INVESTIGATION OF OPPORTUNITIES FOR IMPROVED SEDIMENT MANAGEMENT

For

The Long Island South Shore Estuary Reserve

September 2010

Prepared for:
New York State Department of State
With funds provided under Title 3 of the
Environmental Protection Fund Act
Albany, NY 12231-0001

Prepared by:
Woods Hole Group, Inc.
81 Technology Park Drive
East Falmouth MA 02536
(508) 540-8080

This page left intentionally blank

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

The following report has been prepared by Woods Hole Group, under contract to the New York State Department of State Division of Coastal Resources on behalf of the South Shore Estuary Reserve Council (Council). The Council is the management board charged with creating and implementing the South Shore Estuary Reserve Comprehensive Management Plan, as provided in Article 46, of the New York State Laws of 1993. The South Shore Estuary Reserve (Reserve) is a resource of unparalleled biological, economic, and social value. The Comprehensive Management Plan (CMP), adopted by the Council on April 12, 2001, called for the development of a dredging and dredged materials management plan as one of a number of priority actions aimed at fostering the conservation and enhanced use of the Reserve. This report is the third in a series of 5 reports that will provide the Council with the necessary background to prepare a Dredge Materials Management Plan (DMMP) for the Reserve. The reports will address the following aspects of an overall plan:

- Assessment of Current Dredging Conditions and Future Needs
- Inventory and Distribution Assessment of Contaminated Sediments
- Investigation of Opportunities for Improved Sediment Management
- Investigation of Beneficial Use Opportunities
- Recommendations to Facilitate Implementation

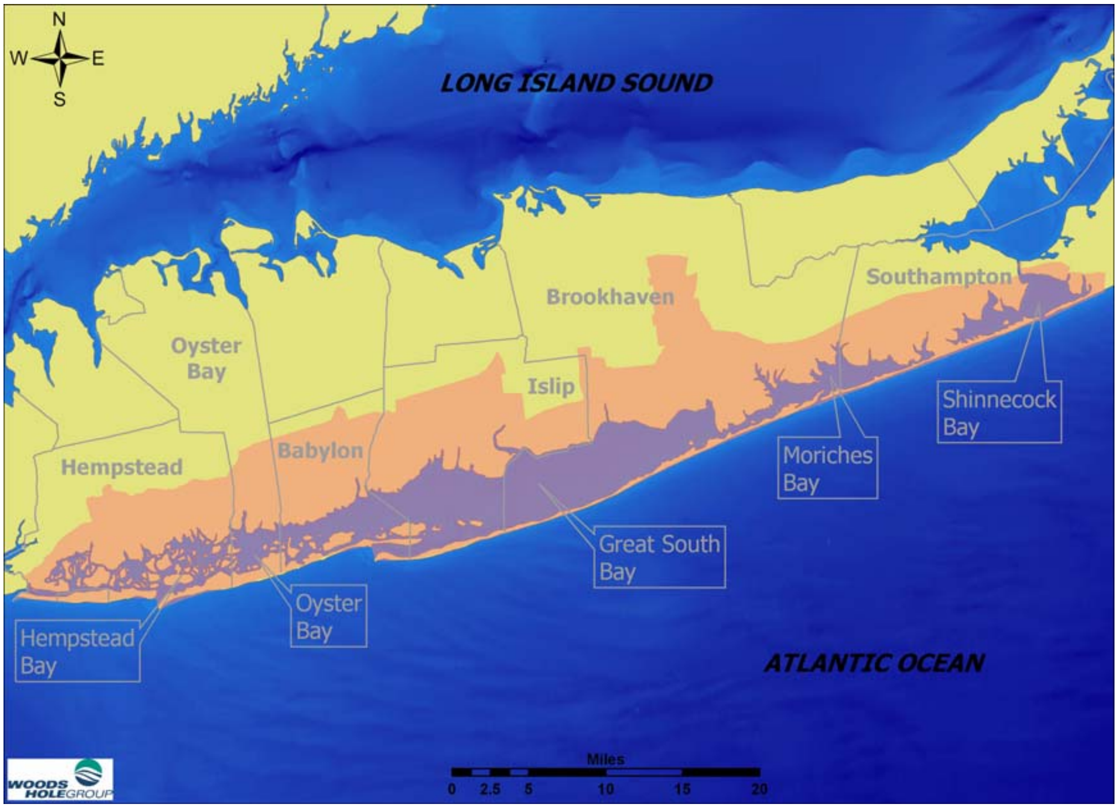

Figure 1. Site map showing extent of the South Shore Estuary Reserve, as well as encompassing towns and major water bodies.

The benefits provided by a Reserve-wide dredging and dredged materials management plan are far reaching. The general concept is to identify management solutions for dredged materials that facilitate channel dredging and maritime center development, while also minimizing negative impacts to marine and cultural resources. The first component of the dredge materials management plan was to quantify the current and future needs for dredging. Through this process, the volume and type of material produced by dredging activities in the Reserve was identified.

The third component of the dredge materials management plan, and the subject of this report, involves the investigation of opportunities for improved sediment management within the Reserve. This effort will provide information useful in helping to maintain navigable waterways, minimize costs associated with dredging and dredged materials placement, and protect the resources of the ecosystem. Causes for sedimentation and strategies to help reduce channel infilling will be addressed, as well as various alternatives for dredging, transportation, dewatering, and placement that may offer opportunities for improved sediment management. By combining results from the Assessment of Current Dredging Conditions and Future Needs, the Inventory and Distribution Assessment of Sediment Chemistry, and the Investigation of Opportunities for Improved Sediment Management, with the ensuing reports on beneficial use opportunities, and implementation recommendations, the South Shore Estuary Reserve Council will have many of the basic components needed to prepare the Reserve-wide Dredging and Dredged Materials Management Plan (DMMP), and will have identified information gaps that should be addressed to advance a DMMP, as recommended by the CMP.

2.0 ALTERNATIVES FOR SEDIMENT MANAGEMENT

Increasing costs associated with dredging to maintain navigable waterways, as well as pressures on available placement locations, highlight the importance of identifying opportunities for improved sediment management. Additionally, tighter environmental restrictions on dredged material placement, longer hauls to a limited number of placement sites, expensive upland disposal, and long delays in processing permit applications demand more efficient sediment management practices. For the purposes of this analysis, alternatives for sediment management have been broken into two broad categories: sediment reduction and dredge operations. The sediment reduction category addresses activities that can be undertaken to reduce the volume and rate of channel shoaling so that dredging needs are minimized. The dredge operations category addresses available methodologies for dredging, materials transportation, dewatering and processing, and placement that can be used to increase the efficiency of the dredging process and reduce associated costs. For dredge projects within the Reserve it is anticipated that a combination of sediment management alternatives will be required in order to significantly improve existing practices. The volume of dredge material projected over the next 10 years in the Assessment of Current Dredging Conditions and Future Needs (1.7 million CY for non federal projects), the wide variety of dredging projects and sediment types, and the large area of the Reserve suggest that a combination of various alternatives for sediment management must be considered.

2.1 SEDIMENT REDUCTION

Sediment reduction involves reducing the amount of material that settles in navigation channels, boat basins, and other navigable waterways that must be subsequently removed. Effective sediment reduction decreases the volume of material that must be removed to maintain safe navigation, and also reduces the frequency of dredging. Activities that can be undertaken to reduce channel shoaling have been broken into the following five groups: improved watershed management, optimize channel design, advanced maintenance dredging, structural controls, and optimize nearshore placement design. These sediment reduction strategies are discussed in general terms below. Specific application of these strategies to SSER dredging practices is addressed in Section 5.0 of this report.

2.1.1 Improved Watershed Management

One significant source of sediment to estuarine waterways comes from the surrounding upland watershed areas. To a large extent, the degree of sediment contributed by a watershed is related to management of the land, including the development of agricultural lands, roadways, urban development, and the activities of people living within the watershed. In other words, land surface characteristics strongly influence sediment flux from a particular watershed region. In urban areas where impervious surfaces are abundant, storm water rich in sediment is prevented from percolating back through the soils to the groundwater, and is often discharged directly to the downstream water body via storm drainage systems. Soil erosion from poorly controlled construction sites can also contribute significant quantities of sediment to nearby streams and estuaries.

Watershed areas containing agricultural lands can also contribute to an increased sediment flux, as rainfall washes sediment from newly cultivated fields or areas of immature vegetation. In general, urban and agricultural land areas lead to increased rates of runoff and erosion. Because of this, the sediment flux from watersheds into nearby water bodies, while highly variable within and between land uses, exceeds that from natural or undisturbed land areas.

Improved watershed management through the use of Best Management Practices (BMPs) is one strategy for reducing sediment loads to downstream water bodies, which can often exacerbate shoaling within channels and basins needed for navigation. A list of watershed management BMPs specific to reducing sediment flux from urban and agricultural areas is provided in Tables 1 and 2, respectively.

Table 1. Common Best Management Practices for controlling sedimentation from urban watersheds.

BMP	Description
Impervious surfaces	Reduce the amount of impervious surface, particularly driveways and parking areas, to promote infiltration and reduce runoff volumes.
Roadway and landscaping maintenance	Removal of street debris (i.e., street sweeping), management of animal wastes (both domestic and wild), improved landscape maintenance, and structures (e.g., grit chambers) to retain coarse materials like sand and grit.
Construction practices	Protect disturbed surfaces by appropriate grading practices, sequenced construction activities, vehicle track maintenance (e.g., use of pads of solid or aggregate material), and erosion control measures.
Soil erosion control	Maintain vegetative cover and use mulch or geotextiles to reduce the loss of soils. Protect and/or reinforce steep unvegetated slopes
Sediment control	Use structural barriers (e.g., check dams and berms) and silt curtains to trap and retain suspended material.
Retention systems	Establish ponds or subterranean chambers (e.g., vaults and oversized pipes) to temporarily retain storm water runoff and allow sediments to settle out.
Detention systems	Establish dry ponds and swales to slow storm water runoff, reducing erosion and soil loss. Retained water is subsequently released or allowed to infiltrate.
Flow control structures	Control flow rates and the distribution of storm runoff through the use of permeable weirs and flow splitters.
Infiltration systems	Establish vegetated basins and trenches or onsite landscape areas to allow increased infiltration of runoff water and the retention of sediments.
Constructed wetlands	Create (using dams or modifying drainages) wetlands to retain sediment and dissolved nutrients, while providing wildlife habitat and aesthetic value. Wetlands can often be incorporated into community landscape improvement efforts.
Filtration systems	Establish vegetated (e.g., grassed filter strips), mechanical (e.g, sand filter chambers and underground filter cascades), and landscape design approaches for removing materials from runoff water. Develop and follow maintenance plans for these systems to ensure optimum performance.
Riparian buffers	Establish riparian buffers next to water resources to control surface runoff and provide bank stabilization and aquatic and wildlife habitat.
Overlay zoning	Develop water protection overlay zones that require erosion control measures.
Land acquisition	Prioritize acquisition of open space parcels to control urban development and maximize natural areas for infiltration of surface runoff.

