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WESTHAMPTON BEACH:
OPTIONS FOR THE FUTURE

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Convened by: Jay Tanski
New York Sea Grant Extension Program
State University of New York at Stony Brook

Henry Bokuniewicz
Marine Sciences Research Center
State University of New York at Stony Brook

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We are extremely grateful to the following workshop participants who generously contributed their time and considerable expertise to make this effort possible:

Dr. Robert Dean
Department of Coastal and
Oceanographic Engineering
University of Florida
336 Weil Hall
Gainesville, Florida 32611

Dr. Craig Everts
Moffatt and Nichol Engineers
250 West Wardlow Road
P. O. Box 7707
Long Beach, California 90807

Dr. Graham Giese
Woods Hole Oceanographic
Institution
Woods Hole, MA 02543

Dr. Stephen Leatherman, Dir.
Laboratory for Coastal
Research
Room 1175, Lefrak Hall
University of Maryland
College Park, Maryland 20742

Dr. Orrin Pilkey
Department of Geology
Duke University
Box 6729 College Station
Durham, North Carolina 27708

Dr. Choule J. Sonu
Tekmarine, Inc.
572 East Green Street
Pasadena, California 94549

Dr. Gary Zarillo
Department of Oceanography
Florida Institute of Technology
Melbourne, Florida 32901

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Introduction

The situation at Westhampton, New York, is one of the most interesting and perplexing problems associated with shore erosion in the nation. It may also be a portent of more widespread problems facing coastal zone managers in the near future. The complex political history of the Westhampton groin field was thoroughly discussed in an excellent book by Heikoff (1976) while the scientific and engineering aspects of the project have been the subject of several technical studies (e.g., DeWall, 1979). The resolution of the problem remains a topic of intense interest not only among coastal engineers and geologists but also among government agencies, elected officials, coastal property owners, and the general public.

Reflecting the widespread interest in the topic, this document began with discussions initiated during a symposium entitled "Working Solutions: Shore and Beach" held at the University of California, Berkeley. In response to suggestions made at this meeting, a small group of internationally-recognized experts in coastal processes was assembled to examine the Westhampton problem in light of their broad range of practical experience and technical expertise. The participants were familiar with the situation at Westhampton but not involved with local interests. The primary purpose of this effort was to try to review objectively the various options proposed for Westhampton, based on technical knowledge and experience gained from erosion-management strategies implemented in other areas.

This report summarizes the results of the group's review of the six most-discussed alternatives for dealing with the Westhampton problem. Because of the complexity and variability of coastal processes and associated erosion problems, our basic understanding of them often must be distilled from numerous examples and case studies. The viewpoints presented here are based on such distillations. Realizing that the final decision will be based on social and economic concerns, as well as the technical considerations discussed here, we hope this information will aid decision makers in selecting an appropriate strategy for dealing with the Westhampton erosion problem.

The Problem

The general situation at Westhampton and some of the pertinent facts can be summarized as follows:

1. A 3-mile stretch of the populated barrier beach downdrift of a 15-groin field at Westhampton has suffered serious and chronic erosion (Figure 1). In the face of impending litigation, state and federal government agencies proposed a $124 million beach nourishment program as an interim solution. The project would have involved the placement of 8.2 million cubic yards of sand from two offshore borrow areas, located approximately 4000 feet offshore in 40 to 50 feet of water (Figure 2), and periodic renourishment over a 50-year period.

Figure 1. Aerial view of Westhampton in 1983. The two westernmost groins can be seen in the foreground. Moriches Inlet is at the top left-hand corner of the photograph.

