LAKE MONTAUK WATERSHED MANAGEMENT PLAN

FINAL

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Why Prepare a Watershed Management Plan?

Watershed planning is a means to protect and restore water resources, as well as the local economies that rely on these essential coastal resources. The purpose of a Watershed Management Plan is to provide a comprehensive approach to educate, plan for and implement incremental improvements with a goal of protecting and restoring watershed health. Lake Montauk's resources are limited, and poor drainage conditions within the watershed aid in amplifying contaminant inputs to the Lake. This is particularly evident in the southern portion of the Lake, which exhibits high levels of pathogens due to the compromised conditions (poorly draining soils, shallow depth to groundwater, high density residential uses, poor quality wetlands) of the Ditch Plains neighborhood. Human actions exacerbate the existing conditions that are not conducive to pollutant removal, and as a result have direct impact on water quality. Actions such as the discharge of stormwater and sanitary waste without adequate filtration to surface and groundwater, filling and removal of wetlands that provide natural filtering and biological uptake of pollutants, removal of trees and vegetated buffers surrounding waterbodies that cause erosion and lower dissolved oxygen, over-fertilization of lawns, all contribute directly to poor water quality. To facilitate the preparation of a Watershed Management Plan for Lake Montauk, the Town applied for and received a grant from New York State Department of State (funds provided under Title 11 of the Environmental Protection Fund).

The WMP provides a characterization of the existing natural, cultural and human resources within the watershed, identifies key factors impacting the Lake Montauk watershed, provides general and site specific recommendations for watershed improvement, and provides implementation strategies for each of the recommendations provided.

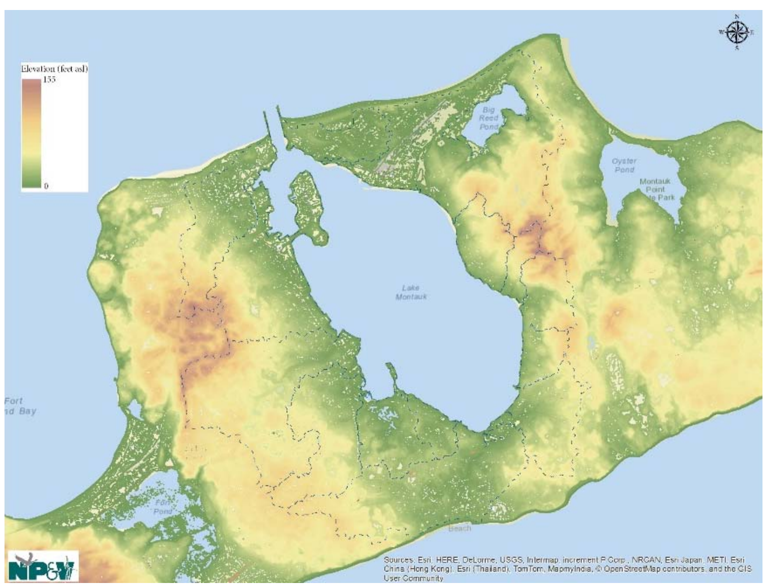
Current Watershed Characteristics

The Watershed

A total of 14 subwatershed areas were defined within the overall Lake Montauk watershed, ranging from approximately 41.6 acres in size to over 519 acres in size. In total, the subwatersheds represent the individual drainage areas that are present within the ±2,760 acre watershed.

Topography

The topography of the Lake Montauk watershed area generally trends from higher elevations along the outer boundaries of the subwatersheds located on the western, southern and eastern sides of the lake, to lower elevations nearing Lake Montauk, and towards



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Block Island Sound to the north and the Atlantic Ocean to the south. The highest elevations occur in hill areas occupied by residential developments in the northwestern portion of the watershed in the vicinity of Flamingo Avenue and North Farragut Road, and in the eastern portion of the watershed, between Talkhouse Lane and Startop Drive. Topographically low areas exist along the shoreline of Lake Montauk, in the northern portion of the watershed between the Block Island Sound and Lake Montauk, and in the southern portion of the watershed between the Atlantic Ocean and Lake Montauk.

Geology

The Montauk peninsula is a sedimentary sand formation deposited as a result of glacial history, lying atop bedrock and other geologic units including beach deposits along the shoreline, outwash deposits on the western and eastern sides of the Lake, and morainal deposits in the remainder of the area (see embedded figure). Lake Montauk divides the moraine on the eastern tip of the South Fork of Long Island.

The geology underlying the Lake Montauk watershed is comprised of six geologic units. The first and deepest is comprised of crystalline bedrock. Above this bedrock lie the sedimentary deposits which form the three major water-bearing units that underlie the area. Lying immediately atop the bedrock is the Raritan formation, which is comprised of the Lloyd sand layer and an overlying clay layer. Directly above the Raritan formation is the Magothy formation. The Magothy formation is comprised of fine to medium sand mixed with silt and clay and some beds of coarse sand and gravel. The uppermost geologic unit underlying the Montauk area consists of the surficial deposits that comprise the Upper Glacial formation. These deposits consist primarily of stratified and unstratified sand and gravel interspersed with clay and isolated beds of clay.

Soils

The soil survey identifies the majority of the Lake Montauk watershed area as lying within an area characterized entirely by Montauk-Montauk, sandy variant-Bridgehampton Association soils. Soils of this association are characterized as deep, rolling and hilly, excessively-drained and moderately well-drained to well-drained soils, having medium to coarse-textured soils on moraines. It is noted that Montauk soils within this association have a fragipan or compact layer that is at a depth of 20 to 30 inches, and that Bridgehampton soils within this association have a compact glacial till at a depth of about 48 inches.

A much smaller portion of the Lake Montauk watershed, located on the northeastern side of the lake lies within an area characterized by Dune Land-Tidal marsh-Beaches association. Soils of this association are characterized as sand dunes, tidal marshes, and beaches of the barrier beach and south shore. The dune land within this association is made up mainly of nearly even-sized sand grains that have been deposited by winds and such dune areas may contain sparse vegetation. The tidal marsh areas have an organic surface layer that ranges from a few inches to several feet in thickness, underlain by white sand.

Surface Water Resources

The NYSDEC has identified 20 freshwater wetlands within or partially within the Lake Montauk Watershed; these areas comprise approximately 700.3 acres of wetland systems, 431.3 acres of which are located within the watershed. It is noted that the largest freshwater wetland, MP-2, is associated with Big Reed Pond located in the northeastern portion of the watershed and is approximately 197.3 acres in size of which approximately 106.22 acres are located within the watershed, and is generally of high quality. The only two freshwater wetlands of moderate quality (MP-41 and MP-42) are located in proximity to the southeastern shoreline of the lake while the only two freshwater wetlands of low quality (MP-19 and MP-36) are located in the southern and west-central portions of the watershed, respectively.

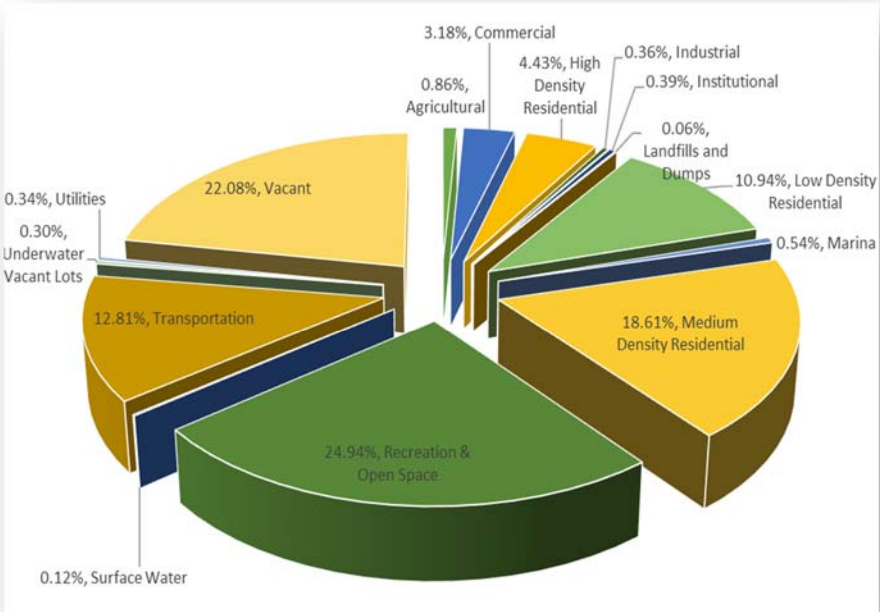
The tidal wetlands within the watershed are located where the shoreline intersects and interfaces with tidal waters. These wetlands contain saline waters, which originate from the ocean-fed surface waters associated with the lake. These features are formed by coastal processes and, with the exception of formerly connected tidal wetlands, are subject to tidal influence. These areas are not only vital to the ecological systems to which they serve, but also function to control storm surges during flood and major storm events which may impact sensitive watershed areas.

Groundwater Resources

Groundwater in the Lake Montauk watershed is derived from precipitation. Rainfall and meltwater entering the ground ("recharge") passes downward through the unsaturated zone to a level below which all porous layers are saturated. The upper surface of this level is referred to as the "water table". Groundwater is a mild expression of topography and consequently, the water table coincides with sea level along the shorelines of the Lake Montauk watershed, and rises in elevation towards the western and southeastern edges of the subwatershed boundaries.

The elevation of groundwater underlying the Lake Montauk watershed ranges from 8 feet above mean sea level (msl) in the northwest part of the watershed, to zero (0) at the above ground surface in areas of wetlands and surface water. In general, groundwater flows from the 8 foot elevation mound on the west side of Lake Montauk toward the north, south, east and west. A secondary mound of groundwater forms in the southeastern higher elevation part of the lake, such that the high points of these two groundwater mounds form a watershed divide between groundwater that flows generally toward Lake Montauk, Block Island Sound or the Atlantic Ocean. As groundwater migrates away from areas of higher elevation toward the shore, it eventually discharges to surface water as a result of surface seepage and subsea (or subsurface) outflow. Near the shore, water entering the system tends to flow horizontally along a shallow flow system and is discharged from the subsurface into streams or marine surface waters. Water that enters the system farther inland and along the western end of the Island generally flows vertically downward deeper into the Upper Glacial aquifer before flowing toward the shores where it is discharged as subsurface outflow.

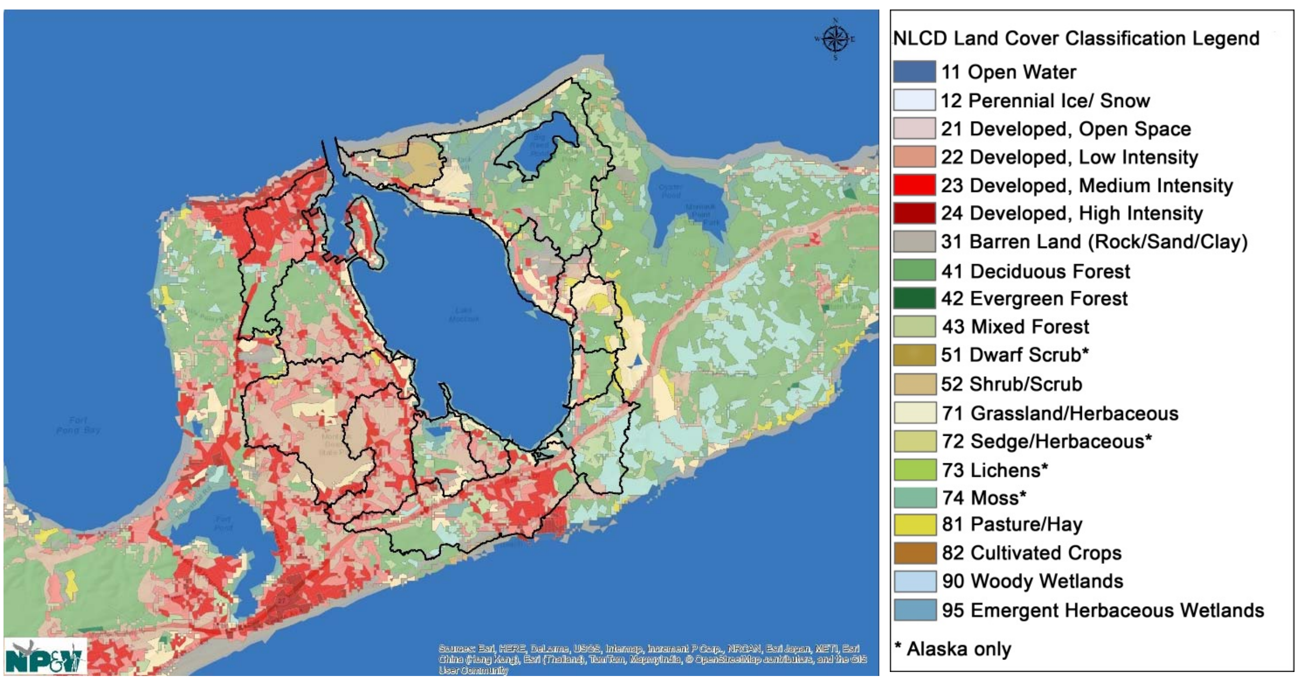
Land Use



The Lake Montauk watershed area is approximately 2,728 acres in size, the majority of which is occupied by Recreation & Open Space (24.94%), Medium Density Residential (18.61%), Transportation/Utilities (13.15%) and Low Density Residential (10.94%) uses. Vacant Land also occupies a significant portion of the watershed, as it currently comprises 22.08% of lands. Although High Density Residential (4.43%), Commercial (3.18%), Agricultural (0.86%) and Marinas (0.54%) occupy a much smaller portion of the watershed, these uses represent the remainder of the major uses that occupy lands. All other uses within the watershed occupy less than 0.5% of the overall land mass.

Land Cover

The majority of the Lake Montauk watershed area is comprised of developed, open space (540 acres or 19.67%), which generally represents areas with a mixture of some constructed materials and vegetation in the form of lawn grasses, and deciduous forest (530 acres or 19.31%), which generally reflects the large quantity of trees that comprise the surface of the island. The next greatest land coverage classifications that occupy the island are categorized as Developed, Low Intensity (15.05%), Developed, Medium Intensity (13.04%), Grassland/Herbaceous (8.63%), and Emergent Herbaceous Wetlands (7.18%). The Developed, Low and Medium Intensity categories primarily reflect single-family residential areas and some associated roadways, while the Grassland/Herbaceous category represents areas dominated by gramanoid or herbaceous vegetation. The Pasture/Hay category represents large mowed areas or large areas of tall grasses, and the Emergent Herbaceous Wetlands primarily represent the vegetated tidal wetlands on the island.



Water Quality

While the central portion of the Lake generally exhibits good water quality, the northwest portion of the Lake (Coonsfoot Cove) and the southern portion of the Lake are areas that do not receive significant tidal flushing and have significant pollution inputs from the watershed; these areas exhibit poor water quality. Water quality data examined was collected by the NYSDEC, SCDHS, and CCE which demonstrated the following impairments:

Bathing Beach Closure Due to High Coliform Levels

- East Lake Drive Beach
- South Lake Drive Beach

High Nitrogen Levels

- Big Reed Pond

Poor Water Column Clarity

- Big Reed Pond

High Chlorophyll-α Levels

- Big Reed Pond

Shellfishing Closure Due to Potential Pathogens

- Coonsfoot Cove (permanent closure)
- Star Island/Western Lake Shore (seasonal closure)
- Montauk Lake Marina and Club (seasonal closure)
- Southern Lake (seasonal closure)

What Can be Done to Improve Water Quality?

The characterization of water resources within the Lake Montauk Watershed, input from the TAC and the public, and regulatory considerations were all considered and factor into the development of recommendations in support of improvement of water quality. The overall intent of this document is to identify those measures that can be implemented to reduce existing water quality impacts and make meaningful strides toward water quality improvement.

Recommendations are divided into six categories: Waterbody Recommendations, Stormwater Runoff and Water Quality Recommendations, Municipal Facility Recommendations, Wastewater Recommendations, Regulatory Recommendations and Public Education and Stewardship.

Primary Recommendations – Waterbody

Lake Montauk

- Establish regular water quality testing for pathogens and other pollutants within the Lake, particularly after large rain events.
- Expand water quality sampling parameters to determine if a significant input of pesticides is affecting Lake water quality.
- Investigate the contribution of septic systems to pollution within the Lake.
- Consider the use of aeration systems the lower portion of the Lake to promote growth of aerobic bacteria and stunt/reduce growth of anaerobic bacteria (most pathogens are anaerobic).
- Determine, identify and map tidal flushing and circulation in Lake Montauk.

Big Reed Pond

- Establish regular water quality testing for pathogens, phosphorus, and chlorophyll-α in Big Reed Pond as the limited sample results available suggest potential pollutants within the pond.

Primary Recommendations – Stormwater Runoff

- Coordinate with the operators of the animal farm located on South Fenimore Drive to prepare an agricultural BMP program and create a vegetated buffer surrounding the on-site pond to reduce pathogen input into the Lake.
- Stormwater Improvement Projects
  - o Create a vegetated drainage depression at the landscape medians between the intersections of West Lake Drive, North Fernwood Drive and Star Island Road.
  - o Investigate the feasibility for drainage improvements on the north side of Montauk Highway, opposite Caswell Road.
  - o Create a bioretention area on the northwest corner of West Lake Drive and Flamingo Avenue.
  - o Provide pre-treatment where feasible for existing and proposed drainage infrastructure.

Primary Recommendations – Municipal Facilities

- Complete a GIS based mapping of the entire stormwater management system and "sewershed". Utilize the GIS mapping and a GIS database to effectively map locations and track maintenance and inspections of stormwater management practices.
- Coordinate with the NYS Office of Parks, Recreation & Historic Preservation to establish a Goose Management Program on the Montauk Downs golf course.

- Obtain funding for and construct a salt brine preparation facility for use in the Town.

Primary Recommendations – Groundwater and Wastewater

- Develop a program to enforce Town Code §210-5-1 and §210-6-1 which requires inspection and regular maintenance (every three years) of septic systems.
- Investigate alternative options for treatment of septic waste in high density areas within the watershed.
- Consider a cost-shared pump-out and water conservation kit program to aid in cost reduction for sanitary system maintenance and/or replacement.
- Provide wetland restoration and water quality improvements within the Lake by reconstructing the wetlands in Ditch Plains to engineered wetlands planted with native species to provide for vegetative pathogen removal of waters seeping from the Ditch Plains area.

Primary Recommendations – Regulatory

- Establish a Lake Montauk Protection Overlay District for properties located within the watershed.
- Develop and implement programs and policies to aid in enforcement of the Federal No Discharge Zone.
- Encourage and incentivize use of green infrastructure in site and drainage design.
- Amend Chapter 255, Article IV of Town Code to include minimum buffer width requirements.
- Work with Suffolk County on tick control measures for areas within the watershed.

Primary Recommendations – Natural Resource and Invasive Species Management

- Encourage and incentivize the use of vegetative buffers on properties that abut the Lake.
- Encourage and incentivize the usage of vegetative buffers and filter strips adjacent to boardwalk areas in industrial and working waterfront areas that abut the Lake.
- Perform regular Early Detection/Rapid Response surveys for highly invasive species approaching the area to aid in prevention of these species becoming established within the watershed.
- Work with the County to revise the Open Space Management Plan for Montauk County Park and consider prohibiting pets from being permitted in the park.

Primary Recommendations – Stewardship and Public Education

- Develop signage to inform the public regarding laws, public safety and human impacts to the bay.
- Develop a public outreach program to educate the public on the resources and importance of the Lake, organize volunteer activities, and provide the public with "good housekeeping" tools.
- Develop a universal communications plan to provide important information to the public in a direct, concise and meaningful way.

How Do These Recommendations Get Funded?

Adoption of this Watershed Management Plan is a key component in securing funding, as it demonstrates the need for the various recommendations to improve water quality. A variety of funding sources have been identified as part of the plan, which include:

- U.S Department of Housing & Urban Development
- New York State Office of Housing & Community Renewal
- New York State Environmental Facilities Corporation
- New York State Department of Environmental Conservation (NYSDEC)
- U.S. Environmental Protection Agency
- FHWA administered by NYS DOT thru Suffolk County DPW-Federal Funding administered by NYS DOT / New York Metropolitan Planning Council (NYMTCC)
- New York State Dept. of Transportation
- New York State Department of State (NYSDOS)
- New York State Office of Parks, Recreation & Historic Preservation
- National Fish and Wildlife Foundation
- Federal Emergency Management Agency (FEMA) thru NYS Division of Homeland Security & Emergency Services (DHSES) (formally NYS SEMO)
- Federal Legislative Grants-Earmarks
- NYS Member Item Funding

Section 5.1 provides a prioritization of the recommendations, as well as implementation responsibilities, order of magnitude cost estimates for the various actions and potential funding sources to aid the Town in implementing the recommended actions.

1.0 INTRODUCTION

1.1 Background

Lake Montauk is the last embayment located on the eastern end of Long Island, located approximately 2.5 miles west of Montauk Point. Lake Montauk's resources are limited, and poor drainage conditions within the watershed aid in amplifying contaminant inputs to the Lake. This is particularly evident in the southern portion of the Lake, which exhibits high levels of pathogens due to the compromised conditions (poorly draining soils, shallow depth to groundwater, high density residential uses, poor quality wetlands) of the Ditch Plains neighborhood. Human actions exacerbate the existing conditions that are not conducive to pollutant removal, and as a result have direct impact on water quality. Actions such as the discharge of stormwater and sanitary waste without adequate filtration to surface and groundwater, filling and removal of wetlands that provide natural filtering and biological uptake of pollutants, removal of trees and vegetated buffers surrounding waterbodies that cause erosion and lower dissolved oxygen, over-fertilization of lawns, all contribute directly to poor water quality.

Watershed planning is a means to protect and restore water resources, as well as the local economies that rely on these essential coastal resources. The purpose of a Watershed Management Plan is to provide a comprehensive approach to educate, plan for and implement incremental improvements with a goal of protecting and restoring watershed health. To facilitate the preparation of a Watershed Management Plan for Lake Montauk, the Town applied for and received a grant from New York State Department of State (funds provided under Title 11 of the Environmental Protection Fund) to prepare this Watershed Management Plan.

A watershed is the total area of land draining to a body of water such as a stream, river, wetland, estuary, or aquifer. A total of 14 subwatershed areas were defined within the overall Lake Montauk watershed, ranging from approximately 41.6 acres in size to over 519 acres in size. In total, the subwatersheds represent the individual drainage areas that are present within the ±2,760 acre watershed. During precipitation events, stormwater flows overland and into stormwater conveyance systems in each subwatershed and eventually discharges to the Lake. During this process, stormwater collects and deposits pollutants in this waterbodies. As a result, minimization of pollutants carried through each watershed to the waterbodies is critical to protecting the health of the Lake. This document provides measures to minimize pollutant inputs and protect existing resources, as well as methods and best management practices to improve water quality and restore watershed health.

1.2 Purpose and Document Organization

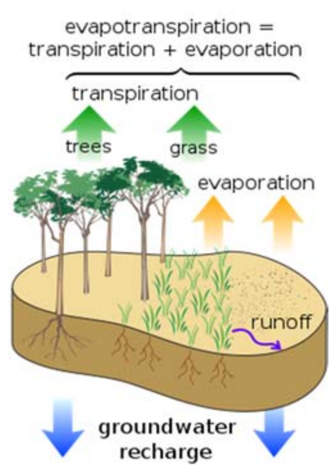
The Watershed Management Plan has been designed as a long term guidance and planning tool for the Town to utilize and implement over the upcoming decade and beyond. The WMP provides a characterization of the existing natural, cultural and human resources within the watershed, identifies key factors impacting the Lake Montauk watershed, provides general and site specific recommendations for watershed improvement, and provides implementation strategies for each of the recommendations provided. Existing watershed characteristics and environmental resources are described in **Section 2.0**. Resources detailed include geology, topography, soils, wetlands, rare, threatened and endangered species, cultural and historic sites, land use and water quality. **Section 3.0** provides an overview of local laws, programs and practices, and identifies potential gaps that warrant consideration in an effort to provide watershed protection and enhancement. Recommendations derived from analysis of resources and existing laws are provided in **Section 4.0**, and an implementation strategy providing details on how to complete each recommendation and funding sources available are provided in **Section 5.0**.

2.0 WATERSHED CHARACTERIZATION

A watershed is defined as "…the total area of land draining to a body of water such as a stream, river, wetland, estuary, or aquifer" **(NYSDOS, 2009)**. Watershed management is of vital importance for the protection of the resources that exist both within the watershed itself and within the water bodies that the watershed drains to. In order to identify the management needs of the watershed and the most efficient opportunities for addressing the identified needs, the physical and biological resources within the watershed must first be characterized. This report serves to define the overall watershed and subwatershed areas of Lake Montauk, and provides a characterization of the resources found within these subwatershed areas.

2.1 Watershed Study Area and Subwatershed Delineation

The Montauk area is comprised of glacial sand deposition features that are surrounded by marine waters. Lake Montauk is a 1,000 acre tidal embayment, located on the eastern tip of the south fork of Long Island. Lake Montauk is connected to Block Island Sound by an inlet that allows for daily tidal inundation with marine waters. Land areas surrounding Lake Montauk are underlain with a fresh water aquifer that floats atop saline waters. Of the precipitation that falls on the land, that which is not subject to evapotranspiration[1] becomes either runoff (overland flow) or recharge (water returned downward into the aquifer). Key elements of the hydrologic water budget (water cycle) are illustrated in the embedded figure.



In order to determine the overall surface watershed of Lake Montauk and to further define more specific areas of stormwater runoff, Cornell Cooperative Extension delineated subwatersheds utilizing the Suffolk County Light Detecting and Ranging (LiDAR) data collected in 2006. For the purpose of the Cornell Cooperative Extension study (**Appendix A**), "a subwatershed was considered to be a collection of catchment areas, which share a common drainage into Lake Montauk." A total of fourteen (14) subwatershed areas were defined within the Lake Montauk watershed ranging from approximately 41.6 acres in size to 518.4 acres in size (**Figure 1**)[2]. The delineation of subwatersheds assists in overall watershed analysis by allowing a comparison between contributing areas surrounding Lake Montauk and identification of areas that contribute the greatest amount of runoff. In total, the subwatersheds represent the individual drainage areas that are present within the total 2,728.32 acre watershed.

[1] Evapotranspiration (ET) is a term used to describe the sum of evaporation and planttranspiration from the Earth's land surface to atmosphere. Evaporation accounts for the movement of water to the air from sources such as the soil, canopy interception, and waterbodies. Transpiration accounts for the movement of water within a plant and the subsequent loss of water as vapor through stomata in its leaves. Evapotranspiration is an important part of the water cycle as pictured above. http://en.wikipedia.org/wiki/Evapotranspiration

[2] All referenced figures are included at the end of this report section.

2.2 Geographic Setting & Features

2.2.1 Topography

The topography of the Lake Montauk watershed area generally trends from higher elevations along the outer boundaries of the subwatersheds located on the western, southern and eastern sides of the lake, to lower elevations nearing Lake Montauk, and towards Block Island Sound to the north and the Atlantic Ocean to the south. **Figure 2** illustrates the LiDAR (Light Detecting and Ranging) topography generated from data collected by Suffolk County in 2006. The highest elevations occur in hill areas occupied by residential developments in the northwestern portion of the watershed in the vicinity of Flamingo Avenue and North Farragut Road (151 feet above sea level), and in the eastern portion of the watershed, between Talkhouse Lane and Startop Drive (155 feet above sea level). Topographically low areas exist along the shoreline of Lake Montauk, in the northern portion of the watershed between the Block Island Sound and Lake Montauk, and in the southern portion of the watershed between the Atlantic Ocean and Lake Montauk. Elevations within this area range from 0 to 30 feet above sea level (asl).

It should be noted that the Lake Montauk watershed area generally exhibits moderate slopes in addition to slopes of less than 10%. The steepest slopes occur in the vicinity of Prospect Hill on the east side of Lake Montauk, which contains slopes up to approximately 35%. In addition, small dune areas on the southwest and northeast sides of Lake Montauk contain slopes up to approximately 30%. These areas are subject to erosion as the elevations decline rapidly at the coastline forming bluffs. Additional information on soils and erosion is contained in **Section 3.2**.

2.2.2 Soils and Erosion

The USDA Soil Survey of Suffolk County, New York provides a complete categorization, mapping and description of the soil types found in Suffolk County **(Warner et al, 1975)**. Soils are classified by similar characteristics and depositional history, into soil series, which are in turn grouped into associations. A soil association is a landscape that has a distinctive proportional pattern of soils; it normally consists of one or more major and at least one minor soil series.

The soil survey identifies the majority of the Lake Montauk watershed area as lying within an area characterized entirely by Montauk-Montauk, sandy variant-Bridgehampton Association soils (see **Figure 3**). This association contains the minor soil groups of Whitman, Scio, and Wallington soils. Soils of this association are characterized as deep, rolling and hilly, excessively-drained and moderately well-drained to well-drained soils, having medium to coarse-textured soils on moraines. It is noted that Montauk soils within this association have a fragipan or compact layer that is at a depth of 20 to 30 inches, and that Bridgehampton soils within this association have a compact glacial till at a depth of about 48 inches. In general, steep slopes, irregular topography, and wetness limit the potential of the soils in this association for farming. In addition, the steep slopes and a high water table severely limit the use of many soils as building sites and for many other nonfarm uses typical of the area. Much of the association is limited for disposal of effluent from cesspools or septic tanks.

A much smaller portion of the Lake Montauk watershed, located on the northeastern side of the lake lies within an area characterized by Dune Land-Tidal marsh-Beaches association. Soils of this association are characterized as sand dunes, tidal marshes, and beaches of the barrier beach and south shore. The topography of the association is typical of sand dunes and beaches, and contains uneven dunes slightly inland from the beaches. The dune land within this association is made up mainly of nearly even-sized sand grains that have been deposited by winds and such dune areas may contain sparse vegetation. The tidal marsh areas have an organic surface layer that ranges from a few inches to several feet in thickness, underlain by white sand. The water level is at or near the surface, and tidal marshes have a heavy vegetative cover of salt-tolerant grasses and reeds. Beaches are subject to continual wave action.

The predominant soil types located in the Lake Montauk watershed (**Figure 4**) include BhB (Bridgehampton Silt Loam, Till Substratum, 2-6% slopes) and MnE (Montauk loamy sand, sandy variant, 15-35% slopes) which are generally moderately-well drained to excessively drained. Significant quantities of BhC (Bridgehampton silt loam, Till substratum, 6-12% slopes), Du (Dune), MfB and MfC (Montauk fine sandy loam), and MkC (Montauk silt loam, 8-15% slopes) are also located in the watershed. These soils are generally moderately-well drained to well drained. A portion of the watershed consists of poorly drained soils (At – Atsion sand, Bd – Berryland mucky sand, Mu – Muck, Ra – Raynham loam, Tm – Tidal marsh, Ur – Urban land, Wa – Wallington silt loam, We – Wareham loamy sand, Wh – Whitman sandy loam) which are primarily located on the south side of Lake Montauk and in proximity to surface waterbodies and known freshwater and tidal wetlands. These areas have consistently experienced drainage issues due to a shallow depth to water and the poorly drained characteristics of these soils. As illustrated in **Figure 4**, a variety of other soils types comprise the remainder of the watershed. **Table 1** below provides a quantification of each soil type within the watershed in addition to the drainage category the soil type falls within.

Table 1
SOIL TYPES AND ABUNDANCE

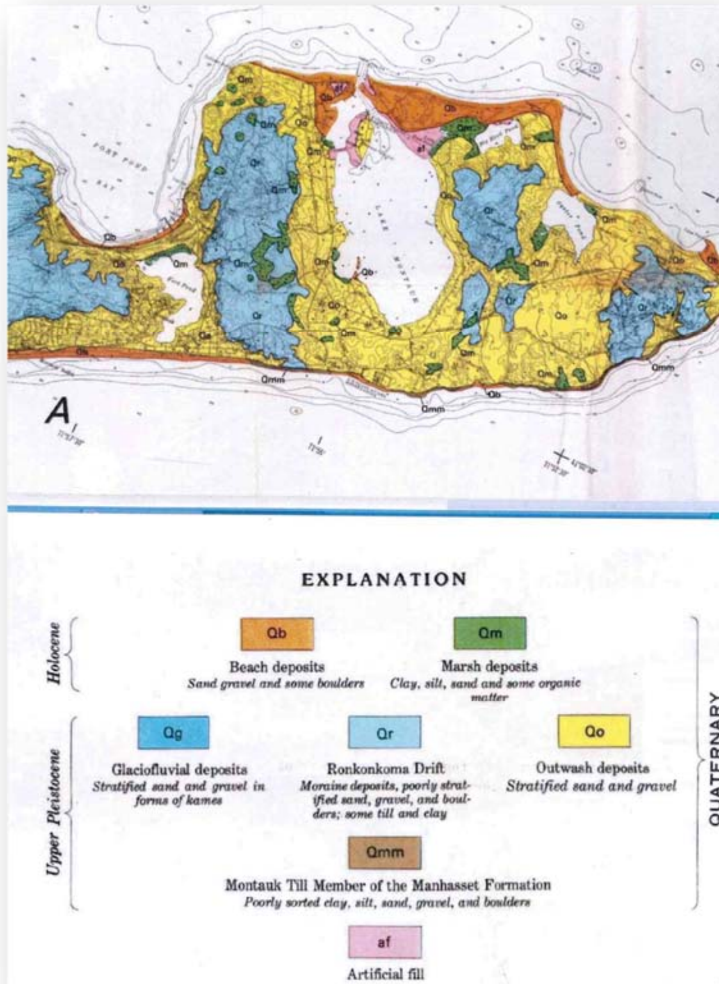
WELL DRAINED SOILS		
Soil Type	**Area (Acres)**	**Percent**
Bc	18.43	0.76%
BgA	14.73	0.60%
BhB	260.84	10.69%
BhC	224.58	9.21%
Bm	12.12	0.50%
Du	238.69	9.78%
Fd	107.32	4.40%
Fs	4.66	0.19%
Gp	3.52	0.14%
MfA	2.52	0.10%
MfB	193.42	7.93%
MfC	149.29	6.12%
MIB	67.11	2.75%
MkA	2.50	0.10%
MkB	108.88	4.46%
MkC	170.39	6.98%
MnB	7.14	0.29%
MnE	298.98	12.26%
RhB	1.38	0.06%
ScB	139.10	5.70%
Subtotal	*2025.62*	*83.03%*
POORLY DRAINED SOILS		
Soil Type	**Area (Acres)**	**Percent**
Bd	11.22	0.46%
Mu	80.93	3.32%
Ra	5.28	0.22%
Tm	52.18	2.14%
Ur	26.44	1.08%
W	12.79	0.52%
Wa	111.06	4.55%
We	12.18	0.50%
Wh	101.83	4.17%
Subtotal	*413.90*	*16.97%*
TOTAL	**2,439.52**	**100.00%**

Source: Suffolk County Soil Survey; Warner et al, 1975; NCRS SSURGO Database; see Figure 9

Erosion is caused by unconsolidated soils becoming subject to overland transport as a result of weathering conditions such as wind and rain. Since the surface of the Lake Montauk watershed area is comprised of glacial sand deposits, unstabilized surfaces are subject to erosion. Natural erosion exists in areas where the topographic elevation declines rapidly toward the coastline causing bluff features. Small bluffs exist sporadically around Lake Montauk, primarily on the north and south sides of the lake, bordering the Atlantic Ocean and Block Island Sound. Erosion can also be caused by increased impervious surfaces resulting in channelized runoff that causes scouring and sediment transport, as well as removal of vegetation that stabilizes surface soils. Erosion and sediment transport throughout the Lake Montauk watershed area should be managed through proper grading and drainage practices incorporating sound engineering principles and erosion control measures. In addition, the Lake Montauk inlet, which was created/stabilized in 1927, has contributed to erosion on the beach on the northwestern side of the watershed (on the west side of the inlet), and sedimentation of the channel to Lake Montauk.

2.3 Geology

The Montauk peninsula is a sedimentary sand formation deposited as a result of glacial history, lying atop bedrock and other geologic units including beach deposits along the shoreline, outwash deposits on the western and eastern sides of the Lake, and morainal deposits in the remainder of the area (see embedded figure). Lake Montauk divides the moraine on the eastern tip of the South Fork of Long Island.



The geology underlying the Lake Montauk watershed is comprised of six geologic units. The first and deepest is comprised of crystalline bedrock, which is found at an elevation of approximately 1,300 to 1,500 feet below sea level (bsl). Above this bedrock lie the sedimentary deposits which form the three major water-bearing units that underlie the area.

Lying immediately atop the bedrock is the Raritan formation, which is comprised of the Lloyd sand layer and an overlying clay layer. The Lloyd sand lies at an elevation of approximately 1,100 to 1,400 feet bsl, indicating a thickness of approximately 250 to 300 feet. This deposit is comprised of coarse quartz sand, gravel and sandy clay with isolated layers of clay dispersed throughout. The overlying clay layer is encountered at an elevation of 850 to 1,100 feet bsl, indicating a thickness of 230 to 250 feet and consists of gray clay to silty clay with some sandy layers.

Directly above the Raritan formation is the Magothy formation. This formation is found at an elevation of 190 to 900 feet bsl, indicating a thickness of 620 to 710 feet. The Magothy formation is comprised of fine to medium sand mixed with silt and clay and some beds of coarse sand and gravel.

The uppermost geologic unit underlying the Montauk area consists of the surficial deposits that comprise the Upper Glacial formation. This layer is encountered throughout Montauk at the land surface, which ranges from 50 feet above sea level (asl) along the northern side of Lake Montauk to approximately 200 feet bsl in isolated depressions encountered across the watershed. The thickness of the Upper Glacial formation ranges from 170 to 250 feet. These deposits consist primarily of stratified and unstratified sand and gravel interspersed with clay and isolated beds of clay.

Montauk's water supply is contained entirely within the Upper Glacial aquifer which floats atop the more dense saline waters contained in the lower and surrounding Upper Glacial aquifer and deeper geologic deposits. Hydrogeology is discussed in more detail in **Section 3.5** (Groundwater).

2.4 Surface Water

2.4.1 Hydrology

Lake Montauk was originally a freshwater lake historically known as "Great Pond." The inlet to the lake was opened between 1902 and 1933 by Carl Fisher, turning the freshwater lake into a saltwater harbor. Circulation within Lake Montauk is dependent upon the inlet, which provides the only means of flushing of the Lake.

Two freshwater streams and one tidal stream feed directly into the lake, and several wetland systems drain either directly or indirectly to the lake. Three significant pond systems are located within the lake's watershed, including Big Reed Pond and Little Reed Pond, located in the northeastern portion of the watershed while an unnamed pond (New York State Department of Environmental Conservation Freshwater Wetland #MP-13) is located in the southwestern portion of the watershed. The most prominent system discharging to the lake is Big Reed Pond which drains to Little Reed Pond, which ultimately drains to Lake Montauk in the vicinity of East Lake Drive, south of the Montauk Airport. As previously indicated, a number of freshwater wetland systems drain directly or indirectly to the lake. Further information regarding these systems is provided in **Section 4.1**.

2.4.2 Surface Water Classifications

The NYSDEC classifies surface waters into several categories, depending on whether the water body is freshwater or tidal. As indicated by the NYSDEC, "All waters of the state are provided a class and standard designation based on existing or expected best usage of each water or waterway segment." Descriptions of these classifications are provided in **Table 2** below, and classifications for waters within the Lake Montauk watershed are provided in **Figure 5**.

Table 2
NYSDEC SURFACE WATER QUALITY CLASSIFICATIONS

Freshwater Classification	Best Usage
AA	Source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. Suitable for fish, shellfish and wildlife propagation and survival.
A	Source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. Suitable for fish, shellfish and wildlife propagation and survival.
B	Primary and secondary contact recreation and fishing. Suitable for fish, shellfish and wildlife propagation and survival.
C	Suitable for fish, shellfish and wildlife propagation and survival. Also, for primary and secondary contact recreation, although other factors may limit the use for these purposes.
D	Due to such natural conditions as intermittency of flow, water conditions not being conducive to propagation of game fishery, or unsuitable stream bed conditions, the waters will not support fish propagation. Suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes.

Marine Water Classification	Best Usage
SA	Shellfishing for market purposes, primary and secondary contact recreation and fishing. Suitable for fish, shellfish and wildlife propagation and survival.
SB	Primary or secondary contact recreation and any fishing. Suitable for fish, shellfish and wildlife propagation and survival.
SC	Suitable for fish, shellfish and wildlife propagation and survival. Also, suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes.
I	Secondary contact recreation and fishing. Suitable for fish, shellfish and wildlife propagation and survival.
SD	Suitable for fish, shellfish and wildlife survival. This classification may be given to those waters that cannot meet the requirements for primary and secondary contact recreation and fish propagation for reasons of natural or man-made conditions.

Source: 6NYCRR Parts 700-705, Water Quality Regulations for Surface Waters and Groundwaters, effective September 1, 1991.
Note: Examples of Primary contact recreation include swimming, diving, and surfing. Examples of Secondary contact recreation include fishing and boating.

As previously indicated, three streams and three major ponds are located within the Lake Montauk Watershed. The lake itself is classified SA, indicating that the most appropriate use is as habitat, for recreation, and for shellfishing for human consumption. Little Reed Pond and its associated stream are classified as SC, suggesting that the most appropriate use for this area is as habitat for fish, shellfish and wildlife and may be utilized for recreational purposes; however, other factors (e.g. size, invasive species) may limit their use for recreation.

Of the freshwater bodies, Big Reed Pond is the only one classified as B indicating that it is most suitable for primary and secondary contact recreation and fishing and is habitat for fish, shellfish and wildlife. The remaining freshwater bodies, including the two streams located on the west side of the lake and the pond associated with freshwater wetland MP-13 have a classification of C. As such, these waterbodies are primarily suitable as fish and wildlife habitat. The waterbodies are appropriate for recreation; however, other factors affecting the waterbodies (e.g., size, invasive species) may not make them the most appropriate locations for recreation. All surface waterbody classifications are depicted on **Figure 5**.

2.4.3 Known Impairments

Several known impairments are located within the Lake Montauk Watershed. These impairments include waterbodies listed on the NYS 303(d) list and shellfish closure areas. It is noted that no Federal or State listed superfund sites occur within the watershed boundaries. The following details each of the impairments identified within the watershed.

NYS 303(d) List

The Federal Clean Water Act requires states to periodically assess and report on the quality of waters in their state. Section 303(d) of the Act also requires states to identify impaired waters, where designated uses are not fully supported. For these impaired waters/pollutants, states must consider the development of a Total Maximum Daily Load (TMDL) or other strategies to reduce the input of the specific pollutant(s) restricting water body uses, in order to restore and protect such uses. The water body/pollutant listings in the Section 303(d) List are segmented into a number of categories. The various categories, or Parts, of the list include:

- Part 1 - Individual Waterbodies with Impairment Requiring a TMDL
- Part 2 - Multiple Segment/Categorical Impaired Waterbodies - Includes (a) Acid Rain Waters, (b) Fish Consumption Waters, and (c) Shellfishing Waters
- Part 3 - Waterbodies for which TMDL Development May Be Deferred - Includes (a) Waters Requiring Verification of Impairment, (b) Waters Requiring Verification of Cause/Pollutant, and (c) Waters Where Implementation/Evaluation of Other Restoration Measures is Pending

The Final NYS 2012 Section 303(d) List was issued by the NYSDEC in October 2012. No waterbodies within the Lake Montauk watershed are included on that list.

Not all impaired waters of the state are included on the Section 303(d) List. By definition, the List is limited to impaired waters that require development of a TMDL. A list entitled "Other Impaired Water body Segments Not Listed (on 303(d) List) Because Development of a TMDL is Not Necessary" is also available and was reviewed. The purpose of this supplemental list is to provide a more comprehensive inventory of waters that do not fully support designated uses and that are considered to be impaired. There are three (3) categories of justification for not including an impaired water body on the Section 303(d) List:

- Category 4a Waters – TMDL development is not necessary because a TMDL has already been established for the segment/pollutant.
- Category 4b Waters – A TMDL is not necessary because other required control measures are expected to result in restoration in a reasonable period of time.
- Category 4c Waters – A TMDL is not appropriate because the impairment is the result of pollution, rather than a pollutant that can be allocated through a TMDL.

In addition, 43 state waterbodies fall under the "B" category, which the NYSDEC defines as follows:

"It is widely accepted that morphology and other natural conditions may contribute to periodic dissolved oxygen depletion at lower depths in significant numbers of thermally stratified waters. However bottom water conditions are not necessarily representative of the water body as a whole and aquatic life and other uses are often fully supported in these waters. Although NYS water quality standards may not be met at times in these waters, the USEPA policy of independent applicability allows for resolving differences in assessment results by weighing the higher quality or more representative data set more favorably in the attainment decision."

No waterbodies within the Lake Montauk watershed were identified as Category 4 or Category B waters.

Shellfish Closure Areas

Shellfish Closure Areas are depicted in **Figure 6**. Shellfish Closure Areas are defined by 6 NYCRR Part 41 andNYSDEC, which will permanently, seasonally, or temporarily close shellfish harvesting areas due to poor sanitary conditions in the waters surrounding the shellfish beds. State regulations are promulgated through the US FDA's National Shellfish Sanitation Program (NSSP) which provides regulations for the sanitary control of shellfish produced and sold for human consumption. A portion of the NYSDEC regulation is included as **Appendix B** of this document; this section defines the closure areas within the Lake Montauk watershed. Shellfish harvesting areas are monitored and regulated by the NYSDEC Bureau of Marine Resources. In addition to permanently closed areas, the NYSDEC monitors Conditional Shellfish areas, which are open to shellfish harvesting at certain times of the year dependent upon water quality (which is directly dependent upon the volume of rainfall or snow melts, i.e., stormwater runoff).

Shellfish closure areas within the Lake Montauk watershed include the lake inlet and waters between Star Island and the western shore of the lake (Coonsfoot Cove), which is permanently closed. The area between Star Island and the eastern lake shoreline, the area in the vicinity of the Montauk Lake Marina and Club and the southernmost portion of the lake are seasonally closed (from May 15th to October 15th each year). The seasonal closures in proximity to Star Island and the Montauk Lake Marina and Club are administrative closures (i.e., they are required to be closed due to the presence of the marina regardless of water quality). Similarly, the permanent closure within Coonsfoot Cove is also an administrative closure due to the year-round presence of boats within this area. The only closure directly related to water quality is the seasonal closure located at the southern end of the lake, which exhibits poor water quality during the closure period of April 1 through December 15. It is noted that an increase in boat use in this area could result in an administrative closure.

GP 0-10-002 Pathogen Impaired Watersheds

Small Municipal Separate Storm Sewer Systems (MS4s) are defined as all separate storm sewer systems that are "Owned or operated by the United States, a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law) having jurisdiction over disposal of sewage, industrial wastes, stormwater, or other wastes, including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the CWA that discharges to waters of the United States" (**40 CFR 122.26(b)(16)**. MS4s are currently regulated under NYSDEC SPDES General Permit for Stormwater Discharges from Municipal Separate Storm Sewer Systems (GP-0-10-002). The Town of East Hampton is a recognized MS4. As a result of pathogen impairments in the Peconic Estuary, a TMDL was developed for the pathogen impaired waterbodies, which included

Lake Montauk. Data analysis within the TMDL indicated that at the majority of sampling stations, pathogen levels regularly exceeded thresholds for fecal coliform and total coliform. The TMDL attributed all of this to non-MS4 non-point source contributions. As such, a 53% reduction goal in pathogens was set for Lake Montauk from non-point sources.

Harmful Algal Blooms

Harmful Algal Blooms (HAB's) are occurrences of large quantities of algae that when present at high concentrations present a threat to humans and shellfish. While no records of harmful algal blooms within Lake Montauk exist, a blue-green algal bloom was recorded in Big Reed Pond.

In July 2010, a large fish kill was reported in Big Reed Pond. Further inspection of the pond revealed approximately 500 dead fish, including white perch, largemouth bass, American eel, banded killifish and pumpkinseed sunfish. Low water levels were noted in the pond and the stream connecting to the pond. Further examination of the bottom of the pond revealed a globular blue-green algae, which was later identified as *Aphanocapsa*, which releases toxins that can be deadly to fish. No other specific records of algal blooms within Big Reed Pond have been recorded.

The Harmful Algal Event Database (www.haedat.iode.org) has compiled data regarding HAB events in the United States. The available dataset was reviewed and although several algal blooms were noted in the Peconic Estuary, none of the available data was specific to Lake Montauk.

2.4.4 Surface Water Quality Data

Surface water quality data provides an indication of the current health of the Lake and other waterbodies within the watershed. Surface water quality data was available from the NYSDEC and SCDHS, which is described in further detail below.

NYSDEC Shellfish Data

As Lake Montauk is an area viable for shellfishing, the NYSDEC monitors fecal coliform levels within the Lake to determine if shellfish are safe for consumption. In order to meet National Shellfish Sanitation Program (NSSP) and Model Ordinance (MO) standards, a single sample may not exceed 70 Most Probable Number (MPN)/100mL (milliliter) and 10% of samples at a single station may not exceed 330 MPN/100mL. Similarly, fecal coliform levels may not exceed 14 MPN/mL for a single sample at a station, and no more than 10% of samples at a station may exceed 49 MPN/mL.

The NYSDEC maintains 29 sampling stations within Lake Montauk (see **Figure 5**). Of these stations, two are located in the southern portion of the lake, four are located in the central portion of the lake, one is located in the vicinity of Montauk Lake Marina and Club, four are located in the north-central portion of the lake (just south of Star Island), while the remainder are located within Coonsfoot Cove and the inlet. Data from 2001 – 2012 was obtained and reviewed (see **Appendix C**). While no station exceeded 49 MPN/100mL in

10% of sampling events, several stations (stations 6, 8A, 11, 13, 15, 17, 18, 19, 20, 22, 29 & 30) had 10 or greater occurrences (approximately 10%) of samples exceeding 14 MPN/100mL. As seven of these stations are located within Coonsfoot Cove, the regular exceedance of fecal coliform thresholds supports the closure of this area for shellfishing. Similarly, the seasonal closure between Star Island and the eastern shoreline of the lake is supported by water quality data as two stations exhibit regular elevated fecal coliform levels. It is noted that water quality levels at station 30, located in the southernmost portion of the lake, typically exceed fecal coliform standards during the summer months, supporting the seasonal closure of this area to shellfishing. Although currently not closed for shellfishing, the western shoreline of the lake may be closed in the future due to the elevated coliform levels detected at these stations (stations 8A and 29). Generally, this dataset indicates a problem with fecal coliform within the lake and supports the closure areas established by the NYSDEC.

NYSDEC CALM Data

As part of Federal requirements for water quality monitoring, the NYSDEC regularly samples waterbodies to determine if they are appropriate for listing on the NYS 303(d) list (described in **Section 3.4.3** above). As part of this program, Big Reed Pond was sampled once in 2003 (see **Appendix D**). These data were obtained, reviewed and analyzed based on standards outlined in NYSDEC Part 703, the NYS Consolidated Assessment Listing Methodology (CALM) and total nitrogen standards established by the Peconic Estuary Program. **Table 3** below provides each analyte, the applicable threshold, and the regulations that established the threshold.

Table 3
SURFACE WATER QUALITY EVALUATION CRITERIA

Analyte	Established Threshold	Regulating Authority
Clarity – Secchi Disc	Visibility is less than 6.6 feet	NYS Section 305(b) CALM Methodology – Public Bathing Use Assessment Criteria
Total Coliform	70 colonies/100ml	6 NYCRR §703.4
Fecal Coliform	14 colonies/100ml	NSSP
Chlorophyl-α	>8 μg/L	NYS Section 305(b) CALM Methodology – Recreation Use Assessment Criteria
Dissolved Oxygen	<4.8 mg/L	6 NYCRR §703.3
Total Nitrogen	>0.45 mg/L	Peconic Estuary Program
Ammonia	>0.035 mg/L	6 NYCRR §703.5
Phosphorus (Freshwater only)	20 μg/L	NYSDEC Water Quality Guidance Value

Review of the data as compared to the above parameters indicates that Big Reed Pond exceeded standards in clarity (visible depth to 1.40 meters), nitrogen (0.46 mg/L) and cholorophyl-α (10.6 μg/L). It is noted that although phosphorus does not exceed the threshold as the sample value was below the detection limit, the elevated cholorphyl-α is indicative of a potential phosphorus problem within the pond. Due to the limited sampling within the pond (one sample) no conclusions can be drawn regarding the water quality within the pond, and more data is needed to define the health of the pond.

<u>SCDHS Surface Water Quality Data</u>
SCDHS maintains one surface water quality sampling station within the center of Lake Montauk (**Figure 5**). The station has been monitored since October 1994 for varying parameters, depending on the sampling year. Generally, each sample was monitored for one or several of the following parameters:

- Secchi disc clarity
- Temperature
- Dissolved Oxygen
- Salinity
- pH
- Total Coliform
- Fecal Coliform
- NH3 (Ammonia)
- NO2 (Nitrite)
- NO3 (Nitrate)
- NOx (Nitrite + Nitrate)
- Urea
- Total Kjeldahl Nitrogen
- Total dissolved Kjeldahl Nitrogen
- Total Nitrogen
- Total dissolved Nitrogen
- Total Phosphate
- Total dissolved Phosphate
- Ortho-phosphate
- Total Phosphorous
- Total dissolved Phosphorous
- Total Organic Carbon
- Dissolved Organic Carbon
- Dissolved Silicate
- Total Suspended Solids
- Total chlorophyll-α
- Fractionated chlorophyll-α
- Aureococcus anophagefferens (brown tide)

Table 4 below presents a summary of results for the sampling station for which data was collected by the SCDHS. Shaded cells represent values which exceed the threshold for impairment established by the NYSDEC Consolidated Assessment Listing Methodology (CALM) for analysis of waters (see **Table 3** above). Parameters assessed in **Table 4** include those that were sampled that have established thresholds for water quality standards for Class SA marine waters in which the sampling station was located.

As illustrated, no parameter exceeds a given threshold more than 25% of the time over the long term sampling period. It is noted that fecal coliform exceeds thresholds more than any other parameter, which is consistent with the NYSDEC Shellfish Data. While this dataset has samples over an extended period of time (over 17 years), this data is not representative of the entire lake as only one sampling point located in the center of the lake exists.

<u>SCDHS Bathing Beach Data</u>

SCDHS maintains two bathing beach sampling locations within the lake Montauk Watershed: one located at East Lake Drive Beach and one located at South Lake Drive Beach. Both stations were sampled for *Enterococci*, total coliforms and fecal coliforms. Review of the data illustrates no occurrences of pathogen exceedances for East Lake Drive Beach, but several exceedances of pathogens for South Lake Drive Beach. This beach is closed for bathing due to the elevated pathogen levels. Anecdotal information indicates that septic discharge associated with the Ditch Plains neighborhood is the major contributor to pathogens in this area, however, this information would need to be verified. In general, consistent with the NSYDEC shellfish sampling data, the southern portion of the lake is impaired by pathogens. Sampling protocols and data results are provided in **Appendix E.**

CCE Coliform Data and DNA Analysis

As part of CCE's efforts to gather data for the preparation of the watershed management plan, sampling for coliform was performed at sixteen individual stations within the lake. Additionally, DNA analysis was performed on each sample to determine the source of coliform detected. Sampling stations were established at known outfalls along the lake shoreline. The following is excerpted from CCE's report regarding the data analyzed:

"*The largest coliform numbers were observed during summer and fall events. All coliform numbers that were above 1,000 (18 samples) came from samples obtained during these 2 seasons. Additionally, the next 9 highest samples, between 550 and 950, all came from fall sampling events. The highest count during a spring event was 540, and 232 for a winter sample.*"

The report continues to indicate that rainfall and lack of rainfall impact coliform concentrations entering the lake (i.e., greater amounts of rainfall result in greater quantities of bacteria entering the lake). **Table 5** summarizes the results of the sampling conducted by station. It is noted that human coliform was detected at Station 6.

Table 4
SURFACE WATER QUALITY RESULTS

Station Location	Station Number	Data Collection Data Range	Total Time Period of Data Collection (Years)	Total Number of Samples Collected	Secchi Disc Clarity		Total Coliform		Fecal Coliform		Chlorophyl-α		Dissolved Oxygen		Total Nitrogen (and Total Kjeldahl Nitrogen)*		Ammonia	
					Count of Samples Below Clarity Threshold (<6.6 feet)	Percent of Samples Below Clarity Threshold	Count of Samples Above 70 colonies per 100 ml	Percent of Samples Above 70 colonies per 100 ml	Count of Samples Above 14 colonies per 100 ml	Percent of Samples Above 49 colonies per 100 ml	Count of Samples above 8 µg/L	Percent of Samples above 8 µg/L	Count of Samples Below Minimum D.O. Threshold (4.8 mg/L)	Percent of Samples Below D.O. Threshold	Count of Samples Above 0.45 mg/L	Percent of Samples Above 0.45 mg/L	Count of Samples Above 0.035 mg/L	Percent of Samples Above 0.035 mg/L
Lake Montauk	060135	10/05/1994 – 12/11/2011	17.22	378	24	6.35%	14	3.70%	40	1.85%	8	2.12%	0	0.00%	24	3.17%	15	3.97%

*TKN was collected up until 2000, when TN was collected and TKN was no longer utilized.

Table 5
CCE WATER QUALITY SAMPLING RESULTS

Station	Coliform Sampling Results by Date (MPN/100 mL) 8/2009 (dry)	11/2009 (dry)	4/2010 (wet)	6/2010 (dry)	8/2010 (dry)	11/2010 (wet)	12/2010 (wet)	3/2011 (wet)	4/2011 (wet)	DNA Sampling Results
1 - Reed Pond	11	24	254	74	104	490	0	232	N/A	Non human (4), Bird - Mute Swan (1), Bird - Mallard Duck, Cormorant (1), Possible Bird - Black Duck (2), Not human, not bird (1)
2 - Bond Property	3,900	No Sample	87	No Sample	360	950	70	43	N/A	Not human, possible wildlife - raccoon or red fox (2), Not human, possible bird - Mallard Duck (1), Not human (1), Not human, possible domestic dog (1), Domestic dog (1), Probable wildlife - muskrat (1), Not human, possible bird (1)
3 - 105 East Lake Drive	1,300	610	268	1,350	1,700	840	99	160	N/A	Possible wildlife - raccoon (2), Not human, possible dog (1), Bird - possible Canada Goose, Cormorant (1), Possible Wildlife - Red Fox (1)
4 - 61&67 East Lake Drive	10,800	62	74	5,300	No Sample	950	700	26	N/A	Probable Bird - Canada Goose (1), Possible Wildlife - Raccoon (1), Possible Wildlife - Deer (1), Bird - Canada Goose (1)
5 - Amsterdam Park	125	76	21	12	No Sample	8,400	11	82	N/A	Wildlife - raccoon (4), Not human, not bird (2)
6 - Ocean Side Drain	1,020	710	540	14,500	1,800	3,200	36	164	N/A	Not human, possible wildlife - red fox (1), Not human (1), Human (2), Probable bird - Herring Gull or Mute Swan (1), Wildlife - muskrat (1), Bird - Herring Gull, Greater Black-Backed Gull (1)
7 - 64 Old West Lake Drive	380	79	510	No Sample	No Sample	14,300	48	214	N/A	Domestic dog (1), Bird - Canada Goose (1), Bird - Mute Swan (1)
8A - Stepping Stones Pond (southern pipe)	274	55	95	No Sample	No Sample	590	No Sample	0	N/A	Wildlife - deer (1), Not Human, Not Wildlife, Possible Domestic Horse (1), Not Human, Possible Bird - Cormorant, Black Duck (1), Probable Wildlife - Deer (1)
8B - Stepping Stones Pond (northern pipe)	N/A	N/A	N/A	124	28	320	0	1	N/A	Probable Domestic Dog (1), Not human, possible domestic dog (2)
9 - Peter's Run 8 Gloucester Avenue	1,300	85	99	1,170	4,300	3,300	66	218	N/A	Not human, possible bird - Canada Goose (2), Bird - Canada Goose (5), Bird - Herring Gull, Mallard Duck (1), Possible bird - Canada Goose (1), Not human (1)
10 - Peter's Run Retention Pond	242	96	138	240	60	580	12	188	N/A	Probable wildlife - raccoon (1), Domestic dog (2), Bird - Mute Swan (1), Possible domestic horse (1)
11 - West lake Drive & Glenmore Avenue	No Sample	33	340	No Sample	No Sample	11,000	No Sample	82	N/A	Probable bird - Herring Gull (1), Not human (4), Probable bird - Herring Gull, Cormorant (1), Domestic - probable dog (2), Possible domestic (1)
12 - Diamond Cove Marina	2	37	17	58	No Sample	240	19	39	N/A	Not human, possible bird - Black Duck, Mute Swan (3), Not human, possible bird - Black Duck (1), Bird - Mute Swan (1), Wildlife - raccoon (1), Bird - Black Duck, Mute Swan (3)
13 - Drum Property	22	380	160	1,330	190	550	No Sample	148	N/A	Not human, possible bird - Mallard Duck (1), Not human (1)
14 - CR 77 Uihlen's Marina	50	No Sample	No Sample	No Sample	No Sample	No Sample	No Sample	No Sample	N/A	N/A
15A - Pipe south of Reed Pond (East Lake Drive, East Side)	N/A	N/A	N/A	N/A	N/A	N/A	No Sample	25	75	Domestic dog (2), Not human (1), Possible domestic dog (1), Not human, not bird (1), Wildlife - muskrat (4)
15B - Pipe south of Reed Pond (Outfall)	N/A	N/A	N/A	N/A	N/A	N/A	No Sample	53	35	Probable domestic dog (9)

Notes: N/A represents no sample taken as pipe was not added to sampling regimen until date of first sample.
SCDHS standard for bathing beaches is 235 CFU (colony forming units) per 100 mL sample. Analysis of this data is based on the SCDHS bathing beach parameter.
The number in parentheses after the DNA sampling results represents the number of isolates of the identified organism in that sample.

DNA analysis was performed on one sample at each station to identify the source of coliform entering the Lake. Results of this analysis are provided in CCE's report (**Appendix A**), which generally indicate that coliform reaching the lake from the sample points is mostly from waterfowl and wildlife. Some evidence of dog coliform was present in samples, and only one station demonstrated coliform from a human source. This occurrence was located at Station 6, which is located near the southern portion of the lake. Generally, these data are consistent with NYSDEC, SCDHS and anecdotal data indicating a coliform problem in the southern portion of the lake, which is in part from septic system located in shallow groundwater areas in proximity to the lake.

2.5 Groundwater

2.5.1 Hydrogeology

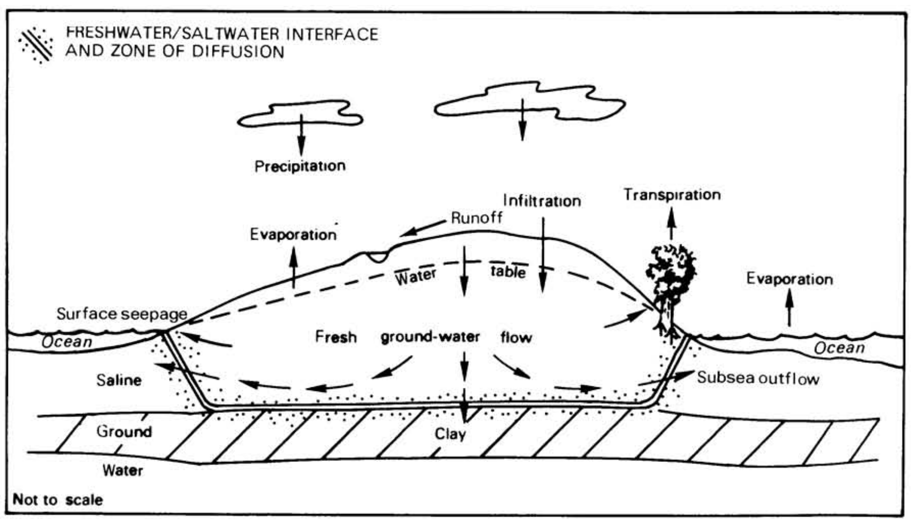
The major water-bearing units beneath the Montauk peninsula are of geologic origin as described in **Section 3.3** and include the Upper Glacial aquifer, the Magothy aquifer, and the Lloyd aquifer. Most fresh groundwater used for water supply purposes on the South Fork is derived from water contained within the upper part of the Upper Glacial aquifer, but some is withdrawn from the underlying Magothy aquifer **(Schubert, 1999)**. However, Montauk's freshwater resources are a hydrogeologic island, separated from the mainland of East Hampton by saltwater, and freshwater is only found in the shallow upper glacial aquifer, limiting the quantity of freshwater resources in the area. The freshwater aquifer lens beneath the Montauk area is marked by a four foot high groundwater contour level, rather than the five and ten foot contour elevations found in western East Hampton (**Town of East Hampton Comprehensive Plan, 2005**). Groundwater contained within the lower part of the Upper Glacial aquifer, as well as the Magothy and Lloyd aquifers is saline and is unsuitable for consumption or irrigation (**Soren, 1978**).

2.5.2 Groundwater Elevation and Flow

Groundwater in the Lake Montauk watershed is derived from precipitation. Rainfall and meltwater entering the ground ("recharge") passes downward through the unsaturated zone to a level below which all porous layers are saturated. The upper surface of this level is referred to as the "water table". Groundwater is a mild expression of topography and consequently, the water table coincides with sea level along the shorelines of the Lake Montauk watershed, and rises in elevation towards the western and southeastern edges of the subwatershed boundaries.

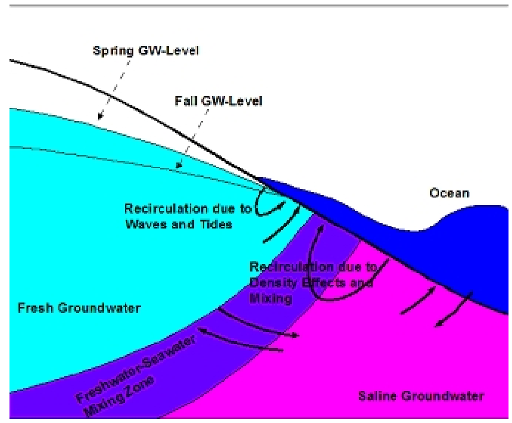
The elevation of groundwater underlying the Lake Montauk watershed ranges from 8 feet above mean sea level (msl) in the northwest part of the watershed, to zero (0) at the above ground surface in areas of wetlands and surface water. Differences in groundwater elevation create a hydraulic gradient, which causes groundwater to flow perpendicular to contours of equal elevation. High points formed by the water table create "groundwater divides", such that groundwater flows radially away from mounds in the water table elevations. The illustration below shows the basic components of the hydrologic cycle and groundwater flow beneath the Lake Montauk watershed area. The fresh groundwater is illustrated above the marine clay deposits, separated by the freshwater/saltwater interface.[3]

In general, groundwater flows from the 8 foot elevation mound on the west side of Lake Montauk toward the north, south, east and west. A secondary mound of groundwater forms in the southeastern higher elevation part of the lake, such that the high points of these two groundwater mounds form a watershed divide between groundwater that flows generally toward Lake Montauk, Block Island Sound or the Atlantic Ocean. **Figure 7** illustrates the water table elevations underlying East Hampton from which the inferred directions of groundwater flow may be determined. As noted, groundwater underlying the Lake Montauk watershed area flows radially outward from higher elevations on the west and east sides of the lake towards surface water perpendicular to the contours of equal groundwater elevation.



3 Illustration from Simmons, 1986; Figure 4, Hydrologic cycle and pattern of ground-water movement.

As groundwater migrates away from areas of higher elevation toward the shore, it eventually discharges to surface water as a result of surface seepage and subsea (or subsurface) outflow[4]. Near the shore, water entering the system tends to flow horizontally along a shallow flow system and is discharged from the subsurface into streams or marine surface waters. Water that enters the system farther inland generally flows vertically downward deeper into the Upper Glacial aquifer before flowing toward the shores where it is discharged as subsurface outflow.



The rate of groundwater flow in the aquifer is dependent on the hydraulic conductivity which describes the ease with which water is transmitted through the saturated pore space of an aquifer. The anistotropic condition that is created by differences in horizontal and vertical hydraulic conductivities is likely due to variations in stratigraphy within the Upper Glacial aquifer. Groundwater flow is also influenced by porosity of the aquifer sediments and is defined as the ratio of void space to a volume of a soil. While hydraulic conductivity and porosity convey the ability of an aquifer to transmit water, the rate of movement is expressed as groundwater velocity. This can be used to estimate groundwater travel times within an aquifer which is important in relation to contamination and discharge. The Cornell Watershed Report estimated that subwatershed 2 (located near the northwest portion of the watershed) generally experiences the greatest groundwater flow rates in the Lake Montauk watershed area. This is likely due to the size of the subwatershed, the relatively small proportion of well-draining sandy soils within the subwatershed, and the significant slope of the watershed. Subwatershed 14 was identified as the area with the lowest groundwater flow rate and runoff volumes, likely due to its small size, relatively flat topography, and well-draining soils.

The USGS figure (embedded) and **Figure 8** illustrates the depth to water in the area of Lake Montauk, which ranges from approximately 0 at areas where surface waters are encountered to 146 feet at the high points of the watershed, located on the western and eastern sides of Lake Montauk. The red areas

[4] Illustration shows spring/fall groundwater levels, fresh-salt water mixing zone and outflow at shoreline.

depicted along the coast of Lake Montauk and on the northern and southern sides of the Lake represent areas that exhibit a depth to water of less than 11 feet. These areas of shallow groundwater are constrained and environmentally sensitive with respect to existing and proposed land use.

Water table fluctuations occur in response to changes in the hydrologic water budget (precipitation, evapotranspiration, runoff and recharge) and result in changes in recharge. Seasonal fluctuations in the water table occur such that the water table rises during the early part of the year, and declines from the beginning of summer through late fall. Water table fluctuations also occur as a result of longer term climatic conditions such as droughts and periods of high rainfall. Groundwater pumpage also affects water table elevations on a more localized basis, dependent upon pumpage rates and well placement.

2.5.3 Sub-watersheds

As noted previously, the water table configuration in the Lake Montauk watershed area is characterized by two (2) principal water table mounds located on the western and eastern sides of Lake Montauk that contain local areas of relatively high water table altitude, each of which are located within the western and central portions of the watershed. **Figure 7** (previously referenced) provides an illustration of the configuration of the water table beneath the Lake Montauk watershed area. Based on the configuration of the water table, the freshwater flow system of Lake Montauk can be further divided into fourteen (14) separate sub-watersheds, each of which correspond to the areas contributing groundwater to Lake Montauk (**Cornell, 2008)**. These sub-watersheds are separated from each other by local groundwater divides that extend outward from the coast of Lake Montauk and converge toward the respective water table mounds. A general description of each sub-watershed area is presented below and illustrated on **Figure 1**:

- **Subwatershed 1** – This area is located along the northwestern side of Lake Montauk, along the coast of Block Island Sound. The area extends from the northwestern side of the Lake Montauk inlet, southwestward towards the intersection of Flamingo Avenue and North Farragut Road.

- **Subwatershed 2** – This area is located along the northwestern coast of Lake Montauk and extends from Star Island on the northwestern side of Lake Montauk, westward towards Foxboro Road. This subwatershed experiences the greatest groundwater flow rates, due to the large size of the area, small proportion of well-draining sandy soils, and significant slope of the subwatershed **(Cornell, 2008)**.

- **Subwatershed 3** – This area is located on the western side of Lake Montauk and is comprised of an area that extends from the western coast of Lake

Montauk, southward to the southern end of Montauk Downs State Park, and westward towards the edge of Fort Hill Cemetery.

- **Subwatershed 4** – This area is located on the southwestern side of Lake Montauk and is comprised of an area which extends from the coast of Lake Montauk, southwestward to South Forest Street, and westward to include the eastern portion of Montauk Downs State Park.

- **Subwatershed 5** – This small area is located on the southwestern side of Lake Montauk and extends from the coast of Lake Montauk southward to Montauk Highway.

- **Subwatershed 6** – This small area is located on the southwestern side of Lake Montauk and extends from the coast of Lake Montauk southward to Montauk Highway.

- **Subwatershed 7** – This area is located on the southern side of Lake Montauk and extends from the coast of Lake Montauk southward to the coast of the Atlantic Ocean, and westward to the intersection of Montauk Highway and South Fox Street. This subwatershed generates the most runoff, due to its large size and almost complete absence of well-draining sandy soil types **(Cornell, 2008)**.

- **Subwatershed 8** – This area is located on the southern side of Lake Montauk and extends from the coast of Lake Montauk southward to the Deforest Road, and eastward towards Ranch Road.

- **Subwatershed 9** – This area is located on the southeastern side of Lake Montauk and extends from the coast of Lake Montauk eastward to the western edge of Montauk Point State Park.

- **Subwatershed 10** – This area is located on the southeastern side of Lake Montauk and extends from the coast of Lake Montauk northwestward to the northwestern corner of Startop Drive. A small portion of Montauk Point State Park lies within the southern portion of this area.

- **Subwatershed 11** – This area is located on the eastern side of Lake Montauk and extends from the coast of Lake Montauk eastward to the end of Melchionna Road.

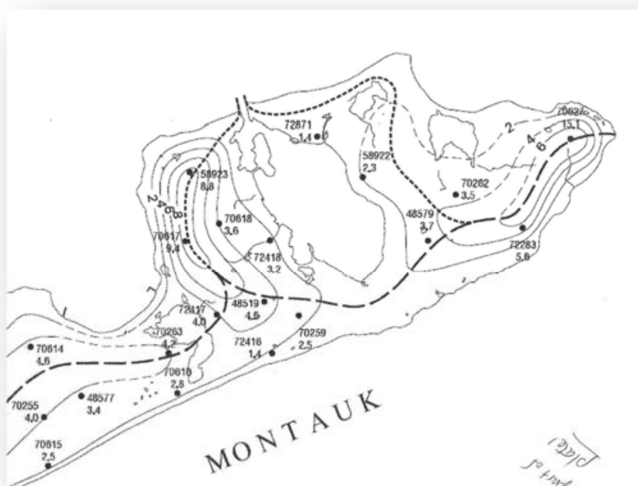
- **Subwatershed 12** – This area is located on the eastern side of Lake Montauk and extends from the coast of Lake Montauk eastward to the end of Prospect Hill Lane and northward towards Deer Way.

- **Subwatershed 13** – This area is located on the northeastern side of Lake Montauk and contains Big Reed Pond and a large portion of Montauk Point State Park. The area extends from the coast of Lake Montauk northward to the coast of Block Island Sound, and eastward towards the Atlantic Ocean. This subwatershed generates a significant amount of runoff, due to its large extent **(Cornell, 2008)**.

- **Subwatershed 14** – The area is located along the northeastern side of Lake Montauk, along the coast of Block Island Sound. The area extends from the northeastern side of the Lake Montauk inlet, south and westward towards the Montauk Airport. This subwatershed has the lowest groundwater flow rate and runoff volumes, due to its small size, well-draining sands, and flat topography (**Cornell, 2008**).

2.5.4 Groundwater Contributing Areas (to Surface Waters)

As discussed previously, groundwater continuously flows from high areas of the water table downward, perpendicular to contours of equal elevation towards Lake Montauk. Two principle water table mounds are located on the west and east sides of the Lake. High points formed by the water table create "groundwater divides", such that groundwater flows radially away from mounds in the water table elevations. The embedded figure and **Figure 9** illustrate the groundwater contributing area to Lake Montauk. The dashed line depicts the South Fork groundwater divide, and the dotted line depicts the contributing area boundaries east and west of Lake Montauk. The area within the dashed-dotted lines discharges to the lake.



As groundwater migrates away from areas of higher elevation toward the shore, it eventually discharges to surface water as a result of surface seepage and subsea (or subsurface) outflow[5]. Near the shore, water entering the system tends to flow horizontally along a shallow flow system and is discharged from the subsurface into streams or marine surface waters. Water that enters the system farther inland generally flows vertically

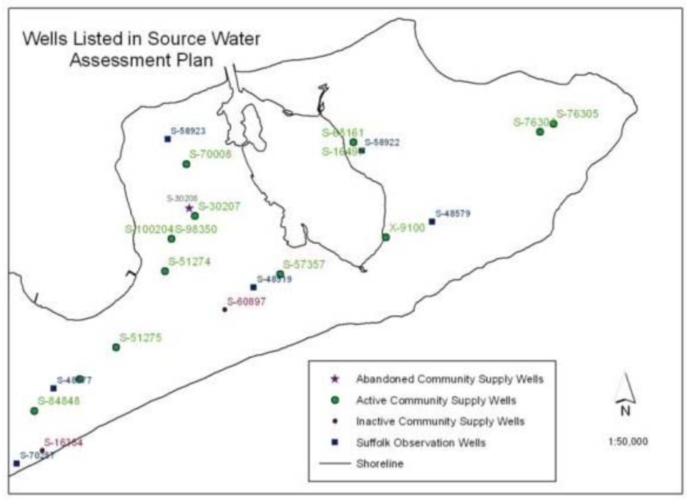
[5] Illustration shows spring/fall groundwater levels, fresh-salt water mixing zone and outflow at shoreline.

downward deeper into the Upper Glacial aquifer before flowing toward the shores where it is discharged as subsurface outflow.

Areas located just outside of the Lake Montauk watershed contribute groundwater to alternate bodies of water including: Block Island Sound to the north of Lake Montauk, Fort Pond and Fort Pond Bay west, the Atlantic Ocean to the south, and Oyster Pond and the Atlantic Ocean to the east.

2.5.5 Groundwater Quality Data

The Lake Montauk watershed area derives its water supply from groundwater stored in the aquifer beneath Long Island. Protection of groundwater quality and maintaining an adequate supply of fresh groundwater is therefore of paramount importance to ensure availability of water supply for human consumption. Additionally, acceptable water quality is especially important to the Lake Montauk area for maintaining favorable shell fishing conditions and for supporting the large seasonal population that visit the Lake Montauk area for recreation.



Because freshwater floats atop saline groundwater in a lens that is used for water supply on Long Island, the concentration of chloride is of interest with respect to water quality. Elevated chloride concentrations result from the wide zone of diffusion where freshwater mixes with salty groundwater, and from salt water intrusion and upconing as a result of low precipitation years/seasons and groundwater withdrawal. Man-induced changes including an increased summer population in the Lake Montauk area, creating an increased demand for water, can also affect the equilibrium conditions that determine the position of the freshwater/saltwater interface. These conditions are an overarching factor in the availability of freshwater for water supply on Long Island, and specifically Lake Montauk. Other water quality factors include activities that take place on the land surface that result in recharge or discharge of pollutants that impair groundwater quality.

This subsection identifies available water quality information for Lake Montauk, with a focus on nitrogen as a primary contaminant of concern resulting from land use density and fertilization, and pathogens as a primary contaminant of concern resulting from improperly functioning on-site sanitary systems, waterfowl, and improper pet waste disposal.

Groundwater wells in the area of Lake Montauk include: abandoned community supply wells, active community supply wells, inactive community supply wells, and Suffolk observation wells (see embedded figure and **Figure 5**, depicting the locations of groundwater quality monitoring sites and groundwater wells). These wells are not routinely monitored for water quality. Since there is no routine monitoring occurring in the area, there is limited data available regarding the groundwater quality of the Lake Montauk watershed; however, a limited number of wells were monitored by the SCDHS for some water quality constituents during 1998-2001. Data collected during this period (summarized in **Table 6** below) indicated that water quality in the vicinity of Lake Montauk is generally acceptable. No volatile organic compounds (VOCs), perchlorate, or pesticides were detected in groundwater samples. In addition, nitrogen concentrations were non-detect, 0-3 mg/l and 0-6 mg/l (see table below). Review of chloride data shows concentrations of >20 mg/l, evidencing some effect of salt water intrusion. However, the concentrations were all below 70 mg/l and below the drinking water standard of 250 mg/l.

Table 6
GROUNDWATER QUALITY RESULTS

Well S No.	VOC's	Nitrates	Perchlorate	Pesticides
S 16497	nondetect	0-6mg/L		nondetect metolachlor, aldicarb, alachlor
S 30207	nondetect	0-6mg/L		nondetect metolachlor, aldicarb, alachlor
S 51274	nondetect	nondetect	nondetect	nondetect metolachlor, aldicarb, alachlor
S 57357	nondetect		nondetect	nondetect metolachlor, aldicarb and alachlor
S 70155	nondetect	0-3mg/L	nondetect	nondetect metolachlor, aldicarb, alachlor
S 76304	nondetect	0-3 mg/L		nondetect metolachlor, aldicarb, alachlor
S 76305	nondetect	nondetect		nondetect metolachlor, aldicarb, alachlor
S 84848	nondetect	nondetect	nondetect	nondetect metolachlor, aldicarb, alachlor
S 100204	nondetect	nondetect	nondetect	nondetect metolachlor, aldicarb, alachlor
S 115703	nondetect	nondetect	nondetect	nondetect metolachlor, aldicarb, alachlor

As noted previously, nitrogen is a primary water quality constituent of concern in the Lake Montauk watershed. Nitrogen is a component of sanitary waste disposal and fertilizer application. There are no sewage treatment plants located within the Lake Montauk Watershed and as a result, the entire area surrounding Lake Montauk uses on-site sanitary disposal systems. Such systems, when properly designed and installed, use a septic tank for solids removal and leaching pools placed above groundwater that allow ammonium (NH_{4+}) in sewage to be converted to nitrite (NO_2) and nitrate (NO_3). This process drives off some nitrogen as a gas and recharges wastewater effluent with elevated nitrogen concentrations. SCDHS regulates density of development under Article 6 of the Suffolk County Sanitary Code (SCSC), and limits the number of gallons per day per acre of discharge and/or the number of units per acre in order to ensure that wastewater effluent does not cause significantly elevated concentrations of nitrogen in the aquifer. SCDHS also has design standards for commercial and residential conventional sanitary systems to ensure proper function. Article 6 applies only to new development after enactment of the law in 1980. Therefore, older subdivisions and old systems installed prior to the design/installation requirements may result in excess density of development and improperly functioning sanitary systems. Sanitary systems that do not have adequate unsaturated leaching depth below the leaching pool discharge do not allow for sufficient conversion of ammonia to nitrate and therefore have a greater groundwater impact (and surface water impact when placed in areas proximate to surface water) than properly functioning sanitary systems. Therefore, since the Lake Montauk area has been characterized as having a shallow depth to groundwater (specifically in the area south of the Lake), nitrogen impacts to groundwater are a concern. This is an existing condition based on historic development. Remedy of this condition would require some form of sewage treatment of existing uses within the contributing area.

In 1978, the Long Island Regional Planning Board completed the Comprehensive Waste Treatment Management Study (known as the 208 study funded under Section 208 of the Water Pollution Control Act) that established a basis for control of density of development to maintain water quality. As noted, in 1980, SCDHS promulgated Article 6 of the SCSC that identified groundwater management zones (GMZ's) and lot sizes for residential development. Lot sizes ranged from 20,000 SF (approximate equivalent of 2 units per acre) in zones other than deep aquifer recharge areas and areas that contribute to water quality of the Long Island south shore bays, to 40,000 SF (approximate equivalent of 1 unit per acre) for long term water supply aquifer recharge areas and areas that do contribute to water quality of south shore bays.

Lake Montauk lies in GMZ IV, which is the less stringent zone in terms of development densities (20,000 SF per dwelling or about 2 units per acre). Developments at densities of 2 units per acre are expected to result in nitrogen concentrations elevated above natural conditions, but are also expected to ensure that nitrogen in groundwater will remain below the drinking water standard of 10 mg/l. Development at densities above 2 units per acre may result in elevated nitrogen above the drinking water standard, depending on the density.

Pathogens have also been identified as a contaminant of concern in the Lake Montauk watershed area, since pathogen contamination in coastal waters can lead to closed shellfishing beds and bathing beaches. Water quality issues involving pathogens can result from improper waste management practices with regard to on-site sanitary systems, waterfowl and pet waste disposal. In the spring of 2009, the Town of East Hampton was notified by NYSDEC that the Town would be covered under an MS4 (Municipal Separate Storm Sewer System) permit issued by the Environmental Proptection Agency (EPA) and administered by NYSDEC, due to the fact that Lake Montauk surpassed its total maximum daily load level of pathogens. The Town of East Hampton subsequently implemented a stormwater management program (discussed below Section 3.8.2, Stormwater).

An overview of contaminants of concern in groundwater in the Lake Montauk watershed area is provided based on review of water quality reports from the local water purveyor. The Lake Montauk area is serviced by the Suffolk County Water Authority (SCWA) and lies within Distribution Area 26. However, a large amount of water provided to the Montauk area comes from Distribution Area 23. In order to comply with State regulations, each distribution area issues an annual report to inform residents of the quality of their drinking water and involves analysis of a variety of organic and inorganic compounds (metals) as well as total coliform, nitrate, nitrite, total trihalomethanes (disinfection by-products) and synthetic organic compounds. The most recent available reports available for review were from 2012.

Review of the results presented in the Montauk Distribution Area report indicated that no radioactive compounds were detected with the exception of radon, which is a naturally occurring radioactive gas. The average value of radon detected was non-detect. In addition, the report indicated that varying concentrations of several analyzed inorganics which included barium, cadmium, chloride, copper, iron, lead, manganese, nickel, nitrate, perchlorate, phosphate, sulfate and zinc were detected. The likely sources of these compounds are the erosion of natural deposits, galvanized pipe, saltwater intrusion, household plumbing, natural occurrences, lead solder, alloys, coatings manufacturing, batteries, fertilizer, septic tanks, solid fuel propellant and fireworks. Concentrations for all of these compounds were found to be within their respective groundwater standard limits with the exception of iron, a naturally occurring metal that exceeded in the high value range of readings; however, the average value and iron did not exceed groundwater standard limits.

The annual SCWA report also indicated that synthetic organic compounds including pesticides, herbicides, pharmaceuticals and personal care products were also detected at varying concentrations including: diethyltoluamide (DEET), 1,4-dioxane, gemfibrozil, ibuprofen and meprobamate. All of these compounds were found to be significantly below their respective groundwater standard limits and averaged a non-detect reading. Volatile organic compounds detected included chlorodifluoromethane, dichlorodifluoromethane, MTBE, and tetrachloroethane, all of which were found to be within their respective groundwater standard limits. The sources of these compounds are refrigerants, aerosol propellants, gasoline, factories, dry cleaners and spills. In addition, several disinfectant and disinfection by-products were detected at varying concentrations below their respective groundwater standard limits. These included: bromochloroacetic acid, bromodichloromethane, bromoform, chlorate, residual chlorine, chloroform, dibromochloromethane, haloacetic acids and trihalomethanes.

A summary of the detection results for key inorganic parameters was compiled from the 2012 Annual Water Quality Report (regulatory groundwater standards in parenthesis):

Barium	ND*-0.15 mg/l, average 0.07 mg/l (2 mg/l)
Cadmium	ND-0.4 ug/l, average ND (5 ug/l)
Chloride	20.6-105.7 mg/l, average 44.8 mg/l (250 mg/l)
Copper	ND-0.25 mg/l, average 0.03 mg/l (1.3 mg/l)
Iron	ND-728 ug/l, average 129 ug/l (300 ug/l)
Lead	ND-.1.9 ug/l, average ND (15 ug/l)
Manganese	ND-154 ug/l, average 24 ug/l (300 ug/l)
Nickel	ND-2.7 ug/l, average 1.1 ug/l (100 ug/l)
Nitrate	ND-4.74 mg/l, average 1.90 mg/l (10 mg/l)
Perchlorate	ND-0.60 ug/l, average 0.22 ug/l) (15 ug/l)
Sulfate	6.2-28.4 mg/l, average 12.1 mg/l (250 mg/l)
Zinc	ND-0.16 mg/l, average ND (5 mg/l)

Note: * ND = Not detected

Based on water quality reports from local water purveyors, iron is the only constituent that exceeded drinking water standards. Iron is typically a natural contaminant present as a result of leaching of the metal from geologic deposits, particularly as a result of the low pH of water recharging and in storage in the aquifer. Iron is primarily an aesthetic parameter that can result in discoloration of water with minimal health concerns in the relatively low concentrations detected. Nitrate and chloride are discussed earlier in this subsection. Nickel is from alloys, coatings, manufacturing or batteries, and perchlorate is from fertilizers, solid fuel propellant, or fireworks. The remaining compounds detected are either naturally occurring compounds, or result from corrosion of household plumbing.

2.6 Flood Zones

The Federal Emergency Management Agency (FEMA) has prepared Flood Insurance Rate Maps (FIRM) which identify zones as well as the frequency which areas may be subject to flooding. In particular, there are four (4) flood zones which have been identified particularly along the shoreline of the lake. **Table 7** provides a summary and description of each of these flood zones. The location of each flood zone is illustrated in **Figure 10**.

Table 7
FEMA FLOOD ZONES

Flood Zones	Description of Flooding Conditions
Zone X	Area of minimal flood hazard, usually depicted on FIRMs as above the 500-year flood level
0.02% Change Annual Flood Hazard	"500-year flood" - has a 0.02 percent chance of a flood occurring in any year.
Zone AE	Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. The base floodplain where base flood elevations are provided.
Zone VE	Coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Base flood elevations derived from detailed analyses are shown at selected intervals within these zones.

Source: Federal Emergency Management Agency (FEMA)

As illustrated, the majority of areas susceptible to flooding occur within the low-lying areas along the shoreline of the lake. Additional inland areas subject to flooding include the Ditch Plains neighborhood south of the lake, portions of the neighborhood west of West Lake Drive north of Duryea Avenue, and the parklands located in the northeast portion of the watershed in the vicinity of Big Reed and Little Reed ponds.

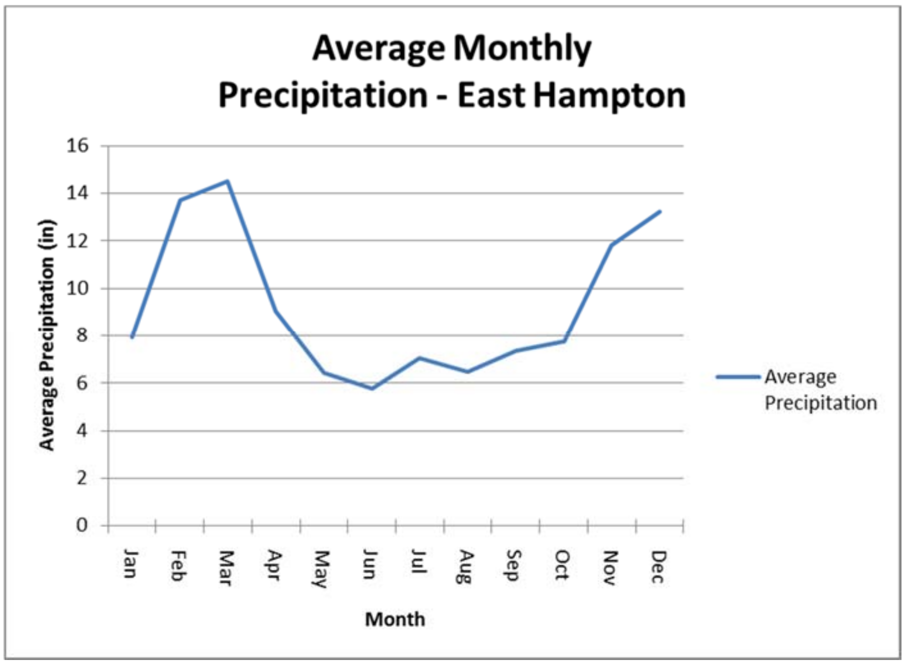
Additionally, Sea, Lake and Overland Surge from Hurricanes (SLOSH) data was reviewed to determine potential flooding areas from hurricanes (**Figure 11**). This dataset was developed by the National Weather Service to estimate potential surge heights from each hurricane category. As illustrated, the majority of the low lying areas along the shoreline of the lake would be vulnerable to Category 1 and 2 hurricanes. Additional inland areas, particularly within the Ditch Plains neighborhood, lands in the vicinity of Big and Little Reed ponds and lands in the northwest portion of the watershed (north of East Flamingo Avenue) become vulnerable from Category 3, 4 and 5 hurricanes.

Generally, both data sets illustrate similar key areas susceptible to flooding during major storm events, indicating that flooding within the Lake Montauk watershed would be mainly the result of low topographic elevation.

2.7 Precipitation

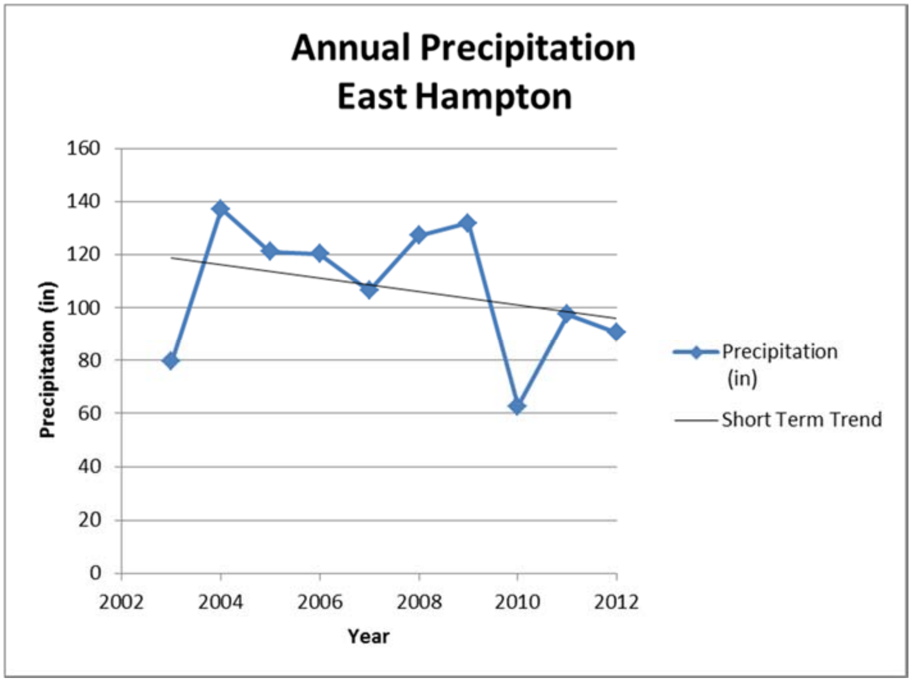
Precipitation trends in East Hampton are similar to that of the Long Island region. Data for East Hampton was obtained from the Northeast Regional Climate Center and analyzed for monthly and annual trends. It is noted that the dataset for East Hampton is extremely limited, as data only exists from 2003 to present. **Graph 1** illustrates average monthly precipitation while **Graph 2** illustrates annual precipitation from 2003 to 2012. As illustrated in **Graph 1**, the majority of precipitation occurs between November and March, while precipitation declines during mid-spring and summer months. The highest average precipitation occurs in March, which averages 14.51 inches within that month. The smallest average quantity of precipitation occurs in June, which only averaged 5.75 inches of precipitation.

Graph 1
Average Monthly Precipitation – East Hampton



As illustrated in **Graph 2**, annual total precipitation varies from year to year as a result of varying climate conditions. The dataset indicates that 2010 experienced the lowest quantity of precipitation, receiving only 62.66 inches of precipitation, while 2004 experienced the greatest quantity of precipitation, receiving 137.26 inches. The data illustrates that the short term trend for precipitation in East Hampton is a decline in annual precipitation; however, as the data is over a relatively short timeframe (nine years) this trend may not be representative of the overall long term precipitation trend experienced by East Hampton.

Graph 2
Annual Precipitation – East Hampton (2003-2012)



2.8 Infrastructure

Infrastructure within the Lake Montauk watershed includes the road system, stormwater infrastructure and individual sanitary systems. There is no railway that runs through the watershed; however, one regular and one summer public bus traverse the area.

2.8.1 Transportation

Within the 2,728 acre watershed, approximately 41.67 miles of roadway exist. Of the total roadways, 3.92 miles are comprised of County roadways and 2.54 miles are State owned roadways. County roadways consist of C.R. 49 (Flamingo Avenue) and C.R. 77 (Lake Drive/Fern Street). The State roadway is solely comprised of S.R. 27, Montauk Highway. The remainder of the roadways are either Town roads or are privately owned.

Some public transportation is locally available. The Suffolk County Transit regular bus route traverses primarily State and County roads in this area, including Montauk Highway, Flamingo Avenue and West Lake Drive (Town road). The additional seasonal bus traverses Montauk Highway from the intersection of Edgemere Street to Montauk Point.

2.8.2 Stormwater

Limited stormwater infrastructure data is available for the Lake Montauk Watershed. Data was compiled from the Town, the Peconic Estuary Program and field visits performed by NP&V, to identify infrastructure locations. The Town's data was collected in 2012 as part of their MS4 reporting requirements, and the data collected by PEP was compiled in 2000 as an initial dataset for the Peconic Estuary. NP&V collected data in 2013 to supplement the existing dataset. As illustrated in **Figure 12**, several direct outfall pipes are located along the lake shoreline. Additionally, several areas of direct overland flow were identified by the Town or PEP along the shoreline. As a result, it can be surmised that at a minimum, areas located in close proximity to the lake shoreline have some direct discharge to the lake.

There is evidence of upland catchment, as illustrated by the abundance of catch basins located in the northwest portion of the watershed. Similar catchment facilities may be provided in other areas of the watershed; however, complete data illustrating drainage infrastructure within the watershed is unavailable at this time.

