APPENDIX B

BORROW SOURCE INVESTIGATIONS

1. **Project Location** The US Army Engineer District, New York (CENAN) is currently conducting a reformulation study of the shore protection and storm damage reduction project for the south shore of Long Island, New York. The project area is located entirely in Suffolk County, Long Island, along the Atlantic and the bay shores of the towns of Babylon, Islip, Brookhaven, Southampton, and East Hampton. The overall study area, is approximately 83 miles long and includes three large estuarial bays: Great South Bay (connected to the ocean by Fire Island Inlet), Moriches Bay (connected to the ocean by Moriches Inlet), and Shinnecock Bay (connected to the ocean by Shinnecock Inlet). The westernmost portion of the overall study area, the Nassau/Suffolk County border at Great South Bay, is located about 47 miles east of The Battery, NY. The area is primarily low-lying and as such, subject to flooding by storm surge from the Atlantic Ocean, surge propagation through tidal inlets, wave setup and run-up, and barrier island over wash and breaching.

2. **Objective.** The objective of the borrow area investigation was to identify and delineate sources of sand borrow material for use as design fill and nourishment material for FIMP beach erosion control project. The geology of the study area sets the framework of the sedimentary development of the shoreline and the offshore. Beach fill sediments were sought which had adequate data available, sufficient quantity, compatible sediment characteristics, would cause minimal adverse wave attenuation, would cause minimal geomorphological effects, contained minimal overburden of fines, contained minimal quantity of fines and minimal adverse environmental effects. Methodology from EM 1110-2-1100 (Coastal Engineering Manual) was used to determine sediment characteristic suitability. Beach sand models were created using samples along the shoreline between Fire Island and Montauk Point. Borrow sources investigated included upland (quarry), maintenance dredging of navigation channels, flood and ebb shoal mining at inlets, and offshore (dredging) sites. Sand Bypassing was evaluated in the Engineering Appendix, but is not expected to provide more than a small percentage of the fill needs. So the other sources were assumed to be required for all the fill, and if it turns out that sand bypassing is a cost effective way of diminishing the fill needs, then it will be become part of the usage plans. Usage plans were developed for the suitable sources.

3. **Study Area Geology** (*derived from Schwab, W.C., Thieler, E.R., Denny, J.F., Danforth, W.W. 2000. Seafloor Sediment Distribution Off Southern Long Island, New York: U.S. Geological Survey Open-File Report 00-243, performed as a part of this study)*. Long Island marks the southern boundary of the late Pleistocene glacial advance in the eastern part of North America (Stone and Borns, 1986). Two end moraines are superimposed along the western part of northern Long Island. The moraines bifurcate in eastern Long Island, where each moraine forms the core of the two peninsulas north and south of Great Peconic Bay (Fig. 1). The topography of Long Island is a reflection of this glacial history and exhibits greater relief on the northern side, where the two moraines are superimposed, and a gentler southward dipping gradient on the outwash plains that make up much of the southern side of the island. The coast from Southampton to Montauk Point is a headland region where the Ronkonkoma moraine and associated outwash sediment are eroded directly by wave action (Williams, 1976). The south shore

of Long Island west of Southampton consists of reworked glaciofluvial outwash and includes shallow back-barrier bays, marshes, and low-relief, sandy (fine- to medium-grained sand) barrier islands.

4. Leatherman (1989) identified 26 historical inlet sites along the Fire Island barrier-island system east of Watch Hill (Fig. 1). Inlet breaches account for most of the littoral sand transport into the back-barrier bays, and relict flood-tidal deltas are common throughout Moriches and Shinnecock Bays (Leatherman, 1985). The great number of relict flood-tidal deltas east of Watch Hill and outcrops of tidal-marsh sediments on the upper shoreface provide evidence of landward migration of this portion of the barrier-island system (Leatherman and Allen, 1985). In contrast, most of Fire Island west of Watch Hill has experienced in-place submergence over the past ~1000 yr (Sanders and Kumar, 1975; Leatherman, 1985; Leatherman and Allen, 1985). From the early 1800's until 1931, the Fire Island barrier-island system from Shinnecock Bay west to Fire Island Inlet, formed a single spit. A strong storm in 1931 opened Moriches Inlet and the "great hurricane" of 1938 opened Shinnecock Inlet and 11 other smaller inlets between Shinnecock and Moriches Inlets (Howard, 1939). All of these inlets subsequently closed naturally except Shinnecock and Moriches Inlets, which were stabilized by jetties in 1954. The east side of Fire Island Inlet was stabilized with a jetty in 1940.

5. Recent USGS Geologic Investigations. Data coverage for the Fire Island to Montauk Point study area extends from 10 miles west of Fire Island Inlet to approximately 10 miles west of Montauk Point, and from 8-m isobath to about 10 km offshore. Sea floor mapping was accomplished by using side scan sonar, high-resolution seismic-reflection profiles, surficial sediment samples, and visual observations. Data products include:

    a. The bathymetric coverage was generated from track line bathymetric data collected and was tidally corrected using NOAA's Sandy Hook control tide station: 8531680. Side scan sonar cross-shore line spacing was 300 m (1000 ft.), and alongshore spacing was approximately 2 km (200 statute miles).

    b. Side scan sonar imagery with contrast augmentation was used to portray backscatter. Backscatter is related to sediment texture where high backscatter indicates coarse-grained sediment or rock outcropping and low backscatter indicates fine sands, silt, or clays.

    c. Fifty-two surficial samples were collected and analyzed in the 1996 tour, 131 in spring of 1997, and 134 in fall of 1997. Reported parameters include sample tour identification; sample number; location in geographic coordinates; percentages of sand, silt and clay; sediment description; and mean sediment diameter, median sediment diameter, standard deviation, skewness, and kurtosis (all in phi units).

    d. Seismic-reflection data, taken in conjunction with the side scan sonar images and surficial sediment samples allowed interpretive mapping estimating Cretaceous rock outcropping, subsurface Pleistocene and Early Holocene sediment filled channels and thicknesses, and mapping of modern reworked deposits and thicknesses.

6. Recent USGS Geologic Results (*derived from Schwab, W.C., Thieler, E.R., Denny, J.F., Danforth, W.W. 2000. Seafloor Sediment Distribution Off Southern Long Island, New York: U.S. Geological Survey Open-File Report 00-243, performed as a part of this study. The most recent results of this study can be found in the originating document)*.

The USGS analysis identified a large outcrop of Cretaceous rock approximately 6km offshore of Watch Hill. To the west of this outcrop a field of shoreface-connected sand ridges that thin in the westward direction was identified. It was hypothesized that these features may reflect onshore sediment transport west of Watch Hill from erosion of the Cretaceous strata traveling via sand waves. Quantification and confirmation have yet to be studied. It was further hypothesized that removal of material from these ridges may interrupt the onshore migration of material from the ridges to the shore face. USACE acknowledges that the potential for this onshore movement is a plausible process. The U.S.G.S. investigators concluded that the coastlines in the study area are influenced by the geological framework. Figure 2 shows estimated thicknesses of Holocene deposits.

7. **Screening Criteria.** Screening criteria included: adequate data available, sufficient quantity, compatible sediment characteristics, would cause minimal adverse wave attenuation, would cause minimal geomorphological effects, contained minimal overburden of fines, contained minimal quantity of fines, minimal adverse environmental effects, and minimal effect on cultural resources. Data meant sediment characteristics at a minimum. Sufficient quantity meant a minimum of 150,000 cy from an upland source within 2 to 4 months, and 250,000 cy from an offshore source. The EM 1110-2-1100 optimal level of sediment compatibility is an overfill factor (defined below) between 1.00 and 1.05. This is not always possible due to limitations in available borrow sites. New York District has had success in long-term placement of sediments with overfill factors between 1.00 and 1.30. This range was adopted for this study. Minimal adverse wave attenuation meant negligible wave changes at the shoreline demonstrated in modeling study. An ERDC rule of thumb of avoiding offshore borrow areas with existing grades shallower than -37 ft. NGVD was utilized. Minimal geomorphological effects meant minimal long term effect on current sediment transport in sensitive offshore areas such as the areas west of Watch Hill on Fire Island. Minimal overburden of fines was defined as less than one foot. Minimal quantity of fines was defined as less than 10%. Minimal adverse environmental effects meant negligible long term impact to flora or fauna as demonstrated by surveying. Minimal effect on cultural resources meant negligible effect upon known cultural resources.

8. **Grain Size Characteristics**. Grain size characteristics are a critical design parameter. Most often, sand with grain size characteristics similar to those of the native beach is sought as beach fill. This is done to maximize compatibility with the existing beach system. Indirectly, selecting compatible material also maximizes the accuracy of predictions of future project performance, which is based on past observations of the native beach response. Occasionally, fills are designed using material with different properties because of limitations on sand availability and the cost to transport it to the project site. Sometimes the choice of a nourishment material with different characteristics is made to satisfy a particular design objective, such as use of a coarser-grained fill material to improve resistance to erosion (EM 1110-2-1100, Chapter 4).

9. Grain size characteristics are quantified based on sieve analyses of samples which are collected throughout the project domain. Those samples acquired on the profile between the berm crest (or mean high water line) and a water depth corresponding to the [position of the typical storm bar should be used to characterize native beach sand for the purpose of assessing the compatibility of sand from potential borrow sources. Compatibility of borrow and native beach material is primarily based on grain size characteristics, and to a lesser extent on color (EM 1110-2-1100, Part V, Chapter 4).

10. Sediment Suitability. The grain size distribution of the borrow material will affect the cross-shore shape of the nourished beach profile, the rater at which material is eroded from the project, and how the beach will respond to storms. Typically borrow material will not exactly match the native beach (except perhaps in some bypassing projects). An analysis is required to assess the compatibility of the borrow material with the native beach, from a functional perspective. A comparative analysis of sand suitability is also required to economically evaluate alternative borrow areas for a given project (EM 1110-2-1100, Part V, Chapter 4). Core composites were developed using averages weighted based on thickness of sediment layers.

11. Early research into compatibility of borrow area material by Krumbein (1957), Krumbein and James 91965), James (1974, 1975), and Dean (1974) addressed this issue by various comparative analysis techniques that utilize the sand size distributions of the natural beach in the fill area and the borrow material in the candidate borrow sites. These approaches develop a factor, or parameter, indicating how much fill is required in light of the different sediment characteristics between borrow and native beach materials. They assume that borrow material placed on the beach will undergo sorting as a result of the coastal processes; and given enough time, will approach the native grain size distribution. The portion of borrow material that does not match the native sediment gain size distribution is assumed to be lost to the offshore. James (1975) developed this concept into a method to calculate an overfill factor, Ra, and a renourishment factor, Rj. Conceptually, the overfill factor is the volume of borrow material required to produce a stable unit of usable fill material with the same grain size characteristics as the native beach sand. The renourishment factor addresses the higher alongshore transportability of the finer grain sizes in the borrow sands and provides an estimate of renourishment needs. Use of the renourishment factor is no longer recommended in beach fill design calculations (EM 1110-2-1100, Part V, Chapter 4).

12. Equations. Mechanical sieve analysis results indicate that the existing beach material consists of coarse to fine sand, however, the coarse material predominates. Simplified methodology of mean grain diameter and standard deviation was utilized due to the large amount of samples analyzed. It is acknowledged that there are more robust methods (e.g., Method of Moments), however the differences in results would not be great enough to change the inclusion or exclusion of a potential source. The simplified mean grain diameter, $M_{\phi i}$, is defined by the following formula:

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

$\phi =$ grain diameter defined in "phi" units

where phi_{84} is the phi transformation of the percentile at which 84 percent of the particles on the grain size distribution curve have larger diameters, and 16 percent have diameters finer than the diameter of the 84th percentile. Whereas, phi_{16} and phi_{50} are the phi value of the 16^{th} and 50^{th} percentile, similarly determined. The mean diameter is used to categorize the beach material into its appropriate component. The standard deviation, $Sigma_{phi}$, is a measure of the natural sorting of the sample. It is simplistically defined by:

$$\sigma_{\phi} = \frac{\phi_{84} - \phi_{16}}{2}$$

= Standard Deviation in phi units

13. **Beach Model Development.** Beach sediment samples were collected in 1995 along 59 selected profile lines in the entire project shoreline, as shown in Figure 3, with nine samples collected per profile line at the following elevations: Back-Berm; Fore-Berm; Mean High Water (MHW); 0 ft. NGVD; Mean Low Water (MLW); -6.0 ft. NGVD, -12.0 ft NGVD; -18 ft. NGVD; and -30.0 ft. NGVD. Eleven beach models were selected to represent the 83 miles of shoreline. Models were selected based on geographic/geomorphic profile location, and are delineated in Figure 3, and described in Table 1. Divisions within one geomorphic region were selected based on constructability factors (e.g., pumping distance), correlation with economic models, grouping based on sediment characteristic similarities, and fill need. Details on how the sediment characteristics were determined follows.

14. All beach sediment samples were used in the development of the beach models with the exception of: samples from elevations -18 and -30 ft. NGVD, anomalous samples, and gravel range samples. These omissions are described below:

    a. Offshore Samples. Offshore samples collected at –18 and –30 ft. NGVD were omitted from the composites. As recommended in EM 1110-2-1100, the most active portion of the profile, located between the natural crest of the berm and the depth corresponding to the typical storm bar. The storm bar is typically located landward of the -18 ft. NGVD contour. Thus, the -18 and -30 ft. NGVD samples were not included in the composites.

    b. Anomalous “Scatter” Samples. Sample mean grain diameter (for all samples) was plotted against sample standard deviation. Beach sediments plotted in this manner typically result in a very dense grouping, with few outliers. The few outlier samples (located significantly away from the central “cluster”) were omitted from beach model composites. Outliers may be comprised of a random shell or cobble, or a limited pocket of silts or clay making its way into the sample cup.

    c. Gravel Samples. Samples that contained more than 16% retained on the ASTM Mesh #10 sieve (i.e., 16% or more of the sample is coarser than 2mm) were omitted from the composites as well. The risk of including gravel samples in the models arose from the potential of having a beach model in the non-sand range (according to the Wentworth Sediment Classification Scale), or from having a bimodal beach model for which our current methods of compatibility analysis are not equipped to model.

15. **Borrow Source Screening.** The potential borrow sources included: upland (quarry), navigation channel maintenance dredging, shoal mining, and offshore. Table 2 shows a comprehensive matrix of all sources investigated. Table 3 shows the list of potential quarries. The following vibracore data sets were used: 1975 FIMP (USACE, 1979); 1976 ICONS (Williams, 1976); 1979 FIMP (OSSI, 1983); 1995 FIMP (MNE and OSI, 1995); 1997 FIMP (collected for this study); and 1998 FIMP (collected for this study) The compatibility is discussed further by beach model. Table 4 shows the result of the screening. Figure 4 shows a comprehensive map with all the potential sources shown.

Table 1

Summary of Native Beach Models

Model	1995 PL	1996 PL	Location	Mean Grain Size (phi units)	Standard Deviation (phi units)	Mean Grain Size (mm)
GSB-D1	P001-P007	F1-F12	Robert Moses State Park to Fire Island Lighthouse	1.34	0.58	0.39
GSB-D2	P007B-P012A	F13-F35	Kismet to Cherry Grove	1.33	0.64	0.40
GSB-D3	P013-P019	F36-F58	Cherry Grove to Watch Hill	1.26	0.58	0.42
GSB-D4	P022-P024	F64-F68	Fire Island Wilderness Area	1.25	0.68	0.42
MB-D1	P027-P029	F72-F79	Smith Point County Park	1.25	0.64	0.42
MB-D2	P031-P037	F81-W17	Moriches Inlet to Westhampton Groinfield	1.15	0.62	0.45
SB-D1	P039-P045	W20-W35	East of Westhampton Groins to Tiana Beach	1.33	0.62	0.40
SB-D2	P045C-P048	W38-P3	Vicinity of Shinnecock Inlet	1.14	0.61	0.45
SB-D3	P050-P052	P7-P11	Southampton Beach	1.26	0.57	0.42
P-D1	P056-P063	P20-P41	Agawam Lake to Amagansett	1.15	0.63	0.45
M-D1	P065-P077	M5-M32	Amagansett to Montauk Point	1.05	0.67	0.48

Table 2

Comprehensive Matrix of Evaluated Sources

		Screening Selections								
Location	Source	Insufficient Data	Insufficient Quantity	Incompatible Sediment Characteristics	Potential Adverse Wave Attenuation	Potential Adverse Geomorph-ological Effects	Overburden of Fines	Excessive Fines	Potential Environ-mental Impacts	Potential Cultural Impacts
Upland	Quarries (12)	3 Quarries	7 Quarries							
Maintenance Dredging	Moriches Inlet (max. 50,000 cy/yr)									Yes
	Shinnecock Inlet (max 60,000 cy/yr)									Yes
	Long Island Intracoastal Waterway			Incompatible						
Shoal Mining	Fire Island Inlet Ebb Shoal			Incompatible						
	Moriches Inlet Ebb Shoal			Incompatible						
	Shinnecock Inlet Ebb Shoal			3 Incompatible Cores	4 Core Locations					
	Fire Island Inlet Flood Shoal	Insufficient Data								
	Moriches Inlet Flood Shoal	Insufficient Data								
	Shinnecock Inlet Flood Shoal			Incompatible						
Offshore	1976 FIMP Reach 2 Cores (46)		2 Cores	20 Cores	12 Cores		1 Core			
	1976 ICONS Cores (56)			42 Cores	10 Cores	1 Core				
	1979 FIMP Cores (60)		4 Cores	36 Cores	2 Cores	3 Cores	1 Core			
	1995 FIMP Reach 1 Cores (15)		2 Cores	8 Cores		1 Core	3 Cores		1 Core	
	1996 FIMP Reach 2 Cores (15)			10 Cores	3 Cores					
	1997 FIMP Cores (10)			5 Cores	1 Core	1 Core				
	1998 FIMP Cores (39)			15 Cores	3 Cores	3 Cores		4 Cores		

Table 3

.

Potential Upland Sources				
Potential Upland Sources	**Location**	**Contact**	**Quantity***	**Grain Size Da**
American Sand & Gravel	Dix Hills, NY	(631) 242-9485	Insufficient	
Bistrian	East Hampton, NY	(631) 324-1123	Insufficient	
Empire Sand & Stone	Westbury, NY	(516) 997-2246	Insufficient	
European Express Sand and Stone	Kings Park, NY	(631) 544-9370	Insufficient	
Guillo	Southampton, NY	(631) 283-7251	Insufficient	
Hubbard Sand & Gravel	Bay Shore, NY	(631) 665-1005	Insufficient	
Stone, Sand, Soil & Rock	Lindenhurst, NY	(631) 956-7645	Insufficient	
Horan Sand & Gravel	Syosset, NY	(516) 364-2972	Sufficient	5 samples (200
Ranco Sand & Stone	Manorville, NY	(631) 874-3939	Sufficient	5 samples (200
East Coast Mines & Materials	Quogue, NY	(631) 645-7005	Sufficient	TBD
Sagaponack	Bridgehampton, NY	(631) 537-2252	Sufficient	TBD
Wainscott	Bridgehampton, NY	(631) 537-4583	Sufficient	TBD
Note: * Specification was 150,000 cy within 2 to 4 months.				

16. Borrow Screening for Beach Model GSB-D1-Fire Island Robert Moses State Park to Fire Island Lighthouse.

    a. Quarries. Out of the six quarries within the range of Model GSB-D1, only Horan Sand and Gravel in Syosset could supply 150,000 cy within 2 to 4 months and provided grain size distributions. The distributions at the time of the sampling (2002) were compatible with the beach model (overfill factor 1.11). Trucked in fill has no wave, geomorphological, and when specified in a detailed enough manner, negligible fines. Environmental and cultural effects (detailed elsewhere in the report) are minimal. The round trip distance from the quarry to the site is over 40 miles, and would require over 10,000 trucks to travel over a minimum of two bridges each way, and would require extra cost to restore roads and bridge surfaces from premature wear.
    b. Maintenance Dredging. This area occasionally receives small amounts of fill from Fire Island Maintenance Dredging. This would be assumed to continue into the future. Historical dredging observations have described Long Island Intracoastal Waterway material as unsuitable for ocean beach placement and won't be considered any further as a source in this study, i.e., less than 90% sand.
    c. Shoal Mining. Fire Island Inlet flood shoal has no data available, but is likely to contain material unsuitable for ocean beach fill. The ebb shoal has coring data, but the characteristics of the sediment were unsuitable.
    d. Offshore. No offshore cores were found to be suitable for this fill area.

17. Borrow Screening for Beach Model GSB-D2- Fire Island Kismet to Point O'Woods.

    a. Quarries. Horan Sand and Gravel in Syosset was suitable with a similar overfill factor 1.11 as for the previous model. See above for screening details.

b. Maintenance Dredging. The maintenance dredging material from Fire Island Inlet meets greater erosion needs further downdrift, so maintenance dredging as fill placement is not considered for this reach.
c. Shoal Mining. Fire Island Inlet flood shoal has no data available, but is likely to contain material unsuitable for ocean beach fill. The ebb shoal has coring data, but the characteristics of the sediment are unsuitable.
d. Offshore. Five offshore cores were found to be suitable for this fill area; ICONS-71, FIMP 79-2-9, 1995 FIMP Core 2, FIMP 97-2 and 97-6. There was adequate data to determine the overfill factors (1.02, 1.02, 1.02, 1.06, and 1.02, respectively). None of the cores is shallower than -37 ft. NGVD so no wave attenuation effects are expected. Four of the cores are located on sand ridges hypothesized to provide transport between offshore and onshore depths in recent studies. It is assumed that with the shortage of borrow sources in the area, borrow sources on the sand ridges may be utilized in such a way, with much adaptive management, and in deeper areas first, to make any impact to on-offshore transport negligible.

18. Borrow Screening for Beach Model GSB-D3- Fire Island Cherry Grove to Davis Park.

a. Quarries. No quarries were within convenient distance from fill area.
b. Maintenance Dredging. Inlets are located outside of convenient fill range.
c. Shoal Mining. Inlets are located outside of convenient fill range.
d. Offshore. Seven offshore cores were found to be suitable for this fill area; ICONS-67, FIMP 79-2-1 and 2-12, FIMP 97-5 and VC98-3, 4, 5 and 6. There was adequate data to determine the overfill factors (1.19, 1.08, 1.02, 1.08, 1.23, 1.28 and 1.25, respectively). None of the cores is shallower than -37 ft. NGVD so no wave attenuation effects are expected. Six of the cores are located on sand ridges hypothesized to provide transport between offshore and onshore depths in recent studies. It is assumed that with the shortage of borrow sources in the area, borrow sources on the sand ridges may be utilized in such a way, with much adaptive management, and in deeper areas first, to make any impact to on-offshore transport negligible.

19. Borrow Screening for Beach Model GSB-D4- Fire Island Wilderness Area.

a. Quarries. No quarries were within convenient distance from fill area.
b. Maintenance Dredging. Inlets are located outside of convenient fill range.
c. Shoal Mining. Inlets are located outside of convenient fill range.
d. Offshore. Four offshore cores were found to be suitable for this fill area; FIMP 79-3-7 and 3-9, and VC98-7 and 8. There was adequate data to determine the overfill factors (1.10, 1.06, 1.04 and 1.21, respectively). None of the cores is shallower than -37 ft. NGVD so no wave attenuation effects are expected. Three of the cores are located on relict headland area hypothesized to provide transport between offshore and onshore depths in recent studies. It is assumed that with the shortage of borrow sources in the area, borrow sources on the sand ridges may be utilized in such a way, with much adaptive management, and in deeper areas first, to make any impact to on-offshore transport negligible.

20. Borrow Screening for Beach Model MB-D1- Fire Island Smith Point County Park.

a. Quarries. Out of the quarries within the range of Model MB-D1, only Ranco Sand and Stone in Manorville could supply 150,000 cy within 2 to 4 months and supplied grain size distributions. The distributions at the time of the sampling (2002) were compatible with the beach model (overfill factor 1.21). Trucked in fill has no wave, geomorphological, and when specified in a detailed enough manner, negligible fines. Environmental and cultural effects (detailed elsewhere in the report) are minimal. The round trip distance from the quarry to the site is over 40 miles, and would require over 10,000 trucks to travel over a minimum of two bridges each way, and would require extra cost to restore roads and bridge surfaces from premature wear.

b. Maintenance Dredging. Moriches Inlet Maintenance Dredging material is occasionally placed in this reach, and this practice is expected to continue.
c. Shoal Mining. Moriches Inlet flood shoal has no data available, but is likely to contain material unsuitable for ocean beach fill. The ebb shoal has coring data, but the characteristics of the sediment were unsuitable.
d. Offshore. No offshore cores were found to be suitable.

21. Borrow Screening for Beach Model MB-D2- Westhampton West of Groins.

a. Quarries. Out of the quarries within the range of Model MB-D2, none met the quantity available threshold. Samples therefore, were not collected.
b. Maintenance Dredging. Moriches Inlet Maintenance Dredging material is usually placed in this beach area at a rate of 50,000 cy/year at 5 years intervals, and this practice is likely to continue.
c. Shoal Mining. Moriches Inlet flood shoal has no data available, but is likely to contain material unsuitable for ocean beach fill. The ebb shoal has coring data, but the characteristics of the sediment were unsuitable.
d. Offshore. One offshore core were found to be suitable for this fill area; 1976 FIMP Cores CB-40. There was adequate data to determine adequate quantity, and overfill factor (1.22). The core is not shallower than -37 ft. NGVD so no wave attenuation effects are expected. No sensitive geomorphological areas were identified in the vicinity of this core.

22. Borrow Screening for Beach Model SB-D1- Westhampton Groins and East of Groins.

a. Quarries. Out of the quarries within the range of Model SB-D1, none met the quantity available threshold. Samples therefore, were not collected.
b. Maintenance Dredging. Shinnecock Inlet Maintenance Dredging material is occasionally placed in this beach area, and this practice is likely to continue.
c. Shoal Mining. Shinnecock Inlet flood shoal has data available, but contains material unsuitable for ocean beach fill. The ebb shoal is located closer to the updrift beachfill placement area, and is discussed there.
d. Offshore. Thirteen offshore cores were found to be suitable for this fill area; 1976 FIMP Cores CB-11, 12, 13, 14, 15, 22, 23 and 24, 1979 Core 5-1, 1998 FIMP Cores VC98-21, 22, 23, and 24. There was adequate data to determine adequate quantity, and overfill factors (1.17, 1.02, 1.02, 1.17, 1.27, 1.16, 1.20, 1.23, 1.26, 1.09, 1.17, 1.12, and 1.18, respectively). The cores are not located in areas shallower than -37 ft. NGVD so no wave attenuation effects are expected. No sensitive geomorphological areas were identified in the vicinity of these cores. Environmental and cultural analyses shall be performed to determine impacts prior to use, in the cases where it has not been done already.

23. Borrow Screening for Beach Model SB-D2- West of Shinnecock Inlet.

a. Quarries. Out of the quarries within the range of Model SB-D2, four met the quantity available threshold. Only one of the four provided sediment characterization data; Ranco Sand and Stone in Manorville. The overfill factor for Ranco was 1.21 for this fill area. Trucked in fill has no wave, geomorphological, and when specified in a detailed enough manner, negligible fines. Environmental and cultural effects (detailed elsewhere in the report) are minimal. The round trip distance from the quarry to the site is over 40 miles, and would require over 10,000 trucks to travel over a minimum of two bridges each way, and would require extra cost to restore roads and bridge surfaces from premature wear. Samples from the remaining three quarries may be collected in the future.
b. Maintenance Dredging. Shinnecock Inlet Maintenance Dredging material is commonly placed in this beach area, and this practice is likely to continue, at a rate of 60,000 cy/year placed at 5-year intervals.
c. Shoal Mining. Shinnecock Inlet flood shoal has data available, but contains material unsuitable for ocean beach fill. The ebb shoal has coring data, adequate volume, and one core was found to be suitable with an overfill ratio of 1.19; 1997 FIMP Core Alt-1. The grade of the shoal at the location of the core is shallower than -37 ft. NGVD, due to its nature of being located on the shoal, hence hydrodynamic and sediment transport modeling is recommended prior to dredging to evaluate potential wave attenuation and geomorphological effects. The core does not contain excessive fines or overburden. Environmental and cultural analyses shall be performed to determine negligible effects prior to use.
d. Offshore. No offshore cores were found to be suitable for this fill area.

24. Borrow Screening for Beach Model SB-D3- Southampton.

a. Quarries. Out of the quarries within the range of Model SB-D3, three met the quantity available threshold but none provided sediment characterization data. Trucked in fill has no wave, geomorphological, and when specified in a detailed enough manner, negligible fines. Environmental and cultural effects (detailed elsewhere in the report) are minimal. The round trip distance from the quarry to the site is over 40 miles, and would require over 10,000 trucks to travel over a minimum of two bridges each way, and would require extra cost to restore roads and bridge surfaces from premature wear. Samples from the three quarries may be collected in the future.
b. Maintenance Dredging. Shinnecock Inlet Maintenance Dredging material is rarely placed in this beach area, and this practice is likely to continue.
c. Shoal Mining. Shinnecock Inlet flood shoal has data available, but contains material unsuitable for ocean beach fill. The ebb shoal has coring data, but the down drift reach (SB-D2) was closer to the coring data, and was considered for placement there.
d. Offshore. Three offshore cores were found to be suitable for this fill area; 1979 FIMP Cores 79-6-17, 1996 FIMP Cores SHIN-12 and 15. There was adequate data to determine adequate quantity, and overfill factors (1.06, 1.24 and 1.26). The cores are not located on grades shallower than -37 ft. NGVD so no wave attenuation effects are expected. No sensitive geomorphological areas were identified in the vicinity of these cores. Environmental and cultural analyses shall be performed to determine negligible effects prior to use.

25. Borrow Screening for Beach Model P-D1- Ponds.

a. Quarries. Out of the quarries within the range of Model P-D1, four met the quantity available threshold but none provided sediment characterization data. Trucked in fill has no wave, geomorphological, and when specified in a detailed enough manner, negligible fines. Environmental and cultural effects (detailed elsewhere in the report) are minimal. The round trip distance from the quarry to the site is over 40 miles, and would require over 10,000 trucks to travel over a minimum of two bridges each way, and would require extra cost to restore roads and bridge surfaces from premature wear. Samples from the three quarries may be collected in the future.
b. Maintenance Dredging. Inlets are not in proximity of fill area.
c. Shoal Mining. Inlets are not in proximity of fill area.
d. Offshore. Eleven offshore cores were found to be suitable for this fill area; 1976 ICONS Core 34, 1979 FIMP Cores 79-6-2, 6-5, 6-8, 6-13, 7-3, 7-7, and 7-9, 1998 FIMP VC98-30, 32, and 33. There was adequate data to determine adequate quantity, and overfill factors (1.06, 1.10, 1.25, 1.16, 1.22, 1.19, 1.23, 1.09, 1.17, 1.16 and 1.10, respectively). The cores are not located on grades shallower than -37 ft. NGVD so no wave attenuation effects are expected. No sensitive geomorphological areas were identified in the vicinity of these cores. Environmental and cultural analyses determined negligible adverse impacts in the areas surrounding cores 1979 FIMP 6-13 and 1998 Core VC98-32. Environmental and cultural analyses shall be performed to determine negligible effects prior to use for the other potential areas.

26. Borrow Screening for Beach Model M-D1- Montauk.

a. Quarries. Out of the quarries within the range of Model M-D1, one met the quantity available threshold but didn’t provide sediment characterization data. Trucked in fill has no wave, geomorphological, and when specified in a detailed enough manner, negligible fines. Environmental and cultural effects (detailed elsewhere in the report) are minimal. The round trip distance from the quarry to the site is over 40 miles, and would require over 10,000 trucks to travel over a minimum of two bridges each way, and would require extra cost to restore roads and bridge surfaces from premature wear. Samples from the quarry may be collected in the future.
b. Maintenance Dredging. Inlets are not in proximity of fill area.
c. Shoal Mining. Inlets are not in proximity of fill area.
d. Offshore. Six offshore cores were found to be suitable for this fill area; 1976 ICONS Core 29, 1979 FIMP Cores 79-8-1, 8-8 and 8-9, 1998 FIMP VC98-34 and 35. There was adequate data to determine adequate quantity, and overfill factors (1.06, 1.09, 1.16, 1.29 and 1.13, respectively). The cores are not located on grades shallower than -37 ft. NGVD so no wave attenuation effects are expected. No sensitive geomorphological areas were identified in the vicinity of these cores. Environmental and cultural analyses determined negligible adverse impacts in the areas surrounding cores 1979 FIMP 8-9 and 1998 Core VC98-34. Environmental and cultural analyses shall be performed to determine negligible effects prior to use for the other potential areas.

Table 4

Results of Screening Analysis				
Beach Model	Suitable Quarries	Maintenance Dredging	Suitable Shoal Mining Source	Suitable Offshore Sources
GSB-D1	Horan	Fire Island Inlet occasional		
GSB-D2	Horan			5 cores
GSB-D3				7 cores
GSB-D4				4 cores
MB-D1	Ranco	Moriches Inlet regular		
MB-D2		Moriches Inlet occasional		1 core
SB-D1		Shinnecock Inlet occasional		15 cores
SB-D2	Ranco	Shinnecock Inlet regular	1 core	
SB-D3				3 cores
P-D1				11 cores
M-D1				6 cores

27. **Borrow Source Recommendations.** Modern reworked deposits formed from erosion of eastern Long Island were targeted as having the highest likelihood of compatibility with beach sediment based on textural characteristics, based on preliminary vibracore data correlation (see Figure 2). While hundreds of miles of seismic data was collected, ease of use was not found. Therefore, Holocene thickness maps (derived by the USGS from the seismic and other data) were utilized for the delineation. Where suitable cores were located in groupings of two or more, a borrow area delineation was drawn to contain the group. Where suitable cores were isolated, it was assumed that the core has a horizontal influence of 2000' by 2000' and a vertical influence equal to the extent of the suitable material in the core. During the pre-construction phase, seismic interpretive profiles can be examined to refine the delineation, and more cores collected for verification purposes. The recommended borrow sources for each beach model area is described below. Borrow Areas are shown on Figures 5, 6, and 7. Borrow source recommendations are summarized in Table 5. Estimated volumes available in each beach model are detailed in Table 6.

27. Recommended Borrow Sources for Beach Model GSB-D1-Fire Island Robert Moses State Park to Fire Island Lighthouse.

    a. Initial Fill. Offshore. While no offshore cores were found to be suitable for this fill area in the immediate vicinity, cores suitable for Beach Model GSB-D2 were found to be suitable for this reach as well (the models were virtually identical). So an area was drawn around Cores ICONS-71, FIMP 79-2-9, 1995 FIMP Core 2 and FIMP 97-2, following the Holocene boundaries called Borrow Area 2C. This area covers 522 acres with an average depth of 12.7 feet. This area is recommended for initial fill. Environmental surveying was completed on this area.
    b. Future Renourishments. Navigation Channel Maintenance Dredging, Quarry or Offshore. Fire Island Inlet Maintenance dredging will be used in this reach for all

future operations. In addition, quarry may be utilized. Further, additional cores may be collected in Borrow Area 2C to confirm its suitability and if material is still shown to be compatible, Borrow Area 2C may be utilized. And environmental surveying may be performed on Borrow Area 1A (2000’ by 2000’ by 10.5 feet depth, surrounding core 1997 FIMP 97-6), and if negligible impacts are found, Borrow Area 1A may be specified.

28. Borrow Sources for Beach Model GSB-D2- Fire Island Kismet to Point O’Woods.

    a. Initial Fill. Offshore. Borrow Area 2C.
    b. Future Renourishments. Offshore. Borrow Area 2C.

29. Borrow Sources for Beach Model GSB-D3- Fire Island Cherry Grove to Davis Park.

    a. Initial Fill. Offshore. Borrow Area 2C was found to be suitable for this fill area as well and is recommended for initial fill (very similar models).
    b. Future Renourishments. Offshore. Additional vibracoring is recommended and if areas are shown to be still compatible, then the suitable borrow areas delineated surrounding core couple 1979 FIMP 79-2-12 and 1998 FIMP encompassing 500 acres at an average depth of 5 feet, called Borrow Area 2B, and two borrow areas of 165 and 200 acres with average depths of 15 and 10.1 feet, respectively, called 2A and 2D are recommended for future renourishments. Environmental and cultural surveys have already been completed on these areas. And/or environmental and cultural surveys may be completed on three additional areas, each 2000’ by 2000’, by 9.5, 4.3, and 17.2 feet depths, respectively, called 2F, 2G, and 2H, and if no adverse impacts are found, these areas may be utilized.

30. Borrow Sources for Beach Model GSB-D4- Fire Island Wilderness Area. No fill is recommended for this area.

31. Borrow Sources for Beach Model MB-D1- Fire Island Smith Point County Park.

    a. Initial Fill. Offshore. Although no offshore cores were found to be suitable for this reach in the immediate vicinity, cores from model areas MB-D2 and SB-D1 were found to be suitable (very similar models). A borrow area was delineated surrounding cores 1975 CB-12 and 13, 1979 FIMP Core 5-1, 1998 FIMP Cores VC98-21, 22, 23 and 24 covering 610 acres with an average depth of 13 feet, called Borrow Area 5B. Environmental and cultural surveys have been performed in this area, and it is thus recommended for use.
    b. Future Renourishments. Offshore or Quarry. Borrow Area 5B is recommended, or quarry, or environmental and cultural surveys may be performed on a 2000’ by 2000’ area with an average depth of 20 feet called Borrow Area 4C surrounding core 1975 FIMP Core CB-40 may have environmental and cultural surveys performed and if no adverse impact is found, then Borrow Area 4C can be utilized.

32. Borrow Sources for Beach Model MB-D2- Westhampton West of Groins.

    a. Initial Fill. No initial fill is recommended.

   b. Future Renourishments. Maintenance Dredging and/or Offshore. Moriches Inlet Maintenance Dredging material is occasionally placed in this beach area, and this practice is likely to continue at a rate of 50,000 cy/year. Additional material may be obtained from Borrow Area 5B.

33. Borrow Sources for Beach Model SB-D1- Westhampton Groins and East of Groins.

   a. Initial Fill. Initial fill from an existing stockpile will be placed.
   b. Proactive Breach Contingency Plan Fill. Fill will be placed as needed as part of a Proactive BCP. Should fill be needed, Navigation Channel Maintenance Dredging material from Shinnecock Inlet may be utilized, or Offshore Borrow Area 5B may be used (similar models and similar suitability).

34. Borrow Sources for Beach Model SB-D2- West of Shinnecock Inlet.

   a. Initial Fill. Initial fill is not recommended for this reach.
   b. Proactive Breach Contingency Plan Fill. Fill will be placed as needed as part of a Proactive BCP. Should fill be needed, Navigation Channel Maintenance Dredging material from Shinnecock Inlet may be utilized, or Quarry or modeling studies and environmental and cultural surveys performed, and if no adverse impact is found, then a 2000’ by 2000’ by 17.8 feet depth, called Ebb Shoal Borrow Area 6B may be used.

35. Borrow Sources for Beach Model SB-D3- Southampton. No fill is recommended for this reach.

36. Borrow Sources for Beach Model P-D1- Ponds.

   a. Initial Fill. Offshore. An area 4000’ by 2500’ with an average depth of 8 feet, called Borrow Area 7B is recommended for use for initial fill. All environmental and cultural survey work has been performed on this area.
   b. Future Renourishments. Offshore. Borrow 7A is recommended. Or any of three 2000’ by 2000’ by 15, 12, or 11 feet depth, surrounding cores 1998 FIMP VC98-30, 1979 FIMP Core 7-9 and 7-7, respectively, called Borrow Areas 6I, 7B, and 7C may have environmental and cultural surveys performed, and if no adverse impacts are determined, then these areas may be utilized.

37. Borrow Sources for Beach Model M-D1- Montauk.

   a. Initial Fill. Offshore. Environmental and cultural survey shall be undertaken on an area 2000’ by 2000’ with a average depth of 13.3 feet, called Borrow Area 8D, surrounding core 1998 FIMP VC98-35, if found to have no adverse impact will be utilized.
   b. Future Renourishments. Offshore. Borrow Area 8D. Or vibracoring, environmental and cultural survey shall be undertaken on an area 4000’ by 1500’ with a average depth of 8 feet, called Borrow Area 8C, surrounding core 1979 FIMP VC 8-1 and 8-8, if found to have no adverse impact will be utilized. Or, environmental and cultural survey shall be undertaken on an area 2000’ by 2000’ with a average depth of 11 feet, called Borrow Area 8B, surrounding core 1976 ICONS-29, if found to have no adverse impact will be utilized. Or, vibracoring, survey shall be undertaken on an area 10000’ by 3000’ with an average depth of

15 feet, called Borrow Area 8A, surrounding cores 1979 FIMP VC 8-1 and 8-8, if found to have suitability confirmed, will be utilized.

Table 5

Results of Borrow Delineation		
Beach Model	Initial Fill	Future Renourishments
GSB-D1	Borrow Area 2C	Fire Island Inlet Dredging and/or Quarry and/or Borrow Areas 2C or 1A*
GSB-D2	Borrow Area 2C	Borrow Area 2C**
GSB-D3	Borrow Area 2C	Borrow Area 2B**, 2A**, and 2D** and/or Borrow Areas 2F*, 2G*, and 2H
GSB-D4		
MB-D1	Borrow Area 5B	Borrow Area 5B and/or Borrow Area 4C*
MB-D2		Moriches Inlet Dredging and/or Borrow Area 5B
SB-D1	Existing Stockpile	Shinnecock Inlet dredging and/or Borrow Area 5B
SB-D2		Shinnecock Inlet dredging and/or Quarry and/or Borrow Area 6B* ***
SB-D3		
P-D1	Borrow Area 7B	Borrow Area 7A and/or Borrow Areas 6I*, 7B*, and 7C*
M-D1	Borrow Area 8D*	Borrow Area 8D, 8C*, 8B* or 8A**
Notes: * indicates environmental and cultural survey needed		
** indicates more vibracoring needed		
*** indicates hydrodynamic and sediment transport modeling recommended		

Available Borrow Volumes

Table 6

Beach Model	Vicinity	Borrow Area ID	Suitable Cores	Average Dredging Cut Depth in ft	Area in acres	Assumed % Unusable	Average Ra	Environmental Analysis Status	Available Volume in cy	Subtotal Available Volume in cy
GSB-D1		no suitable borrow areas							0	
GSB-D1										0
GSB-D2	F15	1A	97-6	10.5	90	25%	1.02	Not Done	1,140,000	
GSB-D2	F32	2C	ICONS 71, 79-2-9, FII 2, 97-2	12.7	522	25%	1.03	Complete	8,010,000	
GSB-D2										9,150,000
GSB-D3	F38	2B	79-2-12, 98-3	5	500	25%	1.05	Complete	3,020,000	
GSB-D3	F43	2F	79-2-1	9.5	90	25%	1.04	Not Done	1,030,000	
GSB-D3	F46	2G	97-5	4.3	90	25%	1.04	Not Done	470,000	
GSB-D3	F49	2A	VC98-6	15	165	25%	1.25	Complete	2,990,000	
GSB-D3	F47	2D	VC98-5	10.1	200	25%	1.28	Complete	2,440,000	
GSB-D3	F54	2H	ICONS 67	17.2	90	25%	1.19	Not Done	1,870,000	
GSB-D3										11,820,000
GSB-D4	F61	3A	79-3-7, 79-3-9, VC98-7	7	609	25%	1.06	Complete	5,150,000	
GSB-D4	F67	3B	VC98-8	4.6	90	25%	1.21	Not Done	500,000	
GSB-D4										5,650,000
MB-D1		no suitable borrow areas							0	
MB-D1										0
MB-D2	W5	4A	CB-37, VC98-12	13	74	25%	1.26	Complete	1,160,000	
MB-D2	W5	4B	CB-43	20	140	25%	1.10	Complete	3,380,000	
MB-D2	W13	4C	CB-40	20	90	25%	1.22	Not Done	2,180,000	
MB-D2										6,720,000
SB-D1	W18	5A	VC98-18, VC98-20	14.5	132	25%	1.16	Complete	2,310,000	
SB-D1	W20	5B exp	CB-14, CB-15, CB-22, CB-23, CB-24	18	300	25%	1.21	Not Done	6,530,000	
SB-D1	W23	5B	CB-12, CB-13, 79-5-1, VC98-21, VC98-22, VC98-23, VC9	13	610	25%	1.20	Complete	9,580,000	
SB-D1	W28	5C	CB-11	15	43	25%	1.17	Not Done	780,000	
SB-D1										19,200,000
SB-D2	W44	6B	97-Alt1	17.8	23	25%	1.19	Not Done	490,000	
SB-D2										490,000
SB-D3	P10	6C	79-6-17, SHIN 12	9.9	110	25%	1.18	Not Done	1,320,000	
SB-D3	P12	6D	SHIN 15	10.2	90	25%	1.28	Not Done	1,110,000	
SB-D3										2,430,000
P-D1	P14	6A	79-6-13	15	74	25%	1.22	Completed	1,340,000	
P-D1	P16	6E	ICONS 34	10	90	25%	1.05	Not Done	1,090,000	
P-D1	P18	6F	79-6-8	9	90	25%	1.16	Not Done	980,000	
P-D1	P23	6G	79-6-5	10	90	25%	1.25	Not Done	1,090,000	
P-D1	P25	6H	79-6-2	10	90	25%	1.10	Not Done	1,090,000	
P-D1	P29	6I	VC98-30	15	90	25%	1.17	Not Done	1,630,000	
P-D1	P39	7A	VC98-32	8	90	25%	1.16	Completed	870,000	
P-D1	M1	7B	79-7-9	12	90	25%	1.09	Not Done	1,310,000	
P-D1	M2	7C	79-7-7	11	90	25%	1.23	Not Done	1,200,000	
P-D1	M6	7D	79-7-3	5	90	25%	1.19	Not Done	540,000	
P-D1	M8	7E	VC98-33	15	90	25%	1.10	Not Done	1,630,000	
P-D1										12,770,000
M-D1	M11	8A	79-8-9, VC98-34	15	184	25%	1.23	Completed	3,340,000	
M-D1	M15	8B	ICONS 29	11	90	25%	1.06	Not Done	1,200,000	
M-D1	M19	8C	79-8-1	8	90	25%	1.09	Not Done	870,000	
M-D1	M27	8D	VC98-35	13.3	90	25%	1.13	Not Done	1,450,000	
M-D1										6,860,000
Total Borrow Volume Available										**75,090,000**

35. **Wave Attenuation Avoidances.** In order to evaluate wave attenuation effects from potential borrow dredging, wave shoreline change modeling was performed utilizing wave conditions developed on the existing conditions bathymetry, and a post-dredge hypothetical bathymetry where the full dredged quantity is assumed to be excavated all at once in order to evaluate wave attenuation effects. Bathymetric data for the numerical domain was acquired from the NOAA bathymetric database. Areas not covered by the NOAA database were defined using beach profile surveys collected in 1995 for this study. The post excavation bathymetry was estimated assuming a cutterhead dredge operation, which results in a fixed cutting depth, and 1V:37.5H final adjusted side slopes, over a 1.85 square mile area. RCPWAVE is the wave model utilized as input to the

GENESIS shoreline change model to determine the shoreline changes. The results of the GENESIS modeling without project (without dredging and without fill placement) and with project (with dredging and with fill placement) future net longshore transport rates show decreased or stable net transport rate within 3 miles down drift of Cherry Grove. This indicates that the dredged borrow depressions do not adversely impact the down drift shoreline. As an added safety factor, borrow areas did not extend landward of -37 ft. NGVD which is seaward of the “depth of closure” for the majority of storm events.

36. Cultural Resource Avoidance. Buffer zones surrounding significant cultural resources have not been delineated and concordant volume reductions in the borrow areas have not been incorporated. These will be accomplished prior to construction.

37. Geomorphologic Impact Avoidance. Towards gaining an understanding of the geomorphologic processes that we shall minimize impacts to, a literature review of onshore sediment movement on Western Fire Island was performed. A summary of the hypothesis of onshore sediment transport from sand ridges offshore of Fire Island appears below.

- In 1961 (a and b) Taney proposed onshore sand transport as the source to balance the sediment transport deficit from Moriches Inlet to Fire Island Inlet.
- In 1972, Duane et al identified sand ridges offshore of Fire Island.
- In 1975, Kumar and Sanders proposed that west of Watch Hill the island was drowning in place.
- In 1976, Williams in “Geomorphology of Long Island” identified cretaceous strata on subbottom profiles.
- In 1977, Williams and Meisberger in “Sand Sources for the Transgressive Barrier Coast of Long Island” propose material migrating onshore from the Continental Shelf.
- In 1983, Kana suggested relic Fire Island Inlet shoals as the onshore source, though presently exhausted.
- In 1985, Leatherman proposed that inlet breaching provided the majority of sediment into the bays east of Watch Hill.
- In 1985, Leatherman and Allen connected frequent inlet breaching east of Watch Hill with landward island migration.
- In 1989, Leatherman identified historical inlet sites along the barrier island system east of Watch Hill.
- In 1999, Rosati et al acknowledged the possibility of onshore transport, although no transport to 160,000 cubic meters/year of onshore transport is still within the level of uncertainty of the data making up the balanced sediment budget. In other words, if no transport exists, the budget is balanced, and if 160,000 m3/year of onshore transport occurs, the budget is still balanced to the accuracy of the supporting data.
- Also in 1999, Schwab et al in “Geological Mapping of the Nearshore Area Offshore Fire Island” propose that the geologic framework influences the shoreline, and describe the side scan sonar, subbottom profiling, and surface sampling performed between 1997 and 1998 for the purpose of mapping the geologic framework. Approximately 6 km offshore of Watch Hill, a large outcrop of Cretaceous strata was proposed, and outside of Watch Hill, the outcrop is proposed to be buried by

Quaternary sediments. And the field of sand waves oriented 30 to 40 degrees with respect to the shoreline were revealed in the data.

- Also in 1999, Foster et al proposed that the thickness of the sand ridges varies from 5 m immediately west of the outcrop, thinning to the west, to less than 1 m offshore of Fire Island Inlet.
- In 2000, Schwab et al in "Seafloor Sediment Distribution off Southern Long Island, New York" concluded that the ridges west of Watch Hill provide sediment to the shoreline west of Watch Hill, contributing to the island stability in that region (as opposed to the drowning-in-place shoreline east of Watch Hill).
- In 2008, Lentz, Hapke and Schwab in "Review of Sediment Budget Estimates at Fire Island National Seashore, New York" propose that removal of sediment from nearshore regions have the potential to alter wave refraction and diffraction patterns, and result in changes in the wave energy reaching the beach.
- In 2008, a two-day technical workshop on offshore sand resources south of Long Island was held at Stony Brook University's School of Marine and Atmospheric Sciences. The workshop was intended to review what is known, or unknown about the volume of offshore sand reserves, the potential for onshore transport, and the character of offshore sand ridges. Workshop attendees included researchers from federal agencies, academia and the private sector as well as federal, state local agency representatives involved in coastal resource management. Bokuniewicz and Tanski summarize the workshop in, "White Paper: Long Island Offshore Sediment Resources". (provided as a sub-appendix). Some of the workshop recommendations include the following:
    - Collection of high-resolution bathymetry of the proposed borrow pits and surrounding areas before and after dredging
    - Collection of periodic bathymetry and sidescan sonar from the 0 m to the 10 m contours
    - Collection of wave, water level, and current data via bottom-mounted instrumentation

    A conclusion of the workshop included the following: adverse impacts on the shoreline can be minimized by project design (such as borrow area size, orientation, and distance offshore).
- In 2013, Schwab et al. in "Geologic Evidence for Onshore Sediment Transport from the Intercontinental Shelf, Fire Island, NY" compare high-resolution mapping (sidescan sonar, seismic profiling and bathymetry) collected in 2011 with that collected in 1996-1997. The conclusion of "outcropping" was changed to "erosion outwash lobe", as the data reveals it is buried by 15 m of Quaternary sediments. The 1996-1997 data was not able to resolve layers less than 50 cm thick. The 2011 data revealed that southeast of the outwash lobe are linear Pleistocene gravely-lag ridges less than 50 cm in height. These ridges extend from the 5m contour offshore 20 km to greater than the 35 m contour, and they vary in height from 6 m at the Watch Hill end to 1m at the Fire Island Inlet end. Net westward transport of fine to medium sand was suggested (as evidenced by low backscatter of the sonar), leaving medium to coarse material in the troughs and on the east-facing flanks (as evidenced by high backscatter). It was proposed that the southwest flanks of the

larger attached ridges have eroded, leaving high scarps, and that these scarps may be migrating landward. Older borrow sites were seen to have filled in, and in some cases the sand ridge systems reformed.

- And more recently, Schwab et al., in “Modification of the Quaternary stratigraphic framework of the inner-continental shelf by Holocene marine transgression: An example offshore of Fire Island, New York”, assert more firmly that the morphology of the inner-continental shelf region is the result of ongoing erosion of the Pleistocene glaciofluvial sediments. The outwash lobe is concluded to define a past Fire Island headland, east of which has eroded for the past 8,000 years providing material west of the lobe, in a sand wave formation. And finally that the comparison of the seafloor mapping between 1996-1997 and 2011 indicate that the nearshore sediment zone has received sediment at the expense of deflation of the sand waves.

38. In summary, more data is needed to quantify these processes, and then modeling is needed to more fully understand them. In order to have sufficient fill for Fire Island, it is impossible with the data currently existing to avoid use of the borrow areas on the ridges. However, steps shall be taken to select the lowest impact areas first, and use the lowest impact portions of that borrow area, collecting data before and after use, and repeatedly. This data can be used for quantification analyses and for modeling prior to the future renourishment cycles. The resulting recommended borrow source for western Fire Island is offshore Borrow Area 2C (the deepest borrow area on the sand ridges), and to dredge the deepest portion of the area for the initial operation. Use of Borrow Areas 1A, 2A, 2B, 2D, 2F, 2G, 3A, and 3B will be deferred until future renourishment operations, at which time, a better understanding of the sediment transport processes will have been gained through pre and post dredging monitoring of Borrow Area 2C.

28. **Borrow Area Monitoring.** Borrow areas 2B, 2C, and 2D have been proposed in the region with the largest sediment thicknesses contained in shore face connected sand ridges. USACE is looking at historic infilling between shore face attached sand ridges. The findings of the historic infilling study will be used for adaptive borrow area management to minimize impacts to the shoreline. Adaptive borrow area management practices include, but are not limited to: dredging in shallow lifts, managing the order that the ridge borrow areas are accessed during the project life, allowing further time in between operations of the borrow areas allow for infilling, minimizing the surface area impacted individual borrow areas. USACE welcomes further collaboration on future research from the community of coastal sedimentation scientists.

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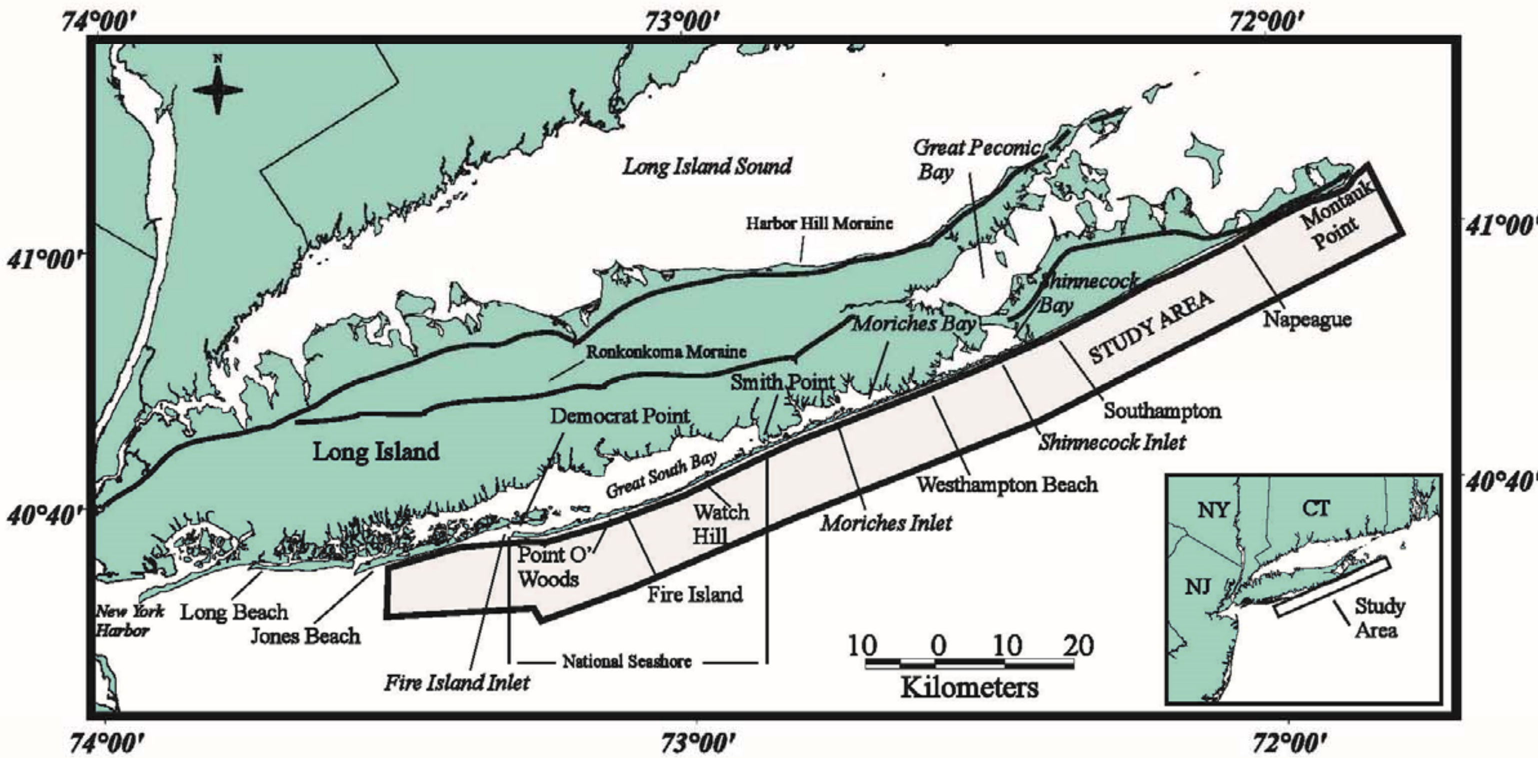


Figure1. Location figure showing the study area and location of late Pleistocene terminal moraines on Long Island, NY.

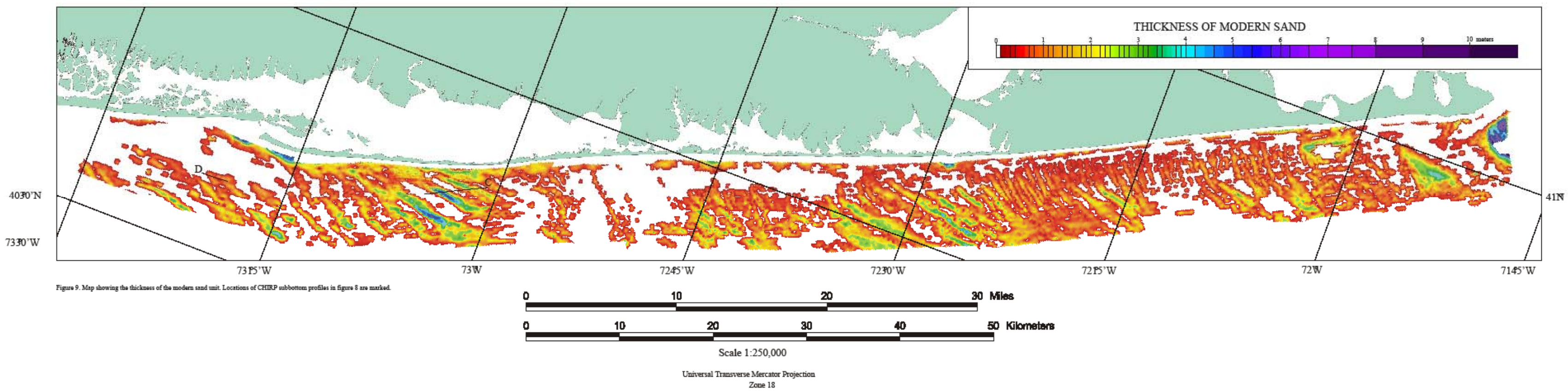
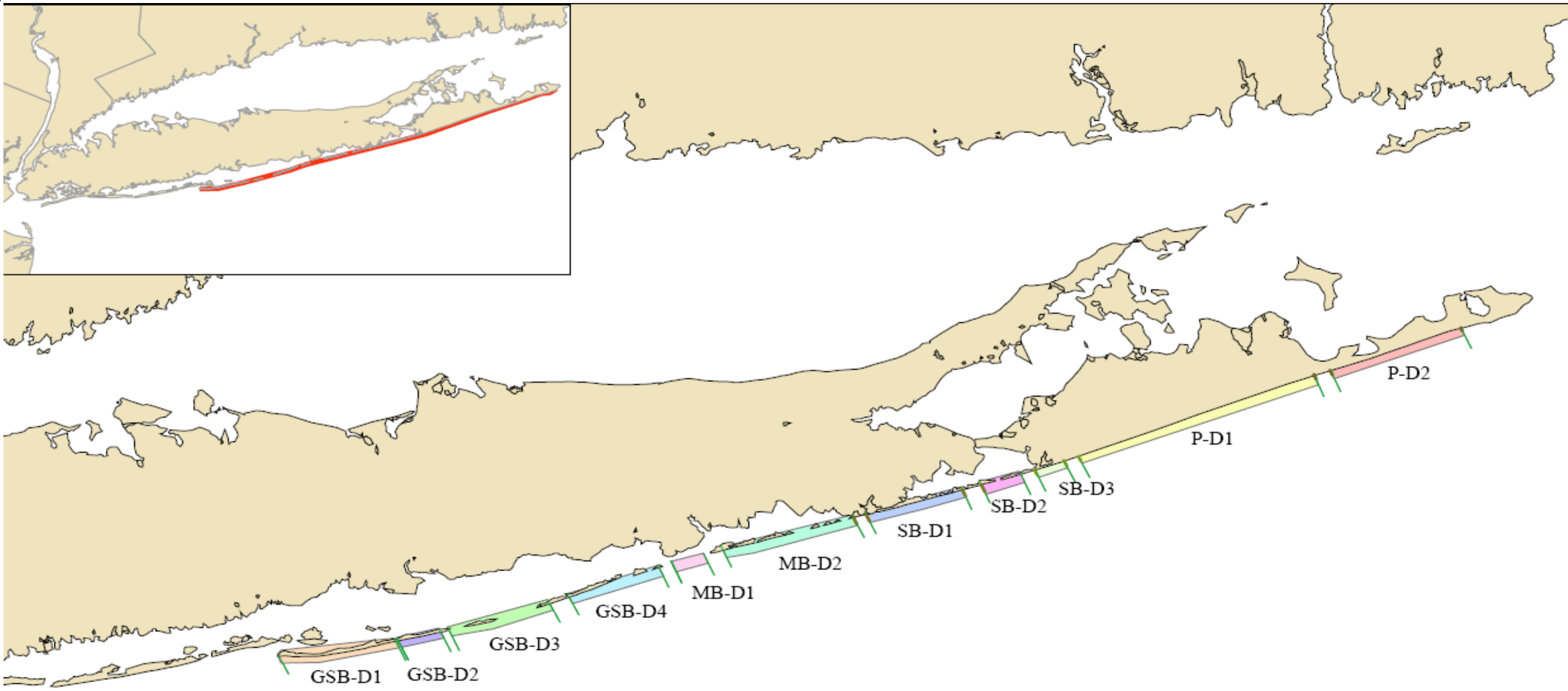
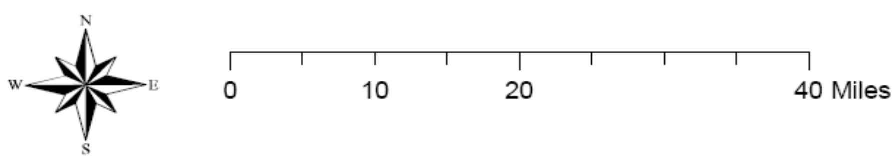


Figure 1

Map of Modern Sediment Thicknesses





Summary of Native Beach Models						
				Mean	Standard	Mean
				Grain Size	Deviation	Grain Size
Model	1995 Profile #	1996 Profile #	Location	phi units	(phi units)	(mm)
GSB-D1	P001-P007	F1-F12	Robert Moses State Park	1.34	0.58	0.39
GSB-D2	P007B-P012A	F13-F32	Kismet to Point O'Woods	1.33	0.64	0.40
GSB-D3	P013-P019	F33-F58	Cherry Grove to Davis Park	1.26	0.58	0.42
GSB-D4	P020-P026	F60-F71	Fire Island Wilderness Area	1.25	0.64	0.42
MB-D1	P027-P030	F72-F77	Smith Point County Park	1.25	0.64	0.42
MB-D2	P031-P037	F79-W18	Westhampton West of Groinfield	1.15	0.62	0.45
SB-D1	P039-P045	W20-W35	Westhampton Groins and East of Groins	1.33	0.62	0.40
SB-D2	P047	W40-P5	West of Shinnecock Inlet	1.35	0.48	0.39
SB-D3	P050-P052	P7-P11	Southampton	1.26	0.57	0.42
P-D1	P056-P063	P13-M12	Ponds	1.14	0.63	0.45
M-D1	P068-P077	M14-M34	Montauk Point	1.05	0.67	0.48

Figure 2

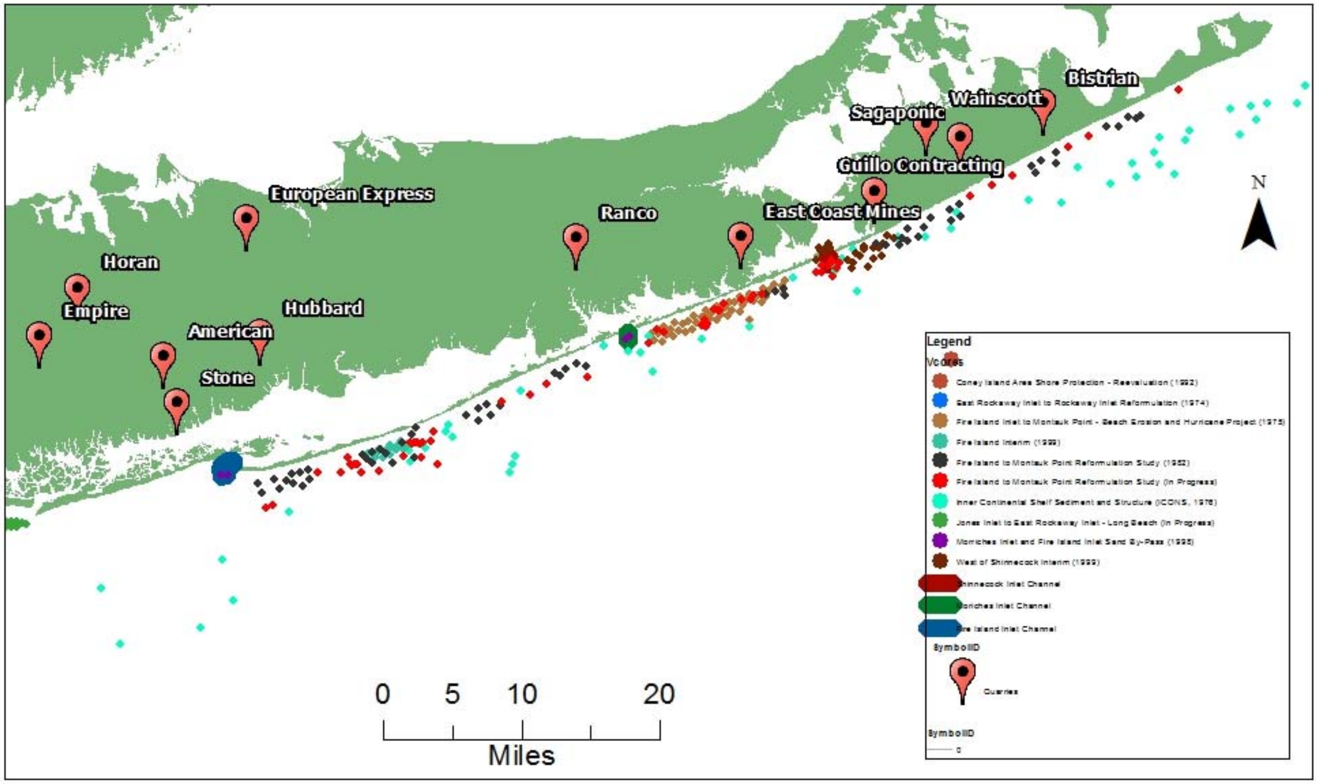

Bistrian
Wainscott
Sagaponic
Guillo Contracting
East Coast Mines
Ranco
European Express
Horan
Empire
Hubbard
American
Stone
N
0
5
10
20
Miles
Legend
Vcores
Coney Island Area Shore Protection - Reevaluation (1992)
East Rockaway Inlet to Rockaway Inlet Reformulation (1974)
Fire Island Inlet to Montauk Point - Beach Erosion and Hurricane Project (1975)
Fire Island Interim (1999)
Fire Island to Montauk Point Reformulation Study (1982)
Fire Island to Montauk Point Reformulation Study (In Progress)
Inner Continental Shelf Sediment and Structure (ICONS, 1976)
Jones Inlet to East Rockaway Inlet - Long Beach (In Progress)
Moriches Inlet and Fire Island Inlet Sand By-Pass (1998)
West of Shinnecock Interim (1999)
hinnecock Inlet Channel
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Figure 3

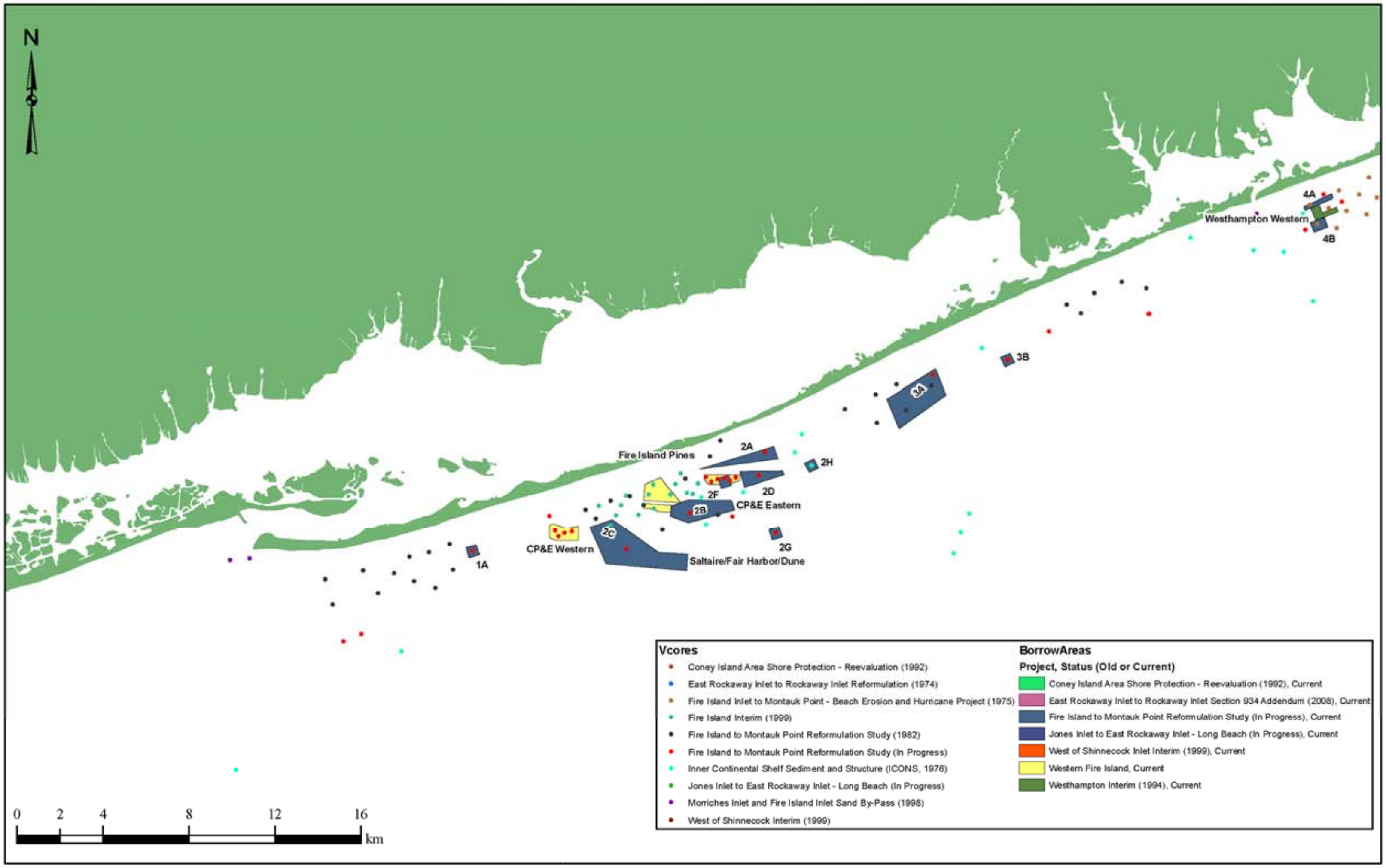

Figure 4 Active Borrow Sites for Fire Island

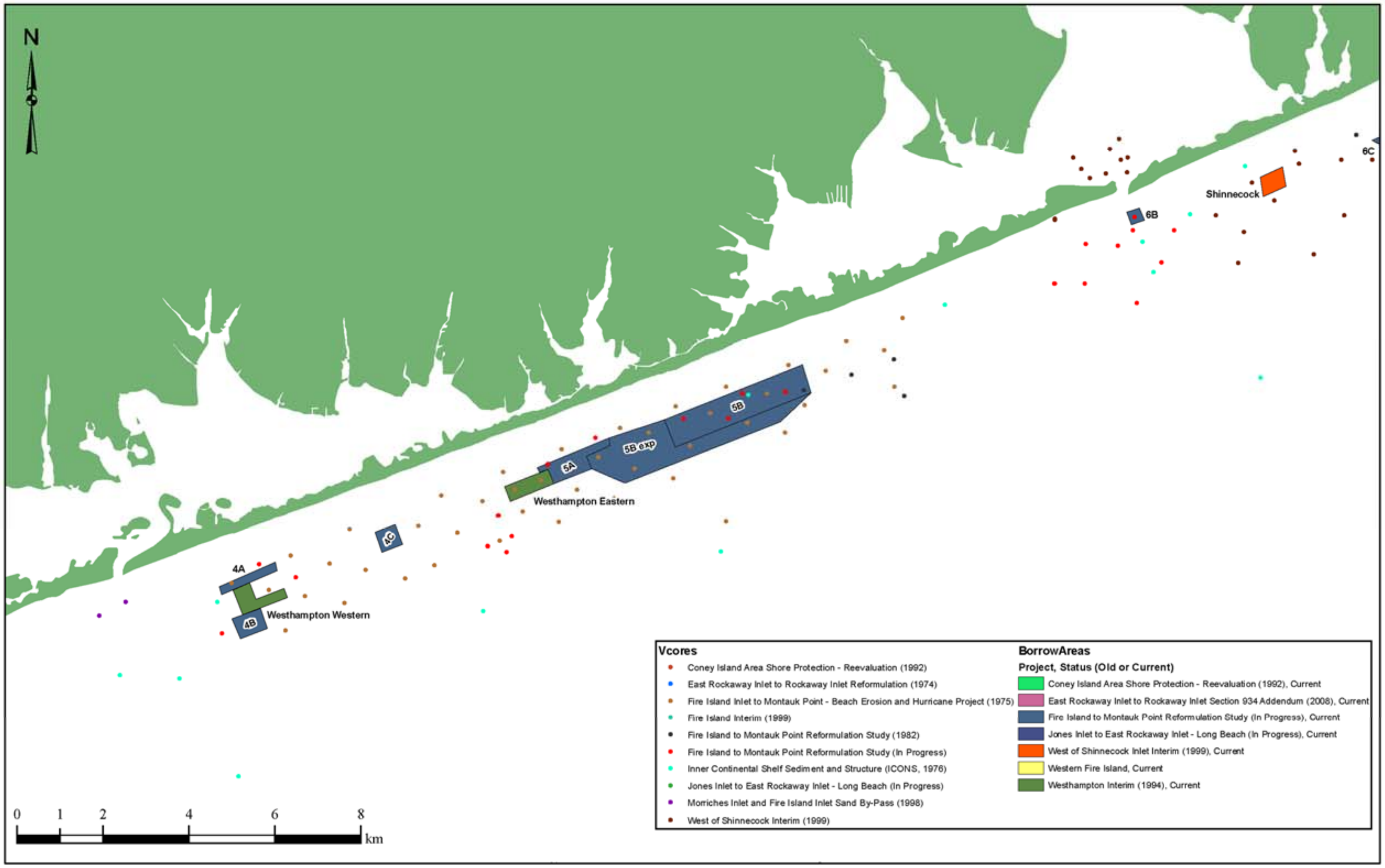

Figure 5: Active Borrow Sites for Westhampton

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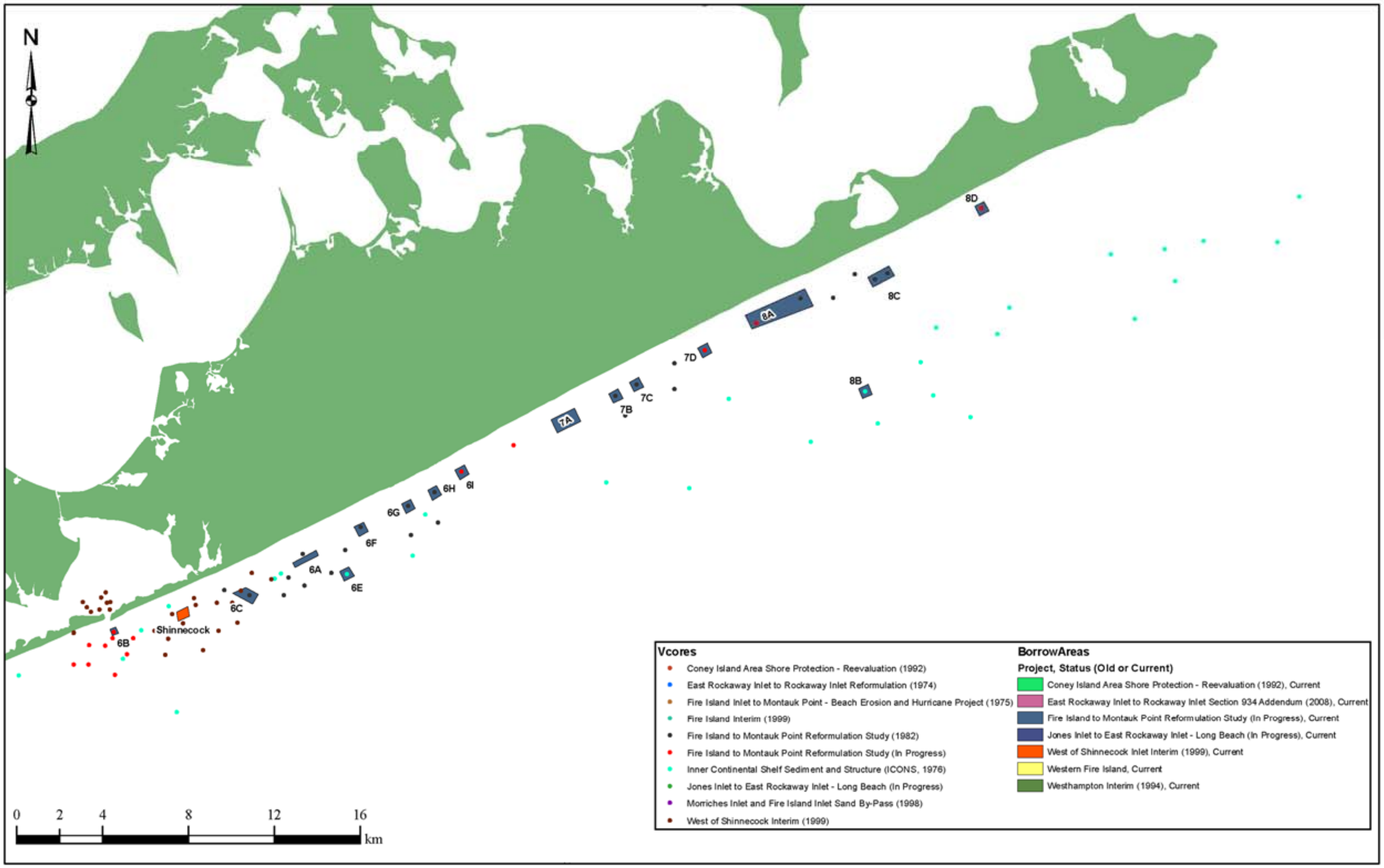

Figure 6: Active Borrow Sites for Montauk