South Shore Estuary Reserve
Technical Report Series

Coordinated Water Resources Monitoring Strategy for the South Shore Estuary Reserve

January, 2000

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under contract with the New York State Department of State

Acknowledgements

This report is one in a series of technical reports prepared by the Department of State or its consultants as baseline information and considered by the South Shore Estuary Reserve Council during preparation of a comprehensive management plan for the Reserve. Members of the Technical Advisory Committee and Citizens Advisory Committee (see end of report) contributed information and insights throughout the preparation of these reports.

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The South Shore Estuary Reserve Council acknowledges the dedication of former Secretary of State Alexander “Sandy” Treadwell over the last five years to bring the Plan to fruition.

Preparation of this plan was financially aided by: the New York State Environmental Protection Fund; New York State legislative member initiatives; and a grant from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of Ocean and Coastal Resource Management, under the Coastal Zone Management Act of 1972, as amended.

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Chapter

1

Introduction

Chapter 1: Introduction

A. Guiding Principles

This Coordinated Monitoring Strategy (CMS) is an integral component of the overall Comprehensive Management Plan for the South Shore Estuary Reserve (SSER). The Management Plan presents goals and objectives for the estuarine system; the Monitoring Strategy describes which physical, chemical, and biological parameters should be measured to assess progress towards achieving water quality goals. Information resulting from a well-designed water quality monitoring program could also be used to evaluate the effectiveness of specific actions and define the need for further actions.

The recommended Monitoring Strategy takes an ecosystem approach to water quality monitoring. Water quality in the SSER is the result of complex interactions among the ocean, the estuary, and the land. Land and water-based activities affect water quality and habitat. Physical factors such as hydrologic inflows and circulation are important forcing functions of the estuarine system, and are closely coupled to chemical water quality. The biological community both responds to and alters the physical and chemical environment. Consequently, the monitoring strategy includes elements to track these functional relationships.

Six principles guided our development of the Coordinated Monitoring Strategy for the SSER.

(*1) Turn Data into Information, then into Strategic Information.*

This evolution is a central attribute of any effective monitoring program. Data are the results of the individual measurements of the physical, chemical, and biological attributes of the system. For example, results of biweekly monitoring of water temperature, salinity, and chlorophyll *a* in Great South Bay are data.

Data become information when they are compiled and used to test a conceptual framework of the nature of the aquatic system. Temperature and salinity data can help infer mixing and circulation patterns; chlorophyll data indicate the abundance of phytoplankton. Measured results can be compared to a desired state of the ecosystem. For those parameters with criteria or standards, comparison between measured results (data) and the criteria or standards becomes information.

Information becomes strategic information when it provides a basis for informed decision making. Continuing the temperature, salinity and chlorophyll *a* example, monitoring results might be used to evaluate trends in groundwater contribution to the hydrologic budget, or to identify trigger conditions for algal blooms.

In order for data gathered during a monitoring program to support management decisions, the water quality monitoring program must be thought of as serving a series of testable hypotheses relevant to specific objectives for the resource. For example, if a management objective is to increase the abundance of certain types of submerged aquatic vegetation in Great South Bay, the monitoring program must be designed to provide strategic information regarding the effectiveness of actions taken to bring about this increase. The spatial and temporal frequency of measurements must be adequate, given the inherent variability in this parameter, to distinguish real trends from noise.

Mathematical models can be valuable tools for linking data and information. For many estuary programs, hydrodynamic and water quality models have been developed to provide a quantitative framework for conceptualizing the system and predicting the effectiveness of control actions. Just as in a monitoring program, it is important to carefully define the objectives and potential applications of models.

(2) Maximize utility of existing programs

Several agencies monitor water quality conditions in the SSER. There is a great deal of variability in the scope and intensity of these existing programs. We considered maintaining the integrity of existing programs among the guiding principles because of the importance of baseline information. Whenever possible, the locations and parameters used in the existing programs should be retained. This will allow the data to be used for trend analysis or to test the effectiveness of specific control actions using a before and after approach.

Historical data can also be factored into the design of the Coordinated Monitoring Strategy. The measured spatial and temporal variability of water quality parameters can provide a quantitative basis for defining the optimal sampling frequency to detect changes of a defined magnitude. For example, if the management goal to "Protect and restore the estuarine ecosystem" includes as an objective to achieve target concentrations of dissolved inorganic nitrogen of 0.14 mg/l, existing monitoring data can be used as a basis to estimate the amount of reduction needed to achieve this objective. Given the magnitude of reduction needed, the historical data can be used to estimate the number of years of monitoring required (at alternate frequencies) to reliably detect a change of this magnitude.

(3) *Incorporate a quality assurance/quality control (QA/QC) program to document data quality and estimate sampling and analytical sources of variability.*

A QA/QC program is a systematic program of planning for and documenting the integrity of the procedures used to collect and analyze samples. It can be expanded to assess the processes used for data management as well. With multiple agencies involved in monitoring, a QA/QC program will enable managers to assess comparability of data sets and determine the extent to which system wide comparisons can be drawn. When volunteer monitoring programs include a formal QA/QC program, the utility of the information generated is greatly enhanced.

A program of replicate samples, split samples, and audit samples would help identify sources of variability in data, and provide feedback to the participating agencies regarding the need to revise their procedures. For trend analysis to be performed, it is essential to be able to identify and quantify sources of variability in the data. The CMS recommends that participating laboratories adopt standard methods for analysis, document their procedures, and improve communication.

(4) Remain flexible to respond to new information

The Monitoring Strategy outlined in this document reflects current management objectives, water quality conditions, and availability of quantitative tools. All three elements are subject to change. The CMS should be considered a "living document" and incorporate provisions for regular review and update based on new information.

For example, the CMS recommends continuing the existing sampling network in the embayments and adding four new stations. We evaluated the sampling network considering (among other factors) compatibility with hydrodynamic and water quality modeling. If the decision is made to develop a computer model, the number and location of sampling points should be reevaluated with respect to the complexity of the framework selected.

The CMS must also recognize the potential for new water quality issues to arise. An example of this is the recent concern over the presence and significance of *Pfiesteria* in the SSER. The Monitoring Strategy must continue to reflect changes in regulatory and scientific information regarding relevant water quality indicators for the estuary.

(5) Include "capstone indicators," organisms that, by their presence or absence, provide information regarding the ecological status of the community.

The SSER is a productive and diverse ecosystem. According to the National Estuarine Eutrophication Assessment (NOAA, draft June 1999), Great South Bay is ranked "high" for eutrophic conditions. Contributing factors to this listing included high levels of chlorophyll *a* (a primary symptom) and moderate levels of submerged aquatic vegetation (SAV) loss and nuisance/toxic algal blooms (secondary symptoms).

The communities of plants and animals present in the loosely coupled bays that comprise the SSER are adapted to ambient conditions of light, salinity, nutrients, temperature, substrate etc. While it is essential to monitor these physical and chemical conditions, the structure and biomass of the biological communities can provide information as well. The biological community integrates the effects of different pollutant stressors and thus provides a holistic measure of their aggregate effect.

In addition to characterizing the biological community, the presence and abundance of single populations can provide important information regarding overall water quality conditions. Key indicator species may be of high value as an economic resource, such as the hard clam (*Mercenaria mercenaria*) or high importance for habitat value such as the SAV eelgrass (*Zostera marina*). Other criteria for indicator species include their relative susceptibility or tolerance to adverse water quality conditions, their ease in measurement, and whether density of the organism is correlated with the extent of contamination.

The presence of nuisance or toxic species of phytoplankton is another capstone indicator providing information regarding ecological status of SSER embayments. Monitoring presence and abundance of *Aureococcus anophagefferens*, brown tide, is an element of the recommended CMS. Health of individuals is another measure of ecosystem integrity. Disease, parasites, and accumulation of heavy metals and organic compounds are related to water quality conditions.

(6) Strive to be cost effective.

Monitoring is expensive. At present, significant resources are dedicated to various monitoring efforts in the SSER. A coordinated strategy will help eliminate any redundancies and increase the value of the overall investment in monitoring. The goal is synergism; in a

well designed program, the value of each individual monitoring component is enhanced by being part of a larger whole.

B. Approach

The Monitoring Strategy outlined in this document was developed through an interactive process that began with a workshop to elicit specific goals and objectives for the estuarine resource. The findings of the workshop are described in more detail in Chapter 2. Following the workshop, we completed a series of detailed interviews with representatives of agencies involved in aspects of water quality monitoring or resource management. Topics covered during the interviews included objectives and details of any ongoing monitoring program. We also asked open-ended questions regarding the water quality and ecological status of the SSER and perceived challenges to effective resource management. We compiled the information into a database with detailed listings of parameters, frequency, spatial locations, depths, analytical methods, and data handling techniques. This database was used to help identify gaps and redundancies in monitoring programs.

From the workshop and interviews, we developed a list of issues related to the broad objectives of ecological integrity (chemical, physical and biological attributes) of the Reserve. The list includes some elements specific to the SSER and other elements characteristic of estuaries in general. We then focused this list of issues into a series of specific hypotheses that could be tested by means of water quality monitoring.

The next step was a gap analysis. We examined the effectiveness of the existing programs to test the specific hypotheses and identified areas where additional monitoring would be required. Finally, we developed the comprehensive water resources monitoring strategy needed to collect data to test the management hypotheses.

The proposed monitoring strategy is presented in a tiered approach; a baseline program is proposed as Tier 1, with optional additions of specific programs as need arises or resources become available.

Chapter

2

Management Issues

Chapter 2: Management Issues

A. Goals and Objectives for the South Shore Estuary Reserve

According to the Long Island South Shore Estuary Reserve Interim Report (March 1998), the South Shore Estuary Reserve Council has adopted five overall goals for the resource:

- Enhance use and enjoyment
- Maintain and improve water quality
- Protect and restore estuarine ecosystem
- Revitalize shellfish and finfish resources
- Promote public education and encourage citizen stewardship

These goals reflect both human and ecologic al perspectives; human use and enjoyment of the estuary are balanced with maintenance and enhancement of its chemical, physical, and biological quality.

The Water Resources Monitoring Work Group focused these overall goals for the estuary into six objectives:

- Characterize conditions needed to achieve and maintain water quality necessary for priority uses and improve the health of the ecosystem.
- Sufficiently reduce inadequately treated point sources of pollution affecting ground and surface waters.
- Sufficiently reduce nonpoint sources of pollution.
- Sufficiently reduce toxic discharges affecting the estuary's waters.
- Eliminate pollution discharge from vessels.
- Provide for adequate water exchange between the bays and the ocean.

These six objectives reflect current water quality and ecological conditions in the SSER along with the Work Group's assessment of which factors are most significant in causing or contributing to impairments. We note that only qualitative linkages between inputs and water quality are stated in the objectives; inputs of point and nonpoint pollutants are to be "sufficiently reduced" to meet water quality for priority uses and improve overall ecosystem health. These objectives also presumably reflect the Work Group's assessment of the state of the information available to characterize the sources and fate of materials in the series of embayments that comprise the SSER.

As the first step in developing the Coordinated Monitoring Strategy, EcoLogic led a workshop to elicit additional specific objectives for the SSER. Participants were asked to articulate their vision for the resource by imagining the reserve 20 years after successful implementation of the Comprehensive Conservation and Management Plan. Responses focused on four inter-rela ted areas:

(1) *Use attainment*
(Human uses of the SSER are achieved, e.g. swimming, shellfishing, recreational access, safe levels of contaminant burden in fishes.)

(2) *Elimination or controls on pollutant inputs that contribute to water quality conditions that impair SSER waters for their desirable use*

(Stormwater runoff, relocation of sewage outfalls, controls on discharges from vessels.)

(3) *Restoration or enhancement of the natural ecosystem*
(Increased diversity, return of endangered species, elimination of algal blooms, habitat restoration for native species assemblage, "pre-development" streamflow regime.)

(4) *Implementation of effective tools for managing the SSER*
(Education, stewardship, water quality model, regulations, enhanced understanding of linkages between the natural and human environments.)

We concluded from this workshop that an effective Coordinated Monitoring Strategy would provide data and information regarding the magnitude and relative significance of contaminant inputs, status of water quality with respect to standards, criteria and guidance values associated with human use attainment, and metrics of ecosystem health. Specific comments made during the March 1, 1999 workshop are appended. The relationship between the SSER and the management objectives is illustrated in Figure 2-1.

B. Overview of Management Issues Relevant to Other Estuary Programs

The effort to develop a Comprehensive Management Plan for the SSER is in many ways parallel to efforts underway elsewhere in the country. Through the National Estuary Program, the U.S. Environmental Protection Agency Office of Water is fostering development of Comprehensive Conservation and Management Plans (CCMP) for estuaries of special concern. The National Estuary Program is providing technical and funding support to partnerships of state, regional, and local agencies to characterize existing conditions and define priority actions for improvement. Once a CCMP for an estuary is in place, additional funds might be available for implementation and monitoring.

While each estuary is unique, water quality and biological habitat issues tend to be relatively consistent. We include these issues to provide context for the activities underway on the SSER. Point and nonpoint sources of nutrients, sediment, and pathogens have degraded water quality and aquatic habitat. In many estuaries toxic substances are a documented problem as well. Public access to shorelines may be restricted. Based on detailed findings from over 20 sites in the National Estuary Program, management issues tend to fall in the following categories.

(1) Nitrogen Loading, Eutrophication, and Hypoxia

Primary productivity in most estuarine ecosystems is limited by nitrogen (N), and excessive N loading stimulates algal growth. This process is called eutrophication. Particularly in embayments with slow flushing rates, algal abundance can increase to levels that reduce light penetration and limit habitat for submerged aquatic vegetation. Excessive growth of algae leads to degraded water quality and associated impairments of estuarine resources for human use.

In estuaries with natural stratification (warmer or fresh water floats on top of cooler or saltier water) algal cells that have proliferated with the abundant supply of N settle into the bottom layer of the estuary where they are decomposed. Because the lower waters are isolated from the atmosphere during stratification, oxygen used in decomposition is not replenished through atmospheric exchange. Respiration of the aquatic community and decomposition of organic material in sediments also deplete oxygen. Hypoxia (low dissolved oxygen concentration) develops when dissolved oxygen (DO) is depleted at a faster rate than it is replenished. In some water bodies diurnal fluctuations in DO levels are pronounced; nighttime respiration of algae and other aquatic life consumes DO at a faster rate than it is replenished through atmospheric exchange or mixing.

Hypoxia can have significant adverse ecological effects. Low levels of DO reduce abundance and diversity of adult finfish, reduce growth rate of early life stages of many aquatic organisms, kill non-motile organisms, and reduce the resistance of many animals to disease.

(2) Pathogens and indicators

Microbiological pathogens such as bacteria, viruses, and protozoa originate from untreated or inadequately treated human sewage and wild and domestic animal waste. Pathogenic microorganisms enter estuaries from point and nonpoint discharges. Human exposure to pathogens can occur from direct contact with or ingestion of contaminated waters. In addition, human exposure can occur from eating raw or partially cooked shellfish harvested from contaminated waters. Pathogen contamination results in restricted resource use by humans. Bathing beaches and productive shellfish beds are closed due to pathogen contamination.

The potential presence and abundance of pathogenic microorganisms is typically assayed using indicator organisms such as coliform or streptococcal bacteria. Indicator organisms are easily measured by standardized protocols and their presence and abundance are correlated to the presence and abundance of pathogens. Ideally, the dieoff rate of indicator organisms is slower than the dieoff rate of the pathogens themselves (that is, the indicator organisms would be present at least as long as the pathogens).

(3) Toxic substances

Toxic substances enter the Nation's estuaries through point and nonpoint sources. Once in the estuary, many toxic substances tend to remain associated with the particulate or sediment phase and accumulate in the system. The ecological effects of a particular toxic chemical vary with its solubility, affinity for lipids, toxicity, and persistence in the estuarine environment.

(4) Land use and development

In many regions intense development along shorelines and within watersheds has significantly altered the land and degraded the quality of water flowing through it. Water quality protection has not been a central tenet of land use policies, and cumulative or downstream impacts of development on water resources have not typically been considered. Significant adverse impacts result from intense development that is not mitigated by water quality and quantity considerations.

Development affects water quality through point and nonpoint discharges of nutrients, sediment, and other chemicals. Point sources are identifiable discharges to surface water or groundwater such as treated effluent from a wastewater treatment plant. Nonpoint sources refer to diffuse sources not traced to a single point or pipe; examples of nonpoint sources include runoff from urban or agricultural land.

Development has also dramatically reduced the extent of natural habitat, particularly wetlands. Natural wetland functions such as filtering sediment and nutrients and moderating hydrologic peaks have been lost. There are adverse ecological impacts of wetland loss and habitat degradation. Urban and suburban development has also restricted public access to the resource.

Agricultural land uses have the potential to adversely impact water quality as well. Nutrients such as nitrogen and phosphorus applied to cropland can be lost to groundwater and surface water. Pesticides can infiltrate to groundwater and wash into streams.

(5) Invasive and Exotic species

Invasive and exotic species are an issue in many of the estuaries included in EPA's National Estuary Program and NOAA's National Estuarine Research Reserve system. Exotic wetland species and aquatic plants are highly visible examples of introduced species. Zebra mussels and nonnative fishes are significant problems in several areas. Estuaries in Louisiana and the Gulf Coast are attempting to manage the nuisance mammalian species Nutria by encouraging development of a fur and tanning industry.

(6) Alteration of natural flow regimes

Restoration and maintenance of fresh water inflows is a major challenge to many of the Nation's estuaries. Urbanization of watersheds and diversion of wastewater effluent have reduced freshwater inflows and altered salinity regime, which affects habitat for estuarine biota. The problem is particularly acute in water short regions such as Corpus Christi Bay, San Francisco Bay and Tampa Bay.

(7) Declines in fish and wildlife populations

Fish and wildlife populations respond to all the water quality and habitat issues discussed above. In addition, harvesting pressure affects the populations.

C. Summary of Management Issues Specific to the SSER

The series of interconnected shallow bays that comprise the SSER share many of these management issues. Long Island is an urbanizing watershed, particularly in the western portion of the Reserve, and the SSER has been affected by changes in hydrology and materials loading. The potential presence of pathogens as indicated by elevated levels of coliform bacteria from stormwater and point source discharges has caused closure of significant areas of shellfish beds. Extensive areas of natural wetlands have been altered or filled, and exotic plant species have encroached into the terrestrial, wetland, and aquatic ecosystems.

Nutrient concentrations and primary productivity are high. As discussed in Chapter 1, NOAA considers Great South Bay a eutrophic estuary, based on elevated concentrations of chlorophyll *a*. However, the shallow well-mixed nature of SSER embayments limits hypoxic conditions to restricted areas near tributaries' mouths. Low DO has also been reported in downstream reaches of tributaries, notably the Patchogue River. Growth of macroalgae reaches nuisance levels in the western embayments. Periodic blooms of brown tide appear to be among the factors contributing to the dramatic decline in the hard clam fishery. Excessive algal growth and turbidity affect light penetration and reduce habitat for SAV.

Based on the March 1, 1999 workshop, interviews with stakeholders, and document review, we have concluded that the overall water quality and ecological goals for the SSER can be expressed as four elements of a "desired state" (Figure 2-1). Three of the elements are human-oriented (noted as "H" on the figure), one is ecological (noted as "E") and one includes elements of both (noted as "H/E"). Each includes elements of water quality, hydrology, and natural habitat. These

four elements of the "desired state" form the basis of the draft CMS. As displayed in Figure 2-1, the four elements of the desired state are a culmination of hydrology, material loading, water quality conditions, and ecological processes in the SSER.

D. Summary of Unknowns

There are gaps in our understanding of causal factors and interrelationships between various components of the ecosystem as reflected in the Work Group's number one objective: characterize conditions needed to achieve and maintain water quality necessary for priority uses and improve health of the ecosystem. In many estuaries, quantitative linkages between inputs and water quality/habitat response are fairly well developed. This is not the case in the SSER. The gaps exist in three areas: load, relationship between load and concentration, and desired concentration to achieve ecological goals.

Nitrogen load to the SSER was estimated during the 208 study completed in the 1970s (Nassau-Suffolk Planning Board, 1978). USGS has proposed a program of monitoring and modeling to update these loading estimates. Sources of nutrients to the SSER include groundwater, surface water and atmospheric deposition. Surface water runoff and streambank erosion are the primary sources of sediment; atmospheric deposition of particulate material is low in comparison. Input of nutrients and particulate material from the atmosphere has been evaluated for other regional estuaries and is likely to be comparable on an areal basis.

The relationship between external load of nutrients and resulting water column concentration is complex in estuaries. Morphometric and hydrologic factors such as flushing rate, depth, and stratification regime are important in moderating mass loading into ambient concentrations. As noted above, many estuaries use mathematical models of various levels of complexity as a framework to analyze data and test hypotheses regarding underlying mechanisms and interrelationships. The models are also used to test the effectiveness of various control strategies.

For many contaminants of concern in the SSER no numerical criteria, standards or guidance values have been promulgated by state or federal agencies. Standards and criteria reflect best scientific judgment of maximum contaminant levels that will protect water bodies for their designated use. Complexities of aquatic ecosystems and regional differences in background geology and water chemistry have hampered efforts to define numerical limits on many naturally occurring substances in estuaries. Coliform bacteria are an exception. Well-defined targets exist for these indicator bacteria to protect public health.

There has been progress towards defining threshold water quality that supports the growth of SAV in estuaries. Criteria for dissolved inorganic N, dissolved inorganic P, chlorophyll *a*, total suspended solids and light attenuation to support SAV have been adopted by a number of estuary management programs based on research conducted as part of the Chesapeake Bay program. Significant questions remain regarding water quality conditions that trigger nuisance algal blooms.

The long-term monitoring data could play a role in defining site-specific relationships between water quality and indices of ecosystem health. Although multiple agencies collect data, few resources have been dedicated to data analysis and interpretation. More historical data need to be transformed to information and strategic information. We consider this a priority area for dedication of personnel and financial resources.

Correlation between measured water quality and ecological conditions might be drawn out of a thoughtful analysis of the potentially rich data set. An example of the potential value of this approach is the recent hypothesis linking abundance of brown tide to the ratio of inorganic and organic nitrogen in the estuary.

E. Working hypotheses for managing the SSER

Following EPA guidance, we formulate the Comprehensive Monitoring Strategy as a series of testable hypotheses that reflect specific management objectives. This framework focuses monitoring on key variables and enables managers to interpret results of the monitoring program in an unambiguous manner. Framing these questions as null hypotheses helps ensure that sufficient information and the right type of information is developed in the monitoring program.

Category: Loading

Hypothesis: Loading of nitrogen and phosphorus to the SSER is not significantly different in 2003 – 2005 than in 2000-2002.

Discussion: The proposed effort by USGS to estimate nutrient transport to the SSER through groundwater and surface water will provide valuable baseline data that can supplement the point source and atmospheric deposition data. At this point, there is no basis for estimating reduction in loading, if any, needed to reach a desired state in the ecosystem. The null hypothesis reflects a cap on loads at current levels. Multiple years are selected for the baseline because of assumed interannual variability.

Hypothesis: Implementation of storm water management practices in the watershed has reduced loading of suspended solids and pathogens to the SSER.

