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A PRELIMINARY ASSESSMENT OF EROSION MANAGEMENT STRATEGIES FOR THE SOUTH SHORE OF LONG ISLAND, NEW YORK

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CONTENTS

INTRODUCTION

Background

In response to erosion problems encountered along the south shore of Long Island, the New York State Department of State, Division of Coastal Resources and Waterfront Revitalization and the Long Island Regional Planning Board are in the process of developing a shoreline management plan. The preparation of the plan is to include an examination and analysis of the environmental, land use and regulatory factors affecting development and erosion control decisions along the coast for the purpose of formulating a comprehensive, coordinated response to erosion conditions on the south shore. To provide part of the technical perspective for this effort, three workshops were held to bring together national experts in coastal processes and engineering who are familiar with the situation on Long Island but not actively involved in local or state issues. The workshops provided a forum to re-examine erosion problems along Long Island's south shore and to discuss possible approaches for dealing with these problems from a technical perspective.

More specifically, the individual workshops have been focused, first, on identifying the generic information needed to develop a sound coastal erosion management program, second, on identifying such technical data presently available for the south shore and, third, on an attempt to use these data to discriminate among the various erosion-control strategies for different reaches of the coast.

The intent of these workshops was to provide technical information and an independent perspective to assist government officials and other interested parties in identifying, assessing, and selecting appropriate erosion management strategies for a particular area. The results of the first two workshops are presented in separate reports (Tanski and Bokuniewicz 1990 and Tanski et al. 1990). This report summarizes the findings of the third and last workshop in this series.

Workshop Objectives

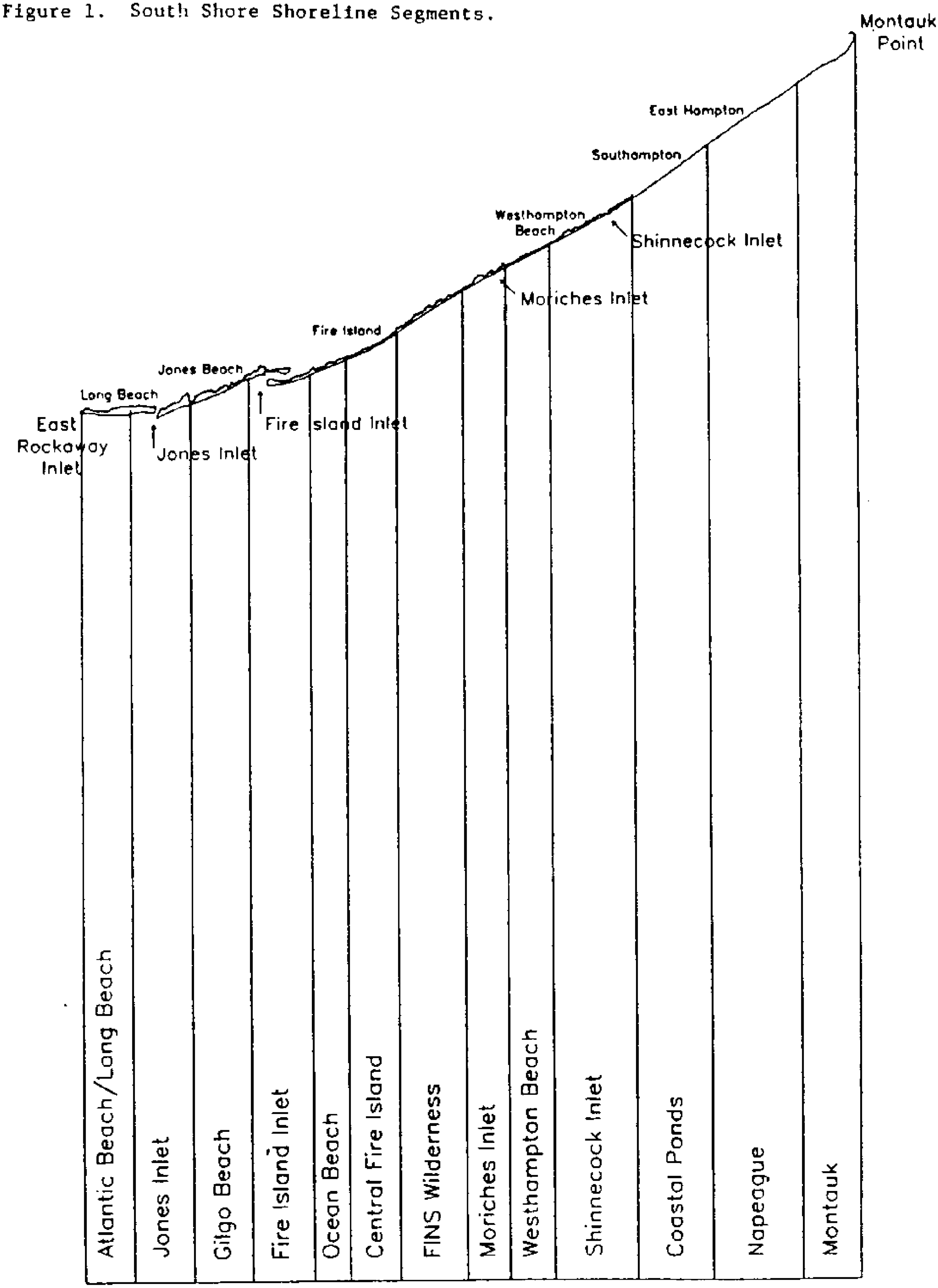
The objectives of this meeting were to try to identify the most promising, appropriate or reasonable regional erosion management options for the south shore in light of the available data, to identify unresolved questions that affect the choice of options and to develop recommendations on technical data needs and appropriate programs to meet these needs.