2.8.3 Sanitary

No private or municipally owned sewage treatment plants are located within the watershed. As a result, all property owners have individual sanitary systems for each building. The age and functionality of these systems is unknown as some structures have been expanded or restored, while others have had very little change since being built. This is particularly true in the Ditch Plains neighborhood located south of the lake. Many of the residences located in this neighborhood were built between the 1950's and the 1970's, and may not have had upgrades to the sanitary systems. As illustrated in **Figure 8**, this area also has shallow depth to groundwater (less than 8 feet), suggesting that some sanitary systems may not have adequate separation distance to groundwater and therefore are not functioning properly. As a result, these systems could be contributing nitrogen and coliform pollution to the lake and to the Atlantic Ocean.

2.9 Natural Resources

2.9.1 Wetlands

<u>Freshwater Wetlands</u>

The freshwater wetlands (i.e., ponds and marshes) are located throughout the Lake Montauk watershed. These features were formed during the retreat of the Laurentide Ice Sheet, when fresh meltwater collected in the kettle holes and depressions formed previously during glacial advance. These areas are of critical importance to the Lake Montauk watershed as they represent ecologically sensitive resources.

The NYSDEC has identified 20 freshwater wetlands within or partially within the Lake Montauk Watershed; these areas comprise approximately 700.3 acres of wetland systems, 431.3 acres of which are located within the watershed. These freshwater wetlands are all catalogued by the NYSDEC on the Montauk Point United States Geological Survey (USGS) 7.5-minute quadrangle and are illustrated in **Figure 13**. NYSDEC classifies freshwater wetlands into four categories, which are described in §664.5 of the NYSDEC regulations. Class I wetlands are considered the most pristine and therefore the most valuable, while Class IV wetlands lack characteristics which would give the wetland a high value. The definitions of each class category, as provided by the NYSDEC, are listed below.

Class I wetlands:
A wetland shall be a Class I wetland if it has any of the following seven enumerated characteristics:
Ecological associations
(1) it is a classic kettlehole bog
Special features
(2) it is resident habitat of an endangered or threatened animal species
(3) it contains an endangered or threatened plant species
(4) it supports an animal species in abundance or diversity unusual for the state or for the major region of the state in which it is found
Hydrological and pollution control features
(5) it is tributary to a body of water which could subject a substantially developed area to significant damage from flooding or from additional flooding should the wetland be modified, filled, or drained
(6) it is adjacent or contiguous to a reservoir or other body of water that is used primarily for public water supply, or it is hydraulically connected to an aquifer which is used for public water supply or
Other
(7) it contains four or more of the enumerated Class II characteristics. The department may, however, determine that some of the characteristics are duplicative of each other, therefore do not indicate enhanced benefits, and so do not warrant Class I classification.

Class II wetlands:
A wetland shall be a Class II wetland if it has any of the following seventeen enumerated characteristics:
Covertype
(1) it is an emergent marsh in which purple loosestrife and/or reed (*Phragmites*) constitutes less than two-thirds of the covertype
Ecological association
(2) it contains two or more wetland structural groups
(3) it is contiguous to a tidal wetland
(4) it is associated with permanent open water outside the wetland
(5) it is adjacent or contiguous to streams classified C(t) or higher under article 15 of the environmental conservation law

Special features
(6) it is traditional migration habitat of an endangered or threatened animal species
(7) it is resident habitat of an animal species vulnerable in the state
(8) it contains a plant species vulnerable in the state
(9) it supports an animal species in abundance or diversity unusual for the county in which it is found
(10) it has demonstrable archaeological or paleontological significance as a wetland
(11) it contains, is part of, owes its existence to, or is ecologically associated with, an unusual geological feature which is an excellent representation of its type
Hydrological and pollution control features
(12) it is tributary to a body of water which could subject a lightly developed area, an area used for growing crops for harvest, or an area planned for development by a local planning authority, to significant damage from flooding or from additional flooding should the wetland be modified, filled, or drained
(13) it is hydraulically connected to an aquifer which has been identified by a government agency as a potentially useful water supply
(14) it acts in a tertiary treatment capacity for a sewage disposal system
Distribution and location
(15) it is within an urbanized area
(16) it is one of the three largest wetlands within a city, town, or New York City borough or
(17) it is within a publicly owned recreation area

Class III wetlands:
A wetland shall be a Class III wetland if it has any of the following fifteen enumerated characteristics:
Covertypes
(1) it is an emergent marsh in which purple loosestrife and/or reed (Phragmites) constitutes two-thirds or more of the covertype
(2) it is a deciduous swamp
(3) it is a shrub swamp
(4) it consists of floating and/or submergent vegetation
(5) it consists of wetland open water
Ecological associations
(6) it contains an island with an area or height above the wetland adequate to provide one or more of the benefits described in section
Special features
(7) it has a total alkalinity of at least 50 parts per million
(8) it is adjacent to fertile upland
(9) it is resident habitat of an animal species vulnerable in the major region of the state in which it is found, or it is traditional migration habitat of an animal species vulnerable in the state or in the major region of the state in which it is found
(10) it contains a plant species vulnerable in the major region of the state in which it is found
Hydrological and pollution control features
(11) it is part of a surface water system with permanent open water and it receives significant pollution of a type amenable to amelioration by wetlands
Distribution and location
(12) it is visible from an interstate highway, a parkway, a designated scenic highway, or a passenger railroad and serves a valuable aesthetic or open space function
(13) it is one of the three largest wetlands of the same covertype within a town

(14) it is in a town in which wetland acreage is less than one percent of the total acreage or
(15) it is on publicly owned land that is open to the public

Class IV wetlands:
A wetland shall be a Class IV wetland if it does not have any of the characteristics listed as criteria for Class I, II or III wetlands. Class IV wetlands will include wet meadows and coniferous swamps which lack other characteristics justifying a higher classification.

Table 8 below lists each wetland, their approximate size, and the NYSDEC classification.

Table 8
NYSDEC FRESHWATER WETLANDS

NYSDEC Freshwater Wetland Number	NYSDEC Classification	NYSDEC Wetland Acreage	Acreage of Wetland Within the Watershed
MP-1	I	21.5	18.42
MP-2	I	197.3	106.22
MP-3	I	1.4	0.93
MP-10	I	31.2	23.69
MP-12	I	13.6	8.85
MP-13	I	78.5	57.87
MP-14	I	124.5	52.42
MP-18	I	14.7	2.67
MP-19	III	22.1	18.59
MP-24	I	21.9	16.08
MP-25	I	30.8	23.25
MP-26	I	11.5	8.1
MP-27	I	33.5	27.62
MP-30	I	65.2	42.64
MP-31	I	3.3	1.9
MP-33	I	4.8	3.73
MP-34	I	10.6	7.19
MP-36	III	1	0.63
MP-41	II	5.1	4.06
MP-42	II	7.8	6.44
Grand Total	**---**	**700.3**	**431.3**

As illustrated in **Table 8** above, the majority of the wetlands within the watershed are Class I, while only two wetlands are Class II and two wetlands are Class III. This is indicative of the generally good quality of freshwater wetlands within the watershed. It is noted that the largest freshwater wetland, MP-2, is associated with Big Reed Pond located in the northeastern portion of the watershed and is approximately 197.3 acres in size of which approximately 106.22 acres are located within the watershed. This wetland is generally of high quality as it is a Class I wetland. The two wetlands of moderate quality (MP-41 and MP-42) are located in proximity to the southeastern shoreline of the lake while the two wetlands of low quality (MP-19 and MP-36) are located in the southern and west-central portions of the watershed, respectively.

Tidal Wetlands

The tidal wetlands within the watershed are located where the shoreline intersects and interfaces with tidal waters. These wetlands contain saline waters, which originate from the ocean-fed surface waters associated with the lake. These features are formed by coastal processes and, with the exception of formerly connected tidal wetlands, are subject to tidal influence. These areas are not only vital to the ecological systems to which they serve, but also function to control storm surges during flood and major storm events which may impact sensitive watershed areas. The NYSDEC maintains a series of tidal wetlands maps which document the location and type of tidal wetlands within New York State and includes a complete inventory for the area of the Lake Montauk watershed. Tidal wetlands within the watershed are illustrated in **Figure 13**. The NYSDEC classifies tidal wetlands into fourteen distinct categories. Definitions for those categories present within the Lake Montauk watershed are provided below.

SM - Coastal Shoals, Bars and Mudflats: The tidal wetland zone that at high tide is covered by saline or fresh tidal waters, at low tide is exposed or is covered by water to a maximum depth of approximately one foot, and is not vegetated.

LZ - Littoral Zone: The tidal wetland zone that includes all lands under tidal waters which are not included in any other category. There shall be no LZ under waters deeper than six feet at mean low water.

IM - Intertidal Marsh: The vegetated tidal wetland zone lying generally between average high and low tidal elevation in saline waters. The predominant vegetation in this zone is low marsh cord grass, *Spartina alterniflora*.

HM - High Marsh: The normal upper most tidal wetland zone usually dominated by salt meadow grass, *Spartina patens*; and spike grass, *Distichlis spicata*. This zone is periodically flooded by spring and storm tides and is often vegetated by low vigor, *Spartina alterniflora* and Seaside lavender, *Limonium carolinianum*. Upper limits of this zone often include black grass, *Juncus gerardi*; chairmaker's rush, *Scirpus sp.*; marsh elder, *Iva frutescens*; and groundsel bush, *Baccharis halimifolia*.

DS - Dredged Spoil All areas of fill material.

The majority of the area along the shoreline of the lake is categorized as SM, suggesting mudflat areas occur which are habitat for fish and shellfish. Vegetated tidal wetlands (HM and IM) exist primarily along the southwestern shoreline of the lake that receive lesser amounts of natural disturbance as a result of public ownership and greater sediment deposition, allowing for the establishment of tidal wetland vegetation. Two other notable areas of vegetated tidal wetlands exist at the southern portion of the lake where a series of freshwater wetland systems ultimately drain to the lake and along the stream that drains Big Reed Pond and Little Reed Pond into the lake. The quality of these wetland areas will depend heavily on the amount of anthropogenic disturbance and influence the wetland areas receive.

2.9.2 Living Resources

Living resources include the significant flora and fauna that are present within the watershed. While significant natural communities are discussed in **Section 4.3** below, this section focuses on the significant plants and animals known to occur within the watershed, lake and other surface water bodies. These resources should be considered in water quality improvements as the habitat of each species should be protected to ensure the continuance of the species. A variety of resources were reviewed to determine living resources within the watershed including CCE's watershed report, the NYNHP, data from the NYSDEC and the Town's Native Plant Guide. The NYNHP has identified twelve rare moths, a rare beetle, an endangered butterfly, one endangered bird, three threatened birds, two rare plants, sixteen threatened plants and fourteen endangered plants as either presently or historically occurring within the watershed (**Appendix F**). It is noted that the lake does not support any anadramous fish populations. **Table 9** below provides a summary of the species identified by general habitat type as it provides an indication of where the species would be expected since the NYNHP does not provide specific locations due to the sensitivity of the information.

Table 9
RARE SPECIES IDENTIFIED BY THE NYNHP

General Habitat Type		Species Type	NYS Legal Status (Endangered, Threatened, Rare, Special Concern)	Current or Historic
GRASSLAND/HEATH/OPEN AREAS			--	--
Species Common Name	**Species Scientific Name**		--	--
Northern Harrier	*Circus cyaneus*	Bird	Threatened	Current
Coastal Heathland Cutworm	*Abagrotis nefascia benjamini*	Moth	Unlisted	Current
An Apamea Moth	*Apamea burgessi*	Moth	Unlisted	Current
Switchgrass Dart	*Dichagyris (Loxagrostis) acclivis*	Moth	Unlisted	Current

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Fringed Dart	*Eucoptocnemis fimbriaris*	Moth	Unlisted	Current
Fawn Brown Dart	*Euxoa pleuritica*	Moth	Unlisted	Current
Violet Dart	*Euxoa violaris*	Moth	Unlisted	Current
The Pink Streak	*Faronta rubripennis*	Moth	Unlisted	Current
A Noctuid Moth	*Hydraecia stramentosa*	Moth	Unlisted	Current
Chocolate Renia	*Renia nemoralis*	Moth	Unlisted	Current
Regal Fritillary	*Speyeria idalia*	Butterfly	Endangered	Current
Midland Sedge	*Carex mesochorea*	Plant	Threatened	Current
Sandplain Wild Flax	*Linum intercursum*	Plant	Threatened	Current
Southern Arrowwood	*Viburnum dentatum var. venosum*	Plant	Threatened	Current
Sandplain Gerardia	*Agalinis acuta*	Plant	Endangered	Current
Fringed Boneset	*Eupatorium torreyanum*	Plant	Threatened	Current
Spring Ladies'-tresses	*Spiranthes vernalis*	Plant	Endangered	Current
Bush Rockrose	*Crocanthemum dumosum*	Plant	Threatened	Current
Slender Spikerush	*Eleocharis tenuis var. pseudoptera*	Plant	Endangered	Current
Michaux's Blue-eyed-grass	*Sisyrinchium mucronatum*	Plant	Endangered	Current
Little-leaf Tick-trefoil	*Desmodium ciliare*	Plant	Threatened	Current
Northern Blazing-star	*Liatris scariosa var. novae-angliae*	Plant	Threatened	Current
FRESHWATER WETLAND			--	--
Species Common Name	**Species Scientific Name**		--	--
Marsh Fern Moth	*Fagitana littera*	Moth	Unlisted	Current
White-edge Sedge	*Carex debilis var. debilis*	Plant	Threatened	Current
Lowland Yellow Loosestrife	*Lysimachia hybrid*	Plant	Endangered	Current
FRESHWATER WETLAND SHORELINE/OPEN AREAS		--	--	--
Species Common Name	**Species Scientific Name**	--	--	--
Whorled-pennywort	*Hydrocotyle varticillata*	Plant	Endangered	Current
Clustered Bluets	*Oldenlandia uniflora*	Plant	Endangered	Current
Featherfoil	*Hottonia inflate*	Plant	Threatened	Current
Orange Fringed Orchid	*Platanthera ciliaris*	Plant	Endangered	Current
Blunt Mountain-mint	*Pycnanthemum muticum*	Plant	Threatened	Current
Whorled Mountain-mint	*Pycnanthemum verticillatum var. verticillatum*	Plant	Endangered	Current
Long-tubercled Spikerush	*Eleocharis tuberculosa*	Plant	Threatened	Current
Swamp Smartweed	*Persicaria setacea*	Plant	Endangered	Historic
FRESHWATER WATERBODY		--	--	--
Species Common Name	**Species Scientific Name**	--	--	--
Spotted Pondweed	*Potamogeton pulcher*	Plant	Threatened	Historic

DRY WOODLANDS		--	--	--
Species Common Name	**Species Scientific Name**	--	--	--
Packard's Lichen Moth	*Cisthene packardii*	Moth	Unlisted	Current
Hairy Woodrush	*Luzula bulbosa*	Plant	Rare	Current
PINE OAK FOREST/ACIDIC SOIL FOREST		--	--	--
Species Common Name	**Species Scientific Name**	--	--	--
Pine Devil	*Citheronia sepulcralis*	Moth	Unlisted	Current
Emmons' Sedge	*Carex albicans var. emmonsii*	Plant	Rare	Current
TIDAL SHORELINE/OPEN AREAS		--	--	--
Species Common Name	**Species Scientific Name**	--	--	--
Piping Plover	*Charadrius melodus*	Bird	Endangered	Current
Common Tern	*Sterna hirundo*	Bird	Threatened	Current
Least Tern	*Sternula antillarum*	Bird	Threatened	Current
Small's Knotweed	*Polygonum aviculare ssp. Buxiforme*	Plant	Endangered	Historic
Golden Dock	*Rumex fueginus*	Plant	Endangered	Historic
Hairy-necked Tiger Beetle	*Cicindela hirticollis*	Beetle	Unlisted	Historic
TIDAL WETLANDS		--		
Species Common Name	**Species Scientific Name**	--	--	--
Salt-marsh Spikerush	*Eleocharis uniglumis var. halophila*	Plant	Threatened	Current
Seaside Plantain	*Plantago maritime var. juncoides*	Plant	Threatened	Historic
Northern Gamma Grass	*Tripsacum dactyloides*	Plant	Threatened	Historic
Screw-stem	*Bartonia paniculata ssp. Paniculata*	Plant	Endangered	Historic
Dwarf Glasswort	*Salicornia bigelovii*	Plant	Threatened	Historic
Salt-meadow Grass	*Leptochloa fusca ssp. Fascicularis*	Plant	Endangered	Historic

Marine Infauna

In 2008 CCE conducted a study on sediment and infauna analysis of the lake (**Appenidx A**). Twenty stations were sampled, which are illustrated in **Figure 5**. Throughout the majority of the stations, the primary species identified were a variety of polychaetes (segmented worms), while only two stations had bivalves, and one station had a ribbon worm. In general, these data illustrate some impairment to Lake Montauk due to the low number of species encountered within the lake (11 species total) and the low number of individuals of each species (maximum of 3 of one species).

Shellfish

Areas within the lake contain known shellfish beds, some of which are seeded as part of the Town's shellfish program. The 2012 annual report indicated that while production of shellfish seed (clams, oysters and scallops) was fairly successful, some seed stock was lost as a result of Hurricane Sandy. It is noted that within Lake Montauk, only clams and oysters are seeded.

Seining surveys performed within Lake Montauk also reveal a variety of shellfish naturally occurring within the lake. Scallops, crabs, shrimp, periwinkles, clams, oysters and slipper shells are periodically identified as occurring within the lake. The most abundant shellfish identified was grass shrimp, which averaged approximately 67 individuals per survey per year. A detailed list of fauna surveyed is provided in **Appendix G**.

Finfish

Finfish have been identified in both Lake Montauk and Big Reed Pond. The seining report, which contains data from 1997 to 2008, identifies a variety of finfish identified within the lake. The most abundant finfish identified during these surveys was striped bass, which averaged 80 individuals per survey per year. In total, 118 different species were identified within the Town survey (finfish and shellfish) and 2005 had the most diversity of species collected, with 79 different species identified. A summary of species collected per year is provided in **Appendix H**.

Big Reed Pond also supports a healthy population of finfish. A 1997 report prepared by the NYSDEC indicated that Big Reed Pond supports largemouth bass, pumpkinseed sunfish, white perch, alewife, banded killifish and American eel. The report utilized data collected in 1984 and 1994 to determine the stability of the fish populations within the pond. Review of the data indicated that the fish populations are healthy and stable, and that no management for fish within the pond were necessary. Fish surveys of the pond were recommended once every ten years. No fish surveys have been conducted in Big Reed Pond since 1994.

2.10 Habitats

NYSDOS Significant Coastal Fish & Wildlife Habitat

NYSDOS has designated three Significant Coastal Fish & Wildlife Habitats within the watershed which are identified as Lake Montauk, Big and Little Reed Ponds and Culloden Point. These areas are designated due to the presence of rare, threatened or endangered species and populations of waterfowl which use the area, the rarity of the ecosystem, the availability of sport fishing, and the irreplaceability of the ecosystem. The habitat narratives which describe the reasoning behind the SCFWH designation for each habitat is provided in **Appendix I**.

As discussed in the habitat narrative, the three habitat areas were designated as a SCFWH for the following reasons:

Lake Montauk:
- Lake Montauk is a relatively large, protected, coastal bay, bordered by much development; not rare in Suffolk County.
- Freshwater tributaries feeding into the lake have significant concentrations of spotted turtle (Special Concern species). Overwintering common loon (Special Concern species).
- Commercial bay scallop fishery important on a level between New York State and Long Island. Commercial hard clam fishery and bait fishery of county-level significance.
- Concentrations of wintering waterfowl, bay scallop, and winter flounder of county-level significance.
- The habitat at Lake Montauk is irreplaceable.

Big and Little Reed Ponds:
- Big and Little Reed Ponds area a relatively large wetland complex containing a transition from brackish to freshwater communities; rare on Long Island.
- Northern harrier (Threatened species) and least bittern (Special Concern species) nesting; blue-spotted salamander (Special Concern species) and spotted turtle (Special Concern species) breeding; bald eagle (Threatened species), short-eared owl (Endangered species), and osprey (Special Concern species) feed and overwinter in the area.
- Recreational fishing use of regional significance.
- One of only 4 major documented alewife spawning streams in Peconics region. Concentrations of blue-spotted salamanders are also unusual in the region.
- The habitat at Big and Little Reed Ponds is irreplaceable.

Culloden Point:
- Culloden Point is a complex perched kettle and stream course system draining to Block Island Sound; marshy meltwater depressions at seaward end of watercourse system. Rare on Long Island.
- Blue-spotted salamander (Special Concern species) and eastern box turtle (Special Concern species). Northern harrier (Threatened species) probable breeder.
- Recreational fishing use of regional significance. Nature study, hiking, fishing from shore, of county-level significance. Access for offshore diving.
- Very large concentrations of blue-spotted salamander and eastern newt, significant on Long Island.
- The habitat at Culloden Point is irreplaceable.

Eel Grass Beds & Submerged Aquatic Vegetation

Eel grass (*Zoster marina*) is a significant habitat vital to the establishment and success of shellfish, finfish and other marine organisms present in Peconic Bay. Two surveys were performed to locate existing patches of eel grass and submerged aquatic vegetation (SAV) in Peconic Bay, the first in 1994 and the second in 2000. The 1994 eel grass bed locations were delineated by Cashin Associates who utilized aerial photography and field surveys to determine the extent of each bed. In 2000 Cornell Cooperative Extension utilized similar methodology to determine the location of SAV (both macroalgae and eel grass) within Peconic Bay, the difference of which is displayed in **Figure 14**. As illustrated, eel grass beds were reduced or lost in some areas while other areas exhibited new areas of SAV. Overall, there appears to have been a net loss in SAV within Lake Montauk between 1994 and 2000.

In 2008, a depth, sediment and benthic community analysis was performed by Cornell Cooperative Extension for the area in the vicinity of Kalikow Dock due to proposed dredging and dock expansion in the vicinity of the dock (**Appendix A**). As outlined in the report and in a 1997 study performed by National Marine Fisheries Service, eelgrass was once predominant in this area. By 2008, once the dock had been installed and the area in the vicinity had been dredged, a complete loss of eelgrass occurred in this area which is mostly attributed to the activities associated with the dock. It is noted that the eelgrass was replaced with several species of seaweeds, and the nearest eelgrass bed is located directly east of the dock, across the channel.

As part of data gathering for the watershed management plan, CCE performed eel grass monitoring within the Lake in 2008. Eel grass was surveyed at two stations within the lake: one located along the lake's eastern shoreline immediately north of Star Island and one located immediately east of Star Island (see **Appendix A**). CCE sampled ten quadrats at two eelgrass sites within the lake. While a comprehensive analysis of eelgrass was not performed for these data, some statistical information was provided. Site "LM" had an average eelgrass shoot density of 79.08 per quadrat, and an average percent of 34.27 of macroalgae per quadrat. In comparison, Site "CG" had an average eelgrass shoot density of 115.29 per quadrat, and an average percent of 51.02 of macroalgae per quadrat. Site CG had a statistically significant higher average of eelgrass shoot density, generally indicating a better overall health of eelgrass at this site. No further information regarding this survey was provided.

<u>NYNHP Significant Natural Communities</u>

The Lake Montauk watershed hosts two NYNHP recognized significant natural communities, which are associated with Prospect Hill, Montauk Downs Grasslands, the East Montauk Peninsula, and Shadmoor State Park. The communities present include Maritime grassland and Maritime shrubland.

Each of these communities was deemed significant due to their quality, age, or rarity within New York State. **Table 10** below summarizes each community, the approximate size, and the reason for the community designation. A full description of each community type as defined by **Edinger (2002)** is provided as **Appendix J**.

Table 10
LAKE MONTAUK WATERSHED SIGNIFICANT NATURAL COMMUNITIES

Community Name	Community Location	Size (Acres)	Area within Watershed (Acres)	EO Rank[1]	Global Rank[2]	State Rank[3]	Description
Maritime grassland	Prospect Hill	35.09	4.82	BC	G2G3	S1	Grassy knolls surrounded by shrub thickets overlooking Oyster Pond and Atlantic.
Maritime grassland	Montauk Downs Grassland	3.0	3.13	CD	G2G3	S1	Rolling morainal hills with very small maritime grassland patches adjacent to very small shrubland and successional maritime forest patches in a complex of mowed lawn with residential developments immediately adjacent. Small patches of red maple blackgum swamp occur to the south within the golf course. Small patches of successional maritime forest, conifer plantations, and artificial ponds occur to the west and east within the golf course. The golf course occurs within an approximately 1800 acre complex of residential development and successional maritime forest between Fort Pond and Lake Montauk on the east end of Long Island. The grassland is within a 300 acre roadless area with numerous intruding roads, but no bisecting roads.
Maritime grassland	Shadmoor State Park	0.76	0.76	C	G2G3	S1	The grassland occurs on the upper slopes of rolling, glacially-derived, morainal deposits. The surrounding landscape consists of maritime shrubland dissected by sand bridal paths with a few openings containing WWII bunkers. There are a few small shallow emergent marshes in low areas; to the south, maritime bluffs descend sharply to the sea. Fire has apparently been an important process in this location, although it has been primarily human-caused. Documented fires occurred in the early 1940s (attributed to prescribed burning) and in 1982. The upland portion of the site was grazed until the early 20th century.
Maritime shrubland	East Montauk Peninsula	420.39	0.27	AB	G4	S4	The community is a large maritime shrubland that follows the coast around Montauk Point. The majority of the community is along the south shore of the peninsula and receives the prevailing northeast winds. Within the community of maritime shrubland there are small wet pockets of shrub swamp and small remnants of maritime grassland. A narrow band of the short variant of maritime shrubland

							occurs along the south edge of the community in some areas and drops off into an eroding slope leading down to the ocean. The maritime shrubland grades into successional maritime forest inland. Small developments and roads occur adjacent to and within the community.
Maritime shrubland	Shadmoor State Park	86.09	50.88	BC	G4	S4	The maritime shrubland occurs on both the exposed edge and the sheltered inland of a morainal headland and is dissected by sand bridal paths with a few openings containing WWII bunkers. The landscape, which consists primarily of gently rolling topography with variable aspect, also contains some small maritime grassland openings on upper slopes and a few small shallow emergent marshes and shrub swamps in low areas; to the south, maritime bluffs descend sharply to the sea.

1. EO RANK

A = excellent quality and viability
B = good quality and viability
C = fair quality and viability
D = poor quality and viability
E = verified extant (with insufficient information to rank A D)
F = failed to find during most recent surveys (but may still be present)
H = historical with no recent information
X = extirpated (no longer exists) from that location (most often due to destruction of habitat)

2. GLOBAL RANK:

G1 = Critically imperiled globally because of extreme rarity (5 or fewer occurrences), or very few remaining acres, or miles of stream) or especially vulnerable to extinction because of some factor of its biology.
G2 = Imperiled globally because of rarity (6 - 20 occurrences, or few remaining acres, or miles of stream) or very vulnerable to extinction throughout its range because of other factors.
G3 = Either rare and local throughout its range (21 to 100 occurrences), or found locally (even abundantly at some of its locations) in a restricted range (e.g., a physiographic region), or vulnerable to extinction throughout its range because of other factors.
G4 = Apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery.
G5 = Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.
GH = Historically known, with the expectation that it might be rediscovered.
GX = Species believed to be extinct.
GU = Status unknown.

3. STATE RANK

S1 = Typically 5 or fewer occurrences, very few remaining individuals, acres, or miles of stream, or some factor of its biology making it especially vulnerable in New York State.

S2 = Typically 6 to 20 occurrences, few remaining individuals, acres, or miles of stream, or factors demonstrably making it very vulnerable in New York State.
S3 = Typically 21 to 100 occurrences, limited acreage, or miles of stream in New York State.
S4 = Apparently secure in New York State.
S5 = Demonstrably secure in New York State.
SH = Historically known from New York State, but not seen in the past 15 years.
SX = Apparently extirpated from New York State.
SE = Exotic, not native to New York State.
SR = State report only, no verified specimens known from New York State.
SU = Status unknown.

PEP Critical Natural Resource Areas
In 1996, the PEP identified areas within the estuary that provided ecologically significant habitat to a variety of species that utilize the estuary. These areas were delineated by the PEP in order to provide a focus for habitat protection. The entirety of the Lake Montauk watershed is designated a PEP Critical Natural Resource Area, observed in **Figure 15**.

2.10 Land Use, Land Cover & Water Use

Quantifying and identifying land use and land cover within a watershed is one of the most important tasks in characterizing a watershed. Land use and land cover provide a reflection of the impervious surfaces within a watershed, which generally contribute the greatest quantity of pollutants running off into surface waterbodies during rain events. By identifying the areas with the greatest quantity of impervious surfaces, improvement projects targeted at either reducing these surfaces or capturing and treating runoff from these surfaces can be identified. Additionally, industrial and commercial uses generally contain the greatest quantity of impervious surfaces, and also have the potential to contribute harsher pollutants (chemical solvents, by products of industrial processes, etc.) to stormwater runoff. As a result, these uses are often appropriate targets for stormwater improvements. Both land use and land cover within the Lake Montauk watershed are described in further detail below.

2.10.1 Land Use and Land Cover

The Lake Montauk watershed area is approximately 2,728 acres in size, the majority of which is occupied by Recreation & Open Space (24.94%), Medium Density Residential (18.61%), Transportation/Utilities (13.15%) and Low Density Residential (10.94%) uses (**Table 11**). Vacant Land also occupies a significant portion of the watershed, as it currently comprises 22.08% of lands. Although High Density Residential (4.43%), Commercial (3.18%), Agricultural (0.86%) and Marinas (0.54%) occupy a much smaller portion of the watershed, these uses represent the remainder of the major uses that occupy lands. All other uses within the watershed occupy less than 0.5% of the overall land mass (**Figure 16**). **Table 11** (below) summarizes the land uses that comprise the Lake Montauk area.

TABLE 11
LAND USE – LAKE MONTAUK

Land Use	Area (Acres)	Percent
Agricultural	23.66	0.86%
Commercial	87.98	3.18%
High Density Residential	122.46	4.43%
Industrial	10.06	0.36%
Institutional	10.79	0.39%
Landfills and Dumps	1.54	0.06%
Low Density Residential	302.17	10.94%
Marina	15.03	0.54%
Medium Density Residential	514.19	18.61%
Recreation & Open Space	689.69	24.94%
Surface Water	3.24	0.12%
Transportation	353.92	12.81%
Underwater Vacant Lots	8.23	0.30%
Utilities	9.46	0.34%
Vacant	609.94	22.08%
TOTAL	**2762.36**	**100.00%**

Land cover data represents the biophysical use of the surface of the earth. Land cover data for the watershed was obtained from the 2006 USGS National Land Cover Dataset (NLCD). This dataset is generated from 30 meter resolution Landsat imagery that classifies land cover based on the color bands provided by the Landsat imagery. A depiction of the 2006 NLCD data is provided in **Figure 17**, and coverage quantities are provided in **Table 12** below.

Table 12
LAND COVER – LAKE MONTAUK

Land Cover Category	Area (Acres)	Percent
Open Water	13.19	0.47%
Developed, Open Space	540.12	19.67%
Developed, Low Intensity	412.68	15.05%
Developed, Medium Intensity	358.25	13.04%
Developed, High Intensity	17.28	0.62%
Barren Land (Rock, Sand, Clay)	127.12	4.63%
Deciduous Forest	530.13	19.31%
Evergreen Forest	2.15	0.07%
Mixed Forest	144.75	5.28%
Shrub/Scrub	46.74	1.71%
Grassland/Herbaceous	237.36	8.63%
Pasture/Hay	34.66	1.28%
Woody Wetlands	97.45	3.53%
Emergent Herbaceous Wetlands	196.78	7.18%
TOTAL	**2,758.66**	**100.00%**

As illustrated in **Table 12**, the majority of the Lake Montauk watershed area is comprised of developed, open space (540 acres or 19.67%), which generally represents areas with a mixture of some constructed materials and vegetation in the form of lawn grasses, and deciduous forest (530 acres or 19.31%), which generally reflects the large quantity of trees that comprise the surface of the island. The next greatest land coverage classifications that occupy the island are categorized as Developed, Low Intensity (15.05%), Developed, Medium Intensity (13.04%), Grassland/Herbaceous (8.63%), and Emergent Herbaceous Wetlands (7.18%). The Developed, Low and Medium Intensity categories primarily reflect single-family residential areas and some associated roadways, while the Grassland/Herbaceous category represents areas dominated by gramanoid or herbaceous vegetation. The Pasture/Hay category represents large mowed areas or large areas of tall grasses, and the Emergent Herbaceous Wetlands primarily represent the vegetated tidal wetlands on the island. It should be noted that there is a slight discrepancy in the acreage total between the Land Use and Land Cover tables. This is a result of the Land Use quantities being parcel based and the Land Cover quantities being area based and not delimited by parcel boundaries.

Generally, these two sets of data indicate that the Lake Montauk watershed area is primarily comprised of Recreation and Open Space and Low Density Development; few areas of higher intensity development currently exist within the Island.

2.10.2 Publicly Owned Land

Publicly owned lands within the watershed are an important factor in understanding the current status of protected land and lands used for municipal purposes. Depending on location of public land, needs of the watershed, and ability to make use of identified holdings, these lands may also provide opportunities for improvements (such as stormwater detention and/or treatment) which would ultimately improve handling or water quality of stormwater runoff.

Figure 18 depicts the publicly owned land within the Lake Montauk watershed area. As illustrated, Suffolk County owns the majority of the publicly owned parcels, in addition to the State of New York and the Town of East Hampton. Some smaller parcels of land are owned by the Peconic Land Trust and are interspersed throughout the area.

More specifically, NYS owned land is mostly comprised of the vacant, wooded land within the Montauk Downs State Park on the west side of Lake Montauk; however, the State owns three parcels of land that consist of paved sections or open ditches along Sunrise Highway. Suffolk County owns 31 parcels of land on the Island, three of which are roadways within developments. The majority of County owned lands consist of vacant wooded parcels that comprise Montauk County Park on the east side of Lake Montauk and additional small county parks; however, seven (7) of the parcels consist of utility sites for the Suffolk County Water Authority. Town owned lands are interspersed throughout the area and include vacant wooded land, four (4) parcels of paved roadways or open ditches, sixteen (16) underwater parcels, and two (2) industrial parcels. A total of 1,218.80 acres (or 44.67%) of the area is in public ownership.

2.10.3 Marinas, Yacht Clubs & Tourist Spots

According to the Town of East Hampton Comprehensive Plan (2005), the Town of East Hampton's estimated seasonal population is more than three times as great as its year-round population. Montauk is the largest commercial fishing port in New York State, and the largest area of support facilities for the commercial fishing industry is at the Montauk Dock area along the western side of Lake Montauk. This area is also a tourist destination for many visitors to Montauk and a major recreational fishing area. There are several restaurants, shops and motels in the Dock area, and smaller nodes of commercial development including support facilities for the fishing industry exist along the northern end of East Lake Drive. There are several marinas and yacht clubs located in the northern portion of Lake Montauk including: six (6) marina facilities located on the northwestern shore of Lake Montauk: Montauk Marine Basin, Uihleiun Marina & Boat Rental, Montauk Sportsmans Dock, Westlake Marina, Diamond Cove Marina, and Offshore Sports Marina on the northwestern side of the lake; two (2) marinas located on Star Island: Star Island

Yacht Club & Marina, and Montauk Yacht Club Resort & Marina; and three (3) marinas located on the east shore of Lake Montauk: Gone Fishing Marina, Rick's Crabby Cowboy Café, and Montauk Lake Club & Marina. These marinas are full service marinas offering boat repair, maintenance, storage, pump out and fueling.

2.11 Human & Socioeconomic Resources

2.11.1 Zoning

As illustrated on the Zoning Map (**Figure 19)** zoning within the Lake Montauk Watershed area is primarily moderate-high density residential and Park & Conservation land. The majority of residential development is located around the perimeter of the Lake, and on the western side of Lake Montauk. The majority of the Park & Conservation land is located on the eastern side of Lake Montauk, with some large portions of land on the west side of the Lake. The remainder of the area consists of a small waterfront zoning area along the northern border of the Lake, and small resort zoning areas on Star Island, near the northern border of the lake, and south of Lake Montauk bordering the Atlantic Ocean. In addition, there is a very small central business zoning area northwest of Lake Montauk. The Lake Montauk area has ten zoning categories in total, six of which are residential and three of which are commercial, and one of which is a special district. As illustrated in **Table 13** below, the Lake Montauk area requires a minimum lot size of 20,000 SF with the exception of the central business district, which is permitted a minimum lot size of 3,000 SF, and permits a maximum impervious lot coverage of 50% with the exception of the business districts, which are permitted a maximum lot coverage of 75-80%.

Table 13
ZONING – LAKE MONTAUK WATERSHED

Zone	Minimum Lot Size	Maximum Impervious Lot Coverage	Total Area (Acres)	Percent of Lake Montauk
A Residential	40,000 SF	40%	294.09	12.26%
A2 Residential	84,000 SF	35%	103.72	4.32%
A3 Residential	125,000 SF	30%	119.61	4.99%
A5 Residential	200,000 SF	30%	89.99	3.75%
A10 Residential	425,000 SF	18%	110.47	4.60%
B Residential	20,000 SF	50%	601.92	25.09%
CB Central Business	3,000 SF	80%	8.14	0.34%
PC Park & Conservation	--	--	971.88	40.51%
RS Resort	84,000 SF	75%	55.51	2.31%
WF Waterfront	20,000 SF	75%	43.97	1.83%
TOTAL	--	--	2,399.30	100.00%

* Based on lot size, as follows:
- \>200,000 SF Lot: 1,800 SF building plus a 25' radius surrounding the building
- 40,000 SF - 200,000 SF Lot: 1,800 SF building plus a 25' radius surrounding the building
- <40,000 SF Lot: 1,000 SF plus a 25' radius surrounding the building

As less than 5% of the Lake Montauk watershed area is zoned for business uses, these uses will have minimal impacts in terms of impervious lot coverage. Conversely, as the majority of the area is permitted for residential uses, these uses will provide the largest component of impervious surfaces within the watershed.

2.11.2 Demographics

Data from the 2010 census was utilized to determine the population of the Lake Montauk watershed area. 2010 census data reveals that the population of Lake Montauk is 1,935 persons, which represents a decrease of 341 people or -14.98% over the 2000 population (2,276 persons). This decrease followed a sharp increase in population density by approximately 1,961 people or 622.54% in the previous decade. According to the Town of East Hampton Comprehensive Plan (2005), East Hampton had the greatest increase in population of all the Towns in Suffolk County from 1990 to 2000. As illustrated in **Figures 20, 20a** and **20b**, despite the decrease in population, the relative population density on the Island has not changed significantly since the 2000 census. The most densely populated area in Lake Montauk was present in the northwestern corner of the Lake, which coincides with the area of high density residential and commercial land uses. The majority of the remainder of the lake was sparsely developed, with the exception of a few small patches of land south and west of the Lake that were moderately developed.

Since there is a prominent seasonal population that inhabits the Lake Montauk area in the summer season, population information is difficult to assess with complete accuracy, as it probably does not include all of the visitors, illegal housing, or workers in group "summer shares." As discussed in the Town Comprehensive Plan, the federal census does not include a count of the seasonal population; however, it does identify the number of vacant housing units used for "seasonal, recreational, or occasional use." Based on this information, as well as a count of campsites and motel capacity, the Suffolk County Planning Department has prepared seasonal population estimates for Towns throughout Suffolk County. The seasonal population estimates for East Hampton Town were reached by the Suffolk County Planning Department by estimating an average of 4.5 persons per household in seasonal homes throughout the Town, assuming a guest factor of 1.2 for year-round households in the Town, and assuming four guests per motel room. The estimates of seasonal guests varied in different areas of the Town of East Hampton. These estimated peak seasonal populations for the year 2000 estimated that the year round population of Montauk was 3,851, and that the estimated additional seasonal population is 26,995, totaling a population of 30,846. Occupants of motels account for 9,704 (about 36%) of Montauk's seasonal population.

2.12 Stormwater Runoff and Pollutant Load Analysis

2.12.1 TR-20 Flow Analysis

As part of data gathering for the watershed management plan, CCE performed a TR-20 analysis for the Lake Montauk watershed area in 2008 (see **Appendix A** for the full analysis). This analysis estimates runoff from precipitation based on land use for each watershed. The CCE analysis provides the following description of the analysis:

"The TR-20 model is the most widely used application for simulating rainfall events and calculating runoff during storms. Direct runoff is computed based on a number of variables including land use, topography, and soil types."

The model analyzed flows from 1, 2, 10 and 100 year rain events for average, dry and wet conditions. It is noted that existing stormwater conveyance structures were not included within their analysis.

The model utilized 2006 LiDAR data to generate subwatersheds. Once these were created, soil group, topography and land use were utilized to estimate runoff from each subwatershed. The following tables summarize the results of this analysis, which demonstrate which watersheds had the maximum and minimum flows and runoff under each scenario.

As illustrated, watersheds 2 (located in the northwest portion of the watershed), 7 (located in the southern portion of the watershed, including the Ditch Plains area) and 13 (located in the northeast portion of the watershed including Big Reed Pond) contribute the greatest runoff to the Lake and have the highest flow rates under varying conditions. In contrast, watersheds 11 and 14 have the least contribution of runoff and smallest flow rate to Lake Montauk. In particular, watershed 14 does not generate runoff under certain storm events due to the sandy soils within the watershed which have a high infiltration capacity. A one year storm event (most common storm event), under average conditions, would generate 4.9 million CF of runoff to the Lake. In contrast, under average conditions, approximately 40.6 million CF of runoff would enter the Lake under a 100 year storm event (worst case scenario). The individual contributions of the subwatersheds will be important when prioritizing improvement strategies for the Lake, while to overall contribution provides information that can assist in providing comprehensive improvements to the entire watershed.

2.12.2 Pollutant Load Analysis

As noted in **Section 3.4.3**, pathogens are the pollutant of concern within the Lake Montauk Watershed. In order to approximate the pathogen load of each subwatershed to the Lake, the US EPA's BASINS (version 4.1) model was utilized. The model considers land use, soil type, and topography in determining pathogen loads. Model results are depicted in **Figure 21** and **Tables 14-17** below. As illustrated, subwatershed 7, which encompasses the Ditch Plain neighborhood, has the greatest contribution of pathogens to the Lake. Subwatersheds 1, 5, 9 and 12 also provide significant contributions of pathogens to the Lake. Subwatershed 14 has contributes the least to pathogens entering the Lake and Subwatershed 13 also contributes fewer pathogens to the Lake than the other watersheds.

Table 14
LAKE MONTAUK WATERSHED MODELED MAXIMUM FLOW RATES AND RUNOFFS

Modeled Maximum Flow Rates and Runoffs												
Storm Event	Dry Conditions				Average Conditions				Wet Conditions			
	Max Flow Rate (ft3/s)	Sub-watershed	Max Runoff Volume (CF)	Sub-watershed	Max Flow Rate (ft3/s)	Sub-watershed	Max Runoff Volume (CF)	Sub-watershed	Max Flow Rate (ft3/s)	Sub-watershed	Max Runoff Volume (CF)	Sub-watershed
1	3.130	2	183,010	7	87.410	2	937,760	7	231.120	2	1,943,647	7
2	32.840	7	613,151	7	198.080	2	1,838,116	7	381.860	13	3,355,235	13
10	130.370	2	1,576,291	7	395.100	2	3,406,392	7	662.400	13	5,794,038	13
100	388.180	2	3,704,284	7	763.370	13	6,738,697	13	1,148.490	13	10,135,332	13

Table 15
LAKE MONTAUK WATERSHED: MODELED MINIMUM FLOW RATES AND RUNOFFS

Modeled Maximum Flow Rates and Runoffs												
Storm Event	Dry Conditions				Average Conditions				Wet Conditions			
	Min Flow Rate (ft3/s)	Sub-watershed	Min Runoff Volume (CF)	Sub-watershed	Min Flow Rate (ft3/s)	Sub-watershed	Min Runoff Volume (CF)	Sub-watershed	Min Flow Rate (ft3/s)	Sub-watershed	Min Runoff Volume (CF)	Sub-watershed
1	0	14	0	14	0	14	0	14	6.640	14	92,663	14
2	0	14	0	14	0.740	14	21,466	14	24.400	14	245,432	14
10	0	14	0	14	7.850	14	135,238	14	63.670	14	545,592	11
100	0.820	14	25,402	14	46.460	14	483,351	14	145.310	14	908,464	11

Table 16
LAKE MONTAUK WATERSHED MODELED FLOW RATES AND RUNOFFS – ENTIRE WATERSHEDS

Modeled Flow Rates and Runoffs – Entire Watershed						
Storm Event	Dry Conditions		Average Conditions		Wet Conditions	
	Flow Rate (ft3/s)	Runoff Volume (CF)	Flow Rate (ft3/s)	Runoff Volume (CF)	Flow Rate (ft3/s)	Runoff Volume (CF)
1	19.500	554,613	381.800	4,941,997	1,174.830	12,033,119
2	121.420	2,624,507	940.730	10,527,741	2,020.610	20,343,190
10	562.220	8,012,175	1,990.950	20,797,983	3,356.210	33,702,637
100	1,836.290	21,015,867	4,022.980	40,635,298	5,634.380	57,045,897

Table 17
POLLUTANT LOAD MODEL RESULTS – PATHOGENS

Subwatershed	Pathogens (counts/100mL)
1	1928.43
2	1885.38
3	1846.80
4	1896.41
5	1947.91
6	1918.45
7	1968.56
8	1775.85
9	1920.55
10	1766.95
11	1880.68
12	1922.55
13	1570.22
14	1558.92

3.0 DESCRIPTION AND ASSESSMENT LOCAL LAWS, PROGRAMS AND PRACTICES AFFECTING WATER QUALITY

Water quality and habitat degradation within the Lake Montauk are regulated through a variety of Federal, State, County and Town legislation. Additionally, the Town has programs and practices designed to reduce pollutants carried by stormwater runoff to surface waters. This report serves to identify existing applicable Federal, State, County and Town legislation aimed at watershed protection, describe existing Town best management programs and practices, and identify any gaps within legislation and practices currently implemented. This assessment will be utilized as a basis to develop recommendations for additional best management practices or legislation that could be implemented to further reduce pollutant runoff.

3.1 Federal and State Roles and Regulations

3.1.1 Federal Agency Roles

US Environmental Protection Agency

The mission of the EPA is to protect human health and the environment. Developing and enforcing environmental regulations, providing financial assistance, performing environmental research, sponsoring and promoting partnerships and programs, and monitoring hazardous materials and reporting related information to the public are several of the duties of the EPA. The EPA provides funding to be used by the responsible State agencies for enforcement and implementation of policies outlined in the federal laws and regulations.

Natural Resource Conservation Service

The Natural Resource Conservation Service (NRCS) is a U.S. Department of Agriculture (USDA) agency that assists private land owners with conserving soil, water and other natural resources.

Army Corps of Engineers (US Department of Defense)

The US Army Corps of Engineers (USACE) is responsible for flood control, navigation, shore protection, environmental restoration, hazardous, toxic and radiological waste site management, and water resource management and regulation.

Fish and Wildlife Service (US Department of the Interior)

The US Fish and Wildlife Service (USFWS) mission is to conserve, protect and enhance fish, wildlife and plants and their habitats for the continuing benefit of the American people.

United States Geologic Survey

The USGS offers an array of services and data related to hydrologic research and development, wildlife and fisheries management, invasive species, geographic information systems, mapping, costal management and watershed planning.

National Oceanic and Atmospheric Administration (NOAA)
NOAA has several roles directly related to watershed protection including its role in the stewardship of coastal waters.

3.1.2 State Agency Roles

New York State Department of State (NYSDOS), Division of Coastal Resources
The Division of Coastal Resources helps protect and enhance coastal and inland water resources and encourage appropriate land use. The Division also works in partnership with local governments in preparation of Local Waterfront Revitalization Programs, which serve as comprehensive land and water use plans, as well as intermunicipal watershed management plans which identify problems and threats and opportunities for achieving long lasting improvements in water quality and establish priorities for action. Financial assistance for the preparation and implementation of such programs and plans is available through the Environmental Protection Fund (EPF).

New York State Department of Environmental Conservation (NYSDEC)
The Department of Conservation works to reduce water pollution through technical assistance for prevention, education, and monitoring. The NYSDEC also provides financial assistance to local governments for a variety of water quality projects. The Department has extensive regulatory authority through its administration of the New York.

New York State Department of Agriculture and Markets
The Department of Agriculture and Markets provides administrative support to the State Soil and Water Conservation Committee (SWCC), which in turn provides guidance to the county Soil and Water Conservation Districts (SWCD). In addition the Department of Agriculture and Markets oversees many aspects of farming that cannot be regulated by municipalities.

New York State Department of Health (NYSDOH)
The Department of Health monitors impacts of nonpoint source pollution through water quality monitoring and reporting programs. New York Public Health Law contains statutes regulating the protection of public water supplies from contamination due to source and nonpoint source pollution.

3.1.3 Regulations

Non-Point Source Pollution Prevention
Section 312 of the Clean Water Act requires States to develop programs for controlling nonpoint sources of pollution. The NYSDEC has been the lead agency for developing New York's Nonpoint Source Management Program. NYSDEC coordinates funding for the program's implementation and conducts water quality studies to evaluate the program's success. The long-term vision for New York's Nonpoint Source Management Program is for State waters to no longer be impaired by nonpoint source pollution caused by natural or human

activities. NYSDEC has developed a Priority Waterbodies List, which identifies waters that are impaired or threatened by point and nonpoint sources of pollution. NYSDEC bases this list on water quality information generated through its monitoring and assessment studies and by reaching out to stakeholders in local communities. The *NYS Section 303(d) List of Impaired/TMDL Waters* identifies those waters that do not support appropriate uses and that may require development of a Total Maximum Daily Load (TMDL). TMDL is a numerical limit on the amount of a particular contaminant that can be discharged to a waterbody from all sources. The Section 303(d) List is updated every two years. These Priority Waterbodies Lists assist state, regional and local establish local water quality priorities.

Federal No Discharge Zone 67 FR 39720

The Peconic Estuary is a Federal No Discharge Zone in which "adequate facilities for the safe and sanitary removal and treatment of sewage from all vessels are reasonably available for the waters of the Peconic Estuary, County of Suffolk, State of New York." The regulation further reads "Within the No Discharge Zone discharges from marine toilets are prohibited under Section 33.e.2 of the State Navigation Law, and marine sanitation devices on board vessels operated in a No-Discharge Zone must be secured to prevent discharges. This statute may be enforced by any police officer or peace officer acting pursuant to their special duties."

State Pollution Discharge Elimination System (SPDES)

The federal Clean Water Act authorizes the development of the National Pollutant Discharge Elimination System (NPDES) to regulate discharges to surface waters. The NYSDEC implements the federal regulations, including discharges to under the State Pollution Discharge Elimination System (SPDES).

Stormwater Management

Phase I of the stormwater regulations were published in 1990 and require a permit for medium and large Municipal Separate Storm Sewer Systems (MS4) operated by municipalities whose populations are 100,000 or greater. A Municipal Separate Storm Sewer System is a conveyance, or system of conveyances owned by a state, city, town or other public entity that discharges to waters of the U.S. and is used for collecting or conveying stormwater.

Phase II of the regulations extends coverage to small MS4s and construction sites of at least one acre. Under Phase II, municipalities with a population of at least 50,000 or a population density of 1,000 people per square mile are required to develop stormwater management programs. Areas that don't meet the population threshold but discharge into a TMDL waterbody for a pollutant related to storm water also must meet Phase II permitting requirements. The Town of is regulated under these requirements.

The NYSDEC Stormwater Phase II Program is administered using two General Permits for stormwater discharges:

1. Construction activity disturbing one (1) acre or greater of land (GP-0-10-001);

2. Certain regulated small municipal separate storm sewer systems (MS4s) (GP-0-10-002).

The General Permit for Stormwater Discharges from Construction Activity (GP-0-10-001) (hereafter "Construction Permit") requires the owner/operator of a proposed construction site with disturbance of 1 acre or greater (and in proximity to surface water or municipal drainage systems that discharge to surface waters), to prepare a Stormwater Pollution Prevention Plan (SWPPP) and obtain permit coverage prior to the initiation of construction activities. The purpose of the Construction Permit is to ensure temporary erosion and sediment controls are utilized to throughout the construction period, to ensure that adequate measures are provided to control off-site flow of stormwater runoff, and to reduce sediments/pollutants carried in stormwater from reaching surface waters of the State.

The second General Permit (GP-0-10-002, hereafter "MS4 General Permit") regulates stormwater discharges from regulated municipal separate storm sewer systems. The MS4 General Permit is required in order to discharge stormwater conveyed through the municipal storm sewer system (includes road drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) to waterbodies of New York State. In order to obtain coverage for these discharges, regulated municipalities are required to develop a Stormwater Management Program (SWMP) "designed to reduce the discharge of pollutants from small MS4s to the maximum extent practicable". Special requirements apply when stormwater is discharged to a water identified on the New York State 303(d) list or a water covered by an EPA-approved Total Maximum Daily Load (TMDL). If a TMDL requiring reduction of a pollutant associated with stormwater is approved by the EPA for any waterbody or watershed into which the municipal separate storms sewer system discharges ("MS4"), the program for the six minimum measures must ensure that reduction of the pollutant of concern specified in the TMDL is achieved. The MS4 Stormwater Management Program is required to identify measurable goals and best management practices for six areas, called "minimum control measures." The six minimum control measures and a general description of the requirements for each are as follows:

1. Public Education and Outreach – provide information to the public regarding stormwater pollution and discharges.
2. Public Involvement and Participation – hold public meetings, sponsor public events, gather public comment on SWMP
3. Illicit Discharge Detection and Elimination – develop and enforce a program to detect and eliminate illicit discharges, develop a mechanism to prohibit illicit discharges into the storm sewer systems, identify, and map all stormwater outfalls and the conveyance system within the MS4's jurisdiction, develop management practices to ensure reduction of all pollutants of concern.
4. Construction Site Runoff Control - develop and enforce a program to address stormwater discharges from construction activities w/ disturbance greater than 1 acre
5. Post-Construction Runoff Control – develop and enforce a program to address post-construction stormwater discharges from new development and redevelopment areas

6. Pollution Prevention and Good Housekeeping – establish best management practices to limit pollutants entering stormwater and stormwater systems (i.e., street sweeping, leaf collection, road salt storage) and conduct employee training on best management practices

Industrial Discharges

The SPDES permit requirements for stormwater discharges from industrial activities is regulated under a general permit (NYSDEC General Permit GP-0-11-009 for Stormwater Discharges Associated with Industrial Activities). This permit is intended to provide SPDES Permit coverage to facilities with stormwater discharges to surface water from a point source that conduct industrial activities, including a wide range of manufacturing, industrial storage, transportation related, and other uses. Uses within the Lake Montauk Watershed that may require this permit include fuel storage, maintenance/service stations, marinas and boat yards. Under this permit, the operator of qualifying industrial uses must develop and implement a Stormwater Pollution Prevention Plan (SWPPP) which identifies specific best management practices (BMPs) to be selected, installed, implemented and maintained at the facility to minimize the presence of pollutants in the stormwater discharges. These include proper storage of materials, precautions for handling and disposing of potential pollutant sources, regular monitoring and training of employees.

Safe Drinking Water Act

The Safe Drinking Water Act of 1974 (SDWA) authorized EPA to regulate public water systems to protect the public's health. The EPA set standards for chemicals that might be found in water that could potentially have adverse effects. EPA has 25 drinking water standards, 10 of which are for synthetic organics. These drinking water protection measures are also written into the state and county regulations. The 1996 amendment of the SDWA places a strong emphasis on the protection of surface and groundwater sources used for public drinking water. As a result of these amendments, states must develop a Source Water Assessment Program (SWAP) and complete assessments of the sources of drinking water used by public water systems. Each source water assessment must include:

- A delineation of the source water assessment areas;
- An inventory of potential significant contaminant sources within the source water assessment area; and
- An evaluation of the source water's susceptibility to contamination. The SWAP for Long Island has been performed by the DOH and Nassau and Suffolk County Departments of Health.

Source Water Assessment Program

A mission of the New York State Department of Health (DOH) is to protect and promote the health of the citizens of New York State. Within the DOH, the Bureau of Public Water Supply Protection has the primary responsibility of administering the Public Water System Supervision program (PWSS) and for assuring that safe, potable water, in adequate quantities, is provided throughout the state. This is accomplished through:

- Oversight of local water supply regulatory programs;
- Training and certification of water supply operators;
- Maintenance of a statewide database on individual public water systems;
- Development and initiation of enforcement policies;
- Plan review;
- Maintenance of a water quality surveillance program; and
- Providing technical assistance to both regulatory units and water suppliers.

3.2 County Regulations

Suffolk County Water Quality Protection and Restoration Program

The Suffolk County Water Quality Protection and Restoration Program (WQPRP) was approved by the Suffolk County Legislature in 1987. The WQPRP is funded through a countywide ¼% sales tax, dedicated to water quality protection in Suffolk County. The WQPRP funds implementation projects that result in the restoration or protection of surface water quality. Eligible projects could include the control and abatement of agricultural and other nonpoint pollution sources, aquatic habitat restoration, pollution prevention initiatives, and education and outreach programs that address vessel waste no-discharge zones.

Fertilizer Limitations: Local Law 41 - 2007

In 2007, the Suffolk County Legislature adopted Local Law 41 – 2007 entitled "A Local Law to Reduce Nitrogen Pollution by Reducing Use of Fertilizer in Suffolk County." The legislature recognized that over-application and/or misuse of fertilizer products has led to the degradation in the local water quality, and has harmed groundwater, drinking water, and wetlands and surface waters within the County of Suffolk. In addition the recognizing the impacts to groundwater and drinking water, the legislature acknowledged that fertilizers are responsible for approximately 50% of the total nitrogen loads to groundwater in the Peconic Estuary and throughout medium-density residential land uses in Suffolk County. As a result, this law was passed and includes the following regulations:

- Fertilizer is not to be applied to County owned properties.
- Fertilizer shall not be applied to any turf on any non-County owned real property by any person between November 1 and April 1 of every year.

Exceptions to the above include lands utilized in farm operations, golf courses (provided that they use only the minimum amount of slow release fertilizer as necessary), the Suffolk County Farm (provided that the farm works towards overall nitrogen reduction), athletic fields (provided that the fields utilize best management practices) and newly seeded or sodded areas. The law also provides for expansion of educational programs and materials geared towards fertilizer use reduction. Home improvement contractors that apply fertilizers are required to obtain a license for fertilizer application and receive training in turf management.

Suffolk County Sanitary Code Article 6

Article 6 provides standards for new development and subdivisions within Suffolk County. The article establishes a minimum area necessary per dwelling unit for use of conventional sanitary systems. If the minimum area per unit is exceeded, a sewage treatment plant (STP) must be utilized for the development. More specifically, for developments located within Groundwater Management Zones III, V and VI, the minimum lot area per unit is 40,000 SF, while in Zones I, II, IV, VII and VIII, the minimum lot area per unit is 20,000 SF. This is the equivalent of 1-acre residential zoning and is based on a nitrogen loading that is equivalent to 6 mg/l with a drinking water standard of 10 mg/l. If an STP is necessary, the Article also provides minimum sizing standards for the STP. The Article also regulates connection of new developments to community water supply systems where such systems currently exist.

Suffolk County Sanitary Code Article 7

The purpose of Article 7 of the Suffolk County Sanitary Code is to safeguard all the water resources of Suffolk County, especially in deep recharge areas and water supply sensitive areas, from discharges of sewage, industrial and other wastes, toxic or hazardous materials, and stormwater runoff by preventing and controlling such sources. This article regulates the discharge of industrial wastes, sewage, toxic or hazardous materials, or other wastes to surface or groundwater from uses pre-dating the enactment of the law, as well as new sources. These discharges are prohibited in deep recharge or water supply sensitive areas. It also regulates the storage of toxic or hazardous materials.

Suffolk County Sanitary Code Article 12

Suffolk County Department of Health Services Article 12 is intended to "… safeguard the water resources of the County of Suffolk from toxic or hazardous materials pollution by controlling or abating pollution from such sources in existence when this Article is enacted and also by preventing further pollution from new sources…" Article 12 is a model law which is very stringent in the protection of Suffolk County's water resources. Conformance to Article 12 requires that hazardous substances be disposed of properly, and that storage facilities be permitted and installed as per the requirements outlined in the article. Any storage of hazardous materials would be subject to design review under Article 12, ensuring that a proper system will be utilized to prevent contaminants from entering the water supply.

3.3 Town Regulations and Practices

The following sections provide a summary of local regulations outlined by various chapters in Town code. In addition, a review of standardized Town practices is provided in order to provide a complete overview of the Town's current stormwater control measures.

3.3.1 Local Laws and Regulations

Chapter 91: Beaches and Parks
The following is prohibited on Town owned beaches:

1. Removal or damage of snow fencing, signs or flagging.
2. Dumping of glass on the beach.
3. Dumping of fill or other materials.
4. Construction of structure without a permit.
5. Camping.
6. Disturbance of protected bird nesting areas.
7. Construction of a fence that prohibits vehicular access without a permit.
8. Domestic animals in protected bird nesting areas.
9. Operation of a vehicle on the beach without a permit.

Leashed domestic animals are permitted on beaches between September 16th (except for Hither Hills State Park which permission begins November 16th) and May 14th (except for Hither Hills State Park which permission ends on April 30th). During the summer months, animals are not permitted on beaches between 10 AM and 6 PM. Clean up of waste from animals is required on all Town beaches.

Chapter 150: LWRP Consistency Review
The purpose of this chapter is to ensure consistency of proposed projects within the Local Waterfront Revitalization Area with the Town's LWRP. A Coastal Assessment Form and conformance with policies outlined in the LWRP is required to be completed by the Town Planning department.

Chapter 167: Littering, Dump Control, Leaves and Yard Waste
Littering is prohibited within the Town. The Town may require maintenance of private property that has accumulated refuse that may be dangerous to the public health, safety or welfare. Fines of up to $1,000 may be enforced for littering activities.

Chapter 180: Natural Resources
This chapter regulates and protects the Town's natural resources including aquifers, water bodies, drainage courses, freshwater and tidal wetlands, dunes, bluffs, beaches, escarpments, woodlands, shrublands, grasslands, large trees, glacial erratics, unique or unusual plants and trees, wildlife habitat and scenic views or overlook areas and all combinations thereof. Discharge of (directly or indirectly) toxic or radioactive substances, industrial waste, sewage

or other contaminants into the air, water or earth in quantities, of characteristics or for such duration which cause or are likely to cause detriment to health, safety, welfare, property, surface water or groundwater are prohibited.

Chapter 206: Fuel Oil Storage Tanks – Installations
This chapter prohibits the underground installation of fuel oil storage tanks.

Chapter 208: Substandard Sanitary Systems in Harbor Protection Overlay Districts
This chapter regulates sanitary systems within a Harbor Protection Overlay District. A substandard sanitary system is defined as "Any sanitary system located in a Harbor Protection Overlay District of the Town of East Hampton and constructed prior to January 1, 1981, which system has not been upgraded or repaired to meet the current requirements of the East Hampton Town Code for sanitary systems located in a Harbor Protection Overlay District…" A rebate is offered to homeowners who upgrade, replace or repair their substandard sanitary systems in this district. Inspection of the existing and new or repaired sanitary system is required to obtain the rebate.

Chapter 210: Scavenger Waste
This chapter regulates sanitary waste delivered to the Scavenger Waste Treatment facility and is designed to assure the proper siting, construction and maintenance of all individual on-site wastewater disposal systems (septic tanks, cesspools, leaching fields, etc.) and sewage treatment plants. Pump out reports and testing of sludge for all waste brought to the facility are required under this chapter. Inspection and maintenance of all on-site sanitary systems within the Town are required once every three years.

Chapter 220: Subdivision of Land
Standard subdivisions must conform to the bulk regulations provided in the respective zoning districts outlined in Chapter 255. The standard subdivision design excludes the following areas from consideration as areas contributing to total lot yield:

(a) Existing water surfaces.
(b) Marshes, bogs, swamps or other areas of high-water table which cannot be normally built upon without excessive fill as may be determined by the Planning Board.
(c) Horizontal area of escarpments, bluffs or the seaward faces of primary dunes.
(d) Beach as defined in § 255-1.20 of the Town Code.
(e) Horizontal areas of slopes which exceed a grade of 20%.
(f) Areas required for reserve area pursuant to the Planning Board's subdivision regulations.
(g) Areas required for recharge basins or for natural area recharge. Design standards are provided for streets and highways, drainage, preservation and protection of natural environment, fire protection and waterways. Specific standards which may affect water quality include the following:
(h) Area required for streets.

(i) Area required for utilities or public facilities, except that minor utility easements of direct service to the subdivision may be included.
(j) Areas which are required setback areas under state or local laws or regulations.

Drainage

- All stormwater systems shall be designed to capture a minimum of two inches of rainfall from the tributary area. Recharge basins must be designed for stormwater runoff from a five inch rainfall event for the tributary area.

Preservation and protection of natural environment

- It is a policy of the Planning Board to require a minimum of a 10% reserved area (exclusive of underwater lands) to be designated as recreational or open space area.
- Open Spaces must be given first consideration in a subdivision design. Areas to be considered are as follows:

a. Areas having significant scenic, recreational, historic, archaeological or ecological value shall be first considered for preservation as reserved areas.
b. Other areas having unusual topographic or natural features shall be considered for protection by means of scenic easements.
c. Open spaces shall be used to set aside significant areas and for use as buffers to protect environmentally fragile areas.
d. Insofar as possible, open spaces shall be allocated throughout the subdivision so as to make their benefits available to all lot owners.
e. Open spaces shall be harmonized with land use patterns in properties adjoining the proposed subdivision, and consideration shall be given to linking the open spaces of adjacent properties or adjacent subdivisions.
f. Insofar as possible, open spaces in different parts of the proposed subdivision shall be linked by scenic easements.
g. Consideration shall be given to using open spaces to provide a theme for the proposed subdivision, such as preservation, conservation, passive recreation and active recreation.
h. Along public roads, residential subdivision plats shall provide reserved area or scenic easement area for at least 10% of the total depth of the subject parcel as a natural buffer from development. The depth of said reserved area or scenic easement shall generally not exceed 100 feet unless other legitimate planning reasons exist for greater reserved area or scenic easement area.

- Proposed grades for streets and lot areas shall bear a logical relationship to the natural topography. It is the policy of the Town of East Hampton to discourage massive regrading where such earthmoving would strip natural ground cover or destroy worthwhile topographic features.

Chapter 234: Vegetation Protection

The purpose of this chapter is to protect trees and other vegetation within the Town. Removal of trees of vegetation is prohibited on private property without written consent of the owner. Removal of trees or vegetation on public property is strictly prohibited without written authorization from the Town.

Chapter 246: Waterways and Boats

This chapter regulates waterways, structures within waterways and boating within waterways. Mooring within Town waters is regulated with permits and within specific mooring locations. Floating homes are prohibited within Town waterways. Docks must have appropriate permits for construction and use. Lake Montauk is a designated "No Discharge Zone" and boaters may not discharge sanitary waste to the waterway. Boats must be pumped out at dedicated pump out stations or by utilizing a pump out boat. All discharge valves must be secured while boating within Lake Montauk.

Chapter 255: Zoning

Town zoning code has several districts that regulate environmentally sensitive areas and protect waterways. The following summarizes each district and the applicable regulations.

1. Flood Hazard Overlay District: A permit is required for all construction within a Special Flood Hazard Area. Buildings and structures must adhere to elevation regulations for each specific flood zone.
2. Harbor Protection Overlay District: This district was created to maintain or improve the surface water quality of the Town's creeks, bays, harbors and ponds. This Overlay District includes stormwater management requirements for impervious surfaces, establishes a minimum 200 foot setback from surface waters for new sanitary wastewater systems and requires a minimum of four feet of separation from groundwater for associated leaching pools. Legally existing sanitary septic systems on a residential property on January 1, 1996 must be replaced or upgraded if:

    - A natural resources special permit is required for work to be performed on the lot or parcel containing the septic system;
    - The work to be performed will increase the habitable floor area of a principal building on the lot or will increase the number of bathrooms within a building on the lot; and
    - The septic system in question does not meet the minimum requirements of the Suffolk County Department of Health Services for vertical separation to groundwater, for setback to surface waters or for septic system capacity, or in that it lacks a septic tank.

    Newly replaced/upgraded sanitary wastewater systems have a minimum 150 foot setback from Lake Montauk. Lot area, location of swimming pools and fuel storage tanks are also restricted under this chapter.

3. Coastal Erosion Overlay District: The purpose of the Coastal Erosion Overlay District is the protection of the Town's natural shoreline and coastal resources. The Town defines four zones as follows:

a. Coastal Erosion Overlay Zone 1: Ocean coastal zone, including bluffs, dunes, beaches, and nearshore areas. This zone is predominantly free of erosion control structures.

b. Coastal Erosion Overlay Zone 2: Bay coastal zone, including bluffs, dunes, beaches, and nearshore areas, which is predominantly free of erosion control structures.
c. Coastal Erosion Overlay Zone 3: Bay coastal zone, including bluffs, dunes, beaches, and nearshore areas, which contains erosion control structures which are isolated and discontinuous, or which have no substantial flooding or erosion protection function.
d. Coastal Erosion Overlay Zone 4: Bay coastal zone, including any remaining bluffs, dunes, beaches, and nearshore areas, which contains numerous erosion control structures. Within this zone the loss of natural resources and features such as bluffs, dunes, and beaches means that in many cases erosion control structures provide the only remaining protection against flooding and erosion.

Construction, placement and modification of erosion control structures is regulated in each zone, and such activities require a permit from the Town prior to employment of erosion control measures.

Article IV: Protection of Natural Resources
Tidal and freshwater wetlands, and beaches dunes and bluffs are protected under this article. Construction of structures, excavation or digging or other modification within these areas or within the Town regulated adjacent area (between 150 and 200 feet depending on the natural feature) requires a Natural Resource Special Permit from the Town. Sanitary systems are required to be located a minimum of 150 feet from any wetland boundary.

3.3.2 Land Use Plans

Town of East Hampton Comprehensive Plan
The Town of East Hampton completed the East Hampton Comprehensive Plan in 2005. This document provides fundamental information pertaining to East Hampton's resources, character and qualities, growth and planning. The Comprehensive Plan was initiated in response to East Hampton's population increase and the growing pressure that increase put on the Town's roads, schools, infrastructure and environment. The Town Board initiated an inclusive, public planning effort in 2001 to study such conditions and determine a course of action to protect resources.

The Plan expresses an overarching goal of preserving the rural qualities that presently exist in the Town while acknowledging that growth will occur. The Plan seeks to preserve these positive qualities while setting fair limits on growth that would not simultaneously impair those same positive qualities that attract growth in the first place. Thus, the Plan relates preservation of the future quality of life to cognizance of current development controls such as utility capacity and availability, transportation networks, zoning, and aesthetics. The plan specific to Lake Montauk recommends several rezonings to promote uses compatible with the existing character and community surrounding the Lake.

Town of East Hampton Local Waterfront Revitalization Program
The Town's LWRP was adopted by the Town in 1999 and approved by the State in 2007. Policies #11-17 address erosion and flood control, and policies #30-40 and 44 address water

resources and natural resource protection. These policies provide guidelines for the Town to follow when reviewing applications within the coastal areas of the Town.

East Hampton Town Water Resources Management Plan

The Town's WRMP was completed in 2004 and was prepared to address concerns regarding water quality and quantity of fresh surface and groundwater within the Town. The following recommendations pertain to stormwater management:

- Carefully control the use of road salt on roads in the SGPA and WROD zones. Evaluate the potential for the use of alternative substances to be used in the future to reduce or eliminate the use of chloride-containing road salts.
- Use swales and natural depressions instead of catch basins to accommodate road runoff where possible and feasible.
- Contain runoff from agricultural fields on site as it has been recently shown that runoff migrating off of town agricultural fields contain toxic chemicals. Every agricultural and nursery operation, and especially anyone owned and/or controlled by the town, should demonstrate, either by the use of berms, swales, or other runoff controlling features, that it is keeping all runoff on site.
- Contain runoff from golf courses and playing fields on site.
- All new construction should have gutters and drainpipes to drywells to recharge all roof water on site. Preexisting buildings should be retrofitted wherever and whenever possible with gutters, leaders and drywells.

3.3.3 Town Programs and Municipal Best Management Practices

The Town currently has several programs geared towards stormwater pollution prevention and best management practices in place to ensure compliance with MS4 requirements. A summary of each program is provided in **Table 18** below.

Table 18: Municipal Best Management Practices

Program	Program Development Responsibility	Program Implementation Responsibility	Program Purpose	Program Description
Catch Basin Inspection and Cleaning Program	Highway Department	Highway Department	A program and/or schedule to inspect and clean catch basins and stormwater inlet structures on a regular basis to remove potential pollutants and debris, prevent clogging of the downstream conveyance system, restore catch basins' sediment trapping capacity, and ensure the system functions properly.	The Highway Superintendent has a notebook of all catch basins with information on when they are cleaned. Cleaning is currently on a regular schedule and is conducted in the spring and summer. The workers note information about cleaning in a notebook where all cleaning data is kept and tracked.
Municipal Stormwater Infrastructure Inspection Program	Highway Department	Highway Department	Establish a regular municipal stormwater inspection and maintenance schedule for municipally-owned stormwater infrastructure. Inspection can identify problems in early stages and allow prioritizing repair and maintenance.	The Highway Superintendant does not have GIS based mapping for stormwater infrastructure – all information is kept in the maintenance notebook. Infrastructure is replaced or added as needed and is partially complaint driven.
Street Sweeping Program	Highway Department	Highway Department	A street sweeping program is intended to prevent or reduce the discharge of pollutants from roadways, streets, and parking areas. The program may include provision for: bio-filters and/or infiltration devices; semi-permeable pavements; control of	Street sweeping is conducted on a daily basis during the appropriate season (mid-March through November). The boat ramp areas are swept in addition to the roadways.

Program	Program Development Responsibility	Program Implementation Responsibility	Program Purpose	Program Description
			litter; surface cleaning protocols; and/or surface repair procedures.	
Mowing & Property Maintenance Program	Highway Department Parks & Building Maintenance	Highway Department	A property maintenance and mowing program is intended to prevent or reduce the discharge of pollutants from town-maintained properties. The program may include provision for: frequency of mowing; procedures for clearing; provisions for trash removal; frequency of inspections of conditions of properties; disturbance during maintenance activities.	The Highway Department mows the road shoulders on a regular basis during the summer. This occurs on a rotating schedule. No fertilizer is used on any Town property as per Town policy. The Town places trash baskets on its properties. The trash is picked up daily by the Parks & Building Maintenance department.
Roadway & Boat Ramp Maintenance Practices	Highway Department & Parks and Building Maintenance	Highway Department & Parks and Building Maintenance	It is important to implement appropriate management practices during the planning, design, operation, and maintenance of roadway projects undertaken by the regulated MS4. Management practices may relate to: implementing proper erosion and sediment controls; minimizing the use of pesticides, herbicides, fertilizers, and chemicals; review and modification of existing policies and practices; developing pavement repair procedures;	The Highway Department is responsible for Town Road maintenance. Parks and Building Maintenance is responsible for maintenance of Town boat ramps. This includes inspection and repair of ramps as needed. Inspection is mostly complaint driven.

Program	Program Development Responsibility	Program Implementation Responsibility	Program Purpose	Program Description
			improvements to drainage systems and outlets; and reducing the use and the generation of hazardous materials	
Beach Maintenance Practices	Department of Parks and Building Maintenance	Department of Parks and Building Maintenance	It is important to implement appropriate management practices during the planning, design, operation, and maintenance of beach projects undertaken by the regulated MS4. Management practices may relate to: implementing proper erosion and sediment controls; minimizing the use of pesticides, herbicides, fertilizers, and chemicals; review and modification of existing policies and practices; development and implementation of pet and animal waste reduction practices; waste disposal practices; beach grading/cleaning procedures; improvements to drainage systems and outlets; and reducing the use and the generation of hazardous materials	The Town cleans the beaches daily in the summer. This occurs during a day shift and a night shift. Only bathing beaches are maintained. Non-bathing beaches are maintained on a complaint driven basis. Fertilizers, herbicides and pesticides are not used per the Town's no chemical use policy. Trash receptacles as Town facilities are emptied every Monday, Wednesday and Friday. Bags for cleanup of pet waste are kept stocked at a variety of locations.
Employee Training Program	Highway Superintendent	Highway Superintendent	Develop a program that provides training to municipal staff whose work may potentially influence the	In house training is conducted by the Highway Superintendent for all Highway Department staff on a yearly basis.

Program	Program Development Responsibility	Program Implementation Responsibility	Program Purpose	Program Description
			quality of stormwater. The training program should inform and educate employees on proper pollution prevention and good housekeeping techniques	

3.4 Best Management Practice Gap Analysis

The Genesee/Fingers Lakes Regional Planning Council in cooperation with the NYSDOS developed a Municipal Nonpoint Assessment Form that was designed to identify gaps in laws and practices for municipalities to guide recommendations for improvement. The form divides BMP's into six groups: Development, Forestry and Agriculture, Waterways and Wetlands, Marinas, Roads and Bridges and Onsite Wastewater Treatment Systems. Each BMP is assessed to determine if a local law, program, or practice is in place that enforces the BMP, and to what degree the BMP is enforced by the law, program or practice. The scoring system for each BMP is as follows:

- **Fully (2 points)**: The municipality implements the practice or its equivalent across the entire area of the municipality. The practice is a) codified in municipal code; b) included in internal operating procedure guidelines or manuals; c) included in specification manuals, or d) is part of a special municipal initiative.
- **Partially (1 point)**: The municipality implements the practice or its equivalent in a specific area of the municipality or implements part of the practice or its equivalent. The practice is a) routinely followed but not codified in municipal code; or b) routinely followed but not included in written internal operating procedure guidelines or manuals which may or may not include specifications.
- **Not at all (0 points)**: The municipality does not implement the practice or its equivalent.
- **Not applicable (n/a)**: The practice does not appear to be relevant to the municipality.

The completed form, identifying gaps in local laws, programs, and practices, is provided below.

Table 19: Regulatory Gap Analysis

BMP Number	Best Management Practices (BMP)	Existing Means of Implementation (law, regulation, practice, etc.)	Degree of Implementation*	Notes
Section 1 - Development				
Part A - Existing Development				
1-01	Identify retrofit opportunities	NYS MS4 General Permit Requirement, Lake Montauk WMP - in development	2a	
1-02	Identify habitat and natural conveyance system restoration opportunities	East Hampton LWRP, Lake Montauk WMP - in development, Town Code Chapter 150	1	Full implementation expected with adoption of Lake Montauk Watershed Management Plan
1-03	Establish retention/detention areas	East Hampton Town WRMP, Lake Montauk WMP - in development	1	Full implementation expected with adoption of Lake Montauk Watershed Management Plan
1-04	Acquire additional land for locating treatment facilities		0	
1-05	Encourage homeowners to place corn post piles away from waterbodies and roadways		0	
1-06	Encourage proper use and disposal of lawn and other household chemicals	Town Code Chapter 167, STOP Collection Days	2a & 1b	
1-07	Institute turf management practices on golf courses and parks and recreation areas	Suffolk County Fertilizer Reduction Law (Local Law 41 - 2007)	1a	Policies address fertilizer use only on County owned properties.
1-08	Undertake storm drain stenciling		0	
1-09	Encourage volunteer programs, such as adopt-a-highways and adopt-a-stream, etc.		0	
1-10	Include high percentage of indigenous plants in new landscaping on privately-owned properties (excluding arboretums, horticultural gardens, and sites requiring turf grasses)	Common practice of the Planning Board during project review	1a	
1-11	Encourage water conservation		0	
1-12	Develop outreach programs targeted at specific problems related to water quality management & resource conservation		0	

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BMP Number	Best Management Practices (BMP)	Existing Means of Implementation (law, regulation, practice, etc.)	Degree of Implementation*	Notes
1-13	Encourage proper control of pet wastes	Town Code Chapter 91	2a	Only applies to Town beaches
1-14	Encourage continued operation of private storm water runoff control structures	NYS GP 0-10-001	1a	Maintenance provisions required for new development/redevelopment for disturbances 1 acre or greater
1-15	Discourage feeding of waterfowl	?	0	
1-16	Discourage the introduction of exotic aquatic species (Eurasian water milfoil, zebra mussels, water chestnut, etc.	Suffolk County Resolution 614-2007, NYS Bill S06826 (in development)	1a	Bill in development would regulate specific invasive species state-wide
1-17	Encourage continued (periodic) operation and maintenance of private septic disposal systems	Town Code Chapter 208 & 255	2a	Only applies to sanitary systems located within the Harbor Protection Overlay District
1-18	Effective and consistent application and enforcement of stormwater regulations & requirements	NYS GP 0-10-001	2a	Does not apply to construction disturbance less than 1 acre
1-19	Require certification of existing on site septic systems for property transfers or building expansions.	SCDHS Article 6, Chapter 208	1	Identification & regulation of poorly functioning sanitary systems discharging to MS4 by local law is required pursuant to NYSDEC MS4 General Permit, Chapter 208 only applies to the Harbor Protection Overlay District
1-20	Require entire property (existing as well as proposed) to be included in stormwater analysis/calculation.	NYS GP 0-10-001	1a	Does not apply to construction disturbance less than 1 acre
Part B - New Development and Substantial Redevelopment				
1-21	Minimize the amount of land disturbed and the duration of disturbance	NYS GP 0-10-001, Town Code Chapter 220	2a	
1-22	Preserve natural features and conform substantially with the natural boundaries and alignment of waterbodies	Town Code Chapters 150, 180, 220 & 255, East Hampton LWRP	2a	
1-23	Retain and protect trees and other natural vegetation on and near disturbed sites	Town Code Chapter 220 & 234	1	Codes protects trees on Town property, and requires property owner permission for vegetation on privately owned land
1-24	Account for topography and soil type in efforts to minimize erosion potential	Town Code Chapter 220, NYS GP 0-10-001	2a	Does not apply to construction disturbance less than 1 acre
1-25	Maintain runoff rates similar to pre-construction levels	NYS GP 0-10-001	2a	Does not apply to construction disturbance less than 1 acre

BMP Number	Best Management Practices (BMP)	Existing Means of Implementation (law, regulation, practice, etc.)	Degree of Implementation*	Notes
1-26	Minimize the creation of impervious areas	Town Code Chapter 220	2a	
1-27	Control increased runoff caused by changed surface conditions to minimize the danger of flooding, erosion, sedimentation and pollutants entering waterbodies prior to, during and after construction	East Hampton LWRP, NYS GP 0-10-001	2a	Does not apply to construction disturbance less than 1 acre
1-28	Use temporary vegetation and mulching to protect exposed and critical areas during development	NYS GP 0-10-001	2a	Does not apply to construction disturbance less than 1 acre
1-29	Redistribute topsoil within the boundaries of the disturbed land for seeding and planting		0	
1-30	Stabilize disturbed soils as soon as possible	NYS GP 0-10-001	2a	Does not apply to construction disturbance less than 1 acre
1-31	Minimize the use of cut and fill operations. Conform such operations to topography and soils to minimize erosion potential and adequately accommodate runoff	Town Code Chapter 220	1	
1-32	Use appropriate solid and hazardous waste generation and disposal practices including source controls and recycling	Suffolk County Article 7 &12, Town STOP program	1	
1-33	Encourage construction site management techniques which include the proper handling and disposal of pesticides and petroleum products and containers	NYS GP 0-10-001, East Hampton Town WRMP	2a	
1-34	Ensure proper operation and maintenance of runoff management facilities	NYS GP 0-10-001	2a	Does not apply to construction disturbance less than 1 acre
1-35	Target training for contractors, inspectors and zoning and planning officials.		0	
1-36	Require tree surveys and/or cutting plans.		0	
1-37	Develop priority list for BMP's -use of vegetative low areas for retention/infiltration.	NYS Stormwater Design Manual, East Hampton LWRP, East Hampton Town WRMP, Town Code Chapter 150	1b	Does not apply to construction disturbance less than 1 acre
1-38	Encourage cluster development.	Town Code Chapter 220	2a	
1-39	Require connection to and/or extension of existing water & sewer if project is within 500 feet of existing public infrastructure	SCDHS Article 6	2a	Applies to properties within sewer districts (no public sewer or water districts in Shelter Island)
1-40	Enact limits on driveway grades.	Town Code Chapter 220	1a	Applies to subdivisions only

BMP Number	Best Management Practices (BMP)	Existing Means of Implementation (law, regulation, practice, etc.)	Degree of Implementation*	Notes
1-41	For redevelopment, employ regulations that provide for technologically advanced (on and off) site wastewater treatment systems to optimize efficiencies and address "challenging" sites	Town's Comprehensive Wastewater Management Plan	1a	Full implementation expected with the completion of the Town's Comprehensive Wastewater Management Plan.
1-42	Implement Federal/State Stormwater (SPDES) Phase II requirements	NYS GP 0-10-001	1a	
Section 2 - Forestry and Agriculture				
Part A - Forestry				
2-01	Consider potential water quality impacts when selecting silviculture system (yarding system, site preparation, pesticides employment, etc.)	N/A	N/A	
2-02	Consider harvesting practices	N/A	N/A	
2-03	Seasonal preference for logging operations	N/A	N/A	
2-04	Have specialists (geologist, soil scientist, geotechnical engineer, wildland hydrologist) review plans in high erosion hazard areas		0	
2-05	Preplan harvest areas, skid trails, and access so as to be on stable soils, avoiding steep gradients, multiple stream crossings, poor drainage areas, etc.	N/A	N/A	
2-06	Limit grades of access roads.	Town Code Chapter 220	1a	Roadway design specifications are only provided in Subdivision Regulations.
2-07	Require stabilization of roads/drives to forestry site.	N/A	N/A	
2-08	Employ natural topography and contour for design of road network	Town Code Chapter 220	2	Roadway design specifications are limited to roadways constructed pursuant to Subdivision Regulations.
2-09	Require stormwater controls for increased runoff from ground cover modification	NYS GP 0-10-001	2a	Does not apply to construction disturbance less than 1 acre
2-10	Consider site restoration		0	
Part B - Agriculture				
2-11	Use Agricultural Environmental Management (AEM)		0	
2-12	Require farms seeking agricultural value assessment to participate in AEM		0	

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BMP Number	Best Management Practices (BMP)	Existing Means of Implementation (law, regulation, practice, etc.)	Degree of Implementation*	Notes
Section 3 - Waterways and Wetlands				
Part A - Modified Waterways				
3-01	Develop an operation and maintenance program for existing modified streams that includes identification of opportunities and actions to restore habitat and the physical and chemical characteristics of these streams.	N/A		
3-02	Improve stream quality by controlling in stream sedimentation and selectively clearing debris	N/A		
3-03	Establish or reestablish riparian buffers	East Hampton LWRP, Town Code Chapters 150 & 255	2a	
3-04	Prevent animal wastes from entering waterbodies			
3-05	Attempt vegetative stabilization before undertaking structural measures	NYSDEC Article 24 & 25 Permitting, Town Code Chapter 255	2a	
3-06	Design and construct shore erosion control facilities, in accordance with an erosion and sedimentation control plan, in areas where marsh creation and soil bioengineering are ineffective or where existing protection methods are being flanked or are failing	NYSDEC Article 24 & 25 Permitting, Town Code Chapters 150 & 255, East Hampton LWRP, NYS GP 0-10-001	2a	
3-07	Schedule the periodic maintenance of sediment control measures, and inspect and repair them as needed in conformance with established schedule.	NYS GP 0-10-001	2a	Does not apply to construction disturbance less than 1 acre
3-08	Protect stream banks through direct nonstructural means, such as new vegetation or protection of existing vegetation; direct structural means, such as revetments and bulkheads; indirect nonstructural means, such as regulating irrigation near stream banks or rerouting overbank drainage; or indirect structural means, such as deflecting channel flow away from stream banks with dikes, board fences and gabions	Town Code Chapter 255, NYSDEC Article 24 & 25 Permitting	2a	
3-09	Use setbacks to minimize disturbance of land adjacent to stream banks and shorelines	Town Code Chapter 255, NYSDEC Article 24 & 25 Permitting	2a	

BMP Number	Best Management Practices (BMP)	Existing Means of Implementation (law, regulation, practice, etc.)	Degree of Implementation*	Notes
3-10	Prevent discharges to waterbodies in amounts that would adversely affect the taste, color or odor of the waters, or would impair the waters for their best usages	NYS GP 0-10-001, East Hampton Town WRMP	2	
Part B - Wetlands and Riparian Area Management and Restoration				
3-11	Consider wetlands and riparian areas and their non-point source (nps) control potential on a watershed scale	Lake Montauk WMP - in development	1	Full implementation expected with adoption of Lake Montauk Watershed Management Plan
3-12	Identify existing functions of those wetland and riparian areas with significant nps control potential when implementing nps management practices. Do not alter wetlands or riparian areas to improve their water quality at the expense of their other functions	Lake Montauk WMP - in development	1	Considered in WMPs recommendations
3-13	Conduct permitting, licensing, certification and non-regulatory nps pollution activities in a manner that protects wetland functions	NYSDEC SPDES Permitting	2a	
3-14	Special zoning considerations to protect wetland areas	Town Code Chapter 255	2a	
3-15	Use appropriate pretreatment practices such as vegetated systems or detention or retention basins to prevent adverse impacts to wetland functions that affect nps pollution abatement from hydrologic changes, sedimentation, or contaminants	NYS GP 0-10-001	1	Only applies to development/redevelopment involving disturbance equal to or greater than 1 acre
3-16	All projects should require wetlands certification.	Town Code Chapter 255, NYSDEC Article 24 & 25 Permitting	2	
Section 4 - Marinas				
Part A - Existing Marinas				
4-01	Clean maintenance areas regularly preferably by vacuuming to remove trash, sandings, paint chips, etc.	NYS GP 0-11-009	2a	Ensure marinas have obtained coverage under GP-0-11-009 during any municipal application review
4-02	Prevent residue from being carried into surface waters by performing abrasive blasting within plastic tarp enclosures on windless days or within spray booths	NYS GP 0-11-009	2a	Ensure marinas have obtained coverage under GP-0-11-009 during any municipal application review
4-03	Provide proper disposal/recycling facilities to marina patrons, preferably covered receptacles	NYS GP 0-11-009	2a	Ensure marinas have obtained coverage under GP-0-11-009 during any municipal application review

BMP Number	Best Management Practices (BMP)	Existing Means of Implementation (law, regulation, practice, etc.)	Degree of Implementation*	Notes
4-04	Establish fish cleaning areas, and implement rules governing the conduct of fish cleaning operations	NYS GP 0-11-009	2a	Ensure marinas have obtained coverage under GP-0-11-009 during any municipal application review
4-05	Educate boaters on the importance of proper fish cleaning practices	NYS GP 0-11-009	2a	Ensure marinas have obtained coverage under GP-0-11-009 during any municipal application review
4-06	Implement fish composting where appropriate		0	
4-07	Store materials in areas impervious to the type of material stored. Build curbs, berms, or other barriers around the areas to contain spills	NYS GP 0-11-009	2a	Ensure marinas have obtained coverage under GP-0-11-009 during any municipal application review
4-08	Use separate, clearly labeled containers for the disposal of oil, gasoline, antifreeze, diesel, kerosene, and mineral spirits	NYS GP 0-11-009	2a	Ensure marinas have obtained coverage under GP-0-11-009 during any municipal application review
4-09	Target outreach programs about proper disposal at marina patrons through the use of signs, mailings, and other means		0	
4-10	Promote the use in bilges of oil-absorbing materials, and replace them as necessary, preferably recycling, or disposing of them in accordance with petroleum disposal regulation	NYS GP 0-11-009	2a	Ensure marinas have obtained coverage under GP-0-11-009 during any municipal application review
4-11	Use a container under the air vent while refueling inboard tanks if the tank vents are not equipped with a fuel/air separator	NYS GP 0-11-009	2a	Ensure marinas have obtained coverage under GP-0-11-009 during any municipal application review
4-12	Prohibit in-water hull scraping or any underwater process to remove paint from boat hulls	NYS GP 0-11-009	2a	Ensure marinas have obtained coverage under GP-0-11-009 during any municipal application review
4-13	Wash the boat hull above the waterline by hand, using only necessary amounts of detergents and cleaning compounds that are phosphate-free and biodegradable	NYS GP 0-11-009	2a	Ensure marinas have obtained coverage under GP-0-11-009 during any municipal application review
4-14	Prohibit the use of detergents and cleaning compounds containing ammonia, sodium hypochloride, chlorinated solvents, petroleum distillates, alcohol, or lye	NYS GP 0-11-009	2a	Ensure marinas have obtained coverage under GP-0-11-009 during any municipal application review

BMP Number	Best Management Practices (BMP)	Existing Means of Implementation (law, regulation, practice, etc.)	Degree of Implementation*	Notes
4-15	Educate individuals about the importance of trash reduction and recycling through: interpretive and instructional signs placed at marinas and boat-launching sites, pamphlets or flyers, newsletters, inserts in billings, meetings and presentations, workshops, and certification programs		0	
4-16	Inspect pumpout facilities regularly, and repair them, if practical, under a maintenance contract with a competent contractor	NYS GP 0-11-009	2	Ensure marinas have obtained coverage under GP-0-11-009 during any municipal application review
4-17	Add language to slip lease agreements mandating the use of pumpout facilities and specifying penalties for failure to comply		0	
4-18	Place dye tablets in holding tanks to identify and discourage illegal disposal	Practice employed by the Bay Constable, pursuant to Federal No Discharge Zone requirements - 67 FR 39720	2a&b	
4-19	Prohibit motorized vessels from areas (define areas) that contain important shallow-water habitats		0	
4-20	Establish and enforce no-wake zones to decrease turbidity and reduce erosion potential from boat wakes	5 mph speed limit within the Lake	2a	Enforced by the Town Harbormaster
Part B - New Marinas				
4-21	Design and site marinas to maximize exchange of marina basin water. Limit basins and channels with square corners that tend to trap flotsam, and place dock structures in a manner that promotes circulation	Common practice during project review	1b	No specific legislation in place.
4-22	Perform a preconstruction assessment, which includes a water quality monitoring and modeling methodology, to predict post-construction water quality conditions	NYS GP 0-11-009	2a	Ensure marinas have obtained coverage under GP-0-11-009 during application review
4-23	Monitor water quality during construction to protect ambient water quality to the maximum practicable extent		0	
4-24	Develop a marina siting policy to discourage development in areas containing important habitat designated by local, State, or federal agencies	Common practice during project review	1b	

BMP Number	Best Management Practices (BMP)	Existing Means of Implementation (law, regulation, practice, etc.)	Degree of Implementation*	Notes
4-25	Conduct surveys and employ rapid bio assessment techniques to assess historic habitat function (e.g. spawning, nursery, and migration pathways) and potential impacts to these and other biological functions and resources		0	
4-26	Encourage the redevelopment or expansion of existing marina facilities that have demonstrated minimal environmental impacts instead of developing new marina facilities		0	
4-27	Consider alternative sites with minimal potential environmental impacts when the use of previously disturbed sites is not feasible	SEQRA Process	1	Not currently specified in special permit requirements
4-28	Minimize disturbance of indigenous vegetation in the riparian area	Town Code Chapter 180 & 255, NYSDEC Article 24 & 25 Permitting	2a	
4-29	Use soil bioengineering or plants, wherever conditions allow, to restore damaged habitat along shorelines and stream banks	Town Code Chapter 180 & 255, NYSDEC Article 24 & 25 Permitting	2a	
4-30	Use properly designed and constructed engineering practices that minimize shoreline disturbance in areas where soil bioengineering and plants are ineffective	Town Code Chapter 180 & 255, NYSDEC Article 24 & 25 Permitting	2a	
4-31	Use appropriate shore erosion control methods, such as returns or return walls, in areas where existing protection methods are being flanked or are failing	Town Code Chapter 180 & 255, NYSDEC Article 24 & 25 Permitting	2a	
4-32	Plan and design all steam bank, shoreline, and navigation structures so that they do not transfer erosion energy to or otherwise cause visible loss of surrounding stream banks or shorelines	Town Code Chapter 180 & 255, NYSDEC Article 24 & 25 Permitting	2a	
4-33	Locate and design fuel stations so that spills can be contained in a limited area	NYSDEC Article 24 & 25 Permitting	2a	
4-34	Design and install underground fuel storage tanks according to State regulations, including the provision of detection systems and automatic fuel tank and pump leak shut-offs	NYSDEC Article 24 & 25 Permitting, SCDHS Article 7 and 12 Permitting, Town Code Chapter 206	2a	
4-35	Provide aboveground fuel tanks and fueling areas with a curbed or diked storage area to handle containment volumes meeting State (and local) codes and inspect regularly	NYSDEC Article 24 & 25 Permitting, SCDHS Article 7 and 12 Permitting, Town Code Chapter 206	2a	

BMP Number	Best Management Practices (BMP)	Existing Means of Implementation (law, regulation, practice, etc.)	Degree of Implementation*	Notes
4-36	Use preferred pumpout systems: fixed-point, portable, dedicated slip-side, and pumpout boats	Federal No Discharge Zone requires the use of pump out facilities - 67 FR 39720	2	
4-37	Design onsite wastewater treatment systems to specifically handle waste from vessels	SCDHS Article 6 Design and Review Process	1	Not currently specified in special permit requirements
4-38	Post pumpout facility location and regulations at the marina. Charge fees that encourage rather than discourage facility use. Consider offsetting the cost of maintaining pumpout facilities by fuel sales where these facilities are conveniently located in close proximity to one another		0	
Part C - All Marinas (Existing and New)				
4-39	Restrict boat repair and maintenance activities to clearly marked designated areas to prevent debris from falling into the water and preventing invasive species	NYS GP 0-11-009	2a	Ensure marinas have obtained coverage under GP-0-11-009 during any municipal application review
4-40	Secure all fueling facilities and storage areas with appropriate shut-off devices and security locks and inspect regularly	NYS GP 0-11-009, SCDHS Article 12	2a	Ensure marinas have obtained coverage under GP-0-11-009 during any municipal application review
4-41	Design fueling stations with spill containment equipment that is stored in a clearly marked location, accessible to work and storage areas. Post emergency phone numbers in a prominent location	NYS GP 0-11-009, SCDHS Article 12	2a	Ensure marinas have obtained coverage under GP-0-11-009 during any municipal application review
4-42	Design a spill contingency plan	NYS GP 0-11-009, SCDHS Article 12	2a	Ensure marinas have obtained coverage under GP-0-11-009 during any municipal application review
4-43	Inspect and maintain all containment berms or devices in accordance with State regulations. Investigate immediately signs of leakage or spillage, and undertake cleanup in accordance with applicable best management practices	NYS GP 0-11-009, SCDHS Article 12	2a	Ensure marinas have obtained coverage under GP-0-11-009 during any municipal application review
4-44	Have a trained operator present and prepared to respond to accidental spills	NYS GP 0-11-009	2a	Ensure marinas have obtained coverage under GP-0-11-009 during any municipal application review
4-45	Maintain daily inventory records to identify abnormal loss or gain of liquid	NYS GP 0-11-009, SCDHS Article 12	2a	Ensure marinas have obtained coverage under GP-0-11-009 during any municipal application review

BMP Number	Best Management Practices (BMP)	Existing Means of Implementation (law, regulation, practice, etc.)	Degree of Implementation*	Notes
4-46	Prohibit the cleaning of hoses, fittings, pumps, and other accessory equipment on piers, docks or adjacent upland to prevent runoff into the marina basin or other surface or groundwater	NYS GP 0-11-009	2a	Ensure marinas have obtained coverage under GP-0-11-009 during any municipal application review
4-47	Create and/or maintain a dedicated fund for maintenance in the case of government-owned facilities		0	
4-48	Restrict the operation of pumpout facilities to trained marina personnel only	NYS GP 0-11-009	2a	Ensure marinas have obtained coverage under GP-0-11-009 during any municipal application review
Section 5 - Roads and Bridges				
Part A - Existing Roads and Bridges				
5-01	Conduct road and bridge maintenance (deicing material usage and storage, pot-hole repair, bridge washing, scraping and painting, etc.) according to best management practices	Town Highway Maintenance Program	1a	
5-02	Conduct right-of-way activities (mowing, brush removal, pesticide and fertilizer use, etc.) -according to best management practices	Town Highway Maintenance Program	1a	
5-03	Include high percentage of indigenous plants in new landscaping on public-owned properties (excluding arboretums, horticultural gardens, and site requiring turf grasses)	Common practice for projects	1b	
5-04	Implement a regular inspection and maintenance plan of existing structures	Town Highway Maintenance Program	1a	
5-05	Develop and identify erosion/sediment control areas (examples include steep slopes, easily erodible soils, and nearby sensitive areas) and retrofit opportunities	Lake Montauk WMP - in development	1	Considered in WMPs recommendations
5-06	Require percentage of roads to be tested with non-ice and non-sand de-icing.	Town DPW Brine Program	1a	Brine only utilized when there is no mix of rain and snow
Part B - New Roads and Bridges				
5-07	Minimize the amount of land disturbed and the duration of disturbance	NYS GP 0-10-001	2a	Does not apply to construction disturbance less than 1 acre

BMP Number	Best Management Practices (BMP)	Existing Means of Implementation (law, regulation, practice, etc.)	Degree of Implementation*	Notes
5-08	Preserve natural features and conform substantially with the natural boundaries and alignment of waterbodies	Roadway design process, NYSDOT review, NYSDEC Article 24 & 25 Permitting, Town Code Chapter 220.	2a	
5-09	Retain and protect trees and other natural vegetation on and near disturbed sites		0	
5-10	Retain additional runoff sites	NYS GP 0-10-001	2a	Does not apply to construction disturbance less than 1 acre
5-11	Minimize the creation of impervious areas		0	
5-12	Treat increased runoff caused by changed surface conditions to minimize the danger of flooding, erosion and pollutants entering waterbodies prior to, during and after construction	NYS GP 0-10-001	2a	Does not apply to construction disturbance less than 1 acre
5-13	Use temporary vegetation and mulching to protect exposed and critical areas during development	NYS GP 0-10-001	2a	Does not apply to construction disturbance less than 1 acre
5-14	Redistribute topsoil within the boundaries of the disturbed land for seeding and planting		0	
5-15	Stabilize disturbed soils as soon as possible	NYS GP 0-10-001	2a	Does not apply to construction disturbance less than 1 acre
5-16	Minimize the use of cut and fill operations. Conform such operations to topography and soils to minimize erosion potential and adequately accommodate runoff	Town Code Chapter 220	1a	Roadway design specifications are limited to roadways constructed pursuant to Subdivision Regulations.
5-17	Control erosion and sedimentation prior to, during and after site preparation and construction	NYS GP 0-10-001	2a	Does not apply to construction disturbance less than 1 acre
5-18	Require long term stormwater management plan.	NYS GP 0-10-001	2a	Does not apply to construction disturbance less than 1 acre
5-19	Require long term sedimentation control & maintenance.	NYS GP 0-10-001	2a	Does not apply to construction disturbance less than 1 acre
Part C - All Roads and Bridges (existing and new)				
5-20	Target existing public holdings, such as parks, for removing unnecessary impervious surfaces	Lake Montauk Watershed Management Plan - in progress	1	

BMP Number	Best Management Practices (BMP)	Existing Means of Implementation (law, regulation, practice, etc.)	Degree of Implementation*	Notes
5-21	Incorporate New York State Department of Transportation design and guidance documents, standard specifications, and procedural manuals (*Highway Design Manual, Environmental Procedures Manual,* Maintenance Guidelines, etc.) into local laws and operating procedures	Town Code Chapter 220	1	Conformance review necessary
5-22	Ensure application of appropriate solid and hazardous waste generation and disposal practices including source controls and recycling		0	
5-23	Ensure proper operation and maintenance of runoff management facilities	N/A		
5-24	Participate in Cornell Local Roads Program activities and training		0	
5-25	Target training programs at highway officials, contractors, construction workers, inspectors, zoning and planning officials		0	
5-26	Target training and outreach programs about the proper handling of materials, leakage and spill prevention and spill response procedures at maintenance staff and workers		0	
Section 6 - Onsite Wastewater Treatment Systems				
6-01	Conduct regular inspections of OWTS at a frequency adequate to determine failure and undertake required maintenance	MS4 General Permit, Town Code Chapters 208 & 255	1b	Identification & regulation of poorly functioning sanitary systems discharging to MS4 by local law is required pursuant to NYSDEC MS4 General Permit, Chapter 208 only applies to the Harbor Protection Overlay District
6-02	Institute setback guidelines	SCDHS Article 6 Regulations, Town Code Chapters 208 & 255	2a	
6-03	Promulgate plumbing codes that require practices that are compatible with OWTS	SCDHS Article 6 Regulations,	2a	
6-04	Target outreach programs at homeowners, contractors and developers	MS4 General Permit	1	NYSDEC MS4 General Permit requires pathogen -specific public education/outreach
6-05	Inspection of all OWTS at property transfer or within 1 year prior to transfer	Town Code Chapters 208 & 255	2a	Chapter 208 only applies to the Harbor Protection Overlay District

BMP Number	Best Management Practices (BMP)	Existing Means of Implementation (law, regulation, practice, etc.)	Degree of Implementation*	Notes
6-06	Require all properties within 500' of municipal service to connect.	N/A - No municipal OWTS systems exist within the watershed	N/A	
6-07	Set goals for effluent limits (nitrogen, phosphorous, BOD, etc.)	SCDHS Article 6 Regulations, NYSDEC Water Quality Regulations (6 NYCRR §703), Pathogen Total Maximum Daily Load, MS4 General Permit	2a	

As illustrated above, while several laws, programs and practices are in place that currently provide means for implementation of best management practices, gaps exist for several BMP's.