Discussion: The significance of stormwater as the major source of coliform bacteria input to the SSER is well documented. Monitoring the effectiveness of specific controls will enable managers to identify priority subwatersheds and develop a database of best management practices most effective in this specific environment.

Category: Water Quality in Embayments

Hypothesis: Average concentrations of dissolved inorganic N and P, chlorophyll *a*, total suspended solids, and light attenuation measured at least monthly from May – September meet relevant criteria for SAV growth requirements.

Discussion: The table below presents an example of water quality indicators based on research and monitoring conducted in other estuaries, particularly the Chesapeake Bay. These criteria are being considered for the Peconic Estuary. The degree to which these criteria are appropriate for the SSER has not been demonstrated. Additional research within SSER embayments is needed to determine site-specific criteria for this system.

Indicator	**Example of Critical Level**
Chlorophyll *a*	Less than or equal to 15 µg/l
Dissolved inorganic phosphorus	Less than or equal to 0.01 mg/l
Dissolved inorganic nitrogen	Less than or equal to 0.14 mg/l
Total suspended solids	Less than or equal to 20 mg/l
Light attenuation	Greater than 20%

Hypothesis: The total area of shellfish closures due to exceedances of shellfish safety standards for indicator bacteria has decreased (indicating improved water quality).

Discussion: This is a key variable from the perspective of use attainability.

Hypothesis: Salinity at key monitoring locations in the SSER is within 15% of the long-term annual mean corrected for tidal stage and antecedent precipitation.

Discussion: Salinity is a key variable, as it reflects the overall hydrology and mixing characteristics of the system. Organisms present in the SSER (including predators and prey) may be adapted to a relatively narrow range of salinity. The value of 15% is suggested as a basis for discussion.

Hypothesis: Sediment quality has improved as indicated by the decline in concentration of selected target compounds in areas of accretion.

Discussion: A focused sampling effort is required to determine the extent and severity of any sediment contamination in the SSER prior to defining the appropriate parameters for use in a long-term monitoring program.

Hypothesis: The ratio of inorganic to organic N is within 10% of the historical mean.

Discussion: This ratio has been implicated as a possible trigger for brown tide blooms. The interannual variability appears to be related to inflow of fresh water from groundwater and surface streams.

Category: Water Quality in Tributaries

Hypothesis: Tributary water quality is adequate to support designated best use.

Discussion: Water quality data collected on tributaries to the SSER can be used to assess compliance with ambient water quality standards and criteria. Biological metrics such as assessment of the macroinvertebrate community can be used to evaluate potential for use impairment.

Category: Ecosystem Indicators

Hypothesis: The abundance and density of SAV (primarily eelgrass) has increased in the system.

Discussion: SAV are selected as a key indicator species in many estuary programs. They are an indicator of overall water quality conditions, particularly light penetration, and play an important role in the processing of energy and materials in the ecosystem. Finally, these plants provide valuable habitat for animals in the estuary.

Hypothesis: The abundance of phytoplankton associated with nuisance algal blooms such as brown tide organism is below ecologically significant thresholds.

Discussion: The presence and abundance of brown tide is a key attribute of water quality and ecological health, due to its documented effect on the growth and survival of shellfish. Blooms also impair the water aesthetically.

Hypothesis: The standing crop of hard clams has increased throughout the SSER. Annual harvest has increased to a level comparable to the 1970s, and the interannual variability is within 20% (indicating that harvest is at a sustainable level).

Discussion: This element of the monitoring program is also considered in the Living Resources initiatives. We include it in the water quality monitoring strategy because of the importance of hard clams as a "capstone indicator".

Hypothesis: The presence of *Pfiesteria* in SSER embayments is below ecologically significant levels. No toxic forms are present, and no fish kills have occurred due to this organism.

Discussion: *Pfiesteria* has been detected in the SSER. Monitoring for the presence of the organisms and its life form is underway.

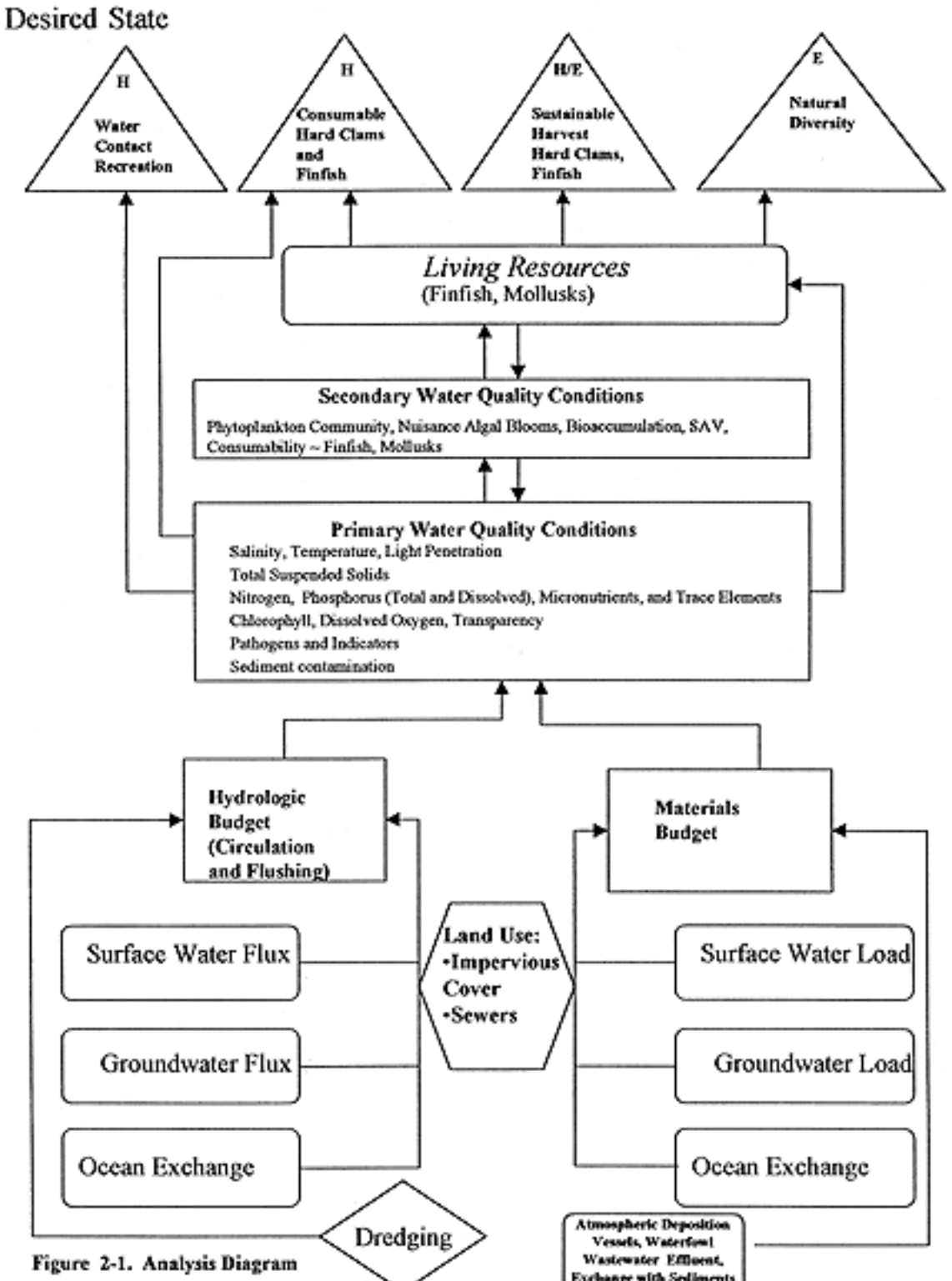


Figure 2-1. Analysis Diagram

Chapter

3

Forcing Functions

Chapter 3: Forcing Functions

The goal of an estuary monitoring program is to allow linking observed patterns in monitored variables to specific management actions (USEPA Office of Water National Estuary Program Monitoring Guidance, December 1995). In order to select appropriate variables and specify a spatial and temporal scale for data collection, a conceptual framework of how the estuary functions is needed. In this section, we briefly discuss the components, interactions, and mechanisms that are operable in the SSER.

We discuss these components, interactions and mechanisms in the context of "forcing functions" defined as physical, chemical, biological, and human-induced factors which play a major role in determining water quality. The SSER, its watershed, and the ocean are linked directly by water moving through the hydrologic cycle. Much of the water quality and management of the estuary are thus connected by this hydrologic cycle. Physical factors such as tidal exchange, light penetration, and groundwater flow are the primary forcing functions in the estuary, while chemical, biological, and human induced factors can both influence and be influenced by the physical factors. The major forcing functions are shown in Figure 3-1.

A. Physical Factors

Physical factors have a profound influence on the water quality and biotic community in the SSER. There is a continuous exchange and dynamic balance between circulation and tidal exchange of seawater through inlets, flow of fresh surface and ground water from the SSER watershed, and effectiveness of the barrier islands in separating the SSER from the ocean. Light availability and substrate composition are other significant physical factors.

(1) Circulation and Tidal Exchange

Ocean water flows into the SSER through five confined inlets along a 75-mile barrier beach. Tidal exchange drives the inflow of water to the estuary; circulation patterns within the loosely coupled series of bays are influenced by wind driven currents and freshwater inflows. Overall, limited freshwater inflows and limited ocean exchange contribute to long residence times for estuary waters (up to three months in Great South Bay) in the SSER. However, there are significant differences in residence time between the embayments of the SSER.

Wong (1981) modeled tidal and low frequency volume flux within Great South Bay. He estimated tidal exchange at 5×10^3 m^3/s and concluded that most exchange between the embayments and the ocean occurs through Fire Island Inlet. This flux varies over multiple time scales: diurnal, seasonal, and annual.

The flow of ocean water into the SSER is influenced by periodic and predictable change in ocean elevation due to tidal changes, and by short-term weather events such as large storms and hurricanes. Long-term regional and global trends in sea level and large-scale climate changes also influence system hydrodynamics.

(2) Groundwater Inflow and Streamflow

In addition to tidal exchange, inflow of fresh water from groundwater, streams, runoff, and rainfall controls the hydrology of the SSER embayments. Precipitation averages around 118 cm (46.5 inches) per year. The total inflow of groundwater to Great South Bay has been estimated at 2×10^8 liters per day (Bokuniewicz and Zeitlin, 1980 and Pluhwoski and Kantrowitz, 1964).

Three main rivers (Connetquot, Carmans, and Patchogue) and numerous small streams drain the 320 km^2 watershed. Discharge from streams coupled with direct precipitation on the 235 km^2 bay contributes about 9.8 x 10^8 liters per day of fresh water. Total freshwater input to Great South Bay has been estimated at 12 x 10^8 liters per day. The estimated 11% contribution to the freshwater budget from direct inflow of groundwater is high compared with other estuaries. These estimates are based on limited data and will be updated with the results of the proposed USGS effort.

This freshwater input is highly variable throughout the year as illustrated in a plot of the annual surface water and groundwater contribution from Champion Creek (Figure 3-2).

(3) Light availability

Light availability is a major forcing function to all biological systems. Organic carbon produced through photosynthetic activity of macrophytes, wetland vegetation and phytoplankton in the SSER bays and surrounding wetlands supports consumer organisms (heterotrophs) within the estuary. Light intensity, quality, and duration (photoperiod) affect activities and processes of estuarine organisms. In the SSER, light appears to be the limiting factor for primary productivity (Adamson 1982, Lively et al. 1983).

The intensity of light at the air-sea surface interface depends on season, time of day, and weather conditions. Below the water surface, light is attenuated primarily by absorption and scattering and to a lesser extent by reflection. In general, light attenuates more rapidly in turbid estuarine waters than in the open ocean. Light is scattered by suspended particulate material both inorganic and organic. In Great South Bay, 65 - 95% of light attenuation is attributed to suspended sediment particles. Most are extremely small particles that have been resuspended from the bottom of the embayments by the action of winds and waves.

(4) Substrate composition

Texture (particle size distribution) of the SSER sediments affects distribution and abundance of benthic organisms, particularly hard clams. Distribution of any contaminants may also be affected by texture. Sediment texture is a result of proximity to inputs and ambient current velocity. The majority of SSER bottom sediments is composed of sand-sized particles. Finer textured silts and clays are present in a small percent of the SSER; these smaller particles tend to be found adjacent to mouths of the main tributaries. Coarse gravelly sand is found in areas with significant tidal changes in water levels such as northern shores of bays or areas where current velocity is high such as Fire Island Inlet. In some areas, such as the eastern side of the Great South Bay, the substrate contains substantial amounts of shell fragments.

(5) Barrier island migration and breaches

The South Shore Estuary and the barrier landforms separating it from the open Atlantic Ocean are geologically young features with a dynamic history. At the height of the Wisconsin Glaciation (the last glacial advance during the Pleistocene epoch, which ended about 11,000 years ago) glaciers extended south to about the approximate mid-line of Long Island. Seaward of the glaciers, extensive outwash plains of sand and gravel were deposited on top of the gently seaward sloping Atlantic Coastal Plain. The approximate east - west orientation of the glacial front is responsible for the east - west orientation of the South Shore. At the maximum areal extent of glaciers, sea level was several hundred feet lower than today.

As the glaciers retreated, sea level rose and coastal processes interacted with the glacial deposits to form barrier landforms. Driven by waves, wind, and rising seas, the sediment composing the landforms migrated both landward, up the coastal plain, and along shore. The landforms were separated from the mainland of ancestral Long Island by shallow bays. As the landforms continued to migrate and change in response to coastal processes and rising seas, the shallow bays also changed; retreating in the path of the barrier landforms but advancing over the mainland as sea level rose. In addition, inlets developed through the barrier landforms, creating barrier islands and pathways for the exchange of oceanic waters, sediment, and marine lifeforms. The cumulative effect of the changes to the barrier landforms and the shallow bays resulted in the present South Shore Estuary. The dynamic nature of the barrier landforms and bays can be expected to continue into the future.

The present day barrier landforms and the South Shore Estuary are subject to a variety of natural influences that contribute to long and short-term changes in the estuary's physical and chemical characteristics and biota. Barrier landforms are migrating up the coastal plain. The principal mechanisms are creation of new inlets (breaches) and overwash. On an undisturbed barrier island, inlets would form during storm events, allowing transfer of sediment from the ocean side of the barrier to bay side. Longshore movement of sand would result in westward migration of the inlets, eating away the barrier island to the west and depositing new sand adjacent to, and landward, of the barrier to the east. Eventually the new inlet would close and another would open at a vulnerable location. The net effect over a long period of time is landward translation of the barrier.

Overwash is secondary in its effect on landward movement of sediment on the barrier landforms, however, if large enough to reach the bay shoreline, it contributes to physical and chemical changes in the bay. Over the thousands of years that the barrier landforms and bays have existed, the biota has adapted to the changes that result from breaches, overwash, and other natural processes. The same is not true for the many changes that have resulted from human actions (e.g., fixed inlets, dredging, shore protection, upland runoff).

From east to west, the barrier landforms include Shinnecock Spit, Westhampton Barrier Island, Fire Island, Jones Island, and Long Beach Island (Rockaway Spit and Coney Island are further west, but outside of the SSER). These spits and barrier islands range from approximately 3.5 miles to 33 miles in length, averaging only about 0.25 miles in width. Except for dune crests, elevations are generally less than 10 ft. The spits and islands are separated from each other by Shinnecock Inlet, Moriches Inlet, Fire Island Inlet, and Jones Inlet respectively, with East Rockaway Inlet separating Long Beach Island from those further west. All of the inlets have been stabilized with jetties and dredging since at least the early 1950's.

(6) Temperature

Water temperature is a significant factor affecting distribution of aquatic life. Organisms are adapted to a range of temperature, metabolism varies as a function of temperature, and reproductive activities are frequently triggered by changes in temperature. Temperature has a synergistic effect on many toxic substances and stressors to the aquatic biota. In addition, temperature affects the saturation of water with dissolved gases.

The range of temperatures in the shallow, well-mixed SSER embayments is fairly wide, wider than exhibited in the Atlantic Ocean. Based on the 21-year data set compiled by Suffolk County,

temperature in Shinnecock Bay can range from below zero (-1.3 °C in winter 1992) to 27 °C (summer 1995).

B. Chemical Factors

Chemistry of estuarine waters is variable both temporally and spatially. Much of the variation results from the different chemical composition of fresh water and seawater and the complexities of the mixing processes. Distinct gradients in chemical composition are common in the SSER as one moves towards Long Island from the barrier islands, and from east to west through the series of loosely coupled bays. Anthropogenic loading influences water chemistry as well.

(1) Salinity

Salinity has a profound effect on the species composition and abundance of submerged aquatic vegetation and benthic fauna. Hard clams and their predators are influenced by salinity. For example, Rosengrat and Haydock (1981) report that no more than 25 – 30 % of an estuary's freshwater inflow can be diverted without the risk of disastrous ecological consequences.

Natural variation in salinity within an estuary can be very high, particularly in comparison with ocean or freshwater environments. Salinity changes daily, seasonally, and over the tidal cycle. TetraTech reported strong spatial variability in salinity in East Bay, South Oyster Bay, and Great South Bay that was related to freshwater inflows (Tetra Tech, 1977).

The extent of nontransient density stratification in SSER embayments due to salinity gradients has not been well characterized. Estuaries can be classified as (A) highly stratified (salt wedge estuary), (B) partially mixed, moderately stratified, (C) vertically homogeneous, or (D) sectionally homogeneous (Pritchard, 1967). The magnitude of river discharge relative to tidal flow, which is low in the SSER, is the main forcing function determining the degree of density stratification. Wind stress, internal friction, and bottom friction also contribute to the degree of turbulent mixing in an estuary.

These four stratification regimes represent a continuum; a particular estuary may exhibit more than one stratification regime over an annual cycle. Over most of the year, SSER embayments are well mixed (type C estuaries). After large storms, transient stratification is detected at the mouths of the larger tributaries (type B).

(2) Nutrient inputs and concentrations

A vital characteristic of the functional relationship between land, estuary and ocean in the SSER is the continual influx and transformation of nutrients. Nitrogen, phosphorus and silicon are the major nutrients in estuaries.

Land runoff, discharges of treated wastewater, and groundwater inflows are the principal sources of these nutrients; the atmosphere and oceans supply secondary amounts. As the population of Long Island increased over the last 50 years, so did the amount of nutrients generated within the watershed. Changes in the amount of nutrients generated on the landscape coupled with hydrologic changes associated with urbanization have resulted in greater nutrient loading to the SSER through surface runoff.

Groundwater concentration of nitrogen has increased in non-sewered areas as the region developed (Stackelberg 1993). The western portions of the SSER watershed are sewered, and approximately half of the wastewater effluent generated within the SSER is discharged to the ocean. The remainder (80 mgd) is discharged to estuarine embayments.

Nutrient loading from atmospheric deposition has increased on a regional scale with industrialization. Today it is estimated that 26% of the nitrogen loading to the SSER comes from atmospheric deposition (Schlenk and Wise, 1999).

Nutrient enrichment from point and nonpoint sources may be a critical factor in the appearance and severity of algal blooms and may also be related to blooms of macroalgae. The magnitude and relative importance of nutrient flux from the sediments is unknown.

Both concentration and chemical forms of the major nutrients are variable in the streams, estuary, and ocean. This variability is seasonal, spatial, and in response to hydrologic conditions.

(3) Toxic substances

If toxic substances were present in the water column, sediments, and biota of the SSER at concentrations in excess of threshold levels, this could limit the estuary's ecological health and use attainment. Examples of toxic substances of concern include heavy metals, pesticides and herbicides, and petroleum related compounds. Definition of threshold levels corresponding to adverse ecological impact for each chemical depends on a number of factors such as chemical speciation (which depends on chemical properties of both water and sediment), toxicity to benthic and water column organisms, persistence, and potential for bioaccumulation.

Toxic substances can enter the SSER via several key pathways including point and nonpoint source discharges, discharges from ships, atmospheric deposition, tributary inflow, groundwater inflow, and ocean exchange. Levels of toxic substances in the water column, sediments, or biota of the SSER have not been adequately characterized. No systematic testing has been conducted to estimate ambient concentrations or assess their ecological significance (Schlenk and Wise, 1999).

C. Biological Factors

(1) Predation

Predation is a major forcing function in the establishment and management of populations for food supply or recreation. The hard clam, for example, is subject to predation by a large variety of organisms, including humans. Multiple chemical and physical factors influence the populations of predators and thus the extent of predation. Small clams are prey for mud crabs, calico crabs, whelks and oyster drills. Grass shrimp, sand shrimp, hermit crabs, finfish, rays, ducks, and geese are other known predators.

(2) Brown tide

We have included brown tide among the forcing functions due to the interrelationship of this alga with other organisms in the SSER ecosystem. The algal species *Aureococcus anophagefferens* is responsible for a harmful algal bloom, called "brown tide" from the appearance of the water in full bloom. The organism causes a marked decline in the feeding response of shellfish even when

present at very low levels (as few as 35,000 cells per ml according to Bricelj 1999). Algal blooms can also reduce light penetration through the water column and limit the habitat for SAV.
Several hypotheses have been advanced regarding the trigger conditions for brown tide. Some are based on changes in water chemistry. For example, variability in circulation of ocean water through Jones and Fire Island inlets may influence the blooms (Nuzzi and Waters 1989). Other data suggest that the presence and severity of bloom conditions may be related to the ratio of organic and inorganic nitrogen in estuarine waters, which reflects the relative contribution of groundwater inflows (LaRouche et al. 1997). Elevated nitrate concentrations following a wet spring might increase the proliferation of these organisms (Sanudo-Wilhelmy 1999).

There are other hypotheses being investigated that focus on ecological and food web effects of the presence of this alga in the phytoplankton community. Many zooplankton species are reportedly not able to graze on *Aureococcus anophagefferens*, which promotes a competitive advantage to the alga (Caron and Lonsdale, 1999; Smayda 1999). The alga appears to be able to supplement its autotrophic carbon fixation (photosynthesis) with heterotrophic production using organic substrates that may be excreted by other phytoplankton (Gilbert and Kana 1999).

(3) Pathogenic organisms

Similar to brown tide, pathogens may be considered a forcing function for their role in affecting use attainment and ecological health of the SSER. Pathogens enter the SSER from both point and nonpoint sources. Four groups of pathogens: bacteria, viruses, protozoa, and helminthes can be present in fecal waste of humans and other animals. Pathogens pose a significant health threat to humans who either ingest contaminated shellfish or swim in contaminated water.

(4) Wildlife

Wildlife, particularly waterfowl, can contribute significantly to the inputs of nutrients and pathogens to the SSER. In addition, the actions of wildlife can affect the species composition and density of submerged and emergent vegetation.

(5) Nuisance species

The ecosystem of the SSER has been profoundly altered through repeated introductions of non-native species as well as by habitat changes that favor the proliferation of nuisance organisms. Proliferation of several nuisance species, notably the macroalga *Codium*, and the crustacean Japanese shore crab, degrades the ecological quality of the SSER. The terrestrial emergent plant species *Phragmites*, which is native to North America, degrades the quality of wetland habitat.