Approach

For this meeting, the coastal engineers and scientists who participated in the first two workshops of this series were brought together as a single group (see Appendix). A management matrix for the south shore was developed before the meeting to provide a framework for the workshop discussions. The shoreline was divided into 13 segments based primarily on land use patterns identified by the Long Island Regional Planning Board and on geomorphic and physical criteria such as shoreline type, location of inlets, etc. These segments are shown in Figure 1 and a brief description of the boundaries is given below.

<u>Segment</u>	<u>Description</u>
Atlantic Beach/Long Beach	East Rockaway Inlet to eastern end of Long Beach groin field.
Jones Inlet	Eastern end of Long Beach to the eastern end of Jones Beach State Park facilities.
Gilgo Beach	Eastern end of Jones Beach to Cedar Beach.
Fire Island Inlet	Cedar Beach to western end of Kismet.
Ocean Beach	Western end of Kismet to the eastern end of Point O'Woods.
Central Fire Island	Eastern end of Points O'Woods to the eastern end of Davis Park.
FINS Wilderness	Eastern end of Davis Park to the western boundary of Smith Point County Park.
Moriches Inlet	Western end of Smith Point County Park to the eastern boundary of Cupsoque County Park.
Westhampton Beach	Eastern boundary of Cupsoque County Park to the eastern-most groin in Westhampton Beach.

Figure 1. South Shore Shoreline Segments.



Shinnecock Inlet	Easternmost groin at Westhampton to the beginning of the headland coast in Southampton.
Coastal Ponds	Start of the headland coast in Southampton to the eastern boundary of East Hampton Village.
Napeague	East Hampton Village to the eastern boundary of Hither Hills State Park.
Montauk	Bluffed headlands between Hither Hills State Park and Montauk Point.

General coastal erosion management policies/objectives that reflect long-range (i.e. based on a 30-to 50-year planning horizon) land use plan goals were developed and assigned to each of the coastal segments by the Long Island Regional Planning Board (Figure 2). These policies can be briefly summarized as follows:

A. **Maintain Shoreline Position**: Maintain location of the present shoreline (usually in response to the presence of higher density development and/or public infrastructure).

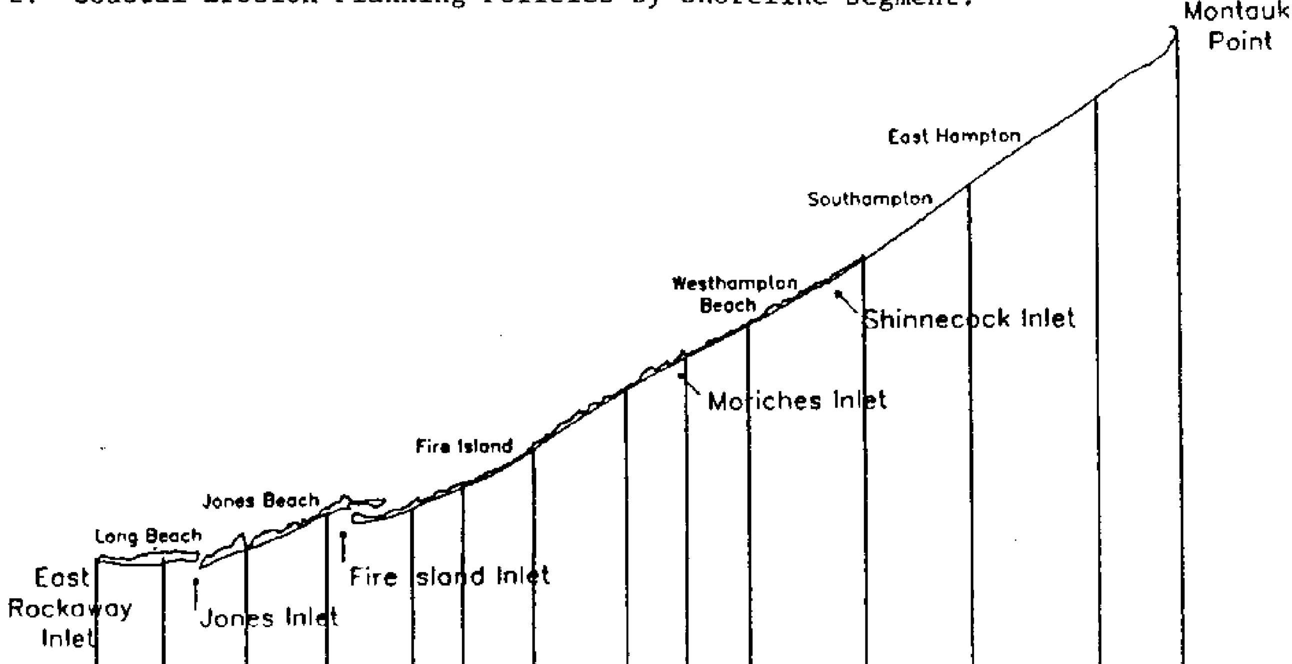
B. **Maintain Beach**: Maintain adequate beaches for recreational activities (usually in areas of relatively high recreational use).