4.0 RECOMMENDATIONS

The characterization of water resources within the Lake Montauk Watershed, input from the TAC and the public, and regulatory considerations were all considered and factor into the development of recommendations in support of improvement of water quality. The overall intent of this document is to identify those measures that can be implemented to reduce existing water quality impacts and make meaningful strides toward water quality improvement. The recommendations provided herein will be incorporated into an Implementation Plan which will further evaluate each recommendation as well as specific improvement projects, with respect to priority in scheduling and methods for implementation.

Recommendations are divided into seven categories: Waterbody Recommendations, Stormwater Runoff and Water Quality Recommendations, Municipal Facility Recommendations, Wastewater Recommendations, Regulatory Recommendations, Natural Resource and Invasive Species Management and Public Education and Stewardship. Each recommendation has a designated identification number for ease of reference in the Implementation Plan, following this section; this number is provided prior to the main description of each of the recommendations. For specific improvement projects, an additional identification number is provided to the project to aid in project prioritization; this number is listed at the end of each project description or location.

4.1 Waterbody Recommendations

As demonstrated in **Section 2.4.4** of the Watershed Characterization, two areas within Lake Montauk in particular demonstrate consistent elevated levels of pathogens; the southern portion of the Lake and the Coonsfoot Cove area (between Star Island and the western shoreline of the Lake). Water quality monitoring data/analysis from CCE suggests that some of these pathogens may come from anthropogenic influences, indicating possible failure of septic systems in the Ditch Plains area. The following recommendations are provided to better understand the extent of the pathogen problem within the Lake and ascertain the source of pathogens impacting the Lake.

B-1: Establish regular water quality testing for pathogens and other pollutants within the Lake, particularly after large rain events.

Lake Montauk is identified within the Peconic Estuary Program's pathogen TMDL as an impaired waterbody. As indicated in **Section 2.4.4**, data for pathogen sampling is limited to what is conducted by NYSDEC; all other sampling efforts are not conducted on a regular basis. In addition, pathogens are the only pollutant that is regularly tested for; a significant lack of data regarding other potential pollutants (e.g. nitrogen) is lacking for the Lake. As a result, there is insufficient data for a full understanding of the dynamics of this waterbody. There is sufficient data to recognize that water quality issues exist in the southern portion of the Lake and Coonsfoot Cove area; however, a clearer understanding of waterbody dynamics and processes could be gained from regular water quality monitoring and measurements of tidal flushing within the system. Identifying and obtaining funding for expansion of efforts in support of regular water quality monitoring of this waterbody would further assist in identification of measures to improve water quality and reduce environmental stress on this ecosystem. Water quality testing should be conducted six-eight times/year in a variety of locations and include the following parameters: temperature, clarity, salinity, dissolved oxygen (all of which can be done in the field), and total coliform, fecal coliform, Chlorophyl-α and total nitrogen via lab testing. Additionally, counts for brown tide algae and red tide algae would also be beneficial.

B-2: Expand water quality sampling parameters to determine if a significant input of pesticides is affecting Lake water quality.

General concern regarding pesticides and potential impacts on the Lake has been expressed by the community. Review of historic aerial photographs does not identify the presence of significant farming operations that could historically have contributed to pesticide input in the lake; however, single family residences have existed in the area since prior to 1938. These residences are a potential source of pesticides entering the Lake as various pesticide applications for tick, mosquito and other common pest control may be used on these residential properties. As such, it is recommended that water quality sampling for pesticides at key outfall locations be conducted in order to determine if a significant input of pesticides is entering the Lake. As pesticide sampling can be costly, initial screenings could be conducted at specific sampling locations. CCE sampling stations 2, 8, 10, 11 and 14 are suggested for initial screening as the stations have upland catchment areas with high density residential uses, the golf course, and some farming uses.

B-3: Investigate the contribution of septic systems to pollution within the Lake.

Data from CCE's DNA testing of sources of pathogens entering the Lake indicate a human source from the southern portion of the Lake (**Section 2.4.4**). Due to the poorly drained soils and the shallow depth to groundwater within the Ditch Plains neighborhood, the potential for failing sanitary systems and direct input into the Lake exists. As a result, outfalls and culverts in the Ditch Plains neighborhood should be investigated to determine if any direct inputs from sanitary systems exists. Systems in this neighborhood should also be inspected (pursuant to the provisions of Chapter 210 of the Town Code) and dye tested if necessary preceding and during heavy storm events or during periods peak usage to determine if any systems overflow and discharge directly to the existing system of wetlands and conveyance ditches that ultimately discharge to the Lake. Further recommendations regarding potential solutions to failing sanitary systems in this neighborhood are provided in **Section 4.2.3** below.

B-4: Establish regular water quality testing for pathogens, phosphorus, and chlorophyll-α in Big Reed Pond as the limited sample results available suggest potential pollutants within the pond.

As described in **Section 2.4.4**, only one sample has been taken from Big Reed Pond by the NYSDEC, which revealed high levels of chlorophyll-α and low levels of clarity, suggesting potential pollution within the Pond. As no other known data exists regarding this pond, no conclusions regarding the health of the pond can be drawn. As a result, regular water quality testing (6-8 times per year) should be conducted within the Pond and include the following parameters: temperature, clarity, TDS, dissolved oxygen (all of which can be done in the field), and enterococcus, fecal coliform, Chlorophyl-α, total nitrogen, total phosphorus and cyanobacteria counts via lab testing. Once a data set is collected, pollutants within the Pond and potential sources can me more clearly identified. Remedial actions can then be determined to improve the health of the Pond.

B-5: Consider the use of aeration systems the lower portion of the Lake to promote growth of aerobic bacteria and stunt/reduce growth of anaerobic bacteria (most pathogens are anaerobic).

Several projects conducted in New York, New Jersey, South Dakota, Minnesota and India have demonstrated success through utilization of aeration systems to reduce pathogens within the target waterbodies. Aeration systems increase the oxygen concentration levels throughout the water column and help circulate waters to the surface, where ultraviolet can kill and or weaken the bacteria which improves water quality. **Appendix K-1** provides information on an example aeration system that that has been utilized successfully in similar situations. Further investigation into this remediation technique should be conducted to determine its feasibility and efficiency, particularly for the southern portion of the Lake.

B-6 Continue to fund and expand the Town's shellfish hatchery and seeding program, including eel grass protection and restoration.

Shellfish are filter feeders, meaning that they feed on particles and organisms floating in the water column. A significant establishment of shellfish within the Lake can assist in reducing pathogens and filtration of the water; thereby improving water quality. The Shinnecock Bay Restoration program currently provides an example of such a program with similar goals.

Eel grass surveys and restoration are also part of the Town's shellfish program. As eelgrass provides essential habitat for shellfish, finfish and other marine organisms, the presence of this habitat would potentially aid in the increase in shellfish within the Lake, thereby promoting increased natural filtration of Lake waters. Continued funding to support eel grass growth in the Lake is important for the long term health of the Lake.

B-7: Manage waterfowl populations.

Waterfowl are a key source of pathogens in surface waters. Therefore managing populations by reducing favorable conditions for waterfowl to congregate near surface water on private and public lands can assist in improving water quality. Methods to control populations include discouraging lawn areas for waterfowl to congregate near surface water on private and public lands; encourage use of fencing, unmowed surface water and wetland vegetated buffer zones, egg oiling and disruptive measures such as border collies and sonic devices where necessary. It is noted that Suffolk County and many east end municipalities are required to conduct goose management under the NYSDEC MS4 Program; therefore teaming with local municipalities, the Peconic Estuary Program and other resources may be possible for training or implementation of goose and waterfowl management programs to assist in reducing the costs for such programs. Additionally, goose/waterfowl management can be accomplished through volunteer efforts. Adoption of local laws prohibiting feeding of waterfowl on public lands (see Recommendation R-2) and providing educational material and signage regarding the issues associated with feeding of waterfowl can also help the public gather greater understanding of the issue. Educational material could also be developed for local homeowners regarding methods to control goose/waterfowl on their properties and the reasons why control of waterfowl is important to water quality.

B-8: Determine, identify and map tidal flushing and circulation in Lake Montauk.

As described in the **Section 2.4.4**, high levels of pathogens were identified in the southern portion of the Lake and in the Coonsfoot Cove area. As pathogen problems area generally not identified in other areas of the Lake, tidal flushing may play a key role in pathogen residence times resulting in the pollution impairment. Consideration should be given to conducting a study that would evaluate the circulation within the Lake and estimate residence time of surface water in key impairment areas of the Lake. Such a study would aid in determining additional remedial factors that could remove Lake impairments.

4.2 Upland Recommendations

This section details recommendations that would apply to the upland areas that contribute to surface waters, involving: stormwater runoff reduction; municipal facility improvements; upland wastewater management; regulatory guidance; natural resource enhancement and invasive species control; and, stewardship and public education. All recommendations pertain to land surface areas and would aid in improving environmental conditions including groundwater and surface water quality.

4.2.1 Stormwater Runoff

Specific best management practices (BMPs) to help reduce pollutant loads from stormwater runoff at specific locations are described below. Stormwater BMPs may provide pollution source reduction, pollutant removal and flood control. The NYSDEC issued an updated Stormwater Design Manual in August 2010 (hereafter "2010 Design Manual") which includes new guidance on the use of low impact design (LID) principles (i.e., preservation of open space and clustering development, reduction of impervious surfaces, retention of natural buffers, etc.) to reduce runoff volumes generated from development activities and the use of "green infrastructure" practices (i.e., rain gardens, bioretention areas, vegetated swales, green roofs, etc.) to provide water quality treatment close to the source of the runoff by utilizing natural features, promoting groundwater recharge and emulation of preconstruction hydrology. Where possible, LID and green infrastructure practices are recommended herein.

Drainage improvement projects were selected based on land use and impervious cover within the contributing area, proximity of potential pollutant sources to surface waters and availability of publically owned land in proximity of the discharge point(s) for physical placement of drainage improvement projects. Sample details and general information on improvement projects are provided in **Appendix L**. In general, it would be beneficial to conduct long term water quality monitoring in proximity to implemented projects to provide a measure of the project's success. Pilot programs for long term monitoring could be considered to provide an initial evaluation of the cost vs. benefits of such a program. The identified improvement projects are described below (see **Figure 22**):

S-1: Coordinate with the operators of the animal farm located on South Fenimore Drive to prepare an agricultural BMP program and create a vegetated buffer surrounding the on-site pond to reduce pathogen input into the Lake.

Inspection of the farm property revealed several areas for potential improvement, especially as it relates to pathogen pollution of the Lake. As such, the Town should coordinate with the operator of the farm to ensure that best management practices are applied on the property. Noted potential improvements include:

- Regular removal and disposal of animal manure within the animal paddocks.
- Establishment of a vegetative buffer around the on-site pond to provide for filtration of nutrients entering the pond.
- Control of animal access to the waterbody to reduce direct deposition of manure.
- Control runoff from the barnyard.
- Compost manure to the maximum extent feasible.
- Store manure in a properly constructed facility if it cannot be utilized.
- Goose management on open mowed areas.

The combined use of improvements to this farming practice could result in a significant pathogen reduction to the Lake, as pathogens from these sources currently have a direct vector to the Lake. It is noted that Station 7 of CCE's DNA analysis identified horses as one of the sources of pathogens taken from that sample, further suggesting that improvements to this farm could foster a reduction in pathogen inputs to the Lake. Improvements at this site would benefit from long term water quality monitoring to demonstrate project success. As such, these improvements could be part of a long term monitoring pilot program.

S-2: Create a shallow vegetated drainage depression at the landscape medians between the intersections of West Lake Drive, North Fernwood Drive and Star Island Road.

The landscape medians at this location form two "triangles" that consist of mowed lawn. Currently, stormwater is captured in this area via raised catch basins that may discharge directly to the Lake. The lawn area presents an opportunity for a shallow vegetated drainage depression that would provide catchment and biological uptake of nutrients and pathogens prior to overflow to the Lake. Vegetation could consist of native grasses that could be mowed periodically so that these areas may continue to be utilized for staging during community events while continuing to provide biological uptake of pollutants in stormwater. Subsurface leaching galleys could be utilized to provide further storage and detention of stormwater in this area. These measures would directly reduce pathogen and nutrient input to the Lake.

S-3: Investigate the feasibility for drainage improvements on the north side of Montauk Highway, opposite Caswell Road.

Information provided by Town staff and data reviewed for this report indicates that the Ditch Plains neighborhood is a potential significant source of pathogens to the

Lake. This area is known for poorly draining soils, shallow depth to groundwater, and high development density all of which contribute to increased runoff and potential failure of septic systems during storm events. As a result, effective improvements for this area are limited. Further discussion of sanitary system improvements is provided in **Section 4.2.3**. A potential stormwater improvement project could be located in the area on the north side of Montauk Highway, opposite Caswell Road (see **Figure 22**).

Additional feasibility analysis should be conducted to determine connectivity of the existing stormwater system and options for stormwater improvements in this area; however, preliminary investigations suggest that a constructed wetland would be beneficial for pathogen treatment. Constructed wetlands have been utilized around the country as effective means of pathogen treatments. An example is provided in **Appendix L**. Generally, these engineered wetlands consist of a wet pond or initial detention area that overflows to a vegetated wetland areas to provide biological treatment, that would eventually overflow and discharge to the Lake. Significant attenuation is provided through such a system, effectively reducing pathogen inputs to the target waterbody.

S-4: Implement the proposed drainage improvement project prepared for the South Lake Beach parking lot in the NYSDEC MS4 Retrofit Plan.

The South Lake Beach parking area is currently asphalt that leads to the beach entrance. In preparation for the Town's Retrofit Plan for the Lake, a drainage improvement project for this area was suggested to reduce runoff from the parking lot. The proposed project included regarding of the parking area that would pitch the runoff to a pervious swale located in the center of the lot.

S-5: Implement the proposed drainage improvement project prepared for the Star Island Town Dock in the NYSDEC MS4 Retrofit Plan.

The Star Island Town Dock currently consists of an asphalt area utilized for parking and storage of fishing equipment and supplies. In preparation for the Town's Retrofit Plan for the Lake, a drainage improvement project for this area was suggested to reduce runoff from the parking lot. The proposed project included installation of permeable pavement for the parking area, installation of garbage receptacles and relocation/organization of commercial fishing equipment.

S-6: Implement the proposed drainage improvement project prepared for the West Lake Drive Boat Ramp in the NYSDEC MS4 Retrofit Plan.

The Star Island Town Dock currently consists of a gravel/dirt area utilized for boat access to the Lake. In preparation for the Town's Retrofit Plan for the Lake, a drainage improvement project for this area was suggested to reduce runoff from the boat ramp. The proposed project included installation of permeable pavement for the ramp, relocation of bluestone storage that occurs on the side of the ramp, and installation of a bioretention area on the side of the ramp.

S-7: Create a bioretention area on the northwest corner of West Lake Drive and Flamingo Avenue.

The parcel located on the northwest corner of West Lake Drive and Flamingo Avenue is currently owned by the Town through purchase utilizing Community Preservation Funds. This site provides an opportunity for installation of a bioretention area to provide catchment and treatment of runoff draining from the surrounding roadways.

S-8: Provide pre-treatment where feasible for existing and proposed drainage infrastructure.

While several direct outfalls exist to Lake Montauk, it is recognized that it may not be feasible to remove all of these due to the constraints inherent in the characteristics of the watershed (e.g., poorly draining soils, presence of wetlands, etc.). As a result, providing treatment of stormwater prior to its discharge to an outfall would aid in water quality improvements without compromising existing drainage. Pre-treatment options include bioretention areas, vegetated swales, catch basin inserts and other green infrastructure techniques. Vegetated options (such as bioretention and vegetated swales) have the additional benefit of providing nutrient uptake through the root systems of the vegetation. These systems can be designed to provide "off-line" treatment for regular storm events. Stormwater drainage system inserts provide a method for treating pollutants within existing drainage infrastructure, where limited land area is available. Many municipalities in Long Island are currently utilizing such inserts to aid in pollution reduction. Inserts require regular maintenance and replacement of filter media to ensure effectiveness of the practice. (See **Appendix L** for examples/cut sheets).

4.2.2 Municipal Facilities Recommendations

M-1: Complete a GIS based mapping of the entire stormwater management system and "sewershed". Utilize the GIS mapping and a GIS database to effectively map locations and track maintenance and inspections of stormwater management practices.

The NYSDEC MS4 Permit requirements include mapping of all outfalls and storm sewershed (or the catchment area that drains into the storm sewer system based on the surface topography in the area served by the stormsewer). Mapping the overall system using GIS provides a means to maintain and update information associated with the stormwater infrastructure, including tracking systems for maintenance (i.e., which catch basin has been cleaned out, the frequency of cleanings needed and, establishment of a regular maintenance schedule). This tracking system would also aid in prioritization of catch basin cleanouts, repairs and replacements, as well as help prioritize areas for street sweeping based on the frequency of necessary drainage cleaning.

It is important to note that all stormwater management systems require maintenance to ensure the practices are properly functioning. GIS is an excellent tool to keep mapping updated and track information such as frequency of inspections and maintenance of the systems. It is important for the Town to keep stormwater system mapping up to date and for the mapping to be used by highway and maintenance staff to ensure maintenance personal are aware of the locations of specific stormwater practices and are fully informed regarding the specific maintenance requirements of the stormwater practice (i.e., maintenance personal know the locations of all systems with inserts and when such inserts need to be changed; know the location of bioretention areas and so vegetation is properly maintained, etc.).

M-2: Coordinate with NYS to establish a Goose Management Program on the Montauk Downs golf course.

Interviews with the Montauk Downs Golf Course facilities manager and inspection of the golf course revealed a need for a goose management program within the golf course. Measures that could potentially reduce the presence of geese on the golf course include egg oiling and disruptive measures such as border collies and sonic devices. The Town should seek to work with the State and the golf course manager to determine the best option for goose management on the golf course, which would further reduce pathogen input from goose waste.

M-3: Obtain funding for and construct a salt brine preparation facility for use in the Town.

Conversations with the Town indicate the desire for expanding the use of brine for treatment of roadways (rather than sand/salt mixes). Brine is sprayed on to roads before snow starts falling to prevent precipitation from forming a strong, icy bond with the pavement and reduces the amount of salt needed during a storm, since larger quantities of dry salt are needed to de-ice a road in temperatures below 20 degrees. The Town currently obtains their brine from the Town of Southampton and would like to reduce cost and efficiency by establishing a Town operated brine facility. Such a facility would provide long term cost savings as the need for transport of the brine would be eliminated. The Town has indicated it would be willing to provide brine to nearby municipalities such as the Village of East Hampton. The facility would allow for improved road maintenance during winter storms and would reduce the need for sand and salt which are known pollutants.

4.2.3 Groundwater and Wastewater Recommendations

W-1: Develop a program to enforce Town Code §210-5-1 and §210-6-1 which requires inspection and regular maintenance (every three years) of septic systems.

All sanitary systems within the groundwater contributing area to Lake Montauk have the potential to contribute nutrients to the Lake. Areas with sanitary systems situated in locations with shallow depth to groundwater have the greatest potential to discharge nutrients and pathogens to Lake Montauk. Sanitary systems without adequate vertical separation between the bottom of the leaching pool and groundwater do not function properly as there is insufficient conversion of ammonia to nitrite and nitrate (the nitrification part of the intended treatment process) and reduced natural attenuation of the sediments separating the system from groundwater. Additionally, as some systems may be located in clay soils with poor leaching capacity, overflow from these systems during storm events may directly discharge pathogens to surface runoff. As a result, there is a greater potential for groundwater transport and surface water release of available nitrogen and biological pollutants (bacteria and virus) to the Lake.

A program which enforces Town Code §210-5-1 and §210-6-1 which require regular sanitary system inspection and maintenance could be established to require property owners to provide proof of inspection and certification of sanitary systems once every three years. In addition to inspection by a licensed contractor, certification of the system could also be achieved through proof of maintenance (i.e., pumping of the sanitary system) within the three year time frame or proof of new system installation compliant with current SCDHS requirements (i.e., systems constructed after 1981). If inspection revealed a failing system or a system which could not be certified pursuant to SCDHS requirements (aged system), the system would either have to be pumped or replaced, depending on the severity of the failure. Once property owners demonstrate certification of a SCDHS approved system (updated since 1981), no additional submission/proofs of a compliant systems would be required (which may encourage property owners to replace antiquated systems rather than continually pumping the systems). **Figure 8** illustrates areas which may potentially have shallow depth to groundwater (less than 8 feet)[1], and could be utilized as a basis for initial strict enforcement of the inspection program. **Figure 4** identifies areas of potential poorly draining soils.

Part of the inspection program could include dye tracking of systems potentially located in poor soils and/or shallow depth to groundwater. This could be accomplished through the use of dyes added to sanitary systems prior to storm events. Systems that are not functioning would become apparent during a storm event as the added dye would exit the system via surface flow and discharge to the nearest waterbody. Tracking of the pigment could also aid in identifying major overland conveyances of stormwater that discharge directly to the Lake.

W-2: Investigate alternative options for treatment of septic waste in high density areas within the watershed.

As described in the **Section 2.2**, portions of the watershed are constrained by poorly draining soils, shallow depth to groundwater and high density of development. As a result, many individual sanitary systems may not be functioning as intended and may provide a direct vector for pathogen contamination to the Lake. As a result, several alternatives to use of individual systems should be considered to aid in improving the conditions that result in the direct discharge of pathogens. Suggested considerations are provided below and further details are provided in **Appendix K-2**.

A. <u>Installation of Small Community Treatment Systems</u> – Wastewater systems can be implemented that achieve pathogen removal to water quality standards as well as nitrogen removal. However requiring property owners to pay for the full cost of improved wastewater systems may be unaffordable. Grants and alternative funding/financing techniques should be investigated to address the affordability issue.
B. <u>Alternative Treatment Systems</u> – Research in alternative systems for coastal areas with significant site constraints such as high groundwater tables, poor soils, and small lot sizes has shown success in removal of bacteria and nitrogen using various bed filters (with sand, peat, foam, or textile media), aerobic

[1] This figure was generated utilizing GIS to graphically evaluate data from both Suffolk County LiDAR topographic data and USGS groundwater elevation data.

treatment units, or fixed activated sludge systems followed by either a traditional type soil absorption field or pressurized drainfields. The University of Rhode Island completed the "National Decentralized Water Resources Capacity Development Project"[2], which has conducted a number of pilot research projects in Towns and Villages throughout Rhode Island, and showed the effective pollutant removal capabilities of these systems. Suffolk County Department of Health Services has announced its intention to investigate possible alternative systems for use in Suffolk County.

C. Investigate Community Sewer Systems in Critical Areas within the Lake Montauk Watershed – There are higher density areas and higher intensity land uses within the Lake Montauk Watershed that do not meet current Suffolk County Sanitary Code density requirements (lots less than 20,000 SF in size and uses including restaurants and hotels within the northwest portion of the watershed, Star Island, Ditch Plains neighborhoods, etc.). A study investigating the feasibility of community sewering would be beneficial in reducing sanitary pathogen inputs to the Lake. Such a study would include an assessment of available parcels/land for siting of a facility, cost of facility construction, cost of landowner connection, and assessment of potential grant funding available. It is noted that the Town is currently conducting a Comprehensive Wastewater Management Plan that will further address the feasibility and needed information to install sewer systems within the Town.

D. Use of Permeable Reactive Barriers in Proximity to the Shoreline – While the above described systems are most likely to occur over a longer period of time, use of Permeable Reactive Barriers in key areas may aid in reducing pathogen inputs to the Lake in the short term. These barriers are installed in proximity to the shoreline where the groundwater output to surface water is fairly shallow and can intercept pathogens and nutrients carried in groundwater to the Lake. Effectiveness of such barriers have been determined to be better than that of sand filters, as demonstrated by a study performed at the University of Waterloo (Smyth et al., 2004).

W-3: Consider a cost-shared pump-out and water conservation kit program to aid in cost reduction for sanitary system maintenance and/or replacement.

It is recognized that sanitary system maintenance may be an economic hardship for some residents within East Hampton given the cost of transportation and disposal of pumped sanitary waste. As such, a cost-share program would aid in making sanitary system maintenance or replacement more affordable and would facilitate and encourage homeowner compliance. Similar programs have been successful in other communities throughout the country, including a recent program initiated by the Town of Southampton for a septic system rebate program that allows for rebates associated with the upgrade, repair, or replacement of existing septic systems that

[2] University of Rhode Island Cooperative Extension Kingston, RI, 2004. NDWRCDP Project Number: WU-HT-01-17. (http://www.uri.edu/ce/wq/nemo/Publications/PDFs/WW.PlanningHandbook.pdf)

comply with the Suffolk County Department of Health Services regulations. Case studies for other such programs conducted in Keuka Lake NY, Jamestown RI, and Fairfax Virginia are provided in **Appendix K-3**.

W-4: Provide wetland restoration and water quality improvements within the Lake by reconstructing the wetlands in Ditch Plains to engineered wetlands planted with native species to provide for vegetative pathogen removal of waters seeping from the Ditch Plains area.

Inspection of the wetland system in the Ditch Plains neighborhood that ultimately discharge to the Lake reveals poor quality wetlands dominated by invasive species that are most likely not providing the best possible biological treatment possible within these wetlands. Restoration of these wetlands could include engineering of the inputs to the wetlands, engineering of the soil beneath the wetlands and restoration with native species, all of which would provide enhanced treatment of groundwater and stormwater entering the system. In order to provide further treatment prior to discharge to the Lake, additional land in the vicinity should be acquired for use as a large scale bioretention area if parcels become available (see Recommendation V-8). Coordination with the NYSDEC would be required for any restoration plan as all of the wetlands are regulated by the State.

4.2.4 Regulatory Recommendations

R-1: Establish a Lake Montauk Protection Overlay District for properties located within the watershed.

Review of local laws, programs and practices indicates several regulatory gaps that could be filled through the establishment of a protection overlay district. Some of these gaps include:

- Specific regulations for marinas to ensure use of best management practices;
- Minimization of the creation of impervious area of sites to be developed or redeveloped
- Protection of large trees and native species
- Creation of vegetative buffers around wetlands

Creation of the protection overlay district could allow for regulations targeted specifically to the Lake Montauk watershed thereby specifically addressing pollutants unique to Lake Montauk.

New York State passed enabling legislation in 2012 which allows local municipalities to establish Watershed Improvement Districts (“WID”). The establishment of a Watershed Improvement District would enable the Town to establish specific plans and a dedicated funding mechanism for specific water quality improvements within the watershed area. WIDs have been established successfully in many areas throughout the County, including long running programs in Montgomery MD, Arlington VA and Philadelphia PA. Many function similar to other utility programs, where a basic fee structure is established based on impervious cover and land use to collect funding for critical projects and programs aimed at improving water quality within the watershed. Examples of improvement projects include low interest loan or grant programs offered to home or business owners within the WID to enable sanitary system upgrades and green infrastructure improvements, restoration projects and planning programs. WID have also established incentive programs where property owners are eligible for reductions in the WID fees when they complete property upgrades that have positive water quality benefits, such as installation of green infrastructure improvements or upgrades to sanitary systems (see Recommendation R-4).

R-2: Develop a law and associated signage prohibiting the feeding of waterfowl as they contribute nutrients to surface water and stormwater runoff.

Several studies demonstrate that waterfowl (particularly resident Canada Geese) significantly contribute to nutrient inputs to surface waterbodies from excrement. Feeding of waterfowl encourages long term residence of birds that would otherwise migrate to other areas. As a result, a larger proportion of waterfowl excrement is generated and has potential to enter surface waterbodies directly or during storm events. Prohibition of feeding of waterfowl would discourage long term residence of these birds thus resulting in improved water quality conditions of Lake Montauk.

R-3: Develop and implement programs and policies to aid in enforcement of the Federal No Discharge Zone.

Recommended implementation program elements include:

- Use of dye tablets to ensure boats are in compliance with the law;
- Expand boat pump-out service to seven day per week service until November 1st of each year;
- Provide a backup phone number for boaters to reach the pump out boat.

Current programs and policies do not provide for regular tracking and testing of boats utilizing the Lake and limits pump-out service to the end of September each year. As the Lake is part of a Federal No Discharge Zone, tracking of boat waste and providing enhanced pump-out service would aid in minimizing sanitary discharge from boats to the Lake. Additionally, a back-up phone number would allow for more boaters to reach the mobile pump-out boat during seasons with high boat traffic.

R-4: Encourage and incentivize use of green infrastructure in site and drainage design.

If a protection overlay district is established as described above, consideration should be given to the inclusion of drainage requirements that encourage cost effective runoff reduction techniques and green infrastructure, such as use of grass swales, use of rain gardens in parking lots and on residential properties, and bioretention infiltration areas. Incentives may be provided to further encourage the installation of green infrastructure techniques rather than conventional drainage systems. As described in Recommendation R-1, WID are another mechanism by which incentives can be created to encourage and incentivize the use of green infrastructure.

R-5: As described in Recommendation W-1, create a program to enforce inspection and certification once every three years for sanitary systems. Additionally, as described in W-3, explore the establishment of a cost share program to aid in septic system inspection and certification.

As described in Recommendation W-1 above, implementation of a sanitary inspection and certification program is a method to ensure that sanitary systems in areas with the greatest potential for transport of pollutants to surface waters and groundwater are properly functioning. It is suggested that a program be developed to enforce the existing Town Code requirements of septic system inspection and certification once every three years, particularly in areas identified as potentially having shallow depth (less than eight feet) to groundwater or in areas with known poorly draining soils. **Figure 8** provides a map which depicts areas of potential shallow depth to groundwater and **Figure 4** illustrates areas with potentially poor soils. In order to ensure the licensed sanitary contractor provides accurate assessments, it is recommended that a fine be incorporated into the Code for a contractor providing false information. Certification of the system could also be achieved through proof of maintenance (i.e., pumping of sanitary system) within the three year time frame, proof of a properly designed system (i.e., system meeting SCDHS design requirements), or proof of adequate depth to groundwater or adequate soils through a test boring. Once a system is certified as meeting SCDHS and/or Town Harbor Protection Overlay District design requirements and having adequate depth to groundwater, no further requirement would apply. If inspection reveals a failing system, the system would either have to be pumped or replaced, depending on the severity of the failure. If system replacement becomes necessary, it would be done so in conformance with SCDHS and/or Harbor Protection Overlay District approved design and oversight as required.

It is recognized that pumping or replacement of sanitary systems can be very costly. As described in W-3, a cost share program could be explored to aide in reducing the cost to homeowners, providing further incentive to perform regular maintenance or replacement of failing systems.

R-6: Amend Chapter 255, Article IV of Town Code to include minimum buffer width requirements.

While Chapter 255, Article IV (Zoning: Protection of Natural Resources; §255-4-30, 40) prohibits clearing or establishment of turf or landscaping within 50 feet of a wetland boundary or bluff or dune crest, no specific standard is required for vegetative buffers and there is no code provision requiring the re-establishment of native vegetative buffers that pre-exist §255-4-30, 40. Although buffers should be as wide as possible to protect water quality, requiring the restoration of a minimum buffer width for those parcels where the native vegetation has been removed would provide an established standard to ensure some protection of a waterbody from stormwater runoff generated from site improvements. It is noted that the majority of the Lake's frontage is currently developed, some of which consists of intense maritime uses that present challenges for the establishment of large buffer areas.

Redevelopment provides an opportunity to establish native buffers and provide stormwater treatment. In recognition of potential site constraints, particularly on water dependent uses, the establishment of a 50 foot wide buffer consisting of native plant species is the minimum recommended for redevelopment of residential properties fronting the Lake, while a minimum 20 foot wide buffer is recommended for the redevelopment of existing commercial properties (where parking lots immediately abut the Lake). In recognition of the limitations of some of the commercial uses that abut the Lake, an option to install a permeable reactive barrier (PRB) behind a bulkhead to provide filtration of stormwater contaminants in place of the vegetated buffer could be given to applicants so that loss of waterfront space vital to the commercial use does not occur. An example of a typical installation of a barrier behind a bulkhead is provided in **Appendix L**.

R-7: Provide dedicated funding for enforcement of waterway regulations within the Lake.

Enforcement of regulations that apply to the Lake are currently limited by a lack of available funding for staffing for the Harbormaster patrol and pump out boat. Dedicating funding to provide a full time patrol staff member for the Lake would aid in ensuring boats are using pump out facilities, following speed restrictions for no wake zones, mooring in proper locations, etc. Additionally, residents have indicated the need to extend the availability of the pump out facilities until mid-November, when many boats are taken out of the water. Funding could be procured through grants, a dedicated line item in the Town's budget or WID funding (if such a District were formed).

R-8: Work with Suffolk County on tick control measures for areas within the watershed.

As of 2015, Suffolk County Vector Control will be tasked with preparing and implementing a yearly tick control plan as a result in the rise of tick borne diseases, such as Lyme disease. The Town has the opportunity to work with the County to ensure concerns regarding pesticide input into the Lake and best management practices to minimize pesticide impacts are utilized for tick control. Practices could include efforts to control ticks on deer, such as the CCE Four Poster Program (which utilizes a pesticide on an apparatus which a deer rub against while feeding, thereby inoculating the deer with tick repellant).

R-9: Implement a moratorium on the installation of new docks so their impacts on the benthos of the Lake can be studied in greater detail.

The Town has expressed concerns regarding the increase in the number of docks within the Lake and their potential impact to the aquatic bed, particularly impacts to eel grass which is key component to the health of the Lake. To date, two studies have been conducted on dock expansion to which the results were inconclusive as to their impacts. As a result, a moratorium would enable the Town to conduct a comprehensive study on the impacts of docks to both the benthic and pelagic community within the Lake.

4.2.5 Natural Resource & Invasive Species Management

Recommendations N-1 and N-2 below would greatly benefit from an incentive program. Such a program could be modeled after the Peconic Estuary Program's recent successful homeowner incentive program, which provides a cash rebate for property owners to install rain gardens that were a minimum of 50 SF in size and/or install rain barrels. A similar program could be created to include commercial properties within the watershed which would aid in further implementation of the recommendations.

N-1: Encourage and incentivize the use of vegetative buffers on properties that abut the Lake.

Encourage the use of vegetated buffers adjacent to the Lake both on public and private lands. Vegetated buffers serve as effective means of stormwater filtration prior to entering the bays, harbors and marine surface waters. Several parcels that directly abut the Lake have lawn that extends directly to bulkheads or other shoreline stabilization structures. As the lawns are generally pitched toward the waterbody, direct discharge from the lawns, which may be fertilized or which may contain goose or pet waste, is entering the waterway. A vegetative buffer created in these areas would provide filtration of pathogens and nutrients prior to overland flow to the Lake. It is noted that these buffer areas could be configured to allow for pathways/walkways to the bulkhead or other dock structures if needed. Educational brochures targeting the benefits of such buffers could be sent to property owners within the watershed, as well as required as a part of any Building Permit, Special Permit, Wetland Permit or variance application review.

N-2: Encourage and incentivize the usage of vegetative buffers and filter strips adjacent to boardwalk areas in industrial and working waterfront areas that abut the Lake.

It is recognized that portions of the Lake (particularly the northwest corner) serve as working waterfronts that depend on the access to the Lake for survival of businesses. Currently, many of these areas have gravel parking lots that may have been installed to serve as pervious surfaces for the business establishment, however, compaction over time has rendered these surfaces as impervious and as such, stormwater will flow directly into the Lake. While limited options for stormwater treatment are available in these areas due to individual site use and shallow depth to groundwater, low growing vegetated filter strips could be installed along boardwalk or bulk headed areas to provide an attractive measure for stormwater filtration while continuing to allow access to the waterfront. Samples of such filter strips are provided in **Appendix L**.

N-3: Perform regular Early Detection/Rapid Response surveys for highly invasive species approaching the area to aid in prevention of these species becoming established within the watershed.

Invasive species contribute to poor water quality as they do not provide the same ecosystem services that native species provide. As a result, early detection and rapid response to new invasive species within the watershed would provide a means for ensuring that such species do not become established thereby degrading the quality of natural areas within the watershed.

N-4: Work with the County to revise and adopt an amendment to the Open Space Management Plan for Montauk County Park and consider prohibiting pets from being permitted in the park.

Results of CCE's DNA analysis at the outfalls of Big Reed pond identified fecal contamination from dogs. Such contamination is most likely the result of pet owners not picking up pet waste when with their pets in the park. In addition to providing educational material to pet owners, prohibiting pets from the park has the potential to significantly reduce the contribution of pathogens from this area.

4.2.6 Stewardship & Public Education Recommendations

V-1: Develop signage to inform the public regarding laws, public safety and human impacts to the bay.

Many of the signs developed to inform the public regarding the health and welfare of the Lake have been removed, destroyed during storm events or are no longer legible. Repair, replacement and enhancements of such signs would provide the public with better information regarding the importance of best management practices that aid in keeping the Lake clean. Recommendations include:

- Establish attractive and eye catching signage announcing the entrance to the Lake Montauk Watershed in highly visible areas to help increase public awareness of the watershed (i.e., "You are entering the Lake Montauk Watershed").
- Repair/replace Federal No Discharge Zone signs and create new ones indicating strict enforcement of the law.
- Create educational signage indicating the ecological importance of the Lake at key points of public interest/public use.
- Post information signage alerting the public to the reoccurring water quality issue and potential health hazards of swimming at South Lake Beach.
- Create informational signs indicating the location of important destinations, including the pump out boat, fueling stations, restaurants, and mooring areas.

- Adopt sign standards to ensure visibility to boaters utilizing the Lake utilizing standard color coding.

Signs could be created that had a color coded system for locations of important features, for which the corresponding feature would have a flag that matched the color on the sign, to clearly indicate the location of the feature. For example, the pump out boat could have a designated color of gray on the sign, and the boat would have a flag with the same color to clearly demarcate its location to boaters. Features to consider on the sign include the pump out stations at marinas, fueling stations, boat repair, restaurants, permitted transient mooring and docking areas, public boat launches and recreational points of interest.

Standards regarding sign color, font, letter height, and placement should be adopted to ensure visibility to boaters. The Army Corp of Engineers has developed sign standards for use in waterways which could be utilized as a basis for development of standards for the Lake. A copy of the sign standards can be found in **Appendix N**.

V-2: Develop a public outreach program to educate the public on the resources and importance of the Lake, organize volunteer activities, and provide the public with "good housekeeping" tools.

A public outreach program would provide additional pathways to inform members of the community regarding the importance of the health of the Lake and what they can do to aid in improving the health of the Lake. Such a program could include organized volunteer events (e.g. trash removal events, invasive species removal events, wetland plantings/restoration events), and kits/pamphlets providing details regarding homeowner good housekeeping measures (such as correct fertilizer application, planting of native species, reducing lawn area, not feeding waterfowl, and picking up pet waste) that would reduce pollutant inputs into the Lake.

V-3: Seek local partners to fund the development of public education materials.

A map of the overall watershed area could be created outlining all of the important watershed features and attractions. Items to display on the map could include eel grass sanctuary areas, marinas, pump out stations, restaurants, recreational areas, transient mooring and slip areas, and fueling stations. A phone number for the pump out boat should be clearly provided on the map. Such a map could be made available on the Town's website and at marinas and restaurants.

It is recognized that funding for educational signs and kiosks is limited by the Town's budget. While grant opportunities for such educational materials exist, local business and organizations provide an alternative venue for the creation and construction of these valuable educational materials. Local partners could include local businesses, the local chamber of commerce, scouting groups and other environmental groups. Funding from a WID could also be used for public education efforts.

V-4: Develop informational brochures summarizing the Watershed Management Plan.

As the Watershed Management Plan provides a comprehensive assessment of sources of pollution to the Lake, a summary brochure could be developed to inform landowners regarding key issues and potential remedies within the Lake. Such information could be provided on the Town's website or on public information documents that contain "QR" codes that would direct the public to the Town's website.

V-5: Develop educational materials providing information on green infrastructure (e.g., rain gardens, rain barrels) and its benefits to homeowners.

In order to encourage homeowners to utilize green infrastructure on their properties, educational materials outlining the benefits of such practices could be developed and provided to homeowners. Materials could include information such as the benefits of rain barrels and "do it yourself" instructions on how to construct the barrels. Information on what a rain garden is, how it benefits the homeowner and how it ultimately benefits the Lake would also be useful to homeowners not familiar with the concept of green infrastructure.

V-6: Obtain funding for a "Septic System Pumpout, Water Conservation and Education program."

An educational program and/or materials would aid in communicating the importance of sanitary system maintenance and the impacts of failing systems to water quality. Include information that clearly outlines beneficial maintenance practices for optimal system functioning and educate property owners of common actions that are detrimental to the functioning of the system, such as use of harsh chemicals and certain detergents. Such a program could garner participation in sanitary system maintenance and potentially improve water quality in the long term.

V-7: Utilize existing public information documents available through Long Island Invasive Species Management Area (LIISMA) group and Cornell Cooperative Extension to provide public information regarding the harmful effects of invasive species.

Both LIISMA and Cornell Cooperative Extension have educational materials available regarding the impacts of invasive species and the benefits of native species, as well as literature outlining alternatives to invasive species commonly used in landscaping. Town participation in LIISMA and coordination with Cornell could provide a cost effective means of distributing materials to local residents and business owners to assist with the control of invasive species. Such information could be provided on the Town's website or on public information documents that contain "QR" codes that would direct the public to the Town's website.

V-8: Develop educational materials detailing the benefits of natural buffers along shorelines.

As indicated in Recommendation N-1, vegetative buffers provide for biological and physical filtration of stormwater prior to runoff reaching waterbodies. Encouraging the installation and maintenance of natural buffers could be fostered through educational materials demonstrating the benefits and aesthetic appeal of such buffers. Such information could be provided on the Town's website or on public information documents that contain "QR" codes that would direct the public to the Town's website.

V-9: Continue to acquire parcels for preservation identified in the Town Community Preservation Project Plan.

Vacant land availability is patchy within the watershed, however, acquisition of parcels for preservation and/or stormwater improvements is essential to the health of the Lake. As a result, it is recommended that the Town continue to acquire properties identified in the Town Community Preservation Project Plan. This plan identified parcels most appropriate for acquisition given their size, location and current use. Parcel acquisition and prioritization should consider the potential for installation of stormwater improvements on a parcel, as a factor in determining whether or not to acquire a given parcel of land.

Currently, the Torr property (0300-320-03-13.5) is situated adjacent to the west of the discharge point of the swale that traverses the Ditch Plains neighborhood. As the Town currently owns the parcel on the east side of this discharge point, acquisition of the parcel on the west side (if it becomes available) would provide further opportunities for an improvement project (bioretention or creation of vegetated wetlands) that could improve the quality of the water discharging to the Lake. The suggested improvement project that could be beneficial and result in pathogen reduction is described in Recommendation W-4.

V-10: Develop a universal communications plan to provide important information to the public in a direct, concise and meaningful way.

Public understanding of the importance of water quality and human actions that impact water quality is key to enabling long term change in actions and public support of improvement initiatives. Establishment of a universal communications plan to clearly and effectively deliver information regarding water quality and human actions that impact water quality could increase public understanding and draw meaningful public attention to this issue. This message applies Town-wide, as well as universality to the East End communities. Therefore pooling efforts and resources to develop a well thought out and properly funded communications program could significantly improve dissemination of information and provide broader exposure of this information.

5.0 IMPLEMENTATION STRATEGY

The Lake Montauk Watershed Management Plan has been designed to improve water quality within the Lake and of stormwater runoff entering the Lake by promoting best management practices for future development actions and routine municipal maintenance activities, education, environmental stewardship, and improvements in stormwater collection and treatment. By implementing the pollution preventative and corrective actions outlined in the WMP for general best management practices, public education and outreach, stormwater improvement strategies and priority actions, steps can be taken to improve water quality, restore habitat, reduce water quality impairments to shellfish and other aquatic life, and allow for continued recreational opportunities within the Lake.

5.1 Implementation Actions

The following implementation strategy (see **Table 20**) is meant to address the methods and means by which the Lake Montauk WMP will implement the projects and actions outlined in **Section 4.0**. This Section addresses different aspects of implementation including governmental jurisdiction, priority of the actions and potential funding sources to aid the Town in implementing the recommended actions outlined in **Section 4.0**.

Implementation of the Lake Montauk Watershed Management Plan involves many agencies, levels of government, civic groups, and citizens. Inter-governmental coordination and cooperation between the Town, County, State, non-profits, and the community is important to the success of the Shelter Island WMP. Groups such as: Suffolk County Cornell Cooperative Extension (CCE), NYSDEC, EPA, Sea Grant, Peconic Estuary Program (PEP) and the Suffolk County Soil and Water Conservation District (SCSWCD) can also provide information on the development of educational, outreach and stewardship materials as well as educational materials at their disposal relating to subjects such as best management practices (BMP), sanitary system maintenance, and lawn care recommendations, etc. Opportunities for collective efforts are noted as applicable.

Cost ranges for implementation of various recommendations are also provided in **Table 20** ($: $0-$50,000; $$: $50,000-$100,000; $$$:$100,000-$300,000; $$$$: $300,000+). As funding for stormwater improvements is often limited, the recommendations are also ranged in terms of potential timeframes for completion, and are denoted as follows:

O - Ongoing projects, activities and programs are described as occurring annually or more frequently, as well as actions that occur on an ongoing basis, such as education and outreach or monitoring activities.

S - Short-term projects are activities or programs which could be begun or even completed within one or two years of project initiation, and could occur at any time when funding is available and there is an initiative. These projects have the potential to demonstrate immediate progress and success and/or help establish a framework for implementing subsequent program recommendations. Such projects or activities include development of stormwater retrofit plans to address Municipal Separate Storm Sewer Systems (MS4) requirements and pathogen reduction goals, development of educational and outreach materials, or revisions to Town code.

M - Mid-term projects involve continued programmatic and operational measures which may be conducted over two to five years and could begin at any time when funding is available and there is an initiative. Progress on land conservation, the protection of headwaters and unique landscapes, construction of large retrofit or restoration projects, Low Impact Development (LID) and green infrastructure implementation, or more complex planning studies are examples of possible mid-term projects.

L - Long-term projects consist of continued implementation of additional projects necessary to meet watershed management objectives and water quality goals, as well as an evaluation of progress, and updates to existing plans. Long-term recommendations are intended to begin within the next ten years, and could continue to be initiated in later years.

Additionally, potential funding sources have been identified for each recommendation (see **Section 5.2, Table 21** below for a description of each funding source).

Table 20: IMPLEMENTATION STRATEGY

ID No.	Recommendation	Implementation Strategy			
		Cost	Responsible Entity[1]	Timetable	Funding Sources [2]
WATERBODY RECOMMENDATIONS					
B-1	Establish regular water quality testing for pathogens and other pollutants within the Lake, particularly after large rain events.	$$	Town, NYSDEC	S/O	B-1, B-5, C-2b, C-3c, C-6f, F-1, H-1a, H-1d, M-1
B-2	Expand water quality sampling parameters to determine if a significant input of pesticides is affecting Lake water quality.	$$	Town, SCDHS	S/O	B-1, B-5, C-2b, C-3c, C-6f, F-1, H-1a, H-1d, M-1
B-3	Investigate the contribution of septic systems to pollution within the Lake.	$$-	Town	M	A-4, B-1, C-2b, F-1, H-1a, H-1d
B-4	Establish regular water quality testing for pathogens, phosphorus, and chlorophyll-a in Big Reed Pond as the limited sample results suggest potential pollutants in the pond.	$$	Town, NYSDEC	S/O	B-1, B-5, C-2b, C-6f, F-1, H-1a, H-1d, L-1
B-5	Consider the use of aeration systems in the lower portion of the Lake to promote growth of aerobic bacteria and stunt/reduce growth of anaerobic bacteria (most pathogens are anaerobic).	$$$	Town	M	B-1, C-2b, F-1, H-1d
B-6	Continue to fund and expand the Town's shellfish hatchery and seeding program, including eel grass protection and restoration.	$$	Town	S/O	B-1, C-5e, F-1, J-1, K-2, M-1
B-7	Manage waterfowl populations.	$	Town	S/O	A-4, B-1, C-2b, F-1, H-1,
B-8	Determine, identify and map tidal flushing and circulation in Lake Montauk.	$$$	Town	M	A-4, B-1, B-5, C-2b, F-1, H-1a

[1] Town of East Hampton (Town); Suffolk County (SC) Department of Public Works (SCDPW); New York State Dept. of Transportation (DOT); New York State Department of Environmental Conservation (NYSDEC); SC Dept. of Health Services (SCDHS); SC Dept. of Environment & Energy (SCDEE); SC Department of Planning (SCDP);

[2] See **Table 5-2** for Funding Sources Key.

ID No.	Recommendation	Implementation Strategy			
		Cost	Responsible Entity[1]	Timetable	Funding Sources [2]
STORMWATER RUNOFF AND WATER QUALITY RECOMMENDATIONS					
S-1	Coordinate with the operators of the animal farm located on South Fenimore Drive to prepare an agricultural BMP program and create a vegetated buffer surrounding the on-site pond to reduce pathogen input into the Lake.	$	Town	S/M	A-4, B-1, B-5, F-1, N-1
S-2	Create a shallow vegetated drainage depression at the landscape medians between the intersections of West Lake Drive, North Fernwood Drive and Star Island Road.	$$	Town	S	A-1, A-4, B-1, B-5, C-5e, F-1, I-1, I-2
S-3	Investigate the feasibility for drainage improvements on the north side of Montauk Highway, opposite Caswell Road.	$$$	Town, DOT	M	A-1, D-1, D-2, E-1, E-2, F-1, I-1, I-2
S-4	Implement the proposed drainage improvement project prepared for the South Lake Beach parking lot in the NYSDEC MS4 Retrofit Plan.	$$	Town	S	A-1, B-1, B-5, E-2, F-1, I-1, I-2
S-5	Implement the proposed drainage improvement project prepared for the Star Island Town Dock in the NYSDEC MS4 Retrofit Plan.	$$	Town	S	A-1, E-1, E-2, F-1, I-1, I-2
S-6	Implement the proposed drainage improvement project prepared for the West Lake Drive Boat Ramp in the NYSDEC MS4 Retrofit Plan.	$$	Town	S	A-1, E-1, E-2, F-1, I-1, I-2
S-7	Create a bioretention area on the northwest corner of West Lake Drive and Flamingo Avenue.	$$	Town	S	A-1, E-1, E-2, F-1, I-1, I-2
S-8	Provide pre-treatment where feasible for existing and proposed drainage infrastructure.	$ - $$$	Town	S/O	A-1, E-1, E-2, F-1, I-1, I-2
MUNICIPAL FACILITY RECOMMENDATIONS					

ID No.	Recommendation	Implementation Strategy			
		Cost	Responsible Entity[1]	Timetable	Funding Sources [2]
M-1	Complete a GIS based mapping of the entire stormwater management system and "sewershed". Utilize the GIS mapping and a GIS database to effectively track maintenance and inspection of catch basins.	$$	Town	M/O	B-1, C-2b, C-3c, F-1, M-1
M-2	Coordinate with NYS to establish a Goose Management Program on the Montauk Downs golf course.	$	Town, NYSDEC	S	B-1, C-5e, F-1, H-1b
M-3	Obtain funding for and construct a salt brine preparation facility for use in the Town.	$$$$	Town	L	A-4, B-1, B-5, F-1
WASTEWATER RECOMMENDATIONS					
W-1	Develop a program to enforce Town Code §210-5-1 and §210-6-1 which requires inspection and regular maintenance (every three years) of septic systems.	$ - $$$	Town	S/O	Town, F-1, O-1, M-1,
W-2	Investigate alternative options for treatment of septic waste in high density areas within the watershed.	$ - $$$$	Town	M/O	A-3, B-1, C-2, F-1, H-2, N-1
W-3	Consider a cost-shared pump-out and water conservation kit program to aid in cost reduction for sanitary system maintenance and/or replacement.	$	Town	S	F-1, M-1, N-1
W-4	Provide wetland restoration and water quality improvements within the Lake by reconstructing the wetlands in Ditch Plains to engineered wetlands planted with native species to provide for vegetative pathogen removal of waters seeping from the Ditch Plains area	$$$$	Town	L	A-4, B-1, B-2, B-5, C-2b, C-5e, C-7g, F-1, H-1, H-2, J-1
REGULATORY RECOMMENDATIONS					
R-1	Establish a Lake Montauk Protection Overlay District for properties located within the watershed.	$	Town	S	F-1, M-1

ID No.	Recommendation	Implementation Strategy			
		Cost	Responsible Entity[1]	Timetable	Funding Sources [2]
R-2	Develop a law and associated signage prohibiting the feeding of waterfowl as they contribute nutrients to surface water and stormwater runoff.	$	Town	S/O	Town
R-3	Develop and implement programs and policies to aid in enforcement of the Federal No Discharge Zone.	$	Town	S/O	A-5, A-6 & A-7, A-8, F-1
R-4	Encourage and incentivize use of green infrastructure in site and drainage design.	$	Town	S/O	A-1, B-1, B-5, F-1
R-5	As described in Recommendation W-1, create a program to enforce inspection and certification once every three years for sanitary systems. Additionally, as described in W-3, explore the establishment of a cost share program to aid in septic system inspection and certification.	$	Town	S/O	F-1, M-1, N-1
R-6	Amend Chapter 255, Article IV of Town Code to include minimum buffer width requirements.	$	Town	S	Town
R-7	Provide dedicated funding for enforcement of waterway regulations within the Lake.	$$	Town	S/O	G-1c
R-8	Work with Suffolk County on tick control measures for areas within the watershed.	$$	Town	M/O	Town
R-9	Implement a moratorium on the installation of new docks so their impacts on the benthos of the Lake can be studied in greater detail.	$$	Town	S	Town
NATURAL RESOURCE AND INVASIVE SPECIES MANAGEMENT					
N-1	Encourage and incentivize the use of vegetative buffers on properties that abut the Lake.	$	Town	S	F-1, M-1, Town, N-1
N-2	Encourage and incentivize the usage of vegetative buffers and filter strips adjacent to boardwalk areas in industrial and working waterfront areas that abut the Lake.	$	Town	S	F-1, M-1, Town, N-1

ID No.	Recommendation	Implementation Strategy			
		Cost	Responsible Entity[1]	Timetable	Funding Sources [2]
N-3	Perform regular Early Detection/Rapid Response surveys for highly invasive species approaching the area to aid in prevention of these species becoming established within the watershed.	$	Town	S/O	B-1, B-3, C-2b, F-1, H-2, J-1
N-4	Work with the County to revise and adopt an amendment to the Open Space Management Plan for Montauk County Park and consider prohibiting pets from being permitted in the park.	$	Town	S	Town
STEWARDSHIP & PUBLIC EDUCATION RECOMMENDATIONS					
V-1	Develop signage to inform the public regarding laws, public safety and human impacts to the bay.	$	Town, SCDHS	S	A-5, A-7, C-6f, F-1,
V-2	Develop a public outreach program to educate the public on the resources and importance of the Lake, organize volunteer activities, and provide the public with "good housekeeping" tools.	$	Town	S/O	A-7, F-1, M-1, N-1
V-3	Seek local partners to fund the development of public education materials.	$ - $$$$	Town	S/O	F-1, M-1, N-1
V-4	Develop informational brochures summarizing the Watershed Management Plan.	$	Town	S/O	A-7, F-1, M-1, N-1
V-5	Develop educational materials providing information on green infrastructure (e.g., rain gardens, rain barrels) and its benefits to homeowners.	$	Town		A-7, F-1, M-1, N-1
V-6	Obtain funding for a "Septic System Pumpout, Water Conservation and Education program."	$	Town, SCDHS	S/O	F-1, M-1, N-1
V-7	Utilize existing public information documents available through Long Island Invasive Species Management Area (LIISMA) group and Cornell Cooperative Extension to provide public information regarding the harmful effects of invasive species.	$	Town	O	F-1, M-1, N-1

ID No.	Recommendation	Implementation Strategy			
		Cost	Responsible Entity[1]	Timetable	Funding Sources [2]
V-8	Develop educational materials detailing the benefits of natural buffers along shorelines.	$	Town, NYSDEC	S/O	F-1, M-1, N-1
V-9	Continue to acquire parcels for preservation identified in the Town Community Preservation Project Plan. Acquire the Torr property (0300-320-03-13.5) as a priority acquisition in the Capital Plan should the property become available.	$ - $$$$	Town	L/O	B-4, G-1b
V-10	Develop a universal communications plan to provide important information to the public in a direct, concise and meaningful way.	$$	Town	S/O	F-1, Town

5.2 Funding Sources

The potential funding sources table is keyed to the implementation table for the specified recommendations. With each project recommendation listed, it is recommended that the appropriate Town officials contact agency representatives to discuss funding priorities and specific eligibility requirements. The recommendations that call for public education projects can be funded as a component of other construction type projects.

Many of the recommended projects may be funded under the Environmental Protection Agency's Clean Water Act amendments whose programs are administered in New York State mainly through the New York State Environmental Facilities Corporation. The program offers loans and grants for projects that rate high in overall State rankings. On an annual basis, the agency requests applications for projects to be included in the State's Intended Use Plan (IUP) which is the first step in the funding process. Because the New York State Department of State has funded the current study, implementation projects that are being recommended in this study may rank very high in pursuit of Environmental Protection Fund (EPF) grants. Included is the New York State Member Item Funding as well as Federal Legislative Grant funding for which the Town should contact their New York State and federal representatives to access this funding.

Table 21
POTENTIAL FUNDING SOURCES

ID No.	Funding Sources	Program	Eligible Activities
A	New York State Environmental Facilities Corporation	Clean Water State Revolving Fund- 1. Green Innovation Grant Program 2. Loan Financing 3. Section 212- Point Source 4. Section 319- Non Point Source	Water Quality improvement Projects- Loans and Grants for Point Source projects such as STPs and Sewers and Non Point Source projects for stormwater management, land acquisition if related to preserving water quality- projects must be municipally owned-bio-retention, permeable surfaces. Provision for non-municipal projects. Low-interest Loans- for green or non-green projects for projects described above/No Interest Loans for Short Term Financing STPs Sewers-Design & Construction Stormwater Management, structural & non-structural practices sediment, pesticide and fertilizer control, bio-retention, permeable surfaces. Non-Municipal Non-Point Source, Not-For-Profit Land Acquisition, Highway Deicing Material Storage.
		5. Clean Vessel Assistance Program (CVAP) Construction Grant Program	75/25 federal funding for the Purchase Pump-Out boats up to $60,000 finding cap. 75/25 funding for stationary pumpouts purchase and installation
		6. Facility Upgrade Grant Program	75/25 funding for improvements to pumpout boats and/or stationary pumpouts
		7. Information and Education Grant Program	75/25 federal funding for education and promotion - $5,000 maximum funding
B	New York State Department of Environmental Conservation (NYSDEC)	1. Water Quality Improvement Project	Municipal Wastewater Treatment Municipal Separate Storm Sewer Systems (MS4s) Nonagricultural Nonpoint Source Abatement and Control Aquatic Habitat Restoration Water Quality Management
		2. Urban Forestry Grant Program	50/50 cost Share for tree planting along streams

ID No.	Funding Sources	Program	Eligible Activities
	(See above)	3. Terrestrial Invasive Species Eradication Grant Program 4. Open Space Funding- Title 7 5. Section 106- Water Pollution Control 6. Recycling Education Grants (EPF)	50/50 grant program to remove plants and animals as per NYS DEC guidelines Environmental important lands where development pressure exist or are causing pollution Water Quality Planning & Assessments, Development of Water Quality Standards, Ambient Monitoring, development of maximum daily loads, ground water and wetland protection, Non-Point Source control activities, including Non-Point Source Controls Assessment & Management Plans Green Infrastructure component: Tree Planting that addresses environmental issues of heat island effect, stormwater management brownfield restoration design, combined sewer overflow (CSO) or energy demand production-50/50 matching grants. Grants to support Town's recycling program including Composting Program
C	U.S. Environmental Protection Agency (Note on EPA Water Quality Projects- QAPP-Quality Assurance Protection Plan must be EPA adopted at the time that application is submitted)	1. Targeted Watersheds Grants Program 2. Surveys, Studies, Investigations, Demonstrations and Training Grants 3. Assessment and Watershed Protection Program Grants 4. Pesticide Environmental Stewardship Regional Grants	a.75/25 federal funding for protecting and restoring water uses, forming partnerships using new technologies, market incentives and results-oriented strategies/capacity building grants are available. Drainage, Resurfacing, Permeable paving. b. Planning, Wetlands Protection, Coastal and Estuarine Planning Treatment technologies. Examples: Development of Water Protection Guides for Communities Demonstration Projects c.Innovative Water Quality Assessment and Modeling Techniques, Training Handbooks d. Integrated Pest Management Approaches that Reduce the Risks Associated with Pesticide Use in Non-Agricultural Settings

ID No.	Funding Sources	Program	Eligible Activities
		5. Section 320- National Estuary Program 6. Urban Waters Small Grants Program 7. Wetland Program Development Grants	e. Protection of Water Quality Supplies, Protection and Propagation of a balanced , indigenous population of shellfish, fish and wildlife and Habitat Restoration f. Water Quality Improvement Projects – Stewardship, Public Education and Awareness g. Research, investigations, experiments, training, demonstrations, surveys and studies relative to water pollution
D	FHWA administered by NYS DOT thru Suffolk County DPW- Federal Funding administered by NYS DOT / New York Metropolitan Planning Council (NYMTCC)	MAP-21 1. Surface Transportation System (STS) 2. Transportation Alternatives Program	a. Road Reconstruction and Drainage/Impervious Surfaces Stormwater Outflow devices. Roads must be designated on Federal Aid Urban system Maps b. Enhancements to the Transportation System-streetscapes, historic preservation, environmental improvements
E	New York State Dept. of Transportation	1. Consolidated Highway Improvement Program (CHIPS) 2. Multi-Modal Program	Drainage curb, sidewalks, permeable paving Drainage, curb, sidewalks, permeable paving
F	New York State Department of State (NYSDOS)	1. Local Waterfront Revitalization Program (LWRP) - Environmental Protection Funding (EPF)	Water Quality Improvement Projects are eligible if part of overall improvement project-planning & implementation e.g. Storm Drain inserts, various projects that protect harbors, education projects and studies
G	New York State Office of Parks, Recreation & Historic Preservation	1. Environmental Protection Fund (and available federal funding)	a. Parks Development Funding b. Land Acquisition for park purposes c. Marine Law Enforcement
H	National Fish and Wildlife Foundation	1. National Wetland Program Development Grants and Five-Star Restoration Training Grants	Protect, Manage and Restore Wetlands and Streams by a. Monitoring & Assessment b Volunteers Wetland Restoration & Protection, and c. Wetland-Specific Water Quality Standards Partnership with Businesses, Community & Schools Projects that Benefit Multiple Species.

ID No.	Funding Sources	Program	Eligible Activities
		2. Native Plant Conservation Initiative	Achieve a Variety of Habitat Degradation/High Priority Critical Conservation Need/Demo Projects with a High Level of Public Involvement/Leverage Funding Involving Partnerships d. Water Quality Improvement Projects – various initiatives and priorities
I	Federal Emergency Management Agency (FEMA) thru NYS Division of Homeland Security & Emergency Services (DHSES) (formally NYS SEMO)	1. Flood Mitigation Assistance Program 2. Hazard Mitigation Assistance Program See above	Various projects to prevent flooding and protecting public and private resources, e.g. road and property elevations, culverts, buyouts, projects must have a positive benefit-cost ratio, 75/25 funding
J	National Oceanic and Atmospheric Administration (NOAA)	1. Coastal & Marine Habitat Restoration Projects	a. Projects that aid in recovering listed species and rebuilding sustainable fish populations b. Projects that benefit coastal habitat-like wetlands and coral reefs as well as fisheries, marine mammals, sea-turtles and waterways
K	Empire State Development Corporation	1. Strategic Planning and Feasibility Studies 2. Long Island Economic Development Council (LIDC) Funding	a. promotes economic development and employment opportunities consistent with the Long Island Region Economic Development Strategic Plan
L	Federal Legislative Grants-Earmarks	1. Various- thru Congressman and Senators	All initiatives
M	NYS Member Item Funding	1. Various- thru NYS Legislators	All initiatives
N	Private Foundation Funding	1. Various projects	Various depending on the goals of the specific foundation

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FIGURES

Town of East Hampton
and
New York Department of State

Lake Montauk Watershed Management Plan

FIGURE 1
Lake Montauk Surface Subwatershed Boundaries

Legend

Subwatersheds

Source: ESRI WMS; NYSDOS; Suffolk County GIS

0 2,500 Feet

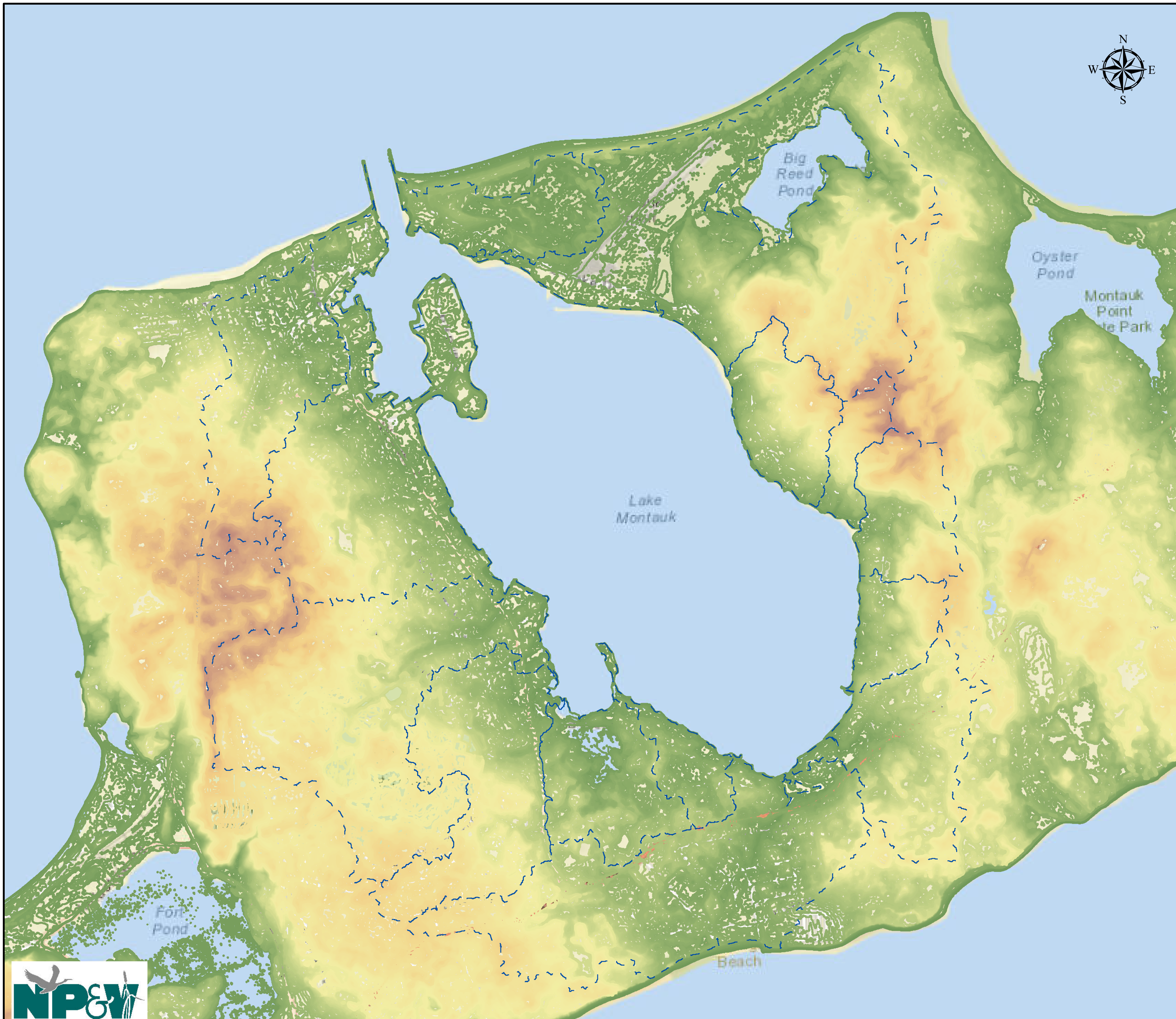
1 inch = 2,500 feet

Town of East Hampton
and
New York Department of State

Lake Montauk Watershed Management Plan

FIGURE 2

Topography



Legend

Subwatersheds

Elevation (feet asl)

155

0

Source: ESRI WMS; Suffolk County LiDAR, 2007

0 2,500 Feet

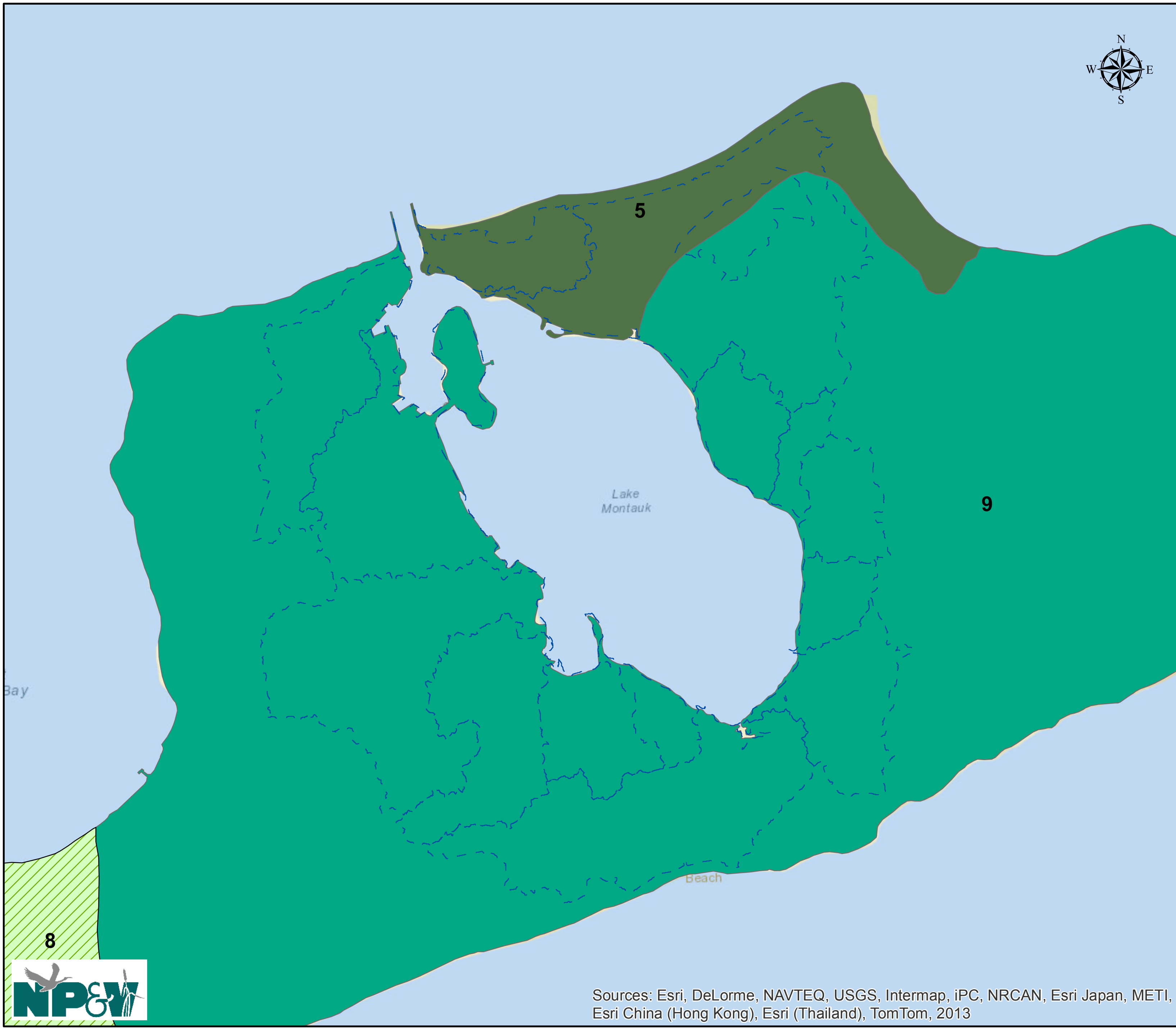
1 inch = 2,500 feet

Town of East Hampton
and
New York Department of State

Watershed
Management Plan

FIGURE 3

Soil Types



Legend

Subwatersheds

Soil Type

- Dune land-Tidal marsh-Beaches association: Sand dunes, tidal marshes, and beaches of the barrier beach and south shore
- Montauk-Montauk, sandy variant-Bridgehampton association: Deep, rolling and hilly, excessively drained and moderately well drained to well drained, medium-textured to coarse-textured soils on moraines
- Montauk, sandy variant-Plymouth association: Deep, rolling and hilly, excessively drained, coarse-textured soils on moraines

Source: USDA Soil Conservation Services

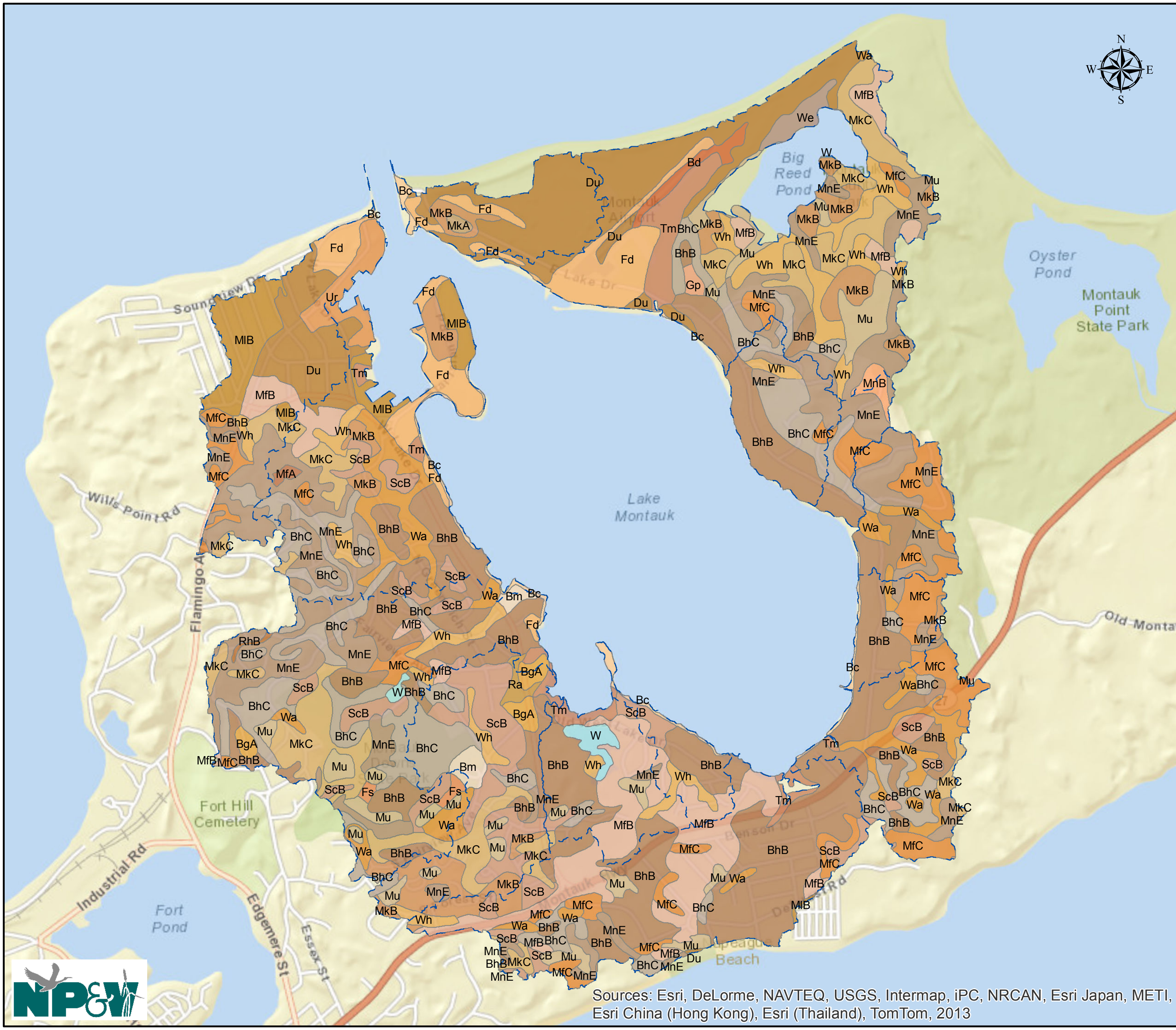
0 3,000 Feet

1 inch = 3,000 feet

Town of East Hampton
and
New York Department of State

Watershed
Management Plan

FIGURE 4
Soils Map



Legend

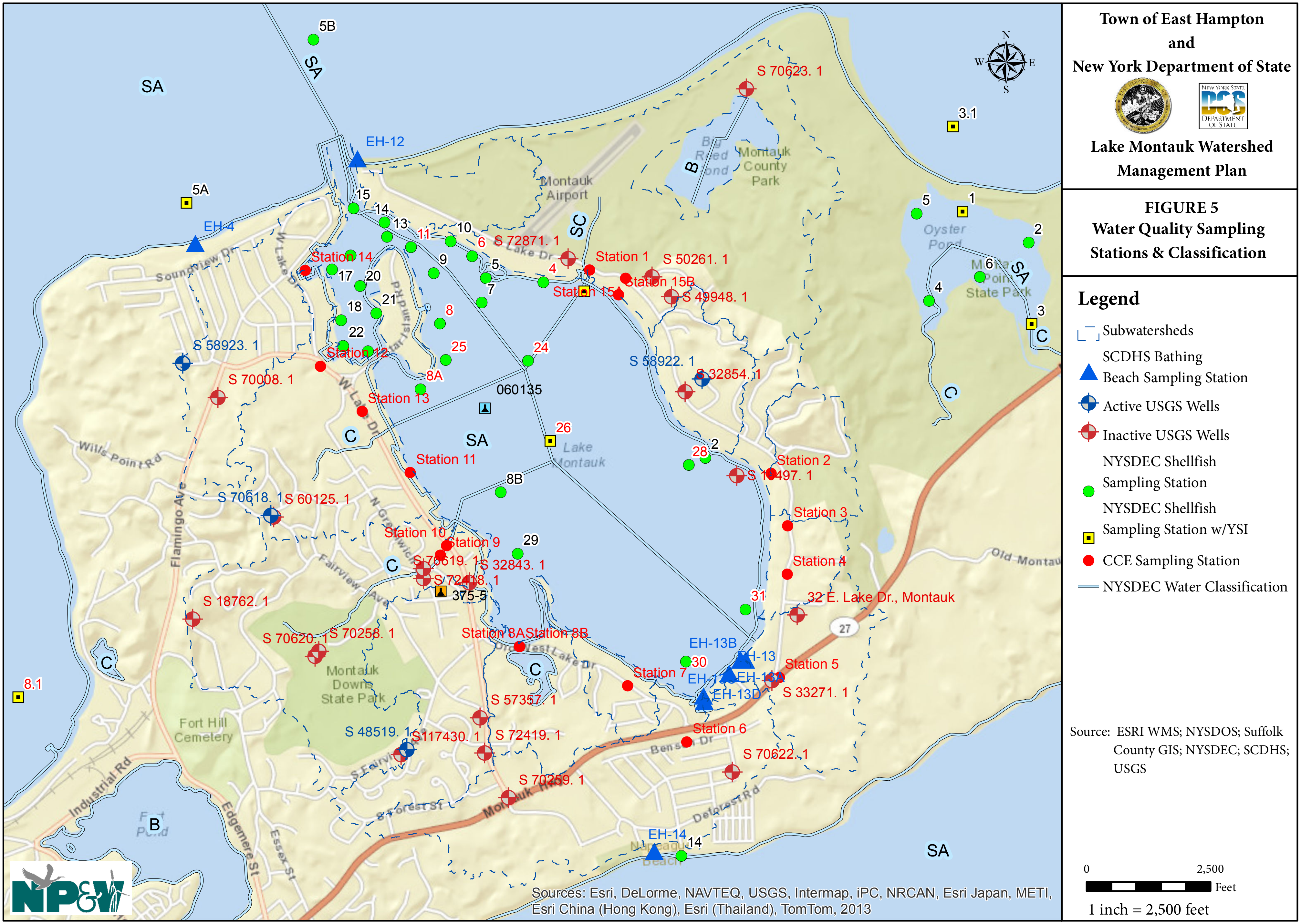
Soil Type

Bc	Gp	Mu
Bd	MfA	Ra
BgA	MfB	RhB
BhB	MfC	ScB
BhC	MkA	Tm
Bm	MkB	Ur
Du	MkC	W
Fd	MlB	Wa
Fs	MnB	We
	MnE	Wh

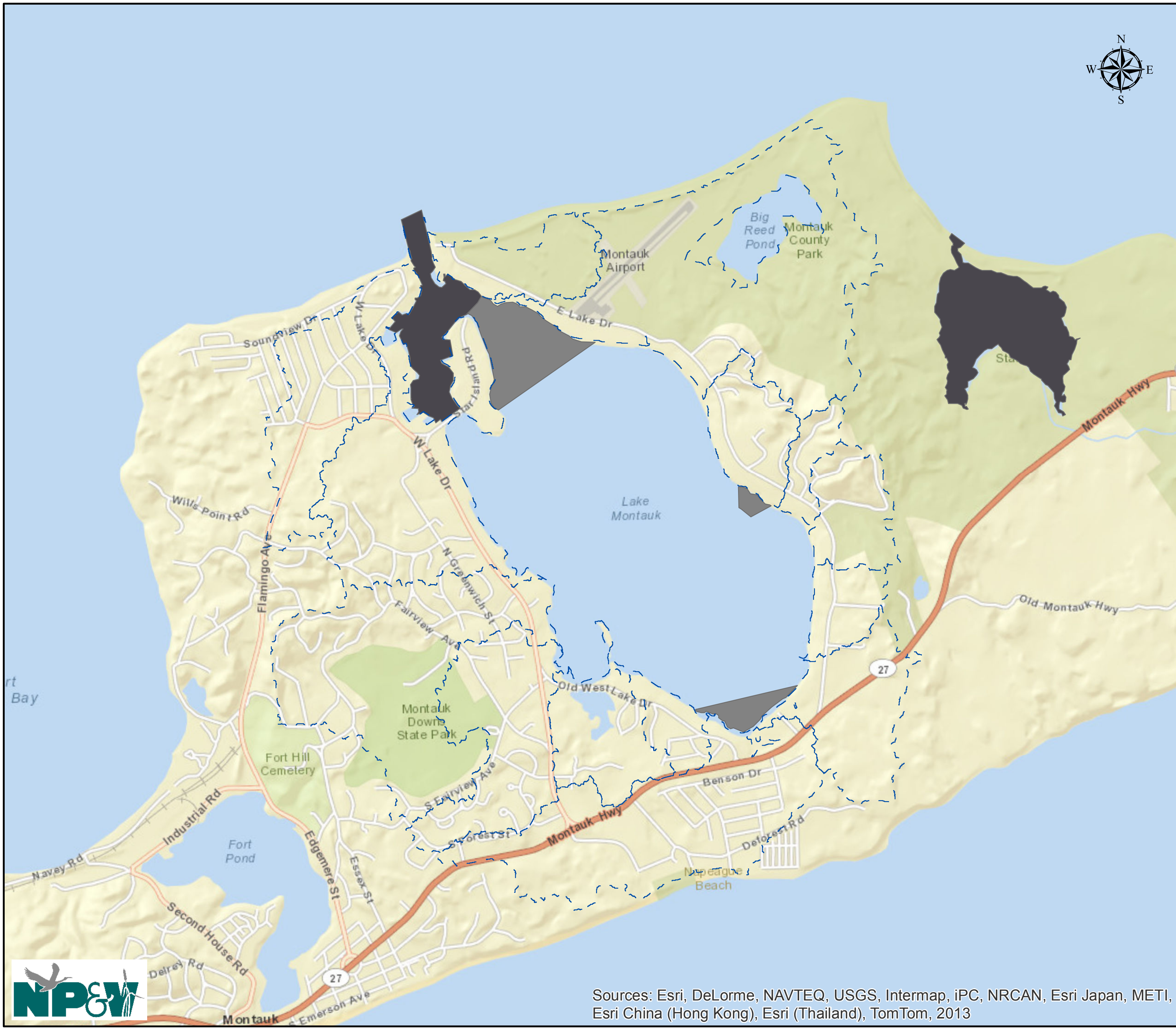
Source: ESRI WMS; NYSDOS; NRCS SSURGO Database

0 2,500 Feet

1 inch = 2,500 feet



Town of East Hampton
and
New York Department of State
Lake Montauk Watershed
Management Plan
FIGURE 5
Water Quality Sampling
Stations & Classification
Legend
Subwatersheds
SCDHS Bathing Beach Sampling Station
Active USGS Wells
Inactive USGS Wells
NYSDEC Shellfish Sampling Station
NYSDEC Shellfish Sampling Station w/YSI
CCE Sampling Station
NYSDEC Water Classification
Source: ESRI WMS; NYSDOS; Suffolk County GIS; NYSDEC; SCDHS; USGS
0
2,500
Feet
1 inch = 2,500 feet
Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
Lake Montauk
Montauk Airport
Big Reed Pond
Montauk County Park
Oyster Pond
Montauk Point State Park
Montauk Downs State Park
Fort Hill Cemetery
Fort Pond
EH-12
EH-4
EH-13B
EH-13
EH-14
S 70623. 1
S 72871. 1
S 50261. 1
S 49948. 1
S 58923. 1
S 70008. 1
S 58922. 1
S 32854. 1
S 70618. 1
S 60125. 1
S 32843. 1
S 18762. 1
S 70620. 1
S 70258. 1
S 57357. 1
S 48519. 1
S 72419. 1
S 70259. 1
S 70622. 1
S 33271. 1
32 E. Lake Dr., Montauk
Station 1
Station 2
Station 3
Station 4
Station 5
Station 6
Station 7
Station 9
Station 10
Station 11
Station 12
Station 13
Station 14
Station 15B
060135
375-5
SA
SC
B
C
Soundview Dr
W Lake Dr
Flamingo Ave
Fairview Ave
Industrial Rd
Edgemere St
Essex St
Old Montauk
Benson Dr
Deforest Rd
27



Town of East Hampton
and
New York Department of State

Watershed Management Plan

FIGURE 6

Known Impairments

Legend

- Subwatersheds

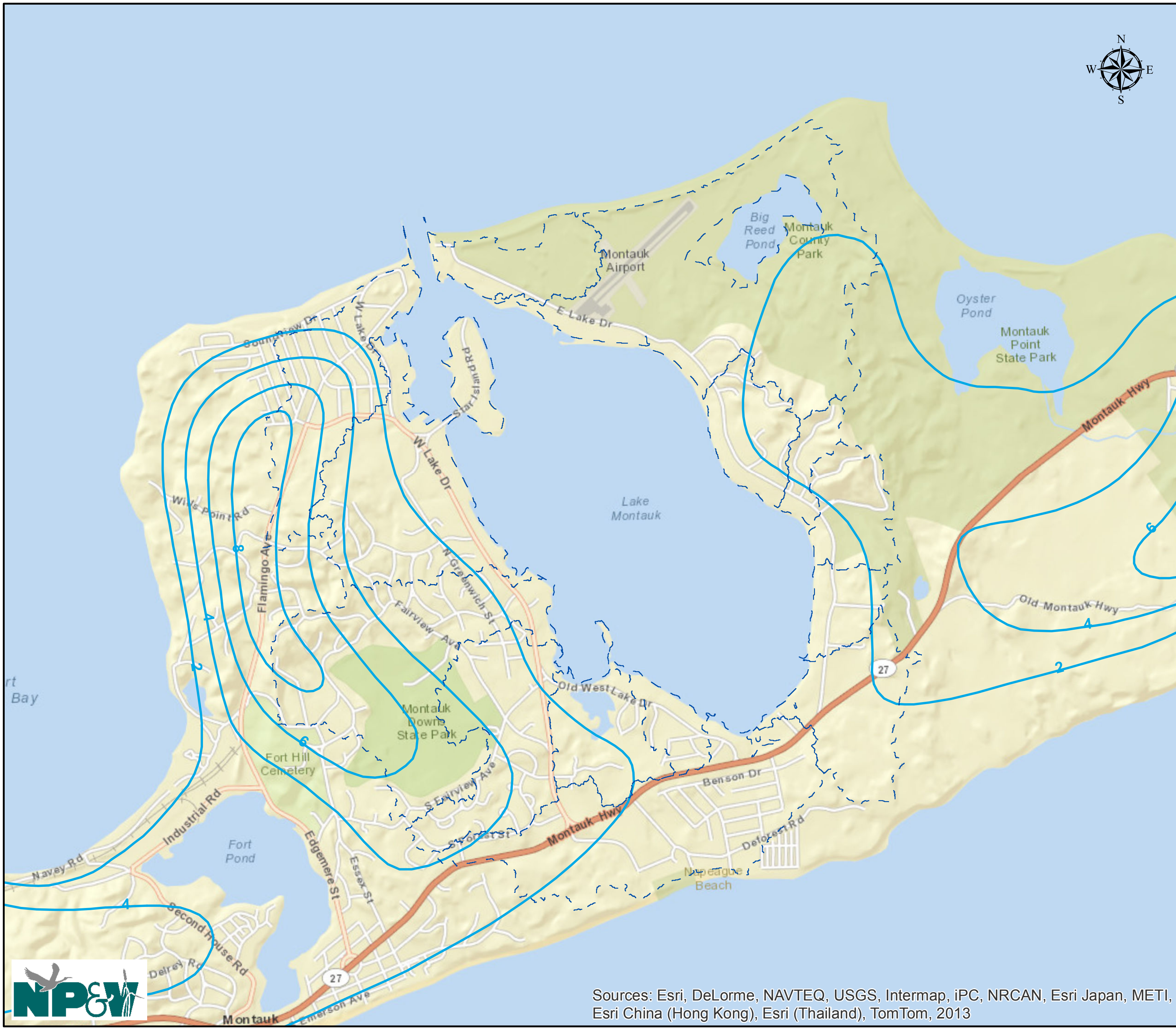
Shellfish Closure Areas

- Seasonal
- Closed
- Holiday

Source: ESRI WMS; NYSDEC; NYS 2012 303 (d) List

0 2,500 Feet

1 inch = 3,000 feet



Town of East Hampton
and
New York Department of State

Lake Montauk Watershed Management Plan

FIGURE 7
Water Table Contour Map

Legend

Subwatersheds

Water Table Contour (feet asl)