D. Human Induced factors

(1) Land use changes (hardened edges, bridges, and impervious cover)

Population growth in the SSER watershed and associated land use changes has created a major stress on the estuary's water quality and ecosystem integrity. The interface between the estuary and the land is an important element in maintaining the health and resiliency of the ecosystem. Shubert (1991) has suggested that the percentage of natural shoreline adjacent to the bay may be an important indicator of the condition of the ecosystem. Both wetlands and naturally vegetated buffer strips play an important role in controlling erosion and reducing sediment and pollution loading to the estuary. Long Island experienced a 47% loss in wetlands between 1954 and 1974

(O'Conner and Terry, 1972). Most of this was a direct response to the development of waterfront properties, marinas, and other water- related uses.

Bridges constructed over streams and rivers have, in many cases, altered the natural flow regime. This has resulted in changes to salinity levels and other water quality conditions in streams.

As the watershed urbanized, the amount of impervious cover increased. Impacts of increasing impervious cover on watershed hydrology have been well characterized. Precipitation tends to run off rather than infiltrate to groundwater, thus reducing groundwater levels. Streams exhibit lower baseflow and higher peak flows; stream channels tend to widen to accommodate the flows. Erosion of streambanks contributes to downstream sedimentation problems, and stream temperature tends to increase. Stormwater runoff is a significant source of pathogens, nutrients, suspended solids and other contaminants.

(2) Sewering

As the region developed, sewage treatment plants were constructed to replace on-site disposal systems. Presently, six municipal wastewater treatment plants discharge a total flow of approximately 80 million gallons per day (mgd) of treated effluent into the waters of the SSER. The discharges are permitted and monitored by NYSDEC but still contain significant levels of nutrients, coliform bacteria, oxygen demanding material, and heavy metals.

Several other wastewater treatment plants serving the watershed area discharge into the ocean. Ocean discharges reduce the input of wastewater related contaminants, but have the net effect of diverting huge quantities of fresh water from the estuary and discharging it directly into the ocean. The result is higher bay salinity and decreased flushing.

(3) On-site Disposal Systems

There are major sections in the eastern portions of the SSER watershed which remain unsewered. Homes and businesses discharge wastewater to on-site disposal systems (cesspools and septic systems). Even when the systems are functioning properly, soluble chemicals such as nitrate percolate into the shallow groundwater and may flow into tributaries or directly into the SSER. Pathogens, including viruses, may migrate downgradient of a functioning on-site wastewater disposal system.

(4) Land application of toxic substances and fertilizers.

Land application of toxic substances can be a significant source of toxic substances to estuaries. For example, heavy metals are present in many materials that may end up in landfills or storage piles. These materials include power station corrosion products, sewage sludge, flyash, dredge spoils, and effluents from oil refineries and other industrial processes. Once in a landfill, leaching of metals into groundwater or surface water is possible.

Long Island has a well-documented history of groundwater contamination from land application of pesticides, herbicides, and fertilizers to agricultural and residential areas. Many of these chemicals will eventually reach the SSER.

(5) Harvesting pressure on resource

A final human induced forcing function is harvesting. Overfishing or overharvesting can have a major impact on populations of fish and shellfish. The record of hard clam landings in Great South Bay demonstrates clear cycles of abundance and decline. Overharvesting might be inferred as a factor in the cycle, although there is not yet consensus on the relative importance of harvesting pressure, water quality, dredging, brown tide, and other factors in contributing to the marked decline since the late 1970s.

(6) Boating

Boating is a popular activity within the SSER. Oil and gas from motorboats enters the water along with occasional litter. Although sanitary waste disposal from certain types of vessels is prohibited, some input is possible.

(7) Inlet control

Inlets to the SSER are maintained by dredging. The inflow of water from the ocean is a significant determinant of water quality.

E. Discussion of interrelationships

By examining the physical, chemical, biological, and human-induced forcing functions of the series of embayments that comprise the SSER, we can begin to construct an ecosystem view of the entire system. Water, whether it is runoff, tidal exchange, groundwater flux, or precipitation, acts as a solvent and carrier for the exchange of nutrients and particles between system components. The rate and volume of water transport are important factors in determining the flux of materials (both dissolved and particulate) from one component to another. In the SSER, the compartments and fluxes of greatest interest are the terrestrial and aquatic ecosystems. Delivery of nutrients, pathogens (and their indicators), sediment, and toxic substances from land to water can be most affected by human actions (Figure 3-3). An effective water quality monitoring strategy will gather data to quantify flux of materials and the resulting concentrations and related water quality conditions in estuarine embayments.

We note a distinction between sampling and monitoring. Sampling may include intensive, short-term efforts to characterize a system or identify significant mechanisms that affect the fate and transport of materials. Monitoring is the long-term synoptic collection and analysis to identify trends in response to management actions. Both are needed in the SSER. There are gaps in our understanding of SSER ecology that require intensive sampling in addition to long-term monitoring.

Finally, we note that forcing functions affecting the SSER vary over widely different time scales. Long term, systematic and strategic data collection in an ecosystem framework is required to differentiate effects of anthropomorphic actions from natural variability. LaRoche et al. (1997) were able to link intensity of brown tide blooms in Peconic Bay with interannual variability in groundwater influx by examining biweekly data collected over 11 years. This is a good example of the power of long term data collection at sufficient intensity in detecting significant trends.

The challenge is to develop a monitoring strategy to assess the health and integrity of the SSER ecosystem. To accomplish this, it is necessary to identify ecosystem characteristics best reflecting attainment of the desired state. This approach requires an emphasis on defining and assessing those parameters that characterize the important features of the ecosystem.

Forcing Functions and Effects on Water Quality

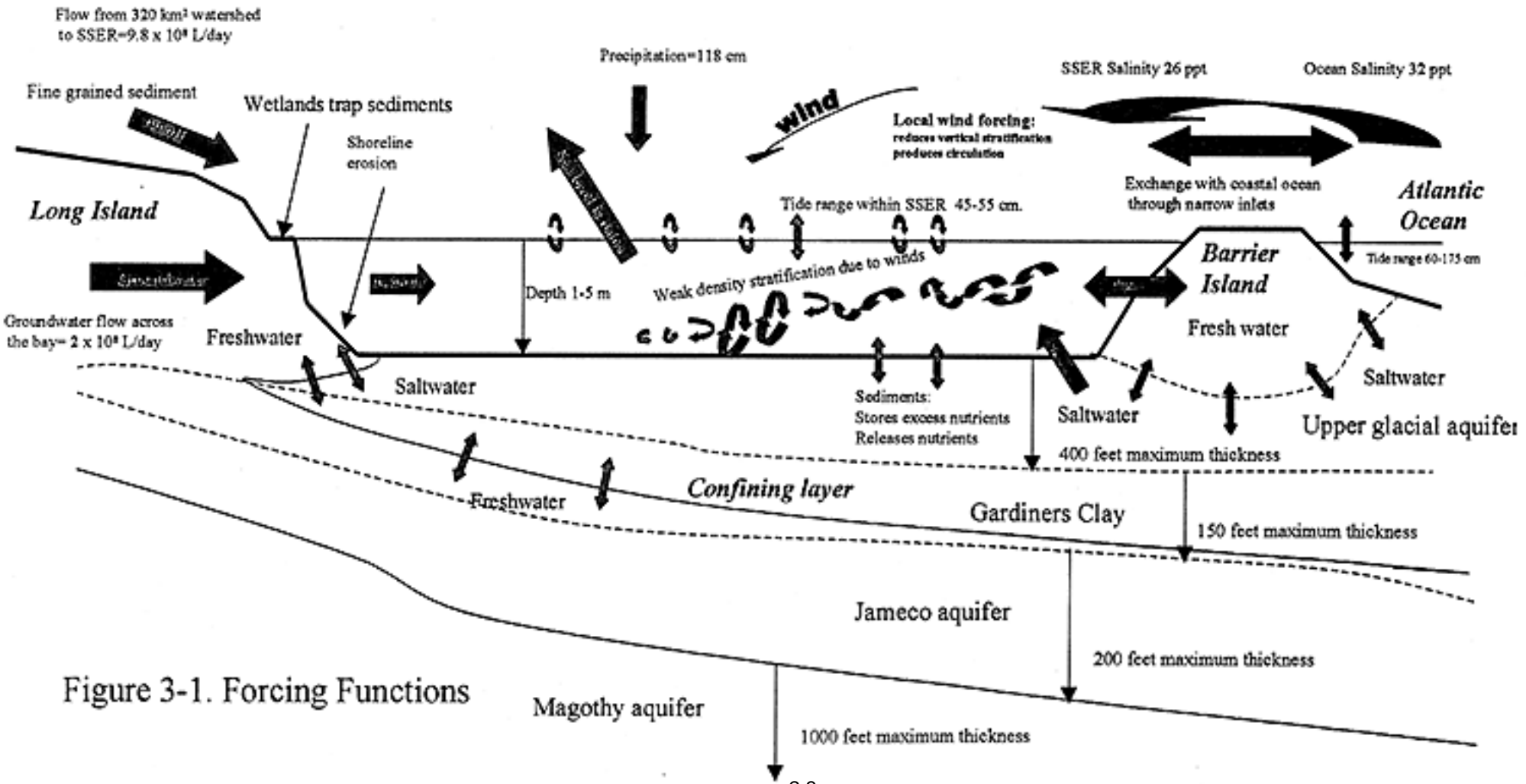
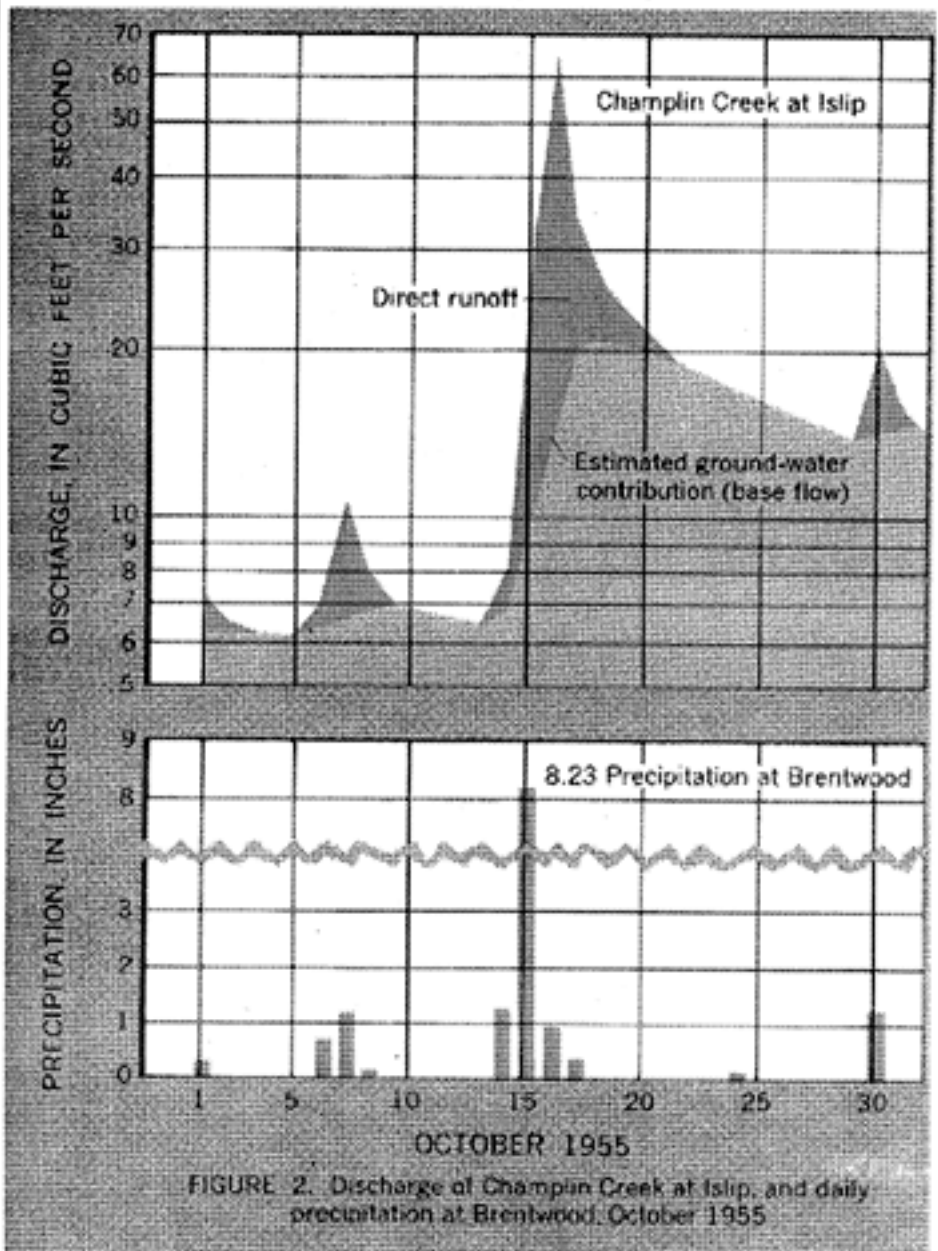


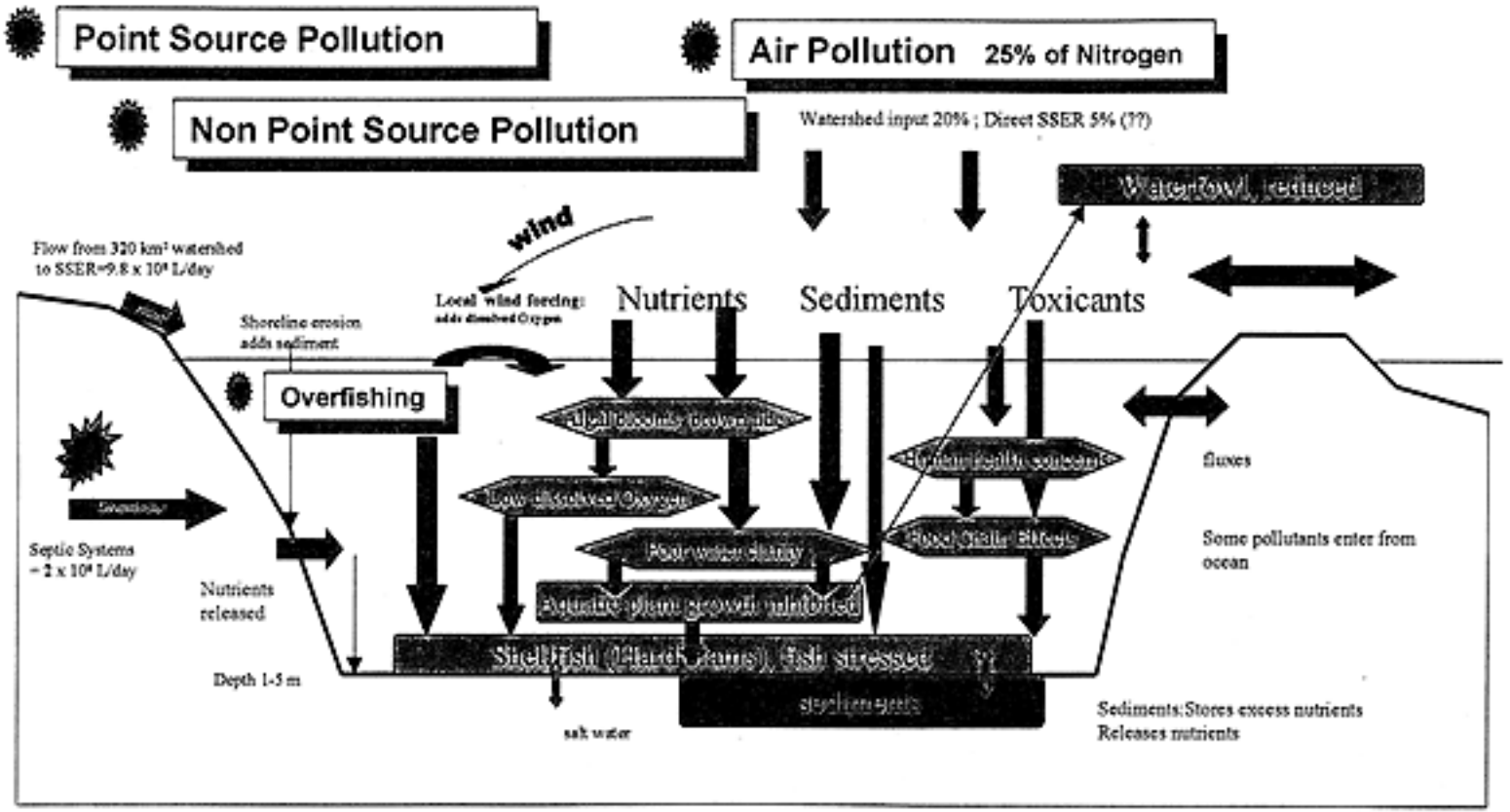
Figure 3-1. Forcing Functions



Source: New York Water Resources Commission (1968)

Figure 3.2. Example of seasonal pattern of runoff and groundwater contributions.

Effect of Pollution on Water Quality



South Shore Estuary Reserve

Figure 3-3. Effect of Pollution on Water Quality

Chapter

4

Summary Compilation of Existing Monitoring Programs

Table 4-1
Existing Federal Programs

	FEDERAL PROGRAMS			
	Ground Water Levels	**Flow Measurement**	**Stream Sampling**	**Coastal Flood Warning**
Agency	USGS	USGS	USGS	USGS
	Water Resources Division	Water Resources Division	Water Resources Division	Water Resources Division
Objectives	Characterize groundwater conditions	Characterize surface water flow regimes	Characterize stream water quality	Provide early warning systems against coastal flooding
Year Initiated	1930's	1930's	1966	1998
Parameters Measured	Groundwater levels	Stage, discharge	Major ions, nutrients, some trace metals	Tide stage and weather conditions.
Depth of Sample	Variable	From standard transect methodology	Depth-integrated sample through water column	N/A
Number of Stations in the SSER	~200	eight	13	Existing-two tide stage gauges. Proposed 12 tide stage gauge continuous recording
Frequency of Measurement	Annual synoptic survey (March). Additional measurements based on monitoring program objectives.	Continuous stage recorders	Discontinued quarterly and annual samples in 1996	Continuous at Reynolds Channel, Point Lookout.
Data Handling and Reporting	Added to national database. Reported in Annual report	Added to national database. Reported in Annual Report	Added to national database. Reported in Annual Report	Added to the National database. Reported in Annual Report
Program Contact	USGS Coram office: Ron Buscilano and Michael Scorca	USGS Coram office: Ron Buscilano and Michael Scorca	USGS Coram office: Ron Buscilano and Michael Scorca	USGS Coram office: Ron Buscilano and Michael Scorca
Comments	Data on the USGS Web Site: http://ny.usgs.gov/rt			

Table 4-1 (continued)
Existing Federal Programs

	FEDERAL PROGRAMS			
Programs	**Helicopter Monitoring**	**EMAP Program**	**Fire Island Characterizatio n**	**Fire Island Beach Erosion Study**
Agency	USEPA	USEPA	NPS	USCOE
	Region 2			NY District -Planning
Objectives	Characterize NY Bight	Characterize US estuaries-over decades	Characterize Fire Island w.q.	Evaluate Beach Erosion
Year Initiated	1977	1950	1995	1995
Parameters Measured	Fecal coliforms enterococcus bacterial densities	Response, Exposure, Habitat, & stress indicators	nutrients, TSS, DO, pH, conductivity	Topographic change, sand transport.
Depth of Sample	One meter (3.14 ft)	N/A	One to two and one half meters.	N/A
# of stations	26	four	seven	84 profiles Aerial photos
Frequency of Measurement	Beach sampling: one/week Phyto. Sampling one to two/week		One/week (goal) actual number is variable	Two/year
Data Handling and Reporting		Internal report	Internal report	Photos digitized analyzed by engineering
Program Contact	Helen Grebe		Jim Ebert	Steven Couch
Comments	Samples are on ocean side of barrier island, none in SSER	Env. Res. Lab. Formed from E-Map-NC		Part of hurricane survey and inlet stabilization study

USEPA= United State Environmental Protection Agency;
NPS = National Park Service;
USCOE = United States Corps of Engineers.

Table 4-1 (continued)
Existing Federal Programs

	FEDERAL PROGRAMS	
Programs	**Estuarine Eutrophication Programs**	**Status and Trends Program Mussel Watch**
Agency	NOAA	NOAA
	Office of Ocean Resources	Center for Coastal Monitoring and Assessment
Objectives	Development of a nationwide assessment of estuaries	Determination of the Status and Trends of the Blue Mussel
Year Initiated	1992	1986
Parameters Measured	Chlorophyll a, nuisance algae, toxic algae, macroalgae, macrophytes, epiphytes, nutrients, DO, anoxia, hypoxia, biological stress, primary production, plankton, benthic organisms, SAV's.	Mussell Population Counts
Depth of Sample	Variable	Intertidal, +0.5 m MLLW
Number of Stations in the SSER	None	Total station =3 Tuthill Point, Moriches Bay; Fire Island Inlet; Jones Inlet
Frequency of Measurement	N/A	Every two years
Data Handling and Reporting	Compile the data into annual reports; compare the data to other estuaries	Compile the data into annual reports; compare the data to other estuaries
Contact	Suzanne Bricker	Tom O'Connor
Comments	They do not collect their own data but utilize data of the SSER gathered by other researchers and agencies.[1]	

NOAA= National Oceanic and Atmospheric Administration
NYSDEC= New York State Department of Environmental Protection
[1] Researchers include: Elizabeth Cosper, Doreene M. Montelone, Robert Nuzzi, and John F. Paul.

Table 4-2
Existing State Programs

STATE PROGRAMS				
	Shellfish Land Certification Program	**Rotating Intensive Basin Surveys (RIBS)**	**Pfiesteria Monitoring Program**	**Remote Sensing of SAV's**
Agency	NYSDEC	NYSDEC	NYSDEC, Suffolk County, and Town of Hempstead	NYSDEC
	Region 1	Central Office	Region 1	Region 1-GIS
Objectives	Public Health: Classification of shellfish areas as Certified or Uncertified for Harvesting	Statewide ambient water monitoring of stream water quality and biological characteristics	Assessment of marine waters for presence and abundance of Pfiesteria.	Monitor tidal wetlands and evaluate protection
Year Initiated	1924	1998	1999 (summer)	1974
Parameters Measured	Fecal and total coliform bacteria	Temp, pH, DO, conductivity, nutrients, volatile organic compounds,, phenolic compounds, biological indicators	Pfiesteria piscida cell counts plus DO, temperature, salinity. At the Suffolk County and Town of N. Hempstead stations,: nutrients, TSS, and Chl. a	Wetland area in 5 classes: (intertidal marsh, high marsh, fresh marsh, littoral zone, coastal shoals).
Depth of Sample	At established shellfish stations. . Water depths range form <1 - 3 m.	Sampling sites are less than 1 m deep	Upper waters	Photographs typically penetrate through 2 m water depth or less.