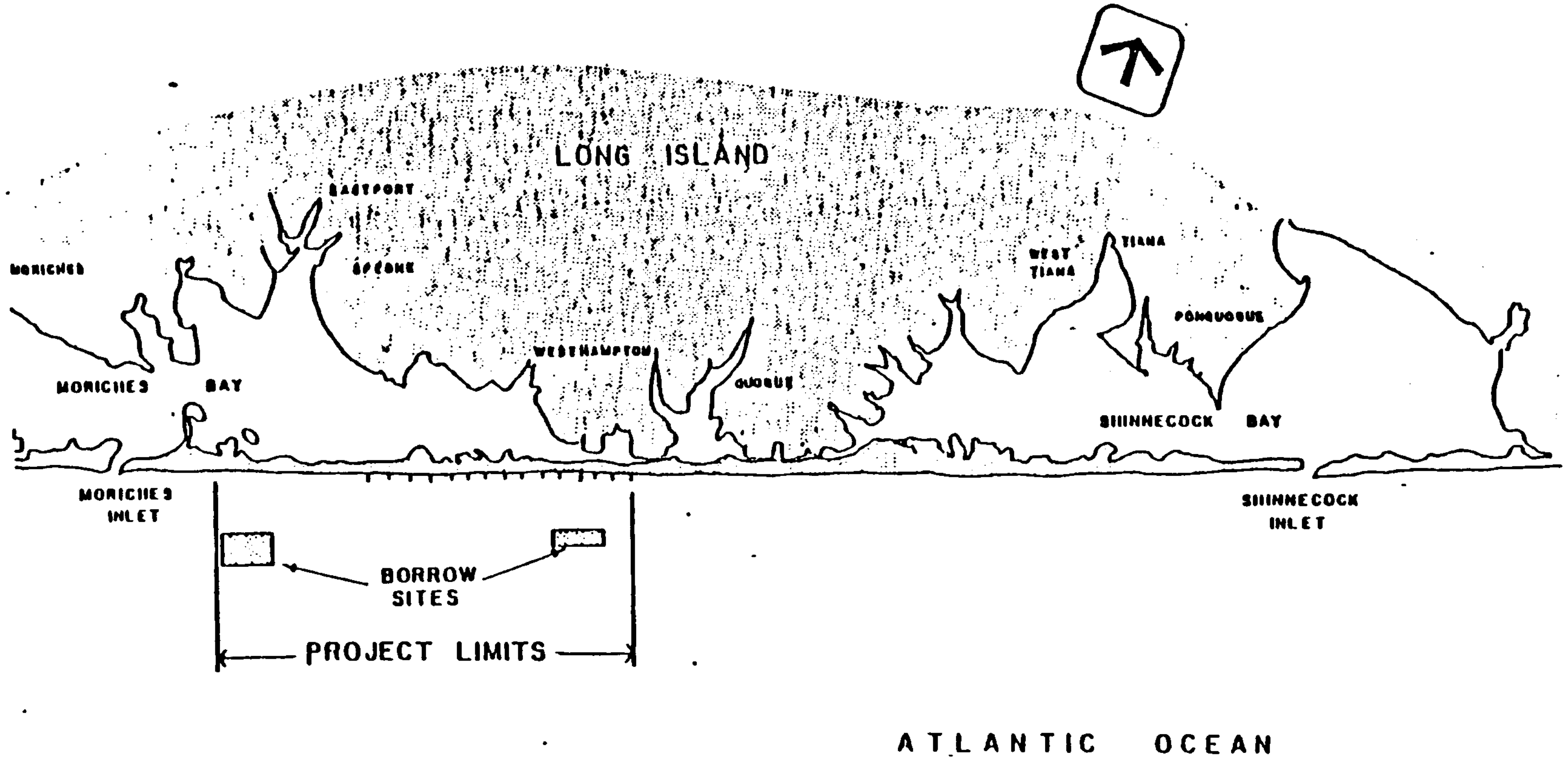

Figure 2. Location map showing boundaries and borrow sites for proposed beach fill project.

Federal and state sponsorship would end after 20 years. Although federal funding was appropriated, the project has not started due to local opposition.

2. New York's Secretary of State has ruled that the proposed interim plan is not consistent with the policies of the State's Coastal Management Program (letter dated October 14, 1987, from Secretary Gail Shaffer to U.S. Army Corps of Engineers, New York District), because:

a. public benefits would be minimal;

b. public access was not provided in the plan;

c. there was no assurance the project will be maintained for the required 30 years;

d. human disturbances of a designated critical fish and wildlife habitat would likely increase; and

e. removal of material from the offshore borrow area may interfere with natural sand transport.

3. Historically, the stretch of beach in Westhampton has been notable for relatively frequent overwashes and the formation of ephemeral inlets. Prior to the installation of groins the long-term shoreline recession rate was typically 1.5 feet per year. After the opening of Shinnecock Inlet to the east in 1933, recession rates as high as 6.8 feet per year were recorded in some sections (McCormick, 1973).

4. The tidal range is about 3.3 feet. The 100-year storm-surge still-water elevation has been calculated to be 11.3 feet above mean sea level. No site-specific wave measurements have been made in the project area. Estimates based on wind records indicate typical waves along Long Island's south shore have heights of between 1.5 to 2.5 feet with periods of 7 to 8 seconds (Jensen, 1983). According to visual observations and intermittent wave gauge data collected further to the west, near Jones Beach, waves higher than 6 to 10 feet occurred less than 1 percent of the time and the maximum recorded wave height was 13.4 feet for the 4-year period between 1950 and 1954 (Panuzio, 1968). The design wave used by the Corps for the Westhampton project was a deepwater wave 17 feet high with a period of 13 seconds (U.S. Army Corps of Engineers, 1980).

5. The net longshore transport rate of sand is about 200,000 to 300,000 cubic yards per year to the west. The gross transport, however, is likely to be close to one million cubic yards per year. One source of this sand is the erosion of the bluffs at the eastern tip of Long Island. Erosion of the bluffs alone does not seem to be sufficient to support the net longshore transport of sand and, further to the west at Fire Island Inlet, the net longshore transport has been estimated to be 600,000 cubic yards per year. Because of the increase in transport rates, McCormick and Toscano (1980) postulated an offshore source of sand.

6. There is a bar about 1000 feet offshore from the section of beach that contains the groins; this bar is a typical feature along the south shore. There may be gaps in the bar in this section, however. To the west of the westernmost groin, the bar attaches to the shoreline, then appears to take its normal offshore position near Moriches Inlet.

7. The original protection plan developed for the area by the Corps of Engineers in the 1950s called for beach nourishment only. Monitoring of the fill was to be undertaken, and, if deemed necessary, groins would be installed starting at Moriches Inlet and proceeding east (updrift) to retain the fill. In response to local concerns over the stability of the fill and the costs of maintaining the design beach without structures, the plan was modified to allow immediate construction of the groins.

8. Eleven groins were built between 1965 and 1966. Four others were added to the west during 1969 and 1970 in response to increased erosion downdrift of the original field.

a. The groins are 480 feet long and 1200 feet apart with elevations of 16 feet above mean sea level at the landward ends and decreasing to 2 feet above mean sea level at the seaward ends.

b. The groin field was begun at the eastern end of the section where overwashes first threatened structures. Eleven groins were built; the westernmost one was about 4 miles east of Moriches Inlet.

c. No fill was added to the compartments of the first 11 groins. The easternmost compartments have filled naturally, resulting in a wide, relatively stable beach with a waterline at or near the seaward end of the groins and in the development of a second line of dunes seaward of the original dune line.

d. Approximately 1.9 million cubic yards of sand dredged from the bay and the intercoastal waterway in the bay was placed in conjunction with the construction of the second set of four groins. However, the groin compartments in the western end of the section are not filled to capacity. As much as one-half of the total length of the individual groins may extend seaward from the waterline (Figure 1).

e. The original plan called for extension of the groin field to Moriches Inlet, if these structures were to be used at all. However, the additional groins were never built due to the lack of local support.

f. The beach within the groin field appears to be in equilibrium with the prevailing conditions. In the eastern section, where the groins are filled to capacity, the beach is fairly stable, and the shape of the shoreline segments between the groins are symmetrical in plan view (i.e., when viewed from above). In the western section, however, where the groins are more exposed and not filled to capacity, the shoreline segments between the groins are skewed in plan view with material in the compartment being redistributed eastwardly or westwardly according to the direction of incoming waves. This pattern of shoreline asymmetry is fairly typical of other sandy coastlines influenced by groin fields (e.g., Sea Isle City, NJ; Everts, 1979).

9. The beach sand presently in the western compartments is fairly coarse so it is unlikely that this is the original fill placed during the construction of the last four groins. This sand has probably accumulated naturally in the compartments.

10. It also appears that the beach to the east of the groin field has been widened and stabilized by the presence of the structures. The length of beach so affected and the volume of sand stored here are unknown but these numbers could be estimated from a more detailed analysis of available data.