C. **Maintain Barrier**: Maintain existence and continuity of barrier islands, spits, bars, etc. for the protection of back-bay environments. This option does not necessarily imply maintaining the actual position of the shoreline.

D. **Private Projects**: Emphasize regulation of private activities and works as the primary means of protecting coastal features and structures.

The designation of policies relating to maintaining the shoreline position, the beach or the barrier (policies A, B, and C above) in

Figure 2. Coastal Erosion Planning Policies by Shoreline Segment.



	Atlantic Beach/Long Beach	Jones Inlet	Gilgo Beach	Fire Island Inlet	Ocean Beach	Central Fire Island	FINS Wilderness	Moriches Inlet	Westhampton Beach	Shinnecock Inlet	Coastal Ponds	Napeague	Montauk
MAINT. SHORE POSITION	X	X	X	X					X				
MAINT. BEACH	X	X		X									
MAINT. BARRIER					X	X	X	X		X	X		
PRIVATE PROJECTS				X	X	X			X	X	X	X	X

an area implies the potential implementation of publicly-funded projects to meet the associated objectives. The overall intent of the Long Island Regional Planning Board's coastal management program, which focuses on a 30- to 50-year time frame, is to protect coastal resources and development from chronic shoreline erosion and not from the impacts associated with catastrophic storms. Any approach appropriate to meet the assigned objectives for the individual shoreline sections must be compatible with these policies and the overall intent of the program. Without these constraints for example, "maintenance" of the beach could be interpreted as either maintaining the existing beach primarily for recreational use or maintaining not only a recreational beach but also a beach that is high and wide enough to provide protection against erosion and flooding during severe storms. However, in this workshop the "maintaining the beach" does not necessarily imply that the beach must also provide storm protection because of the overall intent of the land use plan proposed by the Long Island Regional Planning Board staff.

Based on the general planning goals identified for each segment and the technical information on coastal processes developed during the second workshop, the participants were asked to choose erosion management options that they felt were the most reasonable, promising, or preferable for the individual coastal segment. Eight basic options were considered:

1. Do nothing
2. Shore hardening

3. Groins

4. Breakwaters

5. Beach nourishment/Dune building

6. Sand/Bypassing

7. Relocation/Retreat (including setbacks)

8. Insufficient data to decide.

The participants were allowed to select combinations of the above options as a single alternative. The individual responses for each segment were then compiled and presented to the group as a whole to focus discussions as to the most appropriate strategy for the different coastal segments.

The findings and qualifying discussions resulting from the group's efforts are summarized in the following sections.

QUALIFICATIONS

Given the nature and magnitude of the topic addressed and the inherent limitations associated with using a workshop format, the findings reported here are subject to important qualifications.

The primary purpose of this workshop was to make a preliminary independent assessment of the most appropriate regional approaches for managing erosion based on the available, often incomplete or dated, technical information. The shoreline segments in the management matrix were selected to be large enough to allow for the development of a comprehensive management strategy and the group discussions focused on identifying these more extensive or regional strategies. Very small stretches of the coast, on the order of hundreds of yards, cannot be managed independently in a regional strategy. However, in certain cases extenuating circumstances such as site-specific land use, social/economic factors, and/or pre-existing structures may require management on this smaller scale. Although these cases were not ignored, a detailed analysis of site-specific erosion control options for relatively small stretches of coast were beyond the scope of this workshop. Although local exceptions to the overall strategy for a particular section may be required, these smaller-scale projects should be compatible with a regional approach.