Source: ESRI WMS; USGS

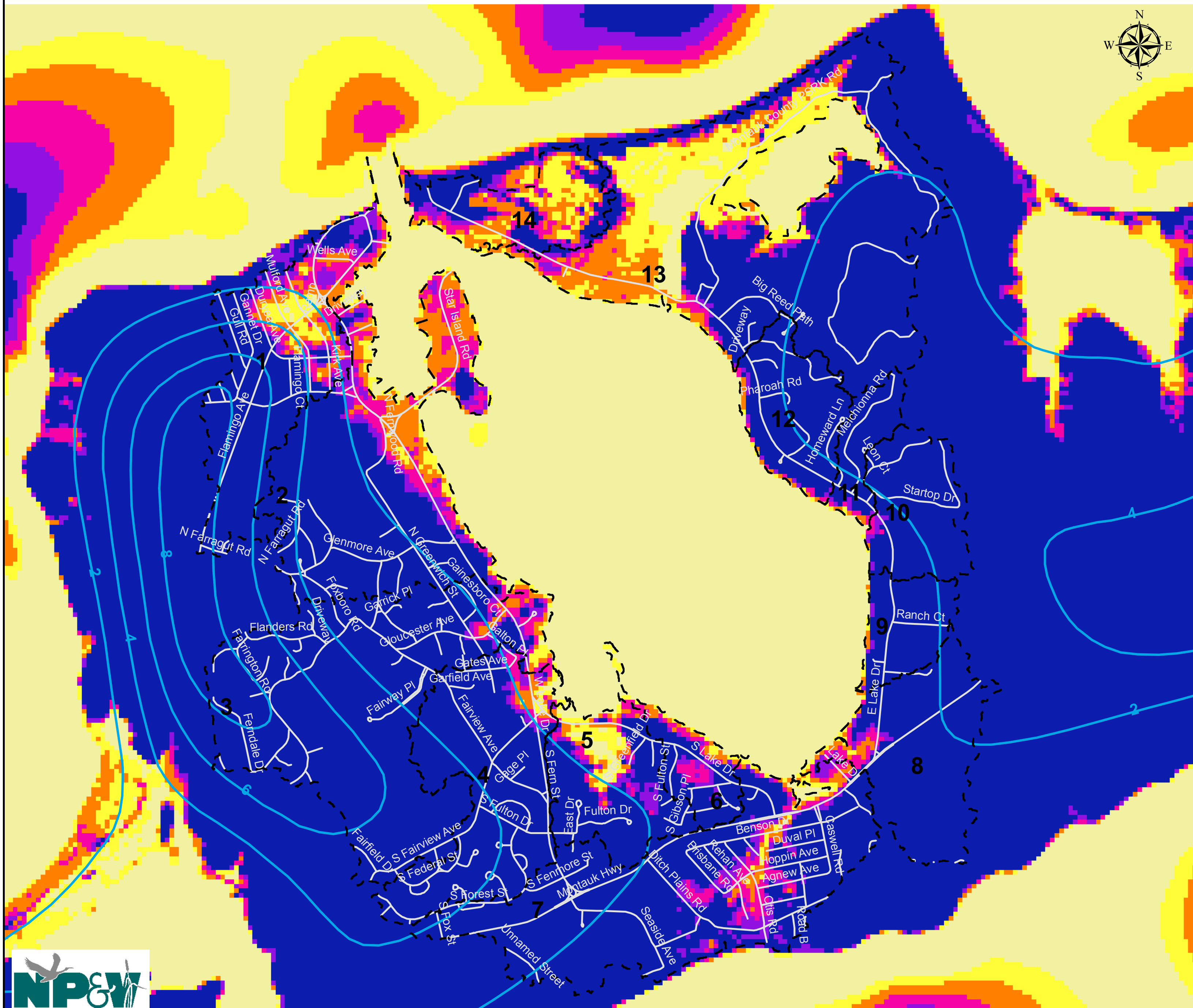
0 3,000 Feet

1 inch = 3,000 feet

Town of East Hampton
and
New York Department of State

Lake Montauk Watershed Management Plan

FIGURE 8
Depth to Groundwater



Legend

Subwatersheds
Water Table Contour (feet asl)
Roads

Depth to Groundwater (feet)

- 0-2
- 2-4
- 4-6
- 6-8
- 8-10
- >10

Source: Suffolk County LiDAR, 2006; USGS

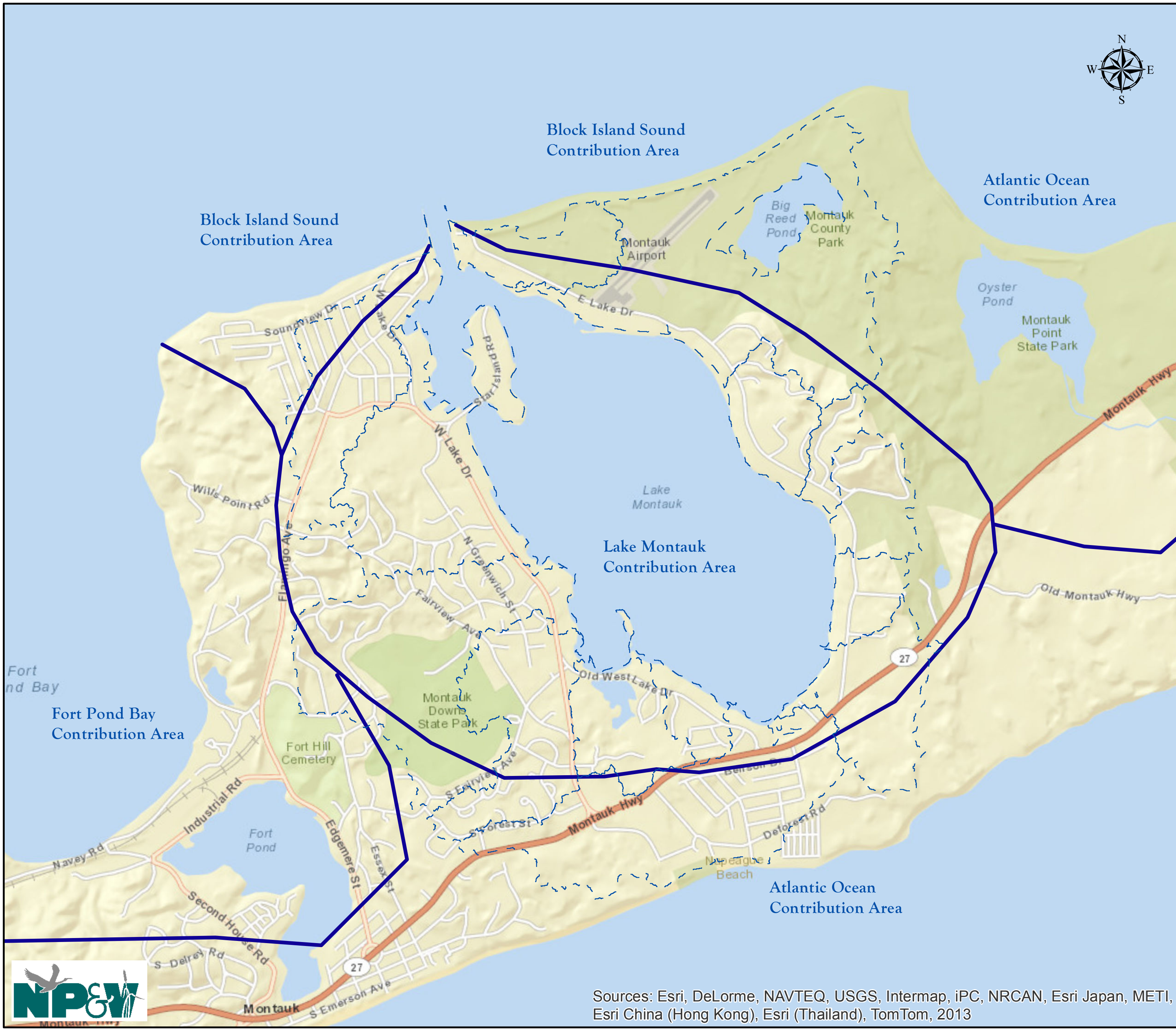
0 2,500
Feet

1 inch = 2,500 feet

Town of East Hampton
and
New York Department of State

Watershed
Management Plan

FIGURE 9
Major Groundwater Subwatersheds



Legend

- Subwatersheds
- Groundwater Divide

Source: ESRI WMS; NYSDOS; NYSDEC

0 3,000 Feet

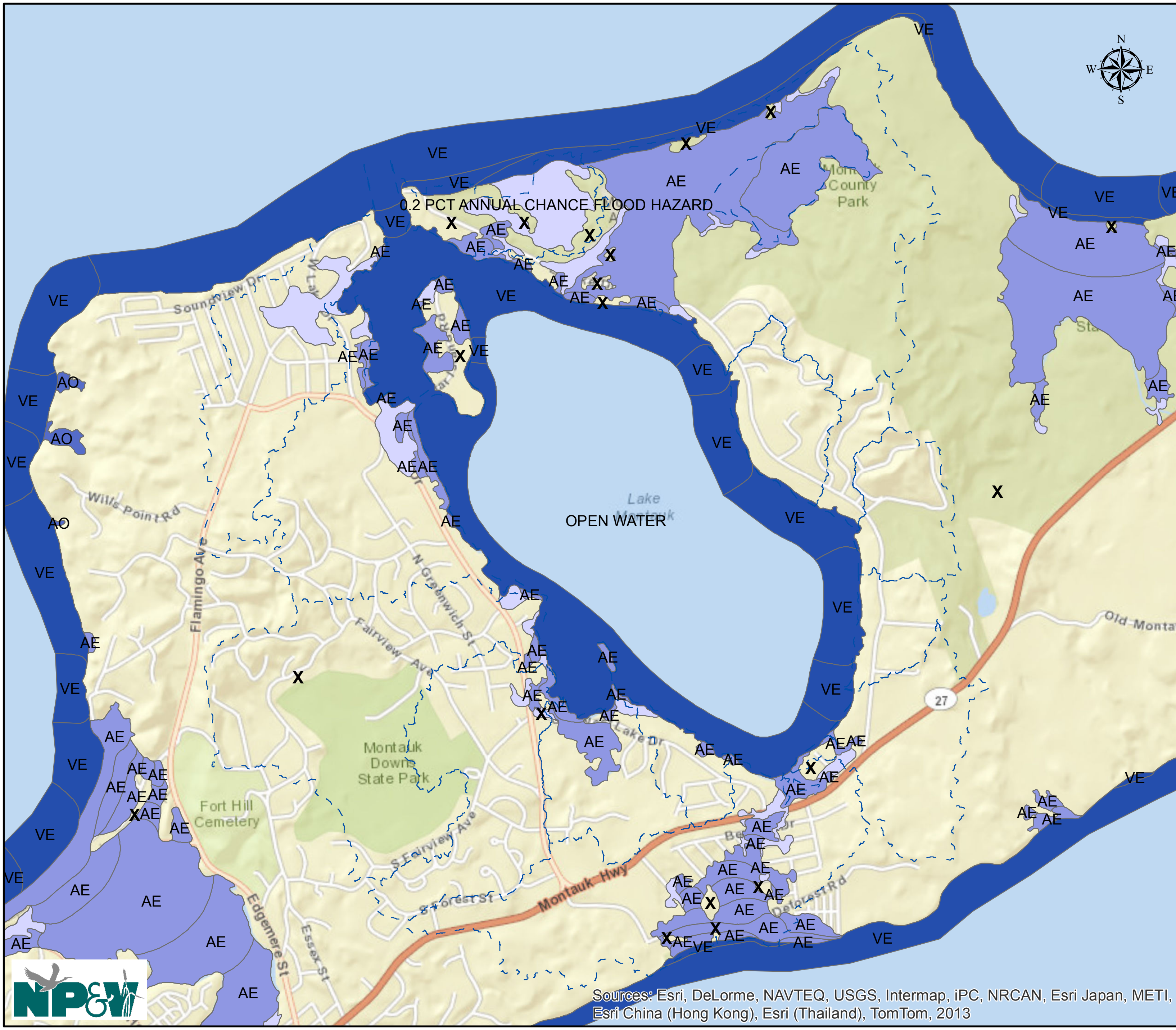
1 inch = 3,000 feet

Town of East Hampton
and
New York Department of State

Watershed
Management Plan

FIGURE 10

FEMA Flood Map



Legend

Subwatersheds

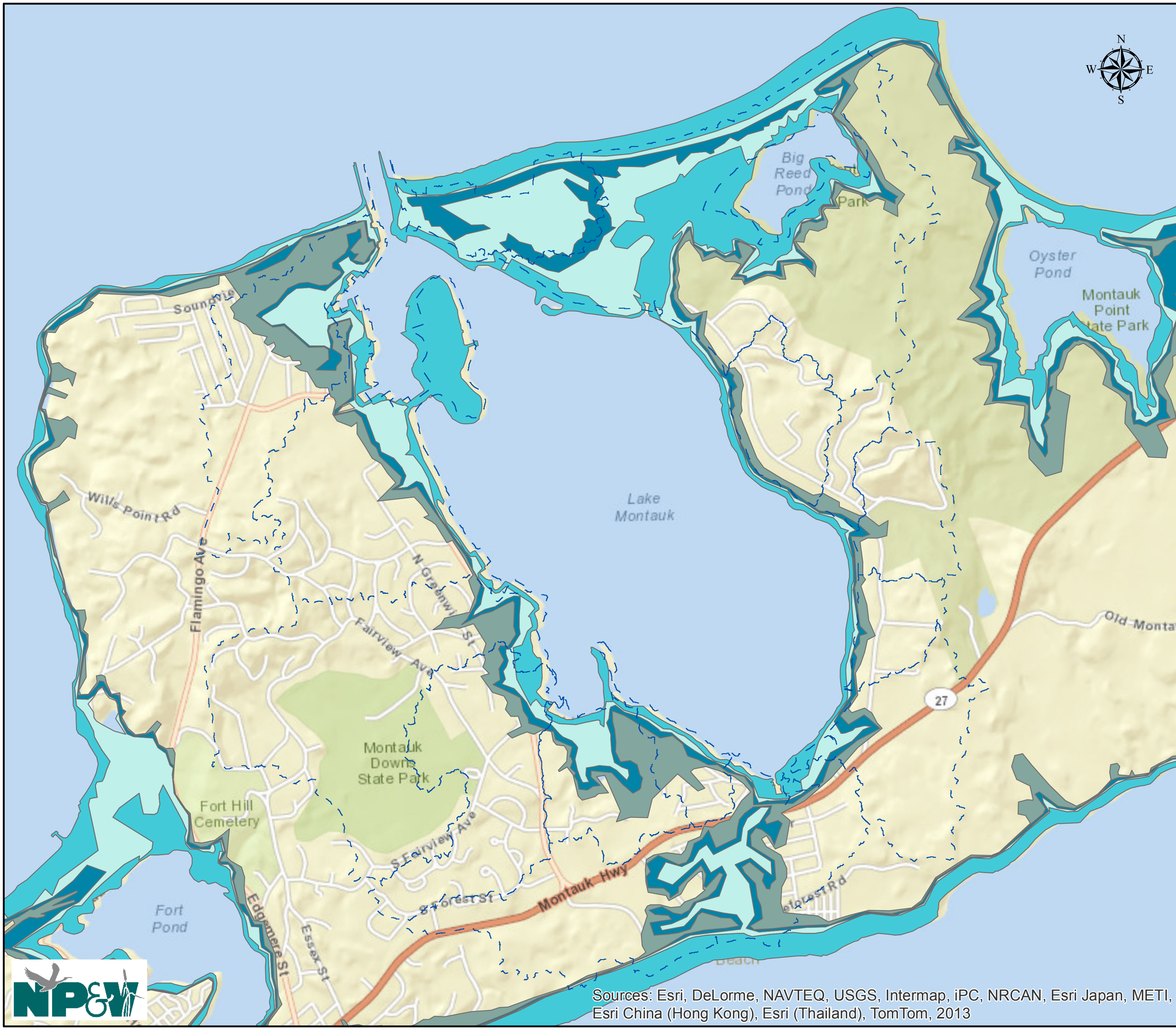
FEMA Flood Zone

- X - Outside of the 500 Year Flood Zone
- 0.2% Annual Chance of Flood
- AE - 100 Year Flood Zone, Base Flood Elevation Determined
- AO - Subject to 100 Year Shallow Flooding
- VE - 100 Year Flood Zone, Velocity Hazard

Source: ESRI WMS; FEMA, 2010

0 2,500 Feet

1 inch = 2,500 feet



Town of East Hampton
and
New York Department of State

Watershed Management Plan

FIGURE 11
Sea, Lake, and Overland Surge From Hurricanes (SLOSH) Map

Legend

Subwatersheds

SLOSH ZONE

1 - Vulnerable from Category 1 to 5 Hurricanes

2 - Vulnerable from Category 2 to 5 Hurricanes

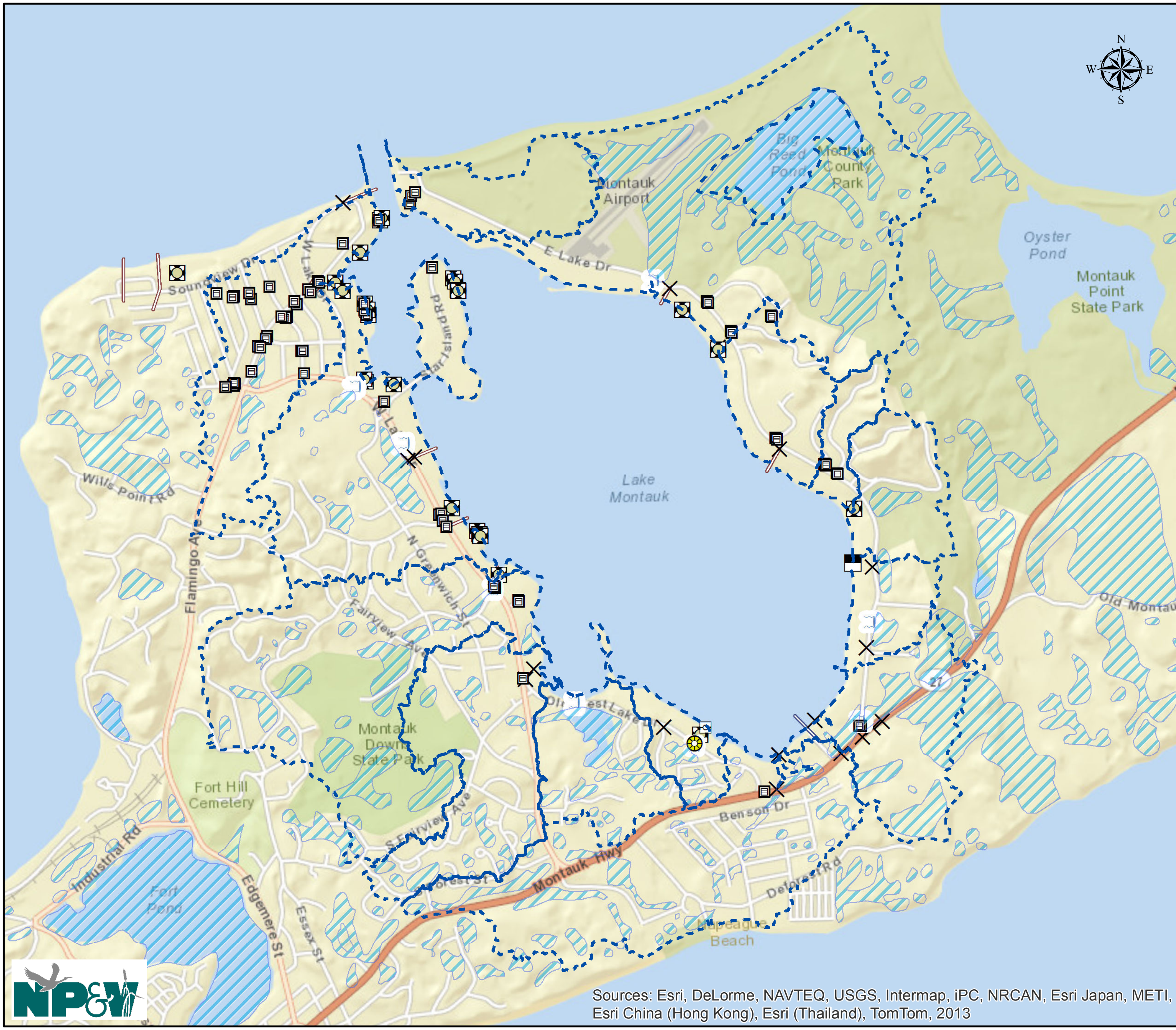
3 - Vulnerable from Category 3 to 5 Hurricanes

4 - Vulnerable from Category 4 to 5 Hurricanes

Source: ESRI WMS; USACE

0 2,500 Feet

1 inch = 2,500 feet



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Watershed Management Plan

FIGURE 12
Stormwater Infrastructure

Legend

- Subwatersheds
- NYSDEC Freshwater Wetlands

Stormwater Infrastructure

- Unconfirmed
- Catch Basin
- Culvert
- Ditch
- Manhole
- Pipe
- Seep
- Swale
- Stormdrain Conveyance
- Road Ends/Direct Overland Flow

Source: ESRI WMS; NYSDOS; Suffolk County GIS; East Hampton GIS; Peconic Estuary Program

0 2,500 Feet

1 inch = 2,500 feet

Town of East Hampton and New York Department of State

Lake Montauk Watershed Management Plan

FIGURE 13

Wetlands

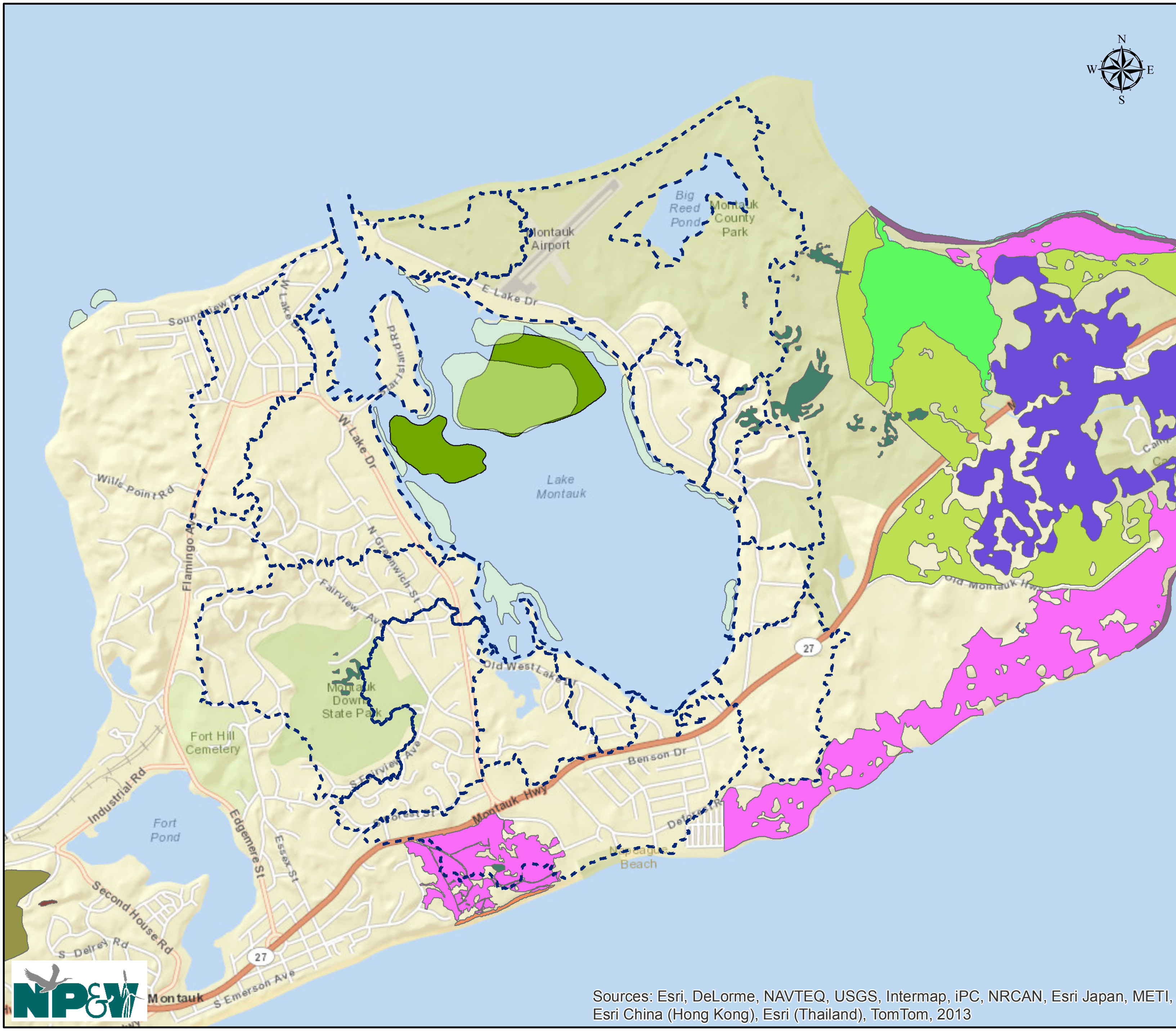
Legend

- Subwatersheds
- DS
- FC
- FM
- HL
- HM
- IM
- LZ
- SM
- NYSDEC Freshwater Wetlands
- Hardened Shoreline

Source: ESRI WMS; NYSDEC

0 2,500 Feet

1 inch = 2,500 feet



Town of East Hampton
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New York Department of State

Watershed Management Plan

FIGURE 14
Significant Natural Habitats

Legend

- Subwatersheds
- Submerged Aquatic Vegetation (2000)
- 1994 Eelgrass Beds

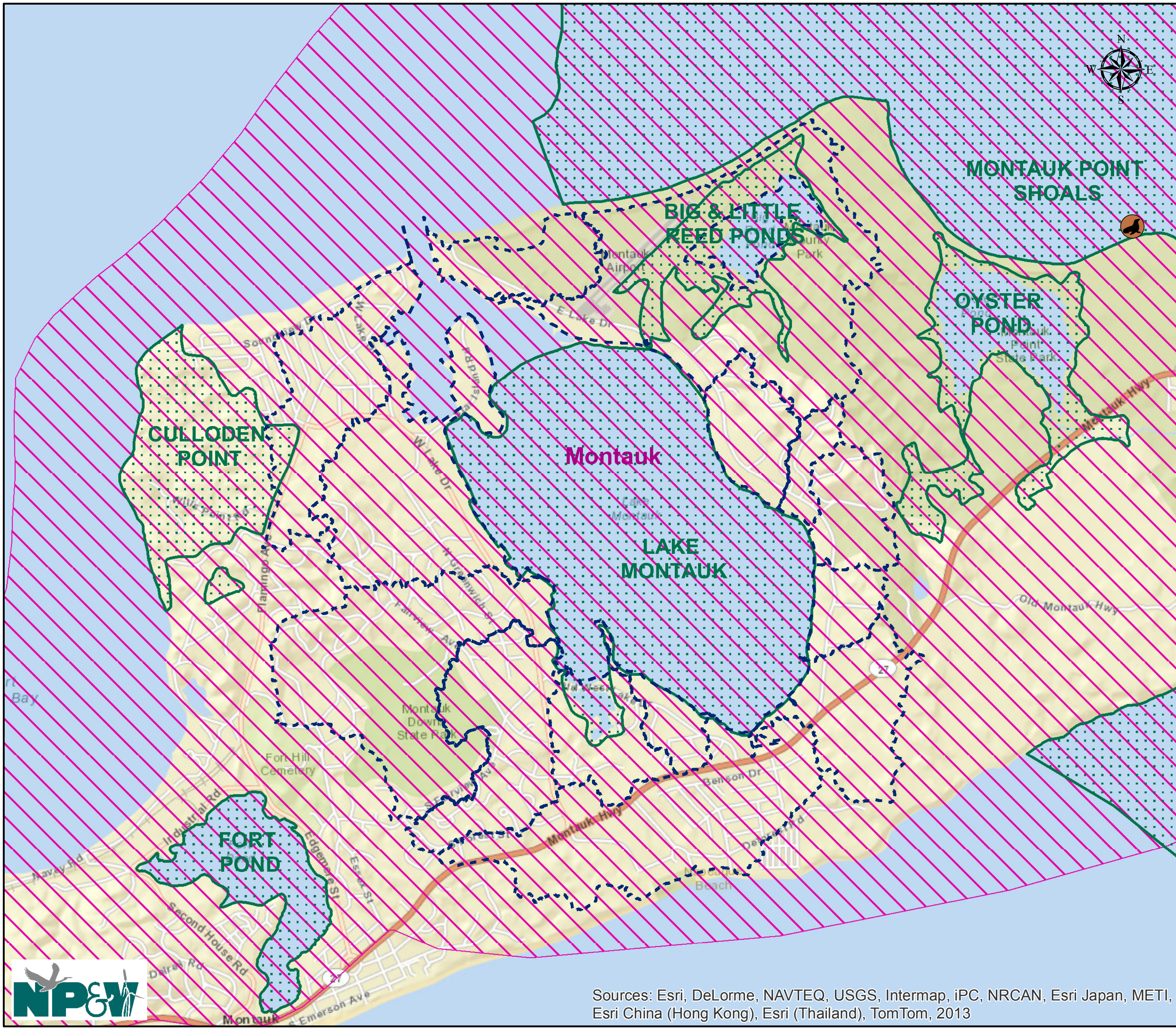
NYNHP Significant Natural Communities

- Coastal oak-heath forest
- Coastal oak-holly forest
- Coastal plain pond
- Coastal plain poor fen
- Coastal salt pond
- Marine rocky intertidal
- Maritime beach
- Maritime bluff
- Maritime grassland
- Maritime heathland
- Maritime post oak forest
- Maritime shrubland
- Successional maritime forest

Source: ESRI WMS; NYSDOS; NYSDEC; PEP; USF&WS

0 3,000 Feet

1 inch = 3,000 feet



Town of East Hampton
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Watershed
Management Plan

FIGURE 15
Resource Management Areas

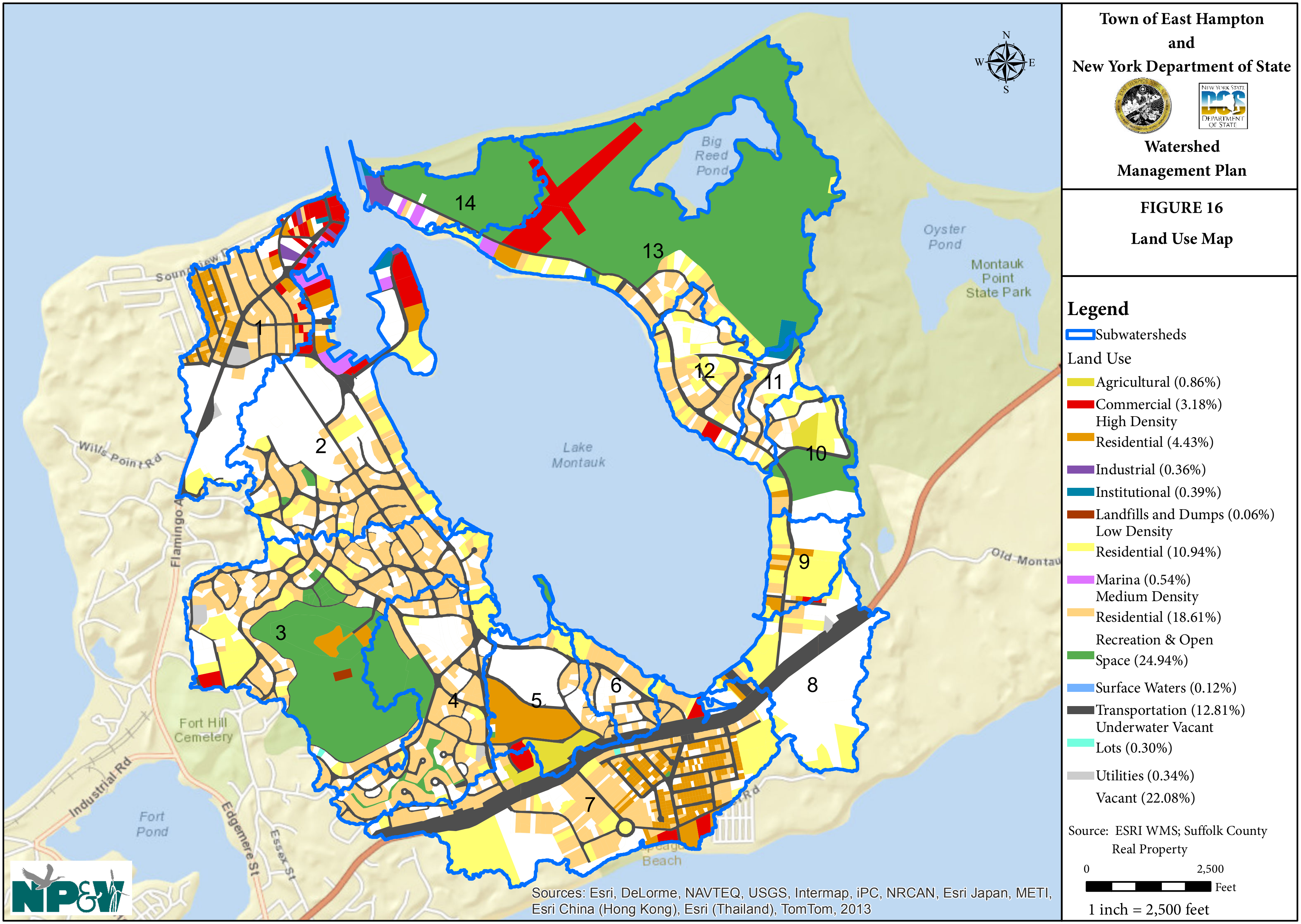
Legend

- Subwatersheds
- Wintering Harbour Seal Sites
- NYS Significant Fish & Wildlife Habitat
- PEP Critical Natural Resource Areas

Source: ESRI WMS; NYSDOS; NYSDEC; PEP; USF&WS

0 3,000 Feet

1 inch = 3,000 feet



Town of East Hampton
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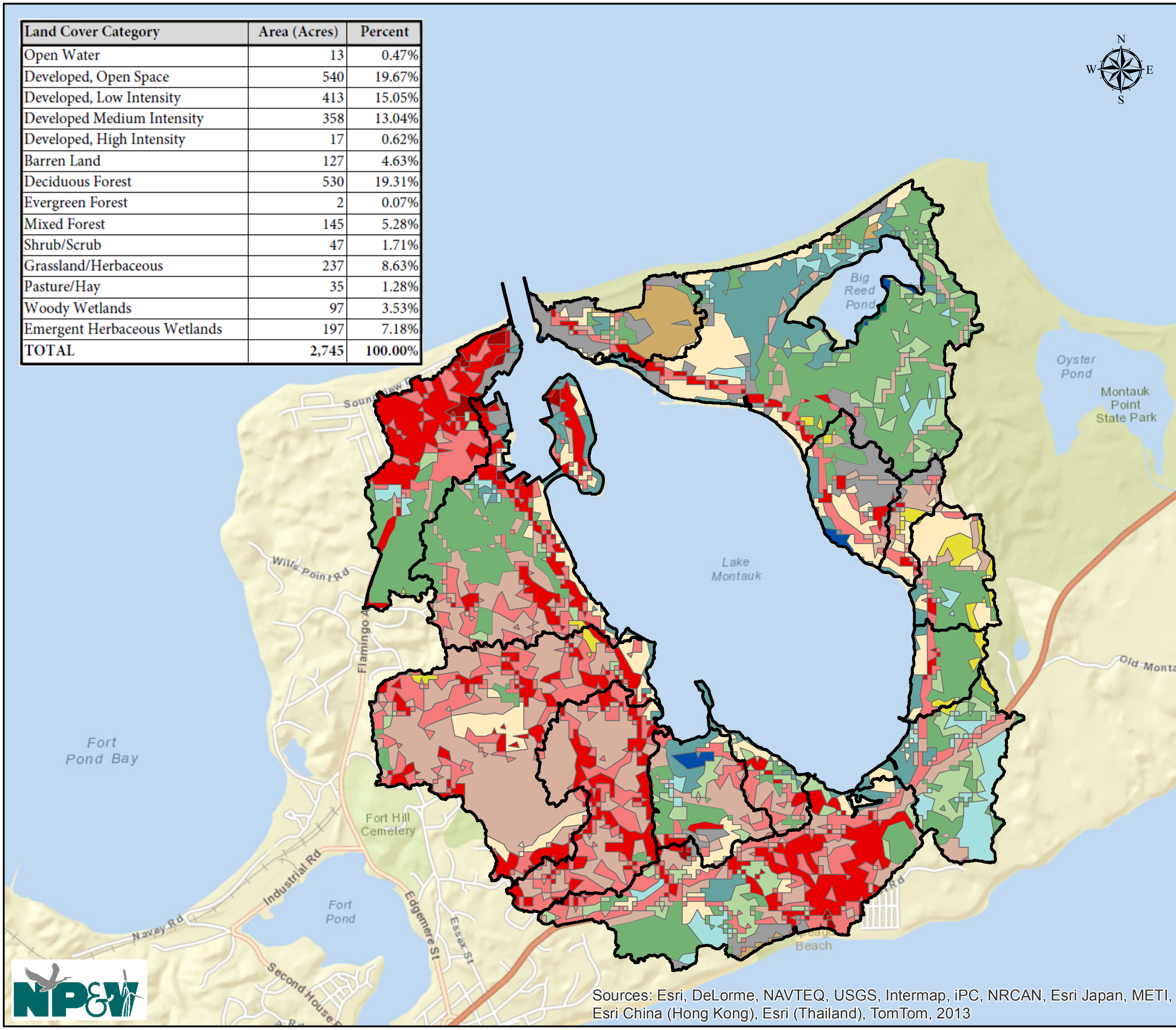
New York Department of State
Watershed
Management Plan
FIGURE 16
Land Use Map
Legend
Subwatersheds
Land Use
Agricultural (0.86%)
Commercial (3.18%)
High Density
Residential (4.43%)
Industrial (0.36%)
Institutional (0.39%)
Landfills and Dumps (0.06%)
Low Density
Residential (10.94%)
Marina (0.54%)
Medium Density
Residential (18.61%)
Recreation & Open
Space (24.94%)
Surface Waters (0.12%)
Transportation (12.81%)
Underwater Vacant
Lots (0.30%)
Utilities (0.34%)
Vacant (22.08%)
Source: ESRI WMS; Suffolk County
Real Property
0
2,500
Feet
1 inch = 2,500 feet
N
S
E
W
Big
Reed
Pond
Oyster
Pond
Montauk
Point
State Park
Lake
Montauk
Fort Hill
Cemetery
Fort
Pond
Industrial Rd
Edgemere St
Essex St
Flamingo A
Wills Point Rd
Old Montau
Beach
1
2
3
4
5
6
7
8
9
10
11
12
13
14
NP&V
Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI,
Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

Land Cover Category	Area (Acres)	Percent
Open Water	13	0.47%
Developed, Open Space	540	19.67%
Developed, Low Intensity	413	15.05%
Developed Medium Intensity	358	13.04%
Developed, High Intensity	17	0.62%
Barren Land	127	4.63%
Deciduous Forest	530	19.31%
Evergreen Forest	2	0.07%
Mixed Forest	145	5.28%
Shrub/Scrub	47	1.71%
Grassland/Herbaceous	237	8.63%
Pasture/Hay	35	1.28%
Woody Wetlands	97	3.53%
Emergent Herbaceous Wetlands	197	7.18%
TOTAL	2,745	100.00%



Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

Town of East Hampton and New York Department of State

Watershed Management Plan

FIGURE 17

Land Cover

Legend

— Subwatersheds

NLCD Land Cover Classification Legend

- 11 Open Water
- 12 Perennial Ice/ Snow
- 21 Developed, Open Space
- 22 Developed, Low Intensity
- 23 Developed, Medium Intensity
- 24 Developed, High Intensity
- 31 Barren Land (Rock/Sand/Clay)
- 41 Deciduous Forest
- 42 Evergreen Forest
- 43 Mixed Forest
- 51 Dwarf Scrub*
- 52 Shrub/Scrub
- 71 Grassland/Herbaceous
- 72 Sedge/Herbaceous*
- 73 Lichens*
- 74 Moss*
- 81 Pasture/Hay
- 82 Cultivated Crops
- 90 Woody Wetlands
- 95 Emergent Herbaceous Wetlands

* Alaska only

Source: USGS National Land Cover Database, 2006

0 3,000 Feet

1 inch = 3,000 feet

Town of East Hampton
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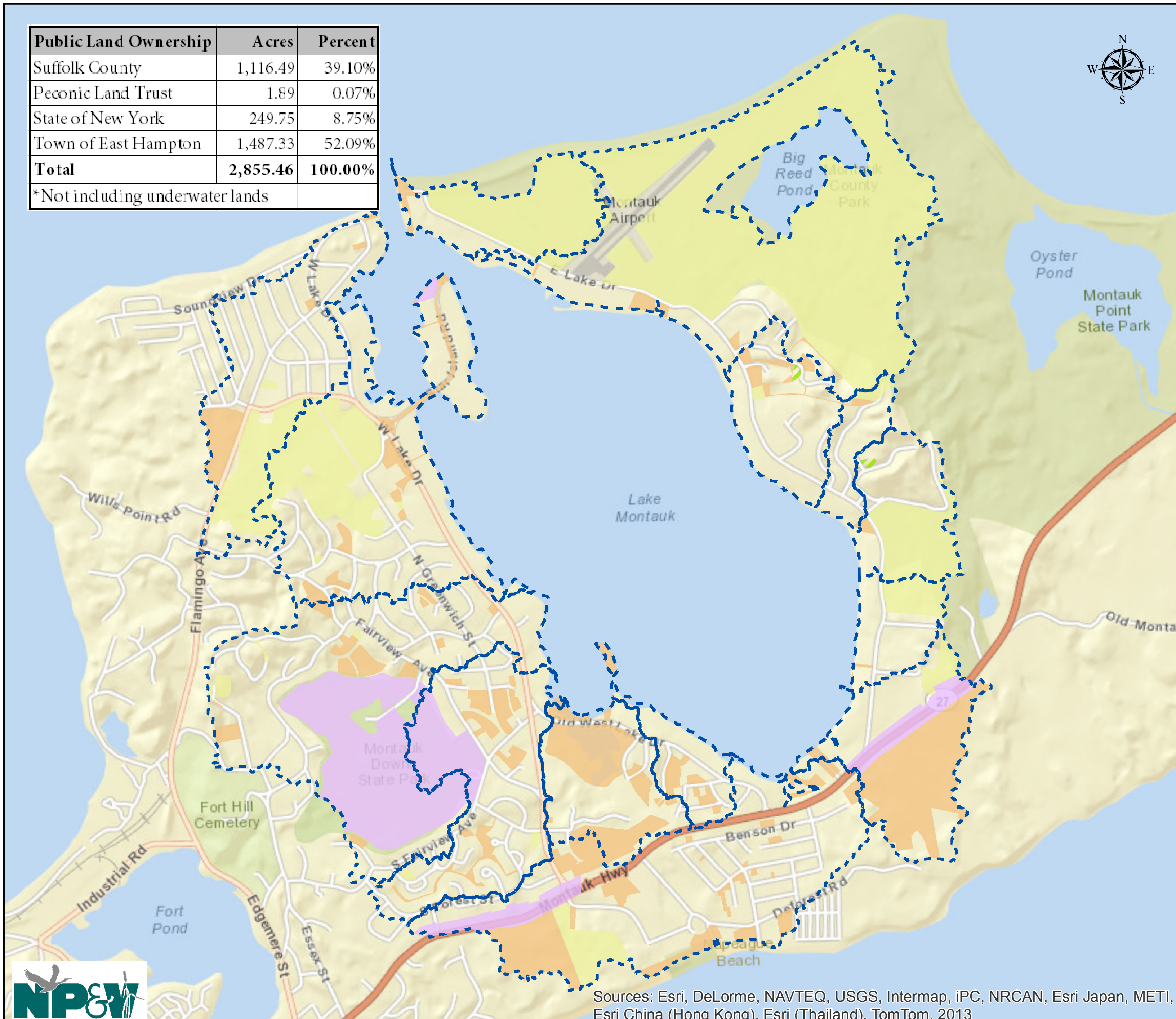
New York Department of State

Watershed
Management Plan

FIGURE 18

Publicly Owned Lands

Public Land Ownership	Acres	Percent
Suffolk County	1,116.49	39.10%
Peconic Land Trust	1.89	0.07%
State of New York	249.75	8.75%
Town of East Hampton	1,487.33	52.09%
Total	**2,855.46**	**100.00%**
*Not including underwater lands		



Legend

Subwatersheds

Publicly Owned Lands

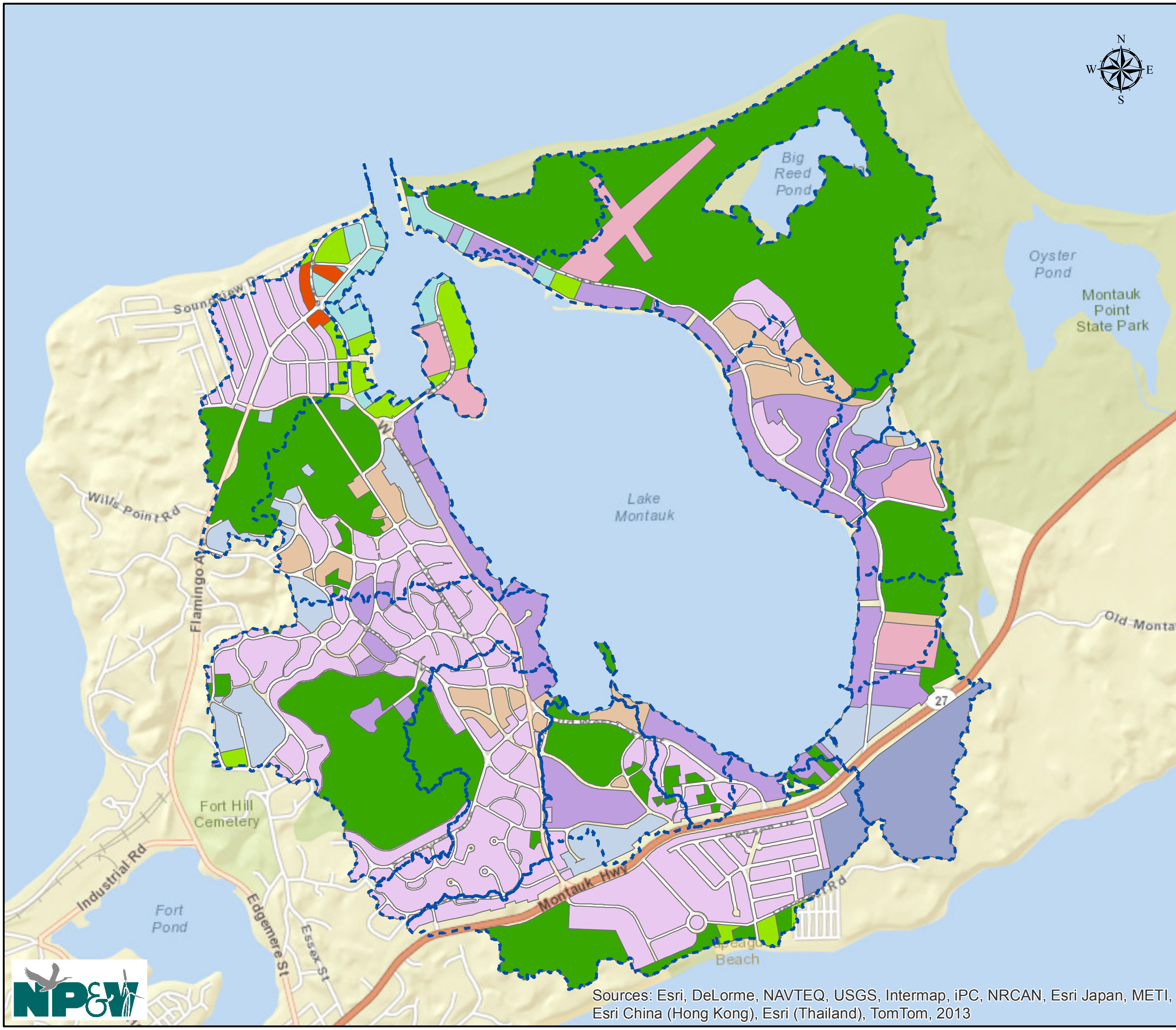
Ownership

- Suffolk County
- Peconic Land Trust
- State of New York
- Town of East Hampton

Source: ESRI WMS; Suffolk County Real Property

0 2,500 Feet

1 inch = 2,500 feet



Town of East Hampton and New York Department of State

Watershed Management Plan

FIGURE 19

Zoning

Legend

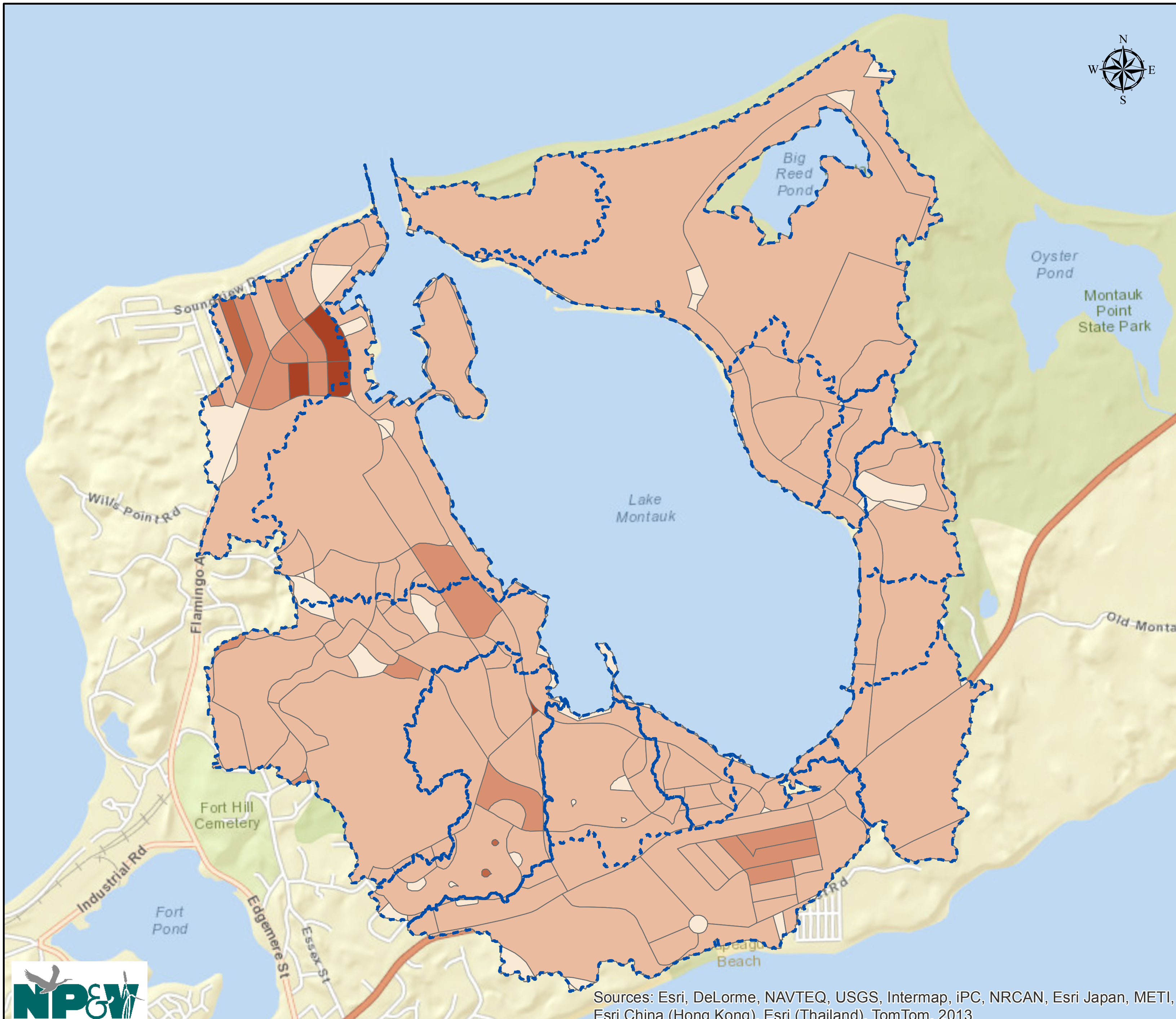
Subwatersheds

Zoning
- A
- A2
- A3
- A5
- A10
- B
- CB
- PC
- RS
- WF

Source: ESRI WMS; Suffolk County Real Property

0 2,500 Feet

1 inch = 2,500 feet



Town of East Hampton
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New York Department of State

Watershed
Management Plan

FIGURE 20

Population

Legend

Subwatersheds

2010 Census Blocks

Population Density (an Index)

- 0.000000
- 0.000001 - 2.000000
- 2.000001 - 4.000000
- 4.000001 - 6.000000
- 6.000001 - 16.200000

Census Sum
total 2010: 1,935
total 2000: 2,276
total 1990: 315

Source: ESRI WMS; NYSDOS; American Fact Finder; Suffolk County GIS

0 2,500 Feet

1 inch = 2,500 feet

Town of East Hampton
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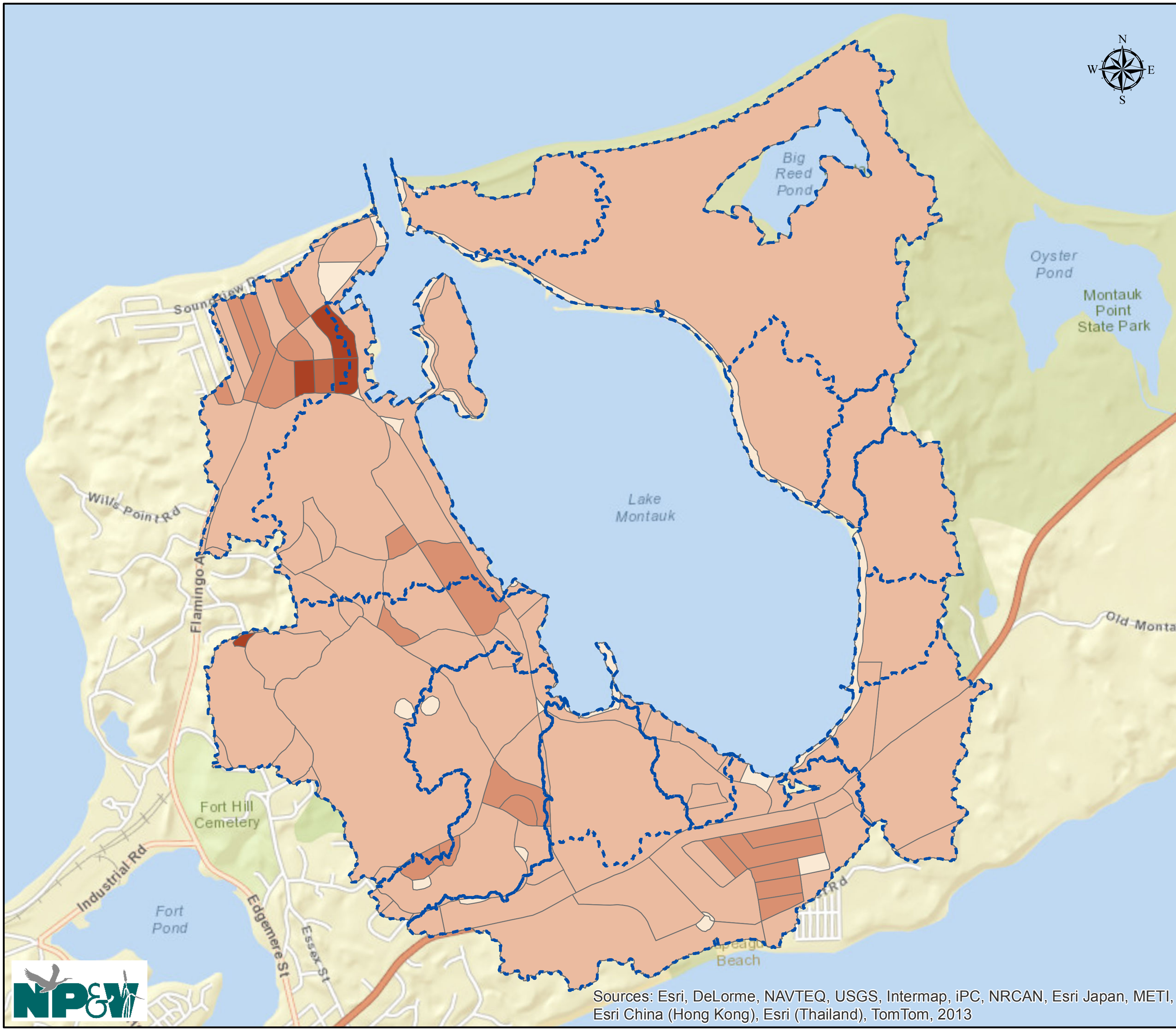
New York Department of State

Watershed
Management Plan

FIGURE 20a

Population in 2000



Legend

- Subwatersheds
- 2000 Census Blocks

Population Density (an Index)

- 0.000000
- 0.000001 - 2.000000
- 2.000001 - 4.000000
- 4.000001 - 6.000000
- 6.000001 - 16.200000

Source: ESRI WMS; NYSDOS; American Fact Finder; Suffolk County GIS

0 2,500 Feet

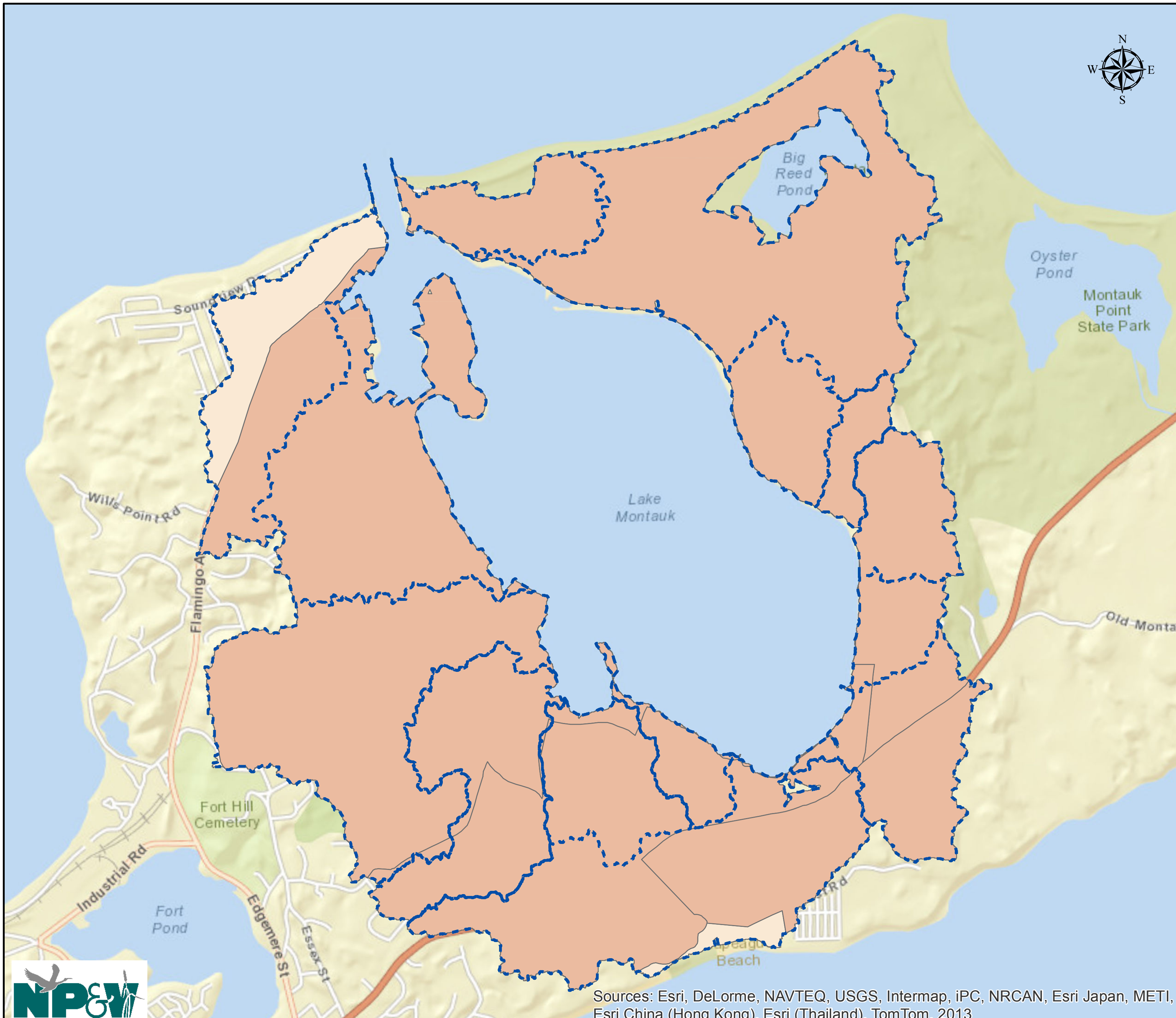
1 inch = 2,500 feet

Town of East Hampton
and
New York Department of State

Watershed
Management Plan

FIGURE 20b

Population in 1990



Legend

Subwatersheds

1990 Census Block Groups

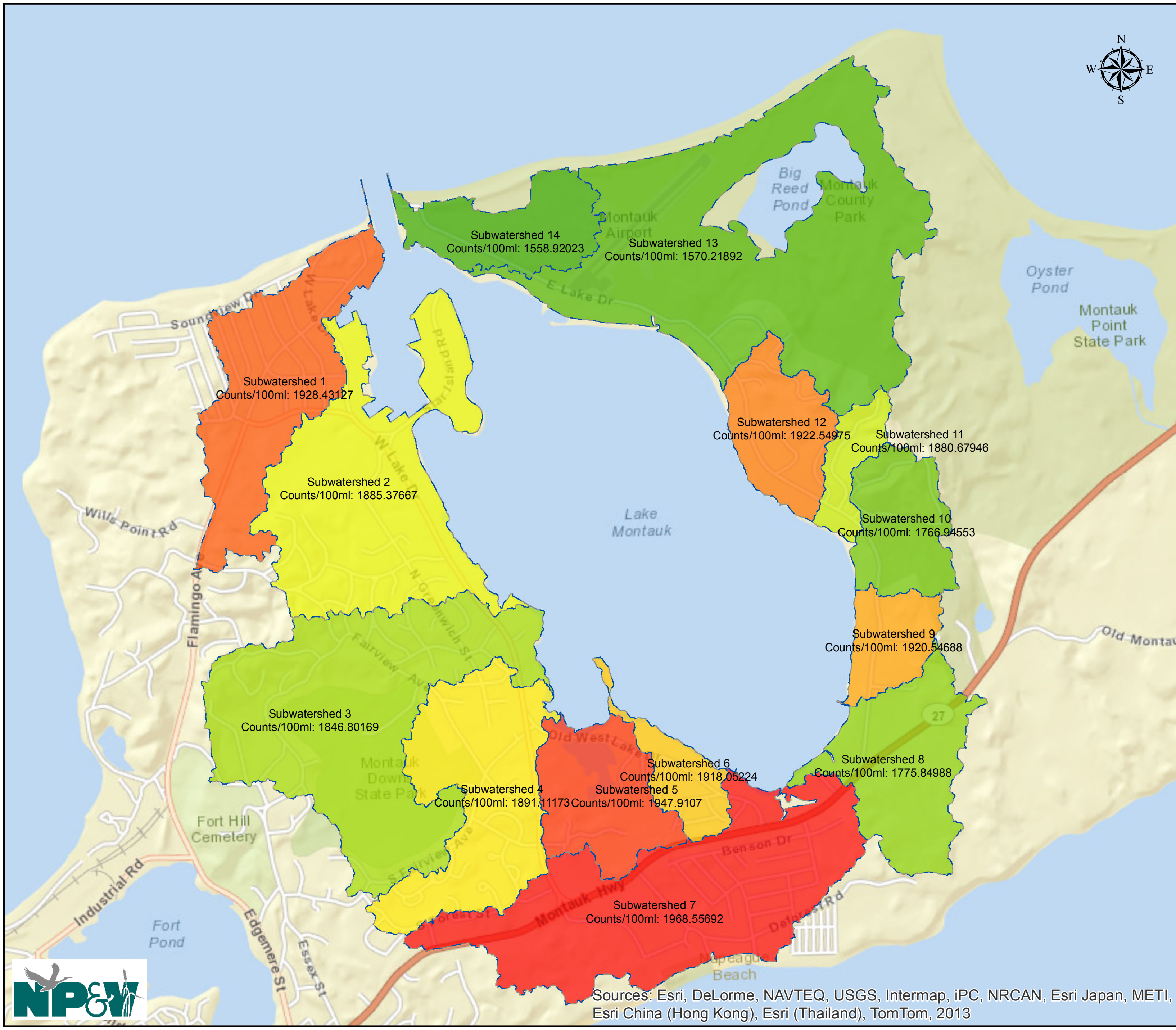
Population Density (an Index)

- 0.000000
- 0.000001 - 2.000000
- 2.000001 - 4.000000
- 4.000001 - 6.000000
- 6.000001 - 16.200000

Source: ESRI WMS; NYSDOS;
American Fact Finder;
Suffolk County GIS

0 2,500 Feet

1 inch = 2,500 feet



Town of East Hampton and New York Department of State

Lake Montauk Watershed Management Plan

FIGURE 21
Pathogen Load by Subwatershed

Legend

Subwatersheds

Pathogens (counts/100ml)

- 1558.92023
- 1570.21892
- 1766.94553
- 1775.84988
- 1846.80169
- 1880.67946
- 1885.37667
- 1891.11173
- 1918.05224
- 1920.54688
- 1922.54975
- 1928.43127
- 1947.9107
- 1968.55692

Source: Suffolk County GIS, USEPA BASINS Version 4.1

0 2,500 Feet

1 inch = 2,500 feet

Town of East Hampton
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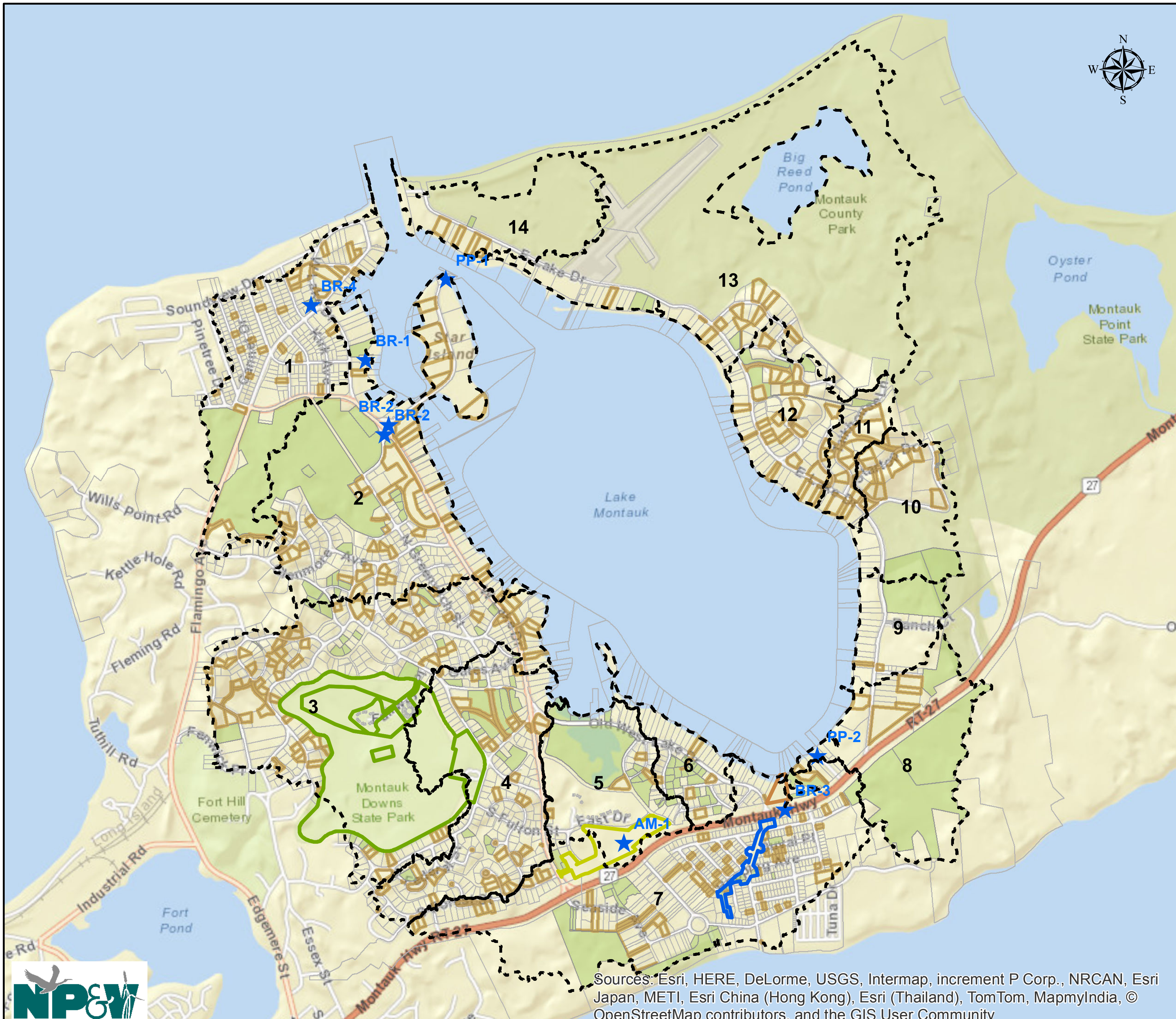
New York Department of State

Lake Montauk Watershed Management Plan

FIGURE 22
Proposed WMP Site Specific Recommendations



Legend

- Subwatersheds
- Proposed Stormwater Improvement Projects
- Management Parcels
  - Agricultural Stormwater Management
  - Golf Course Stormwater Management
  - Potential Acquisition
  - Wetland Restoration
  - Vacant Land (Publicly Owned)
  - Parcels

Source: ESRI WMS; NYSDOS; Suffolk County GIS

0 2,500 Feet

1 inch = 2,500 feet

APPENDICES

Appendix A

Cornell Cooperative Extension Watershed Plan

Lake Montauk Watershed Plan
Cornell Cooperative Extension-Marine

Contents

Lake Montauk Watershed Plan.

A cooperative effort between the Town of East Hampton's Division of Natural Resources and Cornell Cooperative Extension of Suffolk County's Marine Program looked at stream inputs to Lake Montauk during the summer of 2008. The purpose was to observe which streams may be contributing the most runoff to the lake during a stormwater event. Sites were visited during both dry and wet conditions, and assessed based on historical and empirical data. A total of 15 streams, or stations, were then picked for further evaluation for the purpose of this study.

Sites were distributed so as to cover the most of the lake. Stations for the study included sites on the eastern, southern and western portions of the lake.

For the purpose of this study, each station had several components.

> First, each station was monitored for flow four times a year for two years. Second, each station was tested for fecal coliform using membrane filtration for a total of 8 samples (4 times during a wet event, and 4 times for a dry event).
> And lastly, each station had one sample from the fecal coliform study to be also used for a bacterial source tracking study. Cornell Cooperative Extension has developed an E. coli based fecal coliform DNA library. Water samples collected and chosen for the DNA study would be compared to the animal source library in an effort to determine the source of the bacteria within the stormwater flow.

Additionally, as part of the watershed study, Cornell Cooperative Extension was contracted to conduct the following projects in and around the lake:

1. Map and conduct survey of eelgrass beds within the lake.
2. TR-20 modeling of the lake to determine stormwater loadings into the lake.
3. Sediment and infauna analysis.
4. Research alternatives to on site sanitary systems.

Preliminary Report on the Eelgrass Monitoring Effort in Lake Montauk

The following information represents an informal synthesis of the observations and data collected on 23 September, 2008. The data was analyzed using SigmaStat and the graphs were generated in SigmaPlot. Data regarding sediment grain size and organic content is currently being analyzed and will be submitted at a later date.

Eelgrass Monitoring Stations

The eelgrass monitoring stations were chosen at random at the two eelgrass sites, but they were always positioned in eelgrass. The stations were marked with a non-DGPS with an accuracy of ± 9 foot circular error. The GPS coordinates of the nine (9) stations within Lake Montauk are:

Station		
LM1	N 41.06857	W 71.92794
LM2	N 41.06878	W 71.92715
LM3	N 41.06943	W 71.92664
LM4	N 41.07009	W 71.92645
CG1	N 41.07436	W 71.93350
CG2	N 41.07435	W 71.93311
CG3	N 41.07405	W 71.93272
CG4	N 41.07384	W 71.93238
CG5	N 41.07373	W 71.93199

Quadrat Sampling of Eelgrass Shoot Density and Percent Macroalgae Cover

Eelgrass shoot density and percent macroalgae cover were sample at random within a ten (10) meter radius of each station center point (as marked with GPS and indicated with temporary marker buoy). A total of ten, 0.10m^2 PVC quadrats were sampled within the 10m radius of the center point. Quadrats were haphazardly tossed by divers within the designated areas then sampled for percent macroalgae cover and a raw eelgrass shoot density. Macroalgae was identified to at least the genus level (and to species when possible) *in-situ*.

Descriptive Statistics: Wednesday, September 24, 2008, 13:35:26

Data source: Lake Montauk-2008 Eelgrass Monitoring-Lake Montauk Site-Eelgrass Shoot Density

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
LM1-ShtDen	10	0	154.00	94.89	30.01	67.88
LM2-ShtDen	9	0	56.67	54.08	18.03	41.57
LM3-ShtDen	11	0	111.82	85.30	25.72	57.31
LM4-ShtDen	10	0	23.00	30.93	9.78	22.13
LM-Comb. ShtDen	40	0	79.08	87.33	13.81	27.93

Column	Range	Max	Min	Median	25%	75%
LM1-ShtDen	290.00	310.00	20.00	130.00	80.00	190.00
LM2-ShtDen	180.00	190.00	10.00	40.00	27.50	65.00
LM3-ShtDen	270.00	280.00	10.00	90.00	60.00	170.00
LM4-ShtDen	100.00	100.00	0.00	15.00	0.00	30.00
LM-Comb. ShtDen	310.00	310.00	0.00	45.00	10.00	125.00

Descriptive Statistics: Wednesday, September 24, 2008, 13:35:51

Data source: Lake Montauk-2008 Eelgrass Monitoring-Lake Montauk Site-%Macroalgae

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
LM1-%Algae	10	0	1.80	2.25	0.71	1.61
LM2-%Algae	9	0	18.11	16.53	5.51	12.71
LM3-%Algae	11	0	69.55	38.17	11.51	25.65
LM4-%Algae	10	0	42.50	28.89	9.14	20.67
LM-Comb. %Algae	40	0	34.27	36.37	5.75	11.63

Column	Range	Max	Min	Median	25%	75%
LM1-%Algae	5.00	5.00	0.00	1.00	0.00	5.00
LM2-%Algae	50.00	50.00	0.00	10.00	7.50	27.00
LM3-%Algae	100.00	100.00	0.00	95.00	32.50	100.00
LM4-%Algae	80.00	90.00	10.00	35.00	20.00	75.00
LM-Comb. %Algae	100.00	100.00	0.00	25.00	3.00	62.50

Descriptive Statistics: **Wednesday, September 24, 2008, 13:36:13**

Data source: Lake Montauk-2008 Eelgrass Monitoring-Coast Guard Site-Eelgrass Shoot Density

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
CG1-ShtDen	10	0	138.00	109.73	34.70	78.49
CG2-ShtDen	10	0	145.00	126.16	39.90	90.25
CG3-ShtDen	10	0	61.00	27.26	8.62	19.50
CG4-ShtDen	10	0	82.00	50.95	16.11	36.44
CG5-ShtDen	11	0	147.27	92.53	27.90	62.16
CG-Comb. ShtDen	51	0	115.29	93.07	13.03	26.18

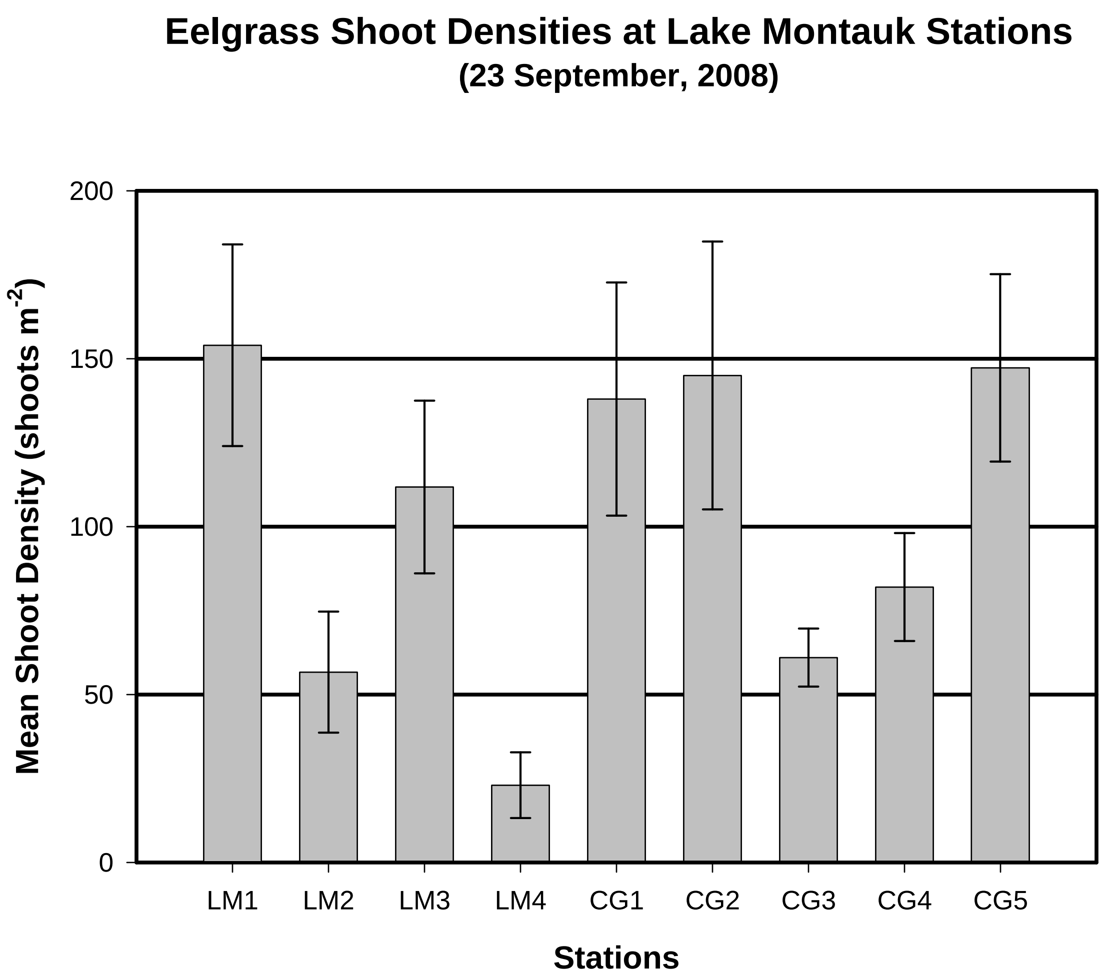
Column	Range	Max	Min	Median	25%	75%
CG1-ShtDen	410.00	420.00	10.00	115.00	80.00	150.00
CG2-ShtDen	380.00	380.00	0.00	135.00	50.00	240.00
CG3-ShtDen	100.00	130.00	30.00	55.00	50.00	70.00
CG4-ShtDen	140.00	160.00	20.00	70.00	40.00	120.00
CG5-ShtDen	250.00	270.00	20.00	170.00	60.00	225.00
CG-Comb. ShtDen	420.00	420.00	0.00	90.00	50.00	167.50

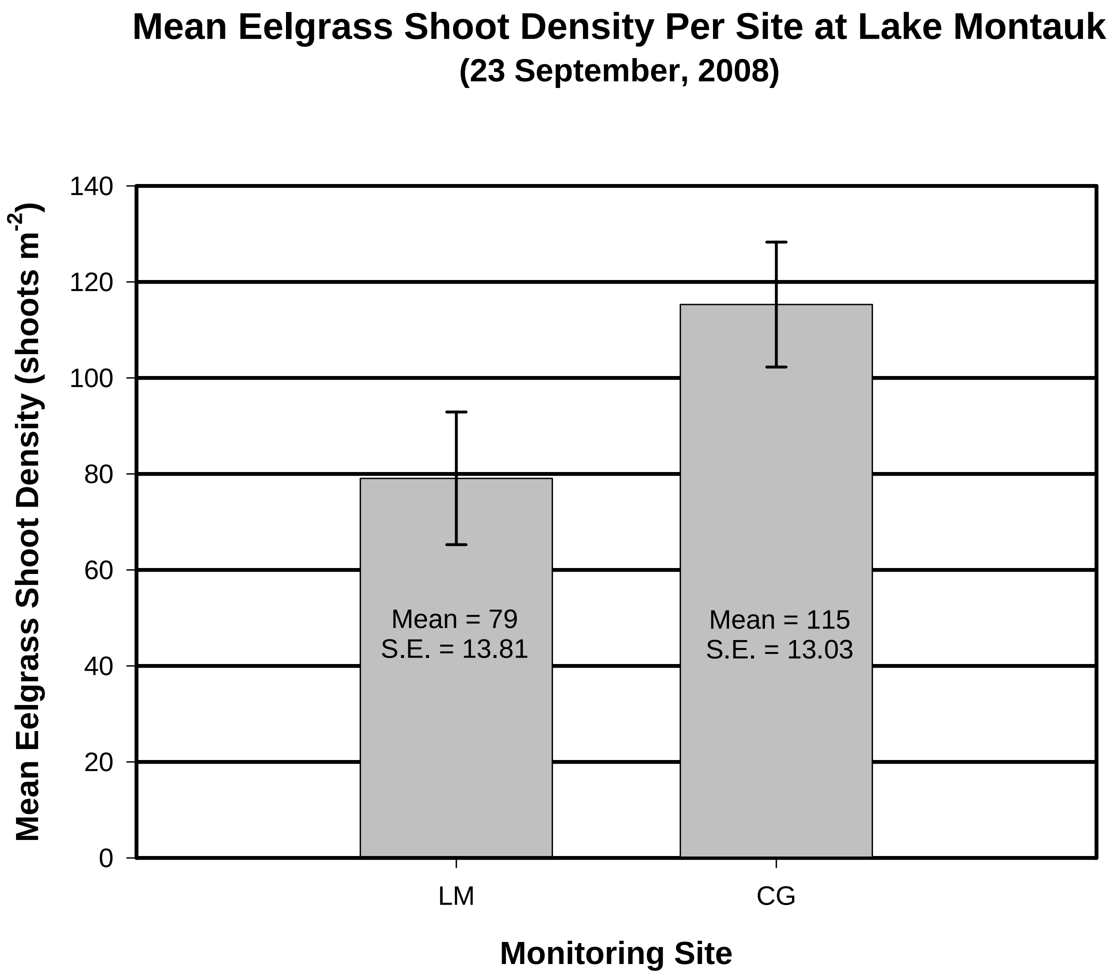
Descriptive Statistics: **Wednesday, September 24, 2008, 13:36:47**

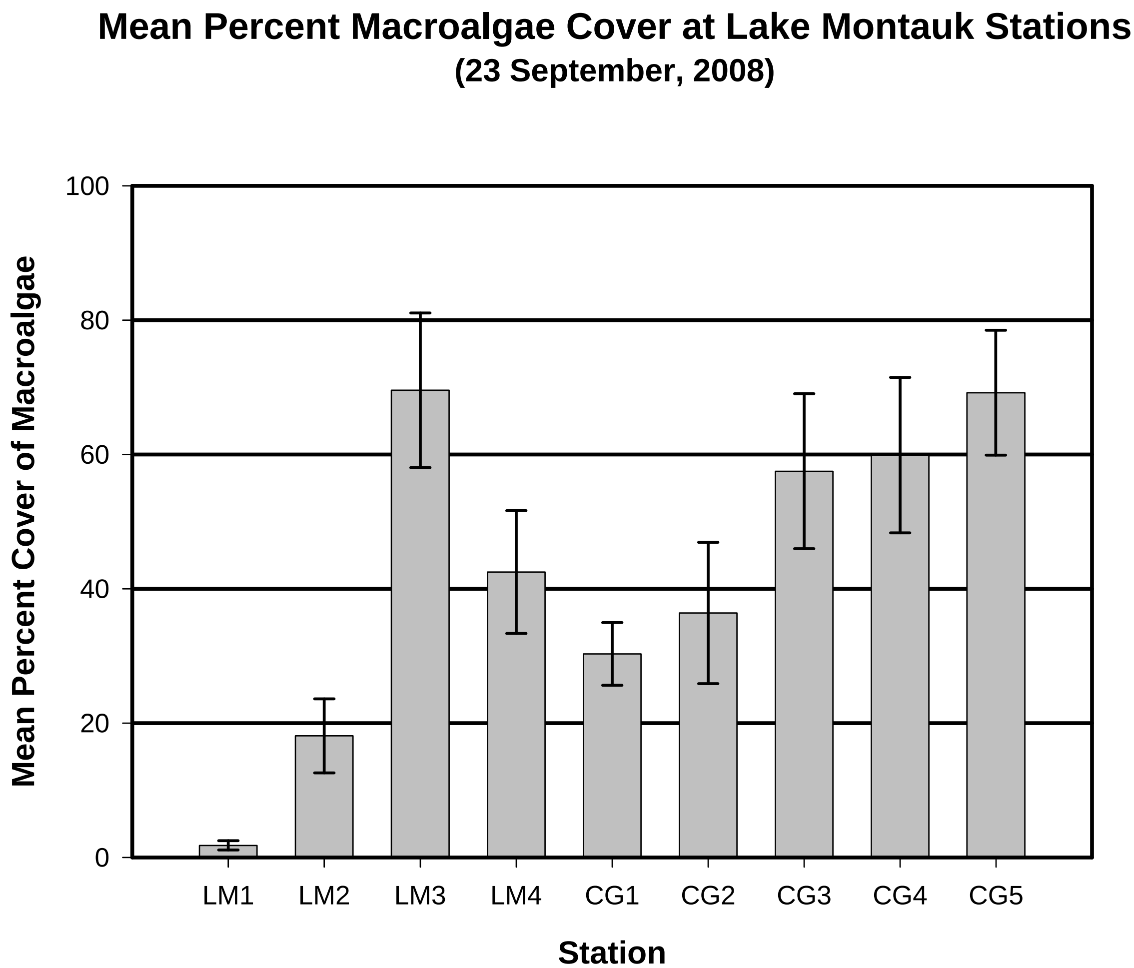
Data source: Lake Montauk-2008 Eelgrass Monitoring-Coast Guard Site-%Macroalgae

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
CG1-%Algae	10	0	30.30	14.75	4.66	10.55
CG2-%Algae	10	0	36.40	33.32	10.54	23.83
CG3-%Algae	10	0	57.50	36.54	11.55	26.14
CG4-%Algae	10	0	59.90	36.62	11.58	26.20
CG5-%Algae	11	0	69.18	30.88	9.31	20.74
CG-Comb. %Algae	51	0	51.02	33.72	4.72	9.48

Column	Range	Max	Min	Median	25%	75%
CG1-%Algae	40.00	50.00	10.00	29.00	20.00	40.00
CG2-%Algae	99.00	100.00	1.00	26.50	10.00	50.00
CG3-%Algae	100.00	100.00	0.00	45.00	33.00	99.00
CG4-%Algae	99.00	99.00	0.00	65.00	30.00	95.00
CG5-%Algae	80.00	100.00	20.00	75.00	50.00	100.00
CG-Comb. %Algae	100.00	100.00	0.00	50.00	21.25	87.50

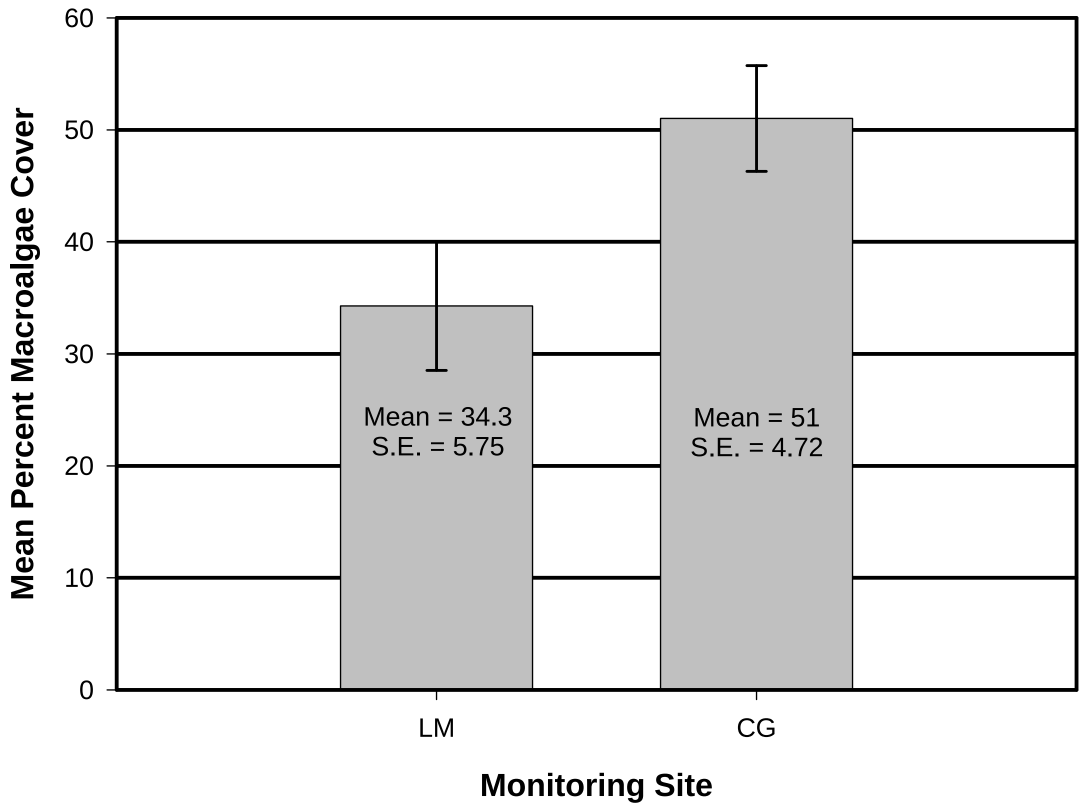

Eelgrass Shoot Densities at Lake Montauk Stations
(23 September, 2008)
Mean Shoot Density (shoots m-2)
200
150
100
50
0
LM1
LM2
LM3
LM4
CG1
CG2
CG3
CG4
CG5
Stations


Mean Eelgrass Shoot Density Per Site at Lake Montauk
(23 September, 2008)
Mean Eelgrass Shoot Density (shoots m-2)
140
120
100
80
60
40
20
0
Mean = 79
S.E. = 13.81
Mean = 115
S.E. = 13.03
LM
CG
Monitoring Site



Mean Percent Macroalgae Cover at Lake Montauk Stations
(23 September, 2008)
Mean Percent Cover of Macroalgae
100
80
60
40
20
0
LM1
LM2
LM3
LM4
CG1
CG2
CG3
CG4
CG5
Station

Mean Percent Macroalgae Cover Per Monitoring Site at Lake Montauk
(23 September, 2008)



Macroalgae Species List

Species	**Site Observed**	**Notes**
Codium fragile	Both	Non-indigenous, invasive
Ulva intestinalis	Both	Epiphytic and non-epiphytic
Ulva flexuosa	LM	
Ulva lactuca	Both	
Laminaria saccharina	Both	Drift material
Sargassum filipendula	CG	
Agardhiella subulata	Both	Drift and attached
Champia parvula	Both	Epiphytic and non-epiphytic
Chondrus crispus	LM	Drift material
Dasya baillouviana	Both	Drift material
Grateloupia turuturu	Both	Non-indigenous, invasive; Drift material
Grinnellia americana	Both	
Polysiphonia species	Both	Epiphytic
Spermothamnion repens	Both	Epiphytic and Drift material

Tr-20 Subwatershed

The TR-20 model is the most widely used application for simulating rainfall events and calculating runoff during storms. Direct runoff is computed based on a number of variables including land use, topography, and soil types. TR-20 is a valuable tool used in analyzing current watershed conditions as well as assessing the impact of proposed changes within the watershed. The model is typically run at the watershed level, as was done in the current study for Lake Montauk.

TR-20 can simulate multiple storm events within one model run. This study looked at the impacts of 1, 2, 10, and 100 year rainfall events. In order to assess the differences between seasons, the model was run in average, dry and wet antecedent soil conditions (e.g. spring runoff would be expected to be higher since the soil is likely already wet prior to a given rain event).

Historically TR-20 calculations were done by hand which was extremely time consuming. To simplify the calculations, the Natural Resources Conservation Service (NRCS) developed a windows-compatible computer program called WinTR-20. This free software package was utilized for all runoff calculations.

It should be noted that a limitation of the current study is that stormwater conveyance systems were not factored into the model. Since stormwater retention structures were excluded from the study, it's likely that calculations over-estimate the amount of runoff that a particular storm generates. While including stormwater structures would enhance the accuracy of the model, it was beyond the scope of the study.

Methods

While it is easiest to perform the TR-20 analysis on the entire Lake Montauk watershed, it was deemed to be more valuable to first divide the area up into discrete subwatersheds. This allows for the comparison between areas surrounding Lake Montauk, and allows us to determine which areas contribute the greatest amount of runoff. In order to remove the variability associated with delineating subwatersheds by hand, various extensions in ArcGIS were utilized to delineate the subwatersheds in a more repeatable manner.

In order to delineate subwatersheds, an accurate topographic map is required. In 2006 an aerial LiDAR survey was conducted and resulted in the production detailed digital topographic maps. While it is beyond the scope of this document to detail the multiple steps required to create subwatersheds in ArcGIS the results can be seen in the following figures. The initial ArcGIS delineating steps produced a map of catchment areas (see Figure 1), which can be characterized as distinct areas where runoff is being conveyed to the same location. In order to determine which catchment areas lead to Lake Montauk, ArcGIS created a map of flow or drainage lines as can be seen in Figure 2. The drainage lines allow for the easy identification of catchment areas which contribute to Lake Montauk. For the purpose of this study, a subwatershed was considered to be a collection of catchment areas which share a common drainage into Lake Montauk. In some cases, some small subwatersheds were joined together to simplify the analysis. So while there is a degree of subjectivity in defining subwatersheds, the catchment areas which contribute to Lake Montauk were quantitatively calculated. Figure 3 represents the delineated subwatersheds of the Lake Montauk watershed. There are a total of 14 subwatersheds ranging in size from 41.6 acres to 518.4 acres. The total watershed was calculated to be 2,728.32 acres.

Figure 1 – Lake Montauk and surrounding catchment areas.