Table 2. Common Best Management Practices for controlling sedimentation from agricultural watersheds.

BMP	Description
Nutrient management	Careful management of soil fertility through scheduled application of fertilizer to ensure proper uptake and to minimize losses.
Irrigation water management	Control the rate, timing, and level of irrigation to reduce soil erosion and leaching of nutrients.
Conservation tillage	Tillage designed to leave at least 30% of the soil surface covered with crop residue to minimize soil loss due to erosion by wind and water.
Contour farming	Tillage and planting of crops along topographic contours to reduce erosion and increase infiltration.
Strip cropping	Use of alternating strips or contours of various row crops, sod, or close-growing crops to minimize surface runoff.
Filter strips and field borders	Use of strips of grass or other close-growing vegetation to reduce transport of sediment and associated nutrients.
Cover crop and rotation	Planting of close-growing grasses, legumes, or small grains to protect and improve soil, and periodic changes in crop type. Residues to cover crops provide green manure and reduce fertilizer needs.
Pasture management and windbreaks	Use of pastures to ensure maintenance of foliage, and the use of trees or shrubs at field edges to reduce sediment losses due to wind and water erosion.
Waste-handling facilities	Use of waste storage ponds, structures, and confined areas to temporarily retain manure and other agricultural wastes at feedlots, animal containment areas, and barnyards.
Water and sediment control structures	Construction of settling basins, earthen embankments, and diversion channels to store or redirect the flow of runoff waters, thus retaining suspended solids and nutrients.
Livestock exclusion	Limit animal access to streams, streambanks, and lakes or ponds through the use of fencing or similar structures to prevent grazing-related erosion.

2.1.2 Optimize Channel Design

Rates of sedimentation in engineered waterways can be aggravated by poor design practices. The main components of a navigation channel design for estuarine waters include the cross-sectional area (width and depth) and orientation. When the cross-sectional area becomes too large, the current velocities through the channel are reduced and increased shoaling typically occurs. This is especially true in areas where wide or deep channels are cut through naturally narrow passages, or where the tidal range is large. Long channels and sharper curves also tend to promote increased shoaling. The placement of entrance channels with respect to the dominant wind and wave direction and shoreline orientation can also affect sedimentation rates. Channels designed perpendicular to the dominant wind and/or wave approach direction often have higher rates of shoaling, especially in areas where the channel abuts sandy shorelines.

Engineering design considerations aimed at minimizing shoaling should be incorporated into all new navigation projects. For existing projects, historical knowledge of the area should be combined with engineering design practices during permit renewals to incorporate modifications that will reduce shoaling. Commonly used engineering considerations to optimize channel design for reduced shoaling include the following:

- Align the navigation channel to follow the course of the naturally deeper channel in a river or estuary, as much as is practical. This practice minimizes the re-equilibration process where the channel shoals to its pre-dredge configuration.

- Avoid abrupt changes or right angles in channel orientation which can cause flow restrictions and sediment deposition.

- Align long navigation channels parallel to the prevailing wind direction, so that wind-induced currents can help to maintain sediments in suspension.

- Optimize the channel or basin geometry to increase tidal velocities to keep sediment in suspension and prevent its deposition. This alternative may involve changing the cross-sectional area by reducing the channel width or depth. Conversely, the channel cross section may be increased to induce sediment deposition elsewhere, away from the critical areas of navigation.

- Construction of deposition basins in areas of active longshore transport can be used effectively to intercept and temporarily store sediment that would otherwise accumulate in the navigation channel. The optimum site for a deposition basin is in an area where the wave and current climate is mild, and sand can accumulate at some distance from the channel. Deposition basins can be constructed interior to a structured inlet or basin, or exterior to the basin.

2.1.3 Advance Maintenance Dredging

Advance maintenance dredging is a technique used to reduce the frequency of maintenance dredging. This process involves dredging a channel deeper and/or wider than its design or authorized depth, so that shoaling can occur without compromising use of the channel for navigation. Where properly applied, the practice of advance maintenance dredging can increase the interval between dredging operations, thus reducing the number of mobilization/demobilization events and their associated costs. Advance maintenance dredging is economically sound if the money saved through reduced dredging frequency exceeds the money required to remove the additional sediment.

The site specific depth to shoaling rate relationship is the key issue that controls the effectiveness of advance maintenance dredging. The following three scenarios can develop: the channel shoaling rate increases dramatically with depth, the channel shoaling rate is independent of depth, and the channel shoaling rate increases only slightly with depth. Obviously, advance maintenance dredging can only realize significant benefits with the last two scenarios, and should only be considered as a last resort with the first scenario. Estimates of annual maintenance dredging volume as a function of channel deepening/widening should be developed prior to implementation of an advance maintenance dredging program. These estimates should be based on site specific historical shoaling rate data, as well as data from nearby channels with similar forcing and geomorphic settings that have already been deepened. Other potential impacts of advance maintenance dredging, such as increased tide range upstream and changes in tidal flushing should be evaluated prior to implementation. Empirical relationships developed by the US Army Corps of Engineers may also prove useful in evaluating the effects of dredging depth on shoaling frequency (Rosati, 2005; Trawle, 1981). For more complicated sites the use of numerical models can be valuable in determining the potential benefits of advance maintenance dredging.

2.1.4 Structural Controls

Various structural controls exist for minimizing shoaling and limiting the infilling of channels with sediment. These structural modifications to the natural physical system are classified into two categories: armoring structures and shoreline stabilization structures. Armoring structures serve to protect and retain upland infrastructure and include seawalls, bulkheads, and revetments. Shoreline stabilization structures include groins, jetties, and breakwaters which serve to interrupt alongshore sediment transport patterns in order to preserve surrounding shoreline features. A general description of each of these structural controls and how they can be used to prevent sediment from entering channels and berthing areas is listed in Table 3. More detailed descriptions and examples of these structural features can be found in the Coastal Engineering Manual (USACE, 2002).

Table 3. Structural Alternatives for Sediment Management

Structure Type	Structure	Description	Provided Benefits for Sediment Management
Armoring Structures	Seawall	Vertical structure with primary purpose of preventing inland flooding from storm events accompanied by waves.	Retains upland soils; Resists upland erosion of sediments during storm events.
	Bulkhead	Vertical retaining wall to hold or prevent soil from sliding seaward.	Retains upland soils; Resists upland erosion of sediments during storm events; Stabilizes defined channels and waterways.
	Revetment/ Dike	Sloped structure constructed of erosion-resistant material placed on existing sloping face to protect against waves and currents.	Retains upland soils; Resists upland erosion of sediments during storm events; Stabilizes defined channels and waterways.
Shoreline Stabilization Structures	Groin	A structure extending from the shoreline with the purpose of interrupting littoral transport and trapping sediments.	Prevents longshore drift from reaching downdrift locations, such as harbors or inlets.
	Jetty	A structure extending from the shoreline with the purpose of confining riverine or tidal flow into a channel.	Prevents longshore drift from reaching downdrift locations, such as harbors or inlets; Reduces influx of sediments into the channel; Stabilizes defined inlet location.
	Breakwater	A structure, either shoreline attached or detached, with the primary purpose of protecting shoreline features from waves.	Reduces erosion in harbors and along shoreline by reducing wave impacts; Interrupts alongshore transport and can serve as sediment trap to reduce channel infilling.

All shoreline structures affect habitat and environmental services in the nearshore area. In addition, such structures are frequently associated with impacts to the down drift shorelines and adjacent bottom lands. As a result of these impacts there are regulatory constraints limiting their installation. Some potential negative impacts include scour, loss of aquatic vegetation, loss of benthic habitat, wave reflection, loss of flood storage capacity, loss of groundwater filtration capacity and loss of public access to the shoreline. These impacts must be addressed in any proposal for construction or reconstruction of such structures. Since habitat and water quality values are critical to the health of the estuary, a careful balance must be struck between shoreline structures essential for navigation uses and shoreline conservation to protect other resources.

For the various structural control measures that exist, there are certain design considerations that affect how the structure reduces the infilling of sediment within neighboring channels. For the structural measures listed in Table 4, some distinct critical aspects of design are listed below in bulleted form. For shoreline stabilization structures, possibly most important in design is the proper understanding of the littoral regime within the area.

- For structures offering upland protection and resistance to erosion during storm events (seawalls, revetments, and bulkheads) the structure crest elevation is critical to protect against wave overtopping and any associated upland damages.

- For earth retaining structures, the use of an appropriate geotextile fabric within the design can help to reduce backfill migration, especially the finer-grained sediments.

- For a sloped structure, such as a revetment, using materials that create a slope that is rough and porous can help to reduce wave runup, overtopping, and ensuing upland erosion.

- For structural measures that extend into the water from the shoreline, the length, height, permeability, and alignment of the structures are critical in determining how much longshore sediment will be trapped and how long before sediments will begin to bypass the structures to allow for infilling of the channel or transport to downdrift locations.

- A common practice is to create a series of groin structures (groin field) and the length of stabilized shoreline will define the downdrift section of shoreline that may be affected by erosion as a result of a loss of sediment supply.

- For structures located on both the updrift and downdrift sides of an inlet, an important factor of design affecting sediment management is the alongshore spacing between the structures as this will affect the cross-section area of the inlet channel, as well as the effect on waves passing through the inlet.

- For shoreline attached breakwaters, the length, height, and alignment of the structure should be optimized to offer protection against waves in lee of the structure and reduce wave-induced impacts within the harbor or berthing area. This type of structure can also interrupt littoral transport patterns and the littoral material can be expected to move along the outer face of the structure until it is deposited in the relatively calm waters in lee of the structure.

