	92+790	N.A.	X				X		X	Submerged at time of observation.
35N	92+1000	N.A.	X				X		X	Submerged at time of observation.

TABLE D2 CONT'D.

Groin Number	Location	Type	Condition: Remnant	Condition: Derelict	Condition: Complete	Function: Effective	Function: Ineffective	Incrustation	Safety Hazard	Remarks/Observations
-	93+000	1		X			X		X	Discontinuous in surf zone, off-shore segment submerged at time of observation.
34N	93+060	N.A.	X				X		X	Submerged at time of observation.
32N	93+430						X			Not observed during field reconnaissance.
30N	94+080	5			X	X				Stone rubble adjacent to groin in surf zone. Groin extends seaward of rubble.
27N	94+620	5			X	X				Stone rubble tee in surf zone. Groin extends seaward of rubble. Inshore end at concrete seawall with rubble seaward of wall, adjacent to groin.
25N	94+860	1			X	X				Offshore end of groin terminates at stone rubble tee head. Inshore end at seawall with stone rubble along north face at wall.
23N	94+1110	3			X	X				Stone rubble tee adjacent to groin in surf zone. Groin extends beyond rubble and appears discontinuous beyond rubble.

TABL[illegible]2 CONT'D.

Groin Number	Location	Type	Condition: Remnant	Condition: Derelict	Condition: Complete	Function: Effective	Function: Ineffective	Incrustation	Safety Hazard	Remarks/Observations
-	94+1115			X			X		X	Offshore end appears to terminate in stone rubble tee head.
22N	94+1320	1		X			X		X	Offshore end terminates in surf zone. Offshore segment not visible at time of observation but confirmed by aerial photographs.
20N	94+1550	3			X	X				Stone rubble tee adjacent to groin extends seaward of stone rubble. Note loss of sheet steel plate and infill concrete along south face.
16N	95+000	3			X	X				Stone rubble adjacent to groin along north face in surf zone. Groin extends seaward of tee-head.
15N	95+180	1		X			X			Inshore end at stepped-toe curved face seawall. Submerged at time of observation.
14N	95+360	1		X			X			Permeable,inshore end at stepped-toe curved face seawall.
10A-N	96+370	1		X			X			Submerged at time of observation. Inshore end at stepped-toe curved face seawall.

TABLE 2 CONT'D.

Groin Number	Location	Type	Condition: Remnant	Condition: Derelict	Condition: Complete	Function: Effective	Function: Ineffective	Incrustation	Safety Hazard	Remarks/Observations
-	96+700	3		X		X		X	X	Inshore end at stepped concrete wall. Inshore end of derelict groin impermeable with deterioration seaward. Note loss of steel sheet and infill concrete along along north face.
-	96+1270	1		X			X		X	
6N	97+430	1			X	X		X		
4N	97+1020	1		X			X	X	X	
3N	98+120	1		X			X	X	X	
2N	98+240	1		X			X	X	X	
-	98+800						X			Not observed during field reconnaissance.
-	98+1050						X			Not observed during field reconnaissance.
1N	99+190	1		X			X	X	X	
-	99+340	1		X			X	X	X	
2S	99+790	1			X	X		X		
3S	100+220	1		X			X	X	X	

TABLE D2 CONT'D.

Groin Number	Location	Type	Condition: Remnant	Condition: Derelict	Condition: Complete	Function: Effective	Function: Ineffective	Function: Incrustation	Function: SafetyHazard	Remarks/Observations
4S	100+470	1		X			X			
5S	100+710	4			X		X	X		Inshore end at vertical concrete seawall.
-	100+1160	1		X			X	X	X	
8S	101+410	1			X	X		X		
8D	102+360	1			X	X		X		Offshore end in nearshore rock outcrop. Stone rubble adjacent to groin in shore end at vertical concrete wall.
-	102+570	1			X	X		X		Offshore end in nearshore rock outcrop. Deterioration of steel plate along north face.
9S	102+760	1			X		X		X	
-	102+990	1		X			X		X	Stone along south face.
12S	103+130	1		X			X		X	Offshore end at surf zone.
-	103+350	1		X			X		X	Offshore end at surf zone.
15S	103+560	1		X			X	X	X	
-	103+830	1		X			X		X	Offshore end at surf zone.

TABLE 2 CONT'D.

Groin Number	Location	Type	Condition: Remnant	Condition: Derelict	Condition: Complete	Function: Effective	Function: Ineffective	Incrustation	Safety Hazard	Remarks/Observations
-	103+1090	1		X			X		X	Offshore end at surf zone.
20S	104+160	1		X			X		X	Offshore end at surf zone.
24S	104+760	6			X	X		X		
-	104+1100	6	X				X	X		
29S	105+150	3			X	X		X		
32S	105+570	3			X	X		X		Deterioration in steel sheet along south face.
34S	105+860	1			X		X	X		
36S	106+030	6			X	X				Offshore portion submerged at time of observation, possible incrustation.
38S	106+330	6		X		X				Offshore portion submerged at time of observation, possible incruststion.
40S	106+620	6			X	X		X		Piping located along south face.
42S	106+920	6			X	X		X		
43S	106+1070	6			X	X		X		Semipermeable. Inshore end at vertical concrete wall.

TABLE 2 CONT'D.

Groin Number	Location	Type	Condition: Remnant	Condition: Derelict	Condition: Complete	Function: Effective	Function: Ineffective	Incrustation	SafetyHazard	Remarks/Observations
45S	107+160	1		X			X			Completely permeable in surf zone. Offshore segment submerged at time of observation.
46S	107+400	N.A.					X			Observed in aerial photography only.
49S	108+010	1			X	X		X		
51S	100+300	1			X	X		X		
53S	108+650	1			X	X		X		
55S	108+1000	1			X	X		X		
58S	109+170	1			X	X		X		Deterioration of sheet steel along south face. Minor separation between concrete cap and steel sheet piling.
60S	109+460	1			X	X		X		Slight separation between concrete cap and steel sheet piling.
-	109+690	1			X	X		X		
-	109+950	4			X	X				Stone rubble along entire exposed north and south faces. Possible incrustation.

TABLE [illegible] CONT'D.

Groin Number	Location	Type	Condition: Remnant	Condition: Derelict	Condition: Complete	Function: Effective	Function: Ineffective	Incrustation	Safety Hazard	Remarks/Observations
65S	109+1220	4			X	X		X		Stone rubble along entire exposed north face and along south face at seaward end. Land end at vertical concrete wall.
66S	110+020	1			X	X		X		Inshore end terminates in dune.
70S	110+730	1			X		X	X		Inshore end at vertical concrete seawall. Offshore end at stone rubble tee head.
73S	111+090	7		X		X				Inshore end at dune. Offshore end terminates in surf zone. Stone rubble farther seaward of groin end.
76S	111+520	7			X	X		X		Offshore end of groin extends beyond stone rubble tee-head. Visible inshore end in dune.
78S	111+820	7			X	X				Offshore end of groin extends beyond stone rubble tee-head. Seaward end terminates at off-shore rock outcrop. Inshore end at dune.