On the other hand, the coastal segments in the management matrix were not made so large as to preclude discriminating among segments of the shoreline where different tactics should be applied. Care must be taken to insure that any approaches implemented in one segment are compatible with those in adjacent sections. Because the coast operates as a dynamic system, changes in one section, whether natural or man-made, may require a revision of selected management strategies in other sections. Any coastal management plan cannot be static but should be periodically adjusted to accommodate expected, or unexpected, changes.

GENERAL STRATEGIES

Several erosion-related issues and problems were identified that transcended the segment boundaries and pertained to the entire shoreline. As a result, the success of any comprehensive regional erosion management program would depend on implementing the general strategies and policies, described below, along the coast as a whole.

1. The integrity and continuity of the longshore transport of sand must be maintained through each section. Where the transport of sand has been or will be interrupted, a mechanism for bypassing or restoring sand transport must be inaugurated and maintained. In sections where the continuity of long shore transport has been disrupted in the recent past, some additional nourishment may be necessary to rebalance the sand budget. Sand trapped in tidal deltas at stabilized inlets or accumulated in shoals seaward of groin fields may need to be relocated back on to the beach. All of the strategies identified for the various coastal segments in this report must incorporate appropriate plans for sand bypassing. This policy would also apply to the western boundary of the study area. The continuity of longshore transport across East Rockaway Inlet to the New York City beaches to the west should be maintained.

2. Because inlets play a dominant role in the processes affecting coastal change, proper management of inlets is of critical importance. The most severe erosion trends found on the south shore are associated with inlets. The loss of large volumes of sand into inlet deltas appears to be a principal cause of shoreline recession. In addition, the stabilization of the inlets has resulted in large accumulations of sand updrift of the jetties. Based on long-term shoreline changes, the erosion and accretion processes associated with Long Island's inlets seem to become more substantial from east to west. As a result of their complex, dynamic nature and the influence inlets exert over large portions of the coast, the creation of special inlet management zones should be an integral part of any long-term erosion mitigation plan.

   Presently, most inlet dredging projects are undertaken in response to navigation concerns. In keeping with the first recommendation in this section, effective management programs for inlets should be designed not only to stabilize channels for navigation but also to incorporate provisions for maintaining the longshore transport of sand across the inlets. This longshore transport is not unidirectional along the south shore especially in the vicinity of inlets. Both the eastward and westward drift of sand must be accommodated at different times. The development of the most appropriate, cost-effective bypassing strategy would require a detailed analysis of the physical characteristics of each inlet. Such a plan should provide for the periodic dredging and bypassing of sand to the downdrift beaches on a regular basis, but structures may be included in the plans for some inlets to facilitate the bypassing operations. Impoundment basins and/or small, perhaps tapered, groins in the area immediately downdrift of the inlet could help retain material on the beach in the shadow of the downdrift jetty and prevent sand from being transported back in to the inlet by localized reversals in the direction of longshore transport caused by wave refraction around the shoals and jetties associated with the inlets.

Inlet bypassing was identified as the single most important erosion management strategy for the south shore. As a result, bypassing was assumed at all inlets in subsequent discussions of the most viable erosion management approaches for the individual sections.

The management of new inlets was also addressed. The formation of new inlets along the barrier island section of the south shore could cause substantial changes which, in turn, could severely affect the present biological resource and human uses of the back barrier bays and the mainland shoreline as well as the barrier island. Impacts associated with new inlets could include: increased flooding and erosion on the mainland shoreline due to increased water levels and wave action in the bays; changes in shoaling patterns, water circulation, temperature, and salinity which could significantly alter the present environmental condition in the bays; and disruption of the longshore transport of sand along the ocean shoreline which would result in increased downdrift erosion. In addition, new inlets would also change the tidal exchange between the bay and ocean at the presently stabilized inlets. The expected increased rate of shoaling would adversely affect channel maintenance operations and could eventually preclude the use of existing inlets for navigation purposes. Given the investment society already has in the existing inlets and the magnitude and nature of the changes associated with the formation of new inlets along the south shore, the occurrence of these features would probably be unacceptable from a management standpoint. As a result, management plans should incorporate provisions for preventing new inlets or closing ones that may form. If they will not close quickly naturally, they should be closed artificially. This can be accomplished most economically if action is taken promptly while the inlet is small.

3. The shoreline should be monitored uniformly and continuously to document the effects of past policies and erosion-control strategies and to provide the information necessary to adequately evaluate proposed strategies. Any policy decision should be based on a prediction of the effects of that decision. Selected erosion management strategies may fail to achieve the desired results or conditions may change so that adjustments will be needed to improve the effectiveness of the approach employed.

   A shoreline erosion management plan cannot be static and the proper changes can only be initiated if the current conditions and trends along the coast are known. Implementation of a basic monitoring program is essential for maintaining an effective, comprehensive regional erosion management program for the south shore. Elements of such a program are outlined later in this report.