Number of Stations in the SSER	Total station =201; Great South Bay=41; Babylon=39; Islip=24; Nicoll Bay=43; Patchogue=3; Bellport=20	13	27	Entire shoreline is photographed
Frequency of Measurement	Five times per yr. March 9-Dec. 27	Once every four years. Multiple samples collected , April to October	Sample 1 to 3 times starting in July	One flight per five years. during growing season
Data Handling and Reporting	Reported in Annual Report	Inc. into Unified Watershed Assessments	Water samples sent to U. of N. Carolina;	Aerial photos are interpreted and digitized.
Contact	Bill Hastback	Jeff Myers	Karen Chytalo	David Fallon
Comments	Compliance with FDA program; Hempstead collects data.	Currently no routine sites in SSER; Consideration is being given to establishing some.		Photos filed, waiting to be interpreted

NOAA= National Oceanic and Atmospheric Administration
NYSDEC= New York State Department of Environmental Protection

Table 4-3
Existing Regional and County Programs

REGIONAL AND COUNTY PROGRAMS				
Programs	**Land Use and Stream Assessment**	**Ground Water Monitoring**	**Bathing Water Quality Program**	**Drinking Water Monitoring**
Agency	**Long Island Regional Planning Board**	**Nassau County**	**Nassau County**	**Nassau County**
		Dept. of Public Works	**Dept. of Health**	**Dept. of Health**
Objectives	**Evaluate the impact of landuse on streams**	**Monitor ground water quality.**	**Develop public bathing beach water quality ratings for beach closures**	**Insure drinking water meets federal drinking water standards**
Year Initiated	**1989**	**1987**		**1973-1991**
Parameters Measured	**Salinity, temp. DO, alkalinity, pH, TN, Chlorophyll a, benthic macrofauna**	**Inorganics, organics, mostly volatile organics, pesticides**	**Total and fecal coliforms**	
Depth of Sample				
Number of Stations in the SSER		**500 monitoring wells; about 1/2 in SSER watershed**		
Frequency of Measurement		**Every 2-3 years**		
Data Handling and Reporting		**Electronic data base, no written report**		
Program Contact	**Dewitt Davies**	**Jim Mulligan**	**Bruce MacKay**	**Bruce MacKay Marne Surfore**
Comments		**100 % of the drinking water in Nassau county is from wells**		**Have historic data sets.**

Table 4-4
Existing Suffolk County Programs

	SUFFOLK COUNTY PROGRAMS			
Programs	**Ground water and Stream Sampling**	**Surface water quality monitoring**	**Bathing beach water quality monitoring**	**Drinking water quality monitoring**
Agency	Suffolk County	Suffolk County	Suffolk County	Suffolk County Water Authority (SCWA)
	Department of Health	Department of Health Services - Bureau of Marine Resources	Department of Health Services	Water Supply
Objectives	Calibrate regional groundwater model	Characterize estuary water quality	Open or close bathing beaches	Monitor drinking water quality
Year Initiated	1998	1977	Before 1977	About 1960
Parameters Measured	Ground water elevation and stream discharge.	Secchi, temp, DO, salinity, total and fecal coliform, NH_3, NO_2, NO_3, Urea, TKN, Filtered TKN, TDP, SRP, TP, TOC, DOC, Chl.a (total and nannoplankton), SiO_3,Aurecoccus , metals, pesticides.	Total coliform, fecal coliform bacteria	Bacteria, inorganic chemicals[1], volatile organic compounds[2], pesticides[3], herbicides[4], other pollutants[5].
Depth of Sample	NA	Two feet	Surface	Samples at wellhead and within distribution system.
Number of Stations in the SSER	16 observation wells, 12 stream sites	42	21 public beaches	464 wells
Frequency of Measurement		Variable. Goal is biweekly during recreational season, monthly year-round.	At least one sample/year	As required by state and federal regulation. 4x/yr for bacteria

Data Handling and Reporting	Input to groundwater model	Data entered into database. 20 year summaries and analysis recently published.	Running log average calculated. Beaches are closed if the data exceed state standards. Annual report is prepared.	SCWA operates certified lab (largest groundwater testing facility in US)
Program Contact	Marty Trent	R. Nuzzi or R.M. Waters	R. Nuzzi or R.M. Waters	Karen Randazzo
Comments	Additional groundwater and surface water monitoring summarized in following table	Most extensive water quality monitoring program in SSER.		1997 analyzed more than 54,880 samples

[1] Inorganic chemicals monitored include nitrate, chloride and lead
[2] Volatile organic compounds monitored include benzene, trichloroethylene and trihalomethane
[3] Pesticides include aldicarb and lindane
[4] herbicides monitored include simazine and atrazine
[5] other pollutants monitored include radioactivity (tritium) and asbestos.

Table 4-4 (continued)
Existing Suffolk County Programs

SUFFOLK COUNTY PROGRAMS (continued)		
Programs	Groundwater Monitoring	**Surface water quality monitoring**
Agency	Suffolk County	Suffolk County
	Department of Health	Department of Health
Objectives	Water level and water quality	Characterize water quality of streams
Year Initiated	mid-1970's	mid-1970's
Parameters Measured	Ground water elevation, inorganic parameters, metals, volatile organic compounds, pesticides.	Pesticides (unfiltered samples), inorganic parameters, metals, volatile organic compounds
Depth of Sample	Most wells are screened in the upper glacial aquifer (depth 10 - 30 ft)	mid-stream
Number of Stations in the SSER	Approximately 500 monitoring wells	90 - 100
Frequency of Measurement	Water levels are measured quarterly. Water quality monitoring variable, typically every 2 - 3 years	Quarterly monitoring of 8 - 10 streams Annual monitoring of remainder. Sampling conducted during baseflow conditions
Data Handling and Reporting	Annual data summaries	Annual data summaries
Program Contact	Marty Trent	Marty Trent
Comments	When program began, many private wells utilized this resource. Most residences now on public supply (tested by SCWA)	Suffolk County periodically collaborates with USGS on sampling and analysis

Table 4-5
Existing Town Programs

	TOWN PROGRAMS			
Programs	**East Bay Sanitary Survey**	**East and West Bay Sampling Survey**	**Shellfish Analysis for Coliform Bacteria**	**Hard Clam Grow Out Program**
Agency	Town of Hempstead	Town of Hempstead	Town of Hempstead	Town of Hempstead
Objectives	Evaluate shellfish areas for harvesting (open or conditional)	Evaluate shellfish areas for harvesting	Shellfish certification	Shellfish production
Year Initiated	1973	1973	1978	1986
Parameters Measured	Total and fecal coliforms in seawater	Turbidity (Secchi), salinity, temperature, total and fecal coliform, ammonia, nitrates and nitrites, orthophosphates , particular organic matter, total and fecal coliforms, chlorophyll a, DO, BOD		Temp, salinity, chlorophyll of bay water used for clam plant.
Depth of Sample	Three feet	Three feet	Three feet	Three feet
Number of Stations in the SSER		30 stations for nutrients and total and fecal coliforms		
Frequency of Measurement	Monthly or 0.25" of rainfall	Monthly	Random sampling through the year	
Data Handling and Reporting				
Program Contact	Michael Foley	Michael Foley	Michael Foley	Michael Foley
Comments				

Table 4-6
Existing Citizen Programs

CITIZEN MONITORING			
Programs	**Cooperation with NYSDEC and Nassau County for Beach and Shellfish Closures**	**Study of DO & Nutrients on the Patchogue & Carmens River**	**Coalition of Educational Organizations; Water Quality Monitoring**
Agency	Town of Oyster Bay	Dowling College	South Shore Estuary Watch (SSEW)
Objectives	Beach closure and Shellfish Certification	Education and research	Education and Research
Year Initiated	Early 1990's	1997	1999
Parameters Measured	Do collection of samples and send to NYSDEC (Coliforms)	DO, temp, salinity, pH, nitrate, nitrite, ammonia, ortho-phosphate, C.O.D., benthic samples, sediment samples, secchi	Physical, Chemical and Biological Parameters; DO, temp., salinity, pH, nitrogen, phosphorous, heavy metals, BOD, COD, secchi
Depth of Sample		One foot intervals	Variable
Number of Stations in the SSER	50	Five east/west transects Five per season	Five stations per tributary, One tributary per school (presently seven schools), one time/month
Frequency of Measurement		Five per season	One time/month
Data Handling and Reporting	Carried out by NYSDEC and Nassau County	Project write ups by students and faculty	Project write ups by students and directors
Program Contact	Frank Rouch (1995-present); Jay Adler (1991-1995) & Nancy Kearney	Lori Zaikowski	Lori Zaikowski and Paul Lichtman
Comments	.	Have begun a similar study Swan River in Patchogue and they have historical data on Connetquot River dating back to 1965.	SSEW is to be initiated fall 1999.

SSEW = South Shore Estuary Watch

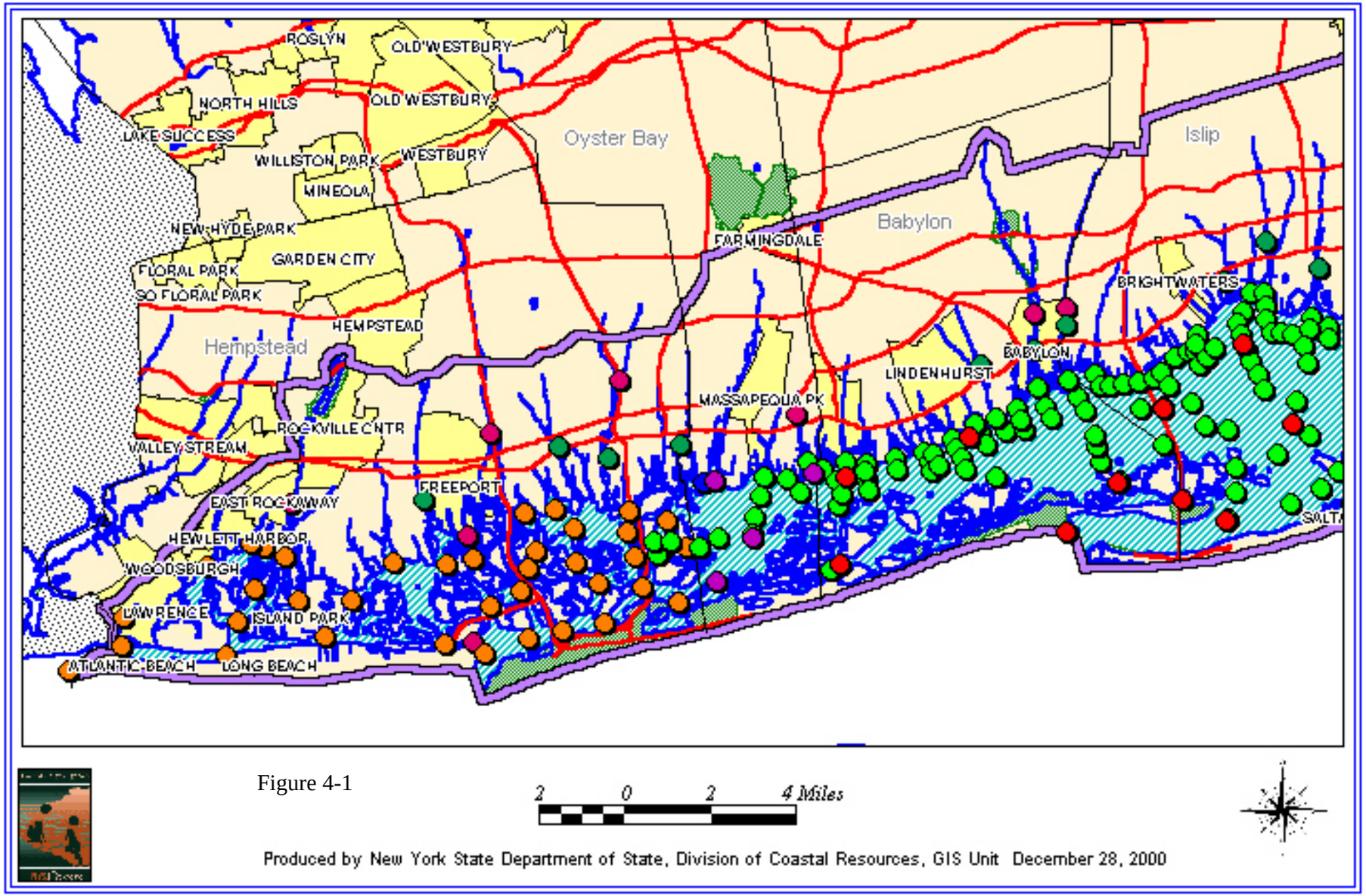

ROSLYN
OLD WESTBURY
NORTH HILLS
OLD WESTBURY
LAKE SUCCESS
WILLISTON PARK
WESTBURY
MINEOLA
Oyster Bay
Islip
NEW HYDE PARK
GARDEN CITY
FARMINGDALE
Babylon
FLORAL PARK
SO FLORAL PARK
BRIGHTWATERS
HEMPSTEAD
Hempstead
BABYLON
LINDENHURST
MASSAPEQUA PK
ROCKVILLE CNTR
VALLEY STREAM
FREEPORT
EAST ROCKAWAY
HEWLETT HARBOR
WOODSBURGH
LAWRENCE
ISLAND PARK
ATLANTIC BEACH
LONG BEACH
2 0 2 4 Miles
Produced by New York State Department of State, Division of Coastal Resources, GIS Unit December 28, 2000
Suffolk County Dept of Health, Bureau of Marine Resources
NYSDEC Region 1; Shellfish Evaluation
Town of Hempstead; Shellfish Evaluation
EMAP Program
NYSDEC RIBS; Biomonitoring and Sampling Locations
USGS; Water Resources Division; Stream Water Quality
New Locations
State Parks
Villages
South Shore Estuary
Highways
Town Boundary

Figure 4-1

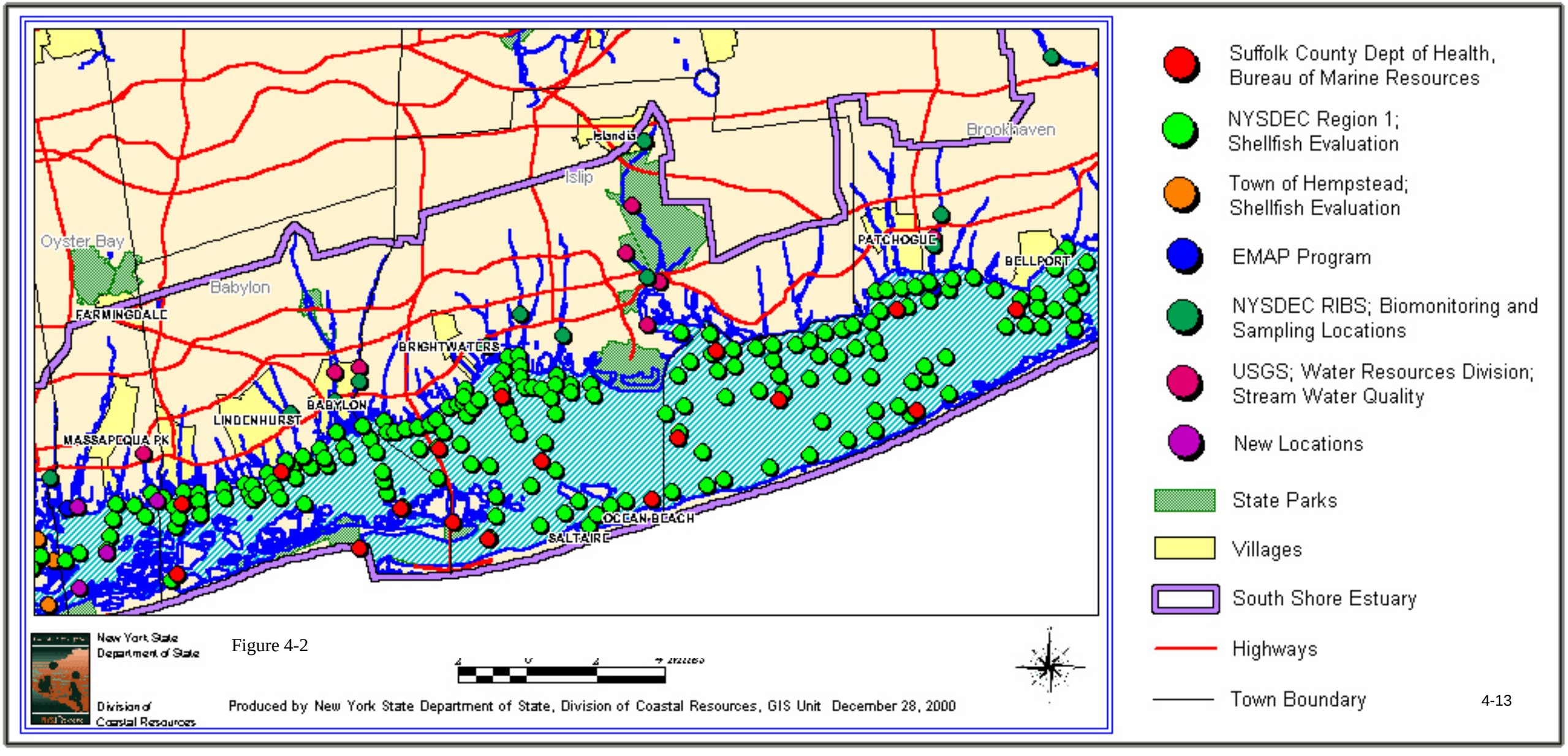

Oyster Bay
Babylon
Islip
Brookhaven
FARMINGDALE
BRIGHTWATERS
BABYLON
LINDENHURST
MASSAPEQUA PK
PATCHOGUE
BELLPORT
OCEAN BEACH
SAILTAIRE
Suffolk County Dept of Health, Bureau of Marine Resources
NYSDEC Region 1; Shellfish Evaluation
Town of Hempstead; Shellfish Evaluation
EMAP Program
NYSDEC RIBS; Biomonitoring and Sampling Locations
USGS; Water Resources Division; Stream Water Quality
New Locations
State Parks
Villages
South Shore Estuary
Highways
Town Boundary
New York State Department of State
Division of Coastal Resources
Produced by New York State Department of State, Division of Coastal Resources, GIS Unit December 28, 2000

Figure 4-2

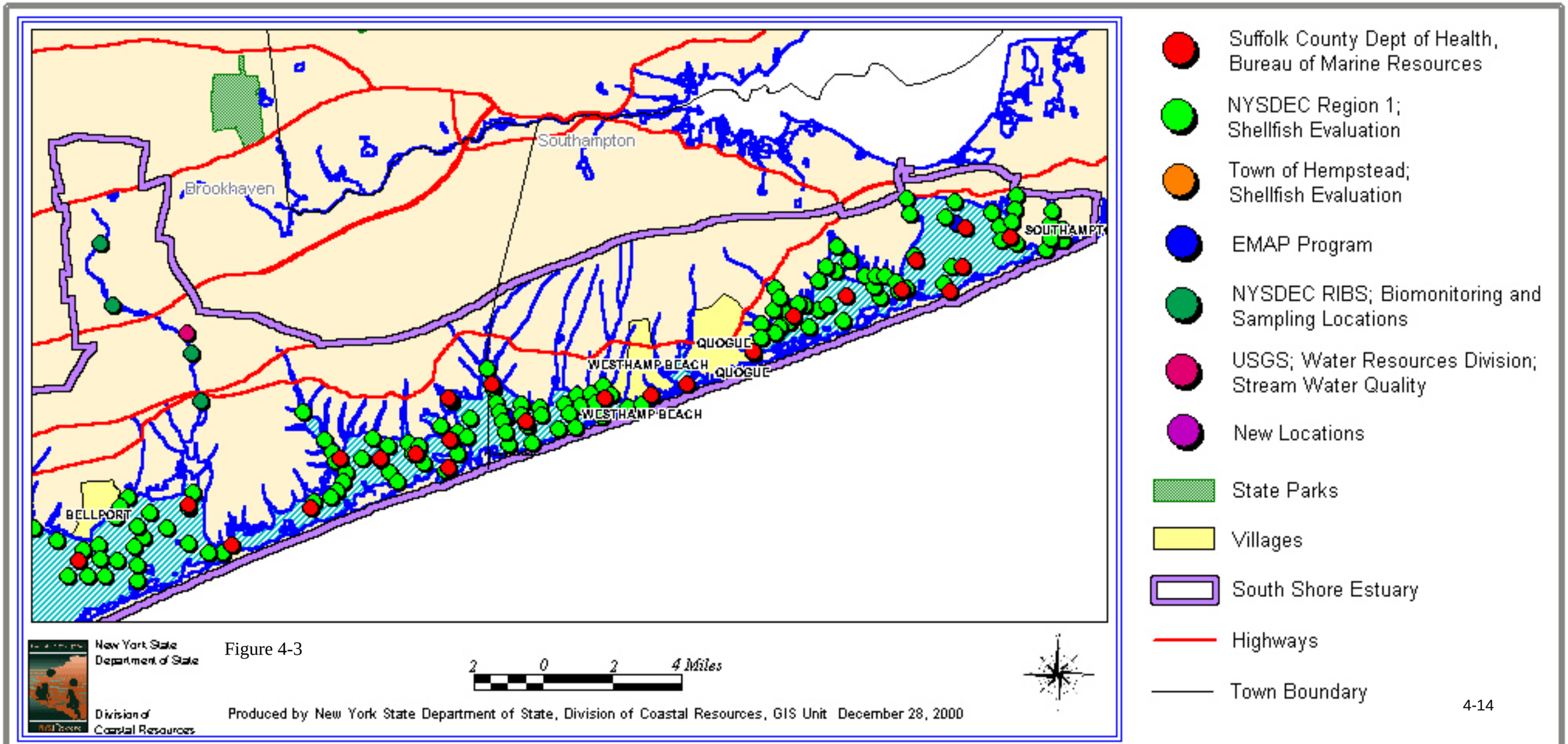

Southampton
Brookhaven
SOUTHAMPTON
QUOGUE
WESTHAMP BEACH
QUOGUE
WESTHAMP BEACH
BELLPORT
Suffolk County Dept of Health, Bureau of Marine Resources
NYSDEC Region 1; Shellfish Evaluation
Town of Hempstead; Shellfish Evaluation
EMAP Program
NYSDEC RIBS; Biomonitoring and Sampling Locations
USGS; Water Resources Division; Stream Water Quality
New Locations
State Parks
Villages
South Shore Estuary
Highways
Town Boundary
New York State Department of State
Division of Coastal Resources
2 0 2 4 Miles
Produced by New York State Department of State, Division of Coastal Resources, GIS Unit December 28, 2000

Figure 4-3

Chapter

5

Gap Analysis

Chapter 5: Gap Analysis:
Alignment between issues and the existing program

In Chapter 2 we outlined a series of working hypotheses to guide design of a long-term monitoring effort in the SSER. The working hypotheses (addressing loading, water quality, and ecological integrity issues) reflect goals for the SSER and the current state of understanding of functional relationships within the ecosystem. There are specific data needs to test these hypotheses.

Existing monitoring programs, tabulated in Chapter 4, have been developed largely in response to particular regulatory requirements or water quality issues. There is tremendous variation in size and intensity of the existing monitoring programs as well as in their duration. Data gathered by the existing monitoring programs may not be sufficient to test the working hypotheses for the long-term monitoring effort. In this chapter we summarize results of a gap analysis comparing data needed to test these working hypotheses with data provided by existing programs. Results of the gap analysis have been used as a basis for recommending additional monitoring parameters and locations for the Coordinated Monitoring Strategy.

Working hypotheses are presented in categories corresponding to the central management challenges facing the SSER: hard clam population, shellfish purity, control of brown tide (nuisance algal blooms), and maintenance/restoration of a natural ecosystem. Clearly there are overlaps between the categories; attributes of the natural ecosystem, for example, will include control of nuisance algal blooms and stable populations of hard clams. The working hypotheses are listed under a single issue, but are cross-referenced to note interrelationships.