- Detached breakwaters are typically aligned parallel to the shoreline and the primary design factors that will affect sediment supply to downdrift areas include the structure length, height, distance offshore, permeability, and structure orientation. In addition, a detached breakwater can be segmented (multiple structures) and the breakwater gap distance (between adjacent structures) becomes an important factor in affecting littoral drift patterns.

- Reduced wave energy in lee of a detached breakwater will reduce the entrainment and transport of sediment by wave action in this region. A sediment trap can thus be created to reduce infilling of downdrift channels.

2.1.5. Optimize Nearshore Placement Design

The proper nearshore placement of sediments from dredging projects can assist in reducing sedimentation in engineered waterways. Alternatives for placing dredged sediments in the nearshore (littoral zone) are dependent on a number of factors including:

1) type of material (i.e. sands or silts),
2) volume of material,
3) rate and direction of littoral transport,
4) dredging and placement methods,
5) the existing profile, as well as
6) environmental restrictions.

While these factors affect the choice and availability of placement sites, there may also be certain objectives or desired benefits in enhancing nearshore profiles and/or beaches. The placed material can help to restore and feed the littoral system. It can also assist in reducing wave energy, which in turn, can reduce erosion of the surrounding area. There is also the potential ecological benefit of providing habitat for aquatic species and other wildlife.

In providing this additional sediment to the littoral system, there are some best practices and considerations to be made that can help alleviate the deposition of sediments within maintained waterways:

- Placement near a jetty structure that stabilizes an inlet (and interrupts the alongshore sediment transport pattern) should occur on the downdrift side of the structure in order to restore littoral transport and lessen the potential for material placed updrift to bypass the structure and reenter the dredged channel.

- The littoral transport direction should be considered when creating “feeder” beaches or nearshore berms to reduce the migration of sediments into nearby maintained channels.

- The construction of dunes and widening of beach widths can reduce the near term likelihood of overwash and potential breaching of barrier islands during storm events. The long term effect of such placements on the stability of coastal barriers is uncertain since these very overwash and breaching events are part of the natural cycle by which barriers respond to sea level rise.

- When constructing a nearshore berm, knowledge of the coastal processes (waves, winds, and currents) is necessary to assess the potential movement of placed sediment and response of the berm.

- A nearshore berm can reduce wave energy in lee of the feature to help limit wave-induced transport and erosion near the shoreline. Performance will depend on appropriate design geometry for the water depth and prevailing conditions, as well as the intensity and frequency of actual storm events.

2.2 DREDGE OPERATIONS

Opportunities for improved sediment management are available at all stages of the dredge operation process, starting with different dredging methodologies and continuing through materials transportation, dewatering and processing, and final placement or reuse. Available alternatives for each stage of the dredging process are discussed in general terms below. Specific application of these strategies to SSER dredging practices is addressed in Section 5.0 of this report.

2.2.1. Dredge Methodologies

Dredging methods can be divided into two primary categories, mechanical and hydraulic, with each consisting of a variety of equipment types. The choice of dredging method is usually made based on site specific characteristics such as sediment type, water depth, site exposure to waves and currents, and dredged materials placement location. However, opportunities to improve the efficiency of the dredging process as well as the management of sediment removed still exist.

Mechanical dredging involves the use of backhoes, draglines, or clamshells to scoop and remove sediment from the channel. The equipment can either work from the shoreline or from a floating barge. The process of mechanical dredging does not introduce additional water to the dredged material, as the sediments tend to come out in mass as they existed on the sea floor. Because of this mechanical dredging is often the preferred method for removal of fine-grained sediments, which can present challenges for dewatering. Mechanical dredging can, however, produce extensive water turbidity at the dredging site as seawater mixed with sediment drains from the bucket. Sediments excavated from the channel bottom are placed either directly onshore in a dewatering facility, or in scows and then towed to an offloading site where the material can be dewatered. Mechanical dredging is useful for working in close quarters near bulkheads and pier faces; however, production rates are generally small when compared with larger pipeline dredges (Table 4).

Table 4. Operational characteristics for various types of dredge equipment.

Dredge Type	Percent Solids by Weight	Production Rates (yd^3/hr)	Vert. Accuracy (ft)	Horiz. Accuracy (ft)	Minimum Dredge Depth (m)	Maximum Dredge Depth (m)
Clamshell	~ in *situ*	30-600	2	1	0	48
Backhoe	~ *in situ*	25-200	1	3	0	7-15
Suction	10-15	25-5,000	1	3	2	16-19
Dustpan	10-20	25-5,000	0.5	3	2-5	16-19
Cutterhead						
6-8 in	10-20	32-140	1	3	1.2	4
10-12 in	10-20	80-700	1	3	1.4	8
14-16 in	10-20	210-1,145	1	3	1.5	12
20-24 in	10-20	400-2,100	1	3	1.6	15
30 in	10-20	750-3,270	1	3	1.7	15
Hopper	10-20	500-1,960	2	10	3-9	21

Hydraulic dredging is commonly performed using a cutterhead or dustpan type dredge coupled with a suction pipe and pump, which removes sediment from the sea floor and transports it via pipeline to a settling basin or reuse site (e.g. beach nourishment). A cutterhead dredge utilizes a rotating head, mounted with smooth or toothed metal blades to dislodge the sediment. The cutterhead and suction pipe are mounted on a boom at the front of the dredge. The boom is moved back and forth cutting through the sediment, as the dredge vessel is stabilized by spuds. Once a complete swing of the boom is finished, the dredge advances along the channel using the spuds. The dredged sediments are hydraulically pumped to a settling basin or reuse site as a slurry of water and sediment, with typical solids content on the order of 10 to 20 percent by weight. The capacity of hydraulic dredges is usually defined by the diameter of the dredge pump discharge. Size classifications range from 4 to 36 inches, with most plants in the 12 to 16 inch range. Fine-grained materials are typically pumped to dewatering basins where the sediments are allowed to settle before the water is drained. Coarser sand sized sediments are often pumped directly onto a beach. Booster pumps can be added to the discharge line to facilitate the pumping of dredged material greater distances. Production rates for medium-sized cutterhead dredges are typically between 80 and 1,200 cy/hr (Table 4).

The operational characteristics for various types of dredge equipment shown in Table 4 should be used as a guide in selecting the best equipment for a particular dredge project. Additional considerations include the following:

- For projects involving removal of fine-grained material, it is important to select a dredge method that minimizes the water content of the sediments. This tends to reduce the costs of handling, treating, and final disposal. Mechanically dredged sediments do not typically require intensive dewatering operations, and thus can sometime reduce overall project costs.

- In cases where the distance between the dredge location and the dewatering/placement site is great, sediments can be transported by scows or barges. This is especially beneficial for fine-grained sediments where high water content can become an issue during dewatering. A potential drawback to the use of scows and barges is that the material will require rehandling a second time to move into the dewatering basin, waiting trucks, or the placement site.

- Accessibility to the site by the various type of dredge equipment must also be considered. Narrow channel widths, shallow depths, submerged obstructions, and overhead restrictions such as bridges or wires can often limit the type and size of equipment that can be used. For hydraulic dredges, the ability to deploy pipelines across roadways and major navigable waterways in highly urban areas can be problematic. Similarly, dredge equipment maneuvered through the use of spuds in highly trafficked navigational channels can be a limiting factor, as the dredge is not able to move quickly enough to allow through passage of vessels.

- In environmentally sensitive areas where sediment resuspension during dredging has the potential to adversely impact water quality and benthic resources, it is important to select a methodology that minimizes the loss of sediment. In general, hydraulic dredging does a better job than mechanical dredging at minimizing sediment resuspension.

- While greater production rates mean shorter dredge times, the mobilization and rental fees associated with larger dredges are higher. In some cases, lower production rates may actually be desired to minimize sediment resuspension or to meet constraints imposed by transportation, processing, or disposal components of the project.

3.0 SEDIMENTATION PROCESSES IN THE SOUTH SHORE ESTUARY RESERVE

Steps to improve sediment management practices in the SSER must be based in part on a sound understanding of the processes that govern sediment input and movement in the estuary. This includes knowledge of the sources of new sediment to the estuary as well as the mechanisms that transport sediment along the shorelines and waterways. Although development of a detailed sediment budget for the SSER is beyond the scope of this project, some of the information gathered will provide key components of a conceptual sediment budget. The sediment information in combination with improved strategies for dredge operations will facilitate integrated management of dredged materials that will provide sustainable solutions to sediment-related needs.

3.1 SOURCES OF SEDIMENT

The primary sources of new sediment to the SSER include the following:

- Rivers – Rivers that drain watershed areas from the mainland areas of Long Island can be significant sources of sediment to the estuary. These rivers primarily contribute fine-grained sand, silt, and clay sized material to the SSER.

- Upland surface runoff – Upland areas without stabilizing vegetation or that slope steeply towards the shoreline can represent a source of sediment to the estuary, especially during periods of heavy rainfall. Both fine-grained and sandy sized material can be produced from upland runoff.

- Shoreline erosion – Natural shoreline areas in the SSER can contribute significant quantities of sediment to the estuary as they erode in response to waves, storm surge, and sea level rise. Shorelines susceptible to erosion include natural beaches, dunes, bluffs, and salt marsh areas, contributing a range of material from fine to coarse grained. Loss of aquatic vegetation and nearshore shallow emergent or intertidal vegetation contributes to mobilizing sediment.

- Tidal inlets – Tidal inlets represent an important component of a coastal sediment budget as the flood and ebb tidal deltas can serve as both sources and sinks of sediment. The five ocean inlets in the SSER link the estuary to the south facing barrier beaches and the open ocean, thus providing a source of sandy sediment to the ebb tidal deltas within the estuary.

- Barrier beach overwash – Storm-induced overwash of the barrier beaches that form the southern boundary of the SSER also serve as a sediment source to the estuary. This process is most important in low lying or narrow sections of the barrier beach, where waves and elevated water levels during storms push sand sized material into the estuary. Overwash is a natural process that tends to widen the barrier in low areas, providing a platform for future barrier development and making the widened areas less susceptible to breaching.

The relative importance of these sediment sources to the SSER, and their potential to influence channel sedimentation processes has been evaluated using existing data sources. Descriptions of the data sources, methods of analysis, and results are provided below.