ANALYSIS OF SHORELINE SEGMENTS

Atlantic Beach/Long Beach Segment

The high degree of development and the large number of groins already in place along this segment of the coast resulted in a consensus for a strategy based on beach nourishment and maintenance of the existing groins in order to meet the planning objectives of maintaining the shoreline position and recreational beach as shown in Figure 2. Because the beach elevation and volume in this area are relatively low, the present beach probably provides minimal storm protection. If a higher degree of protection against storm damage is desired, the groins would most likely have to be extended to increase the beach width and height and to provide adequate room for dune building.

Although less favored, the use of breakwaters or shore hardening structures were also identified as possible strategies for this area. Breakwaters could be used to provide storm protection by dissipating wave energy before it reaches the shore and by maintaining a protective beach. Shore hardening could be used to protect the upland area but may also hamper the maintenance of an easily accessible recreational beach.

There is little quantitative information on the behavior of beaches in this area. An assessment of the costs and benefits associated with alternative approaches requires a more detailed analysis of the physical processes and beach changes and the development of a site specific structural design.

Jones Inlet Segment

For the portion of the shoreline downdrift (west) of Jones Inlet there was a strong consensus for a strategy coupling beach nourishment and dune building with sand bypassing using material from the navigation dredging projects in the inlet. Provisions should be made to place the material on the beach (as opposed to offshore) and far enough to the west so the sand is not transported eastward back into the inlet by localized wave refraction associated with the inlet shoals. Costs for inlet bypassing operations are highly dependent on the distance material has to be transported. Actual costs for such an operation on Long Island could only be determined with a detailed, site-specific feasibility study.

Longshore transport of sand in this area may be rapid and variable in direction due to the localized effects of the inlet processes. As a result, any beach fill projects should be monitored closely and the results used to adjust bypassing operations. If necessary, a system incorporating groins and/or breakwaters, as described earlier, may facilitate sand bypassing, help retain sand on the downdrift beach and prevent sand from re-entering the inlet.

Because of the accretionary trend associated with the jetty on the portion of the shoreline east of the inlet (updrift), the consensus was that no action was needed in this area at this time.

Gilgo Beach Segment

There was a strong consensus for periodic beach nourishment using material bypassed from Fire Island Inlet as the most preferred approach for addressing the erosion problems in this area. The need for bypassing sand from Fire Island Inlet to maintain the beaches in this area was also identified by other investigators (Morton et al. 1986) based on detailed survey studies of the area. The material should be placed on the beach far enough west to prevent it from being transported back into the inlet by local wave refraction patterns associated with shoaling at the inlet. Artificial bypassing of the total net longshore transport rate of 600,000 cubic yards of sand per year in the area of the inlet may not be required to maintain an adequate beach. Continued monitoring of the fill operations and beach behavior should be done to better define estimates of the actual amount of material that should be bypassed to provide protection. If necessary, groins or breakwaters could be employed to help retain fill in critical areas.

The Ocean Parkway and the two sewage outfalls that cross the beach in this area are of particular concern. If beach nourishment associated with bypassing is not implemented, relocation or shore hardening may be required if the parkway is to be maintained. If nothing is done, debris from the collapse of the road could affect the beach in much the same manner as a shore hardening structure. Any alternative involving abandonment or relocation of the parkway should also incorporate provisions for the removal of debris. Structural solutions involving sheet piling and armoring would most likely be necessary to protect and maintain the integrity of the sewage outfall pipes. If these structures became exposed due to continued erosion of the beach they would tend to act as groins. Additional beach fill would be needed to minimize potential adverse impacts. The fill would have to extend over a substantial portion of this section of shoreline to be effective, perhaps 1 to 1 1/2 miles for each pipe, and would require periodic renourishment.

Fire Island Inlet Segment

The consensus for this segment was for artificial bypassing with beach renourishment for the shoreline west of the inlet. Although it may be more economical to facilitate routine bypassing operations by using a system of breakwaters to form an impoundment area, such a determination would require a more in-depth analysis of the relatively complicated inlet system and site-specific conditions. Much of the information needed to perform such an analysis is contained in the materials developed by U.S. Army Corps of Engineers for this area.

Similar to the situation at Jones Inlet, the portion of shoreline immediately updrift of Fire Island Inlet appears to be accreting based on the available long-term shoreline change data. As a result there was a consensus that the do-nothing alternative was appropriate for this area.