A. Management of hard clams

Related working hypotheses:

(1) Standing crop of hard clams has increased throughout the SSER. Annual harvest has increased to a level comparable to the 1970s, and interannual variability is within 20% (indicating that harvest is at a sustainable level). {*cross reference: brown tide, natural ecosystem*}

Data needs to test:

- Standing crop estimates
- Age (size) distribution estimates
- Harvest (landing) estimate
- Area of certified shellfish harvest

Gaps in existing programs:

- Estuary-wide population estimates (addressed by Living Resources program)

B. Control of pathogens and pathogen indicators from stormwater and maintenance of shellfishing areas.

Related working hypotheses:

(1) The total area of shellfish closures due to exceedances of shellfish safety standards for indicator bacteria has decreased (indicating improved water quality). {*cross reference loading, natural ecosystem*}

Data needs to test:

- Area of certified shellfish harvest

Gaps in existing program:

- None

(2) Implementation of storm water management practices in the watershed has reduced loading of total suspended solids, and pathogen indicators to the SSER. {*cross reference: natural ecosystem*}

Data needs to test:

- Storm event sampling results (flow and concentration) to estimate load of indicator bacteria and TSS. We recommend designing these investigations as before and after studies of the effectiveness of control measures.
- Priority subwatershed designation

Gaps in existing program:

- BMP implemented at local level, not centrally tracked
- Tributary loading estimates are not part of existing program.
- Percent impervious cover in subwatersheds (information collected but not interpreted in every area).

C. Control of brown tide

Related working hypotheses:

(1) The ratio of inorganic to organic N is within 10% of the historical mean. {*cross reference natural ecosystem, loading}*

Data needs to test:

- Water column concentration of dissolved organic N (DON) and dissolved inorganic N (DIN)
- Estimated groundwater flux
- Groundwater concentration of DIN, DON
- Flushing analysis and N load analysis of individual embayments to assess vulnerability to enrichment and nuisance algal bloom conditions (could also be used to locate strategic monitoring points for an early warning of developing blooms).

Gaps in existing programs:

- Inconsistent measurements of water quality parameters (Town of Hempstead and Suffolk County do not monitor same suite of N parameters in water column).
- Groundwater flow
- Groundwater N species data
- Flushing analysis of embayments

(2) The abundance of phytoplankton associated with nuisance algal blooms such as brown tide organism is below bloom thresholds. {*cross reference natural ecosystem, hard clams*}

Data needs to test:

- Chlorophyll *a* concentration in water column (total and associated with small plankton cells)
- Species composition of phytoplankton community (dominant taxa by numbers and biovolume)
- Presence and abundance of *Aureococcus anophagefferens*

Gaps in existing programs:

- Only Suffolk County monitoring size fractionated chlorophyll a and presence/abundance of *Aureococcus anophagefferens*
- Limited data on phytoplankton community composition
- No data on biovolume of taxa

D. Maintenance/restoration of the natural ecosystem.

Related working hypotheses:

(1) Loading of nitrogen and phosphorus to the SSER is not significantly different in 2003 – 2005 than in 2000-2002.

Data needs to test:

- Estimates of N and P load from tributaries, direct runoff, groundwater, ocean exchange and atmospheric deposition

Gaps in existing programs:

- No recent loading estimates for most budget compartments (adequate data may be available to characterize atmospheric deposition and ocean exchange)
- No data available to estimate nutrient flux from sediments of embayments and potential contribution to budget
- No program in place to explicitly estimate nutrient export as a function of land use. *Note: there is a need for more detailed assessment and tracking of land use data to relate land use and water quality.*

(2) Average concentrations of dissolved inorganic N and P, chlorophyll *a*, total suspended solids, and light attenuation measured at least monthly from May – September meet site-specific criteria for SAV growth requirements. { *cross reference brown tide*}

Data needs to test:

- Verification of appropriate target levels for SAV criteria for the SSER embayments (site-specific criteria for dissolved inorganic nitrogen, dissolved inorganic phosphorus, chlorophyll a, total suspended solids, and light attenuation).
- Water column measurements of parameter list throughout SSER at defined frequency and annual duration

Gaps in existing programs

- Light penetration not measured
- TSS not consistently measured
- Need consistent protocols for N and P fractions
- Limited nearshore data for TSS, light penetration

(3) Salinity at key monitoring locations in the SSER is within 15% of the long-term annual mean corrected for tidal stage and antecedent precipitation. {*cross reference loading, brown tide*}

Data needs to test:

- Salinity at multiple stations selected based on circulation and tidal exchange
- Profiles of salinity, temperature, and dissolved oxygen measured at 0.3 meter depth intervals through water column in selected isolated embayments and at mouths of tributaries

Gaps in existing programs

- Limited profile data
- Limited nearshore data

(4) Sediment quality has improved as indicated by the decline in concentration of selected target compounds. *{ cross reference loading}*

Data needs to test:

- Synoptic survey of sediment contaminant levels
- Selection of contaminants of concern

Gaps in existing programs

- Not included in any existing program

(5) The abundance and density of SAV (primarily eelgrass) has increased in the system { *cross reference brown tide*}

Data needs to test:

- Regular surveys (preferably annual) of total area with SAV
- Estimates of percent cover or biomass of all SAV
- Species composition of SAV
- Tidal elevation during survey

Gaps in existing programs

- Aerial photographs not interpreted or field verified

Chapter

6

Draft CMP

Chapter 6: Proposed Coordinated Monitoring Strategy

A. Introduction

The Comprehensive Monitoring Strategy (CMS) is the outcome of a process that began with defining goals and objectives for managing the South Shore Estuary Reserve. These broad management goals and objectives were translated into system-specific hypotheses based on the state of understanding of how the SSER functions. Next, we compiled and reviewed existing monitoring programs to determine the extent to which these programs could provide data at the spatial and temporal scales needed to test the management hypotheses. The recommended CMS builds on the existing programs, adding parameters and sampling sites needed to determine the extent to which management of the SSER is successful in achieving water quality and ecological goals.

The CMS includes physical, chemical, biological, and human-induced attributes of the entire system, which includes the land, estuary, and ocean. We have organized the recommended strategy into two tiers. The Tier 1 monitoring program is designed to assess trends in water quality and the extent to which desired uses of the SSER (from both the human and ecological perspective) are met. This is a baseline program with recommended elements to be repeated at defined intervals. Most of the Tier 1 monitoring programs are designed to be carried out each year. A summary of recommended Tier 1 elements is included as Table 6-1.

Tier 2 activities are envisioned as short-term investigations, more intensive in temporal and/or spatial scale, designed to test specific hypotheses regarding water quality or ecological issues in the SSER. A number of significant questions remain regarding the nature of the system and Tier 2 projects can be designed to fill these data gaps. For example, the recommended Tier 1 monitoring program includes chlorophyll *a* measurements at all stations as a routine index of overall phytoplankton abundance. The species composition (relative abundance of major taxa and seasonal succession) of the phytoplankton community is not well characterized. Consequently, the Tier 1 program also includes monitoring species composition, biomass and biovolume of the phytoplankton community at a limited number of stations. As a Tier 2 project, we recommend characterizing the phytoplankton community throughout the entire monitoring network. The results of this Tier 2 project would help determine which stations should be routinely monitored for phytoplankton. A summary of recommended Tier 2 activities is presented in Table 6-2. These recommended activities reflect the current status of the resource and gaps in our understanding of how it functions. By their nature, Tier 2 activities will be dynamic.

Based on the findings of a particular Tier 2 investigation, Tier 1 monitoring could be expanded to include additional parameters or locations. For example, the potential for sediment contamination by metals or organic compounds has been identified as a concern for the SSER. Data to fully characterize the presence and extent of affected sediments have not been collected. A screening level program of sediment monitoring is recommended as a Tier 2 activity. These results may identify a subset of parameters that would be appropriate for long-term monitoring for trend analysis and use attainment. The results of the Tier 2 project would then guide design of a Tier 1 program. A mechanism for reviewing findings of Tier 2 investigations and incorporating additional parameters into the Tier 1 baseline program is a necessary part of the CMS.

In the following sections we present the recommended Tier 1 and Tier 2 programs for monitoring the SSER and its watershed. Physical, chemical, biological and human- induced (e.g. land use)

attributes of the tributary and watershed, estuary, and ocean are discussed. We also summarize recommendations for improved coordination among agencies, implementation of a quality assurance/quality control program, and centralized data analysis and reporting.

It is not the intent of the CMS to recommend specific contractors or consultants for any aspects of the monitoring program, either Tier 1 or Tier 2. . New York State law requires open procurement for award of public funds. References to specific agencies, work efforts, or models are included when necessary to describe current or proposed activities.

B. Physical Parameters

(1) Tributary and Watershed Program

Stream discharge. The recommended Tier 1 monitoring program includes monitoring discharge of freshwater to the SSER through its major tributaries. The USGS currently operates nine continual gauges on rivers and streams flowing into the SSER. Discharge has been monitored at other sites within the SSER for various periods of record. The sites currently monitored are:

- Carmans River at Yaphank
- Swan River at East Patchouge
- Connequot River at Oakdale
- Carlls River at Babylon
- Sampawams Creek at Babylon
- Massapequa Creek at Massapequa
- Bellmore Creek at Bellmore
- East Meadow Brook at Freeport
- Pines Brook at Malverne

We recommend that USGS continue to maintain the stream gauges and collect flow data at these locations. In addition to characterizing streamflow conditions, these data can be used to estimate material loads (for locations with water quality measurements).

The DEC samples Swan, Connetquot, Carlls, Patchogue, Sampawam and Carmans Rivers as part of their RIBS Rotating Intensive Basin Survey initiative. Of these streams, only the Patchogue is not currently monitored for flow. The value of the chemical and biological data collected as part of the RIBS effort could be greatly enhanced by analyzing the flow regime during sampling events. Return frequency of events such as low flow or flood conditions can be quantitatively assessed through the historical streamflow records. We therefore have included as a recommendation that a gauge site be established on the Patchouge River.

In fall 1999, the South Shore Estuary Watch (SSEW) began monitoring seven tributary streams within the watershed (refer to Table 4-8). Unless standardized methods are adopted for sample collection and analysis, data from this effort will not be comparable to results of other monitoring programs, and will not support loading estimates. We recommend that this and other citizen monitoring programs utilize the EPA methods manual specific for estuarine monitoring (http://earth1.epa.gov/OWOW/monitoring/volunteer/estuary/index.html)

There are no stream gauges located within the eastern Suffolk County portion of the SSER. Most streams in this region are short, low elevation, and drain small watersheds. We recommend that USGS (and others as appropriate) seek candidate sites for a stream gauging station in this region of the reserve. A gauge site could provide information regarding streamflow in an area of the SSER not yet urbanized. If water quality parameters are measured as well, the loading of materials to the SSER from this region could be quantified. Beaverdam Creek (near Westhaven), a tributary to Moriches Bay, may be a possible site.

Groundwater discharge to the estuary. USGS and researchers from Princeton University modeled groundwater flux to the SSER embayments in support of the comprehensive water and wastewater planning for the 208 program. These hydrodynamic models were developed at a fairly coarse scale (grid sizes were approximately 1 mile).

Hydrodynamic modeling has advanced greatly since this work was completed in the mid to late 1970s. Camp Dresser & McKee (CDM) developed a groundwater model of Nassau County subsequent to the 208 work. USGS developed a three-dimensional flow model simulating groundwater movement for the entire island. The groundwater flow model is coupled with a geographical information system for ease in manipulating and displaying data.

In 1996, Suffolk County contracted CDM to develop a regional groundwater model. The project has been separated into three phases: (1) development of a groundwater flow model for the main body of Suffolk County; (2) development of groundwater flow models for the eastern end of Suffolk County; and (3) integration of contaminant transport codes with the groundwater flow models. A draft report of the Phase 1 effort is under review. The model selected for the project is CDM's DYNFLOW (DYNamic groundwater FLOW), a fully three dimensional finite-element computer code. Results of the Phase 1 effort indicate that the model has been successfully calibrated and tested.

USGS has proposed refining their island-wide three-dimensional groundwater model MODFLOW for application within the SSER. The USGS model MODFLOW also uses the finite element approach to modeling groundwater flow in three dimensions. The refined model would enable managers to track groundwater flow, identify groundwater recharge areas, and better define interrelationships between stream flow and groundwater.

Model development, calibration, and testing require a great deal of effort and resources. We therefore recommend that agencies evaluate the potential for cooperating on a groundwater model that has the boundary conditions, grid size and spacing, and number of layers appropriate for managing the SSER. As discussed in the section on forcing functions, groundwater inflows represent a significant fraction of the hydrologic budget of the embayments and thus influence both flushing rate and ambient salinity levels. When coupled with water quality data, a groundwater flux model could be used to assess the contribution of groundwater to the total external load of chemicals to individual embayments.

Developing, calibrating, and testing a groundwater model for the SSER includes both Tier 1 (recurrent) and Tier 2 (short-term, intensive) work elements. The Tier 1 work elements are: (1) synoptic measurements of water table configuration in the upper glacial aquifer and the potentiometric surface altitudes of the Magothy and Lloyd aquifers; and (2) continuous stream discharge measurements. Tier 2 work elements include field characterization of soils and hydraulic conductivity, model development, model calibration and model testing.

(2) Estuary Program

Light penetration. Suffolk County, the Town of Hempstead and the National Park Service currently monitor water clarity using Secchi disks. SSER embayments are shallow and the historical record includes many observations of Secchi disk at bottom (i.e. still visible at the sediment surface). These results limit data usability for statistical trend analysis.

A more robust indicator of light penetration is to measure depth to which a standard percent of ambient light penetrates, or the percent penetration of light at a standard depth. We recommend that light penetration be monitored using a transmissometer (irradiance meter) and reported as: (1) percent of light penetrating to a standard depth (one meter); and (2) percent of ambient light penetration to the sediment surface. This will enable managers to track light penetration, a key parameter affecting habitat for submerged aquatic vegetation. These detailed measurements will help identify the extent to which light penetration limits primary productivity in the embayments. We also recommend that these agencies continue to measure Secchi disk transparency to ensure comparability with historical data and data collected in other estuaries.

While transmissometers can provide detailed data regarding light penetration through the water column, the instruments are difficult to operate and maintain under adverse field conditions. The most reliable data are obtained under calm conditions. It can be challenging to obtain measurements at consistent depths under windy or stormy conditions.

Secchi disk transparency is easily measured, and data collected at frequent intervals in multiple locations in the nearshore subtidal zone provides valuable information regarding SAV habitat. Equipment costs are low. Data can be collected by trained citizens as well as by agency staff. We therefore recommend that Secchi disk transparency measurements be included in the citizen monitoring programs (South Shore Estuary Watch and other educational initiatives) and in the NYSDEC shellfish sanitation monitoring efforts.

Water temperature, tide stage, water circulation, and weather conditions. Several monitoring programs (Town of Hempstead, Suffolk County and National Park Service) measure temperature of the estuarine water as samples are collected.

USGS currently operates a tide-stage and weather-monitoring station on Reynolds Channel at Point Lookout. The station is operated and maintained by USGS in cooperation with the Town of Hempstead Department of Waterways and Conservation. The monitoring station measures water surface elevation, air temperature, water temperature, wind speed, wind direction, precipitation, barometric pressure, and relative humidity. These parameters are measured at 15 minute intervals and reported "near real time" on the New York USGS web site. The web site for accessing the near real-time data is http://ny.usgs.gov/rt-cgi/gen_tbl_pg (go to USGS site number 01310740).

USGS, in partnership with the National Weather Service, has proposed expanding the number of tide-stage monitoring stations within the SSER as part of an improved coastal flood warning system. New tide-stage monitoring sites are proposed for:

- Shinnecock Inlet near Hampton Bays
- Quogue Canal at Post Lane, near Quogue
- Moriches Bay at U.S. Coast Guard Station at East Moriches

- Narrow Bay at Smith Point Bridge, near Shirley
- Patchogue Bay at Patchogue
- Nicoll Bay at Great River
- Fire Island Inlet at U.S. Coast Guard Station at Fire Island, near Babylon
- Great South Bay at Lindenhurst
- Massapequa Bay at Massapequa
- Hudson Bay at Freeport
- Reynolds Channel at Long Beach Blvd., Long Beach
- East Rockaway Inlet at Atlantic Beach Bridge, at Atlantic Beach

Of the sites proposed for the SSER, two would include weather stations as well (Shinnecock Inlet, near Hampton Bays and Fire Island Inlet at U.S. Coast Guard Station at Fire Island, near Babylon).

The Army Corps of Engineers has proposed developing a "Long Island Coastal Monitoring & Modeling System" (termed *LI Shore*) for use in engineering and environmental projects in the SSER. *LI Shore* is an integrated system of monitoring and numerical modeling that is designed to support the Corps needs for navigation and shoreline protection. With additional commitment of funds, the model can be used to support emergency management decisions.

LI Shore would provide circulation models of the SSER embayments. A prototype system installed on Shinnecock Inlet uses modern instrumentation to monitor wind speed and direction, currents across the inlet, water level at the inlet, water level and current in Shinnecock Bay. These data are used to verify a numerical simulation model of circulation and water exchange in the Bay. With additional bathymetric data of the embayment and the perimeter shoreline, the model can be used to predict circulation, water level, and wave height during storms.

The Shinnecock Bay monitoring and modeling study prototype was developed by the NY District and headquarters of the Army Corps of Engineers (through the Corps' Coastal Inlets Research Program). Other partners include the Town of Southampton, U.S. Coast Guard, SUNY Stony Brook, Offshore & Coastal Technology Inc. (Corps contractor) and instrument manufacturers. *LI Shore* is designed to provide data and simulations near real-time (model calculations looking ahead about 24 hours) that are accessible to agencies and the public through the Internet.

The next phase of *LI Shore* is to proceed west in the SSER embayments, with installations of the instrumentation at Moriches Inlet and Bay, Fire Island Inlet and Great South Bay, Jones Inlet and Hempstead Bay, East Rockaway Inlet and Hempstead Bay. Measurements at these sites include: profile of water current across each inlet, water level at inlets, water level and current profile in embayments (one or more site in each embayment), wind speed and direction at Shinnecock and Fire Island, and offshore waves. The researchers measure conductivity and water temperature while they are servicing the equipment; to date, no probes that would provide a near-continuous record of water quality parameters have been installed. The *LI Shore* model can represent groundwater (freshwater) flows in the circulation and associated salinity model. There is an overall need for additional bathymetric data of the embayments and shoreline to improve accuracy of the circulation and wave model.

Once a regional circulation and wave model has been developed, the need for tide stage monitoring stations is greatly reduced or eliminated. Consequently, the decision to support

and extend the *LI Shore* model in the SSER (or to support development of any other hydrodynamic model) should be made in context of the USGS proposal for additional tide-stage monitoring sites. Not all of the 12 proposed tide- stage monitoring stations may be needed to predict coastal flooding once a model is operational. There is a great opportunity for collaboration on developing a unified approach to navigation needs, shoreline protection, and circulation modeling within the SSER embayments. This collaboration could result in substantial cost savings.

We recommend that a hydrodynamic model such as *LI Shore* or an equivalent approach be developed for application within the SSER embayments. Model forcing functions should include groundwater and surface water flows. There is an opportunity for collaboration with the ongoing Suffolk County groundwater modeling effort and/or the proposed USGS groundwater model. The appropriate number and location of permanent weather-monitoring stations to provide meteorological data with sufficient accuracy and precision to drive the hydrodynamic model should be discussed between the key agencies (Army Corps, USGS, and National Weather Service) and the research community. Based on descriptions of the proposed efforts, it appears that at least one additional weather station (at Shinnecock) is needed. The need for a third weather station at Fire Island Inlet should be evaluated.

We further recommend that monitoring stations installed for any hydrodynamic model include instrumentation to monitor water temperature and salinity. These data could test and verify groundwater flux and circulation models of the SSER embayments. In addition, the data could be used to address several data gaps and outstanding management questions such as effects of salinity on hard clams and their predators, and effects of changes in freshwater inflows on brown tide blooms.

As instrumentation continues to improve, consideration should be given to near real-time monitoring of turbidity and chlorophyll *a*. Acquisition of these data on a near-real time scale would be a Tier 2 activity, discussed below with the chemical monitoring program. We recommend that installations be designed with the capacity to accommodate additional monitoring devices for water quality parameters, to support future water quality modeling.

A verified hydrodynamic model is a necessary first step towards developing an integrated hydrodynamic and water quality model of the system. Ideally, a fully integrated model would be able to predict the hydrodynamic and water quality impacts of a range of conditions, both natural and human-induced. For example, it would be useful to predict the effects of wet years and dry years on salinity and nitrogen levels within SSER embayments. An integrated model could be used to test the impacts of alternative wastewater disposal locations, or predict the consequences of inlet breach or closure. Integrating land use and nutrient export data through a GIS system would provide a powerful tool for predicting water quality impacts of alternative land use decisions.

(3) Ocean Program

Ocean temperature and tidal exchange have a major influence on water circulation within the SSER embayments. A hydrodynamic model of the SSER embayments includes monitoring these physical parameters of the ocean system as boundary conditions.

Changes in configuration of inlets, both gradual and catastrophic, have the potential to strongly influence hydrodynamic exchange and water quality within SSER embayments. Aerial photographs of the barrier islands would be a useful baseline monitoring parameter.

(4) Summary of Recommendations: Physical Parameters

The recommendations are summarized in Table 6-3.

C. Chemical Parameters

(1) Tributary and Watershed Program.

Water quality monitoring of tributary streams is typically conducted to meet one or more objectives:
(1) Estimate external loading of materials,
(2) Assess compliance with ambient water quality standards,
(3) Compare concentrations of materials in different tributaries as a function of land use,
(4) Identify impairments to desirable uses,
(5) Evaluate the effectiveness of controls on point or nonpoint sources of pollution, and
(6) Detect trends.

Monitoring programs of tributaries to the SSER embayments have been carried out to meet one or more of these objectives. For example, USGS analyzed water chemistry and bacteria levels in Carmans River between 1966 – 1996 to examine trends and characterize the quality of the shallow groundwater aquifer. The Long Island-New Jersey National Water Quality Assessment Program (NAWQA) conducted several synoptic surveys in 1997 (synoptic surveys sample a large number of sites at the same time) for volatile organic compounds and pesticides. The Long Island Segment of the National Urban Runoff Program (NURP) collected storm and baseline water quality data in surface waters and shallow groundwater below recharge basins. This work was completed in 1982. Two tributaries of Great South Bay, Neguntaogue Creek in Babylon and Beaverdam Creek in Brookhaven, were monitored from April – August 1989 for a comprehensive suite of chemical and biological parameters. These data were collected to contrast water quality in streams with different land use.

At present, tributary monitoring is limited. Suffolk County has conducted a stream monitoring program since the mid-1970s to characterize baseflow water quality conditions in a network of 90 – 100 stream discharging to the SSER. Most streams are sampled annually, and 8 – 10 streams are sampled quarterly. DEC Rotating Intensive Basin Surveys (RIBS) program has been recently initiated for a few streams within Nassau and Suffolk counties. The RIBS program focuses on assessing the extent and severity of any impairment to designated best use of the stream. Use impairment is assayed by monitoring the biological community (especially macroinvertebrates) and conducting limited chemical testing of sediments and water. Citizen monitoring programs coordinated by the South Shore Estuary Watch analyze dissolved oxygen, nutrients, chemical oxygen demand, and composition and abundance of the benthic community. Samples are collected and analyzed in segments of several streams. Unfortunately, the analytical methods used by the SSEW cannot detect low levels of nutrients. Implementing a comprehensive quality assurance/quality control (QA/QC) program could enhance utility of data gathered through the citizen program. A QA/QC program is under development (Paul Licthman, personal communication, March 1, 1999). We recommend that the program be consistent with EPA guidance for volunteer monitoring of estuaries.

We recommend chemical monitoring of selected SSER tributaries. Specific hypotheses to be tested through the proposed tributary monitoring effort include:

(1) Implementation of stormwater management practices in the watershed has reduced the external load of suspended solids and pathogens (as assessed by indicator organisms) to SSER embayments.

(2) Annual loads of nitrogen and phosphorus to SSER embayments have not significantly changed.

(3) Tributary water quality is adequate to support designated best use.

(4) Concentration of nitrogen species in streams varies as a function of land use.

The first two hypotheses relate to external load; therefore, recommended locations for chemical monitoring must consider locations of stream gauges. Frequency and timing of monitoring must be adequate to capture the annual range of hydrologic conditions and reflect the critical period for potential peak loads or water quality impairment. For example, hypoxic conditions (low dissolved oxygen) are most severe during low flow, warm temperature conditions. The monitoring program to test the third hypothesis is therefore designed to sample more intensively during summer and fall. In contrast, the monitoring program to test effectiveness of storm water controls is focused on periods of precipitation and snowmelt.

Both Tier 1 and Tier 2 programs are needed to test these hypotheses. To test the first hypothesis we recommend short-term, intensive, "before and after" water quality monitoring as stormwater management improvements are implemented. We consider this a Tier 2 activity, because it is intensive in scope and limited in duration. Selection of appropriate sites for the recommended "before and after" monitoring depends on location of planned improvements to stormwater collection and treatment systems. Communication with representatives of Town Departments of Public Works and Engineering is necessary.

We consider monitoring to test remaining hypotheses (related to loads, concentrations, and use impairment) as part of the Tier 1 program. This baseline monitoring programs should be carried out each year. Sampling locations and parameters are listed in Table 6-4. Additional details regarding analytical methodologies for tributary monitoring are summarized in Table 6-5. Locations were selected based on the extent of historical information, spatial coverage within the SER, and a representative mix of land use.

Water quality sampling to support loading estimates should be conducted as close to the stream gauging site as possible. Additional discussion of tributary monitoring that can be used to assess the extent to which designated uses are met is presented in section D (biological parameters, tributary and watershed sampling). To complement the biological monitoring we recommend monitoring water temperature, pH, dissolved oxygen, and salinity at sites throughout the tributaries. Physical parameters of the stream environment (depth, velocity, and substrate composition) should be recorded as well.

(2) Estuary Program

Water quality monitoring within SSER embayments is a central activity of the CMS. Routine monitoring of embayments has been underway since completion of the 208 investigations in 1977. Suffolk County conducts the most extensive program. Over the years, the lists of

analytes and analytical limits of detection have changed; monitoring stations have remained relatively consistent.

The majority of water quality monitoring within SSER embayments is performed by three agencies:

(1) Suffolk County Department of Health Services, Office of Ecology, Bureau of Marine Resources.
(2) Town of Hempstead, Department of Conservation & Waterways.
(3) NYSDEC, Shellfish Sanitation Program.

The National Park Service also monitors water quality at several stations off Fire Island.

Recommendations for Tier 1. Based on our assessment of goals and working hypotheses, Tier 1 monitoring of chemical indices of water quality in SSER embayments is needed to meet two broad objectives: (1) assess whether current water quality conditions support desired uses, and (2) evaluate trends in water quality. The suite of recommended chemical parameters includes several not directly associated with use impairment (that is, New York has not adopted an ambient water quality standard for the chemical). These chemicals are recommended because of the interrelationships between water chemistry and the biological community.

The recommended list of analytes, sample locations, depths, and methods for Tier 1 chemical monitoring is presented in Table 6-6. Recommended monitoring stations are shown in Figure 6-1. The Tier 1 program calls for biweekly monitoring for a suite of parameters. Biweekly sampling may not be required for some parameters exhibiting minimal variation. Other parameters such as chlorophyll *a* and abundance of *Aureococcus anophagefferens* are highly dynamic and sampling should be conducted at short time intervals to capture this natural variability.

We recommend that biweekly sampling be implemented beginning in the year 2000. Sampling at this frequency should continue for a minimum of three years. After sufficient data have been collected, a statistical analysis can be performed to quantitatively examine the reduction in standard error of the mean of each parameter gained by a biweekly versus monthly sampling regime. This analysis will provide an objective framework for defining optimal sampling frequency.

Implementation of the recommended program will require changes and additions to the ongoing programs of Suffolk County and the Town of Hempstead. The existing monitoring network should be retained, with a few modifications. We recommend adding a total of four monitoring stations in South Oyster Bay. Suffolk County and the Town of Hempstead should discuss the logistics of adding the four stations to the programs and determine which agency will add which site(s). The recommended Tier 1 program calls for a consistent list of water quality parameters and analytical methods throughout the SSER. Specific impacts on existing monitoring programs of Suffolk County; the Town of Hempstead, and NYSDEC (Shellfish Sanitation) are summarized in Table 6-7.

Recommendations for Tier 2. The Tier 1 baseline program will provide data for trend analysis and use attainment. To address additional issues and remedy data gaps; Tier 2 programs can be implemented to supplement baseline monitoring. Examples of Tier 2 programs for chemical monitoring are:

- Sediment quality assessment of depositional areas located at tributary mouths, wastewater outfalls. Analytes:
  - Texture (particle size distribution)
  - Total solids
  - Total organic carbon
  - Copper, cadmium, chromium, nickel, zinc, lead, mercury
  - Total polyaromatic hydrocarbon
  - Trichloroethylene (TCE)
  - BTX (benzene, toluene, xylene)
  - MBTE

We recommend that sediment testing be carried out as soon as resources are available. Many of the researchers and agency representatives interviewed considered this a significant unknown issue. Consider separate analyses of the upper layer of sediment cores (approximately 50 cm, representing material deposited within the last 50 years).

- Pesticide scan (*compounds selected based on results of Pesticide Concentrations in Surface Waters of New York State in Relation to Land Use – 1997 by Patrick Philips, Gary R. Wall, David A. Eckhardt, Douglas A. Freehafer, and Larry Rosenmann*. USGS WRI 4101
  - Chlordane,
  - DDT plus breakdown products (DDE, DDD)
  - Aldrin
  - Dieldrin
  - Carbaryl
  - Diazonon

We recommend that filtered surface water and sediment samples be screened for the presence and concentration of these pesticides, which were selected based on the results of low-level pesticide sampling conducted by USGS and NYSDEC. However, the list of potential pesticides in surface waters of the SSER is large. We therefore recommend that the analysis include a library scan for the presence of other pesticides. The list of target compounds should be reviewed annually in light of the most recent findings of the Suffolk County Health Dept. and Town of Hempstead groundwater testing programs, the USGS and NYSDEC low-level monitoring programs, and the Suffolk County Water Authority.

- Diurnal investigations of dissolved oxygen, salinity, water temperature

(3) Ocean Program

Chemical quality of ocean water flowing into the SSER is an important determinant of water quality. The Tier 1 monitoring program outlined in Table 6-6 will provide data and information regarding boundary conditions of salinity, temperature, nutrients, and suspended solids.

D. Biological Parameters

(1) Tributary and Watershed Program

Two aspects of biological monitoring are recommended for Tier 1. First, macroinvertebrate assessment of streams will provide data and information regarding the existence and extent of impairment. The biological community integrates the effects of different pollutant stressors and provides a holistic measure of their aggregate effect. Benthic macroinvertebrates are good indicators of localized conditions. Because they have limited migration patterns or a sessile mode of life, they are well suited for assessing site-specific impacts of point and nonpoint discharges. Many agencies, including NYSDEC, use macroinvertebrates as indicators of stream quality. Sampling is relatively easy and inexpensive. We recommend rotating macroinvertebrate field sampling throughout the SSER watershed so that each of the major streams is sampled every three years.

Second, monitoring pathogen indicators in tributaries would address several objectives:
(1) loading estimates,
(2) comparisons of water quality between streams with contrasting land use,
(3) compliance with ambient water quality standards, and
(4) Before and after assessment of the effectiveness of stormwater management.

The recommended Tier 1 monitoring program for tributaries includes measurement of fecal coliform bacteria at those tributary streams selected for chemical monitoring. These data would be used to support analyses of objectives 1 – 3. As discussed above, intensive monitoring needed for a "before and after" assessment of the effectiveness of stormwater controls is a Tier 2 activity. Design of this program is dependent on the location, timing, and extent of planned improvements.

The recommended biological monitoring program for tributaries to the SSER is outlined in Table 6-8.

(2) Estuary Program

Biological monitoring within SSER embayments is recommended to meet several data gaps and management objectives. Existing biological monitoring efforts are designed to assess compliance with bacterial standards for water contact recreation and shellfish sanitation; monitor presence and abundance of the brown tide alga, *Aureococcus anophagefferens*; evaluate areal extent of SAV beds; and record harvest of hard clams. In 1999, additional sampling was initiated to document the presence and abundance of *Pfiesteria*.

Tier 1. The recommended Tier 1 biological monitoring program for SSER embayments is based on these existing programs with some modifications (Table 6-9). Biweekly sampling is recommended year-round (winter sampling as conditions allow). Visual mapping of the extent of macroalgae beds is recommended as an annual activity. Finally, we recommend implementation of a regular program of aerial photography and field verification to assess the status of SAV.

The recommended program would require a substantial commitment by the participating agencies. There are financial and workload implications of these recommendations that will need to be considered.

Tier 2. The Tier 1 monitoring program is centered on indicator organisms; measuring the presence and abundance of several key species to provide information regarding the overall ecological status of the SSER and its suitability for desirable uses. Because our understanding of the SSER ecosystem is incomplete, the Tier 2 program includes short-term, intensive monitoring programs to address some data gaps. Again, there are labor and cost issues associated with each of the Tier 2 recommended projects. The lack of the data has, in many cases, restricted management efforts in the past.

Examples of Tier 2 issues include:

(1) Annual succession of phytoplankton species
(2) Species composition and abundance of zooplankton
(3) Species composition and abundance of ichthyoplankton
(4) Species composition, abundance, and diversity of benthic macroinvertebrates.
(5) Monitoring for *Enterococcus*, an additional indicator of the potential presence of pathogens, at bathing beach sites.

(3) Ocean Program

No biological monitoring of the ocean is recommended as part of the CMS. Currently, EPA collects samples for pathogen indicators (fecal coliform and *Enterococcus*) at beaches along the ocean side of Fire Island as part of their helicopter monitoring program. Samples collected at inlets can be used to estimate input of bacteria to SSER embayments from the ocean.

E. Human- Induced Parameters

Land use and waste disposal decisions clearly have potential to affect water quality in the SSER. Other, less evident, linkages affects water quality as well. For example, wetland disturbance and filling can reduce natural filtering and attenuation of stormwater flows. Harvest of hard clams affects standing crop of filter feeding organisms. Dredging of inlets can affect tidal exchange and the potential for resuspension of suspended solids. The CMS consequently includes tracking several key human-induced activities as part of Tier 1 Recommended parameters are summarized in Table 6-10 and discussed below.

(1) Tributary and Watershed Program

Impervious cover is a significant factor influencing stormwater runoff, both peak flows and total volume. The planning agencies for Suffolk County and Nassau County track land use. Coordination with these agencies is necessary to compile data on a subwatershed basis. The Department of State's Division of Coastal Resources has supported development and use of a GIS for tracking and analyzing change in land use. There is a need for a detailed inventory of land use on a subwatershed basis that can be used to support nutrient loading and hydrologic (stormwater runoff) models.

The total area of wetlands filled and disturbed can be compiled through permit records of NYSDEC and the Army Corps of Engineers. We recommend compiling these data every three years.

Stream stabilization or restoration projects in the watershed might influence downstream transport of sediment. We recommend tracking these actions and compiling the data every three years.

(2) Estuary Program

Towns and NYSDEC currently record landings of hard clams. These data should be compiled for all SSER embayments each year. Cooperation of the Bluepoint Company, Inc. in Great South Bay would increase the accuracy of the estimates, and we recommend that representatives of this private company be asked to participate as part of the CMS.

Dredging activities also affect water quality. The location of dredging, volume of material removed, and results of any analytical testing associated with disposal should be tracked as part of the CMS.

As part of the State Pollution Discharge Elimination System (SPDES) program, each permitted outfall to SSER embayments is monitored for effluent volume and quality. These data are reported to the State in monthly Discharge Monitoring Reports (DMR). We recommend including a mechanism for accessing DMR (or summaries) and SPDES permit renewal requests as part of the CMS.

(3) Ocean Program

We recommend tracking inlet dredging and beach stabilization programs.

E. Quality Assurance/Quality Control Program

The Coordinated Monitoring Strategy recommends continued participation of several agencies in collecting and analyzing samples. A Quality Assurance/Quality Control (QA/QC) program is needed to ensure that data quality is adequate to support management decisions.

The Town of Hempstead Department of Conservation & Waterways, NYSDEC Shellfish Sanitation Program, and Suffolk County Bureau of Marine Resources use certified laboratories to analyze samples collected in SSER waters. New York State Department of Health through the Environmental Laboratory Approval Program (ELAP) certifies Hempstead and Suffolk County laboratories. The USGS and private laboratories are also certified through ELAP. The DEC laboratory is certified through the federal Food and Drug Administration shellfish sanitation program; this laboratory, in turn, certifies the Town of Hempstead shellfish sanitation laboratory. As certified laboratories, these facilities are required to utilize standard written protocols for sample handling, instrument calibration and checking, sample analysis, and data reporting. A regular audit program is in place to verify precision and accuracy of analyses.

However, there is a need for additional QA/QC measures to be incorporated into the CMS. As presented in Tables 6-5 and 6-6, analytical protocols need to be standardized between participating laboratories. Communication between personnel of the various laboratories needs improvement. Procedures for sample collection, handling, and reporting should be better documented. These measures will greatly improve data usability.

Standard EPA protocol includes five elements in a QA/QC program: precision, accuracy, representativeness, comparability, and completeness. These five elements (called the PARCC parameters) need to be incorporated into both field and laboratory programs.

The recommended QA/QC program is summarized in Table 6-11. Field replicate samples should be collected at a frequency of 1:20 (5%). An annual program of sample splits between participating laboratories is recommended.

F. Program Management

The CMS is envisioned as a means to gather data to indicate whether water quality and resource-related goals for the SSER are being met. Monitoring activities will occur over time, and individual participants will change over the years. It is very important to identify a program leader committed to making this long-term monitoring program a priority. There will always be competition for funding and allocation of staff time, and a long-term monitoring program such as the CMS will require a strong advocate.

One agency and individual within the agency should be identified to serve as overall program manager. This leader would be responsible for coordinating activities of participating agencies and serving as a point of contact for data and information. Examples of responsibilities of the program manager include:

- Reviewing detailed monitoring plans of participating agencies.
- Developing and distributing protocols for unified data handling, including data screening.
- Overseeing data analysis (plotting and statistical analysis for trends).
- Maintaining a central database of results.
- Convening meetings to discuss results and decide whether modifications are needed.
- Advocating for funding of Tier 1 monitoring.
- Advocating with institutions and funding agencies for implementation of Tier 2 programs.
- Preparing an annual summary "State of the SSER" report.
- Meeting with the public to discuss progress.

Based on these responsibilities, the program manager would need a technical background in marine environmental science or engineering coupled with experience in marine water quality monitoring and data analysis. Strong communication skills will be needed to foster communication between participating agencies and deal effectively with the public.

G. Cost Estimate

Costs of implementing the recommended CMS are difficult to estimate; some recommendations call for additional parameters to be collected and analyzed by agency staff already working on SSER monitoring programs. Additional data collection requires time in data handling, interpretation, and reporting in addition to longer field days. The critical points for needing to add staff are not known.

The estimated cost of Tier 1 monitoring as outlined in this document is presented in Table 6-12. These figures represent costs associated with implementing the recommended program of

sampling and analysis. There are also costs associated with program management, data handling (including database development and statistical analysis), and inter-agency coordination.

The Army Corps of Engineers provided cost estimates for their proposed modeling program. Total cost for the LI Shore Model was estimated by the Corps at $ 1,642,800 (year 1) and $755,200 (year 2). Adding temperature and salinity sensors would cost an additional $5000 per gauge per year.

TABLE 6-1

Tier 1 Elements

Physical Parameters		Frequency
Land	Discharge from tributaries	Near- continuous USGS surface water gauges
	Groundwater discharge to selected bays (modeled using annual synoptic surveys of groundwater altitude, plus streamflow)	Annual synoptic survey, plus near-continuous data from USGS gauge sites
Estuary	Light penetration	Biweekly sampling, year-round (as conditions allow)
	Temperature	Near-continuous recording devices at select locations, plus biweekly monitoring
	Waves	Near-continuous recording devices at select locations,
	Currents	Near-continuous recording devices at select locations,
	Winds	Near-continuous recording devices at select locations,
	Water level	Near-continuous recording devices at select locations,
Ocean	Currents (at inlets)	Near-continuous recording devices at select locations,
	Water (sea) level	Near-continuous recording devices at select locations,
	Temperature	Near-continuous recording devices at select locations,
	Inlet migration and erosion/deposition of barrier beach	Annual aerial photos
Chemical Parameters		**Frequency**
Land	Tributary concentration of TSS, TP, SRP, TKN, DKN, NH_3-N, NO_2+NO_3-N, salinity	Annual biweekly monitoring program (modified to capture base flow plus storms)
	Groundwater concentration of dissolved N species, chlorides, target organic compounds	Annual monitoring program (frequency to be defined by USGS and other agencies involved in groundwater modeling)
	Temperature, DO, pH, salinity (or specific conductance) in tributary reaches	Annual monitoring program, concentrated during low flow, warm water conditions
	DO and salinity profiles at mouths of tributaries	Annual mo nitoring program, concentrated during low flow, warm water conditions
Estuary	TSS, turbidity, TP, SRP, TKN, DKN, NH_3-N, NO_2+NO_3-N, urea, TOC, salinity, DO	Annual monitoring program, biweekly sample collection
Ocean	Salinity	Near-continuous recording devices at inlets

TABLE 6-1 (continued)

Tier 1 Elements

Biological Parameters		Frequency
Land	Tributary rapid bioassessment screening for macroinvertebrates	Every 3 years (coordinated with NYSDEC RIBS program)
	Pathogen indicators in tributaries in response to stormwater improvements	As projects are implemented (before and after studies)
Estuary	Submerged aquatic vegetation (SAV)	Annual aerial surveys, field verification every 3 years
	Chlorophyll *a* (two size fractions), *Aureococcus anophagefferens* abundance	Annual monitoring program, biweekly sample collection
	Phytoplankton community composition (counts and biovolume of major taxa)	At selected stations (approximately 10), biweekly samples
	Zooplankton community composition (counts and biovolume of major taxa)	At selected stations (approximately 10), biweekly samples
	Macroinvertebrates (species richness and biomass)	At selected stations (6 – 10) four times each year
	Macroalgae beds	Annual visual assessment and mapping during August
	Hard clam population	Annual compilation of statistics (seeding, harvest) from Towns
	Indicators of the potential presence of pathogens in water column and shellfish	Annual compilation of NYSDEC monitoring results
Ocean	None recommended specific to this program	N/A
Human-Induced Parameters		**Frequency**
Land	Impervious cover, by subwatershed	Compile data from town, county, and regional agencies on an annual basis.
	Wetland areas created, disturbed and filled	
	Stream restoration activities	
Estuary	Hard clam harvest	Compile data from town, county, and regional agencies and NYSDEC discharge monitoring reports on an annual basis.
	Hard clam seeding programs	
	Volume and quality of effluent discharges to embayments	
	Dredge activities	Compile data from Corps of Engineers and Towns on an annual basis
Ocean	Inlet dredging and beach erosion control measures	Compile data from Corps of Engineers and Towns on an annual basis

TABLE 6-2

Tier 2 Elements

Recommended Tier 2 Investigation	Priority *
Support completion of three-dimensional groundwater flow model for entire SSER region	High
Support development of hydrodynamic model of embayments	High
Support development of water quality model that will be linked to hydrodynamic model	High
Assess sediment quality in depositional areas of SSER embayments and tributaries	High
Assess flux of nutrients from sediments	High
Work with Towns to design and implement before and after studies to document effectiveness of stormwater control measures	High
Include capability to measure turbidity and chlorophyll on any monitoring installation planned to support hydrodynamic model (to calibrate and verify water quality model component)	Medium
Measure species composition and abundance of the benthic community of SSER embayments (additional effort to complement Tier 1 monitoring)	Medium
Measure diurnal variability in dissolved oxygen, salinity, and temperature in embayments and at mouths of tributaries	Medium
Analyze annual succession of phytoplankton community in SSER embayments (additional effort to complement Tier 1 monitoring)	Medium
Analyze zooplankton community abundance, species composition, and annual succession (additional effort to complement Tier 1 monitoring)	Medium
Measure abundance and species of icthyoplankton	Medium
Do side-by-side measurements of *Enterococcus* and fecal coliform bacteria in bathing beach areas to assess comparability of different indicator	Medium

* Priority reflects the significance of the data and information to management decisions.