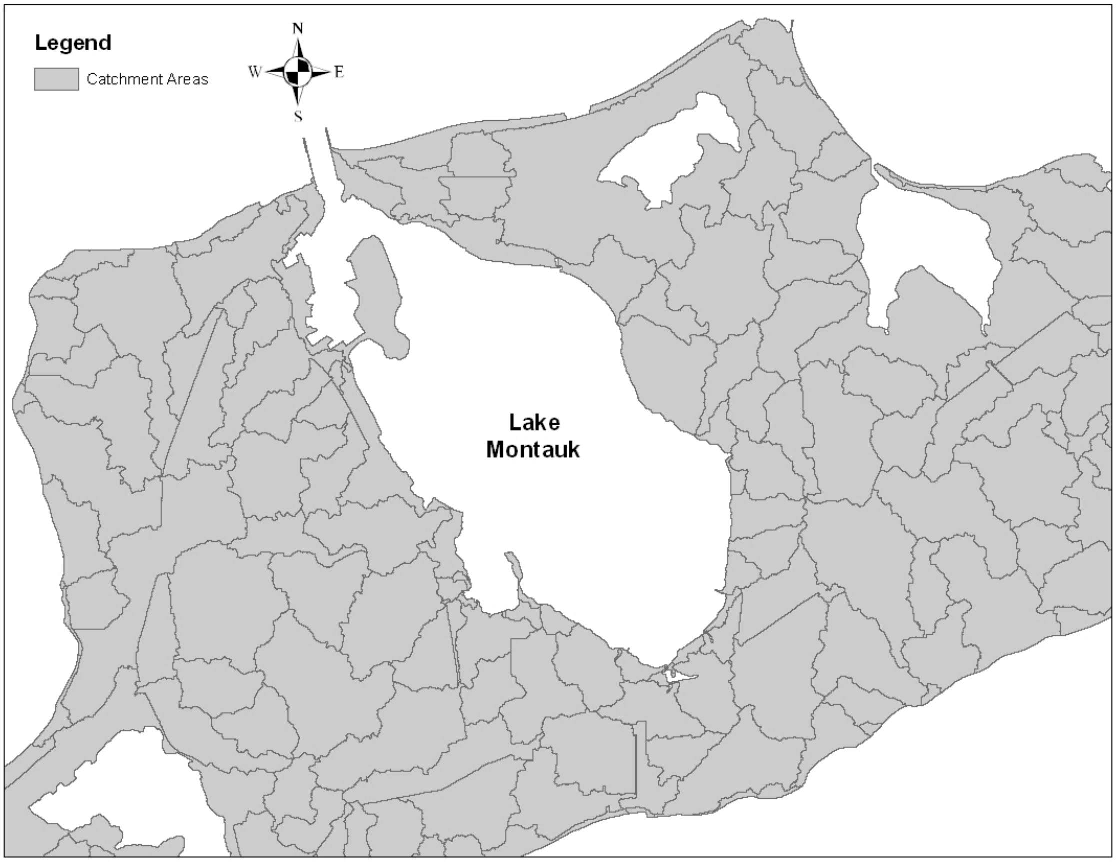


Figure 2 – Drainage lines of Lake Montauk and surrounding area catchments.

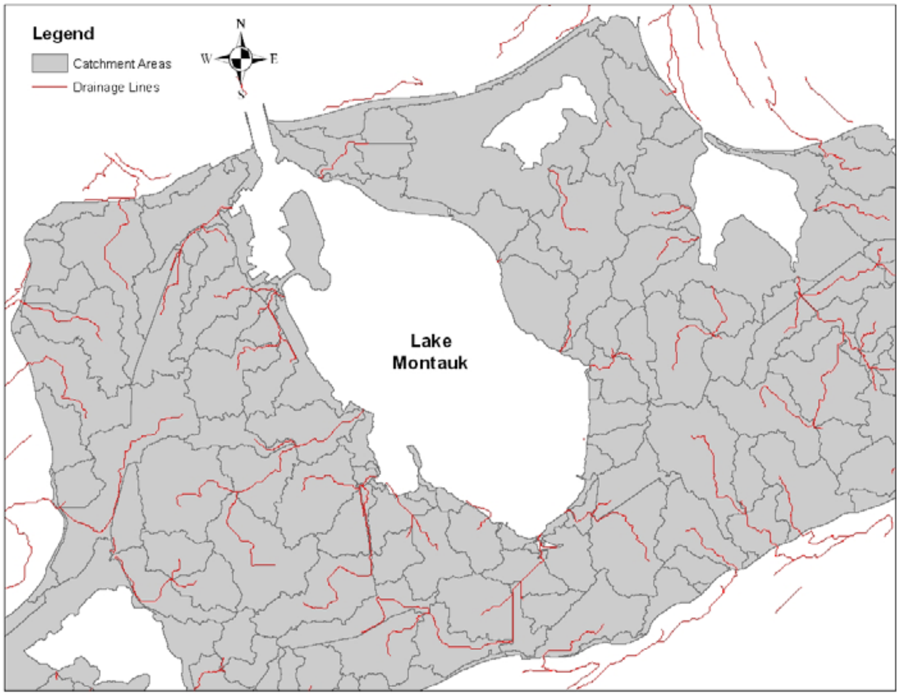
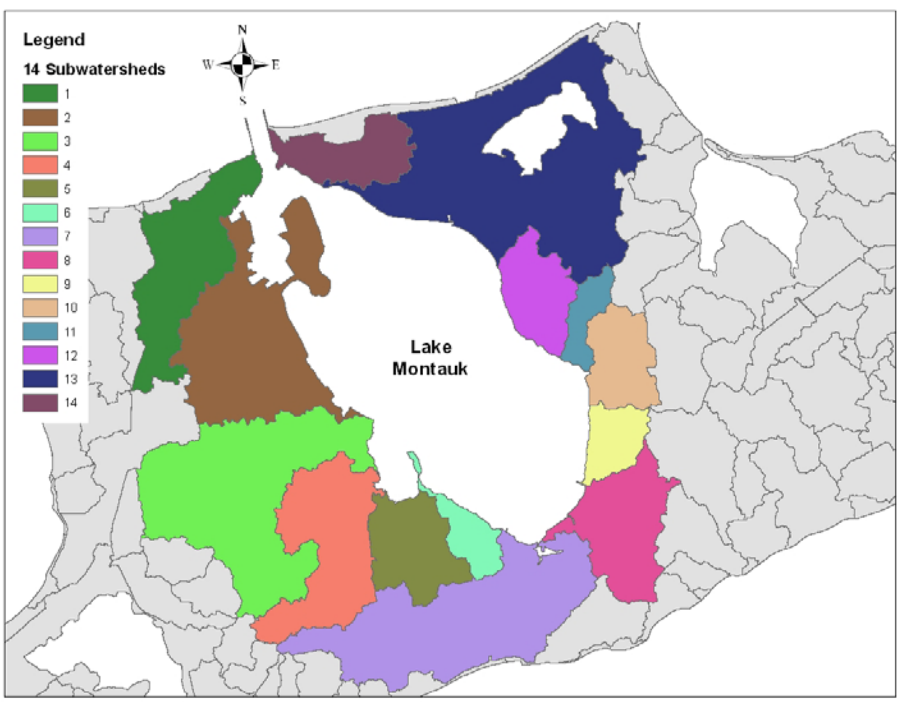


Figure 3 – 14 Subwatersheds of Lake Montauk

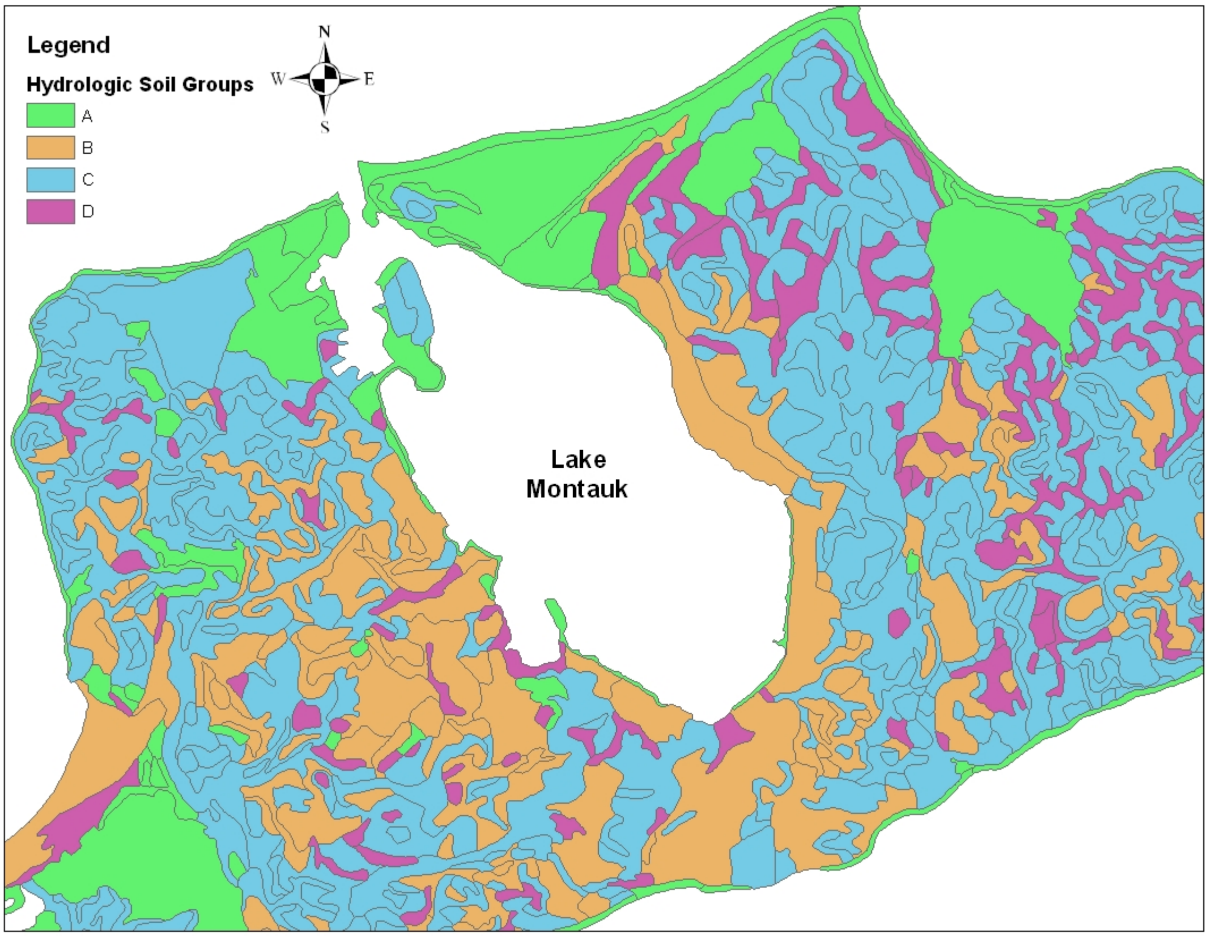


TR-20 Model Input Data

Hydrologic Soil Groups

The first variable that significantly impacts runoff potential is the soil type. Soils are classified by the Natural Resource Conservation Service into four hydrologic soil groups based on the runoff potential. The 4 groups are A, B, C and D. Group A soils are predominantly sand or sandy loam and have the lowest runoff potential while group D soils are clay based and have the greatest runoff potential. Figure 4 represents the soil types surrounding Lake Montauk. The ArcGIS layer was produced by and obtained from the United States Department of Agriculture (USDA).

Figure 4 – Hydrologic soil types from the USDA.



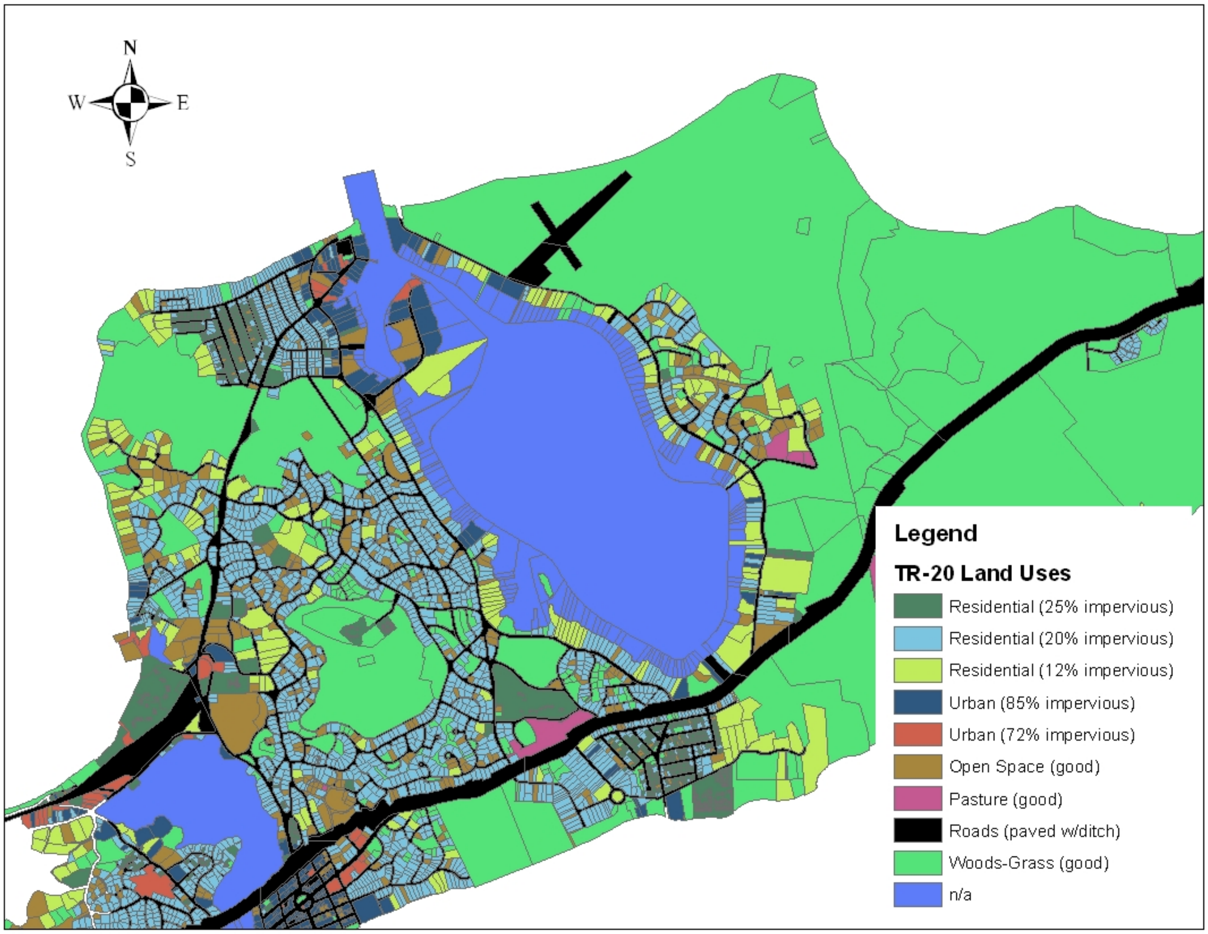
Land Use

A second input which greatly impacts runoff potential is the existing land use. Impervious surfaces like roadways allow very little water to infiltrate into the ground, and the amount of time it takes for water to run off into surface waters is significantly decreased. The Town of East Hampton provided CCE with updated land use maps which were subsequently modified to make them compatible with TR-20. This entailed filling in missing data (e.g. some Town roads) and reclassifying official East Hampton land use designations with the appropriate TR-20 land use condition (see Table 1). Figure 5 demonstrates the land uses present in the Lake Montauk watershed.

Table 1 – East Hampton land use designations and equivalent TR-20 conditions.

East Hampton Designation	**East Hampton Description**	**TR-20 Condition**
1	Low Density Residential	Residential (12% impervious)
2	Med Density Residential	Residential (20% impervious)
3	High Density Residential	Residential (25% impervious)
4	Commercial	Urban (85% impervious)
5	Industrial	Urban (72% impervious)
6	Institutional	Urban (72% impervious)
7	Recreational Open Space	Woods-Grass (good)
8	Agriculture	Pasture (good)
9	Vacant	Open Space (good)
10	Transportation	Roads (Paved w/ditch)
11	Utilities	Residential (25% impervious)
12	Waste Handling Mngmt.	Open Space (fair)
13	Surface Water	n/a
14	Cemetary	Open Space (good)

Figure 5 – Lake Montauk TR-20 land use conditions.



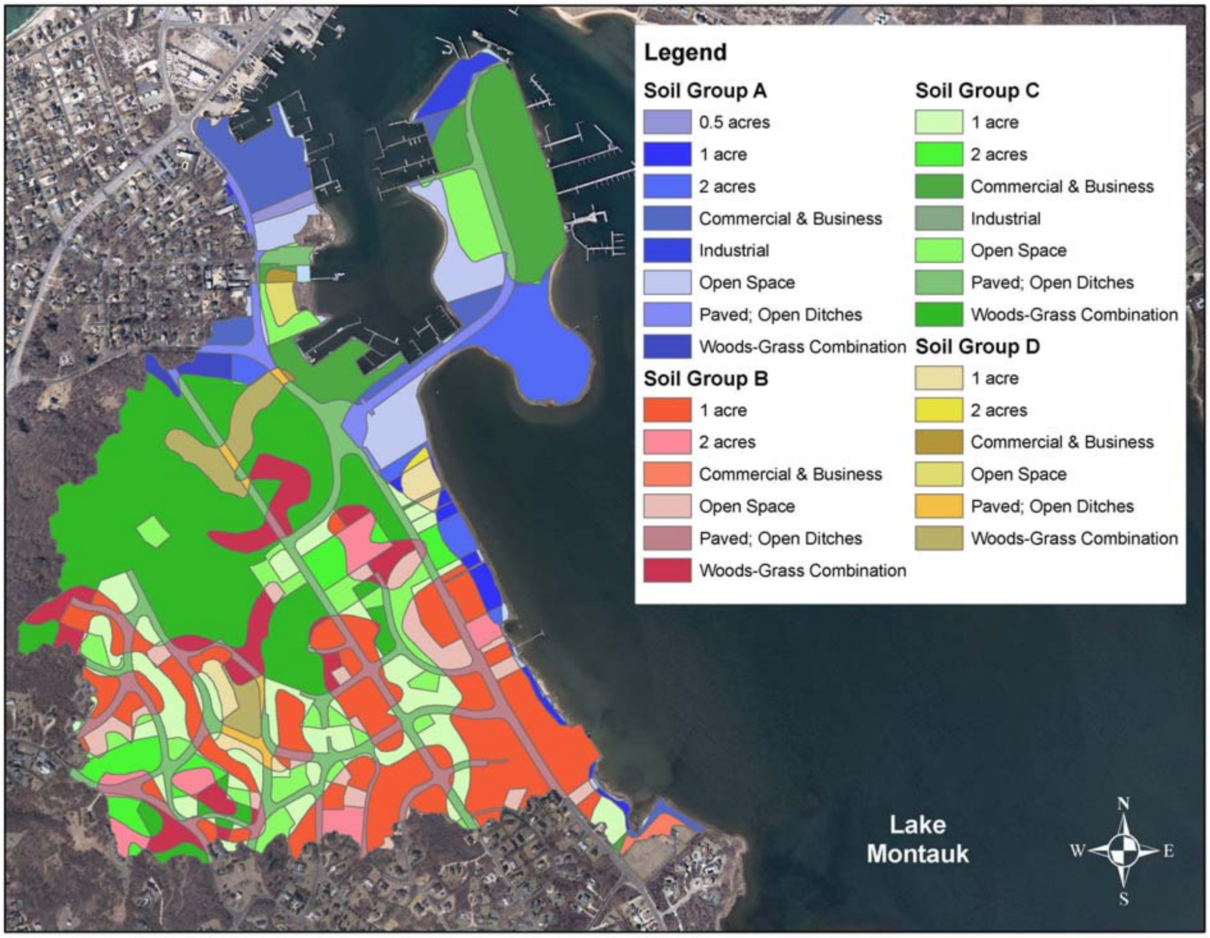
Topography

The final variable which is critical for calculating runoff loading is topography. In addition to using topography to delineate the watersheds, the TR-20 computations require that the average slopes of the drainage lines be determined. Since the LiDAR data is the most accurate topographic data available, it was also used for calculating the average slopes.

Results

Subwatershed, hydrological soil group, land use and topography information was entered into WinTR-20 to calculate stormwater runoff. Effectively, a separate analysis was conducted for each subwatershed. The TR-20 analysis functions by assigning a "curve number" to all areas within a subwatershed. The value of the curve number is dependent upon the land use and the hydrologic soil group. The higher the curve number, the more infiltration occurs at that particular area. To start, the subwatershed is broken down into the different land uses. So for subwatershed 2 for example, the subwatershed is first broken down into 8 different land use areas. But these land uses occur over different hydrological soil groups and the goal is to identify areas with unique combinations of land uses and hydrological soil groups. So the next step is to further break down the land use GIS layer.

Figure 6 – Subwatershed 2 hydrologic soil groups and land use.



This is accomplished by cutting the land use layer with the hydrologic soil group layer. In this case, we end up with 27 unique combinations of land use and hydrological soil groups, as can be seen in Figure 6. The area is determined for each unique combination and the WinTR-20 software generates the curve number. The averaging of all curve numbers weighted by percent area allows WinTR-20 to calculate runoff. The above process was repeated for each subwatershed.

In order to assess the differences between seasons, the model was run in average, dry and wet antecedent soil conditions (e.g. spring runoff would be expected to be higher since the soil is likely already wet prior to a given rain event). Therefore, there will be three complete sets of results. The first assumes normal or average soil conditions, the second assumes dry soil conditions antecedent to various rainfall events, and the third set of results assumes wet soil conditions. Runoff is expected to be significantly higher under antecedent wet soil conditions since there will be a reduced capacity for infiltration, especially in hydrological soil types which are more clay based.

The TR-20 model was run for 1, 2, 10 and 100 year rainfall events. As indicated in the New York State Stormwater Management Design Manual, these correspond to 2.5, 3.5, 5.0 and 7.5 inches of rain within a 24 hour period respectively. The above rainfall events were categorized as Type III rainfalls, which are typical for the East Coast. Type III rainfalls assume a normal type distribution of rain over the 24 hours. The rain starts at Hour 0, increases in strength and peaks at Hour 12, and gradually abates until Hour 24 where it ceases. The results of this study were split up into the following data representations:

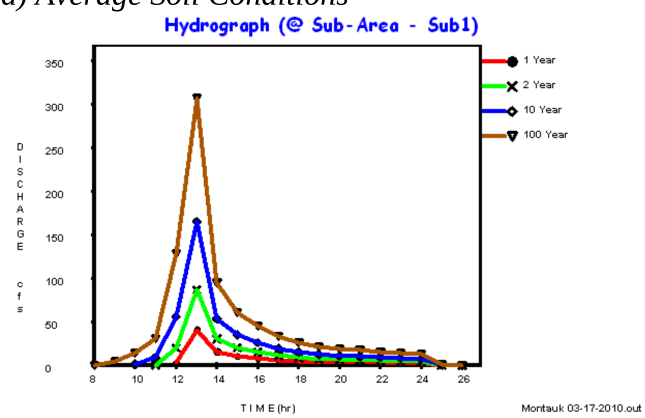
a) Hydrographs – a hydrograph is a graph showing changes in subwatershed discharge over time. The crest of a hydrograph therefore represents the greatest flow rate. Each hydrograph showed curves for each of the rainfall events. For each subwatershed 3 hydrographs were generated: one for average, dry and wet antecedent soil conditions.

b) Runoff Tables – the area under curve of a hydrograph represents the total discharge for the subwatershed in a given rain event. These values were calculated so the impacts of rain event (inches of rain), antecedent soil wetness, and subwatershed could be compared.

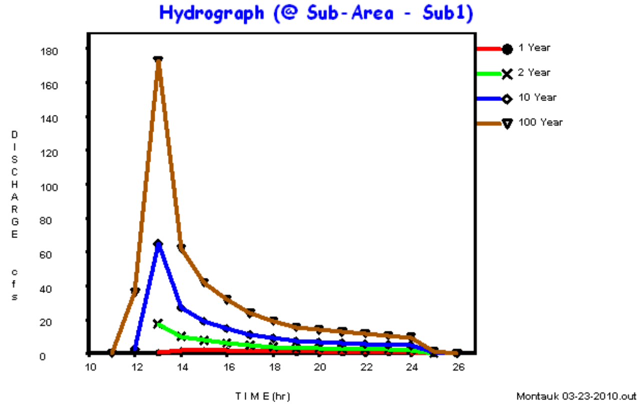
<u>Hydrographs</u>

Figure 7 – Subwatershed 1 Hydrographs

a) Average Soil Conditions



b) Dry Soil Conditions



c) Wet Soil Conditions

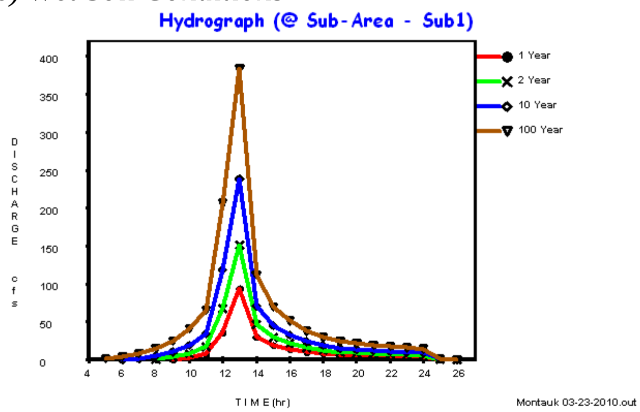
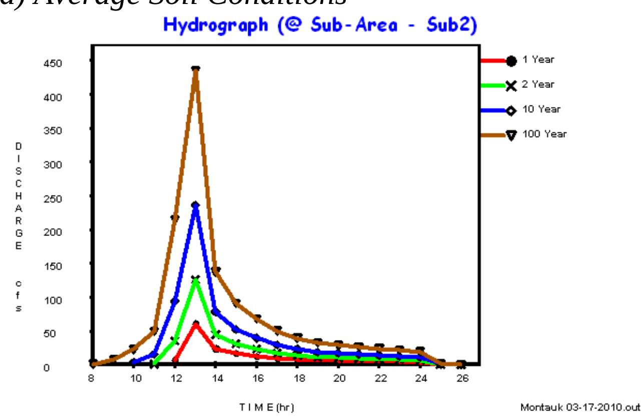
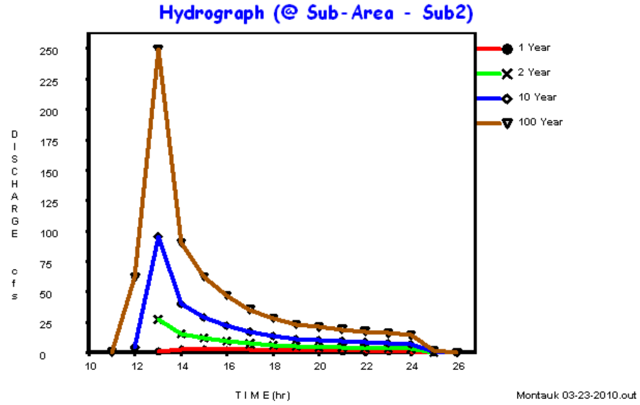


Figure 8 – Subwatershed 2 Hydrographs

a) Average Soil Conditions



b) Dry Soil Conditions



c) Wet Soil Conditions

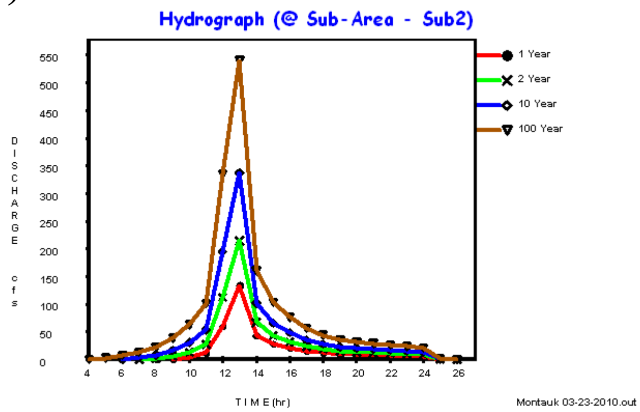
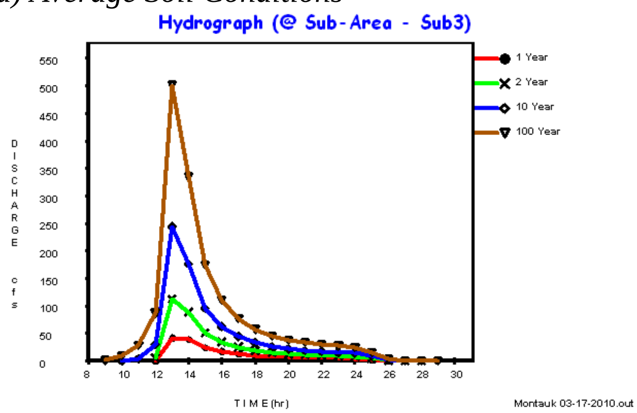
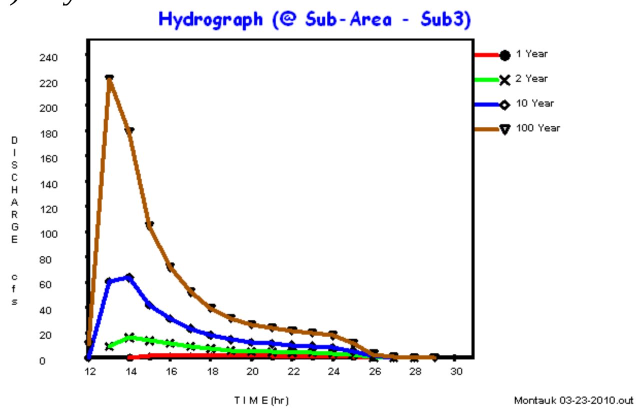


Figure 9 – Subwatershed 3 Hydrographs

a) Average Soil Conditions



b) Dry Soil Conditions



c) Wet Soil Conditions

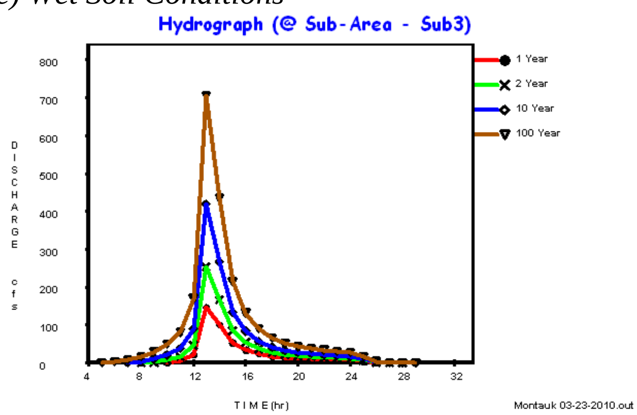
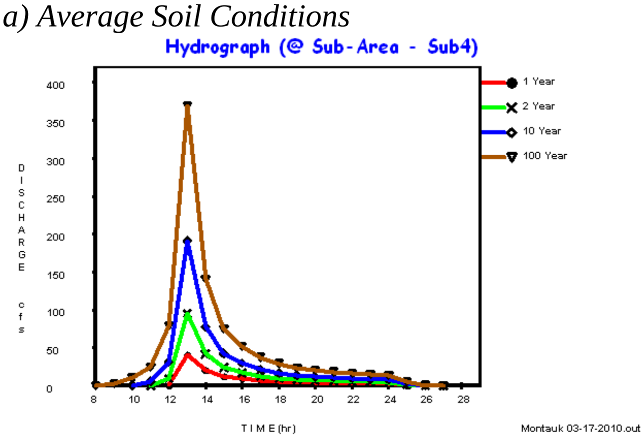
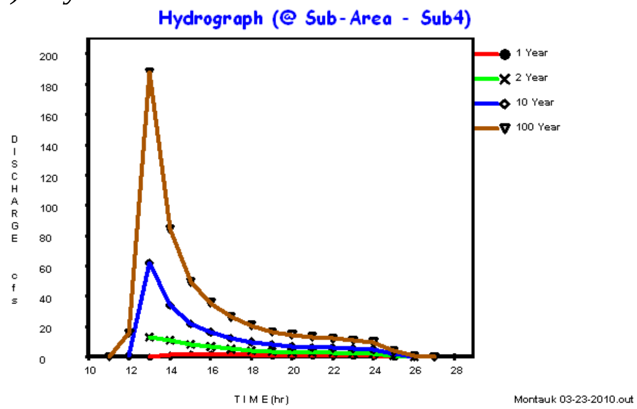


Figure 10 – Subwatershed 4 Hydrographs

a) Average Soil Conditions



b) Dry Soil Conditions



c) Wet Soil Conditions

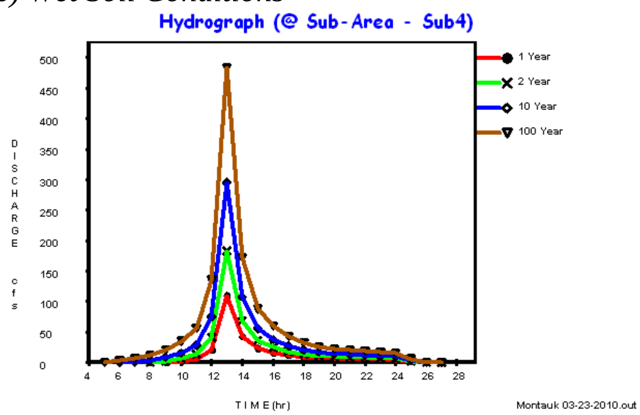
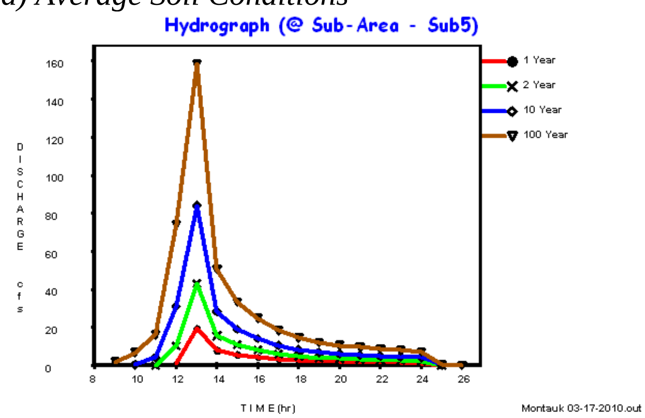
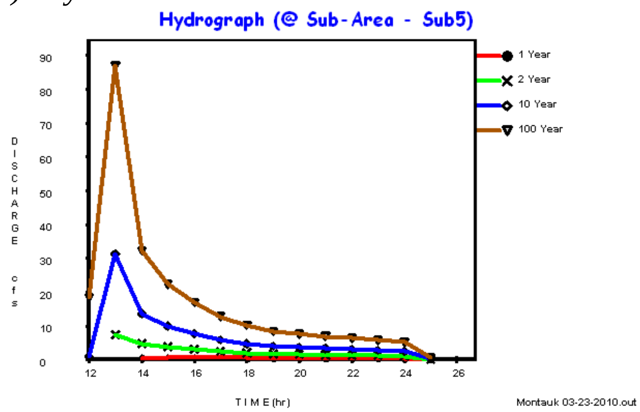


Figure 11 – Subwatershed 5 Hydrographs

a) Average Soil Conditions



b) Dry Soil Conditions



c) Wet Soil Conditions

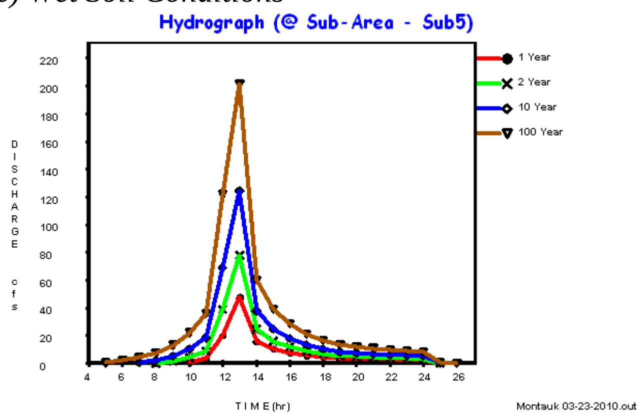
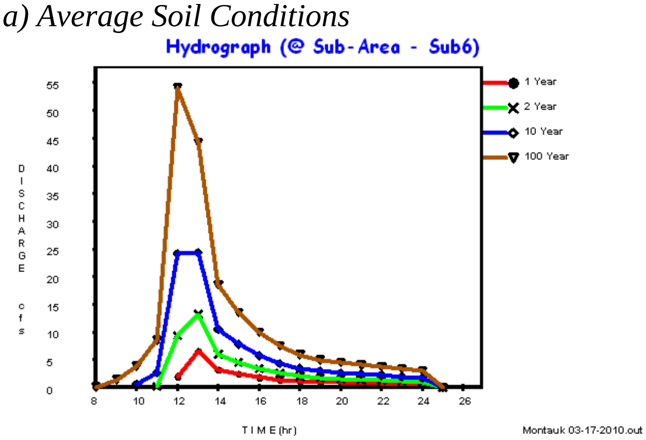
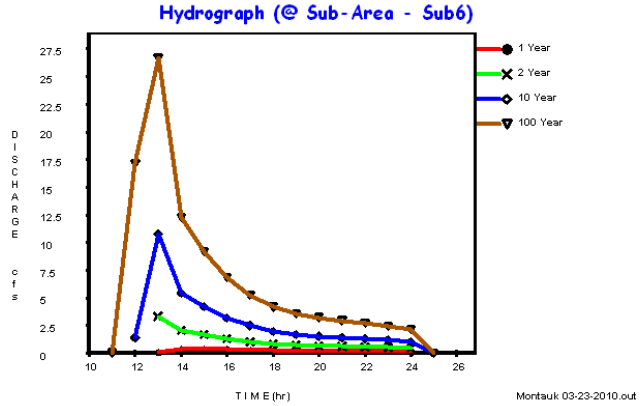


Figure 12 – Subwatershed 6 Hydrographs

a) Average Soil Conditions



b) Dry Soil Conditions



c) Wet Soil Conditions

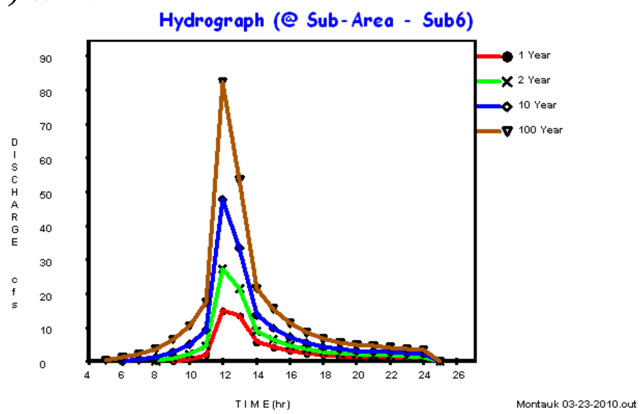
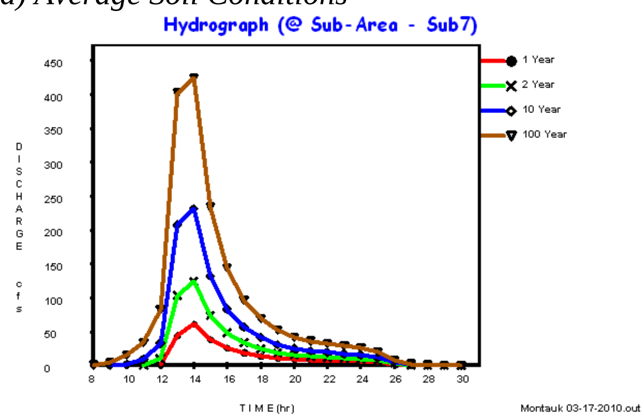
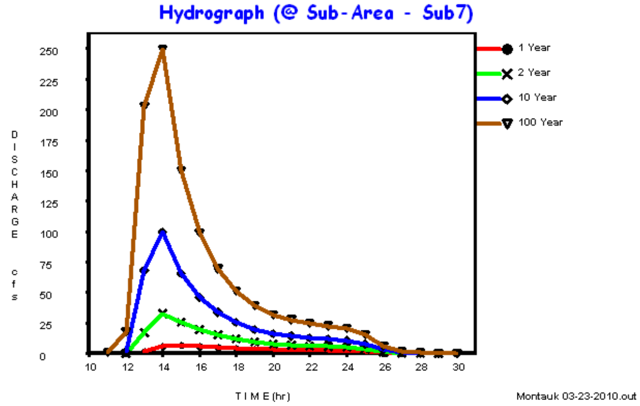


Figure 13 – Subwatershed 7 Hydrographs

a) Average Soil Conditions



b) Dry Soil Conditions



c) Wet Soil Conditions

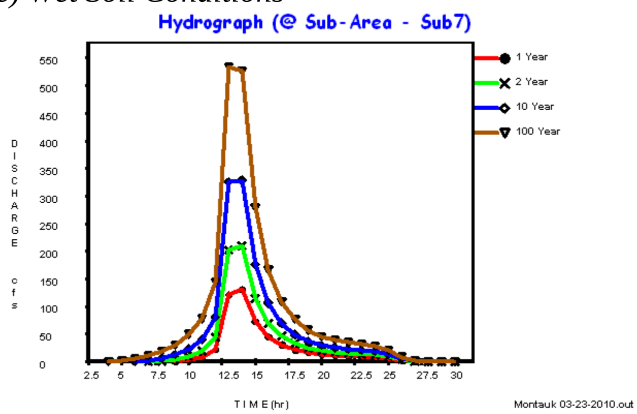
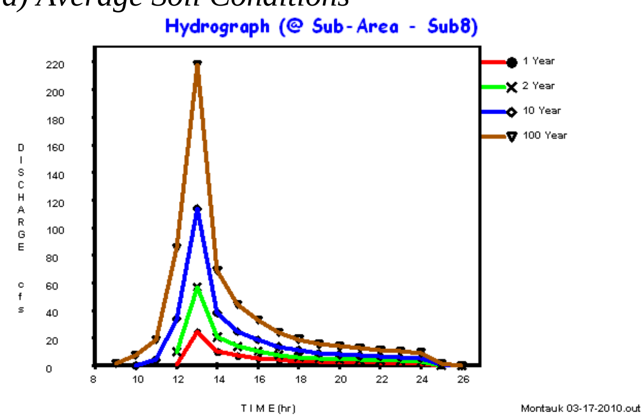
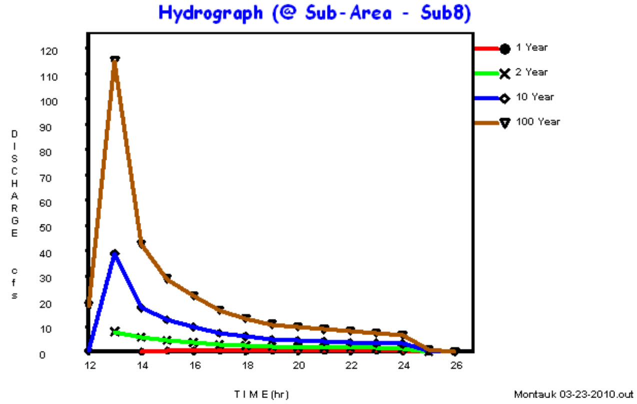


Figure 14 – Subwatershed 8 Hydrographs

a) Average Soil Conditions



b) Dry Soil Conditions



c) Wet Soil Conditions

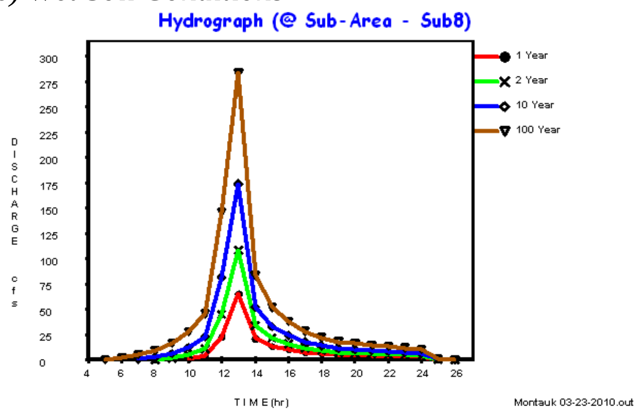
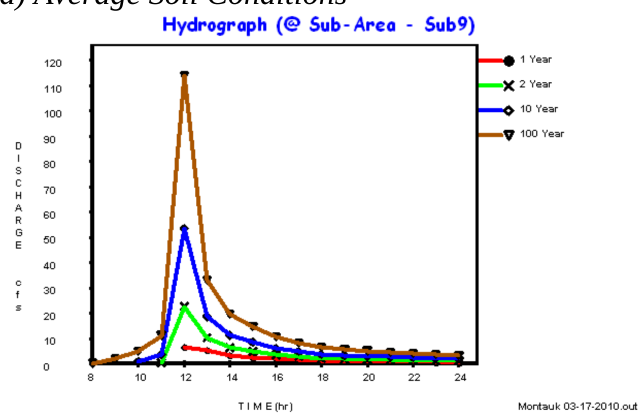
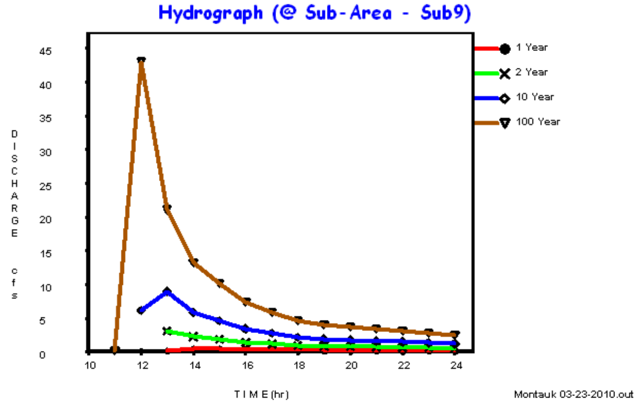


Figure 15 – Subwatershed 9 Hydrographs

a) Average Soil Conditions



b) Dry Soil Conditions



c) Wet Soil Conditions

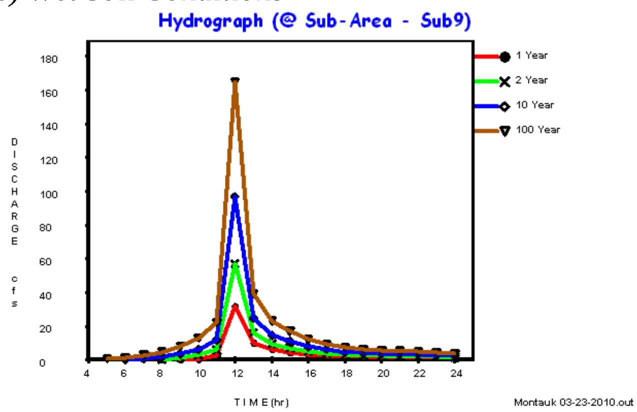
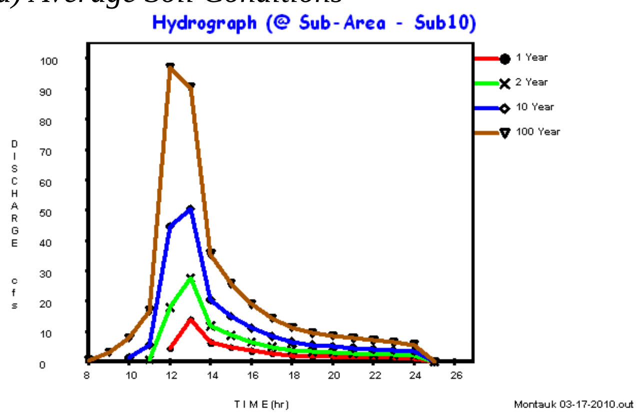
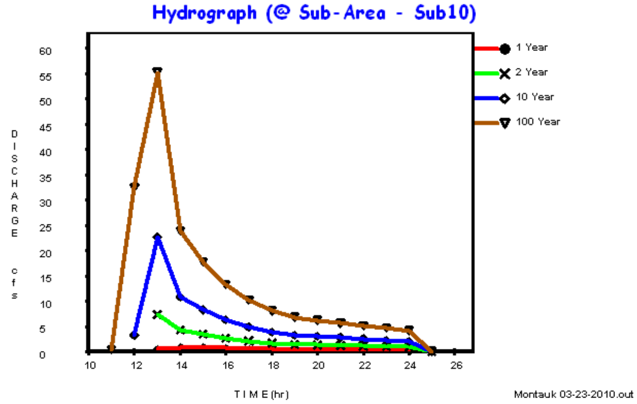


Figure 16 – Subwatershed 10 Hydrographs

a) Average Soil Conditions



b) Dry Soil Conditions



c) Wet Soil Conditions

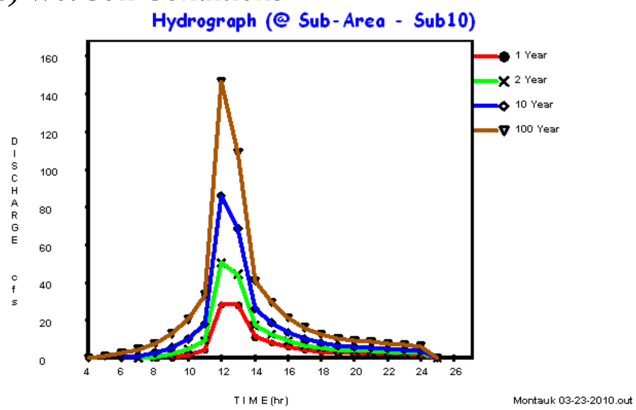
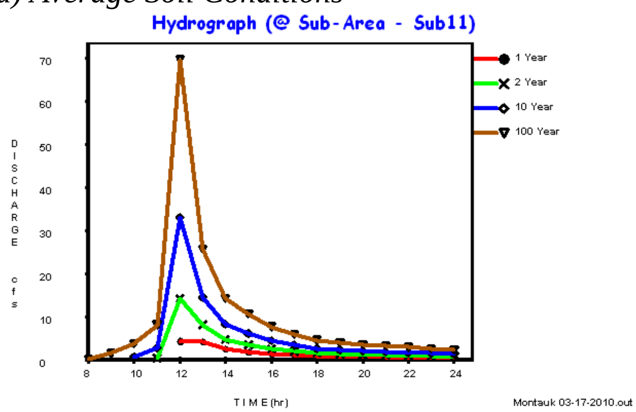
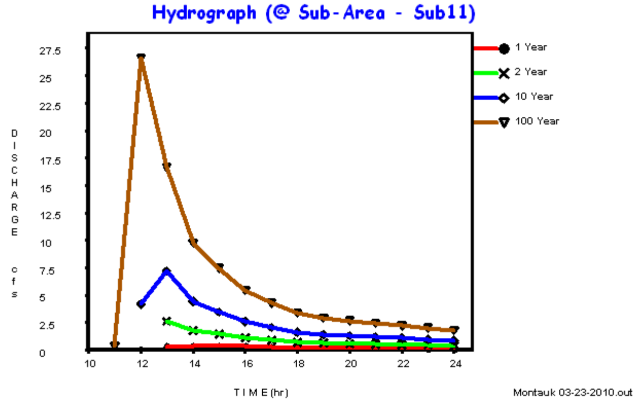


Figure 17 – Subwatershed 11 Hydrographs

a) Average Soil Conditions



b) Dry Soil Conditions



c) Wet Soil Conditions

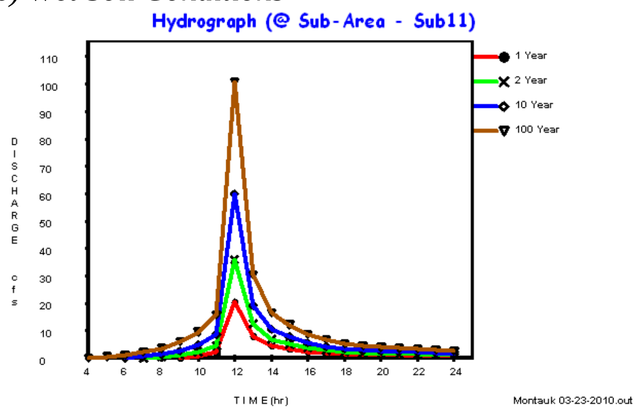
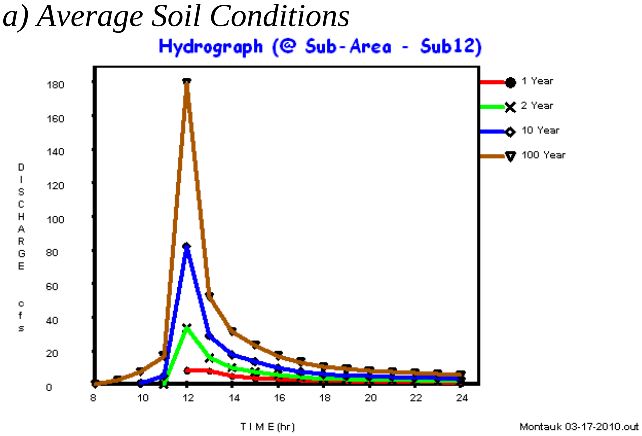
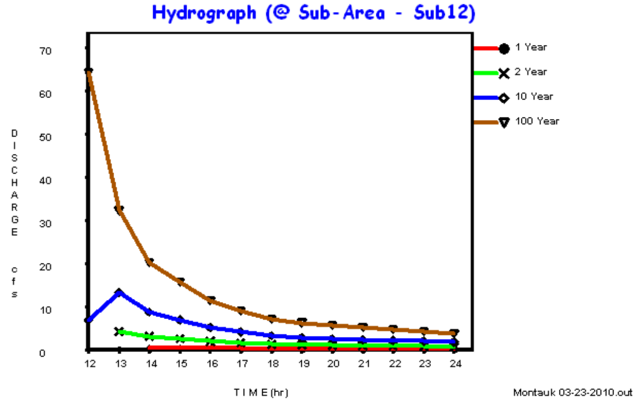


Figure 18 – Subwatershed 12 Hydrographs

a) Average Soil Conditions



b) Dry Soil Conditions



c) Wet Soil Conditions

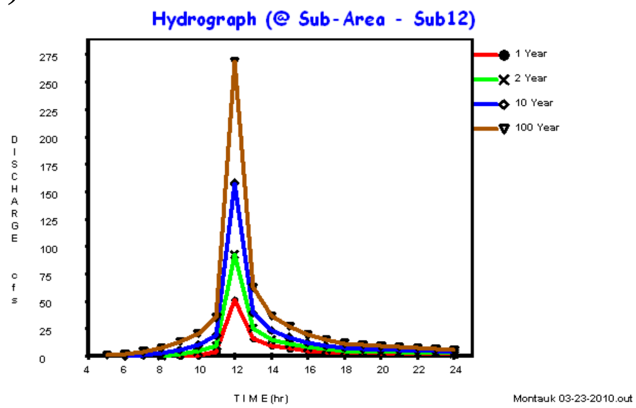
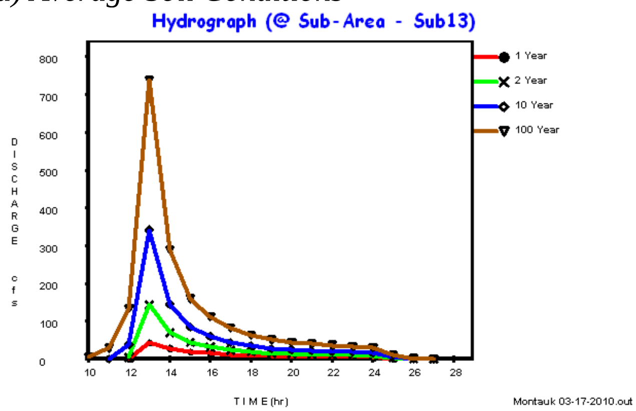
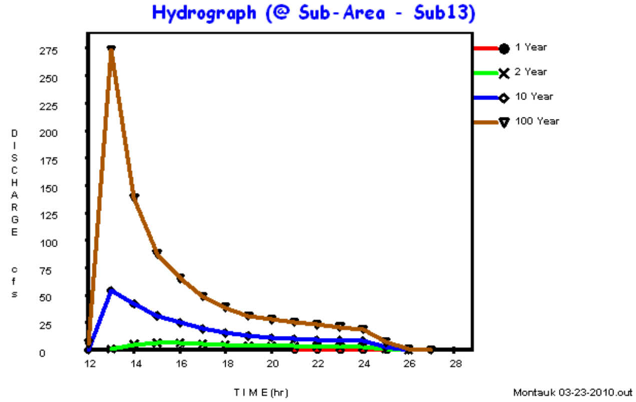


Figure 19 – Subwatershed 13 Hydrographs

a) Average Soil Conditions



b) Dry Soil Conditions



c) Wet Soil Conditions

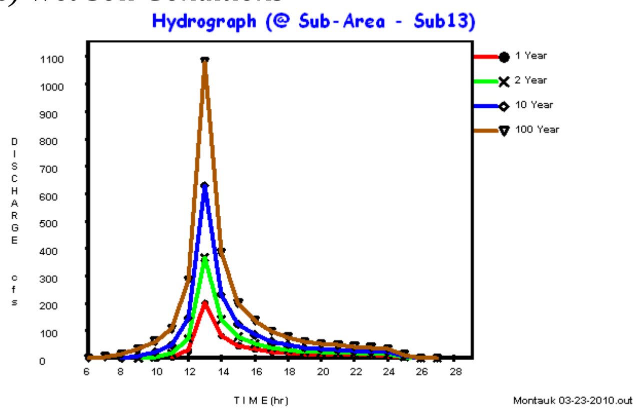
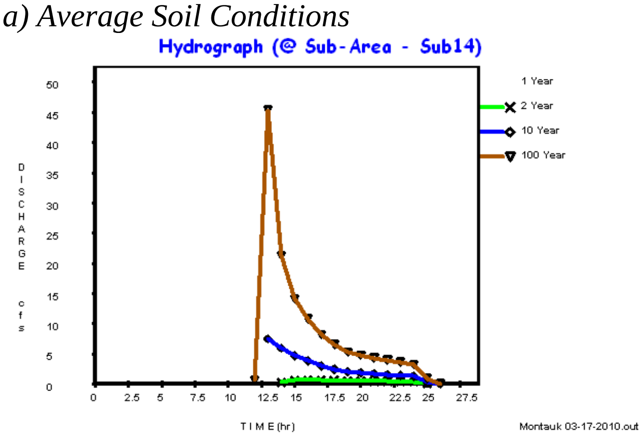
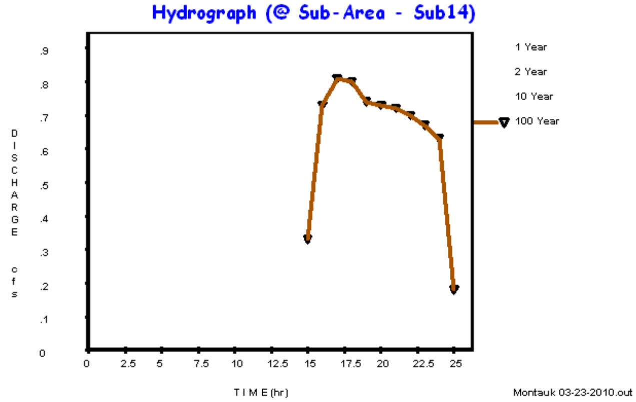


Figure 20 – Subwatershed 14 Hydrographs

a) Average Soil Conditions



b) Dry Soil Conditions



c) Wet Soil Conditions

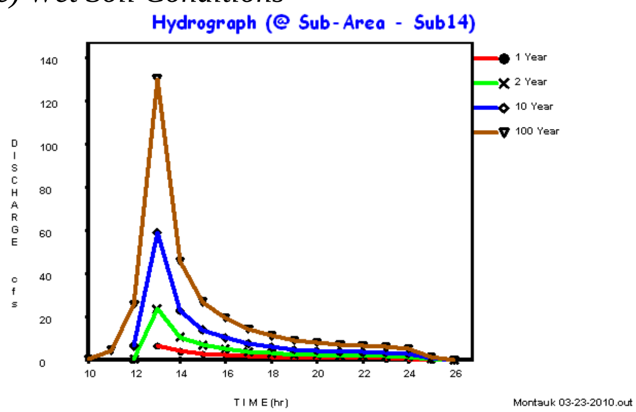
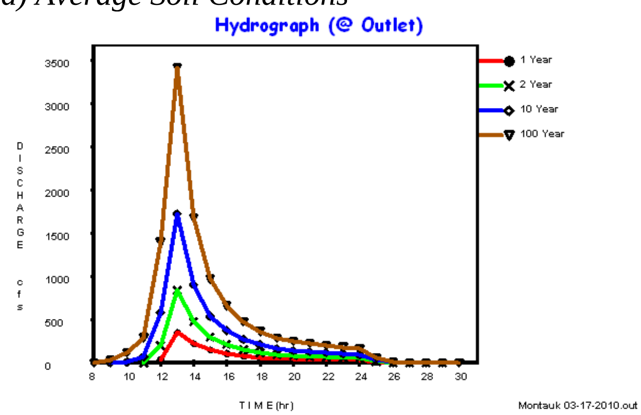
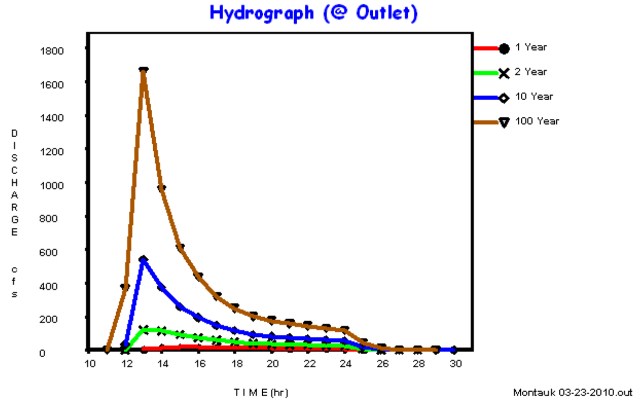


Figure 21 – All Subwatersheds Combined Hydrographs

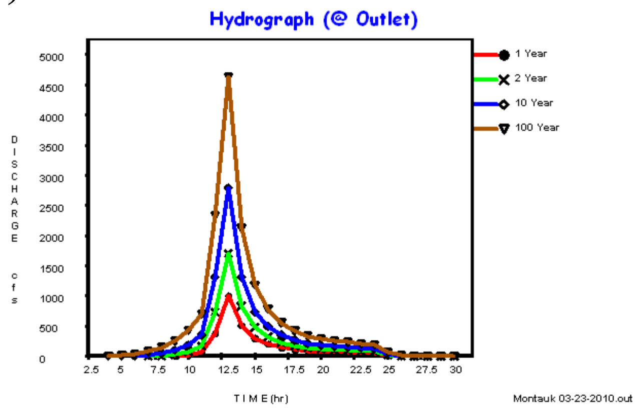
a) Average Soil Conditions



b) Dry Soil Conditions



c) Wet Soil Conditions



Runoff Tables

Table 2 – Runoff Volumes for Average Soil Conditions.

a) 1 Year Rain Event (2.5 inches)

Sub-Watershed	Area (square miles)	Runoff (inches)	Greatest Flow Rate (ft3/sec.)	Runoff (cubic feet)	Runoff (gallons)
1	0.330	0.575	54.750	440,827	3,297,616
2	0.494	0.584	87.410	670,234	5,013,698
3	0.596	0.496	50.080	686,775	5,137,434
4	0.336	0.557	41.440	434,792	3,252,466
5	0.187	0.508	27.380	220,695	1,650,911
6	0.080	0.544	15.760	101,106	756,323
7	0.575	0.702	64.250	937,760	7,014,930
8	0.247	0.473	31.190	271,422	2,030,376
9	0.093	0.536	23.110	115,807	866,296
10	0.148	0.589	31.730	202,518	1,514,940
11	0.065	0.586	16.910	88,491	661,956
12	0.149	0.492	33.160	170,309	1,274,001

13	0.810	0.321	45.590	604,055	4,518,647
14	0.154	0.000	0.000	0	0
All Subs	**4.263**	**0.499**	**381.800**	**4,941,997**	**36,968,705**

b) 2 Year Rain Event (3.5 inches)

Sub-Watershed	Area (square miles)	Runoff (inches)	Greatest Flow Rate (ft3/sec.)	Runoff (cubic feet)	Runoff (gallons)
1	0.330	1.190	125.460	912,321	6,824,632
2	0.494	1.204	198.080	1,381,784	10,336,459
3	0.596	1.072	123.020	1,484,320	11,103,487
4	0.336	1.164	96.560	908,613	6,796,896
5	0.187	1.090	66.590	473,538	3,542,309
6	0.080	1.145	36.970	212,805	1,591,893
7	0.575	1.376	135.060	1,838,116	13,750,061
8	0.247	1.036	78.890	594,488	4,447,081
9	0.093	1.132	54.900	244,577	1,829,565
10	0.148	1.212	71.610	416,726	3,117,329
11	0.065	1.207	38.420	182,267	1,363,449
12	0.149	1.065	82.790	368,657	2,757,746
13	0.810	0.791	143.860	1,488,497	11,134,734
14	0.154	0.060	0.740	21,466	160,580
All Subs	**4.263**	**1.063**	**940.730**	**10,527,741**	**78,752,972**

Table 2 – Runoff Volumes for Average Soil Conditions (continued).
c) 10 Year Rain Event (5 inches)

Sub-Watershed	Area (square miles)	Runoff (inches)	Greatest Flow Rate (ft3/sec.)	Runoff (cubic feet)	Runoff (gallons)
1	0.330	2.295	251.430	1,759,476	13,161,791
2	0.494	2.315	395.100	2,656,835	19,874,504
3	0.596	2.128	260.170	2,946,487	22,041,251
4	0.336	2.258	196.630	1,762,584	13,185,044
5	0.187	2.155	138.480	936,215	7,003,373
6	0.080	2.231	75.270	414,645	3,101,758
7	0.575	2.550	257.680	3,406,392	25,481,582
8	0.247	2.076	167.480	1,191,272	8,911,333
9	0.093	2.214	112.140	478,352	3,578,318
10	0.148	2.326	142.250	799,757	5,982,597
11	0.065	2.318	76.610	350,037	2,618,455
12	0.149	2.119	173.280	733,506	5,487,008
13	0.810	1.713	348.970	3,223,510	24,113,527

14	0.154	0.378	7.850	135,238	1,011,651
All Subs	**4.263**	**2.100**	**1,990.950**	**20,797,983**	**155,579,720**

d) 100 Year Rain Event (7.5 inches)

Sub- Watershed	Area (square miles)	Runoff (inches)	Greatest Flow Rate (ft3/sec.)	Runoff (cubic feet)	Runoff (gallons)
1	0.330	4.389	486.070	3,364,853	25,170,850
2	0.494	4.416	760.060	5,068,070	37,911,797
3	0.596	4.164	521.330	5,765,588	43,129,591
4	0.336	4.340	383.400	3,387,783	25,342,378
5	0.187	4.200	274.280	1,824,641	13,649,265
6	0.080	4.304	146.640	799,924	5,983,849
7	0.575	4.724	482.760	6,310,508	47,205,879
8	0.247	4.093	336.830	2,348,688	17,569,405
9	0.093	4.280	219.000	924,727	6,917,435
10	0.148	4.430	273.110	1,523,183	11,394,199
11	0.065	4.420	147.310	667,455	4,992,913
12	0.149	4.151	343.890	1,436,897	10,748,735
13	0.810	3.581	763.370	6,738,697	50,408,955
14	0.154	1.351	46.460	483,351	3,615,717
All Subs	**4.263**	**4.103**	**4,022.980**	**40,635,298**	**303,973,138**

Table 3 – Runoff Volumes for Dry Soil Conditions.
a) 1 Year Rain Event (2.5 inches)

Sub- Watershed	Area (square miles)	Runoff (inches)	Greatest Flow Rate (ft3/sec.)	Runoff (cubic feet)	Runoff (gallons)
1	0.330	0.070	1.980	53,666	401,449
2	0.494	0.074	3.130	84,927	635,297
3	0.596	0.045	2.070	62,308	466,098
4	0.336	0.064	1.810	49,958	373,712
5	0.187	0.048	0.760	20,853	155,992
6	0.080	0.060	0.410	11,151	83,418
7	0.575	0.137	6.820	183,010	1,369,010
8	0.247	0.038	0.760	21,806	163,117
9	0.093	0.057	0.450	12,315	92,125
10	0.148	0.076	0.970	26,131	195,476
11	0.065	0.074	0.420	11,175	83,592
12	0.149	0.044	0.540	15,231	113,935
13	0.810	0.001	0.230	1,882	14,077

14	0.154	0.000	0.000	0	0
All Subs	**4.263**	**0.056**	**19.500**	**554,613**	**4,148,793**

b) 2 Year Rain Event (3.5 inches)

Sub-Watershed	Area (square miles)	Runoff (inches)	Greatest Flow Rate (ft3/sec.)	Runoff (cubic feet)	Runoff (gallons)
1	0.330	0.318	18.490	243,797	1,823,725
2	0.494	0.326	29.960	374,137	2,798,742
3	0.596	0.256	16.310	354,465	2,651,579
4	0.336	0.304	14.150	237,301	1,775,134
5	0.187	0.265	7.830	115,126	861,204
6	0.080	0.294	4.860	54,642	408,748
7	0.575	0.459	32.840	613,151	4,586,685
8	0.247	0.237	8.070	135,998	1,017,334
9	0.093	0.287	6.650	62,009	463,856
10	0.148	0.330	10.860	113,465	848,778
11	0.065	0.327	5.570	49,380	369,385
12	0.149	0.252	8.470	87,232	652,537
13	0.810	0.099	6.750	186,297	1,393,601
14	0.154	0.000	0.000	0	0
All Subs	**4.263**	**0.265**	**121.420**	**2,624,507**	**19,632,679**

Table 3 – Runoff Volumes for Dry Soil Conditions (continued).

c) 10 Year Rain Event (5 inches)

Sub-Watershed	Area (square miles)	Runoff (inches)	Greatest Flow Rate (ft3/sec.)	Runoff (cubic feet)	Runoff (gallons)
1	0.330	0.930	81.830	712,990	5,333,536
2	0.494	0.945	130.370	1,084,539	8,112,919
3	0.596	0.811	76.040	1,122,933	8,400,120
4	0.336	0.904	62.000	705,658	5,278,689
5	0.187	0.830	40.910	360,584	2,697,355
6	0.080	0.885	23.520	164,483	1,230,415
7	0.575	1.180	103.120	1,576,291	11,791,477
8	0.247	0.775	46.590	444,719	3,326,726
9	0.093	0.872	34.110	188,402	1,409,347
10	0.148	0.952	47.300	327,330	2,448,595
11	0.065	0.947	25.080	143,005	1,069,749
12	0.149	0.805	48.780	278,656	2,084,493
13	0.810	0.480	57.670	903,260	6,756,855

14	0.154	0.000	0.000	0	0
All Subs	**4.263**	**0.809**	**562.220**	**8,012,175**	**59,935,235**

d) 100 Year Rain Event (7.5 inches)

Sub-Watershed	Area (square miles)	Runoff (inches)	Greatest Flow Rate (ft3/sec.)	Runoff (cubic feet)	Runoff (gallons)
1	0.330	2.364	245.310	1,812,375	13,557,505
2	0.494	2.389	388.180	2,741,762	20,509,801
3	0.596	2.162	245.370	2,993,564	22,393,414
4	0.336	2.320	189.560	1,810,981	13,547,078
5	0.187	2.194	132.250	953,158	7,130,116
6	0.080	2.288	72.880	425,239	3,181,005
7	0.575	2.773	268.740	3,704,284	27,709,971
8	0.247	2.098	157.570	1,203,896	9,005,769
9	0.093	2.267	108.440	489,803	3,663,978
10	0.148	2.402	139.880	825,888	6,178,074
11	0.065	2.393	75.110	361,362	2,703,177
12	0.149	2.151	164.840	744,583	5,569,870
13	0.810	1.554	273.820	2,924,305	21,875,319
14	0.154	0.071	0.820	25,402	190,019
All Subs	**4.263**	**2.122**	**1,836.290**	**21,015,867**	**157,209,602**

Table 4 – Runoff Volumes for Wet Soil Conditions.
a) 1 Year Rain Event (2.5 inches)

Sub-Watershed	Area (square miles)	Runoff (inches)	Greatest Flow Rate (ft3/sec.)	Runoff (cubic feet)	Runoff (gallons)
1	0.330	1.323	146.330	1,014,286	7,587,385
2	0.494	1.340	231.120	1,537,865	11,504,033
3	0.596	1.243	154.680	1,721,092	12,874,659
4	0.336	1.293	113.660	1,009,310	7,550,160
5	0.187	1.243	80.780	540,007	4,039,532
6	0.080	1.271	43.240	236,223	1,767,071
7	0.575	1.455	148.410	1,943,647	14,539,491
8	0.247	1.211	99.080	694,909	5,198,277
9	0.093	1.257	64.170	271,584	2,031,592
10	0.148	1.349	83.020	463,832	3,469,701
11	0.065	1.342	44.670	202,653	1,515,948
12	0.149	1.243	102.830	430,273	3,218,665
13	0.810	0.998	208.520	1,878,028	14,048,628

14	0.154	0.259	6.640	92,663	693,169
All Subs	**4.263**	**1.215**	**1,174.830**	**12,033,119**	**90,013,981**

b) 2 Year Rain Event (3.5 inches)

Sub-Watershed	Area (square miles)	Runoff (inches)	Greatest Flow Rate (ft3/sec.)	Runoff (cubic feet)	Runoff (gallons)
1	0.330	2.197	243.020	1,684,343	12,599,762
2	0.494	2.218	381.270	2,545,512	19,041,750
3	0.596	2.098	262.630	2,904,948	21,730,519
4	0.336	2.160	190.660	1,686,086	12,612,796
5	0.187	2.098	136.620	911,452	6,818,133
6	0.080	2.132	72.670	396,245	2,964,118
7	0.575	2.357	240.560	3,148,575	23,552,976
8	0.247	2.057	169.560	1,180,369	8,829,774
9	0.093	2.115	107.960	456,962	3,418,312
10	0.148	2.229	136.910	766,405	5,733,108
11	0.065	2.221	73.660	335,389	2,508,882
12	0.149	2.098	173.880	726,237	5,432,630
13	0.810	1.783	381.860	3,355,235	25,098,902
14	0.154	0.686	24.400	245,432	1,835,960
All Subs	**4.263**	**2.054**	**2,020.610**	**20,342,408**	**152,171,783**

Table 4 – Runoff Volumes for Wet Soil Conditions (continued).
c) 10 Year Rain Event (5 inches)

Sub-Watershed	Area (square miles)	Runoff (inches)	Greatest Flow Rate (ft3/sec.)	Runoff (cubic feet)	Runoff (gallons)
1	0.330	3.585	391.900	2,748,462	20,559,922
2	0.494	3.609	613.610	4,141,908	30,983,622
3	0.596	3.467	433.720	4,800,503	35,910,252
4	0.336	3.540	310.110	2,763,307	20,670,972
5	0.187	3.467	224.280	1,506,198	11,267,143
6	0.080	3.508	118.110	651,983	4,877,170
7	0.575	3.772	381.800	5,038,788	37,692,755
8	0.247	3.417	279.340	1,960,778	14,667,642
9	0.093	3.487	175.900	753,393	5,635,770
10	0.148	3.622	219.690	1,245,365	9,315,979
11	0.065	3.613	118.410	545,592	4,081,311
12	0.149	3.467	283.490	1,200,126	8,977,563
13	0.810	3.079	662.400	5,794,038	43,342,411

14	0.154	1.550	63.670	554,548	4,148,306
All Subs	**4.263**	**3.403**	**3,356.210**	**33,702,637**	**252,113,231**

d) 100 Year Rain Event (7.5 inches)

Sub-Watershed	Area (square miles)	Runoff (inches)	Greatest Flow Rate (ft3/sec.)	Runoff (cubic feet)	Runoff (gallons)
1	0.330	5.984	640.820	4,587,670	34,318,151
2	0.494	6.012	1,000.250	6,899,737	51,613,615
3	0.596	5.848	719.700	8,097,300	60,572,009
4	0.336	5.932	510.320	4,630,491	34,638,476
5	0.187	5.847	371.040	2,540,161	19,001,726
6	0.080	5.895	194.500	1,095,621	8,195,815
7	0.575	6.197	616.440	8,278,200	61,925,240
8	0.247	5.790	465.040	3,322,478	24,853,862
9	0.093	5.870	289.250	1,268,258	9,487,230
10	0.148	6.027	357.150	2,072,285	15,501,769
11	0.065	6.016	192.570	908,464	6,795,784
12	0.149	5.847	467.930	2,023,979	15,140,413
13	0.810	5.386	1,148.490	10,135,332	75,817,546
14	0.154	3.342	145.310	1,195,677	8,944,283
All Subs	**4.263**	**5.760**	**5,634.380**	**57,045,897**	**426,732,945**

Discussion

Generally speaking, the hydrographs show a normal distribution with the greatest flow rate occurring about an hour after the peak of a storm event. The delay is attributed to the time it takes the runoff to concentrate. Subwatersheds which are smaller (shorter distance for runoff to travel) or have steeper slopes will have the greatest flow rate occur earlier in comparison to large or minimally sloped watersheds.

Within a subwatershed and a given antecedent soil condition, the size of a storm has a large influence on the greatest flow rate and the amount of runoff generated. This is intuitive since once a soil becomes saturated with water all subsequent rainfall will be forced to run off. In subwatershed 1 under normal soil conditions, a 1 year 3.5 inch rainfall event will have a greatest flow rate of 54.75ft^3/second (Figure 7a) and generate a total runoff of approximately 440,827 ft^3 (Table 2a). However, during a 10 year 5.0 inch rainfall event the greatest flow rate will be 251.43ft^3/second (Figure 7a) and the total runoff will be 1,759,476ft^3 (Table 2c). Obviously, the greater amount of rainfall which exceeds the soil capacity, the greater amount of runoff is generated. An exception to this can be seen in subwatershed 14. Even in a 10 year rainfall event comparatively little runoff is generated (Table 2c) and in a smaller 1 year rainfall event no runoff is generated (Table 2a). The reason for this is because subwatershed 14 is largely comprised of sand which has an extremely high capacity to infiltrate water, and also the watershed is relatively flat.

Antecedent soil condition also has a significant impact on the hydrographs and runoff generated. In general when soils are dry they can absorb a significant portion of a rainfall event. If they are very moist or partially saturated with water, then they can absorb proportionately less rainfall. For a 2 year storm event in subwatershed 2, under dry soil conditions the greatest flow rate is 29.96ft^3/second (Figure 8b) and the total runoff is 374,137ft^3 (Table 3b). But with the same storm event under conditions where the soil was already wet prior to the rainfall, the greatest flow rate and total runoff increase to 381.27ft^3/second (Figure 8c) and 2,545,512 ft^3 (Table 4b) respectively. The antecedent soil condition also impacts the timing of when discharges commences. When the soil is already saturated prior to a rainfall event, the runoff/discharge starts earlier in comparison to when the soil was dry prior to the rainfall. Using subwatershed 2 during a 2 year rainfall event as an example, discharge starts around hour 12 (Figure 8b) when the soil was dry compared to hour 6 (Figure 8c) when the soil was already wet. This occurs because dry soil absorbs most if not all the early rainfall therefore causing the runoff to initiate later in the storm event.

Although there are some variations between rainfall events and antecedent soil conditions, in general subwatershed 2 had the highest greatest flow rates. This can be attributed to a number of factors including the size of the watershed (one of the larger ones), hydrological soil group composition (relatively small proportion of well draining sandy soils), and the significant slope of the watershed (approximately 140 foot drop in elevation). The greatest total runoff however in dry or average conditions comes from subwatershed 7. Although there are a couple of subwatersheds which are larger, subwatershed 7 generates the most runoff because of its size and almost complete absence of well draining sandy type soils. It’s also worth noting that even though a large portion of it is undeveloped, subwatershed 13 generates a significant amount of runoff due to its large extent. Regardless of the size of the rainfall event and antecedent soil condition, subwatershed 14 always had the lowest flow rate and runoff volumes. This is partly attributed to its small size (though there are 5 smaller subwatersheds), but to a much greater degree to the fact that it is almost completely comprised of very well draining sand and is relatively flat.

When the runoff generated from all subwatersheds are added together, it can be seen that the total inputs to Lake Montauk are very significant. As would be expected, greater rainfalls and higher antecedent soil moisture conditions result in dramatically greater runoff volumes (Table 5). For example, for a 1 year rainfall event under normal soil moisture conditions there is 4,941,997 ft^3 of runoff, which equates to approximately 37 million gallons. Under worst case conditions, a 100 year rainfall event with wet antecedent soils, the runoff volumes increase to a staggering 57,045,897 ft^3 or approximately 427 million gallons.

Table 5 – Total runoff volumes for all subwatersheds.

Rainfall Event (Years)	Normal Soil (cubic feet)	Dry Soil (cubic feet)	Wet Soil (cubic feet)
1	4,941,997	554,613	12,033,119
2	10,527,741	2,624,507	20,342,408

10	20,797,983	8,012,175	33,702,637
100	40,635,298	21,015,867	57,045,897

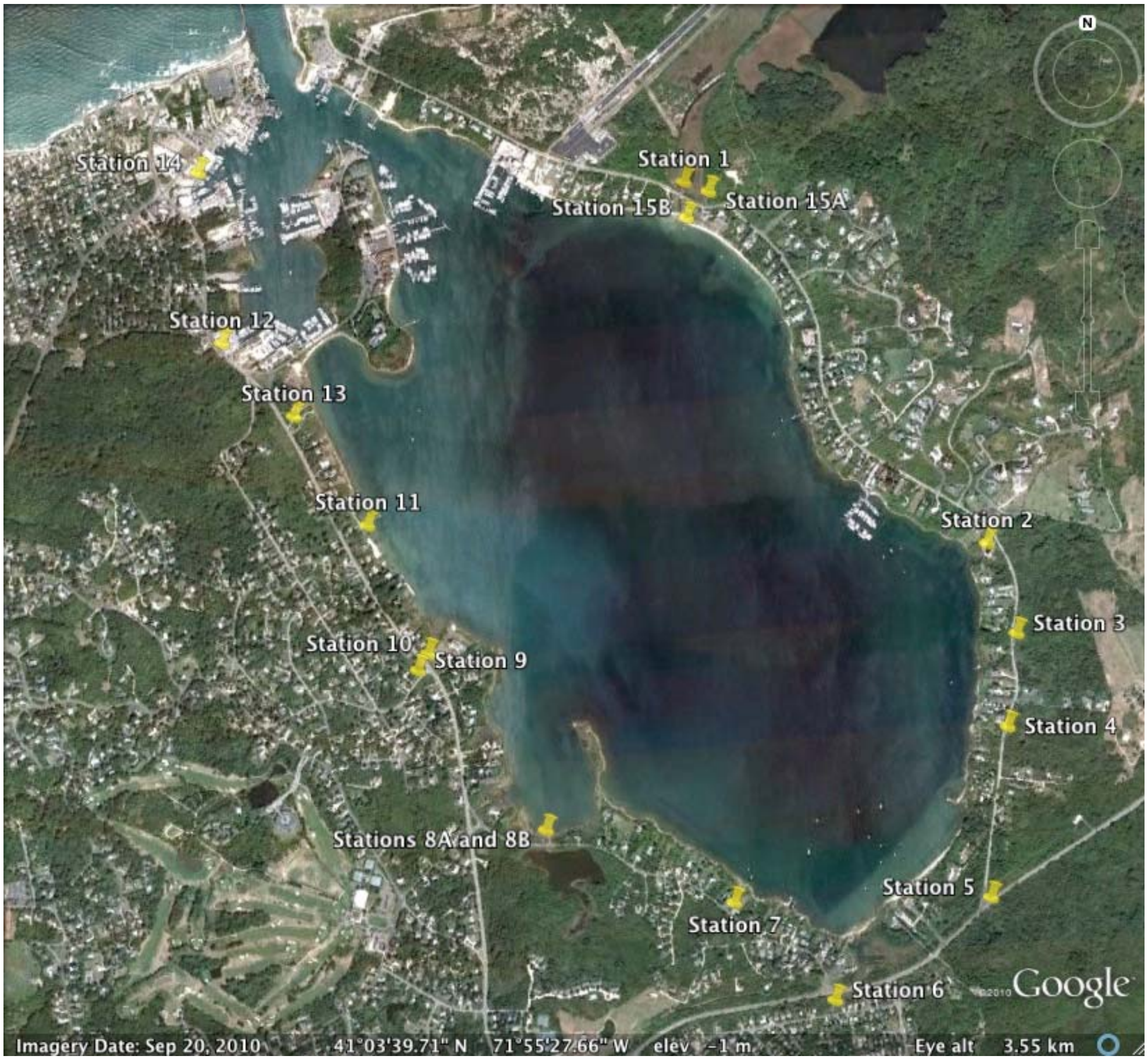
As mentioned previously, it's important to note that this analysis does not take into account stormwater water conveyance systems. This significantly impacts the values for both the greatest flow rates and total runoff produced. In some cases, greatest flow rates will occur earlier than predicted since conveyances carry water faster than natural runoff. Also, in most subwatersheds the peak discharges and runoff volumes have been over estimated since storage devices such as leaching basins and detention ponds are not taken into consideration. While a detailed analysis could not be incorporated into the model since it was beyond the scope of the project, a few examples highlight the significance of stormwater structures. As demonstrated in Table 6, detention ponds are able to prevent a significant amount of runoff from reaching Lake Montauk.

Table 6 – Examples Highlighting the Impact of Detention Ponds

Detention Pond Name	Subwatershed Number	Approximate Pond Area (ft^2)	Average Available Depth (ft)	Average Capacity (ft^3)	% of Runoff Absorbed
Glouchester West Lake	3	9,513	1	9,513	1.4
Drum Property	2	31,518	0.75	19,699	2.9
Ditch Plains	7	27,846	1.25	34,808	3.7

The provided examples assume average soil conditions and a 1-year rain event. As can be seen, the detention ponds capture between 1.4 and 3.7% of their respective subwatersheds' runoff. In antecedent dry conditions the percentages would increase since the water level in the ponds prior to the rainfall would be lower (thus increasing the available pond capacity) with the inverse being true during antecedent wet conditions. However, the positive impact of stormwater structures is greater than the percent of water captured. In addition to preventing some water from reaching Lake Montauk, detention basins also have the benefit of capturing some pollutants in the water that passes through due to the increased residence time which promotes particulate settling. Some leaching structures also capture what is referred to as the "first flush", which is thought to contain a higher proportion of pollutants. Finally, it's also worth mentioning that the additive effect of other existing stormwater structures such as leaching pools will further increase the percentage of absorbed water thus preventing the associated pollutants from being directly discharged into Lake Montauk.

Streamflow and Coliform Sampling Stations



Station 1: Reed Pond Outflow

Address: East Lake Drive

Location & Pipe Description: 36 in pipe discharging water from Little Reed Pond. There is a stream channel located below the pipe.

West side of East Lake Drive

Pipe into Lake Montauk

Aerial Photo of Site 1

Station 2: Bond Property

Address: East Lake Drive
Location & Pipe Description: Pipe is located in a headwall. Retention Pond constructed June-July, 2010.

© 2011 Google
Google earth
Imagery Date: 9/19/2010
1994
41°03'37.52" N 71°54'25.94" W elev 7 ft
Eye alt 488 ft
N

Station 3:

Address: 105 East Lake Drive
Location & Pipe Description: The pipe diameter was 12 inches. Channel present.

Aerial Photo of Site 3

Station 4:

Address: 61&67 East Lake Drive

Location & Pipe Description: Pipe diameter is 12 inches.

Pipe on eastern portion of road.

Pipe on western portion of the road. Note silt fence in front of pipe.

Aerial of Site 4

Station 5: Amsterdam Park

Address: Drains intersection of East Lake Drive and Montauk Highway
Location & Pipe Description: Pipe diameter is 24 inches. No bottom lip on pipe-cracked. Pipes and channels on both sides of the road.

Aerial of Site 5

Station 6: Ocean Side Drain

Address: Benson Drive

Location & Pipe Description: Two pipes found. One discharges directly into channel and the other is raised above the channel. The pipe that discharges into the channel was underwater and flowing. The pipe raised above the channel was dry. Water flows through wetland.


Pipe located above the channel.


Pipe that discharges directly into channel.

Aerial of Site 6

Station 7:

Address: 64 Old West Lake Drive

Location & Pipe Description: Have to lift cover to access pipe. Pipe approximately 16 inches. There is a channel across the street, but there is no pipe apparent.

Pipe located under cover to the left. There is no stream channel.

Looking down at pipe

Aerial of Site 7

Station 8: Stepping Stones Pond Outflow

Address: Old West Lake Drive
Location & Pipe Description: Pipes are two black 12 inch corrugated plastic.

Aerial of Site 8

Station 9: Peter's Run-Stream

Address: 8 Gloucester Avenue
Location & Pipe Description: Pipe diameter is 24 inches. There is a creek that the pipe discharges into. The stream has a sandy bottom.

Aerial of Site 9 and 10

Station 10: Peter's Run-Retention Pond

Address: West Lake Drive and Gloucester Avenue.
Location & Pipe Description: Discharge from the pond/lake.

Station 11:

Address: West Lake Drive and Glenmore Avenue
Location & Pipe Description: Pipe diameter is 18 inches. Pipe discharges directly to beach. No stream channel present.

Aerial Site 11

Station 12: Diamond Cove Marina

Address: Diamond Cove Marina, 364 West Lake Drive

Location & Pipe Description: Outfall discharges directly into lake through bulk heading at Diamond Cove Marina. Pipe on other side of the street is 16 in and has a small channel.

Aerial of Site 12. The red dot is of the pipe found across the street from the marina outfall

Station 13: Drum Property

Address: West Lake Drive

Location & Pipe Description: Outlet of the pond, located on the west side of the street. Pipe is 16 inches.

Aerial of Site 13

Station 14: Sea Otter/Uihlen's Marina

Address: 444 West Lake Drive
Location & Pipe Description: Pipe diameter is 4 ft. Discharges directly into lake from marina.

Aerial of Site 14

Station 15A and 15B: South of Reed Pond outfall

Address: East Lake Drive
Location & Pipe Description: Pipe diameter is 12 ft. Pipe runs from east side of East Lake Drive (15A) to outfall along beach (15B)

Aerial of 15B

Streamflow

In most cases flow readings were taken for pipes that were partially filled and using calculations to determine the average velocity of the water. To determine the partially filled portion of a pipe, measurements of the pipes' diameter as well as the portion of the pipe that was filled with water was recorded. Nearly all the pipes for the contributing streamlets had round pipes. Appendix A of the flow meter manual provided the calculations for partially filled round pipes. Water flow was measured using a Global Water Flow Probe.

Sampling procedures;

1. Point the propeller into the flow that is to be measured. The propeller must flow freely, so check for any debris to ensure proper functionality.
2. Pressing the reset button will start the flowmeter to record minimum, maximum and average velocities. Averages are updated once per second. Maintain flowmeter within the stream flow for one minute.
3. Record average velocity, pipe diameter and height of water within the pipe.

Using this data allows for volumetric flow calculations. From Global Water:

Appendix A: Calculations for Partially Filled Round Pipes

B	C	B	C
0.01	0.0013	0.51	0.4027
0.02	0.0037	0.52	0.4127
0.03	0.0069	0.53	0.4227
0.04	0.0105	0.54	0.4327
0.05	0.0147	0.55	0.4426
0.06	0.0192	0.56	0.4526
0.07	0.0242	0.57	0.4625
0.08	0.0294	0.58	0.4723
0.09	0.0350	0.59	0.4822
0.10	0.0409	0.60	0.4920
0.11	0.0470	0.61	0.5018
0.12	0.0534	0.62	0.5115
0.13	0.0600	0.63	0.5212
0.14	0.0668	0.64	0.5308
0.15	0.0739	0.65	0.5404
0.16	0.0811	0.66	0.5499
0.17	0.0885	0.67	0.5594
0.18	0.0961	0.68	0.5687
0.19	0.1039	0.69	0.5780
0.20	0.1118	0.70	0.5872
0.21	0.1199	0.71	0.5964
0.22	0.1281	0.72	0.6054
0.23	0.1365	0.73	0.6143
0.24	0.1449	0.74	0.6231
0.25	0.1535	0.75	0.6318
0.26	0.1623	0.76	0.6404
0.27	0.1711	0.77	0.6489
0.28	0.1800	0.78	0.6573
0.29	0.1890	0.79	0.6655
0.30	0.1982	0.80	0.6736
0.31	0.2074	0.81	0.6815
0.32	0.2167	0.82	0.6893
0.33	0.2266	0.83	0.6969
0.34	0.2355	0.84	0.7043
0.35	0.2450	0.85	0.7115
0.36	0.2546	0.86	0.7186
0.37	0.2644	0.87	0.7254
0.38	0.2743	0.88	0.7320
0.39	0.2836	0.89	0.7384
0.40	0.2934	0.90	0.7445
0.41	0.3032	0.91	0.7504
0.42	0.3130	0.92	0.7560
0.43	0.3229	0.93	0.7612
0.44	0.3328	0.94	0.7662
0.45	0.3428	0.95	0.7707
0.46	0.3527	0.96	0.7749
0.47	0.3627	0.97	0.7785
0.48	0.3727	0.98	0.7816
0.49	0.3827	0.99	0.7841
0.50	0.3927	1.00	0.7854

H= Height of water; D= Diameter of pipe (in feet)

H/D = Column B

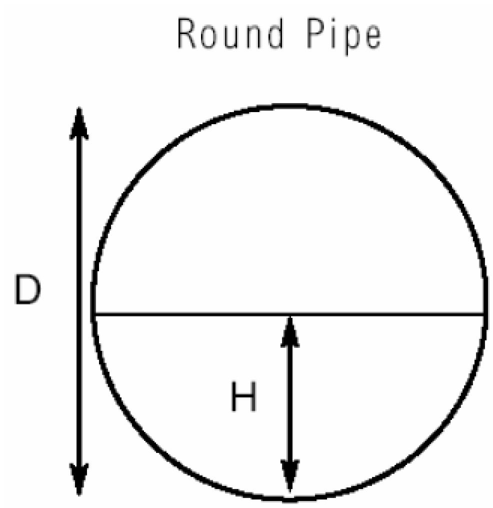
Read Column C adjacent to your pipe's B

C x D2 = Filled area, A (sq.ft.)

A x Average Velocity = Volumetric flow (CFS)

CFS x 448.83 = Gallons/minute (GPM)

GPM x 1440 = Gallons/day (GPD)



Alternatively, some stations did not have clearly evidence pipes, such as station 7. For early flow samples, the stream either had no measurable flow, or due to lack of rain flow, the stream bed was dry, with no flow. Flow samples taken in 2011 had mesurable flow, and a velocity-area method/midsection method was used to calculate streamflow. In essence the stream is broken up into measurable segments and these partial flows are added to determine total discharge.

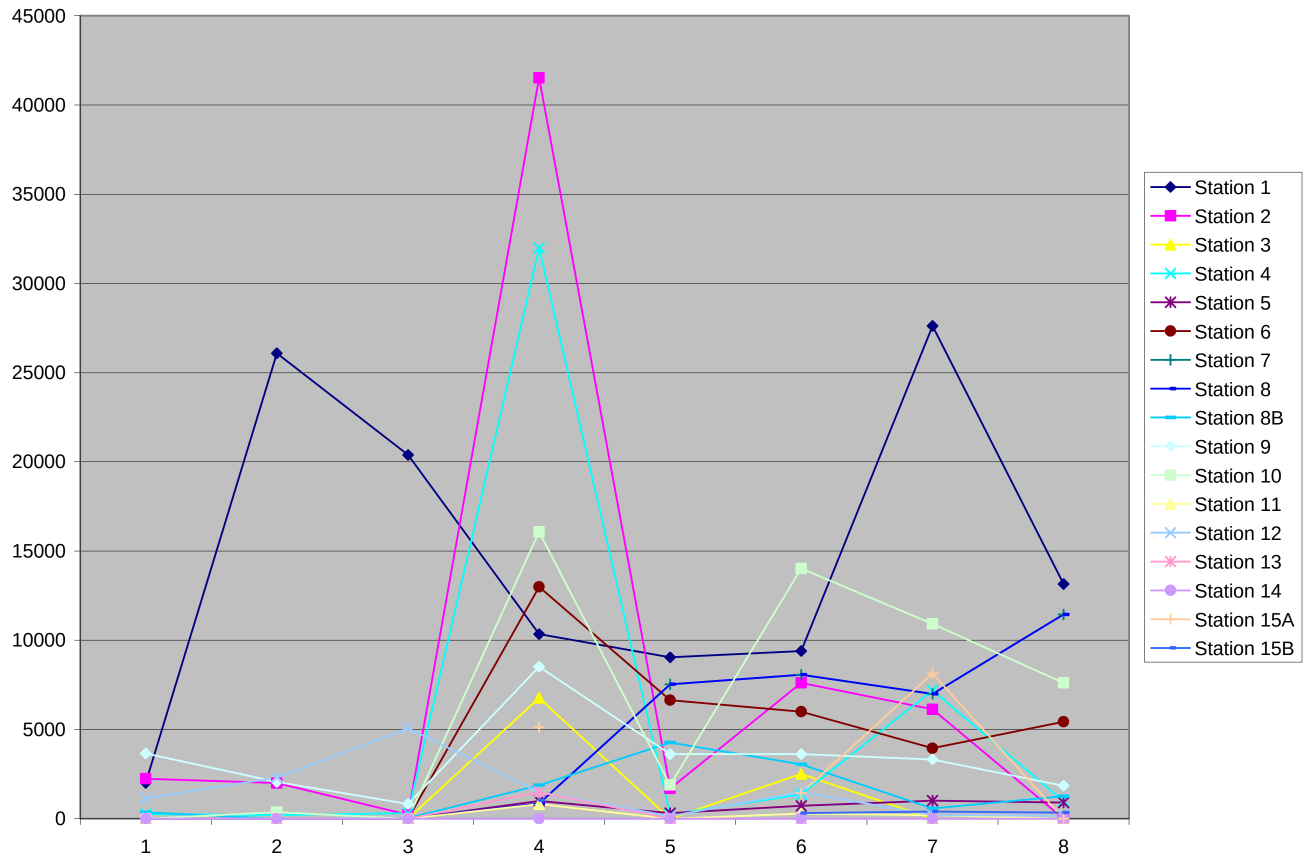
The partial discharge for each increment is: $q_x = v_x\ [(b_{(x+1)} – b_{(x-1)}/2]\ d_x$
v_x = mean stream velocity at observation point x
$b_{(x-1)}$ = distance from the datum to the preceding observation point
$b_{(x+1)}$ = distance from the datum to the next observation point
d_x = depth of the water at observation point x

Sum all partial discharges for total discharge of stream.