Ocean Beach Segment

The consensus for this section was for beach nourishment and dune building in conjunction with set backs and/or retreat/relocation if necessary, but the nature of the problem in this area was subject to different interpretations. Some participants preferred doing nothing and relying on inlet bypassing operations at Moriches Inlet to the east and relocation, if necessary. Others, however, felt that the relatively high population density would preclude the implementation of relocation/setback options. The relatively high degree of development coupled with high erosion rates may justify the use of prefilled groins to maintain a beach in this situation. One of the reasons for selecting this alternative was that profile data taken between 1955 and 1979 indicate large volume losses in the area offshore of this section, probably the result of the reworking of old ebb-tidal delta deposits associated with Fire Island Inlet. As this source is depleted, erosion rates along this section may increase rapidly in the future. In addition, it was also noted the segment immediately to the west is relatively uninhabited and exhibiting accretion, thus, minimizing the potential for adverse downdrift impacts associated with the structures.

Although identification of the most effective alternative would require a more detailed cost-benefit analysis, this analysis would also depend on answering a more fundamental question: Why is there apparently a high erosion rate here? Although the problem may be alleviated by better management of other coastal compartments, the causes of erosion and physical processes operating at the site would need to better diagnosed to determine the exact nature of the problem and potential means for addressing it.

Central Fire Island and FINS Wilderness Segments

Because of the relatively low overall density of development and low, long-term shoreline erosion rates in these two sections, the consensus was for a do-nothing approach while encouraging setbacks and relocation/retreat where possible. Again, the selection of this strategy was predicated on the assumption that bypassing operations at the inlets to the east would be implemented.

However, it was also noted that certain areas in these sections may be susceptible to breaching and inlet formation during storms. As described previously, the formation of new inlets would probably have a number of impacts including: shoaling of the stabilized inlets, increased flooding and erosion on the bay shoreline due to increased water level elevations, changes in environmental conditions in the bay (i.e. water circulation, shoaling, salinity and water temperatures) and increased downdrift erosion due to the disruption of the longshore transport of sand. These types of changes would probably be substantial and could severely affect the biological resources and human uses of the present back bay environment, (including the mainland shoreline) as well as the barrier island and the existing stabilized inlets. There was a general consensus that because of the nature and magnitude of the associated impacts, the occurrence of new inlets would most likely be unacceptable in terms of the present uses of the mainland shoreline, bay and barrier island. Management programs should incorporate provisions for preventing the formation of new inlets and for closing new ones as quickly as possible.

In these sections, specific areas particularly susceptible to breaching (as indicated by such factors as island width, elevation, dune morphology, and back bay bathymetry) should be identified. Because the presence of marshes on the bay side of the barrier appears to inhibit inlet breaching, artificial filling and the creation of marshes in areas experiencing bay side erosion was suggested as one approach to this problem. Material from bay dredging projects, which usually is not suitable for ocean front beach nourishment, may be used to bring the bay bottom up to an elevation that would allow for marsh creation along the bay shoreline. Although ocean beach nourishment may not be practical for the entire length of shore, dune building efforts should also be considered to minimize the potential for breaching in these areas.

Moriches Inlet Segment

Bypassing material at Moriches Inlet was the most preferred approach for addressing erosion problems on the shoreline west of the inlet. Marsh creation on the bay side may be used to minimize the potential for new inlets in areas susceptible to breaching. If monitoring indicates additional action is necessary, supplemental beach nourishment in conjunction with relocation of threatened structures would be a reasonable approach for this area.

Westhampton Beach Segment

Obviously, the groin field and its associated downdrift impacts are of primary concern in this section. A more detailed analysis of the situation at Westhampton Beach and the options available for dealing with this problem are contained in a separate report by Tanski and Bokuniewicz (1988). Some action is needed to avoid a breach in the area downdrift of the field. There was a strong consensus for an approach incorporating artificial beach fill and dune building in conjunction with an extension of the groin field in some form.

Surveys indicate that the groins have trapped approximately 2 million cubic yards of sand in an offshore shoal suggesting that artificial bypassing of some of this material could be used to help restore longshore transport and the downdrift beaches. Because complete restoration of the downdrift beach to pre-groin field conditions may not be feasible due to the extent of the past erosion, relocation of some structures may be needed. Although modification of the groin field to enhance bypassing was also discussed, there were strong concerns that implementation of this alternative could upset the present apparent equilibrium in the groin field and adversely affect the protective beach presently retained by the structures. As a result, attempts to modify these structures would require more detailed studies to adequately ascertain the potential impacts before this option was employed.

Closure of a breach west of the groin field could be accomplished most effectively and economically if action was taken while the inlet was small. For this reason, a contingency plan for filling any breaches in this area should be developed until longer-term measures are implemented in this area.

Shinnecock Inlet Segment

The consensus was for beach nourishment in conjunction with regularly scheduled bypassing at Shinnecock Inlet as the preferred alternative for dealing with shoreline erosion problems west of the inlet.

Because the beach immediately west of the inlet is subject to increased erosion due to disruptions and reversals of sediment transport associated with the shadowing effect of the inlet, this area may require special efforts. Frequent filling in this area or the use of structures such as small tapered groins may be required to retain bypassed material on the beach and prevent it from returning to the inlet. As with the other inlets, a detailed analysis would be needed to identify the most effective bypassing procedures.

The available data indicates that the portion of the shoreline east (updrift) of the inlet is accreting due to the influence of the eastern jetty suggesting that no action is needed at the present time.

Coastal Ponds and Napeague Segments

Because these two sections are similar in terms of their physical characteristics and general land use patterns they were essentially treated as a single unit. Although beach nourishment and dune building were generally the preferred options for these sections, the lack of adequate information on the sources, rate, timing, and direction of sand transport along the eastern portion of the south shore resulted in different perceptions of the nature of the problem and alternatives for dealing with it. Of particular concern was whether erosion of the shoreline in this area supplies the entire downdrift sand transport system or whether there is an offshore source contributing to the sediment budget. Available data was insufficient to resolve this question.

Unlike the coast to the west, the lack of major inlets in these two sections and the one further east precludes the use of inlet bypassing as a viable option for addressing erosion on a regional basis. However, maintaining the continuity of longshore transport is still important. Proper management of the coastal ponds found in this area could help alleviate some of the more localized erosion problems associated with these features. Sand lost from the near-shore system in the form of the over-washes and flood-tidal deltas in the ponds resulting from storm events and dredging activities should be returned to the beach to help restore the transport of material along the beach. This should be done after major storms, and/or in conjunction with the periodic dredging that is usually undertaken to control water levels and water quality in these ponds.

Because of the size requirements, effective beach nourishment projects cannot be implemented by individual property owners; smaller-scale measures are the only feasible alternatives for individuals or small communities. Several participants identified relocation/retreat and instituting appropriate setbacks as a preferred alternative in cases involving individual structures. This alternative is particularly suitable in this section because the lots are generally larger providing the necessary room. While New York is not presently enrolled, state participation in a recently-implemented program (known as the Upton-Jones Amendment) of the National Flood Insurance Program could help provide incentives for homeowners to relocate. This program allows the use of flood insurance funds for voluntarily moving erosion-threatened structures.

Although generally less favored and viewed by some of the participants as an alternative of last resort, shore hardening may be an acceptable option in certain situations where protection against catastrophic storm damage is necessary and relocation/retreat is not feasible. Decisions regarding the use of shore hardening for erosion control would have to be made on a case-by-case basis due to the variability in the quantity, quality and direction of movement of sand in the coastal sediment budget in these areas. To minimize potential adverse impacts that may be associated with shore hardening, a number of factors should be considered in the decision-making process. These factors include proper siting of the structure to minimize the frequency of exposure and identifying the need for possible mitigative measures, such as providing sand from an upland source. The state of Florida Division of Beaches and Shores has developed recommended procedures for evaluating permit applications for shore hardening. A more detailed discussion of the factors that must be considered regarding the use of shore hardening as an erosion control alternative is given in the proceedings of the first workshop in this series (Tanski and Bokuniewicz 1990).

Montauk Section

No consensus was reached for any single alternative in this section. The divergence of opinion was largely due to questions regarding the role of bluff erosion in supplying sand to the littoral system. Although the available data indicate the volume of material supplied by bluff erosion to longshore transport is relatively small compared to estimates of the rate of sand transport further west, (Tanski et al. 1990) more detailed information on the composition, height, and actual recession rates of the bluffs as well as better wave information would be required to make a more precise determination of the actual contribution of bluff erosion to the sediment budget and, thus, the most suitable options for this area.

Relocation and instituting setbacks were identified as viable options due to the generally larger lot sizes and less dense development found in this area, but where this strategy is not possible, shore hardening alternatives might also be appropriate. The decision to allow shore hardening, however, must be made for each site based on the bluff height, composition, recession rate, location of the structure, and an analysis of the type and amount of sand that could be moved by the longshore transport system in a particular area. The type of information needed and the questions that should be addressed when examining the potential armoring of a bluff are also discussed in some detail in the proceedings of the first workshop (Tanski and Bokuniewicz 1990). It was also noted that hardening of certain headlands or promontories could prove to be effective for stabilizing some of the pocket beaches in this area.