TABLE 6-3

Physical Parameter Recommendations

Recommendation	Tier	Affects
Continue stream gauging at nine sites in SSER watershed	1	USGS
Consider additional stream gauge locations at Patchouge River and a site in eastern Suffolk County that flows to the SSER.	1	USGS
Measure light transmission through water column of estuary embayments using transmissometer.	1	Town of Hempstead, Suffolk County
Add Secchi disk transparency measurements to all near-shore sampling sites.	1	NYSDEC, citizen monitoring, NPS
Install a permanent weather monitoring station at Shinnecock Inlet.	1	USGS, NWS, ACOE
Discuss the need for a third weather monitoring station at Fire Island Inlet.	1	USGS, NWS, ACOE
Discuss the need for additional tide stage monitoring stations to meet objectives for coastal flood warning system	1	USGS, ACOE
Add continual measurements of temperature and salinity at hydrodynamic data collection stations	1	ACOE
Aerial photographs of barrier islands to track changes in inlet topography.	1	ACOE

Recommendation	Tier	Affects
Support development of hydrodynamic model of SSER embayments (LI Shore or equivalent)	2	Technical agencies, universities, potential contractors
Complete three-dimensional groundwater flow model for entire SSER region using refined grid size	2	USGS, Suffolk County, CDM, universities, and potential contractors
Build in capability to monitor turbidity and chlorophyll *a* at hydrodynamic data collection stations.	2	ACOE or other potential contractors

ACOE = Army Corps of Engineers
CDM = Camp, Dresser & McKee
NOAA = National Oceanographic and Atmospheric Administration
NPS = National Park Service
NYSDEC = New York State Department of Environmental Conservation
NWS = National Weather Service
USGS = United States Geological Survey

All recommendations reflect new initiatives

TABLE 6-4

Chemical Parameter Recommendations for SSER Tributaries

Objective (Hypothesis)	Sample Locations	Parameter List	Frequency	Tier
Annual loading of nutrients and sediment. Relative concentration of N species. Priority Areas for Remedial Measures	Carmans River *(top priority)* Carlls River East Meadow Br. Patchogue River Connetquot Brook Swan River Sampawans Cr. Massapequa Bellmore Pines Brook	TSS, TKN, DKN, NH_3-N NO_3+ NO_2 -N, TP, SRP, salinity, temperature, dissolved oxygen, pH	Biweekly to Monthly, plus additional samples during high flows	1
Use impairment	Swan River Sampawams Cr. Beaverdam Cr. Neguntatouge Cr Carmans River Carlls River East Meadow Br. Patchogue River Connetquot Brook	Salinity, temperature, dissolved oxygen, pH	Monthly: May, June and October Biweekly: July, August and September	1

Objective (Hypothesis)	Sample Locations	Parameter List	Frequency	Tier
Effectiveness of stormwater management practices	To be determined *	TSS, TKN, TP, fecal coliform bacteria, *Enterococcus*	Storm sampling, before and after improvements	2

- Monitoring locations to be selected as stormwater improvements are implemented, requires consultation with Dept. Public Works and Engineering of involved Towns.
- *All elements on this table are new (not part of an existing monitoring program for the SSER).*

TABLE 6-5

Analytical Recommendations for Tributary Monitoring
TIER 1

Biweekly sampling frequency, year-round
Additional sampling during high flows
Stations: Downstream of USGS flow gauges, nine streams
(plus recommended addition of Patchouge and small stream in eastern Suffolk Co.)

Parameter	Depths	Limit of Detection	Rationale/Notes
Water temperature, dissolved oxygen pH, specific conductance	Mid depth, mid channel	Field meter	General habitat quality, water quality surveillance, salinity
Total Kjeldahl N (TKN)	Flow-weighted composite sample	0.03 mg/l	Concentration and load
Nitrite + Nitrate N	Flow-weighted composite sample	0.0002 mg/l (as N)	Concentration and load
Total P	Flow-weighted composite sample	.001 mg/l	Concentration and load
Soluble Reactive P (SRP)	Flow-weighted composite sample	0.0006 mg/l	Concentration and load
Total Suspended Solds (TSS)	Flow-weighted composite sample	2 mg/l	Concentration and load

Recommended analytical methods are modified versions of procedures published in 17th edition, Standard Methods for the Examination of Water and Wastewater, or EPA , Methods for chemical analysis of water and wastes (40 CFR part 136 compilation). Modifications for the estuarine environment have been made by the laboratories participating in the Chesapeake Bay Monitoring Program.

Detailed method descriptions and Quality Assurance/Quality Control measures are summarized in August 1996. Recommended Guidelines for Sampling and Analyses in the Chesapeake Bay Monitoring Program, available through EPA Region 3 (CBP/TRS 148/96 EPA 903-R-96-006).

All elements are new

TABLE 6-6

Chemical Parameters, Recommendations for SSER Embayments
TIER 1

Biweekly sampling frequency, year-round (winter sampling as weather permits)
Stations: Mid-bays, at ocean inlets, near wastewater outfalls, and near tributary inlets

Parameter	Depths	Stations	Limit of Detection	Rationale/Notes
Water temperature	0.5 m below surface 0.5 m above bottom	All	Field meter (0.1°C)	Assess water temperature, stratification
Salinity *	0.5 m below surface 0.5 m above bottom	All	Field meter (specific conductance, 10% of scale)	Assess water temperature, stratification
	Discrete sample at 0.5 m (Nisken bottle)	Every 5 stations	Induction salinometer 0.1 ppt	Comparability with historical data, quality control for meters
Chlorophyll *a* (total and < 10 µm)	Tube through photic zone	All	Fluorometric 1µg/l	Primary production, phytoplankton community composition.
Total Kjeldahl N (TKN)	Discrete sample at 0.5 m (Nisken bottle)	All	.03 mg/l	Total N and fractions (Nutrient status plus brown tide conditions). SAV criteria
DKN			.026 mg/l	
Urea			.05 mg/l	
Ammonia			.004 mg/l	
Nitrite + nitrate			.0002 mg/l as N	
Total P	Discrete sample at 0.5 m (Nisken bottle)	All	0.001 mg/l	SAV criteria, nutrient status particulate and dissolved partitioning
Soluble Reactive P (SRP)			0.0006 mg/l	
Total Suspended Solids (TSS)	Discrete sample at 0.5 m (Nisken bottle)	All	2 mg/l	Light penetration, SAV criteria
Turbidity	Discrete sample at 0.5 m (Nisken bottle)	All	0.5 NTU	Light penetration, correlation
Total Organic Carbon	Discrete sample at 0.5 m (Nisken bottle)	All	0.1 mg/l	Trophic status, impacts of treated wastewater discharge

- We recommend that NYSDEC Shellfish Sanitation program measure salinity, temperature, and Secchi disk transparency when collecting samples for bacterial analysis.

Recommended analytical methods are modified versions of procedures published in 17th edition, Standard Methods for the Examination of Water and Wastewater, or EPA , Methods for chemical analysis of water and wastes (40 CFR part 136 compilation). Modifications for the estuarine environment have been made by the laboratories participating in the Chesapeake Bay Monitoring Program. Detailed method descriptions and Quality Assurance/Quality Control measures are summarized in August 1996. Recommended Guidelines for Sampling and Analyses in the Chesapeake Bay Monitoring Program, available through EPA Region 3 (CBP/TRS 148/96 EPA 903-R-96-006).

TABLE 6-7

Implications of Recommended Tier 1 Monitoring Program on Existing Water Quality Monitoring Programs

Agency and Program	Recommended Changes to Monitoring Program
Suffolk County Health Dept.	Retain existing monitoring network, discuss with Town of Hempstead the logistics of adding 4 stations in South Oyster Bay
	Standardize monitoring frequency to biweekly, year-round, with winter monitoring as conditions allow
	Add TSS
	Add phytoplankton, zooplankton and macroinvertebrates at limited number of stations
	Add turbidity
	Eliminate (from Tier 1) silica, dissolved organic carbon.
Town of Hempstead Water Quality Monitoring Program	Retain existing monitoring network, discuss with Suffolk County the logistics of adding 4 stations in South Oyster Bay
	Standardize monitoring frequency to biweekly, year-round, with winter monitoring as conditions allow.
	Add TSS
	Add phytoplankton, zooplankton and macroinvertebrates at limited number of stations
	Add turbidity
	Add total organic carbon
	Add TKN (total plus dissolved fractions)
	Add size fractionation of chlorophyll analysis
	Add soluble reactive P
	Eliminate (from Tier 1) BOD and particulate organic material
NYSDEC (shellfish sanitation)	Add Secchi disk transparency
	Add turbidity (minimum) and/or TSS (preferable)
	Add salinity

TABLE 6-8

Biological Parameter Recommendations, SSER Tributaries
TIER 1

Monitoring Parameters	Frequency	Location	Comments
Macroinvertebrate community: (Hilsenhoff Biotic Index, EPT richness, species richness, species dominance, species diversity)	Rotating, once every 3 years in each stream, during summer (June – September).	At representative depth, velocity, and substrate conditions, at least one station every mile of stream*	Multiplate deployment in depositional areas; kick screens in upstream reaches.
Fecal coliform bacteria	Monthly, additional samples during high flows	At sites selected for chemical monitoring	Additional monitoring included as Tier 2

* Recommended streams:
Carmans River
Carlls River
East Meadow Br.
Patchogue River
Connetquot Brook
Swan River
Sampawams Cr.
Beaverdam Cr.
Neguntatouge Cr
Pines Brook,
Valley Stream,
Bellmore Creek,
Massapequa Creek,
Seaford Creek.

Note: Macroinvertebrate screening of Swan, Connetquot, Carlls, Patchogue, Sampawam and Carmans Rivers is currently included in the NYSDEC RIBS program; sampling and analysis occur on a five-year rotation. Streams noted with italics in the list above are not currently included in a long-term biological assessment program.

TABLE 6-9

Biological Parameter Recommendations for SSER Embayments
TIER 1

Parameter	**Location**	**Recommended Frequency**	**Objective**
Brown tide (*Aureococcus anophagefferens*)	Mid bay Shinnecock, Moriches, Great South Bay, Oyster Bay **In coves** At inlets connecting bays (see Table 6-2)	**Biweekly**	Bloom monitoring
Hard clam population and harvest (landings)	Estuary wide	Annual (Town leadership)	Trends and use attainment
Fecal coliform bacteria	At all limnological sites, plus shellfish sanitation sites	Per regulations for certified, uncertified and conditional shellfish areas	Public health
Enterococcus	**At bathing beach sites**	**Five samples/month during recreational season**	**Public health, correlation between new and existing indicators**
Phytoplankton (numbers and biovolume of major taxa)	**Selected stations (approximately 10)**	**Biweekly**	**Community structure, annual succession**
Zooplankton (numbers and biomass of major taxa)	**Selected stations (approximately 10)**	**Biweekly**	**Community structure, annual succession**
Macroinvertebrates (benthos)	**Selected stations (6 – 10)**	**Four times annually**	**Biomass and diversity**
Macroalgae beds	**Estuary wide**	**Annual visual surveys in August**	**Trends, attainment of ecosystem goals**
Submerged aquatic vegetation (SAV)	**Estuary wide subtidal zone**	**Annual aerial survey, field verified every 3 years**	**Develop data base for trend analysis**

Note that bolded items represent new recommendations

TABLE 6-10

Human-Induced Parameter Recommendations
TIER 1

Program	Parameters to Monitor	Primary Data Source	Frequency
Tributary and Watershed	Impervious cover, by subwatershed	County Planing agencies	**Annual data compilation**
	Wetland areas disturbed and filled	DEC and Army Corps of Engineers (ACOE)	
	Detailed land use data	Town and County planing agencies	
	Stream restoration activities	Soil and Water Conservation Districts, Town Engineers and Dept. Public Works	
Estuary	Hard clam harvest and seeding	Towns, DEC, Bluepoint Oyster Co.	Annual
	Dredging	ACOE	Every 3 years
	Volume and quality of effluent	DEC	Annual compilation of discharge monitoring reports
Ocean	Inlet dredging and beach erosion control measures	ACOE	Every 5 years

Note that these data are currently gathered; the recommendation is to report the data to a central SSER data repository.

TABLE 6-11

Recommended QA/QC Program: Standard EPA Criteria for Water Monitoring

Element of QA/QC Program	Designed to Assess	Why included	Recommendation
Precision (Laboratory analysis)	Laboratory's ability to obtain equivalent results in analysis of replicate (split samples)	Important to identify and quantify laboratory source of variability for trend analysis	**Participating laboratories analyze and report split samples at a minimum frequency of 1:20**
Precision (Field analysis)	Field team's ability to obtain equivalent results in repeated (separate) sampling of same water stratum	Important to identify and quantify field source of variability for trend analysis	**Sample, analyze and report field replicate samples at a minimum frequency of 1:20**
Accuracy	Laboratory's ability to measure "true" concentrations of analytes	Document data quality, screen for systematic error or bias	Lab certification programs. **Participation in annual round robin of blind audit samples (including matrix spike and matrix spike duplicates with SSER water).**
Representativeness	How well do samples represent ambient conditions	Water quality conditions in SSER can vary with depth, tidal cycle, antecedent rainfall, etc.	**Assess stratification and location of any pycnocline prior to sample collection. If stratified, document and sample at discrete depths in layers.**
Comparability	How well can data be compared to historical results and findings of other agencies or institutions	Multiple agencies, long-term monitoring program	Document procedures for sample collection, analysis, data handling.
Completeness	Refers to the number of samples successfully collected, analyzed, screened, and reported in database compared to planned program.	Important for accountability of programs to constituents / stakeholders, funding agencies and peers. Identifies need for corrective action.	**Adopt program goal (90%) and require participating agencies to report annually.**

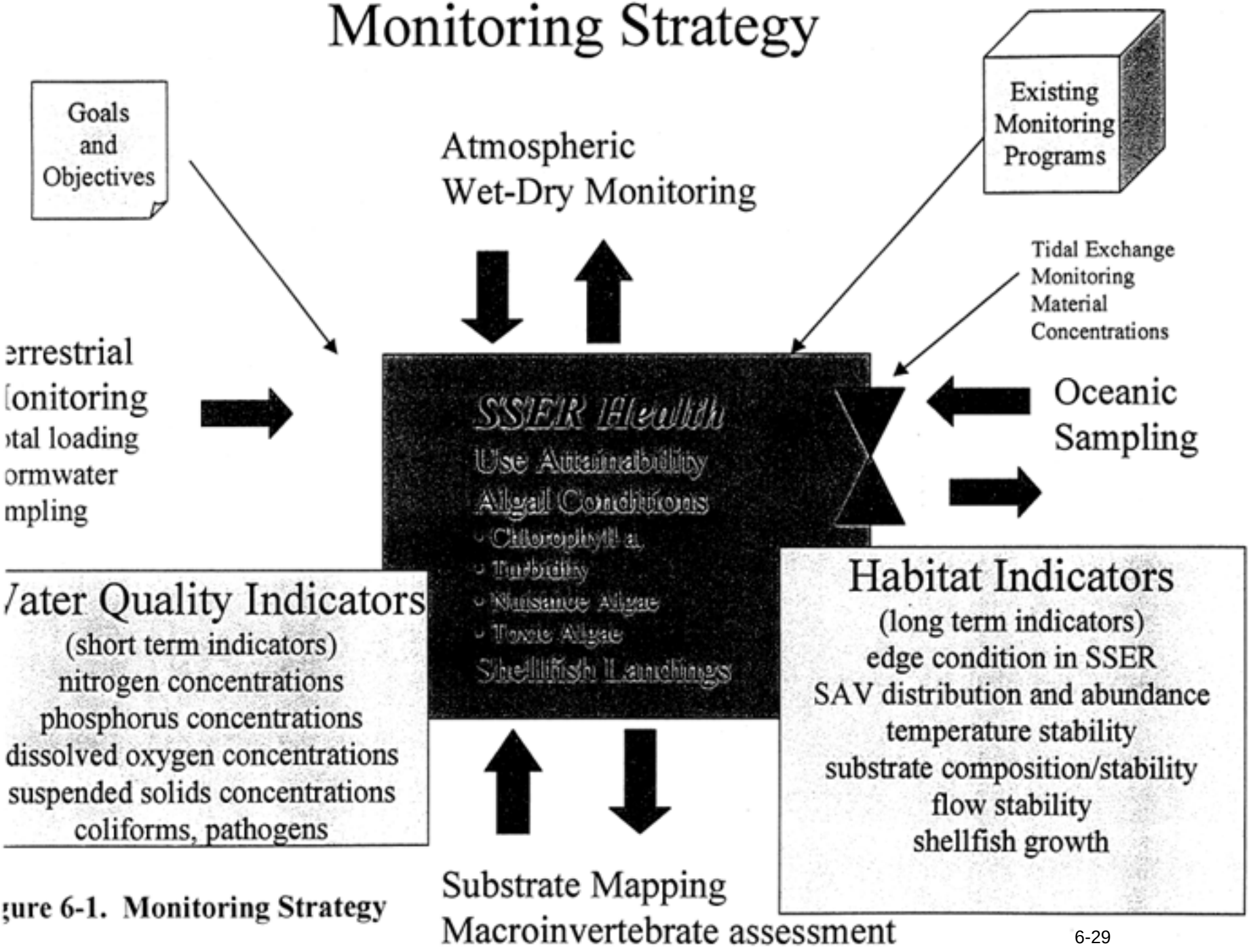
Note that new elements are depicted in bold on this table.

TABLE 6-12

Preliminary Cost Estimate of Recommended Tier 1 Monitoring Program

Item	Unit Cost	Comment
USGS: reinstate water quality monitoring at Carmans River	$10,000/year	Top priority site for water quality monitoring. Other sites recommended as resources are available.
Citizen monitoring of tributaries through South Shore Estuary Watch	$30,000 first year, $20,000 subsequent years	Estimate of Dr. Zaikowski (Dowling College)
Additional 4 monitoring points in South Oyster Bay	$40,000/ yr. (sampling costs only, excludes analytical costs)	Represents approximately 5% increase in total number of sampling stations. Based on 5% increase in staff and equipment resources, estimated $800,000 in T. Hempstead and Suffolk County.
Measure light penetration using transmissometer	$6500/meter	Assume purchase of 2 LiCor meters, year 1
Revisions to analytical parameter list	Field parameters (meters)	According to estimates of Suffolk County, analytical cost is about $300/sample
	TKN, DKN, urea, NO_3+NO_2-N, NH_3-N	
	TP, SRP	
	Chlorophyll *a* (two size fractions, fluorometrically):	
	Salinity (laboratory)	
	Aureococcus anophagefferens	
	TSS	
	TOC	
	Turbidity	
Addition of *Enterococcus* to assess suitability for water contact recreation	$50/ analysis	Contract laboratory cost, internal costs are likely to be lower.
Addition of 5% replicate and split samples for QA/QC	5% QA/QC: additional to base of $592,800: additional $29,640 total $622,440	Total analytical cost estuary program (field plus lab parameters): $300/sample * 76 stations* 26 samples/yr = $592,800 plus 5% QC

Monitoring Strategy



gure 6-1. Monitoring Strategy

SOUTH SHORE ESTUARY RESERVE (SSER) COMPREHENSIVE MONITORING STRATEGY

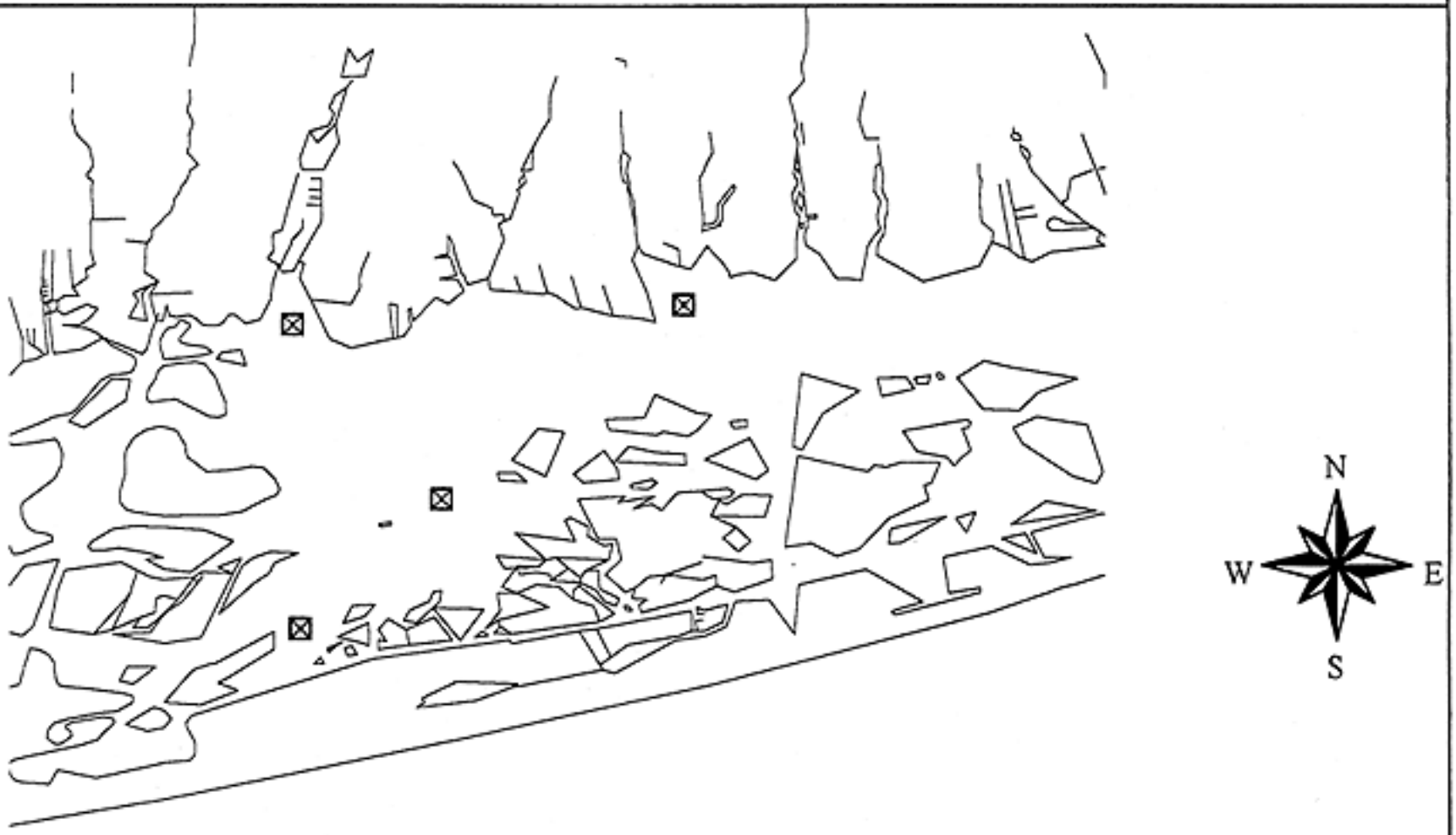


Figure 6-2 Recommended Additional Sampling Locations

LEGEND

- Additional points.shp
- 059hys.shp
- 103hys.shp

Appendix A

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Appendix B

Specific comments during the March 1, 1999 Workshop

Meeting Summary

South Shore Estuary Reserve
Comprehensive Water Quality Monitoring Workshop
March 1, 1999
Babylon, Long Island, New York

Part 1: Vision of the South Shore Estuary Reserve (SSER)

Participants were asked to visualize the SSER after 20 years of successful management. Responses focused on four inter-related areas:

Use attainment
(Human uses of the SSER are achieved, e.g. swimming, shellfishing, recreational access, safe levels of contaminant burden in fishes.)
Elimination or controls on pollutant inputs that contribute to water quality conditions that impair SSER waters for their desirable use
(Stormwater runoff, relocation of sewage outfalls, controls on discharges from vessels etc.)
Restoration or enhancement of the natural ecosystem
(Increased diversity, return of endangered species, elimination of algal blooms, habitat restoration for native species assemblage, "pre-development" streamflow regime.)
Implementation of effective tools for managing the SSER
(Education, stewardship, water quality model, regulations, enhanced understanding of linkages between the natural and human environments.)