For a forecasted rainfall event, technicians were dispatched to Lake Montauk to capture the rainfall event.

Station	5/12/10	10/6/10	11/4/10	2/25/10	2/28/10	3/11/11	3/16/11	4/1/11
1	2014.564	26086.9	20387.69	10349.12	9050.352	9401.301	27613.49	13149.28
2	2239.734	1993.478	219.9267	41514.76	1692.053	7614.239	6125.129	0
3	0	0	0	6768.213	0	2504.148	0	0
4	260.1419	206.8209	316.6944	31986.79	237.5208	1361.786	7191.226	981.7528
5	0	0	0	992.0938	316.6944	722.5804	1007.39	904.8413
6	0	0	0	12991.51	6641.535	6003.622	3948.124	5437.845
7	0	0	0	852.7052	7540.344	8078.94	7001.748	11445.17
8A	0	0	0	2097.293	3245.687	372.2776	3050.608	1563.867
8B	348.3639	0	33.93155	1874.314	4264.065	3050.608	572.743	1264.193
9	3661.806	2058.514	828.1452	8524.251	3622.597	3622.597	3319.69	1850.4
10	0	364.9526	0	16074.51	1896.289	14016.21	10927.9	7614.239
11	0	0	0	818.4146	0	292.6596	194.0965	0
12	1140.1	2314.886	5073.574	1492.27	150.8069	1492.27	191.8838	172.3507
13	0	0	0	1501.39	0	0	0	0
14	0	0	0	0	0	0	0	0
15A	-	-	-	5125.926	-	1429.972	8140.125	0
15B	-	-	-	1017.516	-	311.0392	406.4245	337.1611
Rainfall	0.25"	0.57"	1.07"	1.70"	0.21"	0.66"	0.41"	0.35"

Figure 1.Flow rates of stream inputs to Lake Montauk during rainfall events. Data in Gallons Per Minute (GPM).


45000
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Station 1
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Station 3
Station 4
Station 5
Station 6
Station 7
Station 8
Station 8B
Station 9
Station 10
Station 11
Station 12
Station 13
Station 14
Station 15A
Station 15B

24-hour Streamflow and coliform study

As part of the watershed plan 3 stations were chosen to be monitored during wet event over a 24-hour period .

The three streamlets were chosen based on data collected during the flow analysis and the data obtained during coiform analysis. Coincidently the stations chosen were from the western, eastern and southern portions of the lake.

The 24-Hour survey was conducted from June 22 to June 23 of 2011.

Coliform Enumeration

Using the membrane filtration method, streams were assayed for presence of E. coli bacteria. *E. coli* bacteria is used as an indicator organisms for the possible presence of pathogens in the water. Currently Suffolk County Health codes for bathing beaches use E. coli as their indicator organism for freshwater pathogens. Currently if a single water sample at a fresh water beach is above 235 CFU (colony forming units) per 100ml of sample, the beach is then closed.

Stations for analysis were chosen with collaboration of Cornell Cooperative Extension Marine Program and the Natural Resource Department of East Hampton, based on historical data and known problem areas.

To determine the load going in to the lake, the chosen streams were sampled 4 times during dry events (no rain in the preceding 72 hours), and 4 times during a wet event, for a total of 8 sampling events per station.

Station 1
Reed Pond
Notes:

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	11	24	254	74	104	490	0	232

Station 2
Bond Property
Notes: 11/30/09: No Sample- Pipe under water
6/28/09: No Sample- New retention pond under construction

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	3900	no sample	87	no sample	360	950	70	43

Station 3
105 East Lake Drive
Notes:

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	1300	610	268	1350	1700	840	99	106

Station 4
61&67 East Lake Drive

Notes: 8/9/2010: No sample-no flow

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	10800	62	74	5300	no sample	950	700	26

Highlighted samples indicate samples saved for DNA analysis.

Station 5
Amsterdam Park
Notes: 8/9/2010: No sample-no flow

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	Wet	dry	dry	wet	wet	wet
MPN/100ml	125	76	21	12	no sample	8400	11	82

Station 6
Ocean Side Drain
Notes:

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	1020	710	540	14500	1800	3200	36	164

Station 7
#64 Old West Lake Drive
Notes: 6/28/2010: No Sample-no flow
8/9/2010: No Sample-no flow

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	380	79	510	no sample	no sample	14300	48	214

Station 8A
Stepping Stones Pond (southern pipe)
Notes: 6/28/10: No Sample-no flow
8/9//10: No Sample-no flow

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	274	55	95	no sample	no sample	590	no sample	0

Highlighted samples indicate samples saved for DNA analysis.

Station 8B
Stepping Stones Pond (northern pipe)
Notes: This pipe was not added to the sample list until the 6/28/09 sample event.

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml				124	28	320	0	1

Station 9
Peter’s Run- 8 Gloucester Avenue
Notes:

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	1300	85	99	1170	4300	3300	66	218

Station 10
Peter’s Run- Retention Pond
Notes:

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	242	96	138	240	60	580	12	188

Station 11
West Lake Drive & Glenmore Avenue
Notes: 8/19/2009- No Sample-no flow
6/28/210- No Sample-no flow
8/9/2010- No Sample-no flow
12/1/2010- No Sample-no flow

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	no sample	33	340	no sample	no sample	11000	no sample	82

Highlighted samples indicate samples saved for DNA analysis.

Station 12
Diamond Cove Marina
Notes: 8/9/2010- No Sample-no flow

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	2	37	17	58	no sample	240	19	39

Station 13
Drum Property
Notes: 12/1/2010- No Sample-no flow from creek. Pipe in marina under water.

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	22	380	160	1330	190	550	no sample	148

Station 14
CR 77-Uihlen's Marina
Notes: 11/30/09- No Sample- tidal exchange in pipe/pipe under water.
4/20/10- No Sample- tidal exchange in pipe/pipe under water.
6/28/10- No Sample- tidal exchange in pipe/pipe under water.
8/9/10- No Sample- tidal exchange in pipe/pipe under water.
11/4/10- No Sample- tidal exchange in pipe/pipe under water.
12/1/10- No Sample- tidal exchange in pipe/pipe under water.
3/11/11- No Sample- tidal exchange in pipe/pipe under water.

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	50	no sample	no sample	no sample	no sample	no sample	no sample	no sample

Highlighted samples indicate samples saved for DNA analysis.

Station 15A
Pipe south of Reed Pond (East Lake Drive, East Side)
Notes: 12/1/10: Pipe was not added to sample list until 12/1/10. No Sample-no flow.

Date	8/19/09	11/30/09	4/28/10	6/28/10	8/9/10	11/4/10	12/1/10	3/11/11	4/1/11
Condition	dry	dry	wet	Dry	dry	wet	wet	wet	wet
MPN/100ml							No sample	25	75

Station 15B
Pipe south of Reed Pond (Outfall)
Notes: 12/1/10: Pipe was not added to sample list until 12/1/10. No Sample-no flow.

Date	8/19/09	11/30/09	4/28/10	6/28/10	8/9/10	11/4/10	12/1/10	3/11/11	4/1/11
Condition	dry	dry	wet	Dry	dry	wet	wet	wet	wet
MPN/100ml							No sample	53	35

COLIFORM DISCUSSION

The largest coliform numbers were observed during summer and fall events. All coliform numbers that were above 1,000 (18 samples) came from samples obtained during these 2 seasons. Additionally, the next 9 highest samples, between 550 and 950, all came from fall sampling events. The highest count during a spring event was 540, and 232 for a winter sample.

The use of detention ponds to help alleviate bacterial flush into Lake Montauk can be evidenced by the detention pond located at West Lake Drive and Gloucester.

Station 9
Peter's Run- 8 Gloucester Avenue
Notes:

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	Wet	dry	dry	wet	wet	wet
MPN/100ml	1300	85	99	1170	4300	3300	66	218

Station 10
Peter's Run- Retention Pond
Notes:

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	Wet	dry	dry	wet	wet	wet
MPN/100ml	242	96	138	240	60	580	12	188

In most cases the coliform level dropped significantly from water taken from approximately 225 feet away.

Rain fall and lack of rain fall can have a large impact on the water entering the Lake. For the summer of 2010 (June 20th-Sepetember 20th) for instance, there was a total of 5.95" (June: 0.15"; July: 2.05", August: 0.86", September: 2.89"). The total rainfall for the same period this past year, 2011, was 19.28". The past 10 years the average for the summer season was 9.98" of rain (2000:8.31", 2001: 6.13", 2002: 4.22", 2003:8.33", 2004: 14.60", 2005: 3.68", 2006: 19.07", 2007: 8.02", 2008: 14.43", 2009: 13.00")The smaller amount of rainfall in 2010 was evidenced by the lack of any stream flow in the channel at several stations during 2010. Stations 5 and 7, had little to no flow during the June and August sampling events of 2010. The section on flow discusses in more detail the flow rates at the stations.
Rain fall for sampling events:

August 19, 2009: Dry sampling event.
Total rain for July 2009: 7.4"
Total rain for August 2009: 2.37"
Rainfalls within past month: 8/13:0.15"; 8/12:0.02; 8/2:0.09; 7/31:0.6; 7/30:0.05; 7/26:0.08; 7/25:0.06; 7/24: 0.91; 7/23:2.04;7/21:0.92

November 30, 2009: Dry sampling event.
Total rain for November 2009: 2.57"

11/27:0.42; 11/25:.04, 11/23:0.1;
11/20:0.68;11/15:0.01;11/14:0.4;11/13:0.66;11/5:0.1;11/4:0.04;11/2:0.01;11/1:0.04

April 28, 2010: Wet sampling event.
Total rain for April 2010: 2.21”
4/27:.04, 4/26:0.74; 4/25:0.30-March30:3.66;29:2.49;28:0.02

June 28, 2010: Dry sampling event.
Total rain for June 2010: 1.47”
6/23:0.03; 6/17: 0.02; 6/13:0.14; 6/12:0.16; 6/10:0.23;6/9:0.41;6/1:0.36

August 9, 2010: Dry sampling event.
Total rain for July 2010: 2.05”
7/29:0.2; 7/25:0.43;7/24:0.04;7/23:0.15;7/21:0.3;7/19:0.15;7/14:0.37;7/13:0.46;7/10:0.13

November 4, 2010: Wet sampling event.
Total rain for October 2010: 3.95” 10/27:1.0; 11/4:1.07

December 1, 2010: Wet sampling event.
Total rain for November 2010: 3.15”
12/1:0.35

March 11, 2011: Wet sampling event.
Total rain for February 2011: 3.30”
3/11:0.66;3/7:0.34;3/6:0.04; 2/28:0.21;2/27:0.09;2/25:1.7;2/21:0.18;

April 1, 2011. Wet sampling event.
Total rain for March 2011: 2.18”
3/31:0.48; 4/1:0.35.

November 4, 2010 rain event had the most significant numbers of bacteria. This sample event took place during a 1” rain event (1.07”), and came after a 1.0” rainfall event the week before (October 27).

24-hour Streamflow and coliform study

As part of the watershed plan 3 stations were chosen to be monitored during wet event over a 24-hour period .

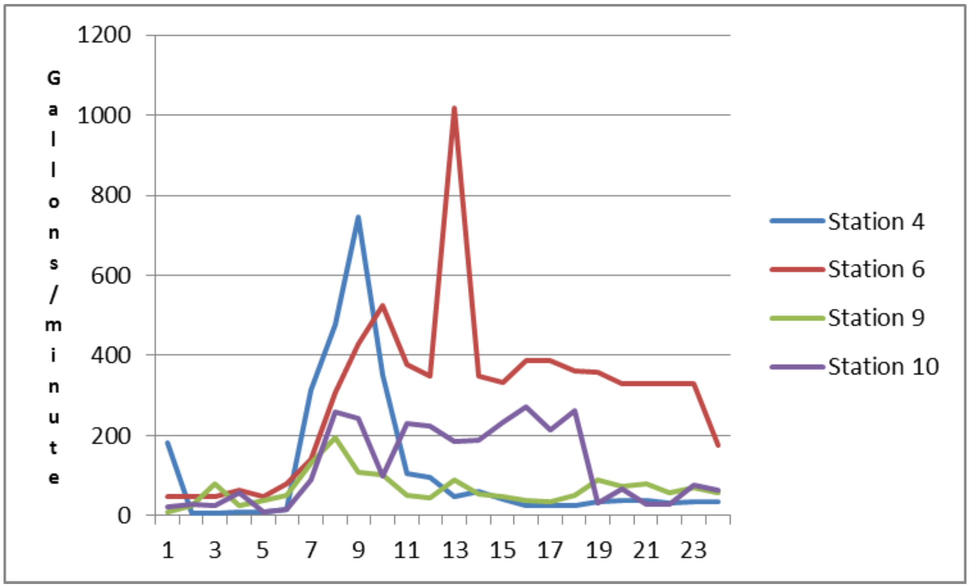
The three streamlets were chosen based on data collected during the flow analysis and the data obtained during coliform analysis. Coincidently the stations chosen were from the western, eastern and southern portions of the lake. Based on the coliform and streamflow data the following stations were determined to be part of the 24 hour study:

Station 4, along the eastern part of Lake Montauk.

Station 6, along the southern part of Lake Montauk.

Stations 9&10 (Peter's Run), along the western part of Lake Montauk.

The 24-Hour survey was conducted from June 22 to June 23 of 2011.



Station	Time	Flowmeter Average velocity	Diameter of Pipe	Height of water	Ratio of Height/Diameter	Column C (from Appendix A, Global Water Manual	Filled Area: Column C X (Diameter X 2)	Volumetric Flow: Fillec Area X Ave Velocity
4	12:20	1.6	12	0.5	0.04	0.0105	0.252	0

4	13:00	1.1	12	0.5	0.04	0.0105	0.252	0.0
4	14:16	1.1	12	0.5	0.04	0.0105	0.252	0.0
4	15:00	2	12	0.5	0.04	0.0105	0.252	
4	16:00	1.7	12	0.5	0.04	0.0105	0.252	0.0
4	17:00	1.7	12	0.75	0.06	0.0192	0.4608	0.0
4	18:00	3.7	12	3.5	0.29	0.189	4.536	0
4	19:00	4.7	12	4	0.33	0.2266	5.4384	1.0
4	20:00	5	12	5.25	0.44	0.3328	7.9872	
4	21:00	4.6	12	3.25	0.27	0.1711	4.1064	0.7
4	22:03	3.9	12	1.5	0.13	0.06	1.44	
4	23:00	3.6	12	1.5	0.13	0.06	1.44	
4	0:00	3.6	12	1	0.08	0.0294	0.7056	0.1
4	1:00	3.2	12	1.25	0.10	0.0409	0.9816	0.1
4	2:00	3.2	12	1	0.08	0.0294	0.7056	0.0
4	3:04	3	12	0.75	0.06	0.0192	0.4608	0
4	4:00	3	12	0.75	0.06	0.0192	0.4608	0
4	5:00	2.9	12	0.75	0.06	0.0192	0.4608	0.0
4	6:00	2.7	12	1	0.08	0.0294	0.7056	0.0
4	7:00	2.9	12	1	0.08	0.0294	0.7056	0.0
4	8:02	2.8	12	1	0.08	0.0294	0.7056	0.0
4	9:01	2.5	12	1	0.08	0.0294	0.7056	0
4	10:00	2.7	12	1	0.08	0.0294	0.7056	0.0
4	11:15	2.6	12	1	0.08	0.0294	0.7056	0.0
6	12:12	0.3	14	6.5	0.46	0.3527	9.8756	0.1
6	13:07	0.3	14	6.5	0.46	0.3527	9.8756	0.1
6	14:12	0.3	14	6.5	0.46	0.3527	9.8756	0.1
6	15:03	0.4	14	6.5	0.46	0.3527	9.8756	0.1
6	16:08	0.3	14	6.5	0.46	0.3527	9.8756	0.1
6	17:07	0.5	14	6.5	0.46	0.3527	9.8756	0.1
6	18:07	0.7	14	7.75	0.55	0.4426	12.3928	0.3
6	19:05	1.2	14	9.5	0.68	0.5687	15.9236	0.6
6	20:07	1.6	14	10	0.71	0.5964	16.6992	0.9
6	21:07	1.7	14	11.5	0.82	0.6893	19.3004	1.1
6	22:10	1.3	14	10.75	0.77	0.6489	18.1692	0.8
6	23:06	1.2	14	10.75	0.77	0.6489	18.1692	0.7
6	0:05	3.5	14	10.75	0.77	0.6489	18.1692	2.2
6	1:06	1.2	14	10.75	0.77	0.6489	18.1692	0.7

6	2:06	1.1	14	11.25	0.80		0.6736	18.8608	0.7
6	3:08	1.3	14	11	0.79		0.6655	18.634	0.8
6	4:07	1.3	14	11	0.79		0.6655	18.634	0.8
6	5:06	1.2	14	11.25	0.80		0.6736	18.8608	0.8
6	6:06	1.2	14	11	0.79		0.6655	18.634	0
6	7:10	1.1	14	11	0.79		0.6655	18.634	0.7
6	8:10	1.1	14	11	0.79		0.6655	18.634	0.7
6	9:08	1.1	14	11	0.79		0.6655	18.634	0.7
6	10:06	1.1	14	11	0.79		0.6655	18.634	0.7
6	11:08	1.1	14	6.5	0.46		0.3527	9.8756	0.3
9	12:00	0.3	24	3.5	0.15		0.0739	3.5472	0.0
9	13:19	0.8	24	3.5	0.15		0.0739	3.5472	0.0
9	14:00	2.4	24	3.5	0.15		0.0739	3.5472	0.1
9	15:15	0.8	24	3.5	0.15		0.0739	3.5472	0.0
9	16:25	0.8	24	4.5	0.19		0.1039	4.9872	0.0
9	17:17	1.2	24	4.25	0.18		0.0961	4.6128	0.1
9	18:18	2.4	24	5	0.21		0.1199	5.7552	0.2
9	19:16	3.6	24	5	0.21		0.1199	5.7552	0.4
9	20:12	2.3	24	4.5	0.19		0.1039	4.9872	0.2
9	21:22	2	24	4.75	0.20		0.1118	5.3664	0
9	22:20	1.9	24	3	0.13		0.06	2.88	
9	23:15	1.7	24	3	0.13		0.06	2.88	
9	0:13	1.9	24	4.5	0.19		0.1039	4.9872	0.1
9	1:13	1.6	24	3.5	0.15		0.0739	3.5472	0.1
9	2:15	1.6	24	3.25	0.14		0.0668	3.2064	0.1
9	3:18	1.3	24	3.25	0.14		0.0668	3.2064	0.0
9	4:16	1.3	24	3	0.13		0.06	2.88	
9	5:12	1.7	24	3.25	0.14		0.0668	3.2064	0.1
9	6:13	1.9	24	4.5	0.19		0.1039	4.9872	0.1
9	7:16	1.8	24	4	0.17		0.0885	4.248	0
9	8:16	1.7	24	4.5	0.19		0.1039	4.9872	0.1
9	9:16	1.7	24	3.5	0.15		0.0739	3.5472	0.1
9	10:14	1.5	24	4.5	0.19		0.1039	4.9872	0.1
9	11:03	1.7	24	3.5	0.15		0.0739	3.5472	0.1
10	12:05	0.7	24	3.25	0.14		0.0668	3.2064	0.0
10	13:16	0.9	24	3.25	0.14		0.0668	3.2064	0.0
10	14:05	0.8	24	3.25	0.14		0.0668	3.2064	0.0

10	15:10	1.9	24	3.25	0.14	0.0668	3.2064	0.
10	16:18	0.2	24	4.75	0.20	0.1118	5.3664	0.
10	17:20	0.4	24	4	0.17	0.0885	4.248	0
10	18:21	1.3	24	6	0.25	0.1535	7.368	0.
10	19:20	2.9	24	7.25	0.30	0.1982	9.5136	0.
10	20:18	2.4	24	8	0.33	0.2266	10.8768	0.
10	21:17	1.5	24	5.75	0.24	0.1449	6.9552	0.
10	22:28	2.6	24	7.25	0.30	0.1982	9.5136	0.
10	23:17	2.2	24	8	0.33	0.2266	10.8768	0.
10	0:19	1.9	24	7.75	0.32	0.2167	10.4016	0.
10	1:17	2.1	24	7.25	0.30	0.1982	9.5136	0.
10	2:22	2.3	24	8	0.33	0.2266	10.8768	0.
10	3:22	2.8	24	7.75	0.32	0.2167	10.4016	0.
10	4:25	2.4	24	7.25	0.30	0.1982	9.5136	0.
10	5:16	2.8	24	7.5	0.31	0.2074	9.9552	0.
10	6:17	0.9	24	3.75	0.16	0.0811	3.8928	0.
10	7:21	1.8	24	3.75	0.16	0.0811	3.8928	0.
10	8:21	1.1	24	3	0.13	0.06	2.88	
10	9:19	1.3	24	2.75	0.11	0.047	2.256	0
10	10:19	2.5	24	3.25	0.14	0.0668	3.2064	
10	11:00	1.9	24	3.5	0.15	0.0739	3.5472	0.

DNA

Various investigations conducted on Long Island (LI) such as the Nationwide Urban Runoff Program (NURP) (Koppelman and Tannenbaum, 1982), the Long Island 208 Waste Treatment Management Plan (Koppelman, 1978), the Brown Tide Comprehensive Assessment and Management Plan (Suffolk County, 1992), The Peconic Estuary Program Action Plan (Suffolk County, 1994), The Comprehensive Conservation and Management Plans of the Peconic Estuary Program and the LI Sound Study, and the LI South Shore Estuary Reserve Draft Comprehensive Management Plan have all contributed to a better understanding of the impacts of nonpoint source pollution upon surface water quality on Long Island. All of these studies have shown that nonpoint source pollution is the primary cause of reduced water quality in LI estuaries. One of the major components that lead to pollution of Long Island waters is coliform bacteria. Coliforms are an indicator of the possible presence of pathogenic organisms and are used by various agencies to determine water quality and to protect public health. The use of coliforms as a water quality standard has been in use since the late 1800s and has provided a good tool in protecting public health. Monitoring of bacterial counts in estuarine waters following storms shows that stormwater runoff accounted for at least 93% of the total and fecal coliform loading. The water quality standards applicable to shellfish growing areas are the highest standards developed for marine waters in New York State. Fecal coliforms are facultative anaerobic bacilli that ferment lactose with the production of gas within 48 hours at a temperature of 44.5^0 C. A prevalent and well-studied member of this group is *Escherichia coli* (*E. coli*).

Water quality is an important factor in Long Island's estuaries where extensive commercial and recreational fisheries exist for both finfish and shellfish. Shellfishing is particularly an important economic and cultural resource on LI, worth many millions of dollars in most years. Good surface water quality on Long Island, and the perception of good water quality, is also extremely important to the area's large and economically important tourist industry also worth millions of dollars annually.

Fecal coliform contamination from nonpoint sources has been recognized as a major threat to surface water quality (Geldrich, et al., 1968; Faust, 1976; Kay, et al., 1994, and others) and can lead to closure of surface waters for purposes of recreation and commercial shellfish harvest. Such closures can have serious negative impacts on the economy of local communities.

Often the most challenging aspect of mitigating nonpoint source pollution (NPS) is determining the exact source of pollutants, and then formulating the best techniques of controlling them. One of the sources generally regarded to be a major cause of shellfish closures has been human wastes coming from improperly functioning On-Site-Waste-Disposal-Systems (OSWDS) (Kator and Rhodes, 1993). Human wastes from boats have also been responsible for shellfish closures. While many studies have indicated that OSWDS (Reneau and Pettry, 1975; Hayes, et al., 1990, and others) and marine heads can be a source of potential contamination, other potential nonpoint sources of bacteria have been identified as run-off from agricultural areas (Faust and Goff, 1977), wild animals (Leonard, et al., 1989) and seagulls (Levesque, et al., 1993), as well as other waterbirds and domestic animals. The most successful remediation strategy is one that recognizes and mitigates each unique source, in itself, as each one may require a different type of remediation technique and different Best Management Practice (BMP). The more dispersed wastes of domestic animals and wildlife are considered nonpoint sources of pollution because they originate in many locations and are transported to surface waters and to groundwater at many different points. The magnitude and character of the animal waste pollution problem depends upon several factors (Koppelman and Tannenbaum, 1982); however, the present study will focus on the species type providing the waste source. NPS problems in coastal communities are attributable to coliforms from humans as well as many species of waterfowl and local wild and domestic mammalian sources.

It is presently difficult to determine the exact source of bacteria found in contaminated areas. Consequently, most coliform mitigation strategies in use today are based on Best Management Practices directed at controlling the stormwater flows themselves, without regard to the specific animals or animal groups contributing to high levels of bacteria in those flows. The utility of the indicator organism concept is limited by its inability to track organisms associated with fecal contamination to their potential sources. Each year millions of dollars are spent on fecal and total coliform assays to determine the extent of bacterial and fecal pollution of aquatic environments and to satisfy increasingly rigid regulatory requirements concerning the microbiological quality of water. Knowing the sources rather than just monitoring the level of microbial pollution of surface waters would enable water quality professionals and watershed managers to better design and implement programs to control pollution and protect source water based on the source animals.

There is evidence now accruing that shows that *E. coli* bacteria found in the gastrointestinal systems of different species of animals and animal groups vary in genetic identity, and that these differences can be measured (Dombek, et al., 2000; Parveen, et al., 1997; Carson, et al., 2001; Samadpour and Chechowitz, 1995; Simmons and Herbein, 1997; Simmons, et al., 2000). The fecal bacteria in animals (including humans) are very much genetically the same. There are unique differences, but the differences are only in a small percentage of an organism's total DNA. The key to using molecular methods to differentiate between bacterial sources is finding these differences against a large background of similarity. It is thought that the distinctions between fecal bacteria from different animals (including humans) occur because the intestinal environments (selective pressures) are not the same, and fecal bacteria develop with detectable differences that can be related to sources. These genetic differences in different strains of *E. coli* may be able to be used to identify the animal species or animal group specific for that strain of *E. coli*. Populations of *E. coli*, like other bacteria, are composed essentially of a mixture of strains of clonal descent. Due to the relatively low rates of recombination, these clones remain more or less independent (Selander, et al. 1987). These clones or strains of bacteria, are uniquely adapted to their own specific environments. As a result, the *E. coli* strain that inhabits the intestines of one species should be genetically different from the strain that might inhabit another.

Researchers have recently begun to develop a variety of techniques in an attempt to identify sources of bacteria in surface waters. These techniques are generally called Bacterial Source Tracking (BST) or microbial source tracking and are divided between molecular methods (genotype), biochemical methods (phenotype) and chemical methods. The principal difference between methods is the subtyping methodologies. Molecular methods include pulsed field gel electrophoresis (PFGE), ribotyping (r-RNA) and polymerase chain reaction (PCR). Biochemical methods include antibiotic resistance analysis (ARA), F-specific coliphage analysis, fatty acid analysis, nutritional patterns for carbon and nitrogen, and fecal bacteria ratios. Chemical methods include optical brightener detection, and caffeine detection. Molecular methods are all referred to as "DNA fingerprinting" and are based on the unique genetic makeup of different strains, or subspecies, of fecal bacteria. Biochemical methods are based on an effect of an organism's genes that actively produce a biochemical substance. The type and quantity of these substances produces what is actually measured. Chemical methods are based on finding chemical compounds that are associated with human wastewaters, and would be restricted to determining if sources of pollution were human or not. Molecular and biochemical methods of BST are dependent on building an initial database of profiles from a range of known sources, determining the differences/similarities between these known sources and then comparing unknowns isolated from contaminated waters to the database of known sources.

All of these various techniques show promise in helping to identify input sources of bacteria at some level. Some may be able to provide evidence to differentiate between human and non-human sources. Some may be able to provide evidence to identify large classes of sources such as human, livestock or wild animals. Still others may be able to provide evidence to identify for the specific animal host species of the bacteria (e.g. human, dog, horse, raccoon, deer, etc.)

Researchers are beginning to verify, with different techniques used and at various levels, the differences in E. coli (and other fecal bacteria) isolated from various host animals. Dombek, et al. (2000) found that rep-PCR DNA fingerprinting is a promising method for determining the source groups of E. coli. Paveen, et al (1997) found that multiple-antibiotic-resistance profiles could be used to differentiate between point source (human) and nonpoint source (non-human) sources of pollution. Paveen, et al. (1999) used ribotyping to differentiate between human and non-human source fecal pollution. Carson, et al. (2001) was able to distinguish E. coli ribotype patterns from human and seven individual non-human hosts. Samadpour and Chechowitz (1995) also used ribotyping to differentiate E. coli between humans and several non-human sources. Hagedorn, et al. (1999) used antibiotic resistance patterns of fecal streptococci to differentiate between waterfowl, humans, deer and beef cows. Simmons and Herbein (1997) and Simmons, et al. (2000) have used pulsed field gel electrophoresis to differentiate *E. coli* isolated from humans and some wildlife species in Virginia. Preliminary analysis by Hasbrouck (2000) of PFGE profiles of *E. coli* isolates from various animals on Eastern LI, is showing banding differences between some of those animals. Wiggins, et al (1999) using antibiotic-resistance analysis of fecal streptococci found differences from various source animals. Bernhard and Field (2000) have described a new PCR-based method for distinguishing human and cow fecal contamination based on *Bifidobacterium* and the *Bacteroides-Prevotella* group.

The field of BST is just beginning and no single method has arisen as the "best" method. BST development is so new that no research comparing BST methods or identifying their relative strengths and weaknesses has yet to be completed. Additionally, methods and techniques are being refined and developed as the process develops and new techniques are likely to be added into the mix. As the field of BST develops and expands, it is important for researchers and managers to determine not only which techniques work best under what conditions (or what questions can be answered by each technique) and for what suite of problems, but also how the different techniques can be used in conjunction with each other to solve problems, as well as to compare results between techniques. As these studies develop, it is important to identify the usefulness of each BST technique over a range of applications so that each can be identified as a specific tool to be used as appropriate and where it best fits.

It is likely that molecular techniques will generate differences at a finer scale (specific animal host) whereas biochemical and chemical techniques will yield faster results but for larger groups of animals (humans, non-human).

PFGE is starting to show promising results in identifying specific host species for *E. coli* found in surface waters. The Cornell P.I. is beginning to produce localized BST results using PFGE. Additionally, Simmons and Herbein (1997) and Simmons, et al. (2000) have had localized BST results using PFGE. Hagedorn, et al. (1999) found that the potential to identify individual strains of different bacteria by genetic profiles indicates that molecular approaches may be suitable for source differentiation of fecal bacteria. However, several issues still need to be examined in order to refine PFGE as a viable tool for use in BST.

As a means of identifying individual coliform sources and developing a BST technique, a preliminary DNA library, specific to eastern Long Island, is being developed by the Cornell Investigator based on *E. coli* isolated from the scat of animals (including humans) which live in association with estuaries of eastern Long Island. This limited DNA library consists of "genetic fingerprints" PFGE of *E. coli* isolates. However, this *E. coli* DNA library needs to be developed, refined, expanded and statistically tested for its use as a BST tool to catalogue and identify bacteria sources found in impacted surface water bodies and in stormwater flows. PFGE has been used to resolve bacterial genomes ranging from microorganisms responsible for nosocomial infections (Allardet-Servant, et al., 1989) and *Vibrio* species colonizing oysters (Buchrieser, et al., 1995) to coliforms isolated from water distribution systems (Edberg, et al., 1994). We are exploring techniques to extend and develop the use of this method as a BST tool for identifying coliform sources in impacted embayments within coastal areas.

Through the limited work being done on developing BST by various researchers using different molecular, biochemical or chemical methods, several issues arise that need to be addressed. Work needs to be continued on clonal differences in order to continue to develop and refine BST as an effective tool in addressing NPS.

All of the molecular BST methods that are being developed rely on building a DNA library of source isolates against which to compare unknown samples. Once the known source library has been developed at a sufficiently large size, and correct source identifications are sufficiently high for the desired purpose, then the task of comparing fecal isolates from unknown origins against the library to obtain source identification can be accomplished.

Some researchers have found that correct classification rates to be higher when the numbers of groupings that the isolates are put into are reduced. For instance when Hagedorn, et al (1999) using ARA, pooled all animal sources into one category of non-human to contrast against human source, the rates of correct classification improved for both the known-source database and the unknown-source isolates from the watershed. Carson, et al. (2001) was able to distinguish *E.coli* ribotype patterns from human and seven non-human hosts. However, classification accuracy was best when the analysis was limited to three host species. Parveen, et al. (1997) suggest that further research is needed to associate specific clusters with specific animal species.

It may also not always be desirable to source track coliforms to individual specific species hosts. Hagedorn, et al (1999) and Harwood, et al (2000) found that regulatory officials in some areas are satisfied if results could determine if human sources were present and then divide the animal sources between livestock (or domestic animals) and wildlife. Also, Samadpour and Chechowitz (1995) found a lack of landowner cooperation if the goal was to identify specific species rather than groups of species.

Station Data & Discussion

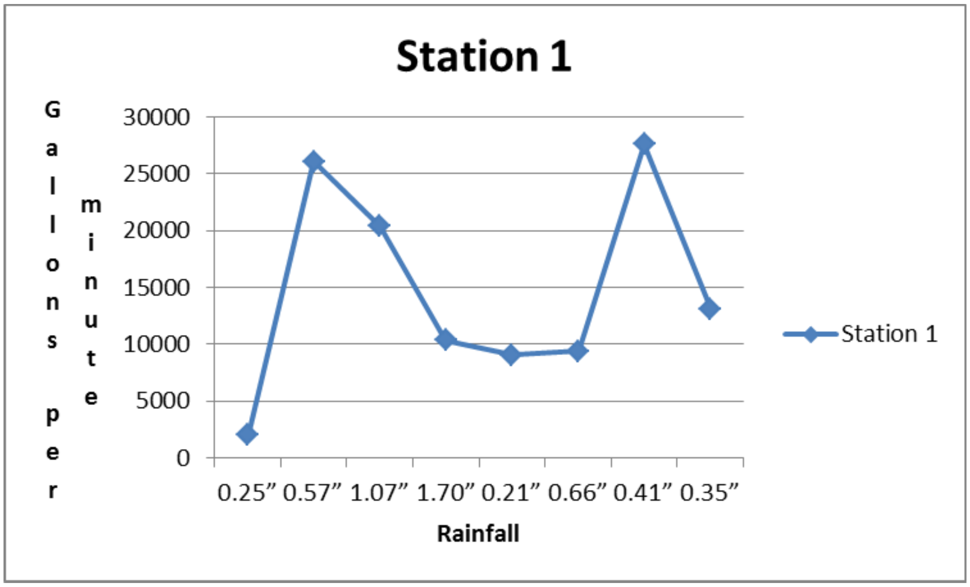
Station 1: Reed Pond Outflow

Address: East Lake Drive
Location & Pipe Description: 36 in pipe discharging water from Big Reed Pond. There is a stream channel located below the pipe.

This station is located at culvert on East Lake Drive, approximately 1500 feet south of Montauk Airport. The culvert is metal, 36 inches in diameter and connects Little Reed Pond to Lake Montauk. Readings for stream flow, coliform enumeration and bacterial source tracking were all taken from the western end of the pipe, where the pipe discharges toward the lake.

Streamflow Data:

2014.564	26086.9	20387.69	10349.12	9050.352	9401.301	27613.49	13149.28
0.25”	0.57”	1.07”	1.70”	0.21”	0.66”	0.41”	0.35”
5/12/2010	10/6/2010	11/4/2010	2/25/2010	2/28/2010	3/11/2011	3/16/2011	4/1/2011



Coliform:

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	11	24	254	74	104	490	0	232

DNA:

CORNELL COOPERATIVE EXTENSION-MARINE
DNA ANALYSIS RESULTS
PREDICTED SOURCE BY ISOLATE
LAKE MONTAUK STATION 1-WET
(REED POND CULVERT)

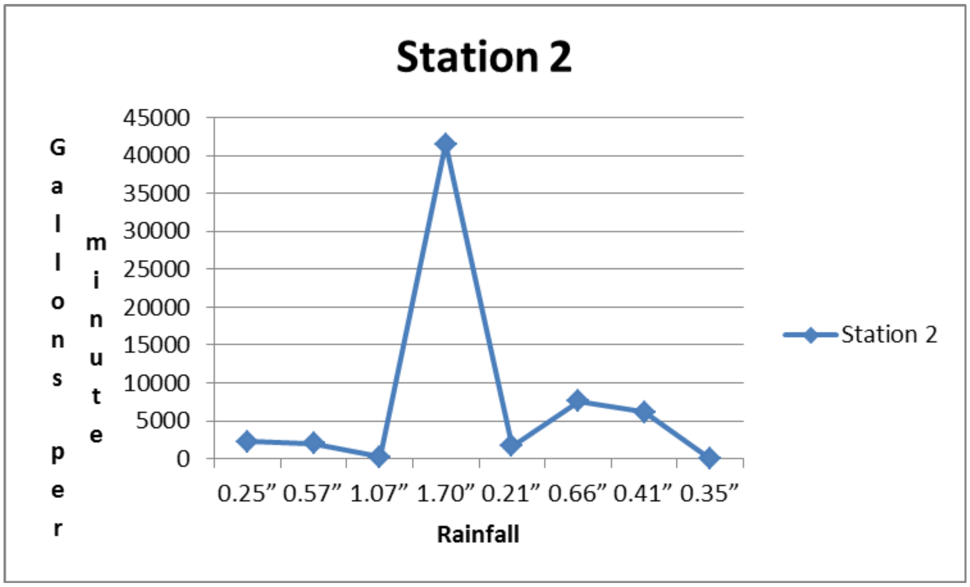
Date	Predicted Source by Isolate
4/28/10	Not Human
4/28/10	Bird-Mute Swan
4/28/10	No Match
4/28/10	Not Human
4/28/10	Bird (Mallard Duck, Cormorant)
4/28/10	Possible Bird-Black Duck
4/28/10	Possible Bird-Black Duck
4/28/10	Not Human, Not Bird
4/28/10	Not Human
4/28/10	Not Human

Station 2: Bond Property

Address: East Lake Drive
Location & Pipe Description: Pipe is located in a headwall. Retention Pond constructed June-July, 2010.

Streamflow Data:

2	2239.734	1993.478	219.9267	41514.76	1692.053	7614.239	6125.129	0
Rainfall	0.25"	0.57"	1.07"	1.70"	0.21"	0.66"	0.41"	0.35"
Station	5/12/2010	10/6/2010	11/4/2010	2/25/2010	2/28/2010	3/11/2011	3/16/2011	4/1/2011



Coliform:
Notes: 11/30/09: No Sample- Pipe under water
6/28/09: No Sample- New retention pond under construction

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	3900	no sample	87	no \	360	950	70	43

DNA:

CORNELL COOPERATIVE EXTENSION-MARINE
DNA ANALYSIS RESULTS
PREDICTED SOURCE BY ISOLATE
LAKE MONTAUK STATION 2-WET
(BOND PROPERTY)

Date	Predicted Source by Isolate
11/4/10	Not Human, Possible Wildlife (Raccoon, Red Fox)
11/4/10	Not Human, Possible Bird (Mallard Duck)
11/4/10	Not Human, Possible Wildlife (Red Fox, Raccoon)
11/4/10	Not Human

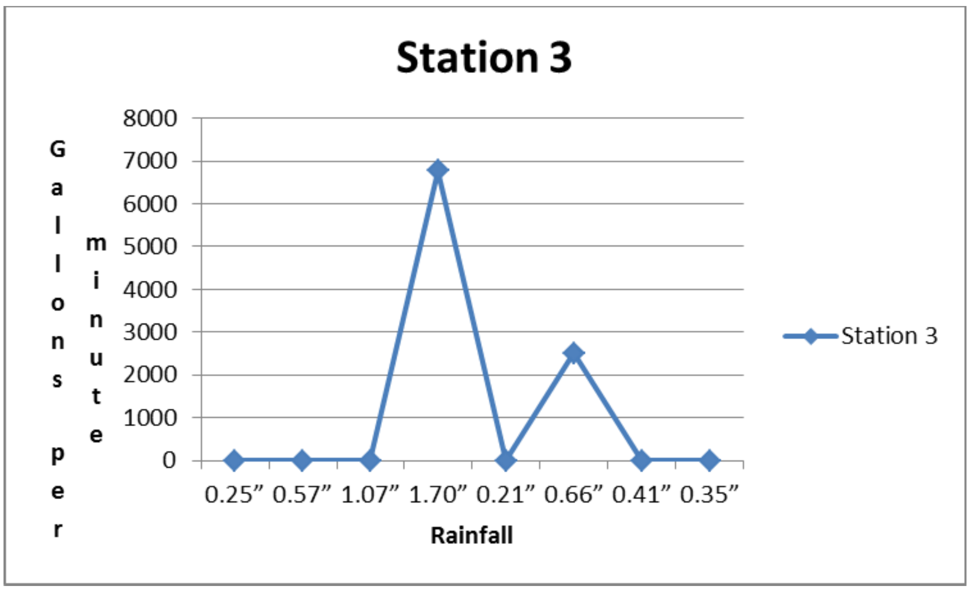
11/4/10	Domestic-Dog
11/4/10	Not Human, Possible Domestic (Dog)
11/4/10	Domestic-Dog
11/4/10	Probable Wildlife-Muskrat
11/4/10	Not Human-Possible Bird

Station 3:

Address: 105 East Lake Drive
Location & Pipe Description: The pipe diameter was 12 inches. Channel present.

Streamflow Data:

3	0	0	0	6768.213	0	2504.148	0	0
Rainfall	0.25”	0.57”	1.07”	1.70”	0.21”	0.66”	0.41”	0.35”
Station	5/12/2010	10/6/2010	11/4/2010	2/25/2010	2/28/2010	3/11/2011	3/16/2011	4/1/2011



Coliform:

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	1300	610	268	1350	1700	840	99	106

DNA:

CORNELL COOPERATIVE EXTENSION-MARINE
DNA ANALYSIS RESULTS
PREDICTED SOURCE BY ISOLATE
LAKE MONTAUK STATION 3-DRY
(105 EAST LAKE DRIVE)

Date	Predicted Source by Isolate
8/9/10	Possible Wildlife (Raccoon)
8/9/10	Not Human (Possible Dog)

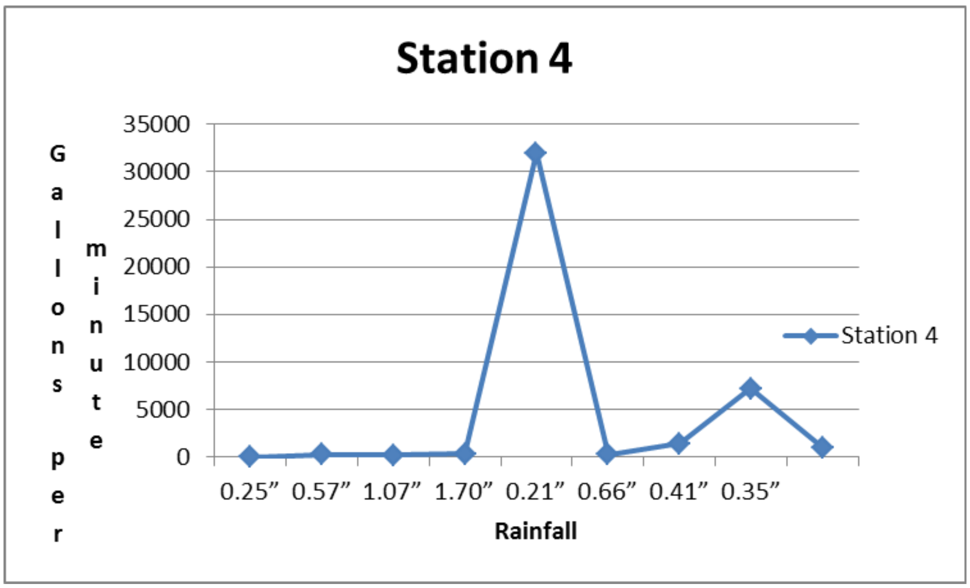
8/9/10	Bird-Possible Canada Goose, Cormorant
8/9/10	Possible Wildlife-Red Fox
8/9/10	Possible Wildlife-Raccoon

Station 4:

Address: 61&67 East Lake Drive
Location & Pipe Description: Pipe diameter is 12 inches.

Streamflow Data:

4	260.1419	206.8209	316.6944	31986.79	237.5208	1361.786	7191.226	981.7528
Rainfall	0.25”	0.57”	1.07”	1.70”	0.21”	0.66”	0.41”	0.35”
Station	5/12/2010	10/6/2010	11/4/2010	2/25/2010	2/28/2010	3/11/2011	3/16/2011	4/1/2011



Coliform:

Notes: 8/9/2010: No sample-no flow

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	10800	62	74	5300	no sample	950	700	26

DNA:

CORNELL COOPERATIVE EXTENSION-MARINE
DNA ANALYSIS RESULTS
PREDICTED SOURCE BY ISOLATE
LAKE MONTAUK STATION 4-WET
(61&67 EAST LAKE DRIVE)

Date	Predicted Source by Isolate

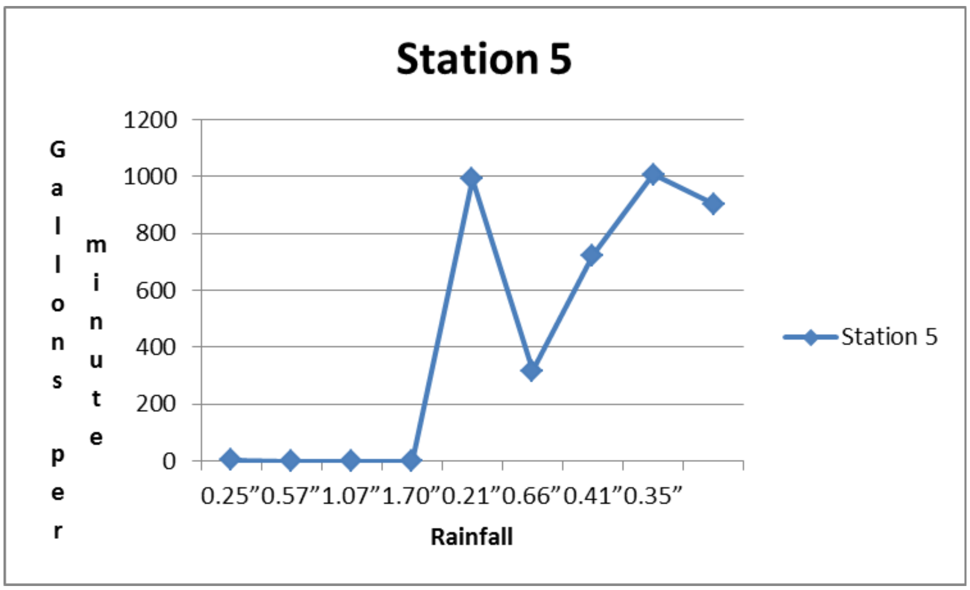
12/1/10	Probable Bird-Canada Goose
12/1/10	Possible Wildlife-Raccoon
12/1/10	Possible Wildlife-Deer
12/1/10	Bird-Canada Goose

Station 5: Amsterdam Park

Address: Drains intersection of East Lake Drive and Montauk Highway
Location & Pipe Description: Pipe diameter is 24 inches. No bottom lip on pipe, it's cracked. Pipes and channels on both sides of the road.

Streamflow Data:

5	0	0	0	992.0938	316.6944	722.5804	1007.39	904.8413
Rainfall	0.25"	0.57"	1.07"	1.70"	0.21"	0.66"	0.41"	0.35"
Station	5/12/2010	10/6/2010	11/4/2010	2/25/2010	2/28/2010	3/11/2011	3/16/2011	4/1/2011



Coliform:

Notes: 8/19/2009: Sample taken from broken pipe on East Lake Drive
11/30/2009: Sample taken from broken pipe on East Lake Drive
8/9/2010: No sample-no flow

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	125	76	21	12	no sample	8400	11	82

DNA:

CORNELL COOPERATIVE EXTENSION-MARINE
DNA ANALYSIS RESULTS
PREDICTED SOURCE BY ISOLATE
LAKE MONTAUK STATION 5-WET

(AMSTERDAM)

Date	Predicted Source by Isolate
11/4/10	Wildlife-Raccoon
11/4/10	Wildlife-Raccoon
11/4/10	Not Human, Not Bird
11/4/10	Wildlife-Raccoon
11/4/10	Wildlife-Raccoon
11/4/10	Not Human, Not Bird

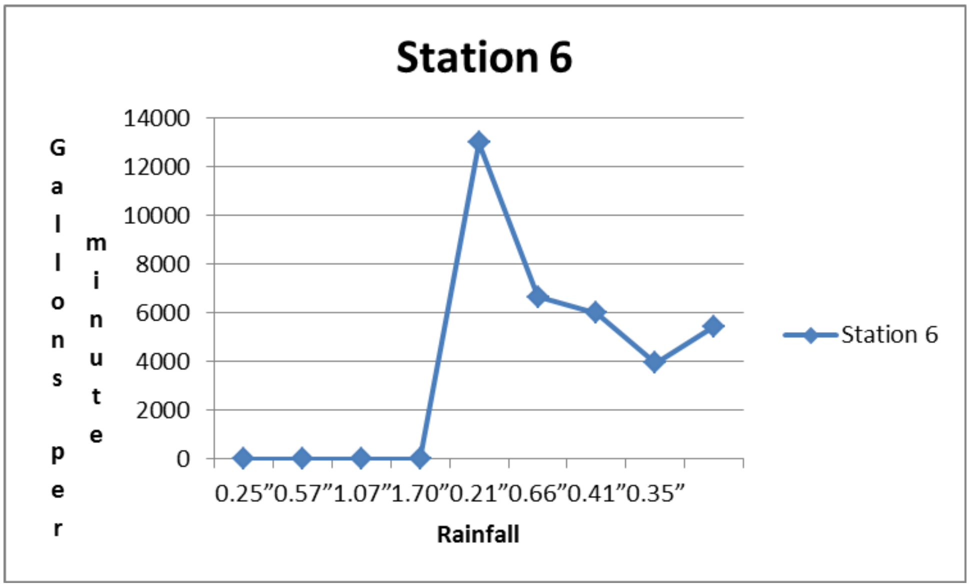
Station 6: Ocean Side Drain

Address: Benson Dr

Location & Pipe Description: Two pipes found. One discharges directly into channel and the other is raised above the channel. The pipe that discharges into the channel was underwater and flowing. The pipe raised above the channel was dry. Water flows through wetland.

Streamflow Data:

6	0	0	0	12991.51	6641.535	6003.622	3948.124	5437.845
Rainfall	0.25"	0.57"	1.07"	1.70"	0.21"	0.66"	0.41"	0.35"
Station	5/12/2010	10/6/2010	11/4/2010	2/25/2010	2/28/2010	3/11/2011	3/16/2011	4/1/2011



Coliform:

Notes: 8/19/2009: Sample taken from culvert under Route 27
11/30/2009: Sample taken from culvert under Route 27

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	1020	710	540	14500	1800	3200	36	164

DNA:

CORNELL COOPERATIVE EXTENSION-MARINE
DNA ANALYSIS RESULTS
PREDICTED SOURCE BY ISOLATE
LAKE MONTSUK STATION 6-DRY

(BENSON DRIVE)

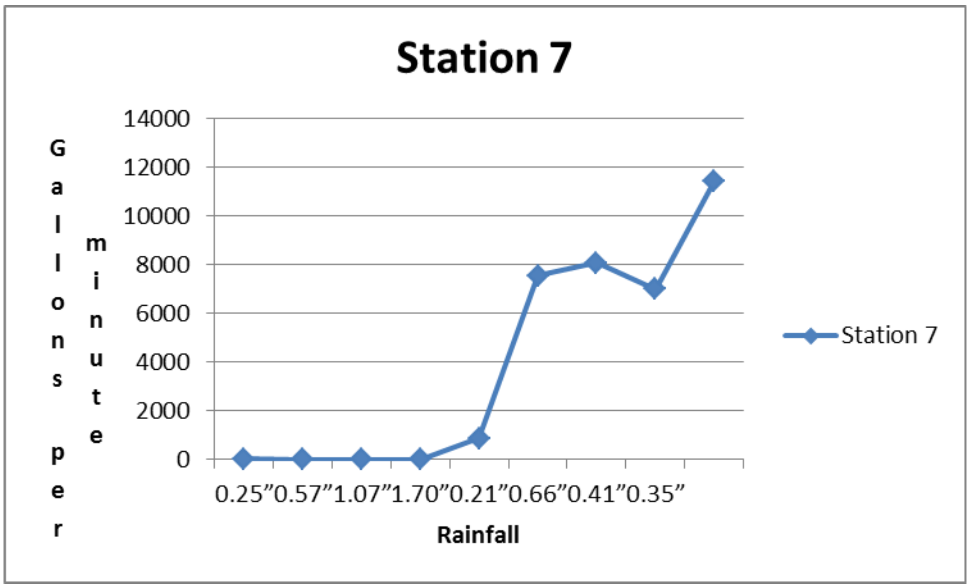
Date	Predicted Source by Isolate
6/28/09	Not Human, Possible Wildlife (Red Fox)
6/28/09	Not Human
6/28/09	Human
6/28/09	Probable Bird (Herring Gull or Mute Swan)
6/28/09	Wildlife-Muskrat
6/28/09	Bird-Herring Gull, Greater Black-Backed Gull
6/28/09	Human

Station 7:

Address: 64 Old West Lake Drive
Location & Pipe Description: Have to lift cover to access pipe. Pipe approximately 16 inches. There is a channel across the street, but there is no pipe apparent.

Streamflow Data:

7	0	0	0	852.7052	7540.344	8078.94	7001.748	11445.17
Rainfall	0.25"	0.57"	1.07"	1.70"	0.21"	0.66"	0.41"	0.35"
Station	5/12/2010	10/6/2010	11/4/2010	2/25/2010	2/28/2010	3/11/2011	3/16/2011	4/1/2011



Coliform:

Notes: 6/28/2010: No Sample-no flow
8/9/2010: No Sample-no flow

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	380	79	510	no sample	no sample	14300	48	214

DNA:

CORNELL COOPERATIVE EXTENSION-MARINE
DNA ANALYSIS RESULTS
PREDICTED SOURCE BY ISOLATE
LAKE MONTAUK STATION 7-WET

(#64 OLD WEST LAKE)

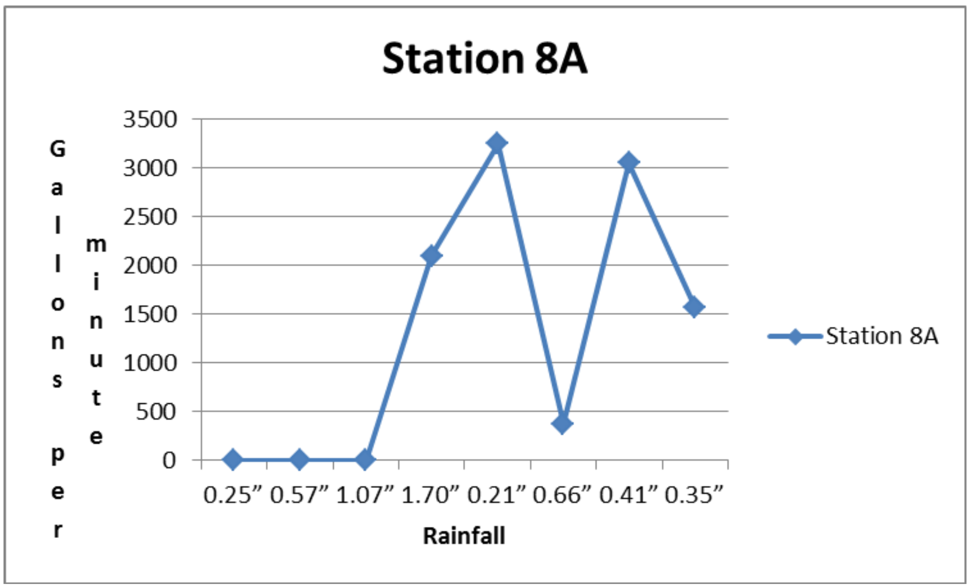
Date	Predicted Source by Isolate
4/28/10	Domestic-Dog
4/28/10	Bird-Canada Goose
4/28/10	Bird-Mute Swan

Station 8: Stepping Stones Pond Outflow

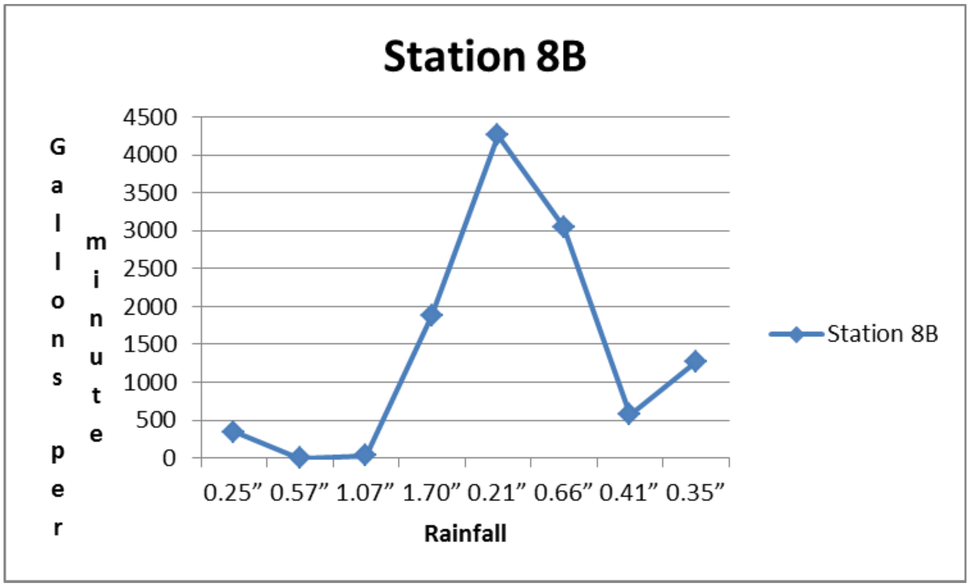
Address: Old West Lake Drive
Location & Pipe Description: Pipes are two black 12 inch corrugated plastic.

Streamflow Data:

8A	0	0	0	2097.293	3245.687	372.2776	3050.608	1563.867
Rainfall	0.25"	0.57"	1.07"	1.70"	0.21"	0.66"	0.41"	0.35"
Station	5/12/2010	10/6/2010	11/4/2010	2/25/2010	2/28/2010	3/11/2011	3/16/2011	4/1/2011



8B	348.3639	0	33.93155	1874.314	4264.065	3050.608	572.743	1264.193
Rainfall	0.25"	0.57"	1.07"	1.70"	0.21"	0.66"	0.41"	0.35"
Station	5/12/2010	10/6/2010	11/4/2010	2/25/2010	2/28/2010	3/11/2011	3/16/2011	4/1/2011



Coliform:

Station 8A
Stepping Stones Pond (southern pipe)
Notes: 6/28/10: No Sample-no flow
8/9//10: No Sample-no flow

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	274	55	95	no sample	no sample	590	no sample	0

Notes: This pipe was not added to the sample list until the 6/28/09 sample event.

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml				124	28	320	0	1

DNA:

CORNELL COOPERATIVE EXTENSION-MARINE
DNA ANALYSIS RESULTS
PREDICTED SOURCE BY ISOLATE
LAKE MONTAUK STATION 8A-WET
(STEPPING STONES POND-SOUTH PIPE)

Date	Predicted Source by Isolate
11/4/10	Wildlife-Deer
11/4/10	Not Human, Not Wildlife, Possible Domestic (Horse)

11/4/10	Not Human, Possible Bird (Cormorant, Black Duck)
11/4/10	Probable Wildlife-Deer

CORNELL COOPERATIVE EXTENSION-MARINE
DNA ANALYSIS RESULTS
PREDICTED SOURCE BY ISOLATE
LAKE MONTAUK STATION 8B-WET
(STEPPING STONES POND-NORTH PIPE)

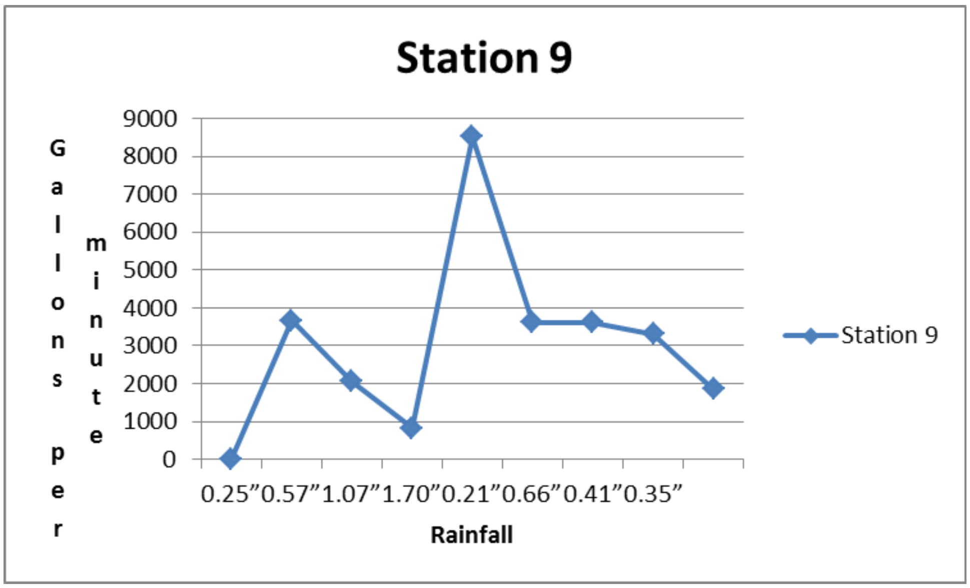
Date	Predicted Source by Isolate
3/11/11	Probable Domestic-Dog
3/11/11	Not Human-Possible Domestic (Dog)
3/11/11	Not Human-Possible Domestic (Dog)

Station 9: Peter's Run-Stream

Address: 8 Gloucester Avenue
Location & Pipe Description: Pipe diameter is 24 inches. There is a creek that the pipe discharges into. The stream has a sandy bottom.

Streamflow Data:

9	3661.806	2058.514	828.1452	8524.251	3622.597	3622.597	3319.69	1850.4
Rainfall	0.25"	0.57"	1.07"	1.70"	0.21"	0.66"	0.41"	0.35"
Station	5/12/2010	10/6/2010	11/4/2010	2/25/2010	2/28/2010	3/11/2011	3/16/2011	4/1/2011



Coliform:

Station 9
Peter's Run- 8 Gloucester Avenue
Notes:

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	1300	85	99	1170	4300	3300	66	218

DNA:

CORNELL COOPERATIVE EXTENSION-MARINE
DNA ANALYSIS RESULTS
PREDICTED SOURCE BY ISOLATE
LAKE MONTAUK STATION 9-DRY
(PETER'S RUN-GLOUCESTER)

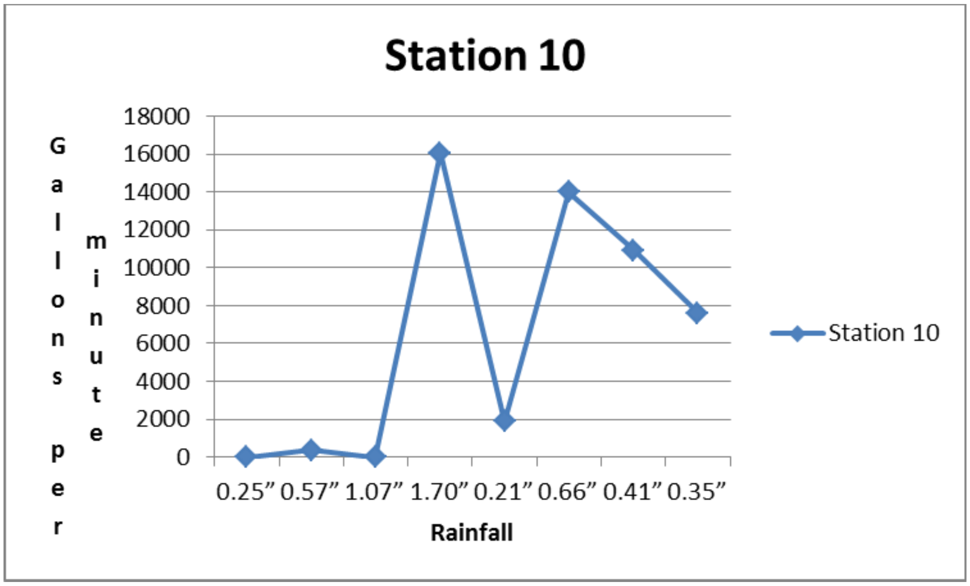
Date	Predicted Source by Isolate
8/9/10	Not Human, Possible Bird (Canada Goose)
8/9/10	Not Human, Possible Bird (Canada Goose)
8/9/10	Bird-Canada Goose
8/9/10	Bird-(Herrin Gull, Mallard Duck)
8/9/10	Bird-Canada Goose
8/9/10	Bird-Canada Goose
8/9/10	Possible Bird-(Canada Goose)
8/9/10	Not Human
8/9/10	Bird-Canada Goose
8/9/10	Bird-Canada Goose

Station 10: Peter's Run-Retention Pond

Address: West Lake Drive and Gloucester Avenue.
Location & Pipe Description: Discharge from the pond/lake.

Streamflow Data:

10	0	364.9526	0	16074.51	1896.289	14016.21	10927.9	7614.239
Rainfall	0.25"	0.57"	1.07"	1.70"	0.21"	0.66"	0.41"	0.35"
Station	5/12/2010	10/6/2010	11/4/2010	2/25/2010	2/28/2010	3/11/2011	3/16/2011	4/1/2011



Coliform:

Station 10
Peter's Run- Retention Pond
Notes:

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	242	96	138	240	60	580	12	188

DNA:

CORNELL COOPERATIVE EXTENSION-MARINE
DNA ANALYSIS RESULTS
PREDICTED SOURCE BY ISOLATE
LAKE MONTAUK STATION 10-WET
(PETER'S RUN-RETENTION POND OUTFLOW)

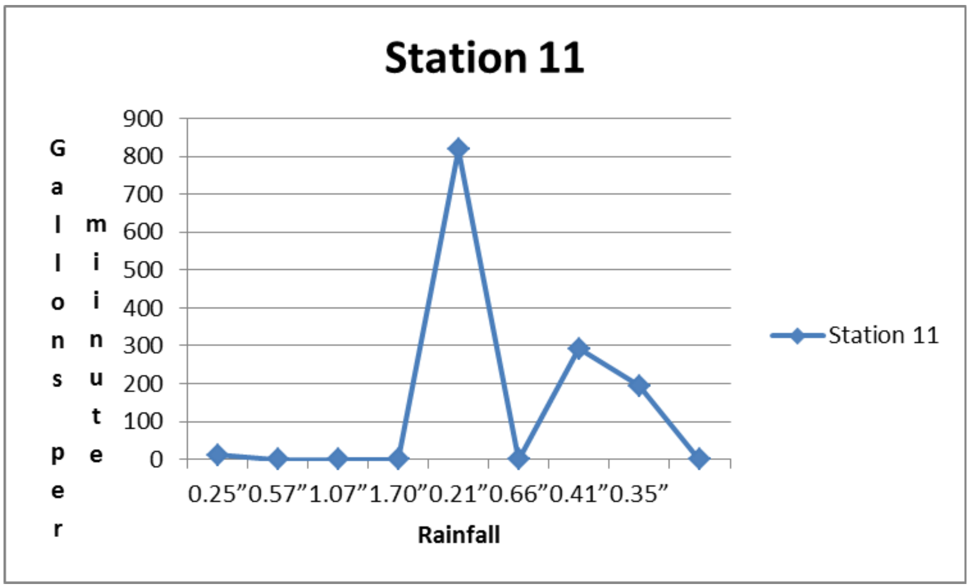
Date	Predicted Source by Isolate
3/11/11	Probable Wildlife-Raccoon
3/11/11	Domestic-Dog
3/11/11	Bird-Mute Swan
3/11/11	Domestic-Dog
3/11/11	Possible Domestic (Horse)

Station 11:

Address: West Lake Drive and Glenmore Avenue
Location & Pipe Description: Pipe diameter is 18 inches. Pipe discharges directly to beach. No stream channel present.

Streamflow Data:

11	0	0	0	818.4146	0	292.6596	194.0965	0
Rainfall	0.25"	0.57"	1.07"	1.70"	0.21"	0.66"	0.41"	0.35"
Station	5/12/2010	10/6/2010	11/4/2010	2/25/2010	2/28/2010	3/11/2011	3/16/2011	4/1/2011



Coliform:

Notes: 8/19/2009- No Sample-no flow
6/28/210- No Sample-no flow
8/9/2010- No Sample-no flow
12/1/2010- No Sample-no flow

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	no sample	33	340	no sample	no sample	11000	no sample	82

DNA:

CORNELL COOPERATIVE EXTENSION-MARINE
DNA ANALYSIS RESULTS

PREDICTED SOURCE BY ISOLATE
LAKE MONTAUK STATION 11-WET
(WEST LAKE&GLENMORE)

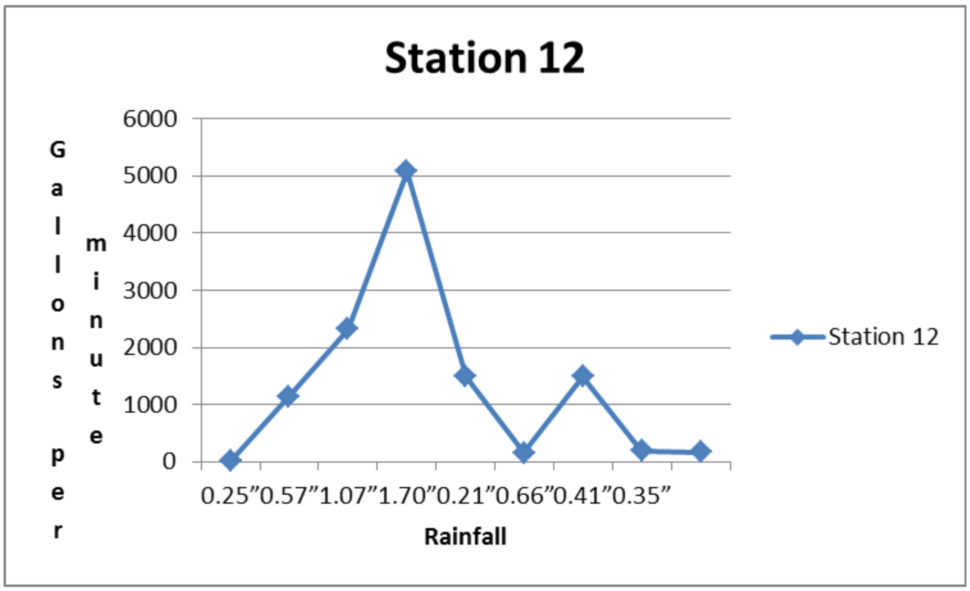
Date	Predicted Source by Isolate
4/28/10	Probable Bird (Herring Gull)
4/28/10	Not Human
4/28/10	Probable Bird (Herring Gull, Cormorant)
4/28/10	Not Human
4/28/10	Not Human
4/28/10	Domestic-Probable Dog
4/28/10	Domestic-Probable Dog
4/28/10	Not Human
4/28/10	Possible Domestic

Station 12: Diamond Cove Marina

Address: Diamond Cove Marina, 364 West Lake Drive
Location & Pipe Description: Outfall discharges directly into lake through bulk heading at Diamond Cove Marina. Pipe on other side of the street is 16 in and has a small channel.

Streamflow Data:

12	1140.1	2314.886	5073.574	1492.27	150.8069	1492.27	191.8838	172.3507
Rainfall	0.25"	0.57"	1.07"	1.70"	0.21"	0.66"	0.41"	0.35"
Station	5/12/2010	10/6/2010	11/4/2010	2/25/2010	2/28/2010	3/11/2011	3/16/2011	4/1/2011



Coliform:

Notes: 8/9/2010- No Sample-no flow

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	2	37	17	58	no sample	240	19	39

DNA:

CORNELL COOPERATIVE EXTENSION-MARINE
DNA ANALYSIS RESULTS
PREDICTED SOURCE BY ISOLATE
LAKE MONTAUK STATION 12-DRY
(DIAMOND COVE)

Date	Predicted Source by Isolate
6/28/10	Not Human, Possible Bird (Black Duck, Mute Swan)
6/28/10	Not Human, Possible Bird (Black Duck, Mute Swan)
6/28/10	Not Human, Possible Bird (Black Duck, Mute Swan)
6/28/10	Not Human, Possible Bird (Black Duck)
6/28/10	Bird-Mute Swan
6/28/10	Wildlife-Raccoon
6/28/10	Bird (Black Duck, Mute Swan)
6/28/10	Bird (Black Duck, Mute Swan)
6/28/10	Bird (Black Duck, Mute Swan)

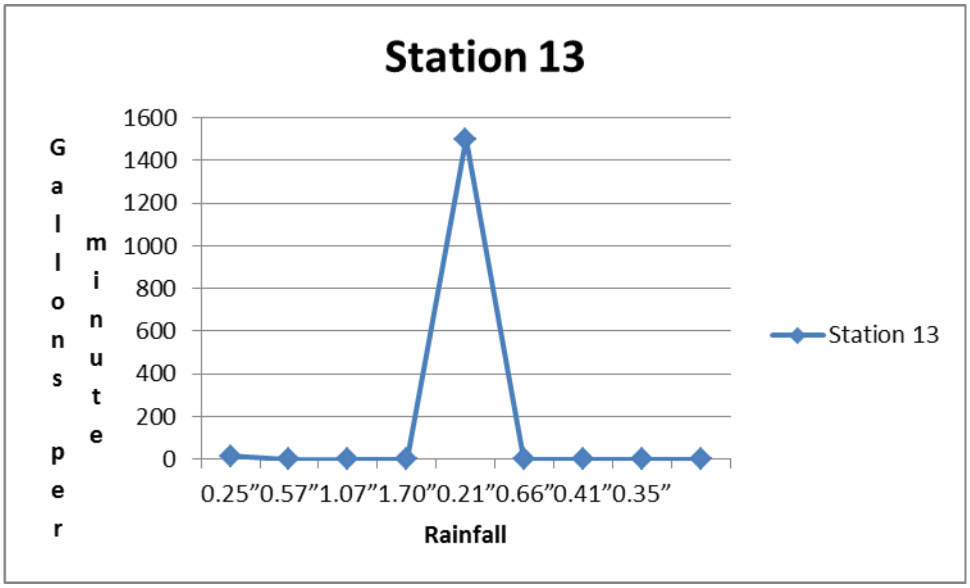
Station 13: Drum Property

Address: West Lake Drive

Location & Pipe Description: Outlet of the pond, located on the west side of the street. Pipe 16in.

Streamflow Data:

13	0	0	0	1501.39	0	0	0	0
Rainfall	0.25"	0.57"	1.07"	1.70"	0.21"	0.66"	0.41"	0.35"
Station	5/12/2010	10/6/2010	11/4/2010	2/25/2010	2/28/2010	3/11/2011	3/16/2011	4/1/2011



Coliform:

Notes: 12/1/2010- No Sample-no flow from creek. Pipe in marina under water.

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	22	380	160	1330	190	550	no sample	148

DNA:

CORNELL COOPERATIVE EXTENSION-MARINE
DNA ANALYSIS RESULTS
PREDICTED SOURCE BY ISOLATE
LAKE MONTAUK STATION 13-DRY

(DRUM PROPERTY)

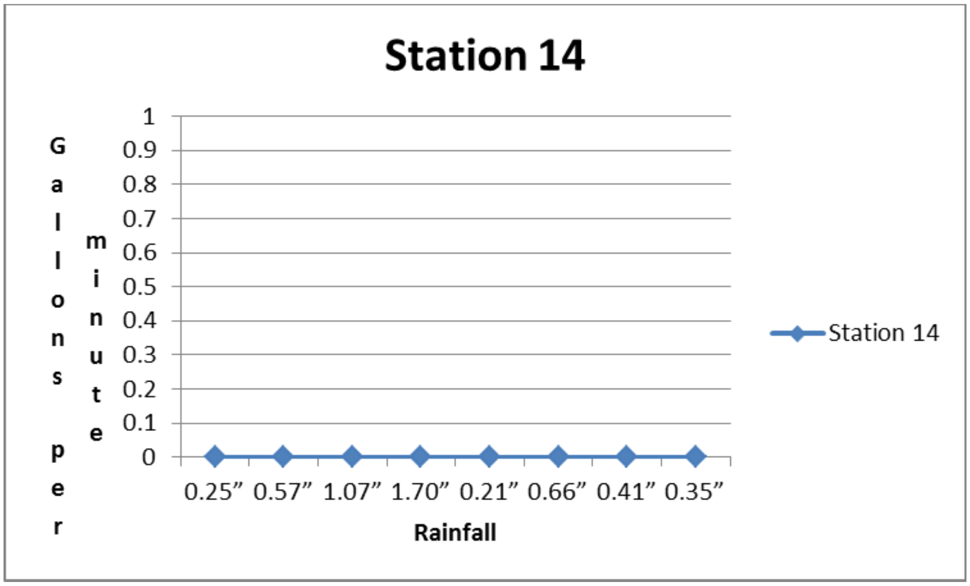
Date	Predicted Source by Isolate
6/28/10	Not Human, Possible Bird (Mallard Duck)
6/28/10	Not Human

Station 14: Sea Otter/Uihlen's Marina

Address: 444 West Lake Drive
Location & Pipe Description: Pipe diameter is 4 ft. Discharges directly into lake from marina.

Streamflow Data:

14	0	0	0	0	0	0	0	0
Rainfall	0.25"	0.57"	1.07"	1.70"	0.21"	0.66"	0.41"	0.35"
Station	5/12/2010	10/6/2010	11/4/2010	2/25/2010	2/28/2010	3/11/2011	3/16/2011	4/1/2011



Coliform:

Notes: 11/30/09- No Sample- tidal exchange in pipe/pipe under water.
4/20/10- No Sample- tidal exchange in pipe/pipe under water.
6/28/10- No Sample- tidal exchange in pipe/pipe under water.
8/9/10- No Sample- tidal exchange in pipe/pipe under water.
11/4/10- No Sample- tidal exchange in pipe/pipe under water.
12/1/10- No Sample- tidal exchange in pipe/pipe under water.
3/11/11- No Sample- tidal exchange in pipe/pipe under water.

Date	8/19/2009	11/30/2009	4/28/2010	6/28/2009	8/9/2010	11/4/2010	12/1/2010	3/11/2011
Condition	dry	dry	wet	dry	dry	wet	wet	wet
MPN/100ml	50	no sample	no sample	no sample	no sample	no sample	no sample	no sample

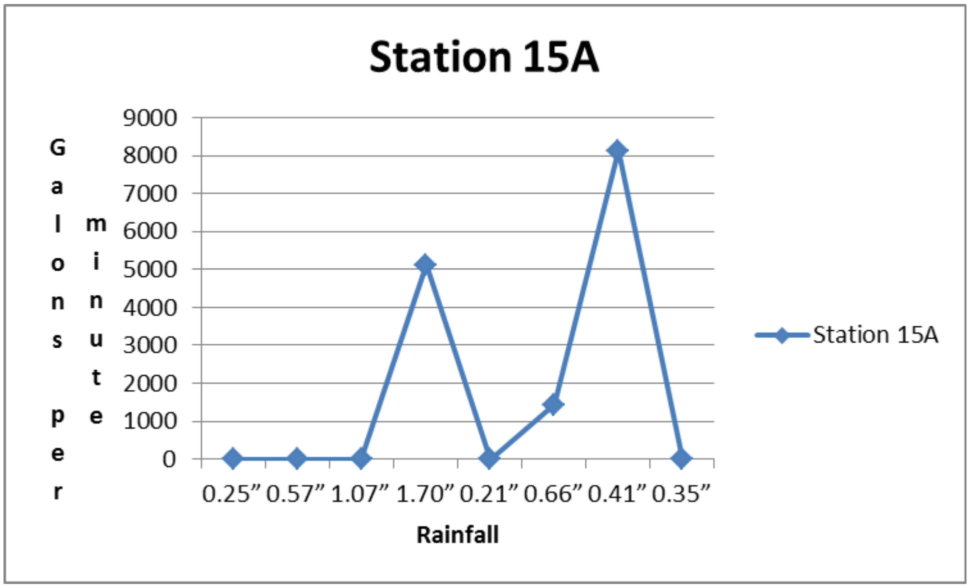
DNA:

Station 15A and 15B: South of Reed Pond outfall

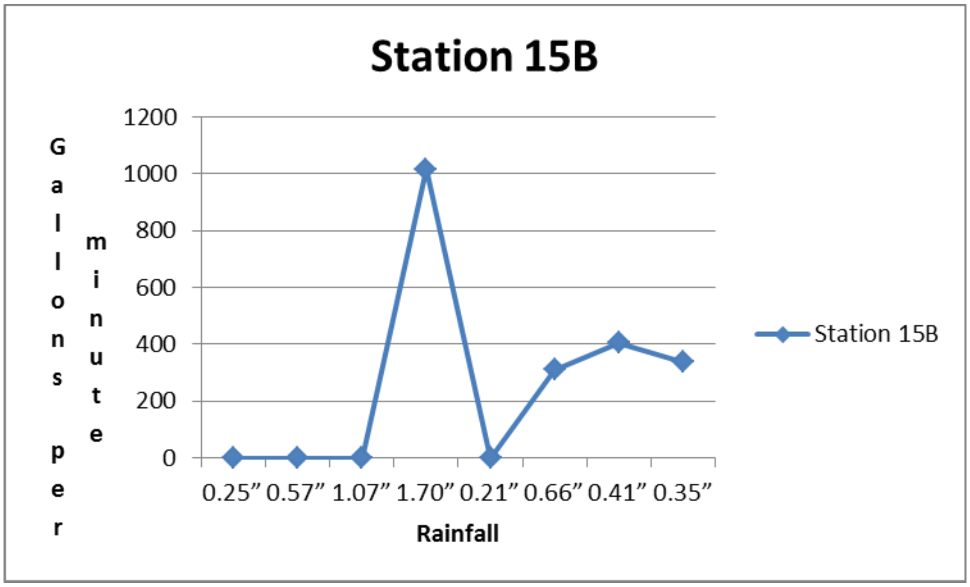
Address: East Lake Drive
Location & Pipe Description: Pipe diameter is 12 ft. Pipe runs from east side of East Lake Drive (15A) to outfall along beach (15B)

Streamflow Data:

15A	-	-	-	5125.926	-	1429.972	8140.125	0
Rainfall	0.25"	0.57"	1.07"	1.70"	0.21"	0.66"	0.41"	0.35"
Station	5/12/2010	10/6/2010	11/4/2010	2/25/2010	2/28/2010	3/11/2011	3/16/2011	4/1/2011



15B	-	-	-	1017.516	-	311.0392	406.4245	337.1611
Rainfall	0.25"	0.57"	1.07"	1.70"	0.21"	0.66"	0.41"	0.35"
Station	5/12/2010	10/6/2010	11/4/2010	2/25/2010	2/28/2010	3/11/2011	3/16/2011	4/1/2011



Coliform:

Notes: 12/1/10: Pipe was not added to sample list until 12/1/10. No Sample-no flow.

Date	8/19/09	11/30/09	4/28/10	6/28/10	8/9/10	11/4/10	12/1/10	3/11/11	4/1/11
Condition	Dry	dry	wet	dry	dry	wet	wet	wet	wet
MPN/100ml							No sample	25	75

Notes: 12/1/10: Pipe was not added to sample list until 12/1/10. No Sample-no flow.

Date	8/19/09	11/30/09	4/28/10	6/28/10	8/9/10	11/4/10	12/1/10	3/11/11	4/1/11
Condition	Dry	dry	wet	dry	dry	wet	wet	wet	wet
MPN/100ml							No sample	53	35

DNA:

CORNELL COOPERATIVE EXTENSION-MARINE
DNA ANALYSIS RESULTS
PREDICTED SOURCE BY ISOLATE
LAKE MONTAUK STATION 15A-WET
(SOUTH OF REED POND-EAST LAKE DRIVE)

Date	Predicted Source by Isolate
3/11/11	Domestic-Dog
3/11/11	Not Human
3/11/11	Possible Domestic (Dog)
3/11/11	Domestic-Dog
3/11/11	Not Human, Not Bird
3/11/11	Wildlife-Muskrat
3/11/11	Wildlife-Muskrat
3/11/11	Wildlife-Muskrat
3/11/11	Wildlife-Muskrat

CORNELL COOPERATIVE EXTENSION-MARINE
DNA ANALYSIS RESULTS
PREDICTED SOURCE BY ISOLATE
LAKE MONTAUK STATION 15B-WET
(SOUTH OF REED POND-LAKE OUTFALL PIPE)

Date	Predicted Source by Isolate
3/11/11	Probable Domestic-Dog
3/11/11	Probable Domestic-Dog
3/11/11	Probable Domestic-Dog
3/11/11	Probable Domestic-Dog
3/11/11	Probable Domestic-Dog
3/11/11	Probable Domestic-Dog
3/11/11	Probable Domestic-Dog
3/11/11	Probable Domestic-Dog
3/11/11	Probable Domestic-Dog

Preliminary Report: Sediment and Infauna Analysis for Lake Montauk, East Hampton

Twenty stations were selected for sediment grain size analysis, percent organic matter and infauna analysis in Lake Montauk, East Hampton. All twenty stations were sampled between 23 September and 30 October 2008. Figure 1 shows the location of the 15 benthic infauna and sediment survey sites, while Figure 2 presents the stations established for the eelgrass eelgrass survey.

A 2" PVC corer was used for sampling by SCUBA diving or snorkeling. Two cores were taken at each station, one for sediment grain size and organic analysis, and one for infauna analysis. Cores were driven into the sediment to a depth of 15 cm. Infauna analysis was conducted in the field by wet sieving the sample immediately after collection through a 1mm mesh sieve. After washing, all specimens retained in the screen were collected and transferred into labeled plastic ziplock bags with seawater. Sediment grain size/ organic samples were obtained, the excess seawater was decanted and the samples were emptied into labeled plastic ziplock bags. All samples were stored in a cooler with ice packs for transport to the lab. Once back at the lab, all sediment samples were frozen until analysis and infauna samples were refrigerated until analysis. Sediment grain size distribution was determined by wet sieving and pipette analysis (Folk, 1961). Organic content of the samples was measured as the weight lost after combustion at 450 degrees C for four hours. Infauna analysis was performed in the days immediately after collection to ensure specimens remained live to ease identification. The animals were identified and counted with the aid of a dissecting microscope.

Figure 1. The sediment and infauna survey stations (LMS) for Lake Montauk.

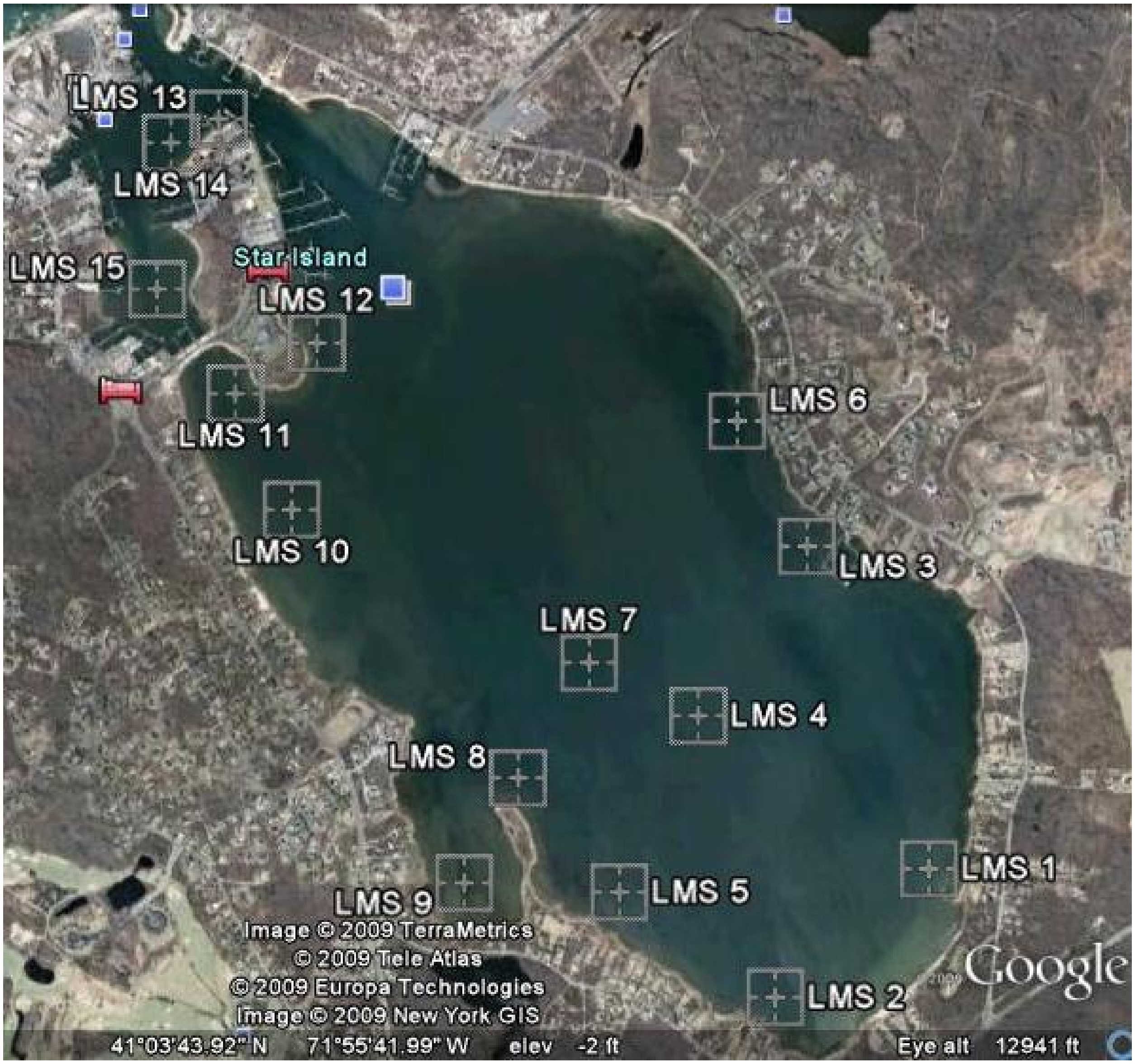


Figure 2. The eelgrass survey stations (Coast Guard [CG] and Lake Montauk [LM]), indicated within the red boxes, for the Lake Montauk Watershed Project.

Results
Sediment Data

Lake Montauk Sediment Analysis for Monitoring Stations
Sampled: Sept 23, 2008
*note: seagrasses tend to prefer sediment with <15% silt and clay and <8% organic matter

Channel Flat Station 1:
Avg % Organics: 0.952%
Avg % Grain Size:
 5.326% gravel
 82.039% sand
 12.635% silt and clay

Channel Flat Station 2:
Avg % Organics: 1.181%
Avg % Grain Size:
 3.886% gravel
 87.436% sand
 8.678% silt and clay

Channel Flat Station 3:
Avg % Organics: 0.626%
Avg % Grain Size:
 11.672% gravel
 83.440% sand
 4.557% silt and clay

Channel Flat Station 4:
Avg % Organics: 0.857%
Avg % Grain Size:
 5.004% gravel
 90.912% sand
 4.083% silt and clay

Coast Guard Station 1:
Avg % Organics: 1.370%
Avg % Grain Size:
 0% gravel
 87.549% sand
 12.451 % silt and clay

Coast Guard Station 2:
Avg % Organics: 1.206%
Avg % Grain Size:
 0 % gravel

90.160% sand
9.040% silt and clay

Coast Guard Station 3:
Avg % Organics: 1.486%
Avg % Grain Size:
5.236% gravel
77.012% sand
17.752% silt and clay *high for seagrass

Coast Guard Station 4:
Avg % Organics: 1.239%
Avg % Grain Size:
0.481% gravel
88.699% sand
10.910% silt and clay

Coast Guard Station 5:
Avg % Organics: 0.875%
Avg % Grain Size:
3.049% gravel
92.357% sand
4.593% silt and clay

***No replicates were done for the LMS stations

LMS 1
Organics: 1.31%
Grain Size:
0% gravel
86.79% sand
13.21% silt and clay

LMS 2
Organics: 0.97%
Grain Size:
0% gravel
83.09% sand
16.91% silt and clay
LMS 3
Organics:0.35 %
Grain Size:
0.05% gravel
98.44% sand
1.50% silt and clay
LMS 4

Organics: 4.10%
Grain Size:
- 0% gravel
- 6.20% sand
- 93.80% silt and clay

LMS 5
Organics: 0.56%
Grain Size:
- 17.93% gravel
- 76.86% sand
- 5.21% silt and clay

LMS 6
Organics: 0.68%
Grain Size:
- 1.41% gravel
- 92.59% sand
- 6.00% silt and clay

LMS 7
Organics: 4.05%
Grain Size:
- 0% gravel
- 31.53% sand
- 68.47% silt and clay

LMS 8
Organics: 0.67%
Grain Size:
- 1.16% gravel
- 87.86% sand
- 10.98% silt and clay

LMS 9
Organics: 1.27%
Grain Size:
- 0% gravel
- 73.08% sand
- 26.92% silt and clay

LMS 10
Organics: 2.94%
Grain Size:
- 0% gravel
- 46.77% sand
- 53.23% silt and clay

LMS 11
Organics: 4.30%
Grain Size:
- 0% gravel
- 38.38% sand

61.62% silt and clay
LMS 12
Organics: 4.75%
Grain Size:
0% gravel
16.68% sand
83.32% silt and clay
LMS 13
Organics: 1.41%
Grain Size:
0.57% gravel
84.51% sand
14.91% silt and clay
LMS 14
Organics: 1.48%
Grain Size:
0% gravel
78.33% sand
21.67% silt and clay
LMS 15
Organics: 6.68%
Grain Size:
0% gravel
33.54% sand
66.46% silt and clay

Infauna Survey
LM1: total- 4 worm casings, 1 tiny thread worm, Family Capitellidae
- large tube built of large grained sand/cobble
- 1 "ice-cream cone" tube ***Pectinaria gouldi***
- 1 tiny thread worm, **Family Capitellidae**
- 2 long, thin tubes, one mud colored, 1 rust colored
Note: eelgrass seed

LM3: total- 3 worms, 1 tube
-1 spaghetti mouthed worm (***Pista palmata***, Family **Terebellidae**)
-1 tiny blood worm about 1 cm long **Family Glyceridae**
-1 large poly. **Family Nereidae** (clam worm)
- large tube built of large grained sand/cobble

LM4: total 1 worm case , 1 bivalve
-1 large tube built of large grained sand/cobble
-1 atlantic awningclam ***Solemya velum***

LM-CG3: total- multiple tube fragments
-tube frags muddy, w/o "skin"

LM-CG5: total- 2 worms, multiple tube fragments
-1 large clam worm **Family Nereidae**
-1 opal worm, **Family Lumbrineridae**
-3 fragments of tube built of fine grained sand, flexible

LMS1: total 3 worms
-1 blood worm about 1 cm long **Family Glyceridae**
-2 tiny thread worms, **Family Capitellidae**

LMS2: total 1 worm, 1 bivalve, fragments of P. gouldi
-1 clam worm **Family Nereidae**
-1 atlantic awningclam ***Solemya velum***
-Multiple fragments of ***Pectinaria gouldi*** tube
Note: bittiolum looking shells (2 collected)

LMS3: total- 2 worms Family Orbiniidae, frag. of "ice cream cone worm" *Pectinaria gouldi* tube
-2 half pinkish half yellowish worms , both Family **Orbiniidae, though 1 missing head**
- frag. of ***Pectinaria gouldi*** tube

LMS4: fragments of tube
-multiple fregments of a mud covered tube with "skin"

LMS5: 1 worm, frag of P. gouldi tube,
-1 clam worm **Family Nereidae (**pretty sure it's ***Neanthes (=Nereis) succinea*)**
-Fragment of tube from ice cream cone worm ***Pectinaria gouldi***

LMS6: total 1 worm
-dead, but looks like a blood worm (**Family Glyceridae**)
Note: bittiolum looking shells (4 collected)

LMS7: total- 1 worm and fragments of muddy tubes
-1 large (@2.5 cm) worm (think Family Maldanidae,)
-multiple fragments of muddy tube, one containing "skin"

LMS8: total- 5 tubes from 3 spp.
-3 "ice cream cone worm" tubes – ***Pectinaria gouldi,*** family **Pectinariidae**
- fragments of a tube built of sand that is less rigid and made of finer sand
-one tiny, thin tube, mud colored

LMS9: total 4 worms of 3 families
-1 small (1cm) bamboo worm **Family Maldanidae**
-2 small bloodworms **Family Glyceridae**
-1 threadworm **Family Capitellidae**

LMS10: total- 1 "ice cream cone worm" *Pectinaria gouldi*, 1 muddy tube

LMS11: 1 worm, several fragments of muddy tube
-1 ribbon worm, **Phylum Nemertea**- probably ***Procephalothrix spiralis***
-multiple fragments of muddy tube with "skin"

LMS12: total- multiple fragments of at least 1 tube
-frags of at least 1 large, mud colored tube with "skin"

LMS13: 2 worms, several tubes
-2 polychaetes of the genus ***Lumbrinerides*** (**Family Lumbrineridae**) a.k.a. opal worms
-several fragments of fine sand covered tubes, flexible

LMS14- total: 1 tiny worm Family **Syllidae**; multiple fragments of tubes, at least from 2 spp.
-tiny polychaete (<1cm) Family **Syllidae**
-Multiple fragments of tubes with "skin"
-1 frag of tube made with fine grained sand, flexible

LMS15: total 1 tube
-1 tube with "skin"

Infauna Species List
Note: P= polychaete, B= bivalve, R= ribbon worm

Species/Family/Phylum	**Site(s) Observed and # per site**	**Notes**
	1 per site unless indicated in ( ) after	
Pectinaria gouldi (P)	LMS10 [tube only: LM1,LMS2,LMS3,LMS5,LMS8(3)]	ice cream cone worm - Family Pectinariidae
Procephalothrix spiralis (R)	LMS11	ribbon worm - Phylum Nemertea
Pista palmate (P)	LM3	spaghetti mouthed worm - Family Terebellidae
Solemya velum (B)	LM4, LMS2	atlantic awningclam - Family Solemyidae
Family Capitellidae (P)	LM1, LMS1(2), LMS9	thread worm
Family Glyceridae (P)	LM3, LMS1, LMS6, LMS9(2)	blood worm

Family Lumbrineridae (P)	LM-CG5, LMS13(2)	opal worm
Family Maldanidae (P)	LMS7, LMS9	bambooworm
Family Nereididae (P)	LM3, LM-CG5, LMS2, LMS5	clam worms, LMS5 is *Neanthes (=Nereis) succinea*
Family Orbiniidae (P)	LMS3(2)	burrowing deposit feeders
Family Syllidae (P)	LMS14	small predators of hydroids, sponges and tunicates

Alternatives to Traditional Septic Systems

A typical Onsite Wastewater Treatment System (OWTS) on Long Island consists of a septic tank and leaching pool(s). The septic tank is used to settle and decompose sewage; and the leaching pool allows the liquid from the septic tank (referred to as effluent) to be released into and filtered by the surrounding soils. Please see **Figure 1** for an illustration.