TABLE 2 CONT'D.

Groin Number	Location	Type	Condition: Remnant	Condition: Derelict	Condition: Complete	Function: Effective	Function: Ineffective	Function: Incrustation	Function: Safety Hazard	Remarks/Observations
80S	111+1120	7			X	X				Offshore end of groin extends beyond stone rubble tee-head. Seaward end terminates at offshore rock outcrop. Inshore end at dune.
82S	112+270	7			X	X				Offshore end of groin extends beyond stone rubble tee-head to offshore rock outcrop. Nearshore rock outcrop begins south of groin. Stone rubble on nearshore rock. Inshore end at dune.
84S	112+570	7			X	X				Offshore end of groin extends beyond stone rubble tee-head to offshore rock outcrop. Stone rubble at nearshore rock outcrop. Inshore end at dune.
86S	112+870	7			X	X				Offshore end of groin extends beyond stone rubble tee-head to offshore rock outcrop. Stone rubble at tee-head on nearshore rock outcrop. Inshore end at dune.
88S	113+200	7			X	X				Offshore end of groin extends beyond stone rubble tee-head to vicinity of offshore rock outcrop. Stone rubble at tee-head on nearshore rock outcrop. Inshore end in dune.

TABLE 2 CONT'D.

Groin Number	Location	Type	Condition: Remnant	Condition: Derelict	Condition: Complete	Function: Effective	Function: Ineffective	Incrustation	Safety Hazard	Remarks/Observations
90S	113+500	7			X	X				Offshore end of groin extends beyond stone rubble tee-head to vicinity of offshore rock outcrop. Stone rubble tee on nearshore rock outcrop. Inshore end at dune.
92S	113+780	7			X	X				Offshore end of groin at stone rubble tee-head at nearshore rock outcrop. Inshore end at dune.
94S	113+1080	7			X	X		X		Inshore end free standing. Offshore end at stone rubble tee-head on nearshore rock outcrop.
101S	114+910	7			X	X				Incrustation on stone rubble. Offshore end at stone rubble tee-head at nearshore rock outcrop. Inshore end at dune, free standing at failing parapet wall.
102S	114+1110	7			X	X				Offshore end at stone rubble tee-head on nearshore rock outcrop. Inshore end free standing at failing papapet wall.
104S	115+280	7			X	X				Offshore end at stone rubble tee-head at nearshore rock outcrop. Inshore end at dune. Land end at dune.

TABLE D CONT'D.

Groin Number	Location	Type	Condition: Remnant	Condition: Derelict	Condition: Complete	Function: Effective	Function: Ineffective	Incrustation	Safety Hazard	Remarks/Observations
105S	115+530	7			X	X				Offshore end at stone rubble tee-head at nearshore rock outcrop. Inshore end not observed.
-	115+780	7			X	X				Seaward end at stone rubble tee-head at nearshore rock outcrop. Land end not observed.
108S	116+020	7			X	X				Offshore end extends offshore beyond stone rubble tee-head. Tee-head on nearshore rock outcrop. Inshore end not observed.
110S	116+270	3			X	X				Offshore end extends to nearshore rock outcrop. Stone rubble along north and south face. Inshore end gunite with concrete cap with end at dune and parapet wall.
158S	123+780	2			X		X			Nearshore rock outcrop observed south of structure.
169S	125+200	1		X			X			

TABLE D2 CONT'D.

Notes:

1) Groin number from "Official Bulkhead and Groyne Plat" of Town of Palm Beach, Florida, adopted February 3, 1932.

2) Groin station from "Official Bulkhead and Groyne Plat" referenced in 1) above.

3) Location relative to Florida Department of Natural Resources reference monuments shown on "Palm Beach County Coastal Construction Control Line", September, 1974, Sheets 25 through 45.

4) Structure condition defined as follows:

Remnant: Abandoned, disconnected, isolated structural member, generally located offshore.

Derelict: Abandoned continuous groin segment, typically permeable.

Complete: Complete groin structure. Continuous onshore and offshore.

5) Structure type as defined by composition or construction as identified in key below:

KEY:

1 - steel sheet piling
2 - stone rubble mound
3 - composite concrete and steel sheet piling
4 - composite timber and steel sheet piling
5 - prestressed, precast concrete sheet piling
6 - adjustable concrete
7 - steel sheet piling with stone rubble mound tee-head
N.A. - data not available

TABLE D3

PIPING AND PIPE SUPPORT STRUCTURES

TOWN OF PALM BEACH

LOCATION	DESCRIPTION	OBSERVATION
85 + 750	drain	Localized scour of berm.
86 + 320	drain	Change in elevation of approximately 3 feet due to discharge scour.
86 + 730	drain	Localized scour of approximately 2 feet from drain at seawall.
88 + 760	pipe and support	Pipe terminates in surf zone. Hazard to swimmers.
94 + 1120	drain in seawall	Armor stone at discharge point.
96 + 160	pipe and support	Support visible, hazard to bathers.
95 + 520	pipe support rack	Hazard to bathers.
95 + 370	piping and supports	Hazard to bathers.
96 + 200 to 230	pipe and supports	Hazard to bathers.
96 + 540	pipe and support	-
96 + 570	pipe and support	Remnant support. Drain discharges at ptepped wall
96 + 1150	pipe support remnant	Vertical piping - possible remnant of pipe support. Hazard to bathers.
99 + 225	pipe and support	Hazard to bathers and beach users.
100 + 530	tee piping and support	Extends through surf zone, numerous pipe appendages.

TABLE D3 CONT'D

PIPING AND PIPE SUPPORT STRUCTURES

TOWN OF PALM BEACH

LOCATION	DESCRIPTION	OBSERVATION
100 + 1050	tee drain and pipe support	Two individual drainage systems extending through surf zone. Numerous appendages and pipe support remnants. Hazard to bathers and beach users.
101 + 260	tee piping and support	Hazard to bathers.
101 + 280	piping	Vertical discharge piping. Localized scour of approximately 1 foot due to discharge.
103 + 140	pipe support	Remnant pipe support. Incrustation observed. Hazard to bathers.
103 + 420	pipe and support	Remnant structure hazardous
103 + 880	pipe and support	Discharges in surf zon hazardous.
104 + 170	pipe and support	Hazard to bathers.
106 + 620	pipe and support	Located along south face of concrete groin.
107 + 400	tee piping	-
109 + 030	pipe and support	-
109 + 1200	pipe and support	Located at north face of rock rubble along timber steel sheet pile groin.

TABLE D3 CONT'D

PIPING AND PIPE SUPPORT STRUCTURES

TOWN OF PALM BEACH

LOCATION	DESCRIPTION	OBSERVATION
110 + 310	pipe and support	Incrustation observed.
114 + 140	pipe and support	Discharges at nearshore rock outcropping.
114 + 275	pipe support	Remnant pipe support.

TABLE D4

DUNES AND MISCELLANEOUS PROTECTIVE STRUCTURES

LOCATION	TYPE	OBSERVATIONS
76 + 000 to 80 + 140	5	Average dune height approx. 3 TO 5 feet. Dunes vegetated from Station 76+000 to approximately 77+1120, moderate vegetation(south of this Station).
82 + 660 to 83 + 390	5	Average dune height approximately 3 to 5 feet. Dune height decreasing to south, vegetated.
86 + 000 to 86 + 500	5	Vegetatead. Dune height decreases to south.
87 + 030 to 87 + 350	5	Vegetated.
87 + 540 to 88 + 870	5	Moderate to sparce vegetation. Dune height approximately 5 to 6 fee
89 + 740 to 90 + 050	2	Breakwater remnant; ineffective.
93 + 000 to 94 + 620	5	Maximum dune height approximately 6 feet. Moderate to well vegetated.
95 + 360 to 96 + 240	5	Dune height approximately 6 feet Well vegetated pocket beach area.
106 + 1090 to 109 + 1220	5	Well vegetated with dune height approximately 5 feet decreasing to south.
116 + 420 to 116 + 540	3	Slope protection in vicinity of Sloan's Curve. Intermittent vegetation due to stone.
116 + 270 to 120 + 000	5	Vegetated embankment height varies from approximately 25 feet north to to 15 feet south.
120 + 450 to 123 + 730	5	Poorly vegetated from 120 + 450 to approximately 120 + 850. Well vegetated thereafter. Dune height varies from 15 to 20 feet.

TABLE D4 CONT'D

DUNES AND MISCELLANEOUS PROTECTIVE STRUCTURES

LOCATION	TYPE	OBSERVATION
123 + 960 to 125 + 100	5	Dune height approximately 10 feet, well vegetated.
125 + 100 to 125 + 980	1	Concrete ship-lap block revetment. Poorly vegetated. Blocks 3 feet square with 0.3 feet block relief Change in structure slope occurs at Station 125 + 680.
126 + 030 to 126 + 920	1	Increased sand infill, sparse, scattered vegetation.
127 + 100 to 127 + 610	1	Increasing sand infill, moderate vegetion decreasing to south. Dun height approximately 4 feet.
128 + 970 to 129 + 090	5	Well vegetated.
129 + 200 to 130 + 060	5	Vegetated dune.
130 + 500 to 131 + 200	5	Undergoing dune toe erosion. Steeply cut toe decreasing vegetation to south.
137 + 200	4	Snow fence installed parallel to dun
131 + 600		Dune poorly vegetated. Evident erosion of dune toe.
131 + 600 to 131 + 1100	5	Dune height approximately 20 feet. Crest of dune vegetated. Evident erosion of dune toe.
131 + 1100 to 132 + 450	4	Fence installed parallel to dune. Dune crest vegetated. Lower portion of dune face not vegetated. Evident erosion of dune toe.
131 + 1160 to 132 + 380	3	Scattered stone, sand infilled possible remnant of beach protective measure.

APPENDIX E

COMPREHENSIVE COASTAL
MANAGEMENT PLAN
FOR
TOWN OF PALM BEACH

APPENDIX E

INVENTORY OF BIOLOGICAL RESOURCES

AUGUST 1986

APPENDIX E
TABLE OF CONTENTS

Plants Reported or Expected to Occur in the Vicinity of the Palm Beach Outcroppings

Contents based mainly on information modified from the Indian River Coastal Zone Study (First Annual Report, 1973-1974, and Second Annual Report, 1974-1975), Carlson (1970), Courtenay, et al. (1974), Daws (1967), Lakela and Long (1970), Phillips and Springer (1960), Saunders, et al. (1967), Steidinger, et al. (1967), and Zimmerman, et al. (1971).

Common Name	Technical Name
Diatoms:	Achanthes manifera
*	Actinoptychus senarius
*	Actinoptychus splendens
*	Actinoptychus undulatus
*	Amphiprora alata
*	Amphiprora gigantea sulcata
*	Amphora granulata
*	Amphora laevis
*	Amphora lindbergii
*	Amphora marina
*	Amphora obtusa
*	Amphora ostrearia
*	Amphora terroris
*	Asterionells japonica
*	Auliscus sculptus
*	Bacillaria paradoxa
*	Bacteriastrum comosum
*	Bellerochea malleus
*	Biddulphia alternans
*	Biddulphia aurita
*	Biddulphia mobiliensis
*	Biddulphia pulchella
*	Biddulphia regia
*	Biddulphia reticulum
*	Biddulphia rhombas
*	Biddulphia tyomeyi
*	Campylodiscus punctulatus
*	Cerataulina pelagica
*	Chaetoceros affine
*	Chaetoceros compressum
*	Chaetoceros decipiens
*	Chaetoceros didymum
*	Chaetoceros galvestonensis
*	Chaetoceros laciniosum
*	Chaetoceros lorenzianum
*	Chaetoceros peruvianum
*	Climacodium frauenfeldianum
*	Cocconeis placentula

Common Name	Technical Name
Diatoms (Continued):	
*	Cocconeis guarnerensis
*	Cocconeis scutellum
*	Corethron criophylum
*	Coscinodiscus centralis
*	Coscinodiscus nitidus
*	Coscinodiscus oculus
*	Coscinodiscus radiatus
*	Coscinosira polychorda
*	Cymatosira belgica
*	Dactyliosolen mediterraneus
*	Diploneis fusca
*	Ditylum brightwellii
*	Eucampia cornuta
*	Eucampia zoodiacus
*	Eunotogramma laeve
*	Eupodiscus radiatus
*	Grammatophora marina
*	Guinardia flaccidea
*	Gyrosigma balticum
*	Gyrosigma febigerii
*	Gyrosigma humii
*	Hemiaulus membranaceus
*	Hemiaulus sinensis
*	Hemidiscus hardmanianus
*	Lauderia borealis
*	Licmophora jurgensii
*	Licmophora lyngbyei
*	Licmophora paradoxa
*	Lithodesmium undulatum
*	Mastogloia braunii
*	Mastogloia lanceolata
*	Mastogloia pumila
*	Mastogloia smithii
*	Mastogloia sublatericia
*	Melosira dubia
*	Melosira nummuloides
*	Melosira sulcata
*	Navicula cancellata
*	Navicula clavata
*	Navicula forcipata
*	Navicula glacialis
*	Navicula lyra
*	Navicula marina
*	Navicula menaiana
*	Navicula nummularia
*	Navicula ornotheoides

Common Name	Technical Name
Diatoms (Continued):	
*	Navicula sulcifera
*	Navicula wawrikae
*	Nitzschia angularis
*	Nitzschia closterium
*	Nitzschia constricta
*	Nitzschia longissima
*	Nitzschia pardoxa
*	Nitzschia pungens
*	Nitzschia seriata
*	Nitzschia sigma
*	Ornotheis fimbriata
*	Paralia sulcata
*	Plagiogramma staurophora
*	Plagiogramma vanheurckii
*	Plagiogramma walliachianum
*	Peurosigma angulatum
*	Peurosigma formosum
*	Peurosigma stringosum
*	Rhabdonema adriaticum
*	Rhaphoneis surirella
*	Rhizosolenia alata
*	Rhizosolenia alata gracillima
*	Rhizosolenia calcar
*	Rhizosolenia calcar avis
*	Rhizosolenia fragilissima
*	Rhizosolenia hebetata semispina
*	Rhizosolenia imbricata
*	Rhizosolenia robusta
*	Rhizosolenia setigera
*	Rhizosolenia stolterfothii
*	Skeletonema costatum
*	Stephanopyxis palmeriana
*	Strepthotheca thamensis
*	Striatella unipunctata
*	Surirella americana
*	Surirella praeclara
*	Synedra splendens
*	Synedra undulata
*	Thalassionema nitzschiodes
*	Thalassiosira aestivalis
*	Thalassiosira decipiens
*	Thalassiothrix frauenfeldii
*	Thalassiothrix mediterranea pacifi
*	Triceratium dubium
*	Triceratium favus
*	Triceratium reticulum
*	Tropidoneis lepidoptera

Common Name	Technical Name
Dinoflagellates:	
*	Ceratium furca
*	Ceratium fusus
*	Ceratium hircus
*	Ceratium trichoceros
*	Ceratium tripos atlanticum
*	Dinophysis caudata acutiformis
*	Dinophysis caudata pedunculata
*	Exuviaella compressa
*	Exuviaella marina
*	Exuviaella perforata
*	Goniodoma polyedricum
*	Gonyaulax balechii
*	Gonyaulax diacantha
*	Gonyaulax diegensis
*	Gonyaulax digitalis
*	Gonyaulax monilata
*	Gonyaulax phoygramma
*	Gonyaulax spinifera
*	Ptycodiscus breve
*	Ptycodiscus splendens
*	Gyrodinium fissum
*	Gyrodinium glaucum
*	Gyrodinium instriatum
*	Gyrodinium spirale
*	Noctiluca scintillans
*	Ornithocercus steinii
*	Ornithocercus thumii
*	Peridinium abei
*	Peridinium claudicans
*	Peridinium conicum
*	Peridinium conicum guardafuiana
*	Peridinium depressum
*	Peridinium divergens
*	Peridinium excentricum
*	Peridinium oblongum
*	Peridinium pellucidum
*	Peridinium spiniferum
*	Peridinium tuba
*	Polykrikos hartmanni
*	Polykrikos schwartzi
*	Prorocentrum gracile
*	Prorocentrum micans
*	Protoceratium reticulatum
*	Pyrodinium bahamense
*	Pyrodinium schilleri
*	Pyrophacus horologicum

Common Name	Technical Name
Dinoflagellates (Continued):	
*	Pyrophacus horologicum steinii
*	Torodinium robustum
*	Torodinium teredo
Other Algae:	
*	Trichodesmium thiebautii
*	Acanthophora spicifera
*	Acanthophora muscoides
*	Acetabularia crenulata
*	Acetabularia farlowii
*	Acicularia shenckii
*	Acinetospora pusilla
*	Acrochaetium aurainvilleae
*	Acrochaetium sargassi
*	Acrochaetium seriatum
*	Agardhiella ramosissima
*	Agardhiella tenera
*	Agmenellum thermale
*	Anacystis aeruginosa
*	Anacystis dimidiata
*	Anacystis montana
*	Anadyomene menzizii
*	Anadyomene stellata
*	Ascocyclus magnusii
*	Ascocyclus orbicularis
*	Asterocystis ramosa
*	Avrainvillea asarifolia
*	Avrainvillea levis
*	Avrainvillea nigricans
*	Batophora oerstedi
*	Boodleopsis pusilla
*	Bostrychia binderi
*	Bostrychia montagnei
*	Bostrychia radicans
*	Bostrychia rivularis
*	Bostrychia tenella
*	Botryocladia occidentalis
*	Bothryocladida pyriformis
*	Bryopsis hypnoides
*	Brongiartella mucronata
*	Bryopsis pennata
*	Bryopsis plumosa
*	Callithamnion byssoides
*	Callithamnion cordatum
*	Callithamnion roseum

Common Name	Technical Name
Other Algae (Continued):	
*	Caloglossa leprieurii
*	Calothrix confervicola
*	Caulerpa ashmeadii
*	Caulerpa cupressoides
*	Caulerpa mexicana
*	Caulerpa paspaloides
*	Caulerpa peltata
*	Caulerpa prolifera
*	Caulerpa racemosa
*	Caulerpa sertulariodes
*	Centroceras clavulatum
*	Ceramium byssoideum
*	Ceramium codii
*	Ceramium corniculatum
*	Ceramium fastigiatum
*	Ceramium floridanum
*	Ceramium strictum
*	Ceramium subtile
*	Chaetomorpha aerea
*	Chaetomorpha brachygona
*	Chaetomorpha linum
*	Champia parvula
*	Chondria collinsiana
*	Chondria dasyphylla
*	Chondria leptacrenon
*	Chondria littoralis
*	Chondria sedifolia
*	Chondria tenuissima
*	Chrysymenia enteromorpha
*	Cladophora fusicularis
*	Cladophora glaucescens
*	Cladophora gracilis
*	Cladophora repens
*	Cladophora sericea
*	Cladosiphon occidentalis
*	Cladosiphon zosterae
*	Codium decorticatum
*	Codium isthomocladum
*	Codium taylori
*	Colpomenia sinuosa
*	Corallina cubensis
*	Corynomorpha clavata
*	Crouania attenuata
*	Cryptopleura fimbriata
*	Cystodictyon pavonium
*	Dasya corymbifera

Common Name	Technical Name
Other Algae (Continued):	
*	Dasya pedicellata
*	Dasyopsis antillarum
*	Derbesia vaucheriaeformis
*	Dictyopteris delicatula
*	Dictyota cervicornis
*	Dictyota dichotoma
*	Dictyota divaricata
*	Dictyota linearis
*	Dictyota occidentalis
*	Digenia simplex
*	Dilophus alternans
*	Ectocarpus confervoides
*	Ectocarpus dasycarpus
*	Ectocarpus elachistaeformis
*	Ectocarpus mitchella
*	Ectocarpus siliculosus
*	Ectocarpus subcorymbosus
*	Enteromorpha chaetomorphoides
*	Enteromorpha clathrata
*	Enteromorpha compressa
*	Enteromorpha flexuosa
*	Enteromorpha intestinalis
*	Enteromorpha lingulata
*	Enteromorpha prolifera
*	Enteromorpha ramulosa
*	Enteromorpha salina
*	Entocladia flustrae
*	Entocladia viridis
*	Entophysalis conferta
*	Entophysalis deusta
*	Erythrocladia subintegra
*	Erythotrichia carnea
*	Eucheuma acanthocladum
*	Eucheuma isiforme
*	Fosliella atlantica
*	Fosliella farinosa
*	Fosliella lejolisii
*	Galaxaura bylindrica
*	Galaxaura obtusata
*	Gelidiella acerosa
*	Gelidium crinale
*	Gelidium pusillum
*	Giffordia conifera
*	Giffordia duchassaigniana
*	Giffordia mitchellae
*	Giffordia rallsiae

Common Name	Technical Name

Other Algae (Continued):

*	Gomontia polyrhiza
*	Goniolithon decutescens
*	Goniotrichum alsidii
*	Gracilaria armata
*	Gracilaria blodgettii
*	Gracilaria cervicornis
*	Gracilaria compressa
*	Gracilaria damaecornis
*	Gracilaria debilis
*	Gracilaria foliifera
*	Gracilaria mammillaris
*	Gracilaria verrucosa
*	Gracilariopsis sjoestedtii
*	Grateloupia filicina
*	Griffithsia globulifera
*	Griffithsia tenuis
*	Grinnellia americana
*	Halimeda discoidea
*	Halimeda incrassata
*	Halimeda tuna
*	Halimeda monile
*	Halymenia agarhdii
*	Halymenia floresia
*	Halymenia gelinaria
*	Halymenia pseudofloresia
*	Herposiphonia secunda
*	Herposiphonia tenella
*	Hildenbrandia prototypus
*	Hypena cervicornis
*	Hypena cornuta
*	Hypena musciformis
*	Hypena spinella
*	Hypoglossum tenuifolium
*	Jania adherens
*	Jania capillacea
*	Jania pumula
*	Kylinia crassipes
*	Laurencia intricata
*	Laurencia tata
*	Laurencia microcladia
*	Laurencia obtusa
*	Laurencia papillosa
*	Laurencia poitei
*	Lithothamnium occidentale
*	Lithothamnium syntrophicum

Common Name	Technical Name
Other Algae (Continued):	
*	Lomentaria baileyana
*	Lomentaria rawitscheri
*	Lophosiphonia saccorhiza
*	Lyngbya confervoides
*	Lyngbya digueti
*	Lyngbya epiphytica
*	Lyngbya gracilis
*	Lyngbya majuscula
*	Lyngbya semiplena
*	Lyngbya sordida
*	Meristotheca floridana
*	Microcoleus chthonoplastes
*	Mictrocoleus lyngbyaceus
*	Monostroma oxyspernum
*	Myrionema strangulans
*	Myriotrichia subcorymbosa
*	Nemacystus howei
*	Oscillatoria laetevirens
*	Oscillatoria lutea
*	Ostreobium quekettii
*	Padina vickersiae
*	Penicillus capitatus
*	Penicillus dumetosia
*	Peyssonnelia rubra
*	Phaeophila dendroides
*	Plectonema terbrans
*	Pocockiella variegata
*	Polysiphonia denudata
*	Polysiphonia echinata
*	Polysiphonia ferulacea
*	Polysiphonia gorgoniae
*	Polysiphonia hapalacantha
*	Polysiphonia havenensis
*	Polysiphonia howei
*	Polysiphonia macrocarpa
*	Polysiphonia ramentacea
*	Polysiphonia subtilissima
*	Polysiphonia tepida
*	Porphrosiphon notarisii
*	Protoderma marina
*	Pseudotetraspora antillarum
*	Pterocladia americana
*	Pylaiella antillarum
*	Rhizoclonium hookeri
*	Rhizoclonium kerneri
*	Rhizoclonium kochianum

Common Name	Technical Name
Other Algae (Continued):	
*	Rhizoclonium raparium
*	Riphocephalus phoenix
*	Rosenvingea intricata
*	Sargassum filipendula
*	Sargassum fluitans
*	Sargassum hystrix
*	Sargassum natans
*	Sargassum polyceratium
*	Sargassum pteropleuron
*	Schizothrix arenaria
*	Schizothrix calcicola
*	Schizothrix mexicana
*	Scinaia complanata
*	Seirospora occidentalis
*	Spatoglossum schroederi
*	Sphacelaria furcigera
*	Sphacelaria tribuloides
*	Spirulina subsala
*	Sporochnus bolleanus
*	Sporochnum pedunculatus
*	Spyridia filamentosa
*	Stichococcus marinus
*	Stictyosiphon subsimplex
*	Stilophora rhizodes
*	Udotea conglutinata
*	Udotea flabellum
*	Ulva fasciata
*	Ulva lactuca
*	Ulvella lens
*	Valonia ventricosa
*	Vaucheria thuretii
*	Wurdemannia miniata

* No common name

Invertebrate Animals Reported or Expected to Occur in the Vicinity of the Palm Beach Outcroppings

Invertebrates of the coastal shelf to the south of the project area (from Courtenay, et al., 1974, and Goldberg, 1973).

Phylum Porifera (Sponges)

Species	Frequency[1]
Callyspongia repens	O
Callyspongia vaginalis	F
Chondrilla nucula	O
Cliona caribbea	O
Cliona celata	C
Dasychalina cyathina	O
Geodia gibberosa	O
Haliclona rubens	F
Haliclona variabilis	O
Haliclona viridis	O
Hircinia campana	C
Hircinia fasiculata	O
Hircinia strobilina	O
Homaxinella waltonsmithi	O
Iotrocata birotulata	C
Microciona juniperina	C
Psuedaxinella rosacea	O
Spheciospongia vesparia	O
Tethya sp.	R
Verongia flura	O
Xestospongia muta	C

Phylum Coelenterata, Class Anthozoa, Subclass Octocorallia (Soft Corals)

Species	Frequency and Occurrence
Briareum asbestinum	C-1-2*
Ellisella barbadeusis	O-3*
Ellisella sp.	C-3*
Erythropodium caribaeorum	R-1-2*
Eunicea asperula	R-1
Eunicea calyculata	C-1-2-3*
Eunicea clavigera	C-1-2-3*
Eunicea fusca	C-1-2-3*
Eunicea knightii	R-1
Eunicea laciniata	O-1-2-3*
Eunicea laxispica	R-1*
Eunicea mammosa	C-1-2-3
Eunicea palmeri	C-1-2-3*
Eunicea pinta	C-3*
Eunicea succinea	F-1-2-3*
Eunicea tourneforti	C-1-3*
Gorgonia ventalina	C-1-3*
Iciligorgia schrammi	A-1-2-3*
Lophogorgia cardinalis	R-3*
Muricea atlantica	C-1
Muricea laxa	R-1-3*
Muricea muricata	F-1-2-3*
Muricea pendula	R-3*

Phylum Coelenterata, Class Anthozoa, Subclass Octocorallia (Soft Corals) (Continued)

Species	Frequency and Occurrence
Muriceopsis petila	A-3*
Nicella schmitti	O-3*
Plexaura flexuosa	F-1-2-3*
Plexaurella dichotoma	C-1-2-3*
Plexaurella fusifera	F-1-3*
Plexaurella grisea	O-1-2-3*
Plexaurella natans	R-3
Plexaurella pumila	R-3*
Psuedoplexaura crucis	R-3*
Psuedoplexaura flagellosa	O-1-3*
Psuedopterogorgia acerosa	C-1-2-3*
Psuedopterogorgia americana	F-1-2-3*
Psuedopterogorgia elisabethia	R-3*
Psuedopterogorgia rigida	C-1-2-3*
Psuedopterogorgia navia	R-3*
Psuedopterogorgia sp. 1	R-3*
Psuedopterogorgia sp. 2	R-3*
Pterogorgia anceps	F-1-3
Pterogorgia citrina	R-1-3*
Pterogorgia guadalupeusis	R-3*
Swiftia exserta	R-3*
Telesto sp.	R-3

Phylum Coelenterata, Class Anthozoa, Subclass Scleractinia (Hard Corals)

Species	Frequency and Occurrence
Acropora eernicornis	Q-1-3*
Acropora palmata	R-1
Agaricia agaricites	C-1-3*
Agaricia lamarcki	A-3*
Cladocora arbuscula	O-1*
Colcophyllia natans	O-3*
Dichocoenia stellaris	R-3*
Dichocoenia stokesi	F-1-3*
Diploria clivosa	F-1-3*
Eusmilia fastigata	O-3*
Isophyllastrea rigida	R-3
Isophyllia multiflora	O-1-3
Madracis decactis	O-3*
Manicina areolata	F-1-3*
Manicina mayori	C-3*
Meandrina danae	A-3*
Meandrina meandrites	C-1-3*
Montastrea annularis	A-2-3*
Montastrea cavernosa	A-1-2-3*
Mussa angulosa	O-1-3*
Mycetophyllia lamarckiana	O-1-3*
Occulina diffusa	A-2*
Porites asteroides	C-1-3*

Phylum Coelenterata, Class Anthozoa, Subclass Scleractina (Hard Corals) (Continued)

Species	Frequency and Occurrence
Porites branneri	R-3
Porites porites	O-3
Scolymia lacera	R-1-3*
Siderastrea radians	R-3*
Siderastrea siderea	C-1-2-3*
Solenastrea bounoni	O
Solenastrea hyades	A-2-3*
Stephanocoenia michelinii	C-2-3*
Tubastrea tunuilamellosa	O

Phylum Mollusca, Class Gastropoda (Snails)

Species	Frequency
Aplysia dactylometra	R
Astraea tuber	O
Bursa granularis	O
Cassis madagascarensis	R
Cassis tuberosa	R
Cerithium muscarum	C-F
Charonia variegata	R
Columbella mercatoria	R
Coralliophila abbreviata	F
Cyphoma gibbosum	O-C
Cypraea cervis	O
Cypraea cineria	O
Cypraea zebra	R
Hypselodoris edeaticulata	R
Fasciolaria tulipa	R-O
Leucozonia ocellata	R
Morula nodulosa	F
Murex dilectus	R
Murex pomum	O
Murex rubidus	R
Muricopsis oxytatus	R
Pleuroploca gigantea	R-O

Phylum Mollusca, Class Gastropoda (Snails)
(Continued)

Species	Frequency
Strombus alatus	O
Strombus costatus	O
Strombus gigas	C
Strombus raninus	R
Terebra dislocata	R
Thais haematoma	F
Trivia pediculus	O
Vasum muricatum	F

Phylum Mollusca, Class Pelecypoda (Clams)

Species	Frequency
Anadara sp.	F
Anomia simplex	O
Arca zebra	O
Arcinella cornuta	R
Barbatia candida	A
Chama macerophylla	O
Chlamys imbricatus	R
Chlamys sentis	O
Glycemeris decussata	O
Isognomon radiatus	F
Lima lima	F
Lima scabra	C
Lithophaga antillarum	O

Phylum Mollusca, Class Pelecypoda (Clams)
(Continued)

Species	Frequency
Lithophaga aritata	C
Lithophaga nigra	C-F
Lyropecten nodosus	R
Macrocallista maculata	O
Ostrea frons	R
Pecten ziczac	R
Pinctada radiata	O
Pinna carnea	O
Plicatula gibbosa	O-F
Psuedochama radians	R
Pteria colymbus	O-C
Rocellaria hians	C
Spondylus americana	C
Spondylus gussoni	C
Tellina listeri	R
Tellina sp.	R
Trachycardium sp.	R

[1]Frequency notation: A=abundant, C=common, F=frequent, O=occasional, R=rare

*Recorded by both Courtenay, et al., and Goldberg

Fishes Reported or Expected to Occur in the Vicinity of the Palm Beach Outcroppings

Contents based mainly on information modified from the Indian River Coastal Zone Study (First Annual Report, 1973-1974, and Second Annual Report, 1974-1975), Bohlke and Chapman (1968), and Starck (1968).

Common Name	Technical Name
Sand Tiger	Odontaspis taurus
Nurse shark	Ginglymostoma cirratum
Blacknose shark	Carcharhinus acronotus
Bignose shark	Carcharhinus altimus
Bull shark	Carcharhinus leucas
Blacktip shark	Carcharhinus limbatus
Spinner shark	Carcharhinus maculipinnis
Dusky shark	Carcharhinus obscurus
Reef shark	Carcharhinus springeri
Tiger shark	Galeocerdo cuvieri
Lemon shark	Negaprion brevirostris
Bonnethead	Sphyrna tiburo
Yellow stingray	Urolophus jamaicensis
Lesser electric ray	Narcine brasiliensis
Spotted eagle ray	Aetobatus narinari
Bullnose ray	Myliobatis freminvillei
Shortnose sturgeon	Acipenser brevirostrum
Ladyfish	Elops saurus
Tarpon	Megalops atlantica
Bonefish	Albula vulpes

Common Name	Technical Name
American eel	*Anguilla rostrata*
Green moray	*Gymnothorax funebris*
Spotted moray	*Gymnothorax moringa*
Purplemouth moray	*Gymnothorax vicinus*
Reticulated moray	*Muraena retifera*
Pygmy moray	*Anarchias yoshiae*
Viper moray	*Enchelycore nigricans*
Goldentail moray	*Muraena miliaris*
Reef eel	*Kaupichthys hyoproroides*
Sailfin eel	*Letharchus velifer*
Key worm eel	*Ahlia egmontis*
Whip eel	*Bascanichthys scuticaris*
Sooty eel	*Bascanichthys teres*
Sharptail eel	*Myrichthys acuminatus*
Speckeled worm eel	*Myrophis punctatus*
False pilchard	*Harengula clupeola*
Redear sardine	*Harengula humeralis*
Herring	*Jenkensia* sp.
Atlantic thread herring	*Opisthonema oglinum*
Spanish sardine	*Sardinella achovia*
Cuban anchovy	*Anchoa cubana*
Striped anchovy	*Anchoa hepsetus*
Bigeye anchovy	*Anchoa lamprotaenia*
Inshore lizardfish	*Synodus foetens*

Common Name	Technical Name
Snakefish	Trachinocephalus myops
Gafftopsail catfish	Bagre marinus
Splitlure frogfish	Antennarius scaber
Sargassumfish	Histrio histrio
Halfbeak	Hyporhamphus unfasciatus
Ballyhoo	Hemiramphus brasiliensis
Atlantic flyingfish	Cypselurus heterurus
Atlantic needlefish	Strongylura marina
Redfin needlefish	Strongylura notata
Timucu	Strongylura timucu
Houndfish	Tylosurus crocodilus
Reef silverside	Allanetta harringtonensis
Bluespotted cornetfish	Fistularia tabacaria
Lined seahorse	Hippocampus erectus
Longspine scorpionfish	Pontinus longispinus
Longfin scorpionfish	Scorpaena agassizi
Barbfish	Scorpaena brasiliensis
Plumed scorpionfish	Scorpaena grandicornis
Spotted scorpionfish	Scorpaena plumieri
Deepreef scorpionfish	Scorpaenodes tredecimspinosus
Leopard searobin	Prionotus scitulus
Bighead searobin	Prionotus tribulus
Snook	Centropomus undecimalis
Crimson bass	Anthias asperilinguis

Common Name	Technical Name
Bank sea bass	Centropristis ocyurus
Rock sea bass	Centropristis philadelphica
Dwarf sand perch	Diplectrum bivittatum
Sand perch	Diplectrum formosum
Speckled hind	Epinephelus drummonhayi
Coney	Epinephelus fulva
Jewfish	Epinephelus itajara
Red grouper	Epinephelus morio
Snowy grouper	Epinephelus niveatus
Nassau grouper	Epinephelus striatus
Red barbier	Hemanthias vivanus
Blue hamlet	Hypoplectrus gemma
Butler hamlet	Hypoplectrus unicolor
Black hamlet	Hypoplectrus nigricans
Barred hamlet	Hypoplectrus puella
Wrasse bass	Liopropoma eukrines
Black grouper	Mycteroperca bonaci
Gag	Mycteroperca microlepis
Scamp	Mycteroperca phenax
Pygmy sea bass	Serraniculus pumilio
Lantern bass	Serranus baldwini
Saddle bass	Serranus notospilus
Tattler	Serranus phoebe
Belted sandfish	Serranus subligarius

Common Name	Technical Name
Freckled soapfish	Rypticus bistrispinus
Whitespotted soapfish	Rypticus maculatus
Greater soapfish	Rypticus saponaceus
Bigeye	Priacanthus arenatus
Short bigeye	Pristigenys alta
Flamefish	Apogon maculatus
Twospot cardinalfish	Apogon pseudomaculatus
Barred cardinalfish	Apogon binotatus
Conchfish	Astropogon stellatus
Freckled cardinalfish	Phaeoptyx conklini
Dusky cardinalfish	Phaeoptyx pigmentaria
Bluefish	Pomatomus saltatrix
Cobia	Rachycentron canadum
Sharksucker	Echeneis naucrates
Whitefin sharksucker	Echeneis neucratoides
African pompano	Alectis crinitis
Yellow jack	Caranx bartholomaei
Blue runner	Caranx crysos
Crevalle jack	Caranx hippos
Horse-eye jack	Caranx latus
Bar jack	Caranx ruber
Atlantic bumper	Chloroscombrus chrysurus
Round scad	Decapterus punctatus
Leatherjacket	Oligoplites saurus

Common Name	Technical Name
Bigeye scad	Selar crumenopthalmus
Lookdown	Selene vomer
Atlantic moonfish	Vomer setapinnis
Florida pompano	Trachinotus carolinus
Permit	Trachinotus falcatus
Dolphin	Coryphaena hippurus
Mutton snapper	Lutjanus analis
Schoolmaster	Lutjanus apodus
Red snapper	Lutjanus campechanus
Cubera snapper	Lutjanus cyanopterus
Gray snapper	Lutjanus griseus
Dog snapper	Lutjanus jocu
Mahogany snapper	Lutjanus mahogoni
Lane snapper	Lutjanus synagris
Yellowtail snapper	Ocyurus chrysurus
Vermilion snapper	Rhomboplites aurorubens
Tripletail	Lobotes surinamensis
Silver jenny	Eucinostomus gula
Yellowfin mojarra	Gerres cinereus
Black margate	Anisotremus surinamensis
Porkfish	Anisotremus virginicus
Margate	Haemulon album
Tomtate	Haemulon aurolineatum
Ceasar grunt	Haemulon carbonarium

Common Name	Technical Name
Smallmouth grunt	Haemulon chrysargyreum
French grunt	Haemulon flavolineatum
Spanish grunt	Haemulon macrostomum
Cottonwick	Haemulon melanurum
Sailors choice	Haemulon parrai
White grunt	Haemulon plumieri
Bluestriped grunt	Haemulon sciurus
Pigfish	Orthopristis chrysoptera
Sheepshead	Archosargus probatocephalus
Sea bream	Archosargus rhomboidalis
Grass porgy	Calamus arctifrons
Jolthead porgy	Calamus bajonado
Spottail pinfish	Diplodus holbrooki
Silver porgy	Diplodus argenteus
Scup	Stenotomus chrysops
High-hat	Equetus acuminatus
Jackknife-fish	Equetus lanceolatus
Cubbyu	Equetus umbrosus
Spot	Leiostomus xanthurus
Southern kingfish	Menticirrhus americanus
Gulf kingfish	Menticirrhus littoralis
Northern kingfish	Menticirrhus saxatilis
Atlantic croaker	Micropogon undulatus
Reef croaker	Odontoscion dentey

Common Name	Technical Name
Black drum	_Pogonias cromis_
Red drum	_Sciaenops ocellata_
Star drum	_Stellifer lanceolatus_
Sand drum	_Umbrina coroides_
Glassy sweeper	_Pempheris schomburgki_
Red goatfish	_Mullus auratus_
Spotted goatfish	_Pseudupeneus maculatus_
Bermuda chub	_Kyphosus sectratrix_
Yellow chub	_Kyphosus incisor_
Atlantic spadefish	_Chaetodipterus faber_
Bank butterflyfish	_Chaetodon aya_
Foureye butterflyfish	_Chaetodon capistratus_
Spotfin butterflyfish	_Chaetodon ocellatus_
Reef butterflyfish	_Chaetodon sedentaris_
Blue angelfish	_Holacanthus bermudensis_
Queen angelfish	_Holacanthus ciliaris_
Rock beauty	_Holacanthus tricolor_
Gray angelfish	_Pomacanthus arcuatus_
French angelfish	_Pomacanthus paru_
Sergeant major	_Abudefduf saxatilis_
Night sergeant	_Abudefduf taurus_
Yellowtail reeffish	_Chromis enchrysurus_
Dusky damselfish	_Pomacentrus fuscus_
Beaugregory	_Pomacentrus leucostictus_

Common Name	Technical Name
Bicolor damselfish	Pomacentrus partitus
Cocoa damselfish	Pomacentrus variabilis
Spanish hogfish	Bodianus rufus
Dwarf wrasse	Doratonotus megalepis
Greenband wrasse	Halichoeres bathyphilus
Slippery dick	Halichoeres bivittatus
Clown wrasse	Halichoeres maculipinna
Blackear wrasse	Halichoeres poeyi
Puddingwife	Halichoeres radiatus
Pearly razorfish	Hempteronotus novacula
Hogfish	Lachnolaimus maximus
Bluehead	Thalassoma bifasciatum
Bluelip parrotfish	Cryptotomus roseus
Emerald parrotfish	Nicholsina usta
Midnight parrotfish	Scarus coelestinus
Princess parrotfish	Scarus taeniopterus
Striped parrotfish	Scarus croicensis
Rainbow parrotfish	Scarus guacamaia
Blue parrotfish	Scarus coeruleus
Bucktooth parrotfish	Sparisoma radians
Redtail parrotfish	Sparisoma chrysopterum
Redfin parrotfish	Sparisoma rubripinne
Stoplight parrotfish	Sparisoma viride
Redeye mullet	Mugil gaimardianus

Common Name	Technical Name
Striped mullet	*Mugil cephalus*
White mullet	*Mugil curema*
Great barracuda	*Sphyraena barracuda*
Atlantic threadfin	*Polydactylus octonemus*
Littlescale threadfin	*Polydactylus oligodon*
Barbu	*Polydactylus virginicus*
Dusky jawfish	*Opistognathus whitehursti*
Bigeye stargazer	*Dactyloscopus crossotus*
Sand stargazer	*Dactyloscopus tridigitatus*
Arrow stargazer	*Gillellus greyae*
Southern stargazer	*Astroscopus y-graecum*
Roughhead blenny	*Acanthemblemaria aspera*
Puffcheek blenny	*Labrisomus bucciferus*
Hairy blenny	*Labrisomus nuchipinnis*
Blenny	*Hypsoblennius* sp.
Rosy blenny	*Malacoctenus macropus*
Saddled blenny	*Malacoctenus triangulatus*
Blackfin blenny	*Paraclinus nigripinnis*
Checkered blenny	*Starksia ocellata*
Molly miller	*Blennius cristatus*
Seaweed blenny	*Blennius mormoreus*
Oyster blenny	*Hypleurochilus aequipinnis*
Barred blenny	*Hypleurochilus bermudensis*
Crested blenny	*Hypleurochilus geminatus*

Common Name	Technical Name
Spotted dragonet	Callionymus pauciradiatus
Spinycheek sleeper	Eleotris pisonis
Sleeper	Eleotris sp.
Emerald sleeper	Erotelis smaragdus
Bridled goby	Coryphopterus glaucofraenum
Goldspot goby	Gnatholepis thompsoni
Clown goby	Microgobius gulosus
Frillfin goby	Bathygobius soporator
Tiger goby	Gobiosoma macrodon
Neon goby	Bogiosoma oceanops
Code goby	Gobiosoma robustum
Darter goby	Golionellus boleosoma
Emerald goby	Gobionellus smaragdus
Tusked goby	Risor ruber
Ocean surgeon	Acanthurus bahianus
Doctorfish	Acanthurus chirurgus
Blue tang	Acanthurus coeruleus
Atlantic cutlassfish	Trichiurus lepturus
Little tunny	Euthynnus alletteratus
King mackerel	Scomberomorus cavalla
Spanish mackerel	Scomberomorus maculatus
Man-of-war	Nomeus gronovii
Harvestfish	Peprilus alepidotus
Butterfish	Peprilus triacanthus

Common Name	Technical Name
Eyed flounder	*Bothus ocellatus*
Gulf Stream flounder	*Citharichthys arctifrons*
Fringed flounder	*Etropus crossotus*
Fourspot flounder	*Paralichthys oblongus*
Summer flounder	*Paralichthys dentatus*
Southern flounder	*Paralichthys lethostigma*
Broad flounder	*Paralichthys squamilentus*
Channel flounder	*Syacium micrurum*
Lined sole	*Achirus lineatus*
Blackcheek tonguefish	*Symphurus plagiusa*
Dotterel filefish	*Aluterus heudeloti*
Orange filefish	*Aluterus schoepfi*
Scrawled filefish	*Aluterus scriptus*
Gray triggerfish	*Balistes capriscus*
Ocean triggerfish	*Canthidermis sufflamen*
Fringed filefish	*Monacanthus ciliatus*
Planehead filefish	*Monacanthus hispidus*
Scrawled cowfish	*Lactophrys quadricornis*
Trunkfish	*Lactophrys trigonus*
Smooth trunkfish	*Lactophrys triqueter*
Puffer	*Lagocephalus laevigatus*
Southern puffer	*Sphoeroides nephelus*
Bandtail puffer	*Sphoeroides spengleri*
Bridled burrfish	*Chilomycterus antennatus*

Common Name	Technical Name
Striped burrfish	Chilomycterus schoepfi
Ballonfish	Diodon holacanthus
Porcupinefish	Diodon histrix