Specific responses included:

CATEGORY	SUBCATEGORY	COMMENT
Use Attainment	Shellfish	Greater abundance of hard shell clams
		Shellfishing is commercially and recreationally viable
		Shellfishing beds are no longer threatened by pathogens from point and nonpoint sources
		All shellfish beds have a plentiful supply and are open for harvest
		A hard clam fishery approaching that of the mid-1970's

CATEGORY	SUBCATEGORY	COMMENT
Use attainment	Shellfish and finfish	
		Fin and shell fishing industry has been reestablished Maintenance and enhancement of fin fishery (primarily flatfish)
	Swimming	Water quality supports swimming in public areas Bathing beaches free from water quality closures (usually coliform) Swimming beaches are open all summer
	Water clarity	In 8 of 10 locations in Fire Island National Seashore, I can see bottom on calm day.
	Public enjoyment	Public enjoyment of the estuary without a significant impact
	Public access	Public access and availability of boating and other water dependent activities
	Fish consumption	No human health advisories for consumption of finfish and shellfish, toxics and pathogens
Control of Inputs	Point Sources (sewage treatment plant effluents)	Sewage treatment plants dump into the coastal ocean
		Removal of 3 sewage outfalls located in the west bay of the Town of Hempstead A significant reduction in the point source loads to the SSER has been met
	Point sources (vessel discharges)	Discharge from vessels fully eliminated through total self containment Sufficient number of pumpout stations (mobile and stationary) available
	Nonpoint sources (general)	Soil and erosion control
		Reduction in nonpoint source inputs of bacteria, nutrients, turbidity New sources of nonpoint pollution are controlled A no-net-increase in nonpoint source loads to the SSER is achieved
	Nonpoint sources (stormwater)	Impacts from stormwater runoff have been lessened Reduced bacteria in stormwater “First flush” stormwater is treated prior to discharge to surface water
	Nonpoint sources (sediments)	Concern over toxics levels in area, especially sediments, is alleviated There are no toxic contaminants in sediments above ERL levels/ sediment screening values

CATEGORY	SUBCATEGORY	COMMENT
Control of Inputs	Nonpoint sources (groundwater plumes)	Localized groundwater plumes are controlled/ remediated; further possible contamination is reduced.
Natural Ecosystem	Diversity	Diversity of organisms both aquatic and terrestrial that rely on the estuary.
		Improvement of biological activity specifically related to shellfish
		Biological diversity is evident in 3 hours in Bay. In 2 hours can observe 8 aquatic species.
		Exotic and alien species are eliminated from SSER
	Endangered species	All federal and NYS threatened and endangered species are found in SSER (if habitat exists); numbers and productivity are increasing
		Improvement in habitat for endangered species
	Resilient ecosystem	System (natural and man-made) is resilient to stresses such as storms
		Barrier island movement during storms is seen as natural, not damage
		A return to lower levels of pollutants closer in magnitude to pre-development or lightly urbanized conditions
		Ecologically balanced system; minimal human impact residential and recreational
	Hydrology	Maintain freshwater inflows (in spite of sewers)
		Maintain streamflows
		Tributaries are protected
		Recognition of the role of ocean exchange
	Wetlands	Rehabilitation of wetlands
		All marshes are functioning at optimal levels without any stormwater impacts or physical obstructions
	Algae and SAV	SAV beds are plentiful throughout the region and reach historic levels
		Levels of macroalgae are reduced and no longer considered a nuisance
		Habitat and SAV national policy implemented throughout state
		Detrimental algal blooms (phytoplankton and macroalgae) are rare
		Answers to the brown tide problem

Meeting Summary, continued

PART 2. Specific criteria related to water quality goals and objectives.

Participants were asked to provide specific comments on the goals and objectives identified by the water quality task force of the SSER council.

Category 1: Conditions needed to achieve and maintain water quality to support priority uses and desired improvements

Specific responses:

- Levels of pathogenic and indicator organisms (e.g. coliform bacteria) are below shellfish standards.
- Control of brown tide
- No visible TSS
- Particulates in runoff (silt) reduced
- Lower nitrogen levels
- Meet water quality criteria for SAV (light, DIN and TSS) established by Peconic Estuary Program and Long Island Sound Study
- Dissolved oxygen (DO) at standard levels (at least 5 mg/l) in creeks and open water
- Baseflow in streams is within 20% of historical median value (historical period defined as prior to sewering)
- Direct groundwater discharge is within 20% of historical median flow
- Control of fishing pressure as needed estuary-wide
- Salinity and conductivity are at standard levels
- Chlorophyll *a* found at standard levels
- Eliminate/control predation of desirable organisms estuary-wide
- No *Phragmites* in tidal wetlands
- Sufficient funding for monitoring program to be run routinely
- Reduce levels of PAH's in sediments and shellfish
- Analyze sediments for toxic substances to determine their effect on water column and shellfish
- Use hard clams as an environmental marker/benchmark. Consider that the water quality conditions required for these organisms to live and reproduce will be adequately protective of other organisms. Also monitor pathogens.

Category 2. Point Sources. List specific point sources that impair SSER for desired use.

- Sewage outfalls: Bay Park, Long Beach, West Long Beach, Patchogue
- Ocean Beach STP
- LILCO: thermal discharge at Oceanside
- Patchogue River
- Fire Island discharges (Ocean Beach etc.)
- Boats
- Marinas
- Groundwater discharge (stream baseflow in major streams)
- Pipes from bulkheads
- Poorly maintained vessel discharge equipment

- Oil from 2 cycle engines

Category 3: Nonpoint Sources. List specific nonpoint sources that impair SSER for desired use.

- Onsite wastewater treatment systems (generally present in eastern section of study area)
- Street ends
- Atmosphere
- Stormwater (95% of coliform causing shellfish closures are from stormwater)
- Animal waste
- Fertilizers
- Organic matter
- Road runoff
- PAH from fossil fuel combustion
- Gas motors
- Metal objects discarded near SSER
- Waterfowl
- Fine-grained sediment resuspension
- Golf courses
- Application/overuse of pesticides/fertilizers
- Landfill leachate
- Runoff from construction activity
- Recharge basins transmit street runoff to groundwater
- Garbage barges with items routinely falling off
- Improper disposal of household hazardous waste
- Former duck farms in Moriches
- Contaminated sediments
- Flooding of low-lying areas

Category 4: Discharges from Vessels. Comment on specific water quality issues related to discharges from vessels. Note where in the SSER these discharges are considered to be a problem.

- Problem is estuary-wide (mobile and at all pump-outs)
- Treated sewage and gray water from vessels
- Uncombusted fuel from 2 cycle engines, outboard motors, and personal water craft
- Propeller damage to SAV beds
- Wake damage to marsh banks
- Operations of pumpouts is a problem (hours and accessibility)
- Disinfection of MSOs

Category 5: Water Exchange. Comment on issues related to inadequate water exchange and how it affects water quality and use attainment

- Minimize excess ocean exchange that increases salinity and favors specific predators
- Changes in ocean exchange through inlets need to account for changes in tide levels and flooding
- Poor circulation in Bellport Bay and Narrows Bay
- Groundwater inflows
- Inlet maintenance – Moriches Inlet

- Need calcium
- Increase ocean exchange to offset point and nonpoint pollution until corrective measures are in place to reduce them
- Understand existing water budget (surface fresh, groundwater, ocean exchange) and implications of change
- Adequate water exchange to maintain stable/static biodiversity
- Stream baseflow and groundwater discharges need to be maintained or restored to sustain salinity in the SSER.

Part 3: Reporting on Specific Monitoring Programs

Representatives of USGS, Citizen Watch, NYSDEC, Suffolk County Health Dept., Town of Hempstead provided descriptions of existing monitoring data, and contact names for further investigation.

Next Steps

EcoLogic will review materials submitted at the kickoff meeting and contact agencies throughout the SSER for additional information. We will gather details of the monitoring programs and continue to discuss the goals of the individual monitoring programs with respect to water quality issues in the SSER.

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Glossary and List of Acronyms

Glossary of Terms

Algae Microscopic plants , primary producers in the aquatic food web

Algal blooms. High abundance of phytoplankton that may occur in estuaries, typically associated with the proliferation of a single algal species.

Aquifer A water-bearing geological formation that will yield water in a usable quantity

Aureococcus anophagefferens. A species of phytoplankton that causes brown tide when abundant in the algal community. This alga depresses the feeding response of shellfish even when present at low levels.

Baseflow. Water flowing in streams during dry weather (groundwater origin).

Bathymetry. The bottom contours and depth of the estuary.

Bathymetric map. A map showing the bottom contours and depth of an estuary or lake.

Bedrock. A general term for consolidated rock that underlies soils or other unconsolidated surficial materials.

Benthic. Pertaining to occurrence on or in the bottom sediments of wetland and aquatic ecosystems.

Best Management Practices. A series of approved practices that can be used to address specific pollution problems. Examples include changes in land use activities, a ban on pesticides, or following design standards for installing a septic system.

Best use. A series of classifications assigned by NYSDEC designating the most desired use of surface and ground water. Both freshwater and saline water are classified.

Bioaccumulate. The process by which toxic pollutants (such as heavy metals, inorganic chemicals, and organic chemicals) amass in the tissues of organisms after repeated intake or exposure.

Biochemical Oxygen Demand (BOD). The use of (or demand for) oxygen dissolved in water during the decomposition or metabolism of biodegradable organic compounds by microbes.

Biodegradation. The metabolic breakdown of materials into simpler components by living organisms.

Brown tide. A harmful algal bloom that gets its name from the brown appearance of the water in full bloom and causes a marked decline in the feeding response of shellfish. Brown tide is caused by the algal species *Aureococcus anophagefferens*.

Buffer strips. Plants (typically grasses or riparian vegetation) placed in strategic positions in an effort to filter out sediment and increase uptake of nutrients in runoff.

Chlorophyll-a. A chemical form of the photosynthetic plant pigment chlorophyll that is present in algae. Concentration of chlorophyll *a* is correlated to algal abundance and is used as an indicator of the trophic status of estuaries and lakes.

Clean Water Act. Federal environmental law regulating water pollution.

Coliform. Bacteria group often used to indicate the potential presence of pathogenic (disease causing) microorganisms in water. Coliform bacteria (technically defined as gram negative rods that ferment lactose and produce gas under specific culture conditions) are present in the intestinal tract of warm-blooded animals and can be found in soils as well.

Combined Sewer Overflow (CSO). An overflow point that releases combined storm water and wastewater to surface waters. CSO function when the hydraulic capacity of the sewerage system is exceeded.

Conductivity. Conductivity is a numerical expression of the ability of an aqueous solution to carry an electrical current. This ability depends on the presence of ions, their total concentration, mobility, valence, and relative concentrations, and on the temperature of measurement.

Confined aquifer. An aquifer saturated with water and bounded above and below by beds with a distinctly lower hydraulic conductivity than the aquifer itself.

Conservation easements. A legal document that restricts the type and amount of development that may take place on a parcel of land. They are often developed for open space preservation, historic preservation, protection of natural habitats, and preservation of areas for public recreation or education.

DDT (*di*chloro*di*phenyl*di*chloroethene) A chlorinated hydrocarbon used as a pesticide between 1942 and 1972.

DDD (*di*chloro*di*phenyl*tri*chloroethane) A metabolite of DDT.

DDE (dichlorodiphenyltrichloroethane) A metabolite of DDT.

Detention basin. A depressed area constructed to protect water resources from upstream land use activities by storing water and pollutants. The removal rate for particulate pollutants depends on the volume of runoff, length of time provided for sedimentation, and the settleability characteristics of the particulate matter. Artificial marshes can be incorporated within the basins to provide additional biological removal of pollutants.

Dilution. A lowering of the concentration of a chemical constituent in a water column through mixing with a less concentrated water column.

Discharge area. An area in which water is lost from the zone of saturation.

Dissolved organic carbon (DOC). Total filterable organic carbon in a water sample.

Dissolved oxygen. Oxygen content of water, a primary factor in habitat for aquatic organisms. Dissolved oxygen is affected by temperature (as water temperature decreases, increasing amounts of oxygen can be dissolved in water), time of day (photosynthetic plants create oxygen

during the day, and use oxygen at night), and pollution (aerobic bacteria and other organisms require oxygen for the breakdown of organic compounds).

Diurnal. Occurring on a daily basis or during the daylight period.

Drainage basin. Used interchangeably with *catchment* or *watershed*. The term can also imply a larger area containing several watershed or *sub-basins*.

Drainage, surface. Runoff, or surface flow of water, from an area.

Dredging. Process of clearing bottom sediment from an ocean, estuary or lake to increase depth, control nuisance aquatic vegetation, control nutrient release from sediments, and/or remove toxic substances.

Ecosystem. A group of living organisms functioning as a unit.

Effluent. Outflow of wastewater treatment plant.

Enterococcus. The enterococcus group is a subgroup of the fecal streptococci that include *Streptococus. faecalis, S. faecium, S. gallinarum, and S. avium.* The enterococci are differentiated from other streptococci by their ability to grow in 6.5% sodium chloride , at pH 9.6, and at 10° C and 45° C. The entrococcus portion of the fecal streptococcus group is a valuable indicator for determining the potential presence of pathogenic microorganisms in surface waters.

Erosion. The wearing away of the land surface by running water, wind, ice , or other geologic agents and by such processes as gravitational creep. Human actions may accelerate this natural process.

Eutrophic. From Greek for "well-nourished," describes an estuary or lake of high photosynthetic activity and low transparency. The highest stage of nutrient availability and biological productivity.

Eutrophication. The process of physical, chemical, and biological changes associated with nutrient, organic matters, and silt enrichment and sedimentation of an estuary or lake. If the process is accelerated by human influences, it is termed *cultural eutrophication*.

Fecal coliform. A type of bacteria whose natural habitat is the colon of warm-blooded mammals, such as man. The presence of this type of bacteria in water may indicate the presence of fecal contamination.

Fish habitat. The zone where environmental conditions support fish life.

Flooding. The temporary covering of soil with water from overflowing streams, runoff from adjacent slopes, and tides.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Forcing Functions. Those physical and chemical factors deemed to be the most important factors controlling the structure and function of the estuarine ecosystem.

Freshwater Water containing only small quantities of dissolved minerals.

Freshwater Wetlands Act Law passed in 1975 that regulates the use and development of the State's freshwater wetland resources for the purpose of preserving, protecting, and conserving the wetlands and the benefits derived from them. Provides for the regulation of all wetlands over 5 hectares (12.4 acres) in size, and for smaller ones if they have been determined by the DEC to be of unusual ecological importance.

Geographic Information System (GIS) Software used to manage and map spatial and attribute data.

Glacial drift Rock material transported by glacial ice and then deposited. Also refers to the assorted and unassorted material deposited by streams flowing from glaciers.

Glacial outwash Gravel, sands, and silt, usually stratified, deposited from melt water as it flows from glacial ice.

Glacial till Unsorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Glaciofluvial deposits Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and occur as kames, eskers, deltas, and outwash plains.

Grab sample (discrete sample) Type of water sample that collects water from a discrete depth. They can be collected by hand, or with specialized collection devices that minimize surface layer contamination and maximizes reproducibility.

Gravel. Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.5 centimeters) in diameter.

Ground water (geology). Water filling all available pores of underlying material below the water table, which is the upper limit of saturation.

Hilsenhoff biotic index. A biological assessment of stream habitat and water quality conditions calculated by enumerating the number and types of macroinvertebrate organisms present. Species are assigned values on a scale of one to ten based on their tolerance to organic pollution.

Hydraulic conductivity. The capacity of a formation to transmit water; expressed as the volume of water that will move in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow.

Hydraulic gradient. The slope of the water table or potentiometric surface; that is, the change in water level per unit of distance along the direction of maximum head decrease. Determined by measuring the water level in several wells.

Hydraulic head. In ground water, the height above a datum plane (such as sea level) of a column of water.

Hydrodynamic model. Mathematical model that simulates water movement.

Hydrogeology. The science of the interactions between water and geologic materials.

Hydrologic budget. A mass balance expression of a lake's hydrologic inputs and outputs.

Hydrologic cycle. An abstraction of water's movement, in solid, liquid and gaseous states, through the atmosphere, lithosphere, and biosphere.

Hypoxia. Low concentrations of dissolved oxygen in the lower waters of a stratified aquatic system.

Ichthyoplankton. Eggs and very young stages of fish (larvae).

Infiltration. The downward entry of water into the immediate surface of soil or other material.

Integrated pest management. A technique using two or more control methods to minimize pesticide pollution of surface or ground waters and provide an economic control of pests.

Land use planning. A method of watershed regulation where a program is developed in order to effectively manage growth and development within the watershed.

Leachate. Liquids that have percolated through a soil and that contain substances in solution or suspension.

Leaching. The removal of soluble material from soil or other material by percolating water.

Limiting nutrients. Chemical factors restricting algal growth if not present in sufficient quantity.

Load. The quantity (i.e., mass) of a material that enters a waterbody over a given time interval.

Macroinvertebrates. Aquatic insects, worms, clams, snails, and other animals visible without aid of a microscope which may be associated with or live on substrates such as sediments and macrophytes. They supply a major portion of fish diets, and consume detritus and algae.

Macrophytes. Rooted aquatic plants and algae.

Management practices. Techniques implemented in order to improve the quality of a certain area.

Mesotrophic. An intermediate stage of nutrient availability and biological productivity. Less nutrient-rich than eutrophic but more than oligotrophic.

Mixing zone. The transition boundary between two types of water (e.g fresh water and saltwater).

Monitoring program. Strategy which collects and analyzes data on the physical, chemical, biological characteristics of an ecosystem.

Mooring regulations. Restrictions on the number, size, and location of docks, or the materials to construct them. These restrictions help to reduce overcrowding and strain on the aquatic resource.

Moraine (geology). An accumulation of earth, stones, and other debris deposited by a glacier. Types are terminal, lateral, medial, and ground.

Nonpoint source pollution. Type of pollution from diffuse sources such as runoff from developed areas. May involve complex transport and delivery mechanisms within the watershed.

Nutrient, plant. Any element taken in by a plant, essential to its growth, and used by it in the production of food and tissue. Plant nutrients are nitrogen, phosphorus, potassium calcium, magnesium, sulfur, iron, manganese, copper, boron, zinc, and perhaps other elements obtained from soil or sediment; and carbon, hydrogen, and oxygen obtained largely from the air and water.

Outwash plain. A landform of mainly sandy or coarse textured material of glacio-fluvial origin. An outwash plain is commonly smooth; where pitted, it is generally low in relief.

Overland flow. The flow of rainwater or snowmelt over land surface toward receiving waters.

Parent material. The great variety of unconsolidated organic and mineral material from which soil forms.

Pesticide. A chemical compound used to eliminate or control undesirable organisms.

pH. A value used to express the acidity of aqueous solutions.

Photic zone. The zone of light penetration into a water body from the surface to depth where ambient light intensity is approximately 1 percent of surface levels.

Photosynthesis. The process of conversion of the sun's energy to chemical energy.

Pieziometric surface. The level to which water would rise if a well were installed at a particular depth.

Plankton. Microscopic plants (phytoplankton) and animals (zooplankton) found in water.

Plume. A relatively concentrated mass of material or water released to the environment.

Primary Productivity. The rate at which algae and macrophytes fix or convert light, water, and carbon dioxide to sugar in plant cells. Commonly measured as milligrams of carbon per square meter per hour.

Producers. Organisms that provide energy for other components of the food web. Photosynthetic organisms are classified as producers.

Residence time. The time it takes an enclosed or semi-enclosed water body to complete one full exchange of water.

Riparian area. Vegetated ecosystems along a waterbody through which energy, materials, and water pass. Riparian areas characteristically have a high water table and are subject to periodic flooding and influence from the adjacent waterbody.

Riprap. Rock and stone rubble used as a blanket or liner to prevent erosion in highly susceptible areas. This practice is suited to sites that are subjected to large volumes of water that cannot be stabilized with less expensive vegetative measures.

Rotating Intensive Basin Surveys (RIBS). A water quality assessment program carried out by NYSDEC. The program focuses on assessing the extent and severity of any impairment to the designated use.

Runoff. The precipitation discharged in stream channels from a drainage area. The water that flows off the land surface without sinking in is called surface runoff; that which enters the ground before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Salinity. The concentration of dissolved solids or salt in water.

Saturated. When referring to soil, the condition where the soil is frozen or the spaces between the soil particles are filled with water.

Submerged Aquatic Vegetation (SAV). Submerged macrophytes growing within the estuary. Plants such as *Zostera marina* (eelgrass) provide important fish habitat.

Secchi disk. A 20cm steel or heavy plastic disk used to measure the transparency of surface waters.

Septic system. The most common on-site system for the treatment and disposal of domestic wastewater from individual residences, involving the transport of wastewater from a residence to a buried tank. Perforated pipes then transport the wastewater to a subsurface drainage system where it percolates into the soil.

Stratification. Layering of water caused by differences in density resulting from chemical or thermal characteristics.

Temperature profile. Water temperature as a function of depth.

Toxicity. A gauge of how detrimental a substance is to a living organism. Toxic effects can either be acute (causing immediate death or impairment) or chronic (causing subtle damage that may not become evident until years after exposure).

Transmissometer (irradiance meter). An instrument that measures percent of ambient light penetration through water.

Turbidity. A measure of light scattering of a water sample. Turbidity is caused by suspended particles such as clay, silt, algae, and other materials suspended in water.

Watershed. A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, estuary, wetland or lake at a lower elevation.

Wetland. A transitional zone between land and open water. Wetlands have characteristic soils, hydrology and plant communities.

List of Acronyms

BOD	Biochemical Oxygen Demand
BMP	Best Management Practice
BTX	benzene, toluene, xylene
CDM	Camp Dresser & McKee
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
Chl. F	Filtered chlorophyll (measures pigments associated with small algal cells)
Chl. T	Total chlorophyll **(**measures pigments associated with all algal cells)
CSO	Combined Sewer Overflow
CMS	Coordinated Monitoring Strategy
CWA	Clean Water Act
DDE	(dichlorodiphenyldichloroethene).
DDD	(dichlorodiphenyltrichloroethane).
DDT	(dichlorodiphenyltrichloroethane).
DMR	Discharge Monitoring Report
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DON	Dissolved Organic Nitrogen
DIN	Dissolved Inorganic Nitrogen
DYNFLOW	Three dimensional groundwater flow model, developed by CDM
E	Ecosystem Issue (Figure 2-1)
ELAP	Environmental Laboratory Approval Program
EMAP	Estuary Mapping program under the auspices of USEPA.
EPT	An index of stream macroinvertebrate community, based on the relative abundance of three types of organisms (mayfly, stonefly, and caddis fly)
GIS	Geographic Information System
H	Human Use Issues (Figure 2-1)
LILCO	Long Island Light and Power Company
MODFLOW	Three dimensional groundwater model developed by USGS
MBTE	Gasoline additive detected in groundwater in many regions of Long Island
NAWQA	National Water Quality Assessment Program
NEP	National Estuary Program
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRCS	Natural Resource Conservation Service
NYSDEC	New York State Department of Environmental Conservation
NYSDOS	New York State Department of State
NYSDOH	New York State Department of Health
NURP	National Urban Runoff Program
PARCC	Five QA/QC parameters; precision, accuracy, representativeness, comparability, and completeness
RIBS	Rotating Intensive Basins Survey
QA/QC	Quality Assurance/Quality Control

SAV	Submerged Aquatic Vegetation
SEQR	State Environmental Quality Review Act
SPDES	State Pollution Discharge Elimination System
SSER	South Shore Estuary Reserve
SSEW	South Shore Estuary Watch
STORET	EPA data management system (STOrage and RETrieval)
STP	Sewage Treatment Plant
TCE	Trichloroethylene
TMDL	Total Maximum Daily Load
TOT	Time-of-Travel
TSS	Total Suspended Solids
USCOE	United State Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UWA	Unified Watershed Assessment

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