3.1.1. Rivers and Upland Surface Runoff

Information on watershed boundaries and associated tributary systems within the SSER was obtained from the Reserve Office. The GIS data layers were used to map the locations of watersheds and river/creek systems contributing to waters of the SSER. A total of 76 watersheds were mapped along with 105 different tributaries (Figure 2). The watersheds range in size from 104 to 18,040 acres (Table 5). The Forge River, Carmans River, and Connetquot River, all located in Suffolk County, are the three largest watersheds measuring greater than 10,000 acres. Six watersheds range in size between 5,000 and 10,000 acres; five of these are located in Suffolk County (Swan River, Orowock Creek, Carlls River, Browns River, and Patchogue River) and Massapequa Creek is located in Nassau County. The remaining 67 watersheds are all smaller than 5,000 acres.

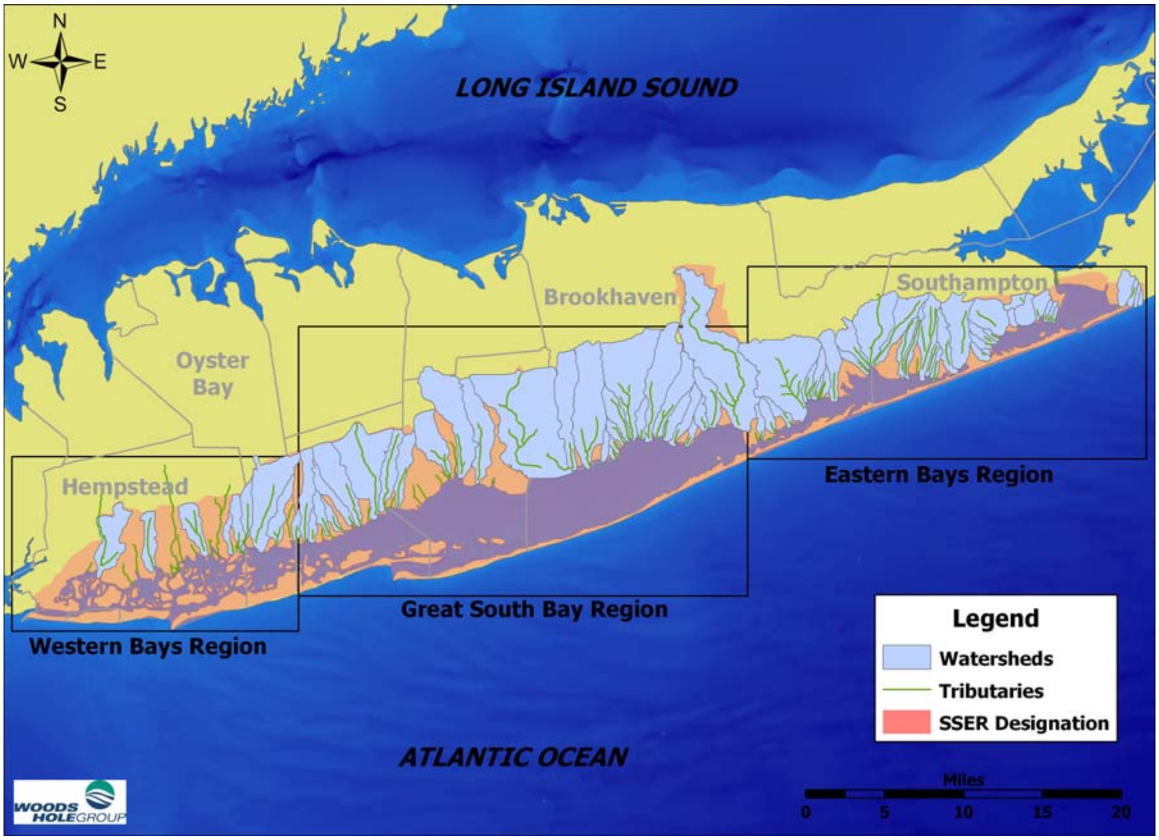

Figure 2. Watersheds and tributaries contributing to waters of the SSER.

US Geological Survey (USGS) data were then researched to identify stream flow (discharge) and sediment load information for each of the rivers and tributaries. Data were available from the USGS National Water Information System web site (USGS, 2010) for 30 of the tributaries impacting the SSER (Figure 3). Historical data for some of the sites were available back to 1937, and six of the sites maintain real-time data collection systems for hydrologic conditions. The historical data generally represent periodic manual measurements of stream flow and suspended sediment concentrations, while the real-time data are collected at 60 minute intervals and reported as daily and monthly averages. Representative stream flow values were calculated as the average of all available historical data, or the mean of the annual stream flow where long-term yearly data were reported (Table 5). Computed averages of the USGS stream flows are shown color-coded and graduated according to magnitude in Figure 3.

Table 5. Watersheds and tributaries contributing to waters of the SSER.

Watershed Name	County	Area (acres)	Tributaries	Avg. Stream Flow (cfs)
Abets Creek	Suffolk	1469.2	Abets Creek	N/A
Amityville Creek	Suffolk	2555.4	Amityville Creek	3.1
Areskonk Creek	Suffolk	281.0	Areskonk Creek	N/A
Aspatuck Creek	Suffolk	1609.9	Aspatuck River	1.7
Beaverdam Creek	Suffolk	2821.8	Beaverdam Creek	2.2
Beaverdam Creek	Suffolk	2098.8	Beaverdam Creek – West	2.2
Browns River	Suffolk	8223.2	Browns Creek; Browns River	N/A
Carlls River	Suffolk	7573.2	Carlls River	29.9
Carmans River	Suffolk	15034.3	Carmans River; Little Neck Run; Yapahank Creek;	59.9
Cedar Creek	Nassau	587.0	N/A	N/A
Cedar Swamp Creek	Nassau	2121.3	Cedar Swamp Creek	4.5
Champlin Creek	Suffolk	4473.2	Champlin Creek	5.0
Connetquot River	Suffolk	18039.3	Connetquot River; Connetquot Brook; West Brook; Rattlesnake Brook; Indian Creek	23.0
Coopers Neck Pond	Suffolk	163.5	N/A	N/A
Corey Creek	Suffolk	619.4	Corey Creek	N/A
East River	Suffolk	2885.3	East River	N/A
Forge River	Suffolk	10638.8	Forge River; Ely Creek; Old Neck Creek; Second Neck Creek	8.0
Great Neck Creek	Suffolk	978.4	Great Neck Creek	N/A
Green Creek	Suffolk	4727.5	Green Creek	5.0
Halsey Neck Pond	Suffolk	221.3	N/A	N/A
Heady Creek	Suffolk	1168.1	N/A	N/A
Hedges Creek	Suffolk	1462.3	Hedges Creek	N/A
Heils Creek	Suffolk	622.9	Heils Creek	N/A
Homans Creek	Suffolk	544.4	N/A	N/A
Howells Creek	Suffolk	435.5	Howells Creek	N/A
Johns Neck Creek	Suffolk	532.1	Johns Neck Creek	N/A
Jones Creek	Nassau	1830.5	James Creek; Jones Creek; Unqua Creek	N/A
Lawrence Creek	Suffolk	698.8	Lawrence Creek	N/A
Little Creek	Suffolk	883.7	Little Creek	N/A
Little Seatuck Creek	Suffolk	1759.4	Little Seatuck Creek	3.5
Massapequa Creek	Nassau	6275.3	Massapequa Creek	12.6
Milburn Creek	Nassau	1810.1	Milburn Creek	6.6

Motts Brook	Suffolk	828.9	Motts Brook	N/A
Mud Creek	Suffolk	3123.3	Mud Creek	4.4
Mud Creek	Suffolk	633.1	Mud Creek	4.4
Namker Creek	Suffolk	186.8	Namker Creek	N/A
Narraskatuck Creek	Suffolk	542.2	Narraskatuck Creek	N/A
Neguntatogue Creek	Suffolk	1550.5	Neguntatogue Creek	4.1
Oneck Drain	Suffolk	481.4	N/A	N/A
Orchard Neck Creek	Suffolk	568.3	Orchard Neck Creek	N/A
Orowoc Creek	Suffolk	6813.6	Orowoc Creek	N/A
Patchogue River	Suffolk	8689.2	Patchogue River	23.3
Pattersquash Creek	Suffolk	879.9	N/A	N/A
Penataquit Creek	Suffolk	3404.7	Penataquit Creek	6.1
Pennimans Cove	Suffolk	103.9	N/A	N/A
Pennimans Creek	Suffolk	452.1	Pennimans Creek	N/A
Penny Pond	Suffolk	225.5	Penny Pond	N/A
Phillips Creek	Suffolk	643.7	Phillips Creek	N/A
Quantuck Creek	Suffolk	3897.0	Quantuck Creek	1.9
Rockaway/Mill/Powell	Nassau	3833.8	Powell Creek; Mill River; Pines Brook	15.1
Sampawams Creek	Suffolk	2498.7	Sampawams Creek	12.3
Santapogue Creek	Suffolk	4225.7	Santapogue Creek	5.9
Seaford Creek	Nassau	1433.1	N/A	5.8
Seamans Creek	Nassau	1333.3	N/A	3.0
Seatuck Creek	Suffolk	4982.9	Seatuck Creek	4.8
Senix Creek	Suffolk	896.3	Senix Creek	N/A
Smith Creek	Suffolk	862.6	Smith Creek	N/A
Speonk River	Suffolk	1206.0	Speonk River	0.8
Stillman Creek	Suffolk	255.5	N/A	N/A
Stone Creek	Suffolk	437.1	N/A	N/A
Strongs Creek	Suffolk	653.9	Strongs River	1.2
Swan River	Suffolk	5755.1	Swan River	14.0
Taylors Creek	Suffolk	348.2	Taylors Creek	N/A
Terrell River	Suffolk	2162.2	Terrell River; Orchard Neck Creek	N/A
Tuthills Creek	Suffolk	1757.0	Tuthills Creek	N/A
Weesuck Creek	Suffolk	2830.8	Weesuck Creek	1.6
Wells Creek	Sufflok	263.5	Wells Creek	N/A
Willetts Creek	Suffolk	2113.3	Willetts Creek	N/A
Woods Creek	Suffolk	604.8	Woods Creek; Ketchams Creek	N/A
Tiana Bay	Suffolk	1218.9	N/A	N/A
N/A	Suffolk	1026.5	Brushy Neck Canal	N/A
N/A	Suffolk	534.0	Tiana Creek	N/A
N/A	Suffolk	319.2	N/A	N/A
N/A	Suffolk	240.6	Daves Creek	N/A
N/A	Suffolk	444.6	Oneck Creek	N/A
N/A	Suffolk	182.9	Fosters Creek	N/A

Unfortunately, the USGS sediment load information was not rich enough to provide an adequate representation of the quantity of material delivered to the SSER from the rivers and tributaries. However, studies have shown a correlation between annual stream flow and suspended sediment loads for a number of similar estuary systems (USGS, 2003). Based on these findings, the watershed area and average stream flow data for the SSER were used to illustrate the relative contributions of sediment to the waterways from the various rivers and tributaries. Figure 4 shows variations in watershed/riverine stream flow in comparison to the projected 10-yr dredge volumes for existing SSER projects. In a qualitative sense, these data show a correlation between watershed areas, stream flow, and dredge volumes. Watershed area and stream flow is greatest in the central portion of the SSER, within the Great South Bay sub-region, and this area also contains the greatest number of dredge projects with larger dredge volumes. The Western and Eastern Bays regions contain smaller watersheds with lower stream flows, and consequently the dredge projects require less sediment removal.

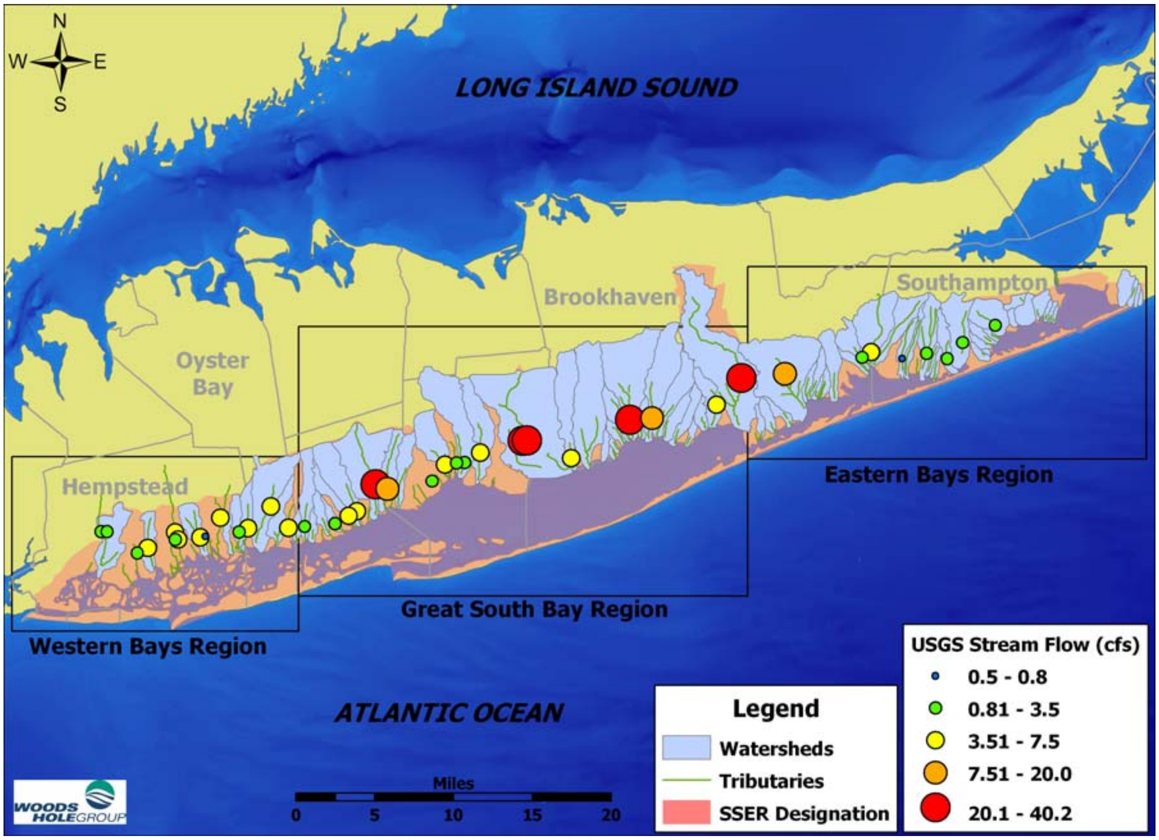

Figure 3. Average USGS stream flow (cfs) for SSER tributaries.

Sediment contributions to the SSER from the various watersheds are not only related to the stream flow of their associated rivers, but also to the degree and type of watershed development. A number of studies have looked at the relationship between urban land uses and sediment loading (USGS, 2003; Dreher and Price, 1994). These studies developed estimates of unit sediment loading for a variety of watershed development types (Table 6). They also calculated an enrichment ratio by comparing the extrapolated sediment load for each land use to the sediment load for the woodland/wetland land use category. As can be seen from the table, land use categories with high levels of impervious area (industrial, commercial, highways, and high-density residential) have the highest sediment loadings and enrichment ratios.

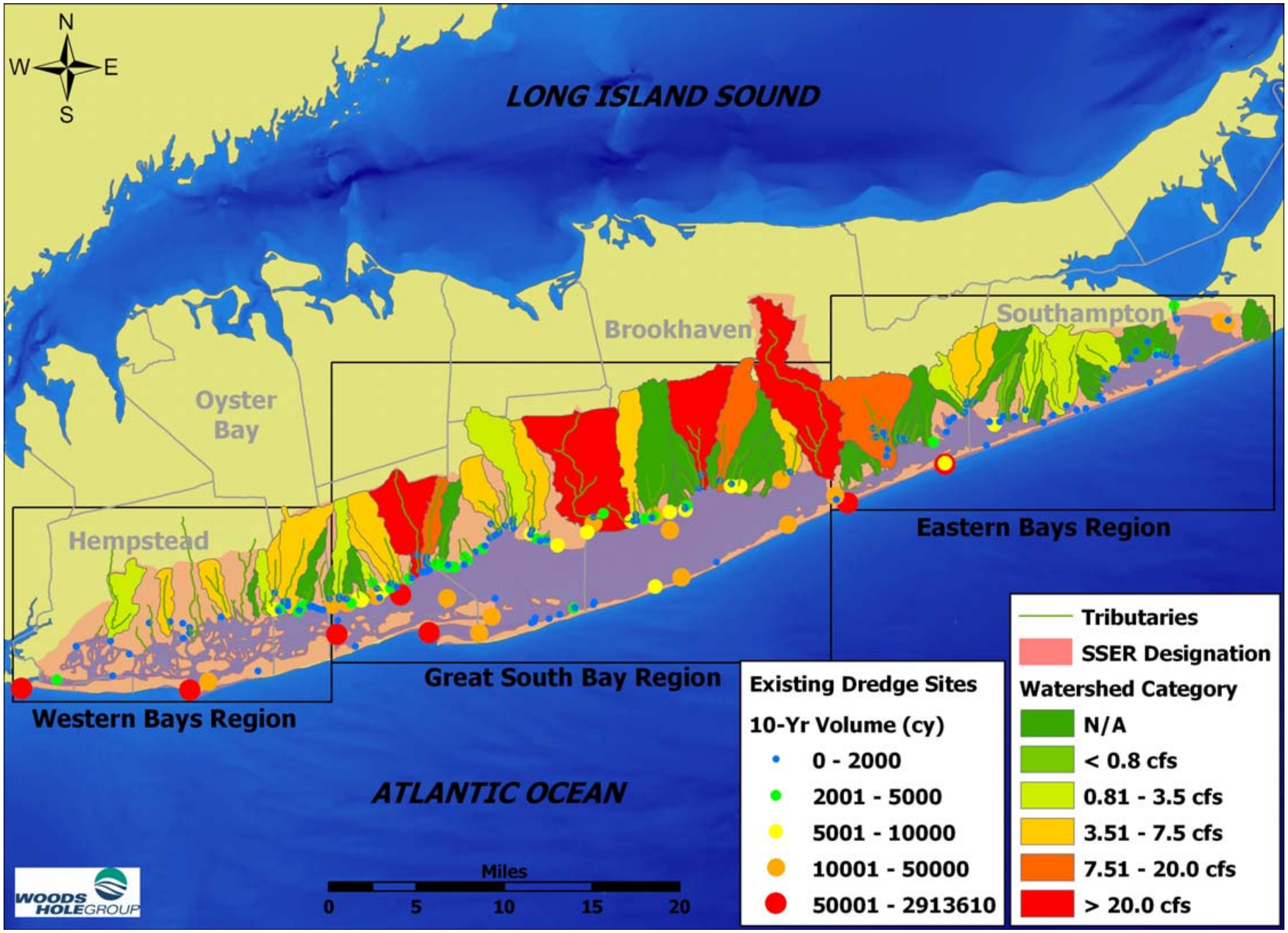

Figure 4. **SSER watershed and tributary stream flow in comparison with estimated 10-yr dredge quantities for existing dredge projects.**

Table 6. Relationship between land use and sediment loading (USGS, 2003).

Land Use Category	Sediment Loading (lbs/inch of rainfall)	Enrichment Ratio
Industrial	16.18	28.53
Commercial/institutional	14.52	25.59
Low-density residential	4.53	7.98
High-density residential	8.17	14.40
Vacant	1.36	2.40
Open land/urban park	1.14	2.00
Highway/arterial road	10.90	19.22
Agriculture	3.40	6.00
Woodland/wetland	0.57	1.00
Railroad	3.68	6.49

Given the heavily developed suburbs of Nassau and western Suffolk County, and the more rural agricultural areas characteristic of eastern Suffolk County, it is likely that significant quantities of material are being transported into the estuary as a result of these watershed development practices. Policies and practices that would tend to restore nearshore and riparian vegetation in the tributaries as well as the bay shorelines would help reduce these sediment inputs (as well as nutrient and contaminant inflows) by filtering surface and groundwater flows (Alexander, 1994).

In an effort to reduce sediment loading caused by watershed development, specific Watershed Management Plans have been developed for Browns River, Green’s Creek, Swan River, and Beaverdam Creek areas. Stormwater retrofit projects and mitigation plans have also been developed for the Towns of Southampton, Islip, Babylon, and Oyster Bay. In addition, the Suffolk County Department of Health Services is currently implementing stormwater management plans in four pilot watersheds on eastern Long Island to address runoff from farms, villages, and commercial properties. Continued work to improve watershed management practices will help to reduce sediment loads to downstream water bodies in the SSER, while also minimizing shoaling rates in channels and basins used for navigation.

3.1.2. Shoreline Erosion

A comprehensive study of shoreline erosion within the SSER has not been performed, and as such quantitative estimates of sediment input from shore-based erosion are not possible. As an alternate more qualitative approach, the extent of natural vs. structured (armored) shoreline within the Reserve has been examined. This approach provides information on the relative potential for sediment loading between the different towns and sub-regions of the SSER.

The methodology included acquisition of a shoreline proxy for the SSER region from NOAA’s Shoreline Website (NOAA, 2009). The NOAA shoreline dataset was derived from NOAA National Ocean Service (NOS) nautical charts, and is available as a medium-resolution digital vector shoreline that is GIS compatible. The tidal datum of the shoreline proxy is mean high water. Standard attribute information included the NOS chart catalog number from which the shorelines were captured, as well as the date of the chart. As part of this project an additional attribute was added to the shoreline shapefile to hold information on the type of shoreline; natural or structured. ArcGIS was then used to display the shoreline proxy over the Spring 2008 digital orthophotography available from the NYS GIS Clearinghouse. The shoreline was broken into segments according to type of shoreline visible on the orthophotogrphy, and assigned the proper shoreline code (Natural, Structured, or Marsh). Google Earth was also used as a tool to identify shoreline type in areas where increased resolution was needed to discern specific coastal features. The following shoreline environments and structures were assigned to the three classifications:

- Natural – beaches, dunes, barrier beaches, coastal bluffs, unprotected upland
- Structured - bulkheads, revetments, jetties, seawalls, retaining walls with minimal beach frontage
- Marsh – marshes

Figure 5 provides a summary graphic of the shoreline classification for the entire SSER region. The distribution of shoreline type is 26% natural, 30% structured, and 44% marsh. The distribution varies significantly between each of the three SSER sub-regions (Figures 5-6). The Western Bays region shows a greater percentage of marsh (67%) than structured (27%) or natural shoreline (6%) areas. In the Eastern Bays region, natural shoreline areas account for 62% of the coast, followed by 30% structured and only 8% marsh areas. The Great South Bay region has nearly equal distributions of natural (35%), structured (35%), and marsh (30%) shorelines. Structured areas are concentrated along the south facing shorelines of the western portion of the Reserve and along the Fire Island communities in the Great South Bay region.

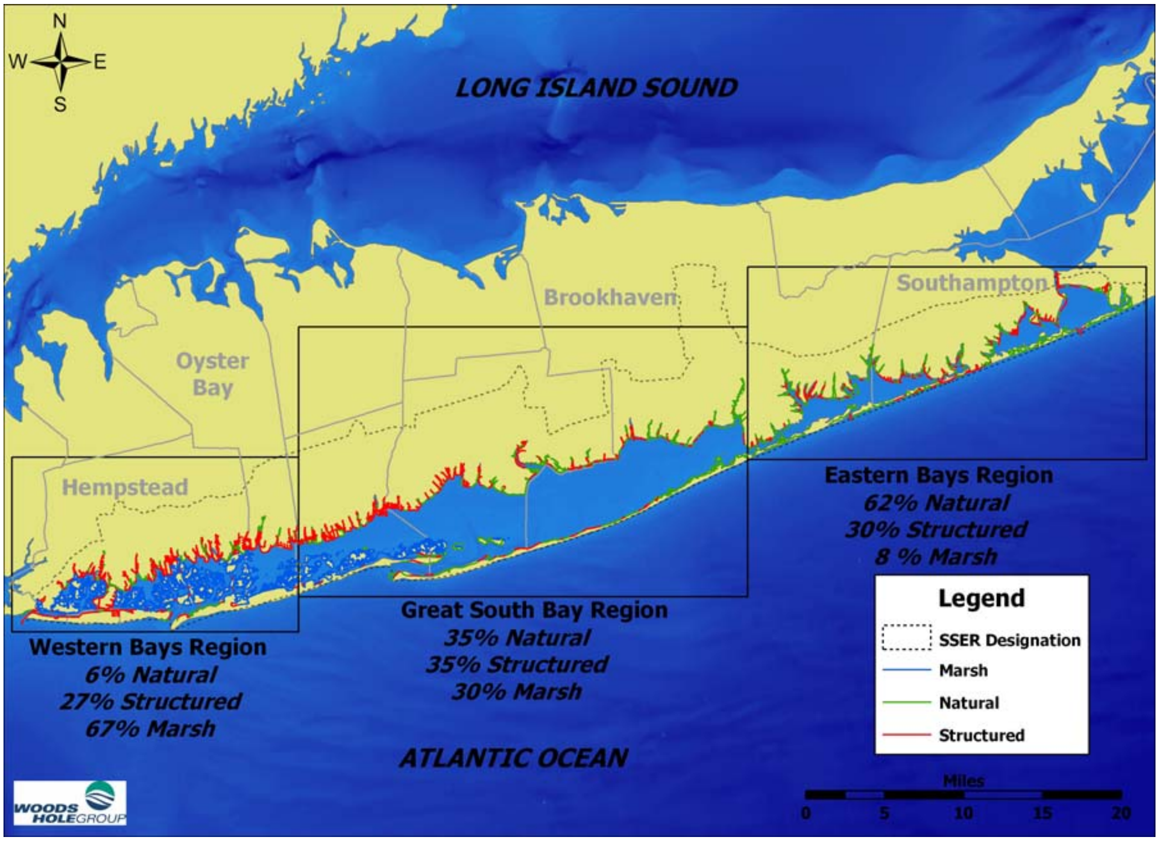

Figure 5. Variation in shoreline type (natural, structured, marsh) within the SSER.

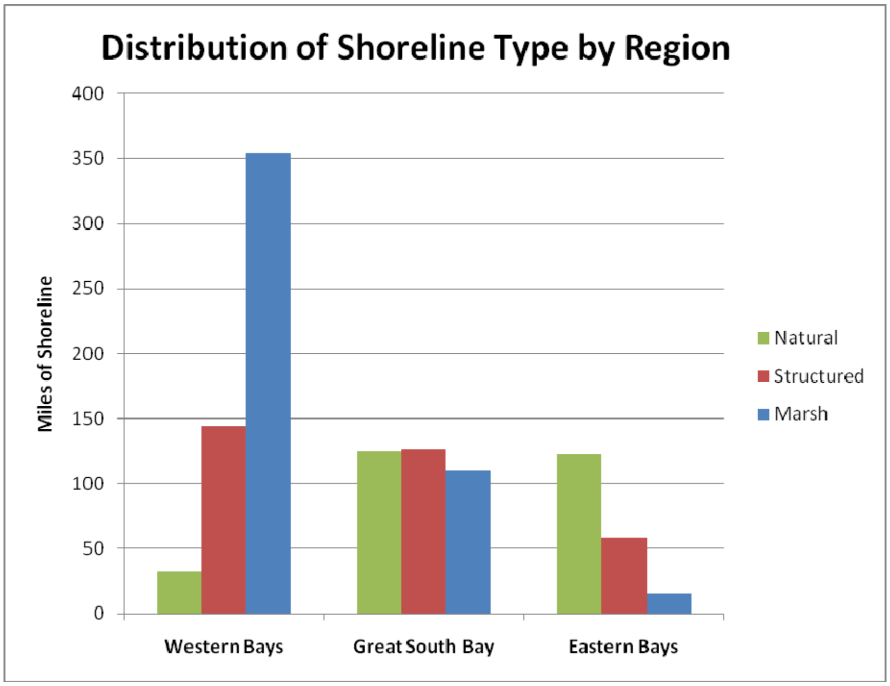

Figure 6. Regional distribution of shoreline type.

The distribution of shoreline type within the six SSER towns is shown in Figure 7. Overall the Town of Hempstead has the greatest number of shoreline miles, with marsh areas accounting for 67% of the town, followed by 26% structured, and only 6% natural. Oyster Bay and Babylon also have high percentages of marsh shoreline at 69% and 59%, respectively. The extent of structured shorelines in the towns of Babylon, Islip, Brookhaven, and Southampton are all relatively similar, averaging just below 50 miles per town. Natural areas are the most common shoreline type in Brookhaven and Southampton, accounting for 77% and 57% of the shoreline in each town respectively.

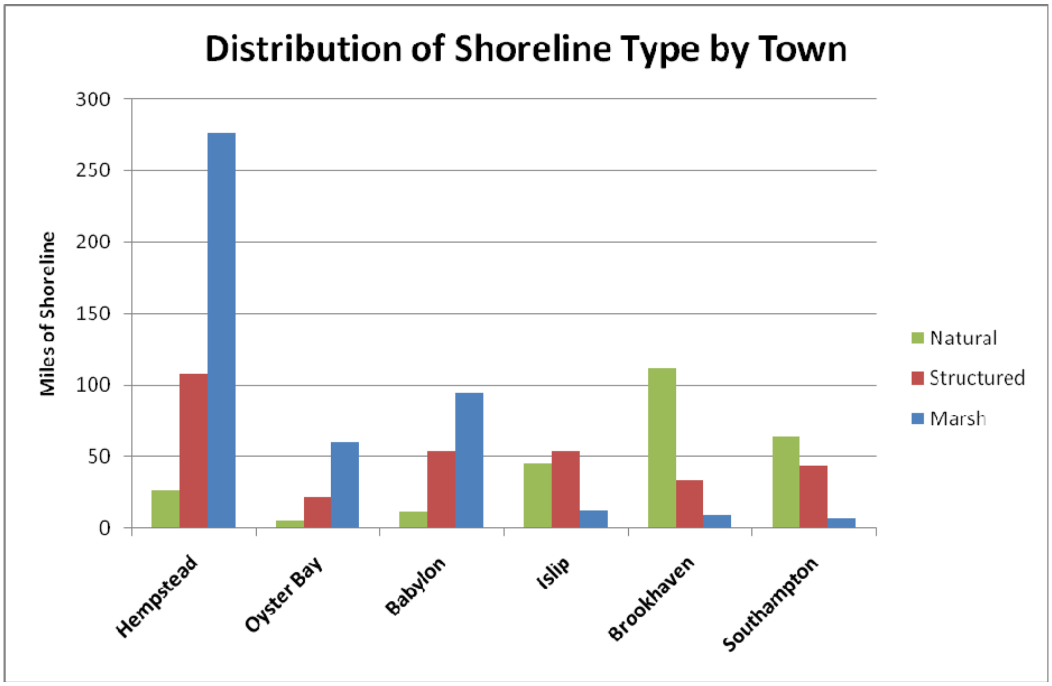

Figure 7. Municipal distribution of shoreline type.

While the shoreline classification analysis does not provide quantitative information on sediment loading to the SSER due to coastal erosion, it does indicate how much of the Reserve shoreline is susceptible to erosion. The greatest contributors are likely the beaches, dunes and coastal bluffs. Since coastal armoring and structured shorelines often exacerbate erosion of nearby natural shorelines, further armoring of natural areas is not necessarily recommended. However, where necessary to protect upland infrastructure, management of eroding estuary shorelines with soft engineering solutions would help minimize sediment contributions to navigation channels and basins.

3.1.3. Tidal Inlets

The five tidal inlets that connect the SSER with the Atlantic Ocean and the south facing, sandy barrier beaches serve as a source of new sediment to the SSER. The smallest contributions of sediment to the Reserve occur at the two western most inlets at East Rockaway and Jones Inlet (Figures 8-9). The geomorphology at these two inlets has formed updrift (easterly) beaches that are offset seaward of beaches on the west sides of the inlets. Although both of the updrift inlet shorelines are stabilized with jetties, much of the westerly moving littoral drift is transported offshore or past the inlet channel, with limited transport into the inlet. A study of Jones Inlet estimates an annual channel dredging rate of 200,000 cy/yr, with 120,000 cy/yr entering the channel from the east, and 80,000 cy/yr entering from the west (Moffatt and Nichol, 1998). Additionally, the interior portions of these two inlets lead to the extensive marsh and tidal creek system of Hempstead Bay. The presence of the marsh results in slightly lower tidal prisms moving through the inlets, and thus less chance to form flood tidal deltas in the back barrier areas just inside the tidal inlets. As such, the western two inlets provide significantly less sediment to waters of the SSER.

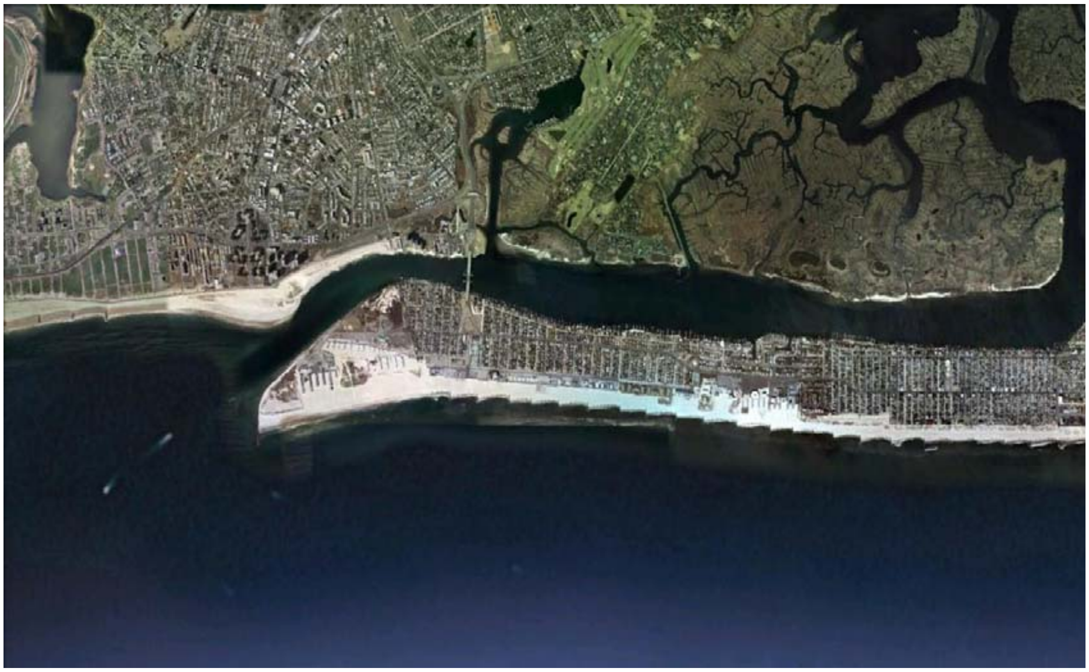

Figure 8. Aerial photograph of East Rockaway inlet showing updrift offset beach and little formation of a flood-tidal delta.

Figure 9. Aerial photograph of Jones inlet showing updrift offset beach and small flood shoals along the flanks of the back barrier marsh islands.

Sediment contributions to the SSER are significantly greater at the three easterly tidal inlets located at Fire Island, Moriches, and Shinnecock (Figures 10-12). All three of these inlets have formed extensive flood-tidal deltas and shoals landward of the inlet throat, where tidal current velocities diminish due to an increase in channel dimensions and bay morphology. Sediment forming these shoals is transported by littoral processes from the seaward side of the barrier, into the inlet channel, and then deposited onto the flood shoals by incoming tidal currents. This sediment source to the SSER is composed primarily of sand sized material. Increased channel and basin shoaling from inlet sedimentation occurs most often at the navigation projects located in the immediate vicinity of the tidal inlets.

3.1.4. Barrier Beach Overwash

Barrier beach overwash acts as a source of new sediment to the SSER when sediment is transported across the barrier islands and deposited in the shallow back barrier areas. This process takes place during storms and periods of elevated water level, as waves erode low spots in the barrier beach, pushing sand across the barrier to form overwash fans. Overwash is a source of sand to the SSER primarily in areas east of Fire Island Inlet, where the barrier is narrower and is not backed by wide fringing marsh. Increased channel and basin shoaling from overwash processes occurs most often at the navigation projects located on the back side of the barrier and east of Fire Island Inlet. In order to conserve the barrier building functions of these wash over deposits, navigation management actions should be carefully considered (channel location, dredging depth and placement locations, etc.).

Figure 10. Aerial photograph of Fire Island inlet showing updrift offset beach and extensive flood shoal formation in the back barrier region.

Figure 11. Aerial photograph of Moriches inlet showing large flood tidal delta in the back barrier region.

Figure 12. Aerial photograph of Shinnecock inlet showing large flood tidal delta in the back barrier region.

3.2 CHANNEL SHOALING PROCESSES

As seen from the previous discussion, a variety of processes are responsible for channel shoaling and infilling at the SSER navigation projects. In an effort to provide targeted and useful recommendations for improved sediment management, an evaluation of dominant channel shoaling processes was performed for each of the 319 existing dredging projects in the SSER DMMP database (Report 1). The dredge project locations were viewed in Google Earth and assigned anywhere from 1 to 3 codes corresponding to the primary, secondary, and tertiary shoaling process. A total of six codes were defined as follows:

- Riverine processes (R) – Shoaling caused by fluvial processes in rivers and major creeks. All projects located within estuarine portions of the SSER tributaries were assigned a riverine code.

- Upland runoff (U) – Shoaling caused by surface runoff from pervious and impervious upland areas. Most projects located adjacent to heavily developed upland areas, or those where sedimentation from upland runoff was clearly visible in the aerial photography, were assigned an upland runoff code.

- Marsh processes (M) – Shoaling caused by sediment derived from nearby salt marsh systems. Projects located in heavily developed areas in close proximity to large salt marsh systems, where others sources of sediment are not readily available, were assigned a marsh code.

- Hydrodynamics (H) – Shoaling caused by tidal circulation and wave-induced transport over shallow shoal areas. Projects located in broad open waterways, away from the influence of shoreline processes were assigned a hydrodynamics code.

- Longshore transport (L) – Shoaling caused by longshore transport into a navigation channel or basin from the adjacent shorelines. Projects located adjacent to natural (unstructured) sandy shorelines, where spit growth, jetty fillets, or shoal patterns suggested significant littoral transport were assigned a longshore transport code.

- Inlet processes (I) – Shoaling caused by inlet channel migration, flood- or ebb-tidal delta formation, or tidal currents associated with inlets. All of the SSER projects located in proximity to the five ocean tidal inlets were assigned an inlet code. In addition, projects located near the smaller, unstructured tidal inlets along the northeast shoreline of the SSER were assigned an inlet code.

Results from the channel shoaling evaluation are provided in Appendix A and summarized in figures 13-14. The data show that the single largest cause for shoaling at the existing SSER dredge projects is from upland runoff processes. These account for nearly 45% of all projects in the Reserve. Following this, hydrodynamic, longshore transport, and riverine processes are the next greatest causes for shoaling, impacting 18%, 15%, and 12% of projects, respectively. Channel infilling from marsh and tidal inlet processes account for the smallest number of projects, accounting for only 8% and 3% of all existing SSER dredge projects.

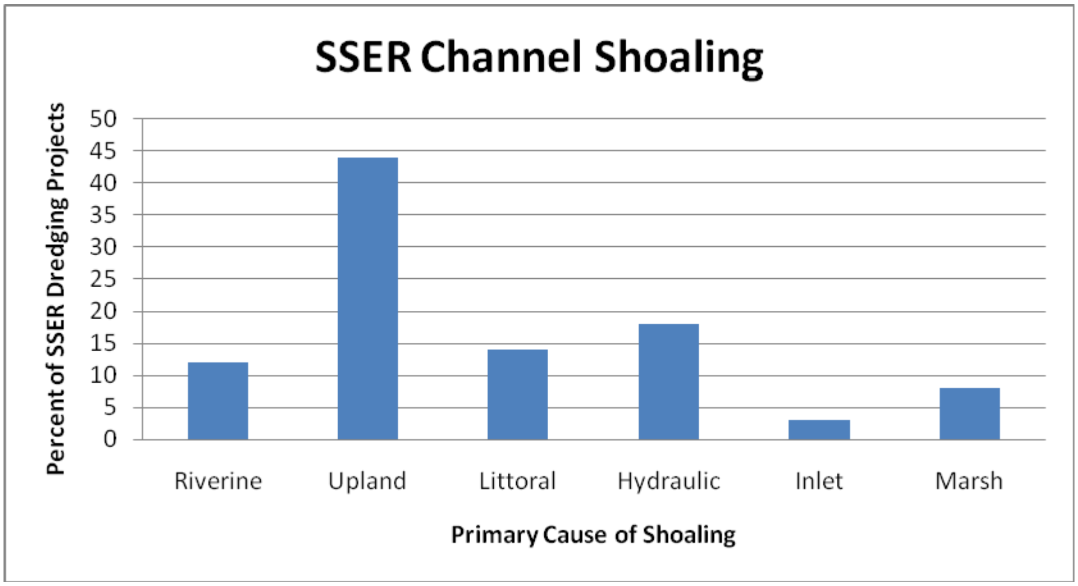

Figure 13. Primary causes of channel and basin shoaling for existing dredge projects in the SSER.

The spatial distribution of channel shoaling processes in the SSER is summarized in Figure 14. The primary causes for channel shoaling are grouped according to location in one of the three Reserve sub-regions (Western Bays, Great South Bay, and Eastern Bays), and percentages of projects affected by the different shoaling processes are shown as a function of the total number of projects within each sub-region. The data show that channel shoaling in the Western Bays region is most heavily influenced by marsh erosion processes, with 42% of projects impacted by this process. Within the Great South Bay region, upland processes are responsible for the largest number of dredging projects (54%), followed by hydrodynamic and riverine processes. Similarly, the Eastern Bays region shows the largest number of projects influenced by upland processes (43%), followed by hydraulic, littoral and riverine.

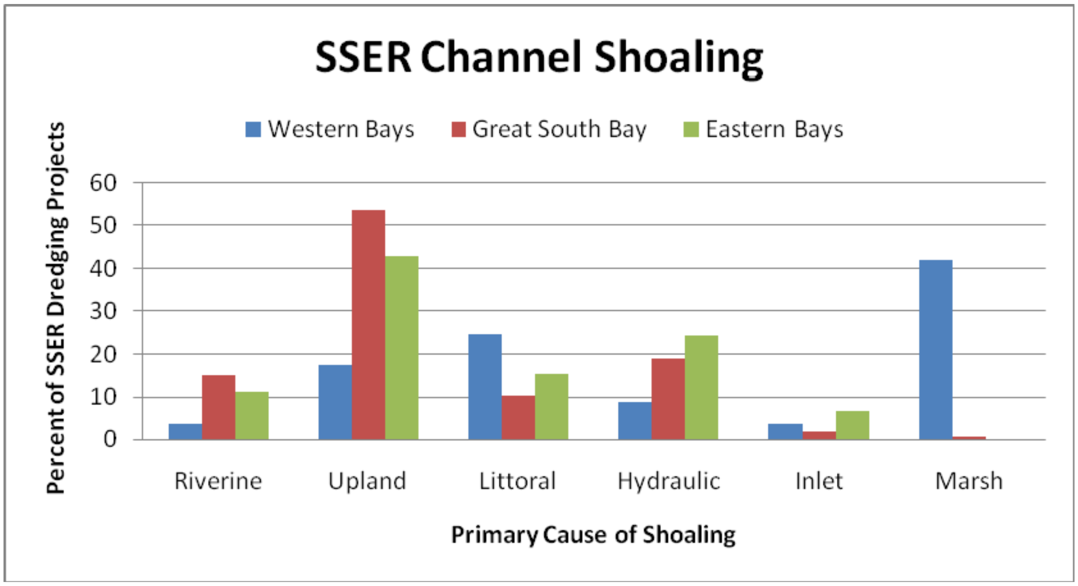

Figure 14. Primary causes of channel and basin shoaling for existing dredge projects in the SSER as a function of location in the three SSER sub-regions.

4.0 FINDINGS ON SEDIMENTATION PROCESSES AND EXISTING SEDIMENT MANAGEMENT IN THE SOUTH SHORE ESTUARY RESERVE

Information gathered during this *Investigation of Opportunities for Improved Sediment Management* has been used to develop the following findings:

- Among the factors responsible for shoaling in SSER waterways, runoff from upland sources appears to impact the greatest number of projects (45%). Other important sources of sediment include redistribution of sediments through tidal circulation, rivers, and littoral drift.

- Rivers and streams are an important source of sediment to waters of the SSER. Tributaries with the greatest annual stream flow, and likely the greatest sediment contributions, are located in the Great South Bay sub-region. The Western and Eastern Bays sub-regions also contain tributaries that contribute sediment to the waterways; however the contributions are lower than in the Great South Bay sub-region.

- Watershed development patterns in the SSER include urban and agricultural areas that typically produce higher sediment loadings, as compared with more natural woodland and wetland land use categories. A number of SSER communities have developed Watershed Management Plans to address sediment and pollutant loading to the estuary.

- Despite extensive shoreline armoring throughout the SSER, approximately 26% of the coastline remains in a natural condition, 44% is marsh, and 30% is structured. This suggests that shoreline erosion is a significant potential source of sediment affecting the navigable channels and basins of the SSER.

- Sediment contributions to the SSER from the ocean tidal inlets are greatest at Fire Island, Moriches, and Shinnecock Inlets, where large flood tidal deltas continue to develop in the back barrier regions.

- The process of barrier beach overwash also serves as a source of sediment to the Reserve during storms when water levels are elevated. This process is most important in the eastern half of the SSER, to the east of Fire Island Inlet.

- Shoaling within SSER channels and basins can be attributed to six primary processes: upland runoff, hydrodynamics, longshore transport, riverine loading, inlet processes and marsh erosion. Upland runoff is the primary shoaling process for nearly 45% of existing dredging projects in the SSER. Hydrodynamic, littoral, and riverine processes impact another 45% of the projects. Regionally, marsh processes are the most important shoaling mechanism in the Western Bays sub-region, while upland runoff is the primary factor in the Great South Bay and Eastern Bays sub-regions.

- Existing structural controls within the SSER to manage channel shoaling and infilling are mostly effective. A few project areas where existing structures allow sand to leak into the adjacent channel could benefit from repairs. New structural controls are not recommended at this time.

- Suffolk County and the Town of Hempstead both operate effective dredging programs utilizing County/municipal owned equipment and resources. These agencies are responsible for the permitting and construction of dredging projects within their jurisdiction considered to be in the public interest. All federal and state projects, as well as those municipal projects in the Town of Oyster Bay, and all private projects are performed by private contractors.

- With the exception of dredging at the five ocean tidal inlets, all dredging work is performed using small hydraulic and/or mechanical dredging equipment.

- Most dredging projects generating sand make use of nearby beach nourishment opportunities for final placement. Most dredging projects generating fine-grained material, not suitable for beach nourishment, utilize diked basins for dewatering and final placement. Very few projects have taken advantage of newer technologies, such as dewatering using geotextiles or polymers. Also, applications for beneficial reuse have been limited in the SSER.

- The number of existing dewatering and long-term placement sites adjacent to the coastline is limited. Existing data on the capacity of these sites is not readily available; however, without a long-range plan for the management of these sites, their use will be limited in the future.

5.0 RECOMMENDATIONS

Recommendations provided below have been developed using information generated as part of this *Investigation of Opportunities for Improved Sediment Management*. Topic specific recommendations are developed within each section of the dredge materials management study.

- Seek a means to continue to refine and update annual shoaling rates computed for SSER dredging projects as part of the *Assessment of Current Dredging Conditions and Future Needs* report. Post-dredge records should be collected from project applicants describing volume removed, as well as dates and locations of dredging and placement sites. Utilize the post-dredge information to refine and update shoaling rates on an annual basis.

- Continue to implement recommendations of the existing Watershed Management Plans. Integrate findings from this study in new watershed management plans or amendments to existing plans for the purpose of managing sediment inputs, fostering sustainable shoreline treatments and providing optimal navigation services. Seek funding for construction of watershed improvement projects and for the development of new Watershed Management Plans where they do not exist.

- Identify and remediate direct discharges to tributaries and waters of the SSER.

- Seek opportunities to restore nearshore and riparian buffers as a means of reducing sediment, nutrient, and contaminant inflows to SSER tributaries and channels.

- Perform an analysis of shoreline change within the SSER to identify specific areas of increased coastal erosion. Evaluate the need for structural solutions in areas of high erosion to minimize sediment loading. Conversely, evaluate the feasibility of using eroding shoreline areas as beach nourishment sites, provided measures can be taken to avoid adverse impacts to nearby navigation projects.

- Replace dilapidated engineering structures that fail to protect navigation channels and basins from shoaling caused by longshore transport. Prioritize projects using existing shoaling rate data. Emphasize use of non-structural management measures where feasible and soft structural measures before resorting to structural measures.

- Consider the use of a numerical tidal flushing/circulation modeling to optimize dredge designs at problem sites with rapid shoaling rates.

- Evaluate the feasibility of purchasing and/or sharing Reserve-wide dredging resources.

- Quantify the capacity of existing SSER upland dewatering and placement sites. Evaluate opportunities to rehabilitate existing sites for additional placements, or alternative reuse options to divert suitable material to appropriate uses. Utilize this information in conjunction with the dredging needs data to project lifespans for the dewatering/placement sites.

- Quantify needs for additional sediment placement/reuse capacity by region and by sediment type. Design and permit additional dewatering/placement sites in each sub-region of the SSER as needed.

- Evaluate the feasibility of designating 1-2 Reserve-wide habitat restoration sites for use as beneficial reuse sites.

6.0 REFERENCES

Alexander, S.V. 1994. Riparian restoration through integrated resource management. Pages 232-239. In: Riparian Ecosystems in the Humid U.S. Functions, Values, and Management. Proceedings of a conference March 15-18, 1993. Atlanta, Ga. National Association of Conservation Districts. 445 pages.

Dreher, D.W., and T.H. Price. 1994. Reducing the Impacts of Urban Runoff: The Advantages of Alternative Site Design Approaches. Northeastern Illinois Planning Commission, Chicago, IL.

Moffatt and Nichol Engineers. 1998. Jones Inlet, Long Island New York, Sand Bypassing Plan. Final Report to the New York State Department of State. 50 pp.

NOAA, “NOAA Medium Resolution Shoreline.” NOAA Shoreline Website. Jul. 2, 2008. Web. 10 Dec. 2009. http://shoreline.noaa.gov/data/datasheets/medres.html.

Rosati, J.D. 2005. Coastal Inlet Navigation Channel Shoaling with Deepening and Widening. US Army Corps of Engineers, ERDC/CHL CHETN-IV-64, 11 pp.

Trawle, M. J. 1981. “Effects of depth on dredging frequency, Report 2: Methods of estuarine shoaling analysis,” Technical Report H-78-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

USGS. 2010. USGS Water Data for USA, http://waterdata.usgs.gov/nwis, accessed on January 11, 2010.

USGS. 2003. A Summary Report of Sediment Processes in Chesapeake Bay and Watershed. Eds. M. Langland and T. Cronin, Water Resources Investigations Report 03-4123. pp. 109.