11. Moriches Inlet, the first inlet west of the groin field, is stabilized by two jetties that were constructed between 1952 and 1954. Although the net annual longshore transport into the inlet has been calculated to be about 260,000 cubic yards to the west (U.S. Army Corps of Engineers, 1982), the inlet channel has not been dredged since the construction of the jetties. At present the inlet is legally closed to navigation due to shoaling, although it is still used by boaters. The U.S. Army Corps of Engineers (1982) estimates annual maintenance dredging requirements for a proposed navigation channel and deposition basin at between 88,000 and 98,000 cubic yards. There appears to be a substantial amount of sand bypassing the inlet and moving to the west.

12. Due to scouring on the bayside, a breach occurred just to the east of the inlet (i.e., between the inlet and the westernmost groin) in 1980 (U.S. Army Corps of Engineers, 1982). The state and federal government decided to fill the new inlet (Kassner and Black, 1982). Consequently, about $11 million was spent to close the breach and to armor part of the bay shoreline to prevent further scour.

13. Chronic erosion has occurred in the entire section between the last groin and the inlet. However,

a. the most serious erosion has been within a mile of the westernmost groin, which is subject to washovers five or six times per year; and

b. at least some sand seems to be bypassing the last groin along a bar that reattaches to the shoreline downdrift of the last groin, even though the westernmost compartments do not appear to be filled to capacity.

The Alternatives

Depending on the specific objectives to be achieved, there are a number of options that could be employed at Westhampton. The following is a summary of the group's assessment of the potential impacts and physical ramifications associated with the six most-discussed alternatives. These alternatives are: do nothing, remove the existing groins, add fill with periodic beach renourishment, modify the existing groins, extend the existing groin field, and construct a segmented breakwater.

Do Nothing

This approach implies no initial costs and would allow the barrier island to reach a state of equilibrium adjusted to existing conditions. The equilibrium would be a dynamic one, that is, the barrier would not remain in its present condition and position but would migrate landward episodically. The erosion occurring now would continue, decreasing the width of the island west of the groins. The frequency of washovers would increase, reducing the elevation of the island in this area. The rate of migration landward would increase as the barrier became narrower and lower in elevation. The lack of detailed information on the sedimentary and physical processes in the area limits the certainty with which predictions can be made regarding the final equilibrium configuration of the western portion of the island. However, experience elsewhere (e.g., Assateague Island, MD; Leatherman, 1979) indicates that the barrier would probably not disappear entirely; instead, ephemeral inlets and massive washovers would drive the portion of the island west of the groins landward during major storms. As the frequency of washovers increased, the island would become uninhabitable. The unstable nature of the area would preclude any improvements and severely restrict access. As a result, the potential for even recreational use of the beach would be minimal and most likely limited to 4-wheel drive traffic during certain portions of the year. The taxable land and structures west of the groin field would be lost. This property has an estimated assessed value of approximately $25 million according to a report prepared by the Long Island Regional Planning Board (1984).

In addition, as the barrier island west of the groin field recedes, the land and structures to the east behind the westernmost groins may be threatened by scouring and flanking around these groins during severe storm events. Although the process could take years, this erosion could eventually cause the groins to fail in sequence from west to east. In a similar situation on Dauphin Island, Alabama, the barrier island actually separated from a groin field. As the island migrated landward behind the groins, the structures were left offshore and eventually were undermined. If this were to occur at Westhampton, placement of fill and/or extension of the western groins landward would be needed to maintain the integrity of the groins and the beach they protect. The shifting of the barrier west of the groin field would lead to breaching and the formation of new inlets. Formation of a new inlet would:

a. Increase the salinity of waters in Moriches Bay affecting marine fauna. The clam population in Moriches Bay may be affected in two ways. First, there is some evidence that the peak survival of clam larvae occurs at a salinity of 27 ppt. If the exchange of ocean water with the bay through a new inlet increases the bay salinity above this optimum value, the recruitment of clam larvae could suffer. There is also evidence that higher salinities may reduce the growth of hard clams by as much as 40 percent (Turner, 1983). The bay, however, is generally not very productive in terms of hard clam harvests (Suffolk County Planning Department, 1987) and since relatively high salinities already exist in the eastern bay (Cerrato, 1986), this type of impact would probably only affect the western bay.

b. Increase flooding on the back-bay shoreline. According to modelling studies conducted in response to the 1980 Moriches Inlet breach, the breach caused a 41 percent increase in the tidal range in Moriches Bay (Pritchard and DiLorenzo, 1985). When a new inlet formed in Chatham, Massachusetts, recently, the tidal range in the bay increased by about 30 percent. The model also indicated that the expected changes in bay water elevations would be even greater for a new breach located further to the east towards the groin field, which is the probable location of an inlet resulting from the effects of the groins. The model predicted that a large breach in this area could increase the present tidal range in the bay by about 60 to 65 percent.

   The magnitude of storm-related changes in water levels associated with a new breach would depend on the length or duration of the storm affecting the coast. In a "worse case scenario" (maximum storm surge coinciding with a spring high tide), a new breach could allow bay storm water levels to increase by as much as 36 to 39 percent over those expected with existing inlet conditions for storms with durations close to the 12-hour tidal cycle, such as hurricanes. A typical winter northeaster, however, may last for three or more days. For storms of such long duration, the increase in water elevation resulting from a new inlet would be much less. This is primarily due to the fact that the present inlet configuration is not very efficient in dampening out storm surges in the bay when the storms are of a long duration. Since the assessed value of mainland residential property and improvements in flood-prone areas around Moriches Bay is approximately $275 million (Long Island Regional Planning Board, 1984), public and private flood and erosion control structures would probably be developed on the north shore of the bay in response to the increased threat.

c. Increase shoaling at Moriches Inlet due to a reduction in tidal flow through the channel. Modelling studies indicate that the tidal exchange between the bay and the ocean is not great enough to maintain two inlets indefinitely (Pritchard and DiLorenzo, 1985). Since Moriches Inlet is already stabilized, new inlets would form but would most likely close by natural filling processes time. Natural closure may require a number of years without the reoccurrence of the type of storm that caused the inlet. The lifetime (and size) of a new inlet is difficult to predict without detailed studies, but such a feature could persist for several years or longer if no action is taken. The 1980 breach remained open for 11 months and reached a width of 2900 feet before it was closed artificially (Schmeltz et al., 1982). Any increases in the bay salinity and flooding hazard would last until one of the inlets was closed either naturally or artificially.

d. Threaten properties behind the groin field. As mentioned previously, the formation of a new inlet near the groin field also could induce scouring and erosion in the area behind the westernmost groins endangering structures and land there if no action is taken. The westernmost groin already is showing signs of being undermined.

If the decision was made to close the inlets as they form, the costs associated with this type of maintenance of the barrier would have to be considered for this alternative. In 1981, about $11 million was spent to close a breach just east of Moriches Inlet.

The recent breach at Nauset Beach in Chatham, Massachusetts, illustrates the types of potential impacts that might be expected with a new inlet at Westhampton, even though the circumstances that caused the formation of the Nauset breach are different from those occurring at Westhampton.

Historically, the inlet at Nauset Beach has followed a cycle of change, having a period of approximately 150 years. This cycle is characterized by downdrift migration of the inlet at a rate of about one-half mile every 10 years, followed by the abrupt breaching of the barrier island at a point many miles updrift of the inlet, and the rapid development of that breach into a new inlet. Such a 150-year event, the formation of a new breach through Nauset Beach, last occurred in January 1987. Fifteen months later, the following changes in the system have occurred:

a. The new inlet has increased in width to approximately 1 mile and has captured an estimated 90 percent of the tidal flow into and out of Chatham Harbor and Pleasant Bay.

b. The tidal range in Chatham Harbor and Pleasant Bay has increased by approximately 1 foot.

c. Winter ice formation in the harbor and bay has decreased because of greater exchange of water between the bay and ocean.

d. New shoals have developed, in some cases ruining shellfish beds and disturbing navigation.

e. Increased tidal flushing in the upper bay has benefited shellfish production there, and new channels, including that at the inlet itself, have developed to the benefit of navigation.

f. Changes in wave energy along the mainland shoreline have resulted in accretion in some areas and rapid erosion in other unprotected areas. Approximately 100 feet of erosion has occurred along a one-quarter mile stretch of beach. One summer cottage has been lost and several others have been moved as a result of the increased erosion and the state's reluctance to allow shore protection structures on the bay shoreline.

Although the magnitude of the effects may not be the same, the formation of new inlets at Westhampton might be expected to cause similar kinds of changes in and around Moriches Bay.

Remove the Existing Groins

Initial costs for removing the groins have been estimated at approximately $12.2 million dollars (PRC Harris, Inc., 1984). The effects of removal of the groin field would, to some extent, mimic a beach nourishment project and allow redistribution of approximately 5 to 7 million cubic yards of sand thought to be presently contained in, and immediately east, of the groin compartments. (Estimates prepared for the Corps of Engineers indicate that approximately 550,000 cubic yards are trapped in the groin field (PRC Harris, Inc., 1984). However, based on the amount of accretion observed in the eastern compartments and to the east of the field, the workshop participants felt this was not an accurate estimate of the amount of sand trapped in the entire groin field but, more likely, referred to the sand trapped in each compartment. The panel's estimate is substantiated by the results of a sediment budget analysis which indicated that between 1967, the year after the first set of groins was completed, and 1979 the section of the shoreline containing the groins experienced a net gain of over 5.7 million cubic yards of sand (Research Planning Institute, 1985).) The pre-groin longshore sediment transport processes should be restored and the shadow effect downdrift of the groin field would be eliminated. Initially, the beach to the west would receive more sand from the increased erosion of the updrift beaches. The release of this sand into the longshore transport system would result in a temporary acceleration of shoaling in Moriches Inlet, and, thus, possibly incur increased maintenance dredging costs.

Since the total amount of sand that would be liberated would be much greater than the net annual longshore transport, it might be expected that the sand supply would mitigate existing conditions for 15 to 20 years, assuming that the historical data indicating annual losses of 260,000 cubic yards from the area are correct. During this period, the erosional pressure to the west of the groin field would be eased but erosion within and to the immediate east of the field would greatly increase, resulting in a simultaneous narrowing of the beach in these sections. Eventually, the original erosion problems experienced by the entire beach before the groin field was constructed should be expected to be reestablished; the entire stretch would experience the pre-groin recession rates of 1.5 to 6.8 feet per year (McCormick, 1973). Thus, structures and properties behind and to the east of the existing groin field, with a total assessed value of $144 million dollars (Long Island Regional Planning Board, 1984) would also be threatened.

As far as we know, this option has never been applied at any other location but behavior of natural barrier beaches may provide a reasonable approximation of what could be expected if this option was chosen. After the sand liberated by the removal of the groins was dispersed (i.e., after 15-20 years), the Westhampton barrier would migrate landward episodically in the face of rising sea level and a limited supply of sand. The occurrence of washovers during major storms and possible ephemeral breaches and inlets would preclude residential or business development and limit access. The effects of the inlets on the bay would be similar to those described in the previous section.

Add Fill with Periodic Beach Renourishment

The fill project proposed for Westhampton called for 8.2 million cubic yards of sand to be placed along a 5-mile stretch of beach. Design specifications require a beach with a 100-foot wide berm 12 to 14 feet above mean sea level and a 16-foot high dune having a crest 40 feet wide. Approximately 4.8 million cubic yards of sand would be used to fill the groin field, and 3.4 million cubic yards to nourish the downdrift beach. The initial cost would be $55.7 million.

Beach nourishment has been used at a large number of locations on East Coast barrier islands. Recent studies have identified more than 90 communities that have implemented projects with nourishment volumes in excess of 250,000 cubic yards of sand per mile of beach (Pilkey and Clayton, 1987). These projects have met with varying degrees of success. Although approximately 20 percent of the replenished beaches have lasted longer than 5 years, many have had useful lifetimes of 2 years or less. One of the most durable beach nourishment projects has been at Miami Beach, Florida, which received 10 million cubic yards of sand over a 10-mile stretch of beach in the late 1970s and has lost only 0.3 percent of the fill per year since construction (see Appendix). The least successful projects include several in New Jersey which have lasted less than one year. Closer to Westhampton, the Rockaway Beach nourishment project has proven to be fairly durable, with a lifetime on the order of 5 years. Most of the replenished beaches north of Florida have required complete replacement of original sand volumes to maintain design beaches for time spans in excess of 5 years.

Although specific maintenance requirements for Westhampton will depend on the results of post-construction monitoring, preliminary estimates by the Corps of Engineers based on historical data indicate annual losses of 260,000 cubic yards from the area, requiring 1.3 million cubic yards of sand at a cost of $10.4 million every five years. The Corps has noted the uncertainty in predicting the stability of the fill (see Appendix) and, based on experience elsewhere, the estimate of renourishment needs for Westhampton may be too low. This uncertainty could substantially increase the cost of maintenance. A 1968 storm, for example, removed more than 735,000 cubic yards of sand from a 6,000-foot stretch of beach west of the first 11 groins (U.S. Army Corps of Engineers, 1980).

To increase durability and reduce losses, it is important to use sand that is as coarse or coarser than the sand naturally present on the beach. If sand of a smaller size than the native sand is used, much greater quantities of sediment will be required to yield the same dry beach width and maintenance requirements will be increased. Calculations show, for one example, that reducing the sand size of the fill by 27 percent compared to the native sand size will reduce the dry sand beach width from 150 feet to 50 feet, a 67 percent reduction. For this same example, to obtain the same width of dry beach with the lesser quality sediment (i.e., finer-grained sand) would require a 90 percent increase in the volume used per unit length. The available data for the Westhampton project, however, indicate the proposed fill material is of good quality and compatible with the sand naturally present on the beach.

It is possible to estimate the longevity of various beach nourishment projects for the case of a long, uninterrupted beach (Dean, 1983). Although this idealized case is not applicable strictly to Westhampton due to the presence of stabilizing groins and the east Moriches jetty, these structures should lengthen the life of the fill material. Table I presents estimates of the probable longevity of a nourishment project with characteristics similiar to the proposed Westhampton project for representative wave heights of 2 feet and 5 feet.

TABLE I

APPROXIMATE LONGEVITY OF NOURISHMENT PROJECT

Project Length = 30,000 ft, Volume = 8,200,000 cubic yards
Nourishment Sediment Assumed to be
of Same Quality as Native Sediment

Time	Percentage of Fill Remaining Within Areas Placed for Representative Wave Heights (H)	
(Years)	H = 2 ft	H = 5 ft
1	93	78
2	90	69
5	83	51
10	77	40
20	67	32
50	51	22

Based on the limited information available on the conditions at the site and the characteristics of the proposed fill material, it is believed that the actual longevity of the beach nourishment project in Westhampton will be bracketed by the two cases above. Table II provides theoretical estimates of the expected rate of loss of the fill material.

TABLE II

EXPECTED FILL LOSSES

Time (years)	Cumulative Loss (% of initial fill)	Average Yearly Loss (% of initial fill)
5	30	6
10	40	4
20	50	2.5
50	65	1.3

The results in Tables I and II do not include the effects of sea level rise. The magnitude of future sea level rise will probably be greater than in the last 100 years and should be accounted for in a detailed design. However, it is believed that any realistic sea level rise scenario would have a relatively small impact on the above results, at least up to 20 years into the future.

Some of the material lost from the filled area will be transported to the west, benefitting downdrift beaches but increasing shoaling at Moriches Inlet. If the project is not maintained, recession will continue to occur west of the groin field, and downdrift shadow effects, as seen now, should be expected to return in about a decade since the groins would not be modified.

The two proposed borrow areas for the initial fill are in 40 to 50 feet of water located 4000 feet offshore. They cover a total area of approximately 300 acres to be dredged to a depth of 20 feet below the existing bottom. It is unlikely that the excavation of the borrow areas would aggravate erosion problems along the shore; wave refraction analysis performed by the Corps indicates no adverse effects in terms of redistribution of wave energy (U.S. Army Corps of Engineers, 1980). If there is an offshore source of sand to the beach, excavation of the borrow areas could disrupt that source. However, if offshore sand is being supplied at all, it should be distributed over the entire shoreline and the borrow areas would only remove a negligible fraction of the total. The protective benefits of having the sand placed directly on the beach would far outweigh the minor effects associated with any possible disruption of the onshore transport.

Filling the groin field is intended to restore downdrift movement of material along the shoreface while the widened beach would provide at least short-term protection. Since no structural alterations are involved, the impacts of this alternative could be considered reversible, and implementation would not preclude the use of other options in the future from a technical standpoint. However, financial considerations of implementing this option may effectively preclude the implementation of other options in the future.

Modify (Shorten or Taper) the Existing Groins

This option would involve shortening all of the groins or tapering the structures along the western section of the groin field in an effort to increase sand bypassing around the groins, while still maintaining a protective beach in the compartments. Shortening of the groins would be designed to reestablish the positive increase in net westward sand transport, thus minimizing downdrift erosion effects. Initial costs for this option would be somewhat less than the $12.2 million needed to completely remove the groins.

If the groins are shortened, some sand will be lost from the groin compartments, reducing the degree of protection provided by the present beach. However, the narrower beach would remain stabilized by the shortened structures. Erosion in the area downdrift of the groin field would be lessened, but this section would still be subject to the erosion that led to the building of groins in the first place. Therefore, a modification to this alternative would be to use construction material from the shortening of the existing groins to build additional shorter, lower groins downdrift to stabilize the beach and fill the new groin compartments with sand. Although the resultant beach would be narrower, the use of shorter, lower groins will minimize the adverse impacts associated with the present groin field. Initial cost for this modified alternative would probably be on the order of $40 to $50 million (somewhere between simple removal and full-scale beach nourishment alone). Since the new, lower groins would help retain fill, beach maintenance costs would be reduced. Any modification that would increase the rate of longshore transport of sand also will contribute to the shoaling of Moriches Inlet, thus increasing maintenance dredging costs.

The design of the groin modification scheme would depend on determining how the length of the groins affects the distribution of the littoral transport of sand. Although this approach has not been tested at other locations, experience indicates this concept is a valid one. However, design studies would be needed to more accurately predict the increased sand bypassing capability and the form of the adjusted beach profile. These studies would have to carefully consider the degree of beach narrowing that would result from shortening the groins as well as potential impacts in the downdrift area caused by extending the modified groin field. Specific groin field modifications that should be considered and tested include: (1) shortening of the groins, (2) tapering of the groin field to the west, (3) completion of a field of low profile, short groins using excess material from the shortening or tapering of the existing groins and (4) removal of alternate groins in combination with shortening or tapering.

Extend the Existing Groin Field

This alternative would involve extending the groin field towards the inlet and filling the compartments of the new and existing groins. The new groins would have the same spacing and dimensions as the existing groins. Initial costs for extending the groins would probably be over $75 million ($20 million for 13 new groins plus more than $55.7 million for fill). Since the groins would help retain fill on the beach, maintenance costs associated with renourishment should be reduced in comparison to renourishment costs without the groins. (The beach in the existing groin field has persisted without maintenance.) The purpose of extending the groins would be to stabilize the shoreline between the westernmost existing groin and Moriches Inlet.

The degree of protection for the beach and barrier island behind the section with new groins would be slightly less than that experienced in the eastern portion of the existing groin field. There is a tendency for the groin compartments to hold a progressively lower volume of sand in the downdrift direction (west). This situation is probably caused by the seaward projection of the shoreline created by the updrift groins. However, with a large initial fill and smaller renourishment episodes, new groins would probably maintain a volume of sand that would be sufficient to stabilize the shoreline in the compartments at an acceptable level. If the rate of sea level rise increases, if the net longshore transport rate at the east end of the groin field is reduced, or if the wave climate adversely changes, nourishment requirements will be changed. However, the beach in the original groin field has remained stable, requiring no renourishment for more than 20 years, even though sea level has been rising since the field was built.

Extension of the groins could aggravate erosion to the west of Moriches Inlet unless a bypassing project is also initiated. Long, high groins, such as those at Westhampton, tend to deflect sand offshore. Even when the sand is not deflected so far offshore that its return to the nearshore system is precluded, the seaward deflection tends to keep sediment further from the beach than would be expected if the groins were not there. However, since the existing jetties at Moriches Inlet are probably more efficient at shunting sand offshore than an extension of the groin field would be, the effects of additional groins with fill on the east side of the inlet would be small. Shoreline comparisons (Crowell and Leatherman, 1985) between 1934 and 1974 indicate that the east end of Fire Island is not receiving sufficient littoral sediment from Westhampton to maintain a stable shoreline. The deficit is approximately 100,000 cubic yards per year. A properly-designed sand bypassing system in conjunction with the extension of the groin field could help mitigate the problem by restoring the longshore transport of sand.

The bypassing system would require that an effective longshore sand trap be located just east of the east jetty at Moriches Inlet. This trap should be located far enough seaward to capture all the material being deflected offshore by the groins. Sand from the trap could be passed efficiently across the inlet and placed on the beaches to the west. An offshore breakwater might be considered to create a depositional trap and a calm-water area from which a dredge could move the sediment to the west. This type of system has been used successfully at Channel Islands Harbor, California, but other bypassing systems could be used and should be considered. The sand bypassing system would benefit both navigation in Moriches Inlet and the beaches of Fire Island. The cost of such a system has not been determined, however.

Construct A Segmented Breakwater

A series of offshore, segmented breakwaters between the groin field and Moriches Inlet would dissipate incoming wave energy and reduce erosion losses by reducing direct wave attack and minimizing the transport of sand out of the area landward of the structures. Some fill would be required to build up the existing beach. The initial cost of the structures ($5,000 or more per linear foot) and associated fill would be greater than any of the other options considered due to the difficulties of offshore construction. However, because they are very effective at stabilizing the shoreline, breakwaters can greatly reduce subsequent renourishment requirements and provide a high degree of protection for the beach and backshore area.

At least 4,000 segmented breakwaters have been constructed as a successful means of shore protection in Japan over the last 20 years. Since the mid-1970s segmented breakwater systems also have been installed at four project sites on the Great Lakes shoreline. The design criteria are relatively well developed and their performance has been highly satisfactory in terms of stabilizing the shore.

Based on experiences with projects in other areas, a segmented breakwater system for Westhampton would probably entail construction of a series of breakwaters, each about 400 feet long and spaced about 100 feet apart, along the 3-mile stretch of beach between the groin field and the east jetty at Moriches Inlet. The easternmost breakwater would be placed near the tip of the westernmost groin while the others would be placed progressively closer to the shore approaching the inlet to reduce disruption of the longshore transport of sand. The beach behind the structures would require an initial artificial fill. The amount of sand needed would depend on the configuration of the breakwaters and the desired uses of the beach.

The actual design of a breakwater system, in terms of exact location, dimensions, spacing of the structures and fill requirements, would require a detailed analysis of site conditions and, preferably, modeling studies to be effective. Installation of a breakwater system could impede possible onshore transport of sand to the beach. However, if there is an offshore source of sand, it would be supplying material along the entire shoreline and the structures would only intercept a small fraction of the total offshore sand supply. More importantly, the segmented breakwater system could reduce the longshore transport of sand by retaining sediment on the beach behind the structures, thus increasing erosion downdrift. If the breakwaters are more efficient in stopping the longshore drift than the existing groin field, then erosion effects similar to those existing adjacent to the groins could be propagated further to the west. Since neither the amount of sand bypassing the existing groins, nor the effectiveness of the hypothetical breakwater system is known, however, the magnitude of this effect and means for minimizing it can only be assessed with more detailed studies.

Summary

When considering engineering measures for shoreline erosion control in a particular area, it is always helpful to conduct experiments to determine the manner in which the shoreline will respond to such measures. Experience gained at analogous sites can be valuable, but if experiments are conducted in the area of interest, and over a representative length of time, the realism of the result is enhanced due to incorporation of information on the actual conditions at the site.

In many respects, the installation of the eleven groins at Westhampton between 1965 and 1966, the additional four groins between 1969 and 1970, and the available observations on the response of the shoreline to these structures should be regarded as an extremely valuable experiment relevant to the potential performance of the various options available. The Westhampton groin field has performed as follows:

1. The groin field has trapped sand from the longshore sediment transport system causing a widening of the beach within the confines of the groin field. Some of this sand has enhanced the existing dunes and formed substantial, additional dunes.

2. Widening of the beach within the confines of the groin field has not been uniform. Substantially greater widening has occurred near the east (updrift end), with a lesser amount near the west end of the field. Such a distribution of sand is frequently found in groin fields in other areas. At Westhampton the present distribution of sand within the groin field appears to be in equilibrium with the prevailing conditions.

3. The groin field has also caused widening of the beach on the updrift (east) side of the groin field. The volume of additional sand trapped in this section of the beach is unknown but could be calculated from further analysis of available data.

4. By trapping sand from the longshore sediment transport system, the groins have reduced the sediment supply to the shoreline between the westernmost groin and the east jetty at Moriches Inlet. This has exacerbated erosion in this area.

5. Some sand appears to be bypassing the groin field along an offshore bar. However, the associated bar material does not return to shore for some distance (on the order of 1 mile) west of the westernmost groin. The zone between the westernmost groin and the point where the bar returns to the shore is an area of especially severe erosion.

Based on the historical behavior of this stretch of beach and on the history of other areas, particularly Assateague Island, Maryland, and Chatham Inlet, Massachusetts, it can be expected that, if nothing is done, the portion of the island to the west of the last groin will continue to narrow and flatten. Overwashing and breaching will become more frequent, resulting in the episodic landward migration of the island at a rapid rate. The area would become uninhabitable and its northward migration could eventually endanger the existing groins in sequence from west to east. Although the limited tidal exchange between the bay and the ocean would probably preclude the formation of a permanent inlet, frequent ephemeral inlets with life spans on the order of several years or more would be expected.

If beach fill is to be added, the grain size of the sand is critical to the success and longevity of the project. There are many examples of successful beach nourishment operations. With suitable material, a project at Westhampton might be expected to lose sand at a rate as low as 2.5 percent of the original volume per year for a total cumulative loss of 50 percent. Periodic maintenance will be required and at many other sites on the northern part of the East Coast losses were larger than expected requiring large supplements of maintenance sand as frequently as every 2 years.

Removing or shortening the groins would liberate up to 5 to 7 million cubic yards of sand. The redistribution of this sand would alleviate some of the erosional tendency to the west, but the erosion would be accelerated within the confines of and updrift of the present groin field. The beach here would be reduced. If the groins are completely removed, a return to the original erosional conditions that led to the construction of the groins should eventually be expected. If the groins are shortened the longshore flow of sand could be improved while maintaining a narrower beach in the vicinity of the groins.

The beach within the groin field appears to be in equilibrium, and it is reasonable to expect that, if the field is extended to the west, any new section would perform in much the same way as the existing section has performed. The new compartments would have to be filled and require periodic renourishment until a natural equilibrium was reestablished. Experience has shown that these structures can significantly increase the life of beach nourishment projects and reduce subsequent maintenance costs. Because long, high groins and jetties, such as those found at Westhampton and Moriches Inlet, tend to deflect material offshore, any plan to extend the groin field should incorporate a sand trapping and bypassing system to return material to the nearshore zone and minimize downdrift erosion effects. Sand bypassing at Moriches Inlet would be required and may be beneficial to Fire Island. A new section added to the groin field may be tapered to the west with progressively shorter and lower groins. Experience suggests that a tapered field could be designed to help maintain longshore transport of sand to the west and to eliminate the abrupt change that now exists at the westernmost groin.

Segmented breakwaters, while relatively expensive in terms of initial costs, could stabilize the beach and provide a high degree of protection for the barrier island during storms. Although rare on U.S. coasts, over 4,000 segmented breakwaters have been constructed in Japan to combat erosion. The design criteria are well-developed and results are usually highly satisfactory. Implementation of this alternative at Westhampton, however, would require more in-depth study to determine exact specifications and potential impacts.

If stabilization is the goal, there are a variety of technically sound engineering approaches available. The best approach will require a combination of structural changes, artificial fill and periodic maintenance, and will also provide for adjustments in the plan to accommodate changing conditions, such as rising sea level. The success of erosion-control projects in other areas has depended upon the incorporation of our best information on coastal processes into the engineering design. For the Westhampton area, information on important parameters, such as wave regime, sediment transport patterns, and the behavior of the beaches, is of relatively poor quality and this will limit the certainty with which solutions can be designed.

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GLOSSARY

(Adapted from the U.S. Army Corps of Engineers
Shore Protection Manual, 1984)

ARTIFICIAL NOURISHMENT. The process of replenishing a beach with material (usually sand) obtained from another location.

ATTENUATION. (1) A lessening of the amplitude of a wave with distance from the origin; (2) the decrease of water-particle motion with increasing depth. Particle motion resulting from surface oscillatory waves attenuates rapidly with depth, and practically disappears at a depth equal to a surface wavelength.

BAR. A submerged or partially submerged bank or mound of sand formed in shallow water by waves and currents.

BARRIER BEACH. A bar essentially parallel to the shore, the crest of which is above normal high water level. Also called OFFSHORE BARRIER and BARRIER ISLAND.

BORROW AREA. A site used as a source for sand for beach nourishment.

BREAKWATER. A structure protecting a shore area, harbor, anchorage, or basin from waves. It is usually built parallel to the trend of the shoreline and seaward of the waterline.

BYPASSING, SAND. Hydraulic or mechanical movement of sand from the accreting updrift side to the eroding downdrift side of a structure, natural feature or inlet entrance. The hydraulic movement may include natural movement as well as movement caused by man.

DOWNDRIFT. The direction of predominant movement of littoral materials.

DRIFT (noun). (1) Sometimes used as a short form for LITTORAL DRIFT; (2) the speed at which a current runs; (3) floating material deposited on a beach (driftwood); (4) a deposit of a continental ice sheet; e.g., a drumlin.

FLANKING. Erosion of material behind a structure caused by waves and currents getting around and behind the structure.

GROIN. A shore protection structure built (usually perpendicular to the shoreline) to trap littoral drift or retard erosion of the shore.

GROIN COMPARTMENT. In a groin system the area between two adjacent groins.

GROIN FIELD. A series of groins acting together to protect a section of beach.

INLET. (1) A short, narrow waterway connecting a bay, lagoon, or similar body of water with a large parent body of water; (2) an arm of the sea (or other body of water) that is long compared to its width and may extend a considerable distance inland. See also TIDAL INLET.

JETTY. (United States usage) On open seacoasts, a structure extending into a body of water that is designed to prevent shoaling of a channel by littoral materials and to direct and confine the stream or tidal flow. Jetties are built at the mouths of rivers or tidal inlets to help deepen and stabilize a channel.

LITTORAL DRIFT. The sedimentary material moved in the littoral zone under the influence of waves and currents.

LITTORAL TRANSPORT RATE. Rate of transport of sedimentary material parallel or perpendicular to the shore in the littoral zone. Usually expressed in cubic meters (cubic yards) per year. Commonly synonymous with LONGSHORE TRANSPORT RATE.

LITTORAL ZONE. In beach terminology, an indefinite zone extending seaward from the shoreline to just beyond the breaker zone.

LONGSHORE. Parallel to and near the shoreline; synonymous with ALONGSHORE.

LONGSHORE BAR. A bar running roughly parallel to the shoreline.

LONGSHORE TRANSPORT RATE. Rate of transport of sedimentary material parallel to the shore. Usually expressed in cubic meters (cubic yards) per year. Commonly synonymous with LITTORAL TRANSPORT RATE.

NEARSHORE (zone). In beach terminology, an indefinite zone extending seaward from the shoreline well beyond the breaker zone.

NOURISHMENT. The process of replenishing a beach. It may be brought about naturally by longshore transport, or artificially by the deposition of dredged materials.

OFFSHORE. In beach terminology, the comparatively flat zone of variable width, extending from the breaker zone to the seaward edge of the Continental Shelf.

OVERWASH. The continuation of wave uprush over the crest of the most landward beach berm and, in some cases, dune crest. This process often results in sand being transported from the seaward side to the bay side of a barrier island.

RECESSION (of a beach). (1) A continuing landward movement of the shoreline. (2) A net landward movement of the shoreline over a specified time.

REFRACTION (of water waves). (1) The process by which the direction of a wave moving in shallow water at an angle to the contours is changed: the part of the wave advancing in shallower water moves more slowly than the part still advancing in deeper water, causing the wave crest to bend toward alignment with the underwater contours; (2) the bending of wave crests by currents.

RENOURISHMENT. The periodic replenishment of sand on a beach.

SCOUR. Removal of material by waves or currents especially at at the toe or base of a structure.

SEGMENTED BREAKWATER. A series of short breakwaters separated by gaps (as compared to a long continuous structure). The gaps help increase water quality behind the structures, maintain longshore transport of sand and reduce construction costs.

SHADOW EFFECT. An increase in erosion downdrift of a coastal structure or natural feature resulting from a disruption of the longshore transport of sand or the wave climate.

SHOAL (verb). (1) To become shallow gradually; (2) to cause to become shallow; (3) to proceed from a greater to a lesser depth of water.

SIGNIFICANT WAVE HEIGHT. The average height of the one-third highest waves of a given wave group. Note that the composition of the highest waves depends upon the extent to which the lower waves are considered. In wave record analysis, the average height of the highest one-third of a selected number of waves, this number being determined by dividing the time of record by the significant period.

SIGNIFICANT WAVE PERIOD. An arbitrary period generally taken as the period of the one-third highest waves within a given group. Note that the composition of the highest waves depends upon the extent to which the lower waves are considered. In wave record analysis, this is determined as the average period of the most frequently recurring of the larger well-defined waves in the record under study.

STILL-WATER LEVEL. The elevation that the surface of the water would assume if all wave action were absent.

STORM SURGE. A rise above normal water level on the open coast due to the action of wind stress on the water surface. Storm surge resulting from a hurricane also includes the rise in level due to atmospheric pressure reduction as well as that due to wind stress.

TIDAL FLUSHING. Exchange between ocean and bay waters resulting from tidal action.

TIDAL INLET. (1) A natural inlet maintained by tidal flow; (2) loosely, any inlet in which the tide ebbs and flows.

TIDAL RANGE. The difference in height between consecutive high and low (or higher high and lower low) waters.

UPDRIFT. The direction opposite that of the predominant movement of littoral materials.

WAVE CLIMATE. The regime of waves occurring in area over an extended period of time, usually characterized by their height, period, length, and frequency of occurrence.

WAVE PERIOD. The time for a wave crest to traverse a distance equal to one wavelength. The time for two successive wave crests to pass a fixed point.

Appendix: Estimating Longevity of Beach Fill Projects

A significant factor in the inability to predict and interpret the performance of beach nourishment projects has been the lack of carefully-monitored projects. This has resulted in limited data that is generally fragmented and of poor quality. At a conceptual level, a fill project's performance will depend on a number of factors including:

1. The geomorphic setting of the project, i.e., along a long, uninterrupted shoreline or downdrift of a littoral barrier, such as an inlet or adjacent to a sink such as updrift of an inlet.

2. The background erosion rates in the project area -- since renourishment does nothing to alter or change the processes causing erosion, a beach fill project will experience erosion or the loss of material at rates comparable to the natural erosion rates occurring in an area before the fill was placed. Longevity will be shorter in areas of high erosion.

3. Length of shoreline filled -- theoretically the longevity of nourishment projects should increase as the length of the project along the shoreline increases (theoretical considerations indicate the longevity to be proportional to the square of the shoreline length of the project).

4. Representative wave height -- longevity decreases as wave height increases (theoretical considerations indicate that the longevity of a project should vary inversely as the wave height raised to the 2.5 power). In practice the value of this parameter will be substantially affected by the intensity and frequency of storms.

5. Sediment quality -- sands finer than those naturally present will erode faster than the natural background erosion rates. Additionally, for a given volume, fine sand will yield significantly smaller beach widths than coarse sand due to beach profile adjustments.

6. The use or presence of stabilizing structures -- groins, jetties, or breakwaters used to contain the fill can significantly increase the lifetime of the project and reduce maintenance costs.

Despite the lack of detailed monitoring information on all projects, the following definitive comments can be made about several Florida projects:

Miami Beach

Project length: 10 miles, volume of sediment: 10 million cubic yards; constructed 1976-1981; First renourishment: 1987 involving 300,000 cubic yards. Thus, the annual nourishment loss is approximately 0.3 percent. An unqualified success.

Delray Beach

Project length: 3 miles (approx.), renourished twice with sand considerably finer than the natural beach material. This project replaced a revetment that failed twice in the late 1960s. A success, but not to the extent of the Miami Beach project.

Jupiter Island

Renourished several times with sand much finer than the native material. This sand moved rapidly both offshore and alongshore. Project longevity was not good.

South Seas Plantation

Project length: 4000 feet, volume: 750,000 cubic yards, constructed in 1981 with good quality material from the ebb tidal shoal of a nearby inlet. As of 1987 (six years after nourishment), the annual loss rates had been 2.8 percent. This period included normal wave and weather conditions as well as two hurricanes and one tropical storm that passed well offshore.

NEW YORK SEA GRANT INSTITUTE

State University of New York and Cornell University
Dutchess Hall
SUNY at Stony Brook
Stony Brook, New York 11794-5001