RECOMMENDATIONS FOR AN EROSION MANAGEMENT MONITORING PROGRAM

To implement an erosion management program on a technically sound and legally defensible basis, the continued collection of certain information on the coastal environment which relates to program decisions will be necessary. The deliberations of this meeting reaffirmed the recommendations made in earlier workshops; a more detailed description of the type of data required for properly managing the south shore and the specific means for obtaining it is provided in the proceedings of the first two workshops in this series (Tanski and Bokuniewicz 1990 and Tanski et al. 1990). Whatever course of action is recommended in a management plan, the long-term success of any approach will require continuous re-evaluation and adjustment. As a result, an effective management plan for the south shore of Long Island must include a monitoring program to meet several critical objectives. The monitoring program should be designed to provide information that will allow managers to:

1. Define and quantify the problem. Development of effective management programs depends on having adequate information on the resource to be managed. Reliable estimates of such factors as the erosional risk, storm vulnerability and the expected degree of recovery after an erosional event for different areas are essential components of any coastal management program. This type of information, which can only be obtained by monitoring shoreline conditions and changes, is necessary to provide a sound technical basis for management and regulatory decisions.

2. Evaluate the effectiveness and impacts of adopted and proposed strategies. Any chosen strategy may fail to perform as anticipated or conditions can change either naturally or because of human activity that alter the effectiveness of a previously chosen option. It will be important to recognize

this situation in order to readjust the plan. The plan cannot be static. Consequently, monitoring is required to provide the basis for changes. For the same reason, it is probably advantageous to begin with smaller scale projects rather than larger ones in order to develop experience in the integrated management of the coast.

3. Establish design criteria. In many places, a variety of approaches and an infinite range of designs will be possible. The final choice will depend largely on a cost/benefit analysis and a proper evaluation of both the estimated costs and the predicted benefits and potential impacts will require specific designs of individual projects. While a monitoring program will probably not generate all the detailed information needed for site-specific designs, it can give the designer and manager invaluable information of a consistently high quality on the long-term local conditions and, therefore, greatly reduce the cost and time for feasibility studies of each proposed project.

4. Develop a better understanding of the causes and effects of observed shoreline behavior. An adequate understanding of the coastal processes and shoreline responses is essential for addressing a number of critical questions that affect the selection of management options in different areas. Several of these types of questions were raised in the discussions and the uncertainty of the answers often led to different recommendations concerning the most appropriate alternative for a particular area. Examples include: How much sand is contributed to the longshore transport by the erosion of the Montauk bluffs? How much, if any, is supplied from offshore sources? Where are they? What volumes of sand need to be bypassed artificially at each inlet? How much is readily available? How much sand is presently impounded around structures as, for example, offshore of the Westhampton groin field? What is the potential for breaching along different stretches of the barrier island? What is the underlying cause of erosion at the communities on the west end of Fire Island? What role does the old Fire Island Inlet ebb-tidal delta play in the local sediment budget of western Fire Island? Information derived from a monitoring program would help answer these types of questions.

To achieve these objectives, it was recommended that any monitoring program include five elements. These are:

1. Continued evaluation of available data. As specific management-related questions arise, available data should be re-analyzed. Often an original data set was collected to address one set of questions but can be applied to others. However, efforts will be required to assemble and compile the

available data in a format that is accessible and usable for management purposes.

2. Maintain a monument system along the coast from which periodic beach and nearshore surveys would be done on a regular basis (i.e. at least twice a year). Such data is indispensable in evaluating shoreline, beach and dune changes, developing reliable sand budgets and identifying multi-year trends which could indicate the adequacy of management strategies or changing conditions. Specific recommendations on the design of this portion of the monitoring program were made in earlier reports (Tanski and Bokuniewicz 1990 and Tanski et al. 1990).

3. Periodic aerial photography. While aerial photography of the coast cannot provide the detailed information that can be obtained from the beach surveys, vertical aerial photographs taken on a regular basis can be used in conjunction with the survey data as a relatively inexpensive means of gathering important information on shoreline conditions, changes, and trends at relatively frequent intervals and over large areas. Photos should be taken on a seasonal basis and, when possible, coordinated with the beach surveys to provide the necessary ground truth.

4. Directional wave gages. The coastal processes are driven by the waves. There is a dearth of historical wave data to analyze the processes for this shoreline and no measurements are presently being made. At least two gages should be established, one in the eastern end and one at the western end of the study area.

5. Application of models. Many excellent models exist for forecasting coastal changes and the effects of human activity. They have been effectively used in other areas but very few have been applied to the New York coast primarily due to the lack of reliable baseline data required to run the models. Information gained from an effective monitoring plan would allow the use of available models to extrapolate and interpolate between measurement points, to assess the importance of observed changes, and to provide more reliable predictions of likely changes in the coastal system in response to prevailing and possible future conditions and of the effectiveness and impacts of proposed activities.

The basic monitoring program described above would involve some effort and expenditure. However, the benefits derived from such a program would far exceed the cost, especially when one considers the value of the resources and development found along the south shore of Long Island as well as the costs associated with implementing most erosion control alternatives. Implementation of the program would provide managers, planners and decision makers with the information they need to identify, evaluate and develop technically sound and defensible erosion management programs for a small fraction of the construction costs of most coastal projects.

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APPENDIX

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