Septic systems generally work well if they are installed in areas with appropriate soils and hydraulic capacities (capacity of soil to absorb and move effluent); designed to treat the incoming waste load to meet public health, ground water, and surface water performance standards; installed properly; and maintained to ensure long-term performance (USEPA, 2002). However, many times these criteria, especially proper maintenance, are not met.

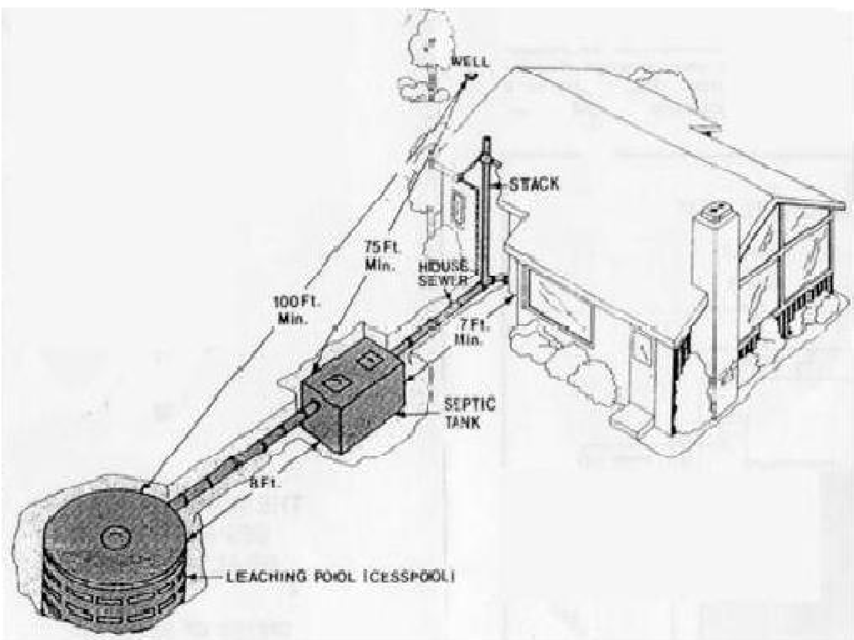
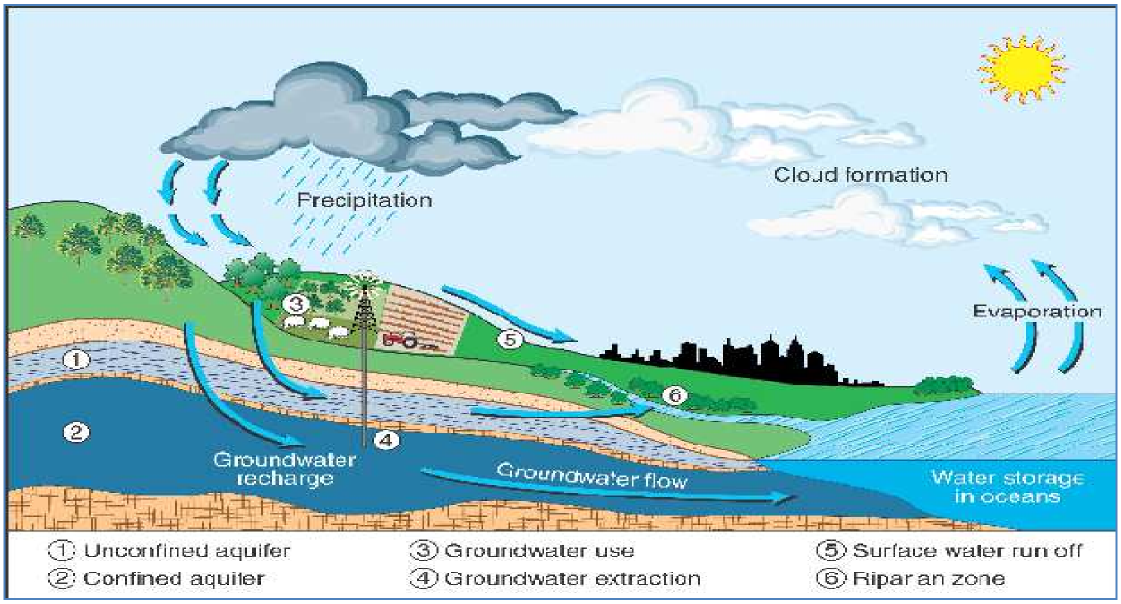


Figure 1: Coventional Sewage Disposal System, Source: http://www.geo.sunysb.edu/groundwater/xuan_xu.htm

Another major shortcoming of septic systems is their inability to remove much of the nitrogen in human waste. According to studies, only 20% of nitrogen that passes through conventional septic systems is effectively removed (Siegrist and Jenssen, 1989; Gold et al., 1990). It is not uncommon for the effluent leaving a typical system to have a total nitrogen concentration of 40-60 mg/L, primarily in the form of ammonia (NH_3) and organic nitrogen. Upon entering the soil, the ammonia is quickly nitrified (converted to Nitrate, NO_3 by oxygen in the soil). Once converted to nitrate, further breakdown is limited due to a lack of organic carbon in the soil, which is required by the microorganisms to breakdown nitrate.

In addition to nitrogen, septic tank effluent also contains phosphates and pathogens (bacteria, parasites, and viruses); which discharge along with nitrogen to the soil. The nitrogen, phosphates, and pathogens not taken out of the effluent by soil filtration; flow into groundwater and travel via groundwater flow to surface waterbodies. See **Figure 2** for an illustration of the hydrologic cycle and how water flows underground.



Source: http://www.willoughby.nsw.gov.au/Groundwater.html

Figure 2: Fate of effluent discharged to soil

Impacts

Nitrogen is the primary pollutant of concern in coastal areas of the eastern United States (USEPA, 2010). This is because in most coastal estuarine and marine waters, nitrogen is the limiting nutrient. Elevated inputs of nitrogen (nitrates) can cause excessive algal growth and lead to eutrophication and low dissolved oxygen levels in estuarine waters (lakes, harbors, and bays). If high concentrations of nitrates leach into groundwater that is used for drinking, it poses many health risks, particularly to babies (methemoglobinemia –blue baby syndrome) and pregnant women.

Phosphorus is mainly a concern when it enters freshwater; streams, rivers, and lakes. In freshwater systems, phosphorus is the limiting nutrient and elevated levels can cause excessive algal growth, eutrophication, and low dissolved oxygen levels.

Pathogens reaching surface or groundwater present health risk as they are capable of causing human disease through contaminated drinking water, recreational contact, or consumption of contaminated shellfish.

Septic system density and distance to groundwater and surface water also affect how well they work. If septic systems are installed at a high density or close to groundwater or surface water, the chance of nutrient and bacterial contamination of surface and groundwater increases.

Alternative Technologies

In an effort to deal with the water contamination issues (pathogens, nitrogen, phosphorus) posed by traditional septic systems and increased hydraulic flows, a wide range of "alternative" treatment technologies have been developed. These systems typically work in combination with the septic tank. The septic tank serves to equalize hydraulic flows; retain oils, grease, and settled solids; and provide some anaerobic (without oxygen) digestion of settleable organic matter. The alternative treatment technology then provides an environment (e.g., sand, peat, artificial media, and oxygen) that promotes additional biological treatment and removes pollutants through filtration, absorption, and adsorption.

A wide variety of alternative treatment technologies exist, many of which use a combination of treatment applications in order to maximize pollutant removal, especially nutrient removal. These technologies can achieve significant pollutant removal rates. However, the performance of various treatment technologies ranges with climate, site conditions, hydraulic loads, and pollutant loads. Local studies are critical in determining the acceptability of specific treatment technologies.

**It is important to note that Suffolk County has not approved any of the alternative treatment technologies discussed in this section. Local studies have to be conducted to determine the effectiveness and feasibility of using these systems in Suffolk County.

Alternative Technologies for Nitrogen Removal

As mentioned above, many alternative technologies use a combination of treatment applications in order to maximize pollutant removal. This is especially true for technologies that remove nitrogen from wastewater. Nitrogen-reducing onsite systems add treatment processes to conventional systems to facilitate the biological processes necessary for nitrogen reduction.

The main treatment processes that onsite nitrogen removal technologies use is sequential nitrification/denitrification. The first step in the sequence uses aerobic processes to transform the organic nitrogen and ammonia products in the septic tank effluent to nitrate (nitrification step). Various treatment devices can achieve this aerobic process, such as sand or gravel filters or aerobic treatment units. The second step requires changing the process from an aerobic environment (with dissolved oxygen) to an anoxic environment (no dissolved oxygen) and providing a source of organic carbon. This allows species of bacteria to grow that will utilize the nitrate formed in the first step to oxidize organic matter and in the process transform the nitrate to nitrogen gas (Washington State Department of Health, 2005). These processes (aerobic treatment, sand/media filters, add-on anoxic filters) are described below.

<u>Aerobic Treatment:</u> the aerobic treatment process involves providing a suitable oxygen rich environment for organisms that reduce the organic portion of the waste into carbon dioxide and water. Aerobic systems are similar to septic systems in that they both use natural processes to treat wastewater, but unlike septic systems, the aerobic treatment process requires oxygen. In an aerobic treatment unit, wastewater enters a compartment where solids settle and are partially digested by microorganisms. In another compartment, a motor pumps air into the chamber and mixes the liquid, allowing air diffusion and provides oxygen for aerobic bacteria that further degrade wastewater. The treated effluent is then either recirculated for further treatment or discharged to a soil absorption field.

Three main types of aerobic systems have been adapted for onsite use: suspended growth, fixed film, and sequencing batch reactor. In suspended growth systems, the microorganisms responsible for the breakdown of wastes are maintained in a suspension with the waste stream. These units contain a main compartment called an aeration chamber in which air is mixed with wastewater. The air mixes with wastewater in the aeration chamber and the oxygen supports the growth of aerobic bacteria that digest solids in the wastewater. The solids that the bacteria cannot breakdown settle out as sludge in a secondary chamber called a settling chamber or clarifier. The settled out sludge is then returned to the aeration chamber, either by gravity or pumping, for further breakdown. See **Figure 3** for a diagram of a suspended growth system.

In fixed film/attached growth systems (sometimes called trickling filters or media filters); the microorganisms grow on sand, peat, or a specially designed synthetic material. Wastewater is exposed to the media in usually one of two ways. In some systems the media is moved relative to the wastewater, alternating immersing the film and exposing it to air. In other systems the media is stationary and wastewater is sprayed or dosed on to the media so the film is alternately submerged and exposed to air. The submersion/immersion of the media in wastewater allows for anoxic processes to take place, whereas exposing it to air allows for aerobic processes to occur. Sand/media filters are discussed more below. See **Figure 4** for a diagram of a fixed film/attached growth system.

In a sequencing batch reactor, aerobic decomposition, settling, and return occur in the same chamber. Air is bubbled through the liquid in the decomposition cycle. The bubbler then shuts off and the wastewater goes through a settling cycle. The bubbler then turns back on and the tank reenters the decomposition cycle and the settled bacteria mix back into the aerobic environment. After settling of bacteria and solids, the treated effluent is discharged to the soil.

Capital costs for a conventional on-site suspended growth system ranges from $7,500 to $15,000 per dwelling unit. The operation and maintenance costs are $400 to $800 per dwelling until when all the suggested operation and maintenance tasks are performed (USEPA, 2010). Capital costs for single-pass filters range from $5,500 to $13,000 per dwelling unit with operation and maintenance costs of $200 to $400.

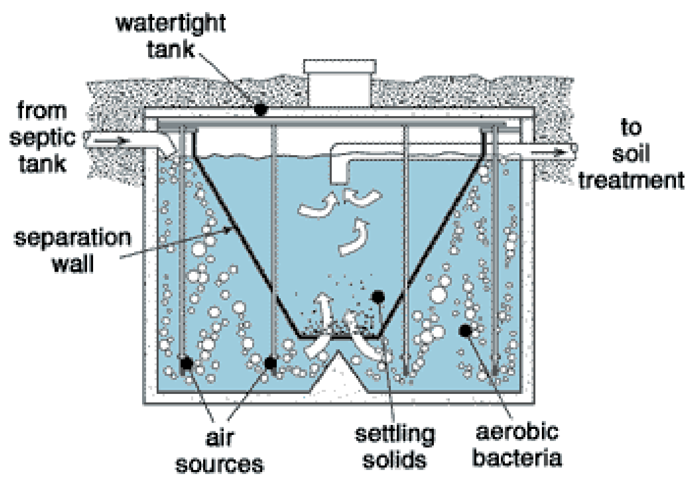


Figure 3: Suspended Growth Aerobic Treatment

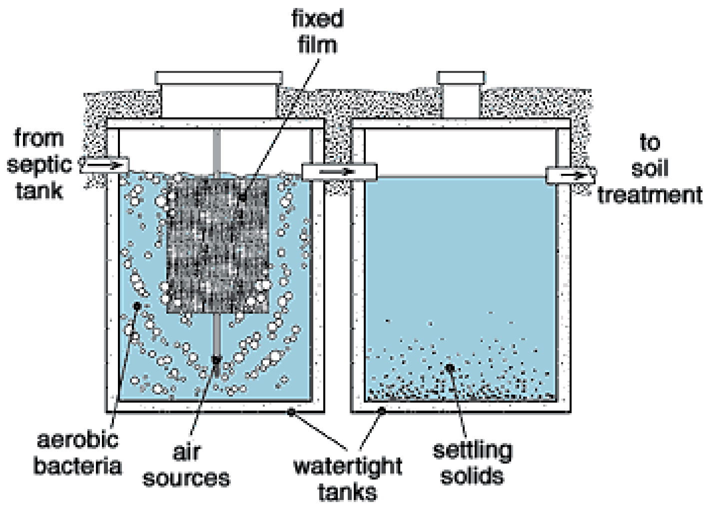


Figure 4: Fixed Film Aerobic Treatment

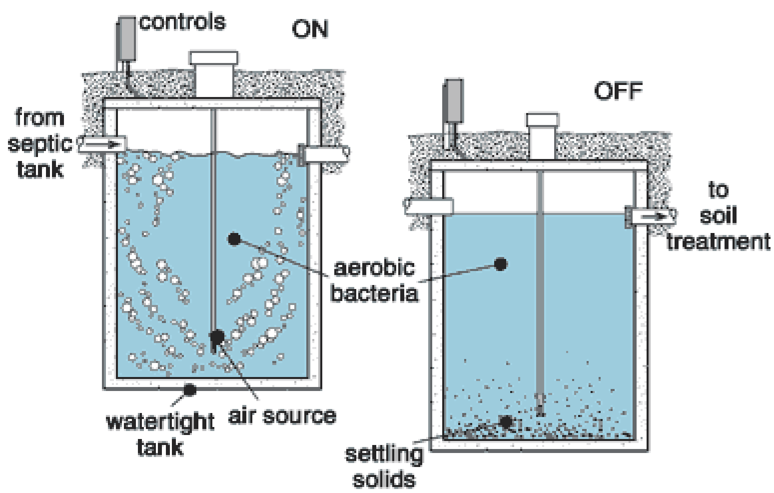
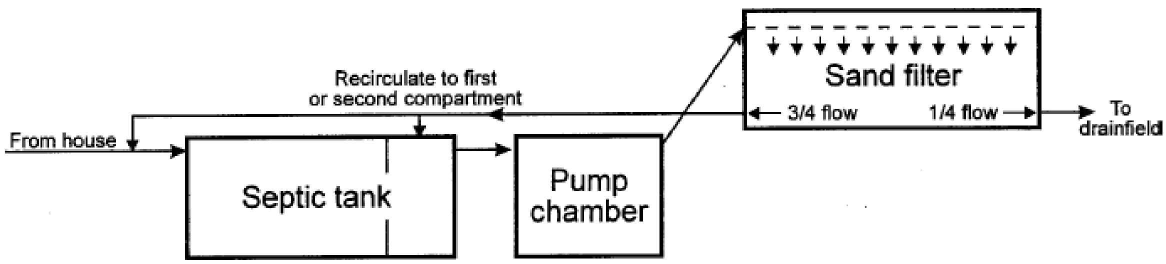


Figure 5: Sequencing Batch Reactor

<u>Sand /Media Filters</u>: Sand/media filters are used to provide further treatment of septic tank effluent, particularly for enhanced nitrogen and bacteria removal. These filters are also used in conjunction with aerobic treatment, as mentioned above.

Effluent from the septic tank is pressurized and sprayed on a volume of sand or other media. Microorganisms in the media promote the removal of nitrogen from wastewater through the bacterial conversion of ammonia and organic nitrogen to nitrates (nitrification) and the reduction of nitrates to gaseous nitrogen (denitrification). Many types of media can be used in these filters, however; washed, graded sand is the most common medium used. Other granular media include gravel, anthracite, crushed glass, expanded shale, and bottom ash from coal-fired power plants. Foam chips, peat, and synthetic textile materials have also been used, mostly in proprietary units.

Two types of filter designs are common, "intermittent (single-pass)" and "recirculating." Intermittent filters discharge treated septic tank effluent to the leachfield after one pass through the filter medium. Recirculating filters collect and recirculate the filtrate through the filter medium several times before discharging it to leachfield, see **Figure 6**. Intermittent filters are most frequently used for smaller applications, sites where bacteria removal is needed, and sites where nitrogen removal is not required. Recirculating filters are used for both large and small flows and are used where nitrogen removal is necessary. Recirculating sand filters generally outperform intermittent filters in removal of biochemical oxygen demand (BOD), total suspended solids (TSS), ammonia, and nitrate.



Source: Piluk and Peters, 2000

Figure 6: Sand Filter

Add-On Anoxic Filters: This technology passes nitrified effluent, from a sand filter or other aerobic treatment unit, through a low-oxygen, carbon-rich environment before soil dispersal. One commercially available product, NITREX, has been shown to regularly produce effluent with nitrogen concentrations of less than 5 mg/L (Heufelder et al., 2007). The Nitrex^{TM} unit is filled with a proprietary wood byproduct mixture that promotes the breakdown of nitrate. Wastewater containing nitrate is applied to the surface of the Nitrex^{TM} filter, as the wastewater moves through the filter, microorganism's breakdown the nitrate to nitrogen gas. With adequate aerobic pretreatment, the manufacturer claims near complete removal of nitrate nitrogen from wastewater. A Nitrex^{TM} unit was installed at the Scully Estate – Environmental Center in Islip, NY in 2008. The wastewater treatment process consists of the following sequence: Septic Tank → BioFilter → NitrexTM → Drainfield.

For a single family home, the cost of a Nitrex filter can range from $4,000 - $7,000. However, this does not include the cost of the septic system, aerobic treatment unit, or soil dispersal system. Operation and maintenance costs of the Nitrex filter is less than $100 a year.

Please see **Figure 7** below for an overview of the removal efficiencies of the technologies discussed above. The removal efficiencies were obtained from the publications cited below the figure.

Figure 7: Biological Nitrogen Removal Performance

Technology examples	TN removal efficiency (%)	Effluent TN (mg/L)
Suspended growth		
Aerobic units w/ pulse aeration	25%–61%[a]	37–60[a]
Sequencing batch reactor	60%[b]	15.5[b]
Attached growth		
Single-Pass Sand Filters (SPSF)	8%–50%[c]	30–60[c]
Recirculating Sand/Gravel Filters (RSF)	15%–84%[d]	10–47[d]
Multi-Pass Textile Filters (AdvanTex AX20)	64%–70%[e]	3–55[e]
RSF w/ Anoxic Filter	40%–90%[f]	7–23[f]
RSF w/ Anoxic Filter & external carbon source	74%–80%[g]	10–13[g]
RUCK system	29%–54%[h]	18–53[h]
NITREX	96%[i]	2.2[i]

Source: Adapted from Washington Department of Health 2005

Notes: Overall performance can vary, depending on system configuration and other factors. For detailed descriptions of treatment processes and technologies, see http://www.psparchives.com/publications/our_work/hood_canal/hood_canal/n_reducing_technologies.pdf.

a. California Regional Water Quality Control Board 1997; Whitmeyer et al. 1991

b. Ayres Associates 1998

c. Converse 1999; Gold et al. 1992; Loomis et al. 2001; Nolte & Associates 1992; Ronayne et al. 1982

d. California Regional Water Quality Control Board 1997; Gold et al. 1992; Loomis et al 2001; Nolte & Associates 1992; Oakley et al. 1999; Piluk and Peters 1994; Ronayne et al. 1982

e. NSF International 2009

f. Ayres Associates 1998; Sandy et al. 1988

g. Gold et al. 1989

h. Brooks 1996; Gold et al. 1989

j. Rich et al. 2003

Other Systems

Leachfield Aeration: This technology involves intermittent aeration of the leach field and surrounding soils, which promotes oxidation of excess organic material and supports conditions for removal of nitrogen, phosphorus, organic carbon, and fecal coliform bacteria. This technology allows for the rejuvenation of a failed or failing leach field and enhances removal of total nitrogen, fecal coliform bacteria, and biochemical oxygen demand (BOD_5, amount of dissolved oxygen consumed in five days by bacteria that perform biological degradation of organic matter).

SoilAir™ is one technology that has been extensively tested. The SoilAir™ technology injects air into the leach field and the air travels into the surrounding soil. The oxygen in the air allows the microorganisms in the soil to thrive and reach high population levels. The microorganisms then eat the accumulated organic matter in the leach field, which assists with unclogging the leach field. The microorganisms also eat the bacteria in wastewater and breakdown nitrogen, thereby reducing bacteria and nitrogen levels in the leach field. In a study conducted by Amador et al (2007), intermittent aeration resulted in improved septic tank effluent infiltration, increased levels of dissolved oxygen and NO_3, lower concentrations of NH_4 and iron (Fe II), and more acidic pH in drainage water. Removal of total nitrogen increased from less than 10% to greater than 50%.

The SoilAir™ System includes a blower with a discharge pipe and either a timer or a microprocessor based controller in an enclosure. The enclosure is connected to a power supply and the blower discharge pipe supplies air to the leach field.

In terms of cost, SoilAir™ is less expensive than the treatment units discussed above. Equipment costs for a typical residential SoilAir™ application ranges from $1,800 to $5,000, depending on system requirements. Installation costs are site-specific, but tend to be around $2,500. Operating costs are limited to energy to power the blower, with a typical system drawing approximately 280 Watts (Amador et al., 2007).

Vegetated Submerged Bed (VSB, also referred to as Constructed Wetlands): A VSB consists of a gravel bed that is planted with wetland vegetation. A septic tank begins the treatment process by retaining organic solids. The effluent flows out of the septic tank and into the VSB and is distributed into and across the width of the bed. The water level in the VSB is maintained below the top of the gravel in the bed. Microbes attach to the subsurface substrates such as the gravel and plant roots. The microbes purify the wastewater by breaking down the chemical components and settling out solids (sand). **Figure 8** provides an illustration of a VSB.

The VSB is capable of removing most of the suspended and larger colloidal particles, BOD, and organic forms of nitrogen. Since the VSB is largely anaerobic, it's not capable of nitrification and therefore nutrient removal. If nitrogen removal is necessary, a separate ammonia removal process would have to be used in conjunction with the VSB.

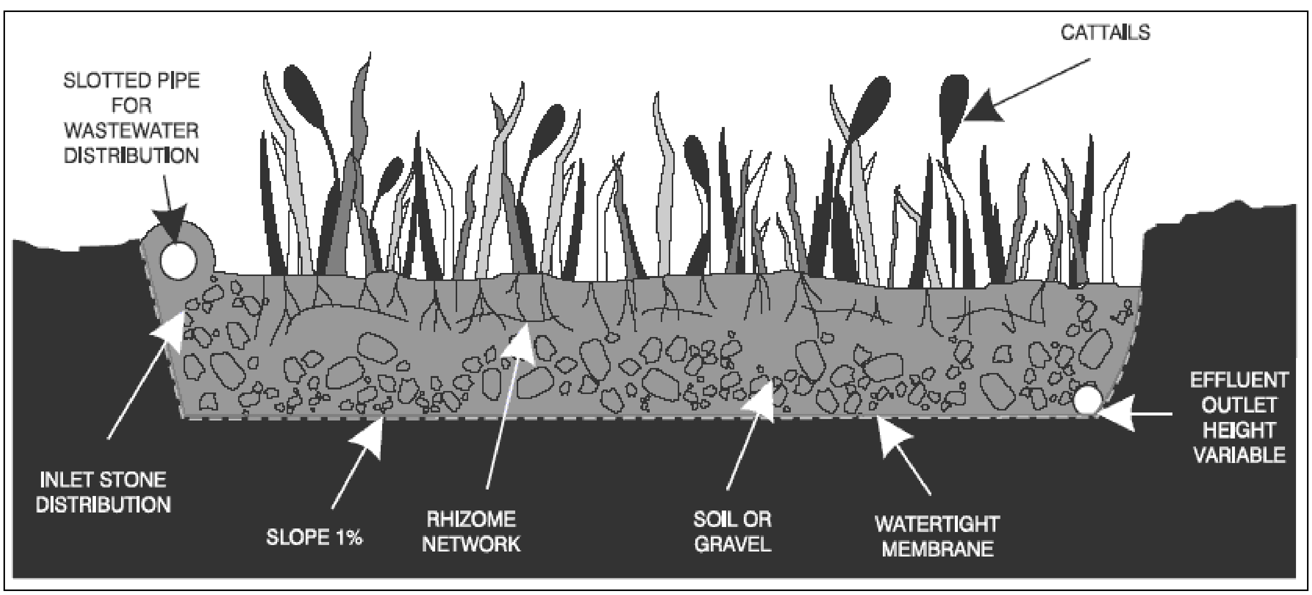


Figure 8: Vegetated Submerged Bed (Source: USEPA, 2010)

Another option for reducing wastewater impacts on groundwater and surface water is to reduce wastewater generation. This could be done through the use of a composting toilet in the home. A brief description of this technology is below.

Composting Toilet: A composting toilet is a well-ventilated container that provides the optimum environment for biological and physical decomposition of human excrement. The process takes place under aerobic (oxygen is present) conditions. Large composting toilets require a basement for installation, but small household composting toilets are more like small self-contained appliances that can be located on the bathroom floor. The composting process involves the transformation of organic matter into an oxidized, humus-like end product by bacteria and fungi. These organisms thrive by aeration, without the need for water or chemicals.

For treatment of high nitrate levels already in groundwater, permeable reactive barriers are an option.

Permeable Reactive Barrier (PRB): PRB's consist of a trench filled with a degradable carbon source (e.g. sawdust, newspaper) and are sited to intercept high-nitrate groundwater plumes before they enter surface waters. As the plumes pass through the low-oxygen, carbon-rich barrier, bacteria break down nitrate molecules thereby removing nitrate from the groundwater entering local surface waters. **Figure 9** provides an illustration of a PRB. Nitrex^{TM}, mentioned above, also develops PRB's. The patented Nitrex^{TM} groundwater nitrogen removal technology was installed at two locations on Cape Cod, MA in the Waquoit Bay watershed. **Figure 10** below illustrates the decrease in algae seen after the installation of the PRB. **Table 1** details the performance of the PRB.

Costs for a PRB range from approximately $5,000 to $15,000 per dwelling unit in the plume area (EPA, 2010). The estimated lifetime of a PRB is greater than 15 years.

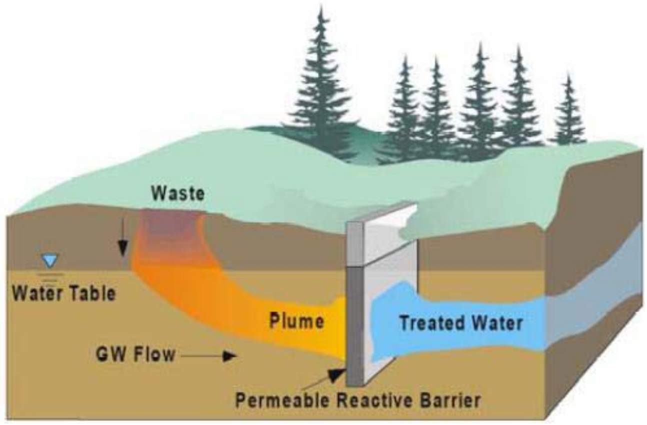


Figure 9: Permeable Reactive Barrier (Source: USEPA, 1998)

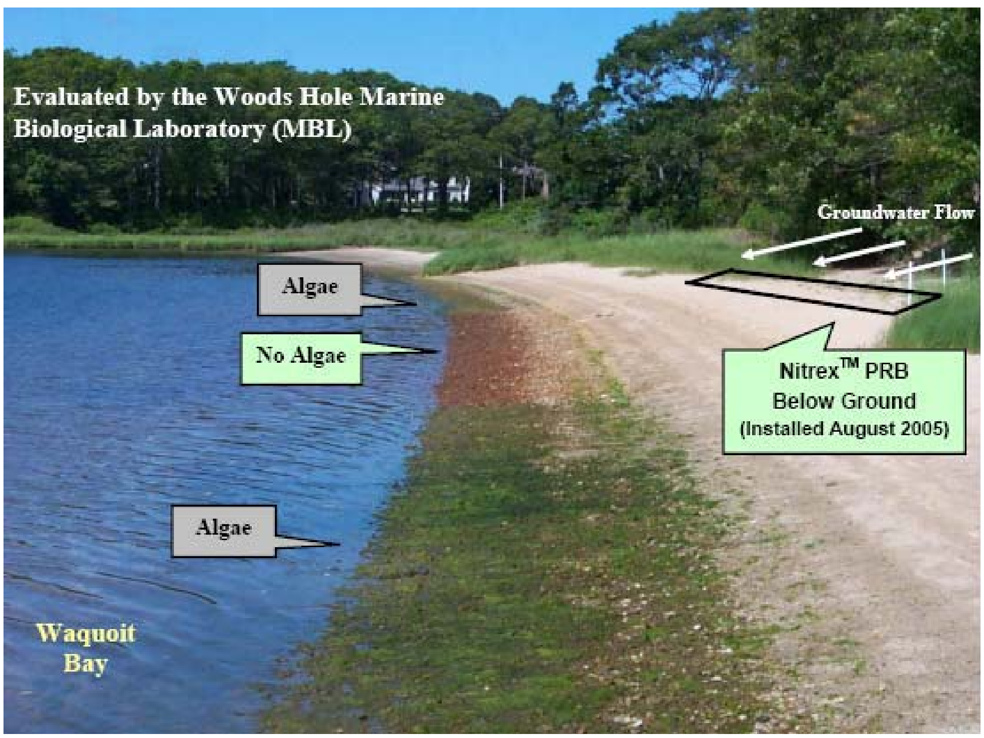


Figure 10: Nitrex PRB Installation shows decrease in algae growth

Table 1: Nitrex Nitrate Removal Efficiency

Site	Influent Nitrate-N (mg/l)	Effluent Nitrate-N (mg/l)
Waquoit Bay, MA	1.74	0.007
Childs River, MA	7.19	0.568

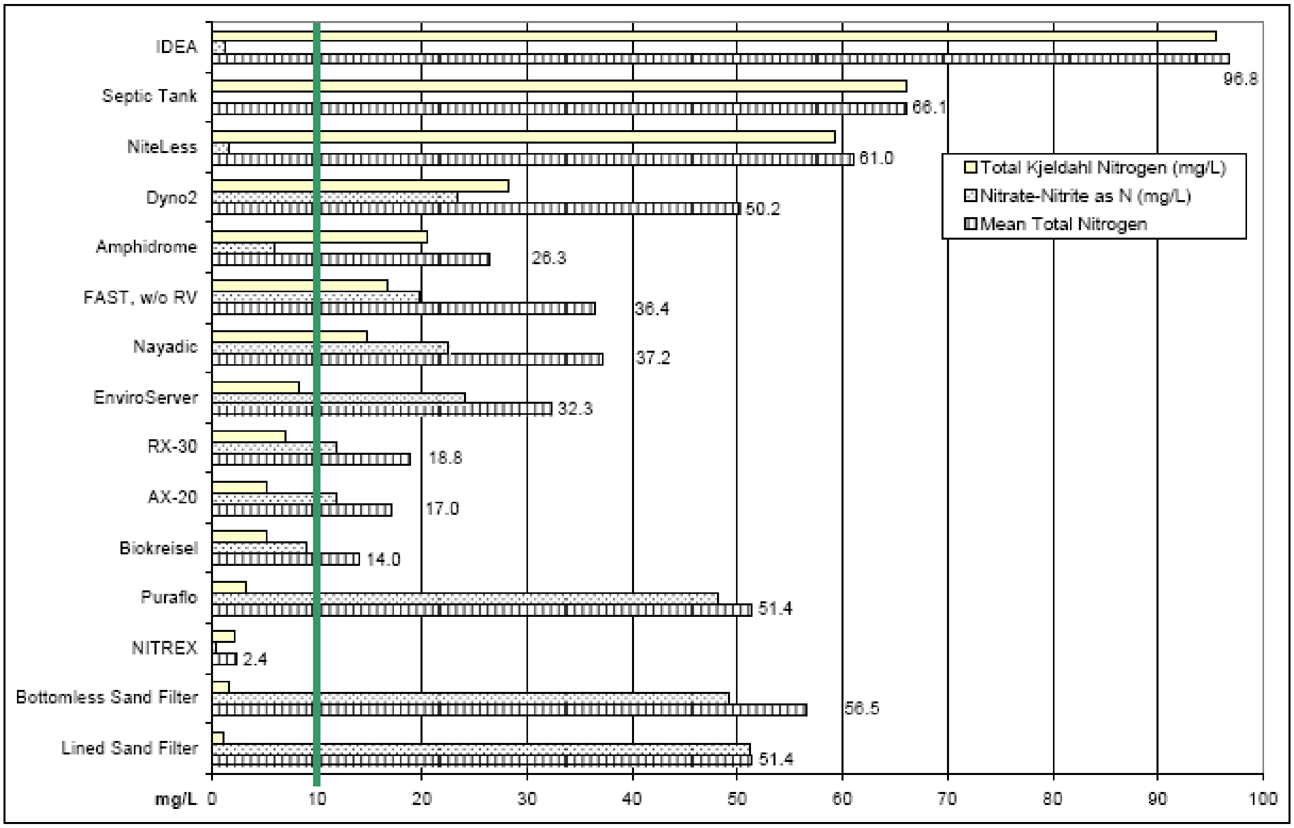
Test Centers/Evaluation of Alternative Treatment Technologies

The Environmental Technology Verification (ETV) is a program funded by the United States Environmental Protection Agency (USEPA). The program is being conducted by the Massachusetts Alternative Septic System Test Center (MASSTC) in partnership with NSF International. Under the ETV program, the Test Center is establishing national protocols for evaluation of nitrogen removal and septic system stress testing. The program tests one unit of technology for 14 months. Currently, six products have completed the ETV process for nitrogen reduction in domestic wastewaters from individual residential homes. The State of Maryland currently recognizes ETV verified technologies for use in the State as part of the State's Chesapeake Bay Restoration Program, where grants are given to homeowners to upgrade septic systems to nitrogen removing technologies. Please see **Table 2** below for an overview of the products.

For a review of the field performance of various alternative technologies, refer to the La Pine Decentralized Wastewater Demonstration Project (Rich, 2005). The La Pine Decentralized Wastewater Demonstration Project has provided some of the most comprehensive field data on the performance of various alternative systems. The project was funded by the EPA and conducted by the Deschutes County, Oregon, Environmental Health Division; Oregon Department of Environmental Quality; and the U.S. Geological Survey. The performance of 15 systems was monitored between 1999 and 2005. **Figures 11-15** below summarize some of the key results.

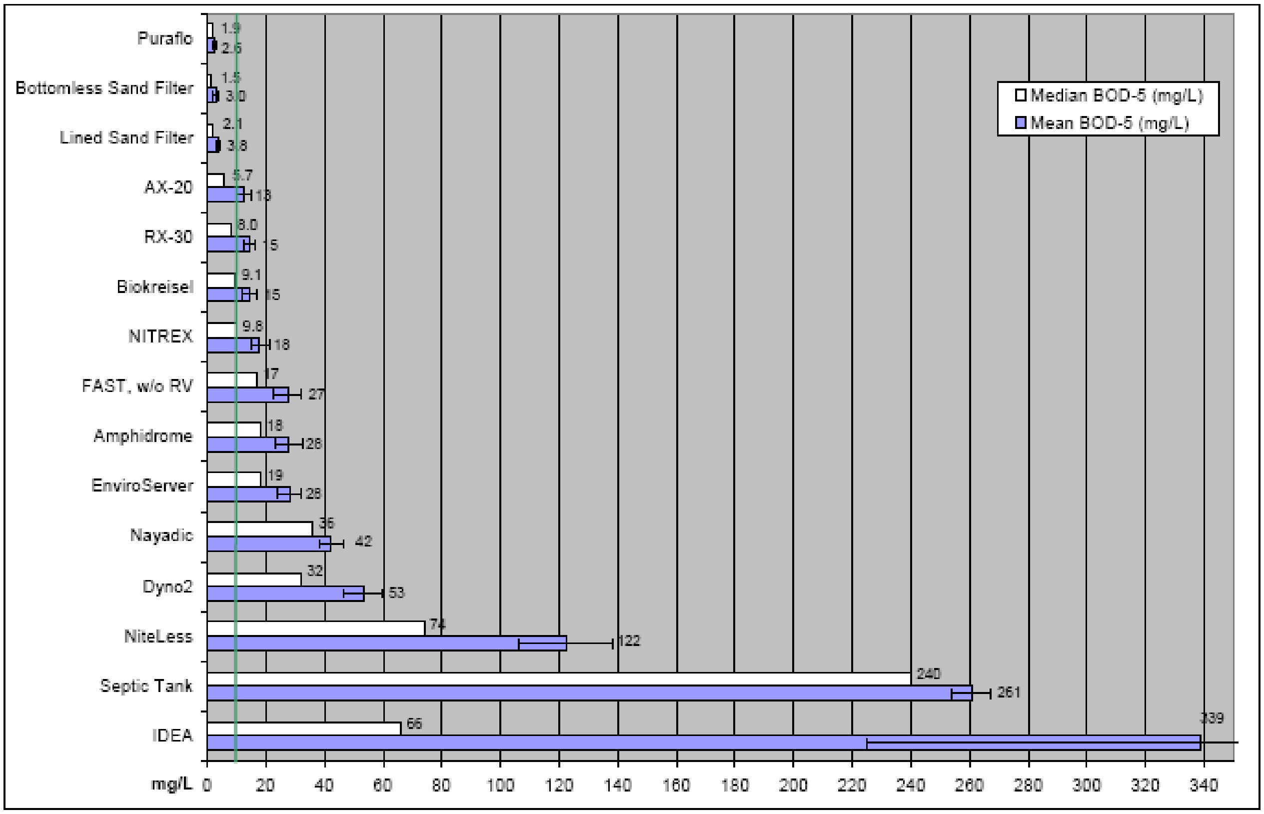
Another good source of information is the Conservation Technology Information Center. From November 9, 2010 to December 14, 2010 the Conservation Technology Information Center, U.S. Environmental Protection Agency, and Tetra Tech hosted a webinar series titled "Decentralized Wastewater Treatment: Treatment Technologies, System Design and Management Strategies." The series included a range of topics, including wastewater treatment processes and technologies, system design, management approaches, and integrating decentralized systems into a new paradigm for managing water resources. The webinars along with the PowerPoint presentation slides can be found at:
https://engineering.purdue.edu/~iwla/webinars/wastewater2010/index.html.

Figure 11: Nitrogen concentrations in the effluent discharged from each treatment unit against the performance standard for the field test of 10 mg/l.



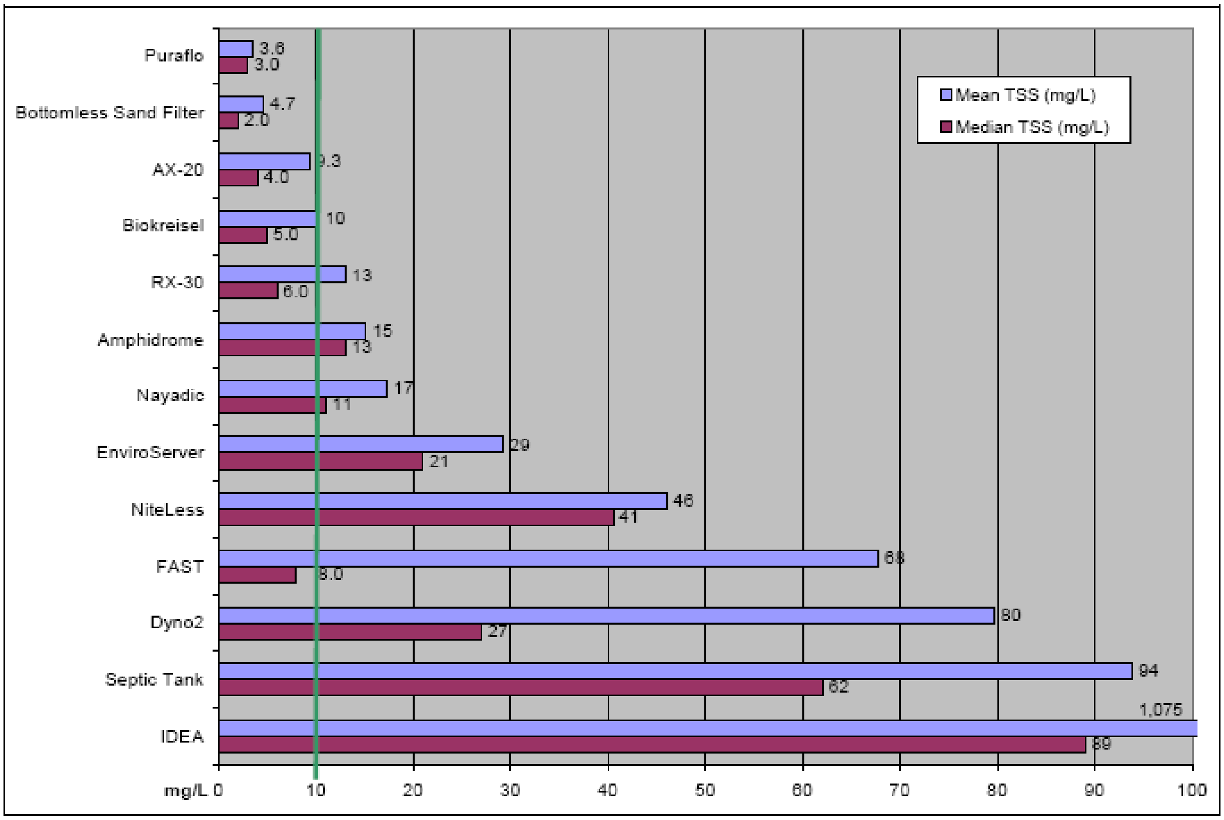
Source: Rich, 2005

Figure 12: Biological Oxygen Demand (BOD_5) of effluent discharged from each treatment unit against the performance standard for the field test of 10 mg/l.



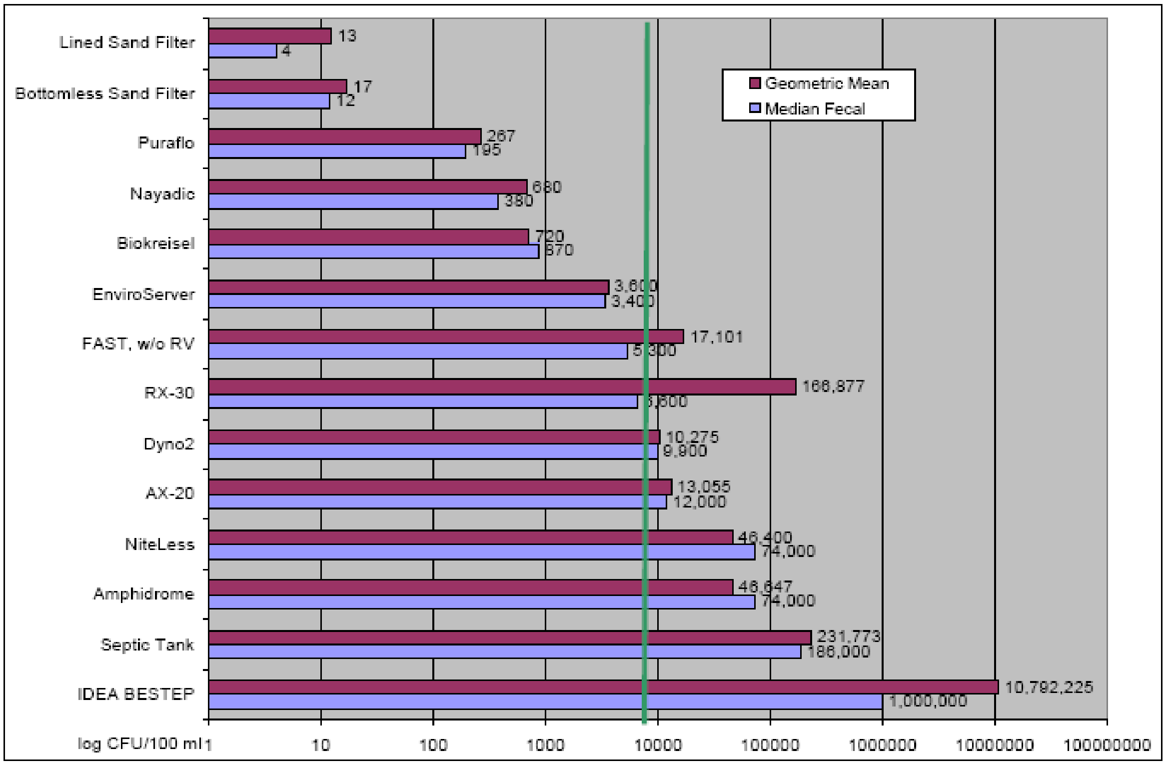
Source: Rich, 2005

Figure 13: Total Suspended Solids in the effluent discharged from each treatment unit against the performance standard for the field test of 10 mg/l.



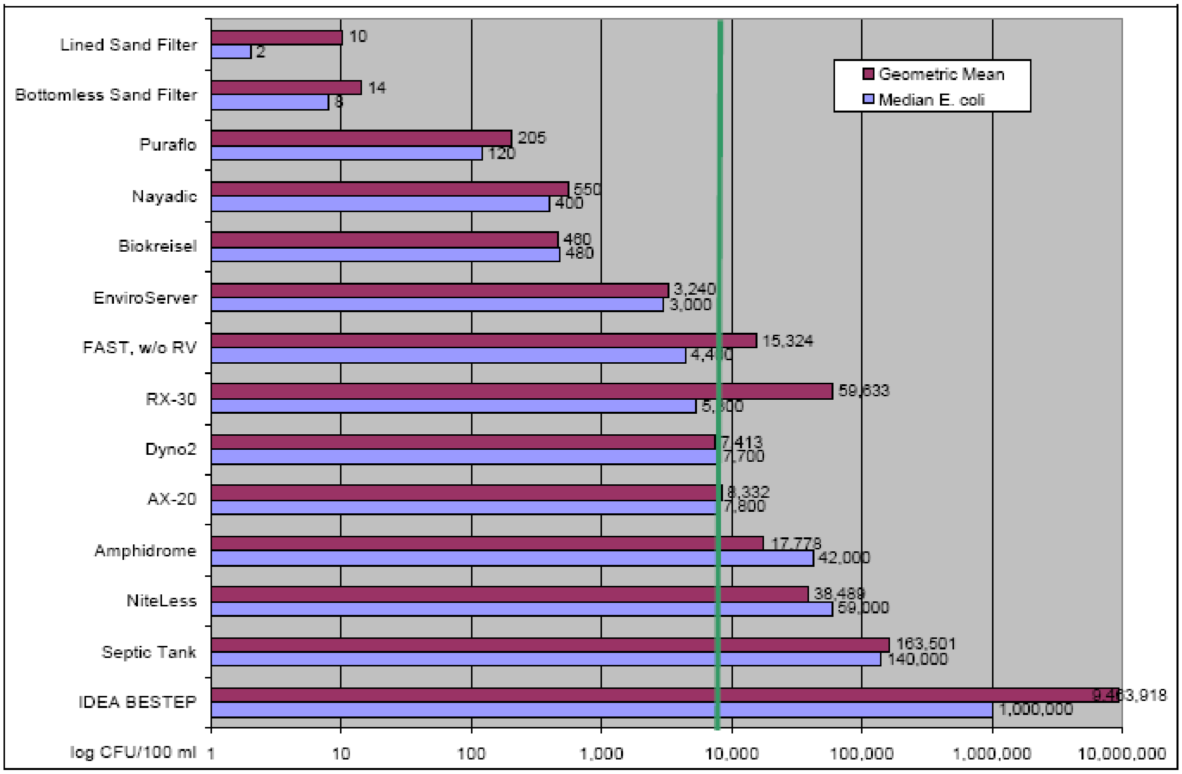
Source: Rich, 2005

Figure 14: Median fecal coliform reduction achieved by each treatment unit.



Source: Rich, 2005

Figure 15: Median E. coli reduction achieved by each treatment unit.



Source: Rich, 2005

Table 2: Products that have completed the ETV process for nitrogen reduction in domestic wastewater from individual residential homes (As of May 16, 2005).

System Name	Technology	Description of Process	Performance	Cost
Waterloo Biofilter® Model 4-Bedroom Waterloo Biofilter Systems, Inc.143 Dennis St.; PO Box 400 Rockwood, Ontario Canada, N0B 2k0 http://www.nsf.org/business/water_quality_protection_center/pdf/Waterloo-VS-SIGNED.pdf	Fixed film trickling filter.	The biofilter unit utilizes a patented lightweight open-cell foam that provides a large surface area. Settled wastewater from a primary septic tank is applied to the surface of the biofilter with a spray distribution system. The system can be set up using a single pass process (without any recirculation of biofilter treated effluent) or can utilize multi-pass configurations. The ETV testing results were generated by returning 50% of the biofilter effluent back to the primary compartment of the septic tank.	It averaged 62% removal of total nitrogen with an average total nitrogen effluent of 14 mg/l over the 13-month testing period. Earlier testing of this product in a single pass mode demonstrated that it could produce a 20-40% TN reduction.	$13,000-17,000 for total system installation. The Waterloo Biofilter® unit only would cost approximately $7,000.
Amphidrome™ Model Single Family System: F.R. Mahony & Associates, Inc. 273 Weymouth St. Rockland, MA 02370 http://www.nsf.org/business/water_quality_protection_center/pdf/Amphidrome_VS.pdf	Submerged growth sequencing batch reactor (SBR) in conjunction with an anoxic / equalization tank and a clear well tank for wastewater treatment	The bioreactor consists of a deep bed sand filter, which alternates between aerobic and anoxic treatment. The reactor operates similar to a biological aerated filter, except that the reactor changes from aerobic to anoxic conditions during sequential cycling of the unit. Air, supplied by a blower, is introduced at the bottom of the filter to enhance oxygen transfer.	It averaged 59% removal of total nitrogen with an average total nitrogen effluent of 15 mg/l over the 13-month testing period at MASSTC.	$7500 for unit only. The manufacturer estimates it would cost $12,000-15,000 for a total installation.
Septitech® Model 400 System: Septitech, Inc. 220 Lewiston Road Gray, Maine 04039 http://www.nsf.org/business/water_quality_protection_center/pdf/SeptiTech_VS.pdf	Two stage fixed film trickling filter using a patented highly permeable hydrophobic media.	Clarified septic tank effluent flows by gravity into the recirculation chamber of the SeptiTech unit. A submerged pump periodically sprays wastewater onto the attached growth process and the wastewater percolates through the patented packing material. Treated wastewater flows back into the recirculation chamber to mix with the contents. Treated water flows into a clarification chamber and is periodically discharged to disposal unit (drainfield, drip irrigation, etc.).	Averaged 64% removal of total nitrogen with an average total nitrogen effluent of 14 mg/l over the 12-month testing period at MASSTC.	$11,000 for Septitech unit includes shipping and installation. The manufacturer estimates that a total system with pressure distribution drainfield would cost approximately $20,000.

Adapted from Washington Department of Health, 2005.

Table 3: Products that have completed the ETV process for nitrogen reduction in domestic wastewater from individual residential homes (As of May 16, 2005).

System Name	Technology	Description of Process	Performance	Cost
Bioclere™ Model 16/12: Aquapoint, Inc. 241 Duchanine Blvd New Bedford, MA 02745 http://www.nsf.org/business/water_quality_protection_center/pdf/Bioclere-VS-SIGNED.pdf	Fixed film trickling filter.	Septic tank effluent flows by gravity to the Bioclere clarifier unit from which it is sprayed or splashed onto the fixed film media. Treated effluent and sloughed biomass are returned to the clarifier unit. A recirculation pump in the clarifier periodically returns biomass to the primary tank. Oxygen is provided to the fixed film by a fan located on the top of the unit.	Averaged 57% removal of total nitrogen with an average total nitrogen effluent of 16 mg/l over the 13-month testing period at MASSTC.	$7500 for unit itself. Price for total system would need to include primary septic tank, Bioclere unit and disposal option, with costs in the range of $12,000 -15,000. The manufacturer recommends use in clusters to reduce per home costs and facilitate maintenance. Experience with 27 home cluster resulted in costs of $6800-8,000 per home.
Retrofast® 0.375 System: Bio-Microbics 8450 Cole Parkway Shawnee, KS 66227 http://www.nsf.org/business/water_quality_protection_center/pdf/Biomicrobics-FinalVerificationStatement.pdf	Submerged attached-growth treatment system, which is inserted as a retrofit device into the outlet side of new or existing septic tanks.	The RetroFAST® 0.375 System is inserted in the second compartment of the septic tank. Air is supplied to the fixed film honeycombed media of the unit by a remote blower. Alternate modes of operation include recirculation of nitrified wastewater to the primary settling chamber for denitrification. Intermittent use of the blower can also be programmed to reduce electricity use and to increase denitrification.	Averaged 51% removal of total nitrogen with an average total nitrogen effluent of 19 mg/l over the 13-month testing period at MASSTC.	Product and installation cost for the Retrofast® 0.375 System ranges is estimated to be from $4,000-5,500 depending on existing tankage. That cost includes the FAST unit, blower, blower housing and control panel. The local representative for Bio-Microbics units believes costs could be as low as $3,500 for multiple units.

Adapted from Washington Department of Health, 2005.

Table 4: Products that have completed the ETV process for nitrogen reduction in domestic wastewater from individual residential homes (As of May 16, 2005).

System Name	Technology	Description of Process	Performance	Cost
Recip® RTS~500 System: Bioconcepts, Inc. P.O. Box 885 Oriental, NC 28571-0885 http://www.nsf.org/business/water_quality_protection_center/pdf/Bioconcepts_Verification_Statement.pdf	Fixed film filter	This is the newest product to complete ETV testing. It is a patented process developed by the Tennessee Valley Authority (TVA) and utilizes a fixed film filter medium contained in two adjacent, equally dimensioned cells. Timers on each of the two reciprocating pumps control the process.	Averaged 58% removal of total nitrogen with an average total nitrogen effluent of 15 mg/l over the 12-month testing period at MASSTC.	Very limited experience with this particular single-family unit. The unit built for ETV testing was a prototype. The cost per unit, by itself, is estimated to be $8,000-10,000. Cost of the septic tank and disposal unit would be extra and the cost would depend on site conditions. Conservatively, cost for a total system could be $11,000-15,000.

Source: Adapted from the Washington Department of Health, 2005

Alternative Systems in Suffolk County
Currently, the only "alternative system" Suffolk County Department of Health allows is the mound system in areas of high groundwater. Otherwise, they require a conventional septic tank and leaching pool system. If a homeowner was interested in installing one of the treatment technologies listed above, the homeowner would be required to obtain a variance. However, variances are very rarely granted.

The main issue with the "alternative" treatment technologies listed above is that they function differently in different environments with different climate, site conditions, hydraulic loads, and pollutant loads. Therefore, Suffolk County would have to conduct a comprehensive study of alternative systems to determine performance and feasibility for use in Suffolk County before alternative systems could be used.

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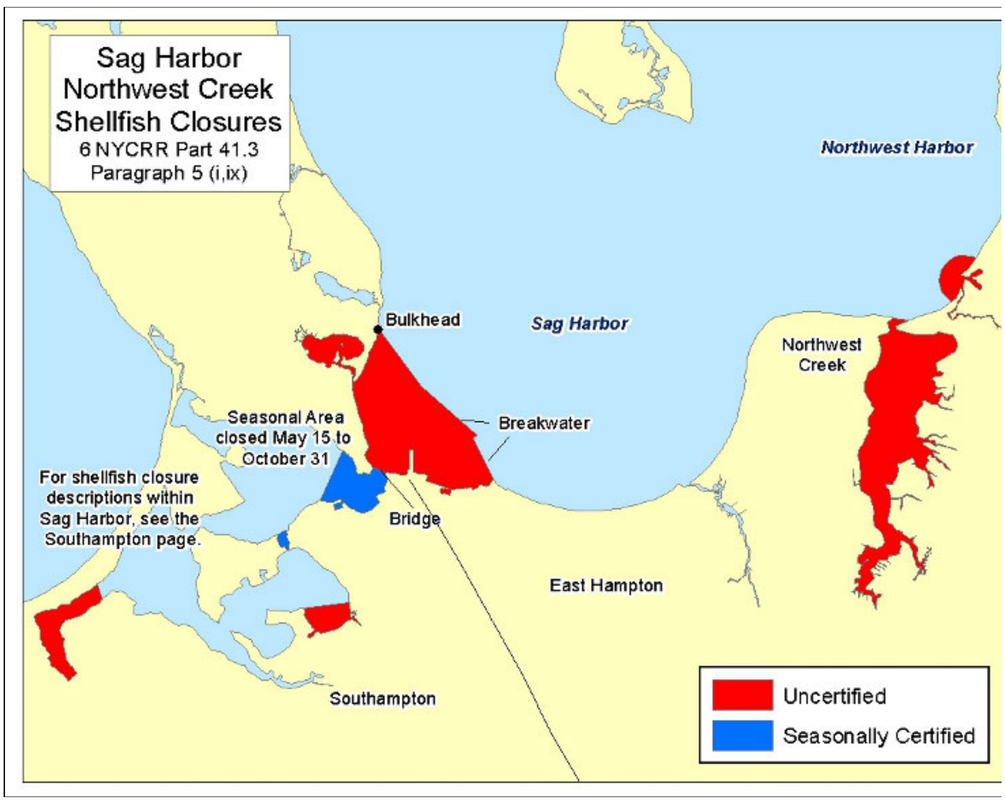
Appendix B

NYSDEC Shellfish Closure Areas Regulations

(5) Town of East Hampton.

(i) Sag Harbor.

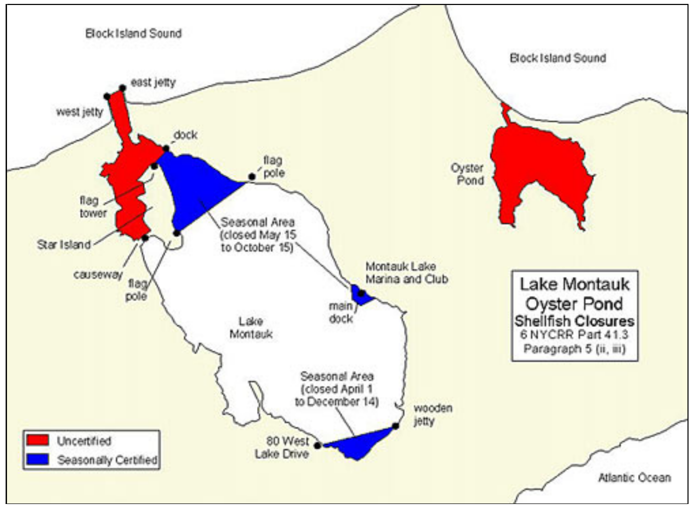
(a) All that area, including tributaries, lying westerly of a line extending northerly along the breakwater located at the entrance to Sag Harbor (local landmark) and thence continuing northerly from the northern end of the breakwater to the northeasternmost extremity of the timber bulkhead protecting the shoreline adjacent to East Harbor Drive, North Haven (local landmark); and easterly of the westernmost portions of the fixed bridge connecting North Haven Peninsula and Sag Harbor (local landmark).



Note: All reference points in Sag Harbor in the Town of East Hampton taken from N.O.A.A. Nautical Chart No. 12358 dated December 1, 1984, except as indicated as "local landmarks."

(ii) Montauk Lake (Montauk Harbor).

(a) All that area lying south of a line extending easterly from the flashing red light on the jetty on the western side of the entrance to Montauk Harbor (Lake Montauk) to the flashing green light on the jetty on the eastern side of the entrance to said harbor; and all that area, including tributaries, northerly of the causeway to Star Island and a line extending easterly from the flag tower at the U.S. Coast Guard Station on Star Island to the southernmost extremity of the dock serving Deep Water Seafood, Inc. (local landmark) and located on the eastern shore of Montauk Harbor (Lake Montauk).



(b) During the period April 1st through December 14th (both dates inclusive), all that area of Montauk Lake and tributaries lying southerly of a line extending easterly from the highest point of the stone chimney (serving the Rispoli residence, 80 Old West Lake Drive) to the northwestern end of northernmost wooden jetty extending from the shoreline at Bridgeford Colony (local landmarks, local name).

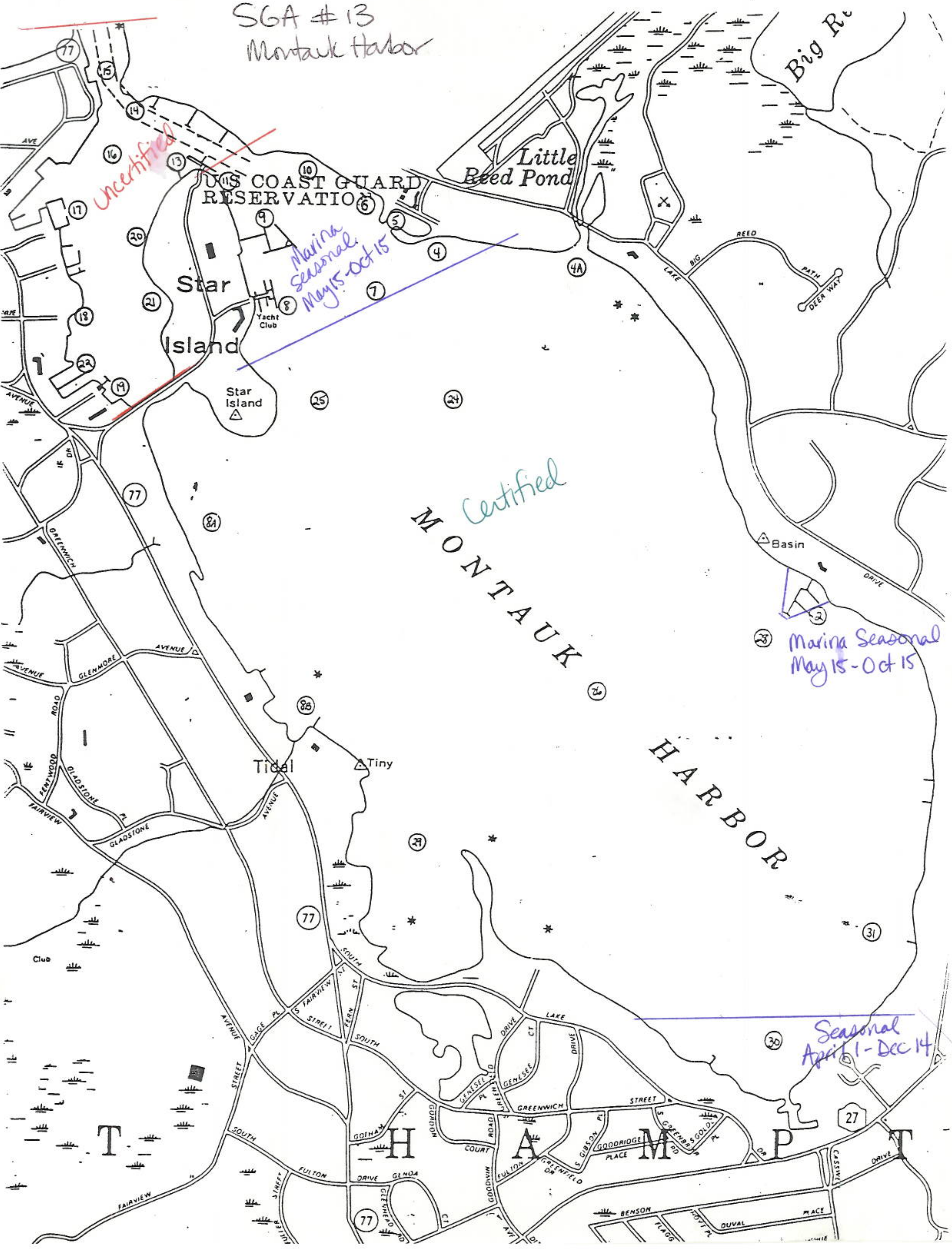
(c) During the period May 15th through October 15th (both dates inclusive), all that area of Montauk Harbor (Montauk Lake) lying south of a line extending easterly from the flag tower at the U.S Coast Guard Station on Star Island to the southernmost extremity of the dock serving Deep Water Seafood, Inc. (local name, local landmark), on the western shore and northwest of a line extending northeasterly from the white flagpole located on the shoreline of the P. Kalikow residence (local name), off Star Island Drive, to a white flagpole at 395 East Lake Drive on the opposite shoreline (local landmark).

(d) During the period May 15th through October 15th (both dates inclusive), all that area of Montauk Harbor (Montauk Lake) at the Montauk Lake Marina and Club (local name, local landmark) lying east of a line extending southeasterly from a point 100 yards northwesterly of the main fixed dock to the southwesternmost end of that same fixed dock, continuing southeasterly along the fixed T- dock to its southeasternmost end and continuing in an easterly direction, 100 yards southeast of the innermost end of the floating T-dock.

Appendix C

NYSDEC Shellfish Data 2001-2012

SGA #13
Montauk Harbor



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2/26/2001	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
4/2/2001	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
4/24/2001	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
6/6/2001	2.9	2.9	2.9	2.9	2.9	2.9	4.0	2.9
6/18/2001								
6/20/2001								
8/29/2001	23.0	2.9	2.9	2.9	3.0	2.9	3.0	9.0
9/18/2001	2.9	2.9	4.0	9.0	2.9	2.9	2.9	2.9
10/17/2001	4.0	4.0	4.0	2.9	4.0	2.9	2.9	3.0
11/15/2001	2.9	4.0	2.9	4.0	2.9	2.9	4.0	2.9
12/13/2001	2.9	2.9		15.0	43.0	43.0	4.0	
1/14/2002	7.0	2.9	2.9	4.0	3.0	4.0	3.0	4.0
2/14/2002	2.9	2.9		4.0	9.0	4.0	2.9	15.0
3/14/2002	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
5/13/2002	3.0	2.9	4.0	4.0	4.0	2.9	2.9	2.9
6/11/2002								
6/26/2002	2.9	2.9	2.9	9.0	2.9	2.9	2.9	4.0
10/8/2002	2.9	3.0	9.0	2.9	4.0	4.0	9.0	4.0
10/22/2002	4.0	2.9	2.9	2.9	2.9	2.9	2.9	2.9
12/4/2002	4.0	4.0	2.9	4.0	4.0	9.0	9.0	2.9
3/4/2003	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
4/29/2003	2.9	4.0	23.0	4.0	2.9	2.9	2.9	2.9
6/26/2003	2.9	2.9	2.9	2.9	4.0	2.9	2.9	2.9
7/29/2003	9.0	43.0	4.0	23.0	7.0	4.0	9.0	23.0
9/25/2003	4.0	2.9	2.9	3.0	2.9	4.0	2.9	2.9
4/5/2004						4.0	2.9	
4/7/2004	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
4/15/2004								
4/19/2004	2.9	2.9	2.9	2.9	2.9	2.9	2.9	43.0
7/1/2004	2.9	2.9	2.9	7.3	2.9	2.9	3.6	23.0
7/14/2004								
7/16/2004								
8/2/2004	2.9	2.9	2.9	2.9	2.9	2.9	9.1	3.6
9/13/2004	11.0	2.9	2.9	15.0	2.9	2.9	2.9	2.9
10/4/2004								
11/15/2004	3.6	2.9	2.9	2.9	3.6	3.6	3.6	2.9
12/29/2004	2.9	3.6	2.9	23.0	2.9	3.6	3.6	2.9
1/11/2005	2.9	2.9	9.1	15.0	9.1	2.9	2.9	9.1
2/8/2005		2.9	2.9	2.9	2.9	2.9	2.9	2.9
3/10/2005	2.9	2.9	2.9	2.9	2.9	3.6	2.9	2.9
5/9/2005	2.9	3.6	2.9	2.9	3.6	2.9	3.6	2.9
7/6/2005	2.9	2.9	2.9	23.0	2.9	2.9	9.1	3.6
9/1/2005	3.6	3.6	2.9	43.0	3.6	3.6	460.0	3.6
9/19/2005	2.9	2.9	2.9	2.9	2.9	3.6	2.9	2.9
10/19/2005		23.0		9.1		2.9		
12/14/2005	3.0	2.9	2.9	2.9	3.6	2.9	9.1	2.9
1/13/2006	2.9	9.1	2.9	2.9	2.9	9.1	2.9	3.6

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4/10/2006	2.9	2.9	3.6	2.9	2.9	2.9	9.1	2.9
5/15/2006		2.9				2.9		
6/12/2006	2.9	2.9	2.9	2.9	2.9	2.9	3.6	2.9
6/27/2006								
7/25/2006	2.9	2.9	2.9	2.9	2.9	2.9	240.0	2.9
8/31/2006								
9/21/2006	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
10/23/2006	3.6	2.9	2.9	2.9	2.9	2.9	2.9	3.6
11/7/2006	2.9	2.9	3.6	2.9	2.9	2.9	2.9	2.9
12/7/2006	2.9	2.9	2.9	3.6	2.9	3.0	2.9	2.9
1/18/2007	3.6	3.6	2.9	2.9	2.9	3.6	2.9	3.6
3/20/2007	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
4/3/2007	3.6	2.9	2.9	2.9	2.9	2.9	2.9	2.9
6/11/2007	7.2	2.9	2.9	2.9	2.9	2.9	3.0	2.9
6/14/2007	9.1	3.6	7.3	9.1	2.9	3.6	3.6	3.0
7/30/2007	2.9	2.9	2.9	2.9	2.9	2.9	2.9	3.6
12/10/2007	3.6	3.0	2.9	2.9	2.9	2.9	2.9	2.9
1/10/2008	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
2/7/2008	9.1	7.3	7.3	2.9	3.6	2.9	3.0	2.9
3/20/2008	2.9	2.9	2.9	3.0	2.9	2.9	2.9	2.9
4/7/2008	3.6	3.6	2.9	2.9	3.6	2.9	2.9	2.9
5/2/2008	2.9	2.9	3.6	2.9	2.9	2.9	2.9	3.6
6/17/2008	2.9	3.6	2.9	3.0	2.9	3.6	15.0	7.3
9/30/2008								
11/24/2008	2.9	2.9	3.6	2.9	2.9	2.9	2.9	2.9
12/16/2008		2.9		2.9		2.9		
1/13/2009	2.9	7.3	2.9	3.6	2.9	2.9	2.9	2.9
2/10/2009	2.9	2.9	2.9	2.9	3.6	2.9	2.9	2.9
3/26/2009	2.9	2.9	2.9	2.9	3.0	2.9	2.9	2.9
4/23/2009	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
6/22/2009	23.0	9.1	3.6	7.3	3.6	3.6	43.0	9.1
7/27/2009		15.0						
9/17/2009	9.1	2.9	3.6	3.6	2.9	9.1	2.9	2.9
12/3/2009	150.0	2.9	2.9	20.0	2.9	9.1	3.6	2.9
1/26/2010	2.9	3.6	2.9	2.9	2.9	2.9	2.9	3.0
3/2/2010	2.9	2.9	3.6	2.9	2.9	2.9	2.9	2.9
3/17/2010	2.9		2.9			2.9		
4/1/2010	2.9		2.9		2.9			2.9
4/27/2010	2.9	2.9	2.9	2.9	3.6	2.9	2.9	2.9
6/24/2010	2.9	2.9		2.9	2.9	2.9	2.9	2.9
9/7/2010	9.1	2.9	43.0	2.9	2.9	2.9	3.6	43.0
9/21/2010	2.9	3.6	3.6	2.9	2.9	2.9	2.9	2.9
10/25/2010	3.6	2.9	2.9	3.0	2.9	3.6	3.6	2.9
12/8/2010	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
1/4/2011	3.6	2.9	2.9	2.9	2.9	3.6	2.9	2.9
4/4/2011	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9

DATE	FC_2	FC_4	FC_5	FC_6	FC_7	FC_8	FC_9	FC_10
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5/18/2011	43.0	23.0	43.0	23.0	2.9	23.0	9.1	2.9
7/12/2011	3.6	3.6	2.9	2.9	2.9	2.9	2.9	7.3
8/1/2011	2.9	2.9	9.1	3.6	2.9	2.9	2.9	2.9
8/18/2011		23.0						
8/31/2011		2.9						
9/28/2011	9.1	2.9	1100.0	43.0	3.6	2.9	3.6	43.0
12/13/2011	2.9	2.9	2.9	2.9	2.9	3.0	2.9	9.1
2/7/2012	2.9	2.9	2.9	2.9	2.9	3.6	2.9	2.9
2/8/2012	2.9	2.9	2.9	2.9	2.9	3.6	3.6	2.9
3/6/2012	7.3	2.9	2.9	2.9	2.9	3.6	2.9	2.9

DATE	FC_11	FC_13	FC_14	FC_15	FC_16	FC_17	FC_18	FC_19
2/26/2001	2.9							
4/2/2001	2.9							
4/24/2001	2.9	2.9	2.9	4.0	3.0	4.0	2.9	2.9
6/6/2001	2.9	3.0	2.9	4.0	2.9	2.9	2.9	2.9
6/18/2001								
6/20/2001								
8/29/2001	11.0	2.9	240.0	23.0	20.0	11.0	23.0	3.0
9/18/2001	4.0	7.0	9.0	75.0	43.0	93.0	9.0	43.0
10/17/2001	3.0	4.0	2.9	2.9	4.0	9.0	2.9	4.0
11/15/2001	2.9	4.0	9.0	3.0	2.9	9.0	2.9	43.0
12/13/2001	9.0							
1/14/2002	4.0	9.0	9.0	4.0	4.0	2.9	2.9	2.9
2/14/2002	2.9							
3/14/2002	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
5/13/2002	4.0	9.0	3.0	3.0	2.9	23.0	23.0	7.0
6/11/2002								
6/26/2002	9.0	2.9	9.0	93.0	2.9	7.0	4.0	2.9
10/8/2002	3.0	4.0	2.9	4.0	7.0	4.0	3.0	2.9
10/22/2002	2.9	2.9	2.9	93.0	2.9	2.9	2.9	2.9
12/4/2002	3.0	3.0	3.0	4.0	3.0	2.9	2.9	2.9
3/4/2003	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
4/29/2003	4.0	2.9	2.9	2.9	4.0	2.9	2.9	2.9
6/26/2003	9.0	15.0	9.0	9.0	4.0	9.0	4.0	4.0
7/29/2003	23.0	9.0	9.0	23.0	93.0	93.0	4.0	2.9
9/25/2003	2.9	15.0	9.0	2.9	2.9	2.9	2.9	2.9
4/5/2004	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
4/7/2004	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
4/15/2004	4.0							
4/19/2004	2.9	2.9	2.9	11.0	2.9	2.9	2.9	2.9
7/1/2004	93.0	9.1	2.9	3.6	3.6	2.9	3.6	3.6
7/14/2004								
7/16/2004								
8/2/2004	3.6	15.0	7.3	9.1	7.3	2.9	2.9	2.9
9/13/2004	2.9	240.0	3.6	3.6	2.9	3.6	2.9	240.0
10/4/2004								
11/15/2004	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
12/29/2004	3.6	15.0	2.9	2.9	9.1	3.6	23.0	2.9
1/11/2005	23.0	7.3	9.1	9.1	23.0	7.3	3.6	23.0
2/8/2005	2.9	2.9	2.9	2.9	2.9	2.9	2.9	
3/10/2005	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
5/9/2005	3.6	2.9	2.9	7.3	2.9	2.9	2.9	3.6
7/6/2005	2.9	23.0	2.9	240.0	21.0	3.6	23.0	21.0
9/1/2005	43.0	23.0	23.0	43.0	9.1	3.6	9.1	23.0
9/19/2005	2.9	3.6	2.9	7.3	3.6	14.0	3.6	23.0
10/19/2005	15.0							
12/14/2005	9.1	3.6	9.1	2.9	3.6	3.6	2.9	2.9
1/13/2006	9.1	2.9	2.9	2.9	3.6	3.6	2.9	3.6

DATE	FC_11	FC_13	FC_14	FC_15	FC_16	FC_17	FC_18	FC_19
3/16/2006	15.0	23.0	2.9	9.1	2.9	2.9	2.9	2.9
4/10/2006	2.9	9.1	2.9	2.9	2.9	2.9	2.9	2.9
5/15/2006								
6/12/2006	2.9	3.6	150.0	15.0	2.9	2.9	3.6	2.9
6/27/2006								
7/25/2006	3.6	23.0	3.6	7.3	2.9	3.6	2.9	93.0
8/31/2006								
9/21/2006	2.9	3.6	2.9	3.6	9.1	3.6	3.0	3.6
10/23/2006	3.6	2.9	2.9	2.9	3.6	3.6	2.9	3.0
11/7/2006	2.9	2.9	2.9	2.9	2.9	3.6	2.9	2.9
12/7/2006	2.9	3.6	2.9	2.9	9.1	7.3	3.6	2.9
1/18/2007	3.6	15.0	2.9	2.9		23.0	3.6	9.1
3/20/2007	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
4/3/2007	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
6/11/2007	2.9	2.9	2.9	2.9	2.9	3.6	3.0	9.1
6/14/2007	9.1	93.0	3.6	7.3	9.1	43.0	15.0	9.1
7/30/2007	9.1	23.0	2.9	2.9		9.1	3.6	3.6
12/10/2007	2.9							
1/10/2008	2.9	3.6	2.9	2.9	2.9	3.6	3.6	2.9
2/7/2008	2.9	2.9	3.6	9.1	3.6	9.1	2.9	2.9
3/20/2008	2.9	75.0	2.9	9.1	43.0	93.0	3.6	43.0
4/7/2008	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
5/2/2008	2.9	2.9	2.9	2.9	3.0	3.6	2.9	2.9
6/17/2008	39.0	9.1	23.0	9.1	3.6	23.0	9.1	23.0
9/30/2008						0.0		
11/24/2008	2.9	2.9	2.9	3.6	2.9	2.9	2.9	2.9
12/16/2008	2.9					0.0		
1/13/2009	2.9	2.9	9.1	2.9	2.9	2.9	2.9	2.9
2/10/2009	2.9	3.6	2.9	3.0	2.9	3.0	2.9	2.9
3/26/2009	2.9	2.9	2.9	2.9	2.9	23.0	2.9	2.9
4/23/2009	2.9	9.1	2.9	2.9	2.9	2.9	2.9	2.9
6/22/2009	9.1	7.3	3.6	3.6	3.6	15.0	23.0	240.0
7/27/2009								
9/17/2009	9.1	3.6	2.9	2.9	3.6	23.0	15.0	3.6
12/3/2009	15.0	9.1	3.6	3.6	9.1	9.1	3.6	21.0
1/26/2010	3.6	2.9	2.9	9.1	2.9	3.6	2.9	2.9
3/2/2010	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
3/17/2010	2.9							
4/1/2010								
4/27/2010	2.9	2.9	2.9	2.9	2.9	2.9	2.9	3.6
6/24/2010	2.9	2.9	9.1	2.9	3.0	23.0	7.3	9.1
9/7/2010	3.0	20.0	2.9	9.1	2.9	7.3	3.6	7.3
9/21/2010	7.3	2.9	2.9	3.6	15.0	2.9	43.0	9.1
10/25/2010	3.0	9.1	43.6	3.0	2.9	9.1	150.0	3.0
12/8/2010	2.9	2.9	2.9	9.1	3.6	2.9	2.9	2.9
1/4/2011	3.6	2.9	2.9	2.9	2.9	2.9	2.9	2.9
4/4/2011	2.9	2.9	2.9	2.9	2.9	3.6	9.1	2.9

DATE	FC_11	FC_13	FC_14	FC_15	FC_16	FC_17	FC_18	FC_19
5/3/2011	2.9	2.9	2.9	2.9	2.9	2.9	3.6	3.6
5/18/2011	460.0	9.1	21.0	15.0	3.6	93.0	9.1	9.1
7/12/2011	23.0	2.9	9.1	3.6	2.9	240.0	3.6	3.6
8/1/2011	9.1	15.0	23.0	9.1	3.6	240.0	43.0	3.6
8/18/2011								
8/31/2011								
9/28/2011	3.6	43.0	3.6	43.0	3.6	93.0	9.1	11.0
12/13/2011	2.9	2.9	2.9	2.9	3.6	2.9	2.9	2.9
2/7/2012	2.9	7.3	2.9	3.6	3.6	3.0	2.9	2.9
2/8/2012	2.9	2.9	2.9	2.9	3.6	2.9	2.9	2.9
3/6/2012	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9

DATE	FC_20	FC_21	FC_22	FC_24	FC_25
2/26/2001					
4/2/2001					
4/24/2001	2.9	2.9	2.9	2.9	2.9
6/6/2001	2.9	4.0	2.9	2.9	2.9
6/18/2001				9.0	
6/20/2001				4.0	
8/29/2001	9.0	11.0	43.0	2.9	9.0
9/18/2001	4.0	3.0	4.0	2.9	2.9
10/17/2001	4.0	2.9	7.0	2.9	4.0
11/15/2001	4.0	3.0	150.0	4.0	4.0
12/13/2001					9.0
1/14/2002	4.0	2.9	2.9	2.9	2.9
2/14/2002					2.9
3/14/2002	2.9	2.9	2.9	2.9	2.9
5/13/2002	4.0	4.0	9.0	2.9	4.0
6/11/2002					
6/26/2002	2.9	2.9	2.9	2.9	2.9
10/8/2002	2.9	3.0	7.0	2.9	2.9
10/22/2002	2.9	2.9	2.9	2.9	2.9
12/4/2002	2.9	2.9	4.0	2.9	23.0
3/4/2003	2.9	2.9	2.9	2.9	2.9
4/29/2003	2.9	4.0	2.9	2.9	2.9
6/26/2003	9.0	2.9	9.0	2.9	2.9
7/29/2003	2.9	2.9	2.9	2.9	2.9
9/25/2003	4.0	2.9	9.0	4.0	2.9
4/5/2004	2.9	2.9	2.9		2.9
4/7/2004	2.9	2.9	2.9	2.9	2.9
4/15/2004					
4/19/2004	2.9	2.9	2.9	2.9	2.9
7/1/2004	3.6	3.6	3.6	2.9	3.6
7/14/2004				23.0	
7/16/2004				3.0	
8/2/2004	7.3	2.9	2.9	2.9	2.9
9/13/2004	9.1	2.9	23.0	2.9	2.9
10/4/2004				3.6	
11/15/2004	3.0	2.9	2.9	2.9	2.9
12/29/2004	3.6	3.6	9.1	2.9	2.9
1/11/2005	15.0	11.0	3.6	15.0	9.1
2/8/2005	2.9	2.9	2.9	3.6	2.9
3/10/2005	2.9	2.9	2.9	2.9	2.9
5/9/2005	2.9	3.6	3.0	2.9	2.9
7/6/2005	2.9		15.0	2.9	2.9
9/1/2005	9.1	7.3	23.0	2.9	2.9
9/19/2005	9.1	3.6	43.0	2.9	2.9
10/19/2005				3.6	3.6
12/14/2005	2.9	2.9	2.9	3.6	3.6
1/13/2006	3.6	2.9	9.1	3.6	3.0

DATE	FC_20	FC_21	FC_22	FC_24	FC_25
3/16/2006	2.9	2.9	2.9	2.9	2.9
4/10/2006	2.9	2.9	2.9	3.0	2.9
5/15/2006				2.9	
6/12/2006	9.1	2.9	7.3	2.9	2.9
6/27/2006				2.9	
7/25/2006	2.9	3.6	2.9	2.9	2.9
8/31/2006				3.6	
9/21/2006	2.9	7.3	2.9	2.9	2.9
10/23/2006	2.9	2.9	43.0	2.9	2.9
11/7/2006	2.9	2.9	2.9	2.9	2.9
12/7/2006	9.1	2.9	3.6	2.9	2.9
1/18/2007	2.9	9.1	2.9	2.9	2.9
3/20/2007	2.9	2.9	2.9	2.9	2.9
4/3/2007	2.9	2.9	2.9	2.9	2.9
6/11/2007	2.9	2.9	6.1	3.0	2.9
6/14/2007	240.0	23.0	14.0	2.9	2.9
7/30/2007	2.9	2.9	3.6	2.9	2.9
12/10/2007					
1/10/2008	2.9	3.6	2.9	2.9	2.9
2/7/2008	23.0	2.9	2.9	2.9	2.9
3/20/2008	39.0	7.3	2.9	2.9	2.9
4/7/2008	2.9	2.9	2.9	2.9	2.9
5/2/2008	2.9	9.1	2.9	2.9	2.9
6/17/2008	15.0	3.6	3.6	7.3	3.6
9/30/2008				2.9	0.0
11/24/2008	2.9	2.9	2.9	2.9	3.6
12/16/2008				3.6	2.9
1/13/2009	2.9	2.9	2.9	2.9	2.9
2/10/2009	2.9	2.9	2.9	2.9	3.0
3/26/2009	3.6	3.6	9.1	2.9	2.9
4/23/2009	2.9	2.9	2.9	2.9	2.9
6/22/2009	23.0	15.0	23.0	2.9	23.0
7/27/2009				2.9	2.9
9/17/2009	15.0	21.0	23.0	2.9	3.6
12/3/2009	43.0	23.0	9.1	2.9	15.0
1/26/2010	2.9	3.6	3.6	2.9	3.6
3/2/2010	2.9	2.9	2.9	2.9	2.9
3/17/2010				2.9	2.9
4/1/2010				3.6	2.9
4/27/2010	2.9	2.9	9.1	2.9	2.9
6/24/2010	3.6	9.1	9.1	3.0	3.6
9/7/2010	23.0	3.6	9.1	2.9	2.9
9/21/2010	3.6	3.6	23.0	3.6	2.9
10/25/2010	9.1	9.1	9.1	3.6	2.9
12/8/2010	2.9	2.9	2.9	2.9	3.6
1/4/2011	3.6	2.9	2.9	2.9	2.9
4/4/2011	2.9	3.6	2.9	2.9	2.9

DATE	FC_20	FC_21	FC_22	FC_24	FC_25
5/3/2011	2.9	2.9	2.9	2.9	2.9
5/18/2011	15.0	3.6	23.0	9.1	240.0
7/12/2011	2.9	2.9	2.9	2.9	2.9
8/1/2011	2.9	3.6	3.6	2.9	2.9
8/18/2011				2.9	3.6
8/31/2011				3.6	2.9
9/28/2011	9.1	23.0	23.0	3.0	3.6
12/13/2011	3.6	43.0	2.9	2.9	2.9
2/7/2012	3.6	3.6	9.1	2.9	2.9
2/8/2012	2.9	2.9	3.6	2.9	2.9
3/6/2012	2.9	2.9	2.9	2.9	2.9

DATE	FC_26	FC_28	FC_29	FC_30	FC_31	FC_4A	FC_8A	FC_8B
2/26/2001		2.9		2.9		2.9		
4/2/2001		2.9		2.9		2.9		
4/24/2001	2.9	2.9	2.9	2.9	2.9	2.9	4.0	2.9
6/6/2001	2.9	2.9	2.9	4.0	2.9	2.9	2.9	2.9
6/18/2001	2.9	23.0	43.0		1100.0	23.0	23.0	
6/20/2001	2.9	2.9	2.9		4.0	75.0	9.0	
8/29/2001	2.9	2.9	2.9	2.9	4.0	2.9	2.9	4.0
9/18/2001	2.9	2.9	2.9	2.9	4.0	93.0	2.9	2.9
10/17/2001	2.9	15.0	2.9	3.0	4.0	2.9	9.0	2.9
11/15/2001	2.9	9.0	4.0	2.9	2.9	2.9	2.9	2.9
12/13/2001				2.9				
1/14/2002	23.0	7.0	2.9	4.0	4.0	2.9	4.0	4.0
2/14/2002				4.0				
3/14/2002	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
5/13/2002	2.9	2.9	15.0	4.0	2.9	2.9	15.0	2.9
6/11/2002								
6/26/2002	2.9	2.9	4.0	2.9	2.9	2.9	2.9	2.9
10/8/2002	2.9	2.9	4.0	2.9	4.0	2.9	2.9	2.9
10/22/2002	2.9	4.0	2.9	2.9	2.9	2.9	2.9	2.9
12/4/2002	9.0	4.0	2.9	2.9	2.9	2.9	7.0	2.9
3/4/2003	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
4/29/2003	2.9	4.0	2.9	2.9	2.9	2.9	2.9	2.9
6/26/2003	2.9	4.0	2.9	2.9	2.9	2.9	3.0	2.9
7/29/2003	2.9	2.9	2.9	4.0	2.9	15.0	2.9	2.9
9/25/2003	2.9	15.0	2.9	2.9	2.9	2.9	2.9	2.9
4/5/2004	2.9		4.0				2.9	2.9
4/7/2004	4.0	2.9	2.9	2.9	2.9	2.9	2.9	2.9
4/15/2004	2.9	2.9	2.9	2.9		4.0	4.0	
4/19/2004	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
7/1/2004	2.9	2.9	3.6	2.9	2.9	2.9	2.9	2.9
7/14/2004	93.0	460.0	460.0		1201.0	460.0	93.0	
7/16/2004	7.2	2.9	93.0		75.0	15.0	9.1	
8/2/2004	3.6	2.9	2.9	23.0	9.1	2.9	2.9	2.9
9/13/2004	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
10/4/2004	2.9	3.6	2.9		2.9	2.9	2.9	
11/15/2004	2.9	2.9	2.9	2.9	3.6	2.9	2.9	3.6
12/29/2004	3.6	2.9	2.9	3.6	2.9	2.9	3.6	2.9
1/11/2005	7.3	9.1	9.1	3.6	3.6	3.6	3.6	3.6
2/8/2005	2.9		2.9			2.9	2.9	3.6
3/10/2005	2.9	2.9	2.9	9.1	2.9	2.9	2.9	2.9
5/9/2005	2.9	2.9	2.9	23.0	2.9	2.9	2.9	2.9
7/6/2005	2.9	2.9	2.9	15.0	2.9	2.9	2.9	2.9
9/1/2005	2.9	7.3	2.9	2.9	3.6	2.9	3.6	3.6
9/19/2005	2.9	2.9	3.6	2.9	3.6	2.9	3.6	2.9
10/19/2005	23.0	23.0	9.1	23.0	43.0	3.6	9.1	
12/14/2005	3.6	3.6	3.6	2.9	3.6	2.9	2.9	15.0
1/13/2006	9.1	3.6	2.9	2.9	9.1	3.6	2.9	9.1

DATE	FC_26	FC_28	FC_29	FC_30	FC_31	FC_4A	FC_8A	FC_8B
3/16/2006	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
4/10/2006	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
5/15/2006	3.6	2.9	7.3		2.9			
6/12/2006	2.9	2.9	2.9	2.9	9.1	2.9	2.9	2.9
6/27/2006	2.9	3.6	3.6		3.6	3.6	2.9	
7/25/2006		2.9	2.9	3.6	9.1	3.6	2.9	2.9
8/31/2006	15.0	93.0	15.0		3.6	23.0	23.0	
9/21/2006	2.9	3.6	2.9	43.0	2.9	2.9	3.6	2.9
10/23/2006	2.9	9.1	2.9	3.6	2.9	2.9	3.6	3.6
11/7/2006	2.9	3.6	2.9	2.9	2.9	2.9	2.9	3.0
12/7/2006	3.6	2.9	2.9	2.9	2.9	2.9	3.6	3.6
1/18/2007	2.9	2.9	2.9	2.9	2.9	2.9	3.6	2.9
3/20/2007	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
4/3/2007	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
6/11/2007	2.9	23.0	2.9	150.0	23.0	2.9	2.9	3.6
6/14/2007	2.9	2.9	2.9	2.9	9.1	3.6	2.9	3.6
7/30/2007	2.9	2.9	2.9	15.0	2.9	2.9	2.9	2.9
12/10/2007		2.9		2.9				
1/10/2008	9.1	2.9	2.9	2.9	3.6	2.9	2.9	2.9
2/7/2008	2.9	3.6	3.6	3.6	2.9	7.3	2.9	2.9
3/20/2008	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
4/7/2008	2.9	9.1	3.6	2.9	2.9	3.6	2.9	2.9
5/2/2008	2.9	9.1	2.9	2.9	2.9	2.9	2.9	2.9
6/17/2008	2.9	9.1	15.0	93.0	93.0	2.9	3.6	3.6
9/30/2008	9.1	3.6	9.1		9.1	3.6	23.0	
11/24/2008	9.1	2.9	3.6	2.9	2.9	2.9	2.9	3.6
12/16/2008	2.9	9.1	2.9	3.6		3.6	2.9	
1/13/2009	2.9	2.9	2.9	9.1	2.9	9.1	2.9	2.9
2/10/2009	2.9	2.9	2.9	3.6	2.9	2.9	2.9	2.9
3/26/2009	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
4/23/2009	2.9	2.9	2.9	3.6	2.9	2.9	3.6	2.9
6/22/2009	9.1	9.1	3.6	93.0	43.0	23.0	3.6	3.6
7/27/2009	2.9	2.9	43.0		2.9	9.1	9.1	
9/17/2009	2.9	3.6	15.0	9.1	9.1	3.6	3.6	3.6
12/3/2009	2.9	9.1	43.0	9.1	43.0	2.9	23.0	2.9
1/26/2010	3.0	6.2	2.9	2.9	2.9	2.9	2.9	2.9
3/2/2010	3.0	2.9	2.9	2.9	2.9	2.9	2.9	2.9
3/17/2010	2.9	2.9	2.9	2.9	2.9	2.9	2.9	
4/1/2010	3.6	2.9	43.0	3.0	9.1	2.9	240.0	
4/27/2010	2.9	2.9	23.0	3.6	9.1	2.9	2.9	2.9
6/24/2010	2.9	2.9	2.9	2.9	9.1	2.9	2.9	2.9
9/7/2010	2.9	3.6	2.9	2.9	2.9	3.6	2.9	3.6
9/21/2010	2.9	2.9	2.9	3.6	2.9	2.9	9.1	2.9
10/25/2010	9.1	2.9	2.9	2.9	2.9	3.0	2.9	3.6
12/8/2010	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
1/4/2011	3.6	2.9	2.9	2.9	2.9	2.9	23.0	3.6
4/4/2011	2.9	2.9	2.9	2.9	3.6	2.9	2.9	2.9

DATE	FC_26	FC_28	FC_29	FC_30	FC_31	FC_4A	FC_8A	FC_8B
5/3/2011	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
5/18/2011	3.6	43.0	460.0	23.0	2.9	9.1	1201.0	460.0
7/12/2011	3.6	3.6	2.9	2.9	2.9	2.9	3.6	2.9
8/1/2011	2.9	2.9	2.9	2.9	9.1	2.9	3.6	3.6
8/18/2011	2.9	3.6	2.9		9.1	43.0	2.9	
8/31/2011	2.9	2.9		2.9	2.9	2.9	43.0	
9/28/2011	3.6	9.1	9.1	240.0	23.0	2.9	3.6	2.9
12/13/2011	2.9	3.6	2.9	2.9	2.9	2.9	2.9	2.9
2/7/2012	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
2/8/2012	3.6	2.9	2.9	2.9	2.9	2.9		2.9
3/6/2012	2.9	2.9	2.9	2.9	3.0	2.9	2.9	2.9

Appendix D

NYSDEC Big Reed Pond CALM Sampling Data 2003

PNAME	WATDEC	PNUM	QUAL	Class	Latitude	Longitude	DATE	ZSAMP (m)	SECCHI (m)	TOTP (mg/l)	NOx (mg/l)	TKN (mg/l)	SO4 (mg/l)	CHLA (ug/l)	PH	ANC (ueq/l)	COND25 (umho/cm)	CL (mg/l)	TCOLOR (ptu)	Ca (mg/l)	Mg (mg/l)	K (mg/l)	Na (mg/l)
Big Reed Pon	14	763		B	410443	715447	6/4/2003	1.0	1.40	<0.007	<0.05	0.46	4.2	10.60	7.08	370	1460	10.6	70	4.8	4.4	1.9	32.0

Appendix E

SCDHS Bathing Beach Sampling Protocols and Data

Suffolk County Department of Health Services
Office of Ecology
Bathing Beach Water Quality Monitoring Database

Data Reliability/ Disclaimer Statement

The attached water quality data has been collected and compiled by the Suffolk County Department of Health Services (SCDHS) during the course of various environmental monitoring and management programs, and is provided to interested members of the public upon request. The information provided is both current and historical, and has been collected under a wide variety of sampling, analytical, and quality assurance regimes. Users should be aware that changes may periodically be made to the data by the SCDHS, and that versions formally transmitted may or may not reflect these changes.

While the SCDHS believes the data to be accurate and has made great efforts to assure its reliability at the time the information was compiled, the information is provided on an "as is" basis. Neither the County of Suffolk nor the Department of Health Services makes any warranty, either expressed or implied, as to the accuracy, completeness, reliability, quality or usability of the information. Any person having been transmitted this data or otherwise obtaining copies thereof, assumes all responsibility and risk for the accuracy and verification of the information.

All recipients are requested to properly cite the data as follows:

> Suffolk County Department of Health Services (SCDHS), 2012. Bathing beach water quality monitoring data provided by the SCDHS Office of Ecology, Yaphank, N.Y.

Suffolk County Department of Health Services
Office of Ecology
Bureau of Marine Resources
Beach Water Quality Monitoring Results

FieldNum	ColDate	Time	Analysis	Result
EH13	6/4/92		MPN-T	< 20
EH13	6/4/92		MPN-F	< 20
EH13	7/1/92		MPN-T	< 20
EH13	7/1/92		MPN-F	< 20
EH13	7/22/92		MPN-T	< 20
EH13	7/22/92		MPN-F	< 20
EH13	6/10/93		MPN-T	40
EH13	6/10/93		MPN-F	40
EH13	8/4/93		MPN-T	< 20
EH13	8/4/93		MPN-F	< 20
EH13	8/27/93		MPN-T	< 20
EH13	8/27/93		MPN-F	< 20
EH13	6/8/94		ENTERO	< 5
EH13	6/8/94		MPN-T	300
EH13	6/8/94		MPN-F	300
EH13	8/4/94		Entero	35
EH13	8/4/94		MPN-T	70
EH13	8/4/94		MPN-F	70
EH13	7/25/01		MPN-T	130
EH13	7/25/01		MPN-F	130
EH13	7/21/03		MPN-T	< 20
EH13	7/21/03		MPN-F	< 20
EH13	5/17/04		ENTERO	< 2
EH13	5/17/04		MPN-T	20
EH13	5/17/04		MPN-F	20
EH13	5/19/04		ENTERO	1
EH13	5/19/04		MPN-T	20
EH13	5/19/04		MPN-F	20
EH13	5/21/04		ENTERO	2
EH13	5/21/04		MPN-T	< 20
EH13	5/21/04		MPN-F	< 20
EH13	5/27/04		ENTERO	247
EH13	5/27/04		MPN-T	5000
EH13	5/27/04		MPN-F	1300
EH13	6/8/04		ENTERO	< 10
EH13	6/8/04		MPN-T	20
EH13	6/8/04		MPN-F	20
EH13	6/16/04		ENTERO	< 2
EH13	6/16/04		MPN-T	< 20
EH13	6/16/04		MPN-F	< 20
EH13	6/17/04		MPN-T	164
EH13	6/17/04		MPN-F	110
EH13	6/28/04		ENTERO	97
EH13	6/28/04		MPN-T	< 20
EH13	6/28/04		MPN-F	< 20
EH13	7/1/04		ENTERO	8

FieldNum	ColDate	Time	Analysis	Result
EH13	7/1/04		MPN-T	20
EH13	7/1/04		MPN-F	20
EH13	7/7/04		ENTERO	5
EH13	7/7/04		MPN-T	< 20
EH13	7/7/04		MPN-F	< 20
EH13	7/13/04		ENTERO	160
EH13	7/14/04		ENTERO	160
EH13	7/14/04		MPN-T	16000
EH13	7/14/04		MPN-F	5000
EH13	7/20/04		ENTERO	104
EH13	7/23/04		ENTERO	< 2
EH13	7/23/04		MPN-T	20
EH13	7/23/04		MPN-F	< 20
EH13	7/26/04		ENTERO	< 2
EH13	7/26/04		MPN-T	< 20
EH13	7/26/04		MPN-F	< 20
EH13	8/3/04		ENTERO	< 2
EH13	8/3/04		MPN-T	< 20
EH13	8/3/04		MPN-F	< 20
EH13	8/10/04		ENTERO	4
EH13	8/10/04		MPN-T	< 20
EH13	8/10/04		MPN-F	< 20
EH13	8/12/04		ENTERO	< 2
EH13	8/12/04		ENTERO	2
EH13	8/12/04		MPN-T	< 20
EH13	8/12/04		MPN-F	< 20
EH13	8/17/04		ENTERO	132
EH13	8/17/04		MPN-T	3000
EH13	8/17/04		MPN-F	230
EH13	8/19/04		ENTERO	400
EH13	8/25/04		ENTERO	4
EH13	8/25/04		MPN-T	110
EH13	8/25/04		MPN-F	< 20
EH13	8/27/04		ENTERO	< 2
EH13	9/1/04		ENTERO	16
EH13	9/1/04		MPN-T	220
EH13	9/1/04		MPN-F	80
EH13	9/10/04		ENTERO	< 2
EH13	5/19/05		ENTERO	< 4
EH13	5/27/05		ENTERO	28
EH13	5/31/05		ENTERO	< 4
EH13	6/6/05		ENTERO	4
EH13	6/8/05		ENTERO	< 4
EH13	6/10/05		ENTERO	< 4
EH13	6/14/05		ENTERO	4
EH13	6/16/05		ENTERO	< 4
EH13	6/21/05		ENTERO	< 4
EH13	6/23/05		ENTERO	32
EH13	6/29/05		ENTERO	< 4
EH13	7/5/05		ENTERO	< 4
EH13	7/7/05		ENTERO	4
EH13	7/12/05		ENTERO	4

FieldNum	ColDate	Time	Analysis	Result
EH13	7/14/05		ENTERO	< 4
EH13	7/19/05		ENTERO	< 4
EH13	7/21/05		ENTERO	12
EH13	7/26/05		ENTERO	< 4
EH13	8/4/05		ENTERO	< 4
EH13	8/8/05		ENTERO	< 4
EH13	8/16/05		ENTERO	< 4
EH13	8/16/05		MPN-T	40
EH13	8/16/05		MPN-F	< 20
EH13	8/18/05		ENTERO	8
EH13	8/23/05		ENTERO	8
EH13	8/25/05		ENTERO	28
EH13	9/8/05		ENTERO	< 4
EH13	8/16/11	10:10	ENTERO	800
EH13	8/18/11	10:53	ENTERO	< 4
EH13	8/22/11	7:53	ENTERO	96
EH13	8/22/11		MPN-T	500
EH13	8/22/11		MPN-F	40
EH13	7/19/12	12:00	ENTERO	4
EH13	8/29/12	9:11	ENTERO	8
EH13A	5/19/04		ENTERO	100
EH13A	5/19/04		MPN-T	1300
EH13A	5/19/04		MPN-F	1300
EH13A	6/8/04		ENTERO	< 10
EH13A	6/8/04		MPN-T	< 20
EH13A	6/8/04		MPN-F	< 20
EH13A	6/16/04		ENTERO	282
EH13A	6/16/04		MPN-T	1300
EH13A	6/16/04		MPN-F	300
EH13A	6/28/04		ENTERO	378
EH13A	6/28/04		MPN-T	20
EH13A	6/28/04		MPN-F	20
EH13A	7/1/04		ENTERO	< 3.33
EH13A	7/1/04		MPN-T	< 20
EH13A	7/1/04		MPN-F	< 20
EH13A	7/7/04		ENTERO	< 2
EH13A	7/7/04		MPN-T	40
EH13A	7/7/04		MPN-F	< 20
EH13A	7/13/04		ENTERO	160
EH13A	7/14/04		ENTERO	100
EH13A	7/14/04		MPN-T	16000
EH13A	7/14/04		MPN-F	5000
EH13A	7/20/04		ENTERO	33
EH13A	7/23/04		ENTERO	38
EH13A	7/23/04		MPN-T	300
EH13A	7/23/04		MPN-F	170
EH13A	7/26/04		ENTERO	< 2
EH13A	7/26/04		MPN-T	< 20
EH13A	7/26/04		MPN-F	< 20
EH13A	8/3/04		ENTERO	6
EH13A	8/3/04		MPN-T	< 20
EH13A	8/3/04		MPN-F	< 20

FieldNum	ColDate	Time	Analysis	Result
EH13A	8/10/04		ENTERO	2
EH13A	8/10/04		MPN-T	< 20
EH13A	8/10/04		MPN-F	< 20
EH13A	8/12/04		ENTERO	2
EH13A	8/12/04		MPN-T	20
EH13A	8/12/04		MPN-F	< 20
EH13A	8/17/04		ENTERO	126
EH13A	8/17/04		MPN-T	3000
EH13A	8/17/04		MPN-F	500
EH13A	8/25/04		ENTERO	4
EH13A	8/25/04		MPN-T	130
EH13A	8/25/04		MPN-F	20
EH13A	9/1/04		ENTERO	228
EH13A	9/1/04		MPN-T	1300
EH13A	9/1/04		MPN-F	800
EH13A	5/27/05		ENTERO	116
EH13A	5/31/05		ENTERO	52
EH13A	6/8/05		ENTERO	12
EH13A	6/10/05		ENTERO	192
EH13A	6/14/05		ENTERO	8
EH13A	6/21/05		ENTERO	< 4
EH13A	6/23/05		ENTERO	68
EH13A	6/29/05		ENTERO	8
EH13A	7/5/05		ENTERO	16
EH13A	7/7/05		ENTERO	8
EH13A	7/12/05		ENTERO	< 4
EH13A	7/26/05		ENTERO	< 4
EH13A	8/16/11	10:04	ENTERO	892
EH13A	8/18/11	10:48	ENTERO	4
EH13A	8/22/11	7:56	ENTERO	800
EH13A	8/22/11		MPN-T	5000
EH13A	8/22/11		MPN-F	3000
EH13A	11/17/11	6:47	ENTERO	170
EH13A	11/17/11		MPN-T	1300
EH13A	11/17/11		MPN-F	800
EH13A	7/19/12	11:50	ENTERO	20
EH13B	8/16/11	10:00	ENTERO	856
EH13B	8/18/11	10:47	ENTERO	12
EH13C	8/16/11	10:20	ENTERO	800
EH13C	8/18/11	11:02	ENTERO	< 4
EH13C	8/22/11	7:37	ENTERO	564
EH13C	8/22/11		MPN-T	5000
EH13C	8/22/11		MPN-F	130
EH13C	11/17/11	7:00	ENTERO	1740
EH13C	11/17/11		MPN-T	5000
EH13C	11/17/11		MPN-F	1100
EH13C	7/19/12	12:10	ENTERO	136
EH13D	8/16/11	10:24	ENTERO	800
EH13D	8/18/11	11:59	ENTERO	28

Suffolk County Department of Health Services
Office of Ecology
Bureau of Marine Resources
Water Quality Monitoring Sites Near Lake Montauk

Appendix F

New York Natural Heritage Program Information

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
Division of Fish, Wildlife & Marine Resources
New York Natural Heritage Program
625 Broadway, 5th Floor, Albany, New York 12233-4757
Phone: (518) 402-8935 • **Fax:** (518) 402-8925
Website: www.dec.ny.gov

Joe Martens
Commissioner

February 13, 2013

Lara Pomi-Urbat
Environmental Scientist
Nelson, Pope & Voorhis, LLC
572 Walt Whitman Road
Melville, NY 11747

Dear Ms. Pomi-Urbat:

In response to your recent request, we have reviewed the New York Natural Heritage Program database with respect to the proposed stormwater management plan for Lake Montauk, located in the Town of East Hampton, Suffolk County.

Enclosed is a report of rare or state-listed animals and plants, and significant natural communities, which our databases indicate occur, or may occur, on your site or in the immediate vicinity of your site. For most sites, comprehensive field surveys have not been conducted; the enclosed report only includes records from our databases. We cannot provide a definitive statement as to the presence or absence of all rare or state-listed species or significant natural communities. This information should not be substituted for on-site surveys that may be required for environmental impact assessment.

The enclosed report may be included in documents that will be available to the public. However, any maps displaying locations of rare species are considered sensitive information, and are should not be included in any document that will be made available to the public, without permission from the New York Natural Heritage Program.

If you are interested in the locations of the significant natural communities listed in the report, a GIS layer of significant natural communities documented by NY Natural Heritage is available for download from the NYS GIS Clearinghouse at http://gis.ny.gov/gisdata/inventories/details.cfm?DSID=1241.

Sincerely,

Nick Conrad

Nicholas Conrad
Information Resource Coordinator
New York Natural Heritage Program

New York Natural Heritage Program

NYS DEC
625 Broadway, Albany, NY 12233-4757
(518) 402-8944 nathert@gw.dec.state.ny.us

Report on Rare Plants, Rare Animals, and Significant Natural Communities

as documented in the Natural Heritage database from the

Lake Montauk Watershed

February 15, 2013

	COMMON NAME	SCIENTIFIC NAME	NY STATE LISTING	NY STATE RANK****
Documented in Lake Montauk Watershed since 1982				
Big Reed Pond				
Moths	Coastal Heathland Cutworm	*Abagrotis nefascia benjamini*	Unlisted	S1S3
Plants	White-edge Sedge	*Carex debilis* var. *debilis*	Threatened	S2
	Whorled-pennywort	*Hydrocotyle verticillata*	Endangered	S1
	Sandplain Wild Flax	*Linum intercursum*	Threatened	S2
	Clustered Bluets	*Oldenlandia uniflora*	Endangered	S1
Flamingo Road Pond				
Plants	Featherfoil	*Hottonia inflata*	Threatened	S2
Fairview Road				
Plants	Lowland Yellow Loosestrife	*Lysimachia hybrida*	Endangered	S1
Greenwich Street Extension				
Plants	Sandplain Wild Flax	*Linum intercursum*	Threatened	S2
Lake Montauk South Shore				
Plants	Southern Arrowwood	*Viburnum dentatum* var. *venosum*	Threatened	S2
Montauk Downs				
Plants	Sandplain Gerardia	*Agalinis acuta*	Endangered**	S1
	Fringed Boneset	*Eupatorium torreyanum*	Threatened	S2
	Sandplain Wild Flax	*Linum intercursum*	Threatened	S2
	Orange Fringed Orchid	*Platanthera ciliaris*	Endangered	S1
	Blunt Mountain-mint	*Pycnanthemum muticum*	Threatened	S2S3
	Spring Ladies'-tresses	*Spiranthes vernalis*	Endangered	S1
Communities	Maritime Grassland			S1

	COMMON NAME	SCIENTIFIC NAME	NY STATE LISTING	NY STATE RANK****
Prospect Hill				
Birds	Northern Harrier	*Circus cyaneus*	Threatened	S3
Butterflies	Regal Fritillary	*Speyeria idalia*	Endangered	SH
Moths	Coastal Heathland Cutworm	*Abagrotis nefascia benjamini*	Unlisted	S1S3
	An Apamea Moth	*Apamea burgessi*	Unlisted	SU
	Packard's Lichen Moth	*Cisthene packardii*	Unlisted	SU
	Switchgrass Dart	*Dichagyris (Loxagrotis) acclivis*	Unlisted	S2S3
	Fringed Dart	*Eucoptocnemis fimbriaris*	Unlisted	S1
	Fawn Brown Dart*	*Euxoa pleuritica*	Unlisted	S2S3
	Violet Dart	*Euxoa violaris*	Unlisted	SU
	The Pink Streak	*Faronta rubripennis*	Unlisted	SU
	A Noctuid Moth	*Hydraecia stramentosa*	Unlisted	S1S3
Plants	Midland Sedge	*Carex mesochorea*	Threatened	S2
	Bushy Rockrose	*Crocanthemum dumosum*	Threatened	S2
	Slender Spikerush	*Eleocharis tenuis* var. *pseudoptera*	Endangered	S1
	Lowland Yellow Loosestrife*	*Lysimachia hybrida*	Endangered	S1
	Blunt Mountain-mint	*Pycnanthemum muticum*	Threatened	S2S3
	Michaux's Blue-eyed-grass*	*Sisyrinchium mucronatum*	Endangered	S1
	Southern Arrowwood	*Viburnum dentatum* var. *venosum*	Threatened	S2
Communities	Maritime Grassland			S1
Shadmoor / Ditch Plains				
Moths	Marsh Fern Moth	*Fagitana littera*	Unlisted	S1S3
	Chocolate Renia	*Renia nemoralis*	Unlisted	SU
Plants	Sandplain Gerardia	*Agalinis acuta*	Endangered**	S1
	Emmons' Sedge	*Carex albicans* var. *emmonsii*	Rare	S3
	Little-leaf Tick-trefoil*	*Desmodium ciliare*	Threatened	S2S3
	Fringed Boneset	*Eupatorium torreyanum*	Threatened	S2
	Northern Blazing-star	*Liatris scariosa* var. *novae-angliae*	Threatened	S2
	Sandplain Wild Flax	*Linum intercursum*	Threatened	S2
	Hairy Woodrush	*Luzula bulbosa*	Rare	S3
	Blunt Mountain-mint	*Pycnanthemum muticum*	Threatened	S2S3
	Whorled Mountain-mint	*Pycnanthemum verticillatum* var. *verticillatum*	Endangered	S1S2
	Spring Ladies'-tresses	*Spiranthes vernalis*	Endangered	S1
	Southern Arrowwood	*Viburnum dentatum* var. *venosum*	Threatened	S2
Communities	Maritime Bluff			S2S3
	Maritime Grassland			S1
	Maritime Shrubland			S4

	COMMON NAME	SCIENTIFIC NAME	NY STATE LISTING	NY STATE RANK****
Stepping Stones Pond				
Plants	Long-tubercled Spikerush	*Eleocharis tuberculosa*	Threatened	S2
	Salt-marsh Spikerush	*Eleocharis uniglumis* var. *halophila*	Threatened	S2
	Sandplain Wild Flax	*Linum intercursum*	Threatened	S2
West Lake Drive				
Moths	Pine Devil	*Citheronia sepulcralis*	Unlisted	S1
Shagwong Point				
Birds	Piping Plover*	*Charadrius melodus*	Endangered***	S3
	Common Tern*	*Sterna hirundo*	Threatened	S3
	Least Tern*	*Sternula antillarum*	Threatened	S3

<u>Historical records: Last documented in the Lake Montauk Watershed from 1920 to 1971</u>

There is no recent information on these plants and animals at these sites. Their current status at these sites is unknown, and it is uncertain whether they are still present. If suitable habitat is present, these species may still occur.

Big Reed Pond				
Plants	Sandplain Gerardia	*Agalinis acuta*	Endangered**	S1
	Swamp Smartweed	*Persicaria setacea*	Endangered	S1S2
	Spotted Pondweed	*Potamogeton pulcher*	Threatened	S2
	Spring Ladies'-tresses	*Spiranthes vernalis*	Endangered	S1
Lake Montauk				
Plants	Sandplain Gerardia	*Agalinis acuta*	Endangered**	S1
	Salt-marsh Spikerush	*Eleocharis uniglumis* var. *halophila*	Threatened	S2
	Seaside Plantain	*Plantago maritima* var. *juncoides*	Threatened	S2S3
	Small's Knotweed	*Polygonum aviculare* ssp. *buxiforme*	Endangered	S1
	Spotted Pondweed	*Potamogeton pulcher*	Threatened	S2
	Golden Dock	*Rumex fueginus*	Endangered	S1
	Spring Ladies'-tresses	*Spiranthes vernalis*	Endangered	S1
	Northern Gamma Grass	*Tripsacum dactyloides*	Threatened	S2
Little Reed Pond				
Plants	Screw-stem	*Bartonia paniculata* ssp. *paniculata*	Endangered	S1
	Dwarf Glasswort	*Salicornia bigelovii*	Threatened	S2S3

	COMMON NAME	SCIENTIFIC NAME	NY STATE LISTING	NY STATE RANK****
Montauk Beaches				
Beetles	Hairy-necked Tiger Beetle	*Cicindela hirticollis*	Unlisted	S1S2
North and East of Montauk Inn				
Plants	Sandplain Gerardia	*Agalinis acuta*	Endangered**	S1
	Salt-marsh Spikerush	*Eleocharis uniglumis* var. *halophila*	Threatened	S2
	Fringed Boneset	*Eupatorium torreyanum*	Threatened	S2
Star Island				
	Salt-meadow Grass	*Leptochloa fusca* ssp. *fascicularis*	Endangered	S1

* Within 0.1 mile of Lake Montauk Watershed.

** Also federally listed as Endangered.
*** Also federally listed as Threatened

**** Conservation status in NYS as ranked by NY Natural Heritage Program on a 1 to 5 scale:
- S1 = Critically imperiled
- S2 = Imperiled
- S3 = Rare or uncommon
- S4 = Abundant and apparently secure
- S5 = Demonstrably abundant and secure
- SH = Historical records only; no recent observations known; may or may not still be present in New York.
- SU = Conservation status not assigned

Information about many of the rare animals, rare plants, and natural communities in New York, including habitat, biology, identification, conservation, and management, are available online in Natural Heritage's Conservation Guides at www.guides.nynhp.org.

Natural communities in this report are considered significant from a statewide perspective by the NY Natural Heritage Program. They are either occurrences of a community type that is rare in the state, or a high quality example of a more common community type. By meeting specific, documented criteria, the NY Natural Heritage Program considers these community occurrences to have high ecological and conservation value.

This report only includes records from the NY Natural Heritage databases. For most sites, comprehensive field surveys have not been conducted, and we cannot provide a definitive statement as to the presence or absence of all rare or state-listed species. This information should not be substituted for on-site surveys that may be required for environmental impact assessment.

Appendix G

Town Seining Surveys

Lake Montauk Floral and Fuana

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
1997			
	S		
		Striped Killifish	13
		Hermit Crab	1
		Mud Whelk	64.5
		Mummichug	35.4444444444444
		Sand Shrimp	212.25
		Pipefish	2
		Striped Killifish	47.2857142857143
		Green Crab	2
		Atlantic Silverside	276.5
		Bluefish	12.5
		Green Crab	2.44444444444444
		Grass Shrimp	16.3333333333333
		Pipefish	1.5
		Sand Shrimp	1.33333333333333
		Mummichug	3
		Lady Crab	1
		Green Crab	1.33333333333333
		Grass Shrimp	227.5
		Atlantic Silverside	68.75
		Green Crab	1.71428571428571
		Hermit Crab	2.33333333333333
		Lady Crab	1.5
		Mummichug	4.33333333333333
		Flounder, Winter	3
		Striped Killifish	132.8
		Grass Shrimp	1.5
		Green Crab	1.33333333333333

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Hermit Crab	5.33333333333333
		Lady Crab	4.33333333333333
		Sheepshead Minnow	75.25
		Atlantic Silverside	36.8125
		Grass Shrimp	198.25
		Atlantic Needlefish	1
		Flounder, Winter	1.5
		Atlantic Silverside	115.142857142857
		Bluefish	55.3333333333333
		Sand Shrimp	1.5
		Moon Snail	2
		White Mullet	3
		Mud Whelk	4
		Mud Crab	1.2
		Mud Whelk	2
		Mummichug	4.25
		Hermit Crab	1
		Northern Puffer	1
		Sand Shrimp	4.14285714285714
		Striped Killifish	28.1666666666667
		Three-spine Stickleback	3
		Sand Shrimp	37
1998			
	S		
		Sheepshead Minnow	3
		Sand Shrimp	1.5
		Pipefish	1
		Mummichug	14.1818181818182
		Mud Whelk	1
		Moon Snail	1
		Lady Crab	1

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Horseshoe Crab	1
		Hermit Crab	2
		Grass Shrimp	18
		Striped Killifish	16.8181818181818
		Striped Killifish	18.5
		Sheepshead Minnow	2
		Pipefish	1
		Mummichug	6.66666666666667
		Atlantic Silverside	14.6908979841173
		Mud Crab	3
		Green Crab	1.5
		Green Crab	1
		Pumpkinseed Fish	12.1428571428571
		Flounder, Summer	1
		Atlantic Silverside	98
		Hermit Crab	4
		Lady Crab	5
		Rock Crab	1
		Sand Shrimp	6.5
		Striped Killifish	3
		Striped Killifish	42.75
		Slipper Shell	10
		Sheepshead Minnow	10.5
		Sand Shrimp	6.5
		Mummichug	20.5555555555556
		Mud Whelk	195.333333333333
		Largemouth Bass	1.5
		Moon Snail	15
		Moon Snail	1
		Hermit Crab	1
		Green Crab	1.5

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Grass Shrimp	11.5
		Atlantic Silverside	216.1
		Largemouth Bass	3
		Bluegills	69
		Bluefish	7
		Atlantic Silverside	40.4
		Bluefish	6.5
		Mud Crab	2
		Nymph	2
		Flounder, Summer	2
		Banded Killifish	17.5555555555556
		Flounder, Winter	1
		Mummichug	53.620881302104
		Permit	1.50099403578529
		Pompano	1
		Sheepshead Minnow	142.61799735333
		Three-spine Stickleback	2.5
		Carp	2
		Mummichug	55.75
		Freshwater Snail	6
		Mud Whelk	7
		Horseshoe Crab	1
		Skimmer	1
		Water Scorpion	1
		White Perch	2
		Flounder, Summer	6
		Four-spine Stickleback	2
		Grass Shrimp	32.25
		Green Crab	3.66666666666667
		Hermit Crab	6
		Grass Shrimp	5

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Darner	1
		Mud Whelk	887
		Pipefish	1
		Mummichug	8.5
		Mud Whelk	5
		Grass Shrimp	48
		Green Crab	1
		Mud Crab	2
		Striped Killifish	15.1666666666667
		Sand Shrimp	1
		Atlantic Silverside	5.83333333333333
1999			
	I		
		Grass Shrimp	508.833333333333
		Striped Killifish	42.75
		Sheepshead Minnow	51
		Mussel	36
		Mummichug	28.875
		Mud Whelk	6
		Menhaden	43.3333333333333
		Green Crab	1.5
	O		
		Hermit Crab	2
		Green Crab	1.5
		Flounder, Winter	1
		Grass Shrimp	118.666666666667
		Menhaden	22.6666666666667
		Mud Crab	1.33333333333333
		Mud Whelk	2
		Mummichug	10.8333333333333
		Striped Killifish	13.6

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Sheepshead Minnow	8.33333333333333
	S		
		Sheepshead Minnow	1
		Mud Crab	12.5
		Mummichug	2
		Mussel	1
		Pipefish	1
		Rainwater Killifish	1
		Sand Shrimp	10.8
		Striped Killifish	42.6666666666667
		Three-spine Stickleback	1.33333333333333
		Flounder, Summer	1.33333333333333
		Spider Crab	1
		Sheepshead Minnow	8.5
		Sand Shrimp	5.33333333333333
		Sand Eel (Sand Lance)	1
		Oyster	1
		Mussel	9
		Mummichug	10.6666666666667
		Mud Whelk	116.75
		Striped Killifish	31.3
		Striped Killifish	22
		Atlantic Silverside	14.5
		Flounder, Summer	1
		Grass Shrimp	6.66666666666667
		Hermit Crab	1
		Mud Crab	2.25
		Mud Whelk	76.3333333333333
		Mummichug	28.6666666666667
		Rainwater Killifish	2.5
		Slipper Shell	6

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Spider Crab	2
		Green Crab	5.5
		Flounder, Winter	1
		Striped Killifish	61.6666666666667
		Tautog	2
		Yellow Perch	1
		White Mullet	8
		Unknown	1
		Flounder, Summer	1
		Four-spine Stickleback	11
		Grass Shrimp	10.6666666666667
		Sand Shrimp	14.5
		Mussel	1
		Grass Shrimp	37.6666666666667
		Banded Killifish	1
		Pipefish	1
		Grass Shrimp	83.125
		Green Crab	1.2
		Grubby	1
		Hermit Crab	3
		Lady Crab	1.5
		Menhaden	143
		Mud Crab	1
		Four-spine Stickleback	2
		Mummichug	24.3636363636364
		Flounder, Summer	1
		Pipefish	1
		Sand Shrimp	34.6666666666667
		Sea Robin	1
		Sheepshead Minnow	1
		Bluefish	2.25

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Blue Crab	1
		Atlantic Silverside	81.9523809523809
		Banded Killifish	1
		Largemouth Bass	58
		Striped Killifish	1
		Mud Whelk	11
		Cunner	1
		Green Crab	3
		Hermit Crab	3.75
		Mud Crab	1
		Mud Whelk	9.6
		Mummichug	5.71428571428571
		Sand Shrimp	11.2
		Cunner	1
		Striped Killifish	3
		Lady Crab	1.33333333333333
		Atlantic Silverside	28.7777777777778
		Flounder, Winter	1.8
		Grass Shrimp	2.33333333333333
		Grass Shrimp	2
		Green Crab	1
		Hermit Crab	1
		Atlantic Silverside	46
		Four-spine Stickleback	1
		Banded Killifish	19
		Butterfish	3
		Mummichug	12.8333333333333
		Sheepshead Minnow	4.00198807157058
		Striped Killifish	12.7616683217478
		Three-spine Stickleback	1.66622516556291
		Tidewater Silverside	46.5884691848907

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
	T		
		Three-spine Stickleback	2
		Striped Killifish	4.85714285714286
		Spider Crab	2.33333333333333
		Anchovy,Bay	1
		Atlantic Silverside	21.2857142857143
		Blue Crab	1
		Sand Shrimp	54
		Atlantic Silverside	6.5
		Blue Crab	2
		Cunner	1.66666666666667
		Cunner	1
		Flounder, Winter	2
		Hermit Crab	1.5
		Grass Shrimp	252.75
		Green Crab	2
		Grubby	2
		Lady Crab	2.33333333333333
		Mud Crab	1.33333333333333
		Green Crab	6.45454545454545
		Pipefish	1.66666666666667
		Flounder, Summer	1
		Sheepshead Minnow	1
		Spider Crab	2.4
		Striped Killifish	8.75
		Tautog	1
		Tomcod	1
		Grass Shrimp	87.5
		Flounder, Winter	1.66666666666667
		Flounder, Summer	3
		Cunner	1

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Blue Crab	1.75
		Atlantic Silverside	3.66666666666667
		Mummichug	2.5
		Lady Crab	1
		Eel, American	1
		Flounder, Summer	2.77777777777778
		Flounder, Winter	2
		Four-spine Stickleback	6.11111111111111
		Grass Shrimp	26.5
		Green Crab	2.7
		Four-spine Stickleback	51.8571428571429
		Hermit Crab	1
		Mantis Shrimp	1
		Mud Crab	7.28571428571429
		Pipefish	1
		Sand Shrimp	19.2
		Sheepshead Minnow	1
		Mummichug	2
		Grubby	1
		Slipper Shell	4
		Lady Crab	1
		Mud Whelk	292
		Horseshoe Crab	1
		Other Marine Fish	10
		Pipefish	2.2
		Sand Shrimp	575.75
		Tautog	1.5
		Squid	1
		Spider Crab	2.46153846153846
		Mud Crab	2.5
2000			

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
	I		
		Atlantic Silverside	3.8
		Menhaden	11.2
		Blue Crab	1
		Bluefish	1
		Grass Shrimp	17
		Green Crab	1
		Mud Crab	1
		Mud Whelk	3.5
		Mummichug	23.4285714285714
		Mussel	1
		Sand Shrimp	101
		Striped Killifish	27.5
	O		
		Atlantic Silverside	1
		Striped Killifish	3
		Grass Shrimp	101
		Sand Shrimp	800
		Winter Flounder	1
		Menhaden	29
	S		
		Lion's Mane Jellyfish	1
		Lady Crab	4
		Hermit Crab	12.6666666666667
		Green Crab	1.4
		Grass Shrimp	11.4
		Mud Whelk	18.8
		Bluefish	1.5
		Sand Shrimp	24.75
		Atlantic Silverside	5
			1

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
			1
		Yellow Perch	1
		Comb Jelly	4.66666666666667
		Mud Whelk	6
		Mussel	1
		Atlantic Silverside	6.33333333333333
		Sheepshead Minnow	4.4
		Striped Killifish	15.7727272727273
		Striped Searobin	3
		Grass Shrimp	21
		Atlantic Silverside	8.75
		Atlantic Silverside	84
		Bluefish	12.5
		Grass Shrimp	50
		Green Crab	1
		Mummichug	7.21428571428571
		Pipefish	2
		Yellow Perch	3.5
		Pumpkinseed Fish	1.33333333333333
		Bluegills	4.66666666666667
		Banded Killifish	5.66666666666667
		Mud Whelk	3.5
		Mummichug	3
		Pipefish	1.33333333333333
		Winter Flounder	5
		Unknown	1
		Three-spine Stickleback	1
		Striped Killifish	12.5
		Mummichug	2
		Sand Shrimp	2
		Banded Killifish	1

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Mummichug	4.66666666666667
		Hermit Crab	1.5
		Green Crab	5
		Sand Shrimp	15.3333333333333
		Sea Cucumber	1
		Sheepshead Minnow	12
		Striped Killifish	2.75
		Three-spine Stickleback	2
		Green Crab	1
		Grass Shrimp	14.3333333333333
		Blue Crab	1.5
		Comb Jelly	2
		Sea Cucumber	1
		Mud Whelk	5.25
		Hermit Crab	1.6
		Mummichug	28.1818181818182
		Windowpane Flounder	1
		Tidewater Silverside	2.66666666666667
		Striped Killifish	13.2727272727273
		Spider Crab	1
		Sheepshead Minnow	46.1
		Mummichug	15.8
		Striped Killifish	26.6363636363636
		Mud Crab	1
		Lady Crab	2.5
		Comb Jelly	3.33333333333333
		Four-spine Stickleback	3
		Grass Shrimp	14.8
		Green Crab	2.46153846153846
		Sand Shrimp	10
		Sheepshead Minnow	2.5

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
			3.25
		Atlantic Silverside	15.1818181818182
		Hermit Crab	1
		Winter Flounder	2
		Mummichug	1.5
		Blue Crab	1
		Rainwater Killifish	13
		Striped Killifish	7.25
		Three-spine Stickleback	2
		Sand Shrimp	13.5
		Rainwater Killifish	1.5
		Atlantic Silverside	25.4545454545455
		Three-spine Stickleback	9
		Bluefish	10.5
	T		
		Blue Crab	3
		Atlantic Silverside	3
		Winter Flounder	6.5
		Unknown	2.5
		Sea Squirt	5
		Green Crab	2.25
		Sea Cucumber	21
		Winter Flounder	6.30769230769231
		Spider Crab	2
		Winter Flounder	5.09090909090909
		Unknown	4
		Tomcod	2
		Tautog	1
		Striped Searobin	1.66666666666667
		Striped Killifish	2.6
		Cunner	9

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Sheepshead Minnow	2
		Bluefish	1
		Sand Shrimp	130
		Pipefish	1.25
		Mummichug	2.6
		Mud Whelk	1.5
		Mud Crab	3
		Hermit Crab	1
		Sand Shrimp	200
		Grass Shrimp	40
		Transverse ark	5
		Spider Crab	2
		Cunner	1.25
		Mud Crab	3.1
		Moon Snail	9
		Menhaden	1
		Lobster	1
		Three-spine Stickleback	4.76923076923077
		Lady Crab	1
		Slipper Shell	12
		Grubby	1
		Green Crab	9.375
		Mummichug	4
		Eel, American	1
		Lion's Mane Jellyfish	1
		Comb Jelly	37
		Bluefish	2.5
		Blue Crab	1
		Atlantic Silverside	6.72727272727273
			1
		Bay Scallop	3

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Blue Crab	5
		Bluefish	1
		Grass Shrimp	800
		Green Crab	10.1428571428571
		Grass Shrimp	36.8571428571429
		Sea Star	1
		Tautog	5.18181818181818
		Striped Searobin	1
		Squid	12
		Spider Crab	4.5625
		Hermit Crab	1.5
		Slipper Shell	65
		Pipefish	2
		Mud Whelk	34
		Mud Crab	1.5
		Lady Crab	2.66666666666667
		Hermit Crab	1.66666666666667
		Grubby	1
		Scup	2
		Sand Shrimp	29
		Pipefish	1.66666666666667
		Sculpin (grubby)	2.5
2001			
	1		
		Mud Whelk	23.1428571428571
		Atlantic Silverside	2.2
		Bluefish	1
		Hermit Crab	3
		Green Crab	1.66666666666667
		Grass Shrimp	49.9166666666667
		Mummichug	17.7857142857143

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Mussel	1.33333333333333
		Sheepshead Minnow	15.4705882352941
		Striped Killifish	1
		Comb Jelly	1
	O		
		Green Crab	1.5
		Atlantic Silverside	5.85714285714286
		Bluefish	1
		Grass Shrimp	33.6666666666667
		Moon Snail	3
		Mummichug	7.46153846153846
		Mussel	1
		Sheepshead Minnow	7.11111111111111
		Striped Killifish	1
		Tidewater Silverside	1
		Mud Whelk	4.4
	S		
		Sheepshead Minnow	7.14285714285714
		Winter Flounder	2.66666666666667
		Tidewater Silverside	2
		Striped Searobin	1
		Striped Killifish	5.5
		Sheepshead Minnow	3
		Striped Killifish	1
		Butterfish	1
		Winter Flounder	1
		Unknown	1
		Tidewater Silverside	20
		Striped Killifish	3.8
		Banded Killifish	4.33333333333333
		Bluegills	1

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Catfish	3
		Mummichug	2.8
		Unknown	17
		Rainwater Killifish	5.5
		Pumpkinseed Fish	23
		Unknown	1
		Yellow Perch	22
		Slipper Shell	37
		Sand Shrimp	70.1428571428571
		Rainwater Killifish	2.33333333333333
		Pipefish	1.4
		Oyster	1
		Anchovy,Bay	1
		Atlantic Silverside	27.2
		Tautog	1
		Pumpkinseed Fish	1.5
		Mummichug	14.9444444444444
		Atlantic Silverside	20.5333333333333
		Blue Crab	2
		Bluefish	1
		Comb Jelly	10.2
		Cunner	1
		Grass Shrimp	239.166666666667
		Green Crab	1.33333333333333
		Grubby	5
		Hermit Crab	1.75
		Yellow Perch	15
		Mud Crab	2
		Comb Jelly	3.5
		Pipefish	1.5
		Rainwater Killifish	3.5

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Sand Shrimp	367.5
		Sheepshead Minnow	8.66666666666667
		Striped Killifish	2.8
		Striped Searobin	3
		Tautog	1
		Unknown	5
		Bluegills	3
		Other Freshwater Fish	1
		Lady Crab	2
		Unknown	1
		Banded Killifish	3
		Atlantic Silverside	7.90476190476191
			4
		Alewife	14.1111111111111
		Atlantic Silverside	12.7421725709246
		Mud Whelk	1
		Mummichug	5.33333333333333
		Rainwater Killifish	10.6666666666667
		Sheepshead Minnow	41
		Blue Crab	1
		Three-spine Stickleback	4
		Bluefish	6
		Atlantic Silverside	13.5714285714286
		Blue Crab	1
		Comb Jelly	15
		Fiddler Crab	1
		Grass Shrimp	23.2857142857143
		Green Crab	3.66666666666667
		Hermit Crab	3.75
		Mud Crab	1
		Mud Whelk	20.6666666666667

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Mummichug	39.5
		Striped Killifish	27.9090909090909
		Other Marine Fish	1
		Eel, American	1
		Grass Shrimp	239
		Green Crab	1
		Mud Whelk	10
		Mummichug	20.9166666666667
		Rainwater Killifish	2
		Sand Shrimp	24
		Striped Killifish	46.5
		Tidewater Silverside	2
		Banded Killifish	2
		Winter Flounder	1
		Rainwater Killifish	5
		Northern Puffer	5
		Mussel	6
		Mummichug	20.5652173913043
		Mud Whelk	16.3333333333333
		Mud Crab	1.33333333333333
		Horseshoe Crab	1
		Hermit Crab	2.125
		Green Crab	2
		Grass Shrimp	134.8
		Comb Jelly	3.2
		Unknown	5.5
		Three-spine Stickleback	6
		Mussel	1.5
		Tidewater Silverside	2
		Striped Killifish	5
		Spider Crab	2

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Sheepshead Minnow	7.4
		Scup	1
		Sand Shrimp	1.7
		Rainwater Killifish	7
		Pipefish	1
		Oyster	1
		Mummichug	11.047619047619
		Mud Whelk	8.53333333333333
		Mud Crab	1.5
		Bluefish	2.66666666666667
		Winter Flounder	4
			1
		Lizard Fish	1
		Blue Crab	1
		Anchovy,Bay	1
		Comb Jelly	37.8333333333333
		Grass Shrimp	7.625
		Green Crab	2.33333333333333
		White Perch	208
		Mummichug	3.83333333333333
		Banded Killifish	2
		Hermit Crab	1.58333333333333
		Lady Crab	1
		Atlantic Silverside	9.26086956521739
	T		
		Striped Searobin	1
		Spider Crab	1
		Sea Squirt	2.5
		Scup	2
		Sand Shrimp	6.5
		Pipefish	2

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Mud Crab	2
		Hermit Crab	1
		Tautog	1.66666666666667
		Grass Shrimp	18.2
		Spider Crab	1
		Green Crab	4.2
		Winter Flounder	1.25
		Grass Shrimp	15.5
		Green Crab	3
		Grubby	1
		Lady Crab	3.66666666666667
		Mud Crab	5
		Slipper Shell	27.5
		Tautog	1.5
		Windowpane Flounder	1
		Winter Flounder	1.33333333333333
		Bluefish	2
		Northern Puffer	1
		Pipefish	1
		Tautog	1.66666666666667
		Scup	1
		Blue Crab	1
		Eel, American	1.33333333333333
		Grass Shrimp	10
		Green Crab	2
		Lady Crab	2
		Mud Crab	1
		Spider Crab	1
			1
		Butterfish	1
		Comb Jelly	1600

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Toadfish	2
		Winter Flounder	1.5
		Mummichug	2
		Cunner	1.75
2002			
	I		
		Atlantic Silverside	6.625
		Sheepshead Minnow	8.33333333333333
		Scup	1
		Grass Shrimp	84.6666666666667
		Menhaden	1.5
		Mud Whelk	50
		Mummichug	4.5
		Rainwater Killifish	14
		Striped Killifish	10.375
	O		
		Striped Killifish	3.5
		Mud Whelk	2
		Mummichug	1
		Menhaden	152
		Comb Jelly	1
		Green Crab	1.5
		Grass Shrimp	38.2727272727273
		Sheepshead Minnow	1.6
		Atlantic Silverside	1.5
	S		
		Grass Shrimp	384.25
		Green Crab	1
		Comb Jelly	3.8
		Comb Jelly	2.66666666666667
		Blue Crab	1

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Atlantic Silverside	7.18181818181818
		Grey snapper	2
		Bluefish	4
		Comb Jelly	3
		Grass Shrimp	8
		Green Crab	1.28571428571429
		Hermit Crab	1.625
		Atlantic Silverside	21.36
		Sheepshead Minnow	80.1666666666667
		Mummichug	18.1818181818182
		Mud Whelk	24.7777777777778
		Mud Crab	1
		Rock Crab	2
		Striped Killifish	20.9393939393939
		Blue Crab	2.25
		Lady Crab	4
		Hermit Crab	2.4
		Striped Killifish	23.7
		Winter Flounder	1
			2
		Rainwater Killifish	2.85714285714286
		Atlantic Silverside	30.5757575757576
		Menhaden	2
		Sand Shrimp	4.16666666666667
		Atlantic Silverside	17.4077102803738
		Sheepshead Minnow	4
		Yellow Perch	11.1666666666667
			1
		Crevalle Jack	2
		Hermit Crab	2.9
		Sundial	1

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Striped Killifish	13.6370854740775
		Smallmouth Bass	6.16666666666667
		Sand Shrimp	26.9788079470199
		Pumpkinseed Fish	6.57142857142857
		Conger Eel	1
		Grass Shrimp	2.5
		Menhaden	1
		Moon Jellyfish	1
		Mud Whelk	2
		Mummichug	15.5687553161327
		Mussel	2.66445623342175
		Rainwater Killifish	16.6522506619594
		Sheepshead Minnow	51.5774193548387
		Slipper Shell	19.2857142857143
		Mud Crab	1
		Mud Whelk	21.2352941176471
		Mummichug	6.45454545454545
		Oyster	1
		Periwinkle	3
		Rainwater Killifish	2.5
		Rock Crab	1
		White Perch	20.4285714285714
		Scup	5.25
		Menhaden	1
		Tautog	1
		Weakfish	5.5
		Winter Flounder	1
		Banded Killifish	2.73333333333333
		Bluegills	2
		Comb Jelly	2
		Largemouth Bass	1.33333333333333

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Mummichug	6.4
		Sand Shrimp	5.54545454545455
		Winter Flounder	1
		Striped Killifish	43.875
		Tidewater Silverside	5
		Permit	2
		Pipefish	1
		Rainwater Killifish	1.44444444444444
		Rock Crab	2
		Sand Shrimp	67.6666666666667
		Scup	5.66666666666667
		Sheepshead Minnow	7.5
		Slipper Shell	54.5
		Spot	2
		Striped Killifish	15.2916666666667
		Sheepshead Minnow	1
		Winter Flounder	1
		Striped Killifish	7.15384615384615
		Spider Crab	1
		Sand Shrimp	2.5
		Rainwater Killifish	2
		Mummichug	4.83333333333333
		Mud Whelk	5
		Lady Crab	1
		Hermit Crab	3.66666666666667
		Green Crab	1.5
		Grass Shrimp	61.3636363636364
		Comb Jelly	2.6
		Blue Crab	1
		Grass Shrimp	42.1176470588235
		Atlantic Silverside	2.28571428571429

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Striped Searobin	1
		Mullet, striped	7.5
		Green Crab	2.09090909090909
		Sheepshead Minnow	2.5
		Rainwater Killifish	2
		Menhaden	1.25
		Mud Whelk	38.75
		Mummichug	14.1666666666667
		Yellow Perch	1.5
		White Perch	2
		Other Marine Fish	2.5
		Pumpkinseed Fish	1
		Largemouth Bass	1
		Hermit Crab	14
		Mummichug	41
		Mud Crab	7.5
		Banded Killifish	9.5
		Mud Whelk	1
		Northern Puffer	1
		Menhaden	77
		Green Crab	1.75
		Grass Shrimp	37.6666666666667
		Comb Jelly	8
		Atlantic Silverside	21.5714285714286
		Oyster	1
	T		
		Toadfish	1.33333333333333
		Tautog	1.4
		Striped Searobin	1.75
		Winter Flounder	1.66666666666667
		Atlantic Silverside	1.5

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Blue Crab	3.23076923076923
		Comb Jelly	11.7272727272727
		Scup	1.5
		Cunner	1
		Grass Shrimp	16.7272727272727
		Hermit Crab	1.5
		Lady Crab	2
		Mantis Shrimp	1
		Menhaden	13
		Striped Killifish	1.5
		Comb Jelly	10.8
		Moon Jellyfish	12.5
		Mud Crab	4.3
		Green Crab	3.5
		Mud Whelk	1
		Goby	1
		Mud Whelk	9
		Grass Shrimp	33.7142857142857
		Green Crab	2
		Hermit Crab	1
		Menhaden	1
		Mud Crab	1
		Four-spine Stickleback	1
		Atlantic Silverside	1
		Blue Crab	3.66666666666667
		Mud Crab	2.125
		Mummichug	1.33333333333333
		Pipefish	1.66666666666667
		Sand Shrimp	6
		Scup	19.25
		Sea Cucumber	12

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Sea Squirt	6
		Slipper Shell	2.5
		Spider Crab	1.33333333333333
		Cunner	2.75
		Hard Shelled Clam/Quahog	1
		Sea Squirt	13
		Northern Puffer	1
		Winter Flounder	1
		Cunner	1.14285714285714
		Toadfish	1
		Tautog	2.08333333333333
		Striped Searobin	1
		Squid	1
		Green Crab	1.2
		Spider Crab	2.5
		Slipper Shell	1
		Slipper Shell	69.2
		Four-spine Stickleback	3.5
		Hermit Crab	1
		Lobster	1
		Moon Jellyfish	1.33333333333333
		Mud Crab	1.61111111111111
		Other Marine Fish	2
		Pipefish	1.5
		Sand Shrimp	1
		Sculpin (grubby)	1
		Scup	20.7777777777778
		Sea Bass	2
		Grubby	5
		Three-spine Stickleback	1
		Pipefish	1

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Sand Shrimp	1.5
		Sand Worm	1
		Atlantic Silverside	1
		Blue Crab	1
		Comb Jelly	10
		Scup	36.6666666666667
		Sea Cucumber	2.16666666666667
		Slipper Shell	12.25
		Striped Killifish	1.5
		Striped Searobin	2
		Grass Shrimp	7.15384615384615
		Tautog	1
		Winter Flounder	1.33333333333333
2003			
	I		
		Striped Killifish	3.11111111111111
		Sheepshead Minnow	6.75
		Sand Shrimp	2
		Mummichug	4.08333333333333
		Mud Whelk	1
		Menhaden	4
		Green Crab	1.33333333333333
		Grass Shrimp	22.375
		Atlantic Silverside	2.25
		White Mullet	1.5
	O		
		Comb Jelly	1.5
		Striped Killifish	7.36363636363636
		White Mullet	1
		Sheepshead Minnow	7.66666666666667
		Mummichug	6.58333333333333

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Mud Whelk	8
		Menhaden	4
		Hermit Crab	1
		Grass Shrimp	32
		Atlantic Silverside	13.8888888888889
		Green Crab	1
		Ribbed Mussel	1
	S		
		Menhaden	61.1022840119166
		Mud Crab	3.66666666666667
		Menhaden	3
		Lady Crab	2.66666666666667
		Hermit Crab	6.45454545454545
		Green Crab	2
		Grass Shrimp	16.2727272727273
		Atlantic Silverside	21.3888387213292
		Coquina	1
		Crevalle Jack	46
		Grass Shrimp	1.5
		Winter Flounder	3.25
		Lady Crab	3.5
		Mummichug	10.5042183622829
		Rainwater Killifish	1.49900596421471
		Sheepshead Minnow	33.0630585898709
		Spider Crab	7.5
		Striped Killifish	58.9740072202166
		Three-spine Stickleback	2.56753688989784
		White Mullet	1
		Yellow Perch	1
		White Perch	2.25
		Smallmouth Bass	1

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Green Crab	2.66666666666667
		Menhaden	1
		White Mullet	135.5
		Striped Searobin	1
		Striped Killifish	15.6666666666667
		Spot	1.5
		Sheepshead Minnow	2.33333333333333
		Sand Shrimp	14.8181818181818
		Pompano	1
		Oysterdrill	1
		Mummichug	5.35294117647059
		Mud Whelk	11.8333333333333
		Mud Whelk	46.1666666666667
		Moon Jellyfish	2
		Mummichug	10.7857142857143
		Lady Crab	9
		Horseshoe Crab	2
		Winter Flounder	1.4990099009901
		White Mullet	2.75
		Striped Killifish	17.3571428571429
		Spot	7
		Slipper Shell	70
		Sheepshead Minnow	11
		Sand Shrimp	6.4
		Periwinkle	5.71428571428571
		Atlantic Silverside	10.6167979002625
		Mud Crab	1
		Mud Whelk	2.5
		Smallmouth Bass	5
		Pumpkinseed Fish	1.66666666666667
		Largemouth Bass	1.66666666666667

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Gold Fish	4
		Banded sunfish	1
		Banded Killifish	2
		Atlantic Silverside	2.75
		Cunner	1
		Grass Shrimp	46.5
		Green Crab	2
		Bluegills	2
		Menhaden	1
		Striped Searobin	1
		Mummichug	7.25
		Pipefish	1
		Sand Shrimp	25.5
		Striped Killifish	10.5
		Winter Flounder	3.6
		Atlantic Silverside	14.6190476190476
		Comb Jelly	7.25
		Grass Shrimp	18.9333333333333
		Green Crab	1.25
		Hermit Crab	3.61538461538462
		Hermit Crab	1
		Mud Whelk	1
		Winter Flounder	10
		Comb Jelly	1
		Grass Shrimp	41.8814229249012
		Green Crab	1
		Hermit Crab	1.0078431372549
		Four-spine Stickleback	1
		Cunner	1
		Comb Jelly	2.33333333333333
		Bluefish	1

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Blood Ark	1
		White Perch	2
		Mud Crab	1.25
		Yellow Perch	13.3333333333333
		Mummichug	4.69332452081956
		Atlantic Silverside	97.3333333333333
		Periwinkle	1
		Rainwater Killifish	2
		Sand Shrimp	34.3457760314342
		Sheepshead Minnow	2
		Slipper Shell	8
		Bluegills	12
		Spider Crab	1
		Striped Killifish	6.45809739524349
		Banded Killifish	5.875
		Barnacle	5
		Mud Whelk	24.6666666666667
		Atlantic Silverside	2.75
		Winter Flounder	1
		White Mullet	4
		Striped Killifish	5.77777777777778
		Sheepshead Minnow	3
		Sand Shrimp	14.5
		Mummichug	11
		Mud Crab	3
		Menhaden	1
		Hermit Crab	3
		Green Crab	1.5
		Grass Shrimp	41
		Comb Jelly	1
		Banded Killifish	15.6666666666667

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Rainwater Killifish	2.5
	t		
		Hermit Crab	2.18181818181818
		Grass Shrimp	3.61538461538462
		Bay Scallop	1
		Four-spine Stickleback	2.33333333333333
		Cunner	1.6
		Comb Jelly	50.5384615384615
		Scup	3.33333333333333
		Sand Shrimp	1.5
		Pipefish	1
		Green Crab	2.9
		Tomcod	1.5
		Hard Shelled Clam/Quahog	1
		Mud Whelk	8.5
		Mud Crab	3.41666666666667
		Moon Jellyfish	2.42857142857143
		Menhaden	1
		Lizard Fish	9
		Lady Crab	1.14285714285714
		Mummichug	9
		Green Crab	3.4
		Grass Shrimp	48.1
		Pipefish	2.5
		Oyster toad	1
		Mummichug	1.33333333333333
		Mud Whelk	2
		Mud Crab	3.4375
		Scup	12
		Hermit Crab	1.33333333333333
		Sea Cucumber	27.5555555555556

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Grass Shrimp	46.2
		Four-spine Stickleback	2.88888888888889
		Eel, American	1.25
		Cunner	1.25
		Comb Jelly	11.5
		Blue Crab	1.33333333333333
		Atlantic Silverside	1
		Lady Crab	1.33333333333333
			1
		Northern Puffer	1
		Four-spine Stickleback	1.8
		Eel, American	2
		Cunner	1
		Comb Jelly	11.7142857142857
		Blue Crab	1.25
		Sand Shrimp	9.33333333333333
		Atlantic Silverside	11.7272727272727
		Goby	1
		Winter Flounder	1.63636363636364
		Tomcod	1
		Tautog	1.66666666666667
		Striped Searobin	2
		Striped Killifish	2.14285714285714
		Striped Bass	1
		Spider Crab	1.875
		Black Sea Bass	1
		Sea Cucumber	5.75
		Winter Flounder	1.5
		Butterfish	1
		Green Crab	2.81818181818182
		Winter Flounder	1.25

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		White Mullet	16.5
		Tautog	1.75
		Striped Searobin	1
		Striped Killifish	48.5454545454545
		Spider Crab	1.92857142857143
		Sheepshead Minnow	19.7777777777778
		Tautog	2
		Spider Crab	1.64705882352941
		Slipper Shell	37.1111111111111
		Mud Crab	2.26086956521739
		Hermit Crab	1.5
		Lady Crab	1
		Lion's Mane Jellyfish	1
		Slipper Shell	35.5454545454545
		Moon Jellyfish	4.2
		Periwinkle	1
		Sand Shrimp	4
		Sculpin (grubby)	1
		Scup	8
2004			
	I		
		Grass Shrimp	218.5
		Mud Whelk	8
		Mummichug	19.8333333333333
		Mussel	1
		Sheepshead Minnow	13
		Atlantic Silverside	1
	O		
		Grass Shrimp	55
		Green Crab	1
		Mummichug	4.33333333333333

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Mussel	1
		Sand Shrimp	1
		Sheepshead Minnow	14
	S		
		White Mullet	5.5
		Flounder, Winter	1
		Mud Whelk	1.06719367588933
		Four-spine Stickleback	2.33333333333333
		Sheepshead Minnow	4
		Mummichug	1
		Mud Crab	2
		Lady Crab	1.33333333333333
		Mummichug	29.6470588235294
			1
		Atlantic Silverside	26.21875
		Sheepshead Minnow	3.99604743083004
		Mud Crab	1
		Moon Jellyfish	1
		Sand Worm	1
		Striped Killifish	2
		Pipefish	1
		Crevalle Jack	1
		Hermit Crab	6
		Green Crab	1.83333333333333
		Sand Shrimp	12.8571428571429
		Sand Shrimp	2
		Mud Whelk	11.5555555555556
		Grass Shrimp	102.1875
		Menhaden	52
		Grass Shrimp	56.5714285714286
		Comb Jelly	16.5

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Tomcod	1
		Striped Killifish	4.25
		Sheepshead Minnow	2.5
		Sand Shrimp	34.6666666666667
		Pipefish	1
		Mummichug	13.25
		Mud Whelk	16
		Mud Crab	1
		Moon Jellyfish	2.5
		Striped Killifish	15.5454545454545
		Green Crab	1.33333333333333
		Hermit Crab	1.01574803149606
		Comb Jelly	22
		Atlantic Silverside	12
		Anchovy,Bay	5.5
		Winter Flounder	2.75
		White Mullet	7
		Unknown	7
		Winter Flounder	2
		Tautog	1
		Blue Crab	1
		Comb Jelly	3.02755905511811
		Grass Shrimp	28.6121372031662
		Hermit Crab	4.5
		Bluegills	1.8
		White Mullet	1
		Slipper Shell	10
		Sand Shrimp	2
		Oyster	1
		Mummichug	18.625
		Mud Whelk	36.8

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Mud Crab	1
		Lady Crab	1
		Winter Flounder	1
		Striped Killifish	2
		Sheepshead Minnow	116.887086092715
		Rainwater Killifish	25.812472357364
		Mummichug	11.0844370860927
		Atlantic Silverside	11.2875494071146
		Green Crab	1
		Anchovy,Bay	1
		Anchovy,Bay	5
		Atlantic Silverside	11.7897049591965
		Atlantic Silverside	10.4
		Comb Jelly	8.75
		Blue Crab	3
		Grass Shrimp	6
		Banded Killifish	10.0714285714286
		Hermit Crab	4
		Yellow Perch	1
		White Perch	3
		Unknown	2
		Sunfish	1
		Sheepshead Minnow	38.5
		Crevalle Jack	2
		Hermit Crab	1
		Pumpkinseed Fish	2.25
		Largemouth Bass	1
		Banded Killifish	5
		Spot	4
		Striped Killifish	13.25
		Atlantic Silverside	3.5

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Yellow Perch	2.42857142857143
		Green Crab	1
		Tautog	1
		Mud Whelk	386.5
		Mummichug	35.8
		Rainwater Killifish	4
		Rock Crab	1
		Sand Shrimp	6.33333333333333
		Sheepshead Minnow	28
		Striped Killifish	19
		Permit	3
		Grass Shrimp	96.6
	t		
		Grass Shrimp	9.5
		Sand Shrimp	1
		Mud Whelk	2.5
		Mud Crab	4.375
		Sunfish	1
		Pipefish	1
		Mummichug	1.5
		Mud Crab	7
		Moon Jellyfish	2
		Lady Crab	1
		Slipper Shell	1
		Green Crab	1.8
		Oyster	1
		Four-spine Stickleback	1.5
		Eel, American	1
		Comb Jelly	85.2
			1
		Unknown	1

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Tautog	1
		Striped Searobin	1
		Spider Crab	1.8695652173913
		Slipper Shell	27.5
		Scup	6
		Hermit Crab	1
		Spider Crab	3
		Sculpin (grubby)	1
		Green Crab	3.33333333333333
		Hermit Crab	1.8
		Snapper (juv. bluefish)	3
		Horseshoe Crab	1
		Grass Shrimp	14.5
		Goby	1
		Four-spine Stickleback	1
		Cunner	1
		Comb Jelly	40.25
		Sea Cucumber	2.42857142857143
			1
		Tomcod	2.45454545454545
		Striped Killifish	3
		Moon Jellyfish	1
		Lady Crab	2.25
		Winter Flounder	1.09090909090909
		Squid	1
		Spider Crab	2.53333333333333
		Slipper Shell	11.25
		Sea Cucumber	8.44444444444444
		Sand Shrimp	2.6
		Pipefish	1.5
		Blue Crab	1

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Hermit Crab	3
		Comb Jelly	61
		Blue Crab	1.5
		Blood Ark	1
			1.33333333333333
		Green Crab	2.5
		Grass Shrimp	14
		Four-spine Stickleback	2
		Cunner	1
		Flounder, Winter	1
		Flounder, Summer	1
		Conger Eel	1
		Comb Jelly	2615
		Sand Shrimp	1
		Lady Crab	1.5
		Slipper Shell	45
		Spider Crab	1
		Squid	2
		Hermit Crab	1
		Winter Flounder	1
		Lady Crab	1.5
		Moon Jellyfish	3.90909090909091
		Mud Crab	4.22727272727273
		Mud Whelk	1
		Pipefish	1.5
		Winter Flounder	2.23076923076923
2005			
	I		
		Mud Crab	1
		Green Crab	1
		Grass Shrimp	3.3

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Atlantic Silverside	1.5
		Mud Whelk	1
		Comb Jelly	1
		Hermit Crab	1
		Mummichug	2.75
		Striped Killifish	1.5
	O		
		Flounder, Winter	1
		Grass Shrimp	28.5294117647059
		Hermit Crab	1
		Mud Whelk	2
		Comb Jelly	1.33333333333333
		Atlantic Silverside	39.3333333333333
		Mummichug	6.1875
		Sheepshead Minnow	1.75
		Striped Killifish	2
		Green Crab	1
	S		
		Mud Whelk	3.6
		Pipefish	1
		Hard Shelled Clam/Quahog	1
		Tautog	1
		Weakfish	1
		White Mullet	10.5714285714286
		Periwinkle	2.6
		Oyster	2
		Northern Puffer	1
		Mummichug	21.125
		Spot	1
		Mud Snail	26
		Sand Shrimp	3.4

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Mud Crab	2.42857142857143
		Mussel	1
		Three-spine Stickleback	2
		Mud Whelk	1
		Barnacle	1
		Moon Jellyfish	1
		Pipefish	1.5
		Sand Shrimp	18.5714285714286
		Sea Squirt	1
		Sheepshead Minnow	1.66666666666667
		Striped Bass	232
		Tautog	2
		Hermit Crab	1
		Sheepshead Minnow	5.58823529411765
		Slipper Shell	5
		Mummichug	8.08333333333333
		Mud Crab	2.5
		Menhaden	1.75
		Striped Killifish	8.17647058823529
		Lady Crab	2
		Striped Killifish	34.25
		Sheepshead Minnow	15.9411764705882
		White Mullet	1
		Grass Shrimp	10
		Green Crab	1.6
		Hermit Crab	2.2
		Lady Crab	3.33333333333333
		Menhaden	104.666666666667
		Crevalle Jack	1.5
		Sea Squirt	5
		Comb Jelly	25.2222222222222

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Striped Killifish	11.1538461538462
		Three-spine Stickleback	1
		Tidewater Silverside	58.5
		Mud Crab	1.2
		Rainwater Killifish	36.5
		Barnacle	6
		Moon Jellyfish	4
		Rainwater Killifish	5
		Lady Crab	1.5
		Hermit Crab	2.72222222222222
		Green Crab	1.71428571428571
		Grass Shrimp	110.64
		Four-spine Stickleback	2.8
		Eel, American	3
		Four-spine Stickleback	1.66666666666667
		Comb Jelly	5.6875
		Menhaden	99.875
		Mummichug	3
		Grass Shrimp	76
		Atlantic Silverside	10
		Striped Killifish	21.5
		Atlantic Silverside	13.9607843137255
		Bluefish	1
		Crevalle Jack	1.8
		Rainwater Killifish	5.66180371352785
		White Perch	4.5
		Spot	8
		Yellow Perch	9.5
		Banded Killifish	2
		Bluegills	1
		Bluegills	11.75

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Largemouth Bass	1
		Pumpkinseed Fish	4
		Three-spine Stickleback	4
		Striped Killifish	21.656208572691
		Carp	1
		Sand Shrimp	1
		Largemouth Bass	2.66666666666667
		Other Marine Fish	4
		Ninespine Stickleback	6.74713787954206
		Mummichug	30.1327020721833
		Menhaden	2
		Grass Shrimp	11.5
		Four-spine Stickleback	2.09952229299363
		Eutima Mira	6.51093439363817
		Eel, American	3.5
		Blue Crab	88
		Banded Killifish	15.5
		Sheepshead Minnow	72.3483295139308
		Eutima Mira	4
		Slipper Shell	1.66666666666667
		Sheepshead Minnow	9.5
		Sand Shrimp	10.925877763329
		Rainwater Killifish	3
		Mummichug	29.600790513834
		Mud Whelk	48.5
		Mud Snail	10
		Mud Crab	2.25
		Lady Crab	1.00390625
		Hermit Crab	2.13856209150327
		Rainwater Killifish	3
		Flounder, Winter	2

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Pumpkinseed Fish	4.75
		Comb Jelly	3
		Atlantic Silverside	11.2984878369494
		Spot	1
		Striped Killifish	3.85158013544018
		Winter Flounder	1.00395256916996
		Bluegills	2
		White Perch	1
		Sand Shrimp	9.43478260869565
		Sheepshead Minnow	24
		Banded Killifish	5
		Bluegills	2.5
		Grass Shrimp	37.1674876847291
		Eel, American	3
		Atlantic Silverside	46.2819417475728
		Ninespine Stickleback	1
		Mussel	2
		Mummichug	12.2727272727273
		Mud Whelk	30.8571428571429
		Atlantic Silverside	26.15625
		Spider Crab	1.33333333333333
		Bluefish	1
		Atlantic Silverside	4
		Blue Crab	2
		Periwinkle	10.1
		Conger Eel	2.33333333333333
		Permit	
		Four-spine Stickleback	7
		Freshwater Snail	1
		Grass Shrimp	444.571428571429
		Green Crab	1.5

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Hermit Crab	1.83333333333333
		Inland Silverside	25
		Menhaden	6
		Mud Crab	2
		Mud Snail	23.5
		Mud Whelk	128.777777777778
		Mummichug	17.5789473684211
		Comb Jelly	1
		Grass Shrimp	44.1428571428571
		Mussel	1
		Flounder, Winter	4
		Largemouth Bass	1
		Mummichug	1.5
		Rainwater Killifish	1
		Smallmouth Bass	1.33333333333333
		Sunfish	2
		White Perch	2
		Atlantic Silverside	16
		Comb Jelly	1
		Oyster	5
		Flounder, Winter	3.33333333333333
		Banded Killifish	12.6666666666667
		Green Crab	2.5
		Winter Flounder	1
		White Mullet	5.8
		Tomcod	1
		Striped Killifish	11.0487804878049
		Striped Bass	7.5
		Spot	1
		Slipper Shell	10.0833333333333
		Sheepshead Minnow	6

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Sculpin (grubby)	1
		Sand Shrimp	2.41666666666667
		Flounder, Summer	2
	T		
		Atlantic Silverside	1.25
		Comb Jelly	22.75
		Blue Crab	2
		Grass Shrimp	2
		Inland Silverside	5
		Mummichug	2
		Rainwater Killifish	1
		Bay Scallop	1
		Sand Shrimp	2
		Sheepshead Minnow	1.66666666666667
		Stickleback	5.33333333333333
		Lion's Mane Jellyfish	1.92857142857143
		Anchovy,Bay	3.5
		Lady Crab	2
		Barnacle	15
		Bay Scallop	1
		Blood Ark	2
		Butterfish	1
		Comb Jelly	59.4857142857143
		Flounder, Summer	4
		Flounder, Winter	1.63636363636364
		Four-spine Stickleback	1
		Sea Squirt	11
		Green Crab	2.15384615384615
		Lady Crab	1
		Winter Flounder	1
		Grass Shrimp	285.6

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Spider Crab	1.5
		Tomcod	2.2
		Winter Flounder	2.125
		Sea Cucumber	4
		Mummichug	1
		Mud Crab	1.16666666666667
		Moon Jellyfish	1
		Comb Jelly	3
		Lion's Mane Jellyfish	1
		Spider Crab	1.5
		Lion's Mane Jellyfish	1
		Hermit Crab	2
		Green Crab	2
		Knobbed Whelk	2
		Conger Eel	2
		Comb Jelly	15.3333333333333
		Blue Crab	1
		Slipper Shell	24
		Alewife	1.5
		Windowpane Flounder	2
		Spider Crab	1.8
		Slipper Shell	7
		Scup	7
		Mud Crab	1
		Hermit Crab	1.75
		Hogchoker	1
		Sea Star	1
		Green Crab	2.54545454545455
		Grass Shrimp	8.83333333333333
		Menhaden	3
		Flounder, Winter	1.45454545454545

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Grass Shrimp	1.91666666666667
		Eel, American	1
		Conger Eel	2
		Comb Jelly	11.2631578947368
		Blue Crab	1
		Sculpin (grubby)	1
		Hard Shelled Clam/Quahog	1
		Sea Cucumber	1
		Four-spine Stickleback	2.25
		Slipper Shell	23.1904761904762
		Snapper (juv. bluefish)	1
		Spider Crab	1.66666666666667
		Spot	4.66666666666667
		Squid	6
		Tautog	1
		Three-spine Stickleback	2
		Tomcod	3
		Whelk	10
		Windowpane Flounder	1
		Scup	2
		Scup	1.5
		Moon Jellyfish	2
		Mud Crab	4.39130434782609
		Ninespine Stickleback	1
		Northern Searobin	1.5
		Pipefish	1
		Sand Shrimp	1.16666666666667
		Unknown	1
		Tautog	1
		Spider Crab	1.77777777777778
		Solitary glassy bubble	4

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		False Angel Wing	1
		Sea Cucumber	6.125
		Hermit Crab	4.57142857142857
		Mud Whelk	1
		Jingle Shell	4
		Lady Crab	2.66666666666667
		Lion's Mane Jellyfish	1
		Slipper Shell	31.5833333333333
		Mud Snail	3
		Periwinkle	5
		Pipefish	1
		Sand Shrimp	2.33333333333333
		Mud Crab	4.5
2006			
	s		
		Anchovy,Bay	2
		Sand Shrimp	15.5714285714286
		Sea Squirt	2
		Sheepshead Minnow	2
		Solitary glassy bubble	24.5
		Sea Squirt	2
		Striped Killifish	14.5
		Mummichug	5.875
		Mud Crab	2
		Moon Jellyfish	1
		Lady Crab	3
		Slipper Shell	6.66666666666667
		Scup	7
		Northern Sennet	1.5
		Periwinkle	9.28571428571429
		Rainwater Killifish	1

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Sand Shrimp	12.625
		Hermit Crab	5.33333333333333
		Mummichug	7.76923076923077
		Sheepshead Minnow	6.25
		Mud Whelk	35.4
		Spider Crab	1
		Striped Killifish	11.1
		White Mullet	2.75
		Atlantic Silverside	1
		Grass Shrimp	14
		Mummichug	3.33333333333333
		Striped Killifish	2.5
		Sea Robin	1
		Flounder, Winter	1
		Bluegills	1
		Largemouth Bass	1
		White Perch	12.8571428571429
		Yellow Perch	1.5
		Atlantic Silverside	25.8636363636364
		Bay Scallop	1
		Mussel	1
		Comb Jelly	39.6363636363636
		Banded Killifish	1.5
		Grass Shrimp	3.8
		Green Crab	1.75
		Hermit Crab	1.85714285714286
		Horseshoe Crab	1
		Lady Crab	1
		Menhaden	33.5
		Mud Crab	1
		Blue Crab	4

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Green Crab	1.75
		Pumpkinseed Fish	1.5
		Mud Whelk	4
		Mummichug	9.99366085578447
		Pipefish	1
		Sand Shrimp	6.80577427821522
		Sheepshead Minnow	29
		Slipper Shell	1.5
		Lady Crab	1
		Spider Crab	1
		Hermit Crab	1.01953125
		Striped Killifish	3.15384615384615
		Tautog	1
		Bluegills	8.5
		Pumpkinseed Fish	10
		Bluegills	1.33333333333333
		Banded Killifish	1
		Mummichug	8.58823529411765
		Striped Killifish	1.50445103857567
		Grass Shrimp	10
		Atlantic Silverside	8.44597249508841
		Blue Crab	1
		Comb Jelly	15
		Flounder, Winter	1.99212598425197
		Grass Shrimp	28.2733245729304
		Mud Whelk	2
		Menhaden	56.75
		Mud Crab	1
		Green Crab	2
		Banded Killifish	5.33333333333333
		Mussel	1

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Oyster	2
		Periwinkle	7
		Pipefish	2.5
		Sand Shrimp	6.28571428571429
		Sheepshead Minnow	6.66666666666667
		Green Crab	1
		Hermit Crab	2
		Comb Jelly	5.44444444444444
		Atlantic Silverside	3.4973474801061
		Banded Killifish	3.99701492537313
		Four-spine Stickleback	1
		Mummichug	14.0843277645187
		Ninespine Stickleback	5
		Sheepshead Minnow	35.9414772727273
		Three-spine Stickleback	3
		Bluegills	3.33333333333333
		Cunner	3
		White Perch	1
		Atlantic Silverside	9.1578947368421
		Atlantic Silverside	19.1666666666667
		Blue Crab	1.5
		Comb Jelly	4.5
		Cunner	1
		Flounder, Winter	1
		Grass Shrimp	13.2857142857143
		Eel, American	1
		Hermit Crab	1
		Largemouth Bass	1
		Smallmouth Bass	3.66666666666667
		White Perch	1
		Yellow Perch	1

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Atlantic Silverside	3
		Blue Crab	1
		Grass Shrimp	6.33333333333333
		Alewife	192.150238473768
		Lady Crab	1
		Mud Whelk	7.66666666666667
		Mummichug	18
		Rainwater Killifish	5.25
		Sheepshead Minnow	12
		Striped Killifish	2.75
		Tidewater Silverside	3
		Comb Jelly	1.5
	T		
		Comb Jelly	115.8
		Blue Crab	1.25
		Slipper Shell	15.5
		Comb Jelly	446
		Flounder, Summer	1
		Green Crab	4
		Lion's Mane Jellyfish	1
		Moon Jellyfish	60.7857142857143
		Mud Crab	3.5
		Periwinkle	1
		Pipefish	1
		Cunner	1.5
		Sea Robin	1
		Mud Crab	12.5
		Spider Crab	1
		Scup	1
		Tautog	1
		Comb Jelly	27

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Moon Jellyfish	36.5
		Eel, American	1
		Green Crab	1.5
		Mud Crab	2
		Skate (clearnose)	1
		Slipper Shell	28
		Three-spine Stickleback	4
		Solitary glassy bubble	1
		Slipper Shell	21
		Sea Cucumber	1
		Sand Shrimp	1.5
		Pipefish	1
		Mummichug	1
		Moon Jellyfish	3.75
		Grass Shrimp	9
		Flounder, Winter	3.5
2007			
	S		
		Sheepshead Minnow	6
		Striped Killifish	11
2008			
	S		
		Sand Shrimp	1.75
		Sheepshead Minnow	6.5
		Mummichug	99.25
		Grass Shrimp	2
		Atlantic Silverside	34
		Atlantic Silverside	3
		Grass Shrimp	5
		Striped Killifish	15
		Sheepshead Minnow	9

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Striped Killifish	18.75
		Atlantic Silverside	21.25
		Stickleback	30
		Mummichug	3
		Sand Shrimp	2.5
		Sheepshead Minnow	8
		Periwinkle	27.3333333333333
		Mummichug	9.625
		Mud Whelk	11.5
		Green Crab	1
		Grass Shrimp	127.25
		Atlantic Silverside	4.33333333333333
		Striped Killifish	20.75
		Sheepshead Minnow	2
		Slipper Shell	10
	T		
		Spider Crab	3.5
		Lady Crab	4.16666666666667
		Grass Shrimp	4.5
		Green Crab	2
		Menhaden	1
		Mud Crab	9.2
		Scup	13
		Solitary glassy bubble	14
		Comb Jelly	3
		Spot	1
		Tautog	1
		Winter Flounder	1
		Mantis Shrimp	1
		Slipper Shell	55
		Pipefish	1

Seine Date By Year	Seine/Trawl Indicator	Species Name	Avg Of Species Count
		Barnacle	11
		Bay Scallop	1
		Blood Ark	2
		Blue Crab	1
		Comb Jelly	98.6
		Grass Shrimp	10.0474308300395
		Green Crab	2.32631578947368
		Hard Shelled Clam/Quahog	1
		Hermit Crab	1
		Periwinkle	6
		Mud Crab	5.01949317738791
		Anchovy,Bay	1
		Rock Gunnel	1
		Sculpin (grubby)	2.5
		Scup	13.5
		Slipper Shell	62.5202086049544
		Spider Crab	1.3997378768021
		Stickleback	1
		Tautog	1
		Tomcod	1
		Winter Flounder	4
		Lady Crab	1.66666666666667

Appendix H

Town Marine Life Inventory Data 1997-2008

Summary of Town Marine Life Inventory Data, 1997 - 2008

Year	Alewife	Anchovy,Bay	Atlantic Needlefish	Atlantic Silverside	Banded Killifish	Banded sunfish	Barnacle	Bay Scallop	Black Sea Bass	Blood Ark	Blue Crab	Bluefish
1997			1	124.3013393								33.91666667
1998				75.00484626	17.55555556							6.75
1999		1		28.95464853	7						1.4375	2.25
2000				15.92469697	3.333333333			3			2.083333333	4.285714286
2001	14.11111111	1		12.4087136	2.833333333						1.2	2.277777778
2002				10.18249354	6.116666667						2.02457265	4
2003				17.83241792	7.847222222	1	5	1	1	1	1.291666667	1
2004		3.833333333		10.88514348	7.535714286					1	1.625	
2005	1.5	3.5		16.97807972	8.791666667		7.333333333	1		2	18.8	1
2006	192.1502385	2		10.01878825	2.957587065			1			1.75	
2007												
2008		1		15.64583333			11	1		2	1	
Yearly Average per Species	**69.25378319**	**2.333333333**	**1**	**24.12592852**	**6.175959962**	**1**	**7.6**	**1.333333333**	**1**	**1.5**	**3.927125506**	**6.102272727**

Summary of Town Marine Life Inventory Data, 1997 - 2008

Year	Bluegills	Butterfish	Carp	Catfish	Comb Jelly	Conger Eel	Coquina	Crevalle Jack	Cunner	Darner	Eel, American	Eutima Mira	FALSE Angel	Fiddler Crab	Flounder, Summer
1997															
1998	69		2							1					3
1999		3							1.133333333		1				1.587301587
2000	4.666666667				11.75				5.125		1				
2001	2	1		3	238.6761905				1.375		1.166666667			1	
2002	2				5.559393939	1		2	1.630952381						
2003	7	1			10.85451007		1	46	1.17		1.625				
2004	1.8				356.4659449	1		1.5	1		1				1
2005	4.3125	1	1		12.50627176	2.111111111		1.65			2.625	5.255467197	1		3
2006	3.541666667				81.86010101				1.833333333		1				1
2007															
2008					50.8										
Yearly Average per Species	**7.930208333**	**1.4**	**1.5**	**3**	**95.22791494**	**1.666666667**	**1**	**9.05**	**1.677705628**	**1**	**1.621794872**	**5.255467197**	**1**	**1**	**2.007936508**

Summary of Town Marine Life Inventory Data, 1997 - 2008

Year	Flounder, Winter	Four-spine Stickleback	Freshwater Snail	Goby	Gold Fish	Grass Shrimp	Green Crab	Grey snapper	Grubby	hard shelled clam/quahog	Hermit Crab	Hogchoker
1997	2.25					110.8958333	1.765079365				2.416666667	
1998	1	2	6			22.95	1.733333333				3.25	
1999	1.577777778	14.39365079				103.3371212	2.761616162		1.333333333		1.892857143	
2000		3				110.6390476	3.736599512		1		2.99047619	
2001						77.11607143	2.27		3		2.201388889	
2002		2.25		1		65.13024987	1.758513709	2	5	1	3.511458333	
2003		2.005555556		1	4	28.94344256	1.988016529			1	2.343658302	
2004	1	1.708333333		1		60.14710658	1.725				2.59063867	
2005	2.237373737	2.80269816	1			81.86162963	1.779287379			1	2.021554622	1
2006	1.873031496	1				12.09891031	2				2.242001488	
2007												
2008						29.75948617	1.775438596			1	1	
Yearly Average per Species	**1.803954051**	**4.75583327**	**3.5**	**1**	**4**	**67.07799513**	**2.184651333**	**2**	**2.125**	**1**	**2.499774663**	**1**

Summary of Town Marine Life Inventory Data, 1997 - 2008

Year	Horseshoe Crab	Inland Silverside	Jingle Shell	Knobbed Whelk	Lady Crab	Largemouth Bass	Lion's Mane Jellyfish	Lizard Fish	Lobster	Mantis Shrimp	Menhaden	Moon Jellyfish
1997					2.277777778							
1998	1				3	2.25						
1999	1				1.433333333	58				1	69.66666667	
2000					2.541666667		1		1		13.73333333	
2001	1				2.166666667			1				
2002					2.333333333	1.166666667			1	1	27.75	4.944444444
2003	2				3.107142857	1.666666667	1	9			9.512785501	2.876190476
2004	1				1.430555556	1					52	2.081818182
2005		15	4	2	1.929129464	1.555555556	1.232142857				36.21527778	2
2006	1				1.5	1	1				45.125	25.50892857
2007												
2008					2.916666667					1	1	
Yearly Average per Species	**1.142857143**	**15**	**4**	**2**	**2.139060074**	**6.180555556**	**1.116071429**	**5**	**1**	**1**	**28.38163487**	**7.574037366**

Summary of Town Marine Life Inventory Data, 1997 - 2008

Year	Moon Snail	Mud Crab	Mud Snail	Mud Whelk	Mullet, striped	Mummichug	Mussel	Ninespine Stickleback	Northern Puffer	Northern Searobin	Northern Sennet	Nymph
1997	2	1.2		23.5		11.75694444			1			
1998	5.666666667	2.333333333		219.0666667		26.54582028						2
1999		3.650297619		73.38333333		12.84529221	11.75					
2000	9	1.92		10.36428571		9.239134199	1					
2001	3	1.976190476		12.01088435		13.28980609	2.458333333		3			
2002		2.648015873		15.47630719	7.5	11.34384523	2.664456233		1			
2003		2.575957557		11.74074074		7.058619835			1			
2004		2.943181818		57.92784365		15.00812918	1					
2005		2.243654244	15.625	27.09186508		11.26925005	1.333333333	2.915712627	1	1.5		
2006		3.666666667		12.26666667		8.580473502	1	5			1.5	
2007												
2008		7.109746589		11.5		37.29166667						
Yearly Average per Species	**5.166666667**	**2.804156137**	**15.625**	**41.12024539**	**7.5**	**12.99120895**	**3.860988309**	**3.43678447**	**1.571428571**	**1.5**	**1.5**	**2**

Summary of Town Marine Life Inventory Data, 1997 - 2008

Year	Other Freshwater	Other Marine	Oyster	Oyster toad	Oysterdrill	Periwinkle	Permit	Pipefish	Pompano	Pumpkinseed Fish	Rainwater Killifish	Ribbed Mussel	Rock Crab
1997								1.75					
1998							1.500994036	1	1	12.14285714			1
1999		10	1					1.311111111			1.75		
2000								1.65		1.333333333	7.25		
2001	1	1	1					1.38		12.25	5.142857143		
2002		2.25	1			3	2	1.291666667		3.785714286	5.921976852		1.666666667
2003				1	1	2.571428571		1.5	1	1.666666667	1.999668655	1	
2004			1				3	1.2		2.25	14.90623618		1
2005		4	3.5			5.9		1.125		4.375	7.880257673		
2006			2			5.761904762		1.375		5.75	3.125		
2007													
2008						16.66666667		1					
Yearly Average per Species	**1**	**3.9**	**1.6**	**1**	**1**	**6.586111111**	**2.166998012**	**1.337698413**	**1**	**5.80952381**	**6.02116**	**1**	**1.4**

Summary of Town Marine Life Inventory Data, 1997 - 2008

Year	Rock Gunnel	Sand Eel	Sand Shrimp	Sand Worm	Sculpin (grubby)	Scup	Sea Bass	Sea Cucumber	Sea Robin	Sea Squirt	Sea Star	Sheepshead Minnow	Skate (clearnose)	Skimmer
1997			51.2452381									75.25		
1998			3.875									39.52949934		1
1999		1	90.68125						1			9.479415176		
2000			132.5583333		2.5	2		7.666666667		5	1	13.4		
2001			93.96857143			1.333333333				2.5		12.82731759		
2002			14.41969948	1	1	12.87301587	2	7.083333333		9.5		19.58467742		
2003			12.48858791		1	7.777777778		16.65277778				10.69885455		
2004			7.050793651	1	1	6		5.436507937				27.61039169		
2005			5.694306179		1	3.5		3.708333333		5.666666667	1	15.38456385		
2006			8.557583427			4		1	1	2		15.30969066	1	
2007												6		
2008	1		2.125		2.5	13.25						6.375		
Yearly Average per Species	**1**	**1**	**43.00136599**	**1**	**1.428571429**	**7.747474747**	**2**	**7.190018315**	**1**	**5.277777778**	**1**	**17.26036449**	**1**	**1**

Summary of Town Marine Life Inventory Data, 1997 - 2008

Year	Slipper Shell	Smallmouth Bass	Snapper (juv.	Solitary glassy	Spider Crab	Spot	Squid	Stickleback	Striped Bass	Striped Killifish	Striped Searobin	Sundial	Sunfish
1997										69.41746032			
1998	10									19.2469697			
1999	5				2.038974359		1			22.21383132			
2000	38.5				2.390625		12			12.36464646	1.888888889		
2001	32.25				1.25					10.5010101	1.666666667		
2002	26.45595238	6.166666667			1.611111111	2	1			14.14719922	1.4375	1	
2003	37.66414141	3			2.79012605	4.25			1	17.58967511	1.25		
2004	18.95		3		2.100724638	4	1.5			8.435064935	1		1
2005	14.6462585	1.333333333	1	4	1.596296296	3.133333333	6	5.333333333	119.75	12.79298733			2
2006	14.53333333	3.666666667		12.75	1					5.918049532			
2007										11			
2008	42.5067362			14	2.449868938	1		15.5		18.16666667			
Yearly Average per Species	**23.46899905**	**3.433333333**	**2**	**10.875**	**1.928381933**	**3.116666667**	**3.833333333**	**12.11111111**	**80.16666667**	**16.23120077**	**1.494444444**	**1**	**1.333333333**

Summary of Town Marine Life Inventory Data, 1997 - 2008

Year	Tautog	Three-spine Stickleback	Tidewater Silverside	Toadfish	Tomcod	Transverse ark	Unknown	Water Scorpion	Weakfish	Whelk	White Mullet	White Perch
1997		3									3	
1998		2.5						1				2
1999	1.5	1.6665195	46.58846918		1		1				8	
2000	3.090909091	3.753846154	2.666666667		2	5	2.5					
2001	1.366666667	5	5.4	2			5.083333333					208
2002	1.370833333	1	5	1.166666667					5.5			11.21428571
2003	1.805555556	2.56753689			1.25						23.17857143	2.125
2004	1				1.727272727		3.333333333				4.5	3
2005	1.25	2.25	58.5		2.066666667		1		1	10	5.79047619	2.5
2006	1	3.5	3								2.75	4.952380952
2007												
2008	1				1							
Yearly Average per Species	**1.443398268**	**2.941816308**	**14.27551359**	**1.444444444**	**1.615454545**	**5**	**3.571428571**	**1**	**3.25**	**10**	**12.92946429**	**20.15659341**

Summary of Town Marine Life Inventory Data, 1997 - 2008

Year	Windowpane Flounder	Winter Flounder	Yellow Perch	
1997				
1998				
1999			1	
2000	1	4.316433566	2.25	
2001	1	1.821428571	18.5	
2002		1.142857143	6.333333333	
2003		2.966921692	7.166666667	
2004		1.678613054	1.714285714	
2005	1.5	1.282238142	9.5	
2006			1.25	
2007				
2008		2.5		
Yearly Average per Species	**1.25**	**2.264615146**	**6.066326531**	

Appendix I

NYSDOS Significant Coastal Fish &Wildlife Habitat Assessments

COASTAL FISH & WILDLIFE HABITAT ASSESSMENT FORM

Name of Area:	**Lake Montauk**
Designated:	**March 15, 1987**
Date Revised:	**May 15, 2002**
County:	**Suffolk**
Town(s):	**East Hampton**
7½' Quadrangle(s):	**Montauk Point, NY**

Assessment Criteria

Ecosystem Rarity (ER)--the uniqueness of the plant and animal community in the area and the physical, structural, and chemical features supporting this community.

ER assessment: Relatively large, protected, coastal bay, bordered by much development; not rare in Suffolk County. 0

Species Vulnerability (SV)--the degree of vulnerability throughout its range in New York State of a species residing in the ecosystem or utilizing the ecosystem for its survival.

SV assessment: Freshwater tributaries feeding into the Lake have significant concentrations of spotted turtle (SC). Overwintering common loon (SC).
Calculation: $16 + (16/2) =$ 24

Human Use (HU)-- the conduct of significant, demonstrable commercial, recreational, or educational wildlife-related human uses, either consumptive or non-consumptive, in the area or directly dependent upon the area.

HU assessment: Commercial bay scallop fishery important on a level between New York State and Long Island. Commercial hard clam fishery and bait fishery of county-level significance. Calculation: $\sqrt{(16 \times 9)} + (4/2) =$ 14

Population Level (PL)--the concentration of a species in the area during its normal, recurring period of occurrence, regardless of the length of that period of occurrence.

PL assessment: Concentrations of wintering waterfowl, bay scallop, and winter flounder of county-level significance. 4

Replaceability (R)--ability to replace the area, either on or off site, with an equivalent replacement for the same fish and wildlife and uses of those same fish and wildlife, for the same users of those fish and wildlife.

R assessment: Irreplaceable. 1.2

Habitat Index = [ER + SV + HU + PL] = 40 **Significance = HI x R = 48**

NEW YORK STATE
SIGNIFICANT COASTAL FISH AND WILDLIFE HABITAT
NARRATIVE

LAKE MONTAUK

LOCATION AND DESCRIPTION OF HABITAT:

Lake Montauk is located three miles west of Montauk Point on the South Fork of Long Island in the town of East Hampton, Suffolk County (7.5' Quadrangle: Montauk Point, NY). Lake Montauk was the largest freshwater lake on Long Island, but it has been estuarine since its inlet into Block Island Sound to the north was permanently opened in the 1920's. The approximately 900 acre lake had a healthy growth of eelgrass on the bottom. Presently, eelgrass beds are located only in the northern and western portions of the lake. The fish and wildlife habitat also includes a small freshwater pond (Stepping Stones Pond) off the southwest shoreline of the lake. The lakeshore has been extensively disturbed by residential, commercial and marine development. The water quality is progressively deteriorating due to chronic runoff, boat wastes and increasing subsurface wastewater contributions from shoreline development.

FISH AND WILDLIFE VALUES:

Lake Montauk was a rare ecosystem when it was freshwater but as a coastal embayment, with a maintained inlet and extensive shoreline development, it is not unusual in Suffolk County. Despite the development, Lake Montauk remains a high quality estuary supporting significant populations of fish and wildlife. A comprehensive study of the lake found nearly fifty species of birds, primarily shore and water birds, feeding, nesting, or roosting along the lake shore. Over-wintering waterfowl include common loon (SC), American black duck, red-breasted merganser, Canada goose, white-winged scoter, scaup, goldeneye and bufflehead. During the 1987-1996 period, the annual average number of waterfowl observed was 153 individuals; a peak value of 477 birds was observed in the early 1990s. Other wildlife includes the spotted turtle (SC) which resides in the freshwater tributaries and the small freshwater pond adjacent to Lake Montauk.

The Lake Montauk area provides a variety of marine and estuarine habitats for a wide diversity of fish and invertebrates. The commercial bay scallop fishery is significant on Long Island and other regions of New York State. The hard clam and bait fisheries are significant in Suffolk County. Portions of this habitat area are closed to shellfishing between April 1 and December 14, and between May 15 and October 15. The lake is also the only enclosed embayment on the South Fork supporting a large lobster population.

Fish species that reside and are harvested in the area include bluefish, weakfish, fluke, flounder, blowfish, white bait and striped bass. Lake Montauk is an important commercial fishing port on the South Fork (in 1989 Montauk Harbor was the largest commercial fishing port in the state with respect to landing and number of vessels); the concentration of bait fish is important to this fleet.

In the vicinity of Stepping Stones Pond, the New York Natural Heritage Program has documented several listed and rare plant species, including: coast flatsedge (*Cyperus polystachyos* var *texensis*), long-tubercled spikerush (*Eleocharis tuberculosa*, T), and the best example in New York State of salt marsh spikerush (*Eleocharis halophila*).

IMPACT ASSESSMENT:

Any activity that would further degrade the water quality in Lake Montauk would adversely affect the biological productivity and viability of the commercial fishery in this area. All species of fish and wildlife may be affected by water pollution, such as chemical contamination (including food chain effects), oil spills, excessive turbidity, waste disposal (including boat wastes) and stormwater runoff. Use of pumpout facilities in the no-discharge zone should be encouraged and enforced. Existing sources of pollution, both point and non-point, should be identified and then eliminated or reduced so as to improve water quality in Lake Montauk. The fringing wetlands around Lake Montauk have been impacted and/or lost by increased development along the lake shore. Restoration of wetlands in and around this area should be explored to reduce water pollution in the lake. Restoration opportunities may exist at this site for eelgrass beds, but improvement of water quality may be required before this is possible.

Unrestricted use of motorized vessels including personal watercraft in the protected, shallow waters of bays, harbors, and tidal creeks can have adverse effects on aquatic vegetation and fish and wildlife populations. Use of motorized vessels should be controlled (*e.g.*, no wake zones, speed zones, zones of exclusion) in and adjacent to shallow waters and vegetated wetlands.

Alteration of tidal patterns in Lake Montauk could have major impacts on the fish and wildlife communities present. Dredging to maintain the inlet and boat channels in the lake should be scheduled between September 15 and December 15 to minimize potential impacts on aquatic organisms and to allow for dredged material disposal when wildlife populations are least sensitive to disturbance. Dredging and its effects are a particular threat to submerged aquatic vegetation habitats, such as eelgrass, in Lake Montauk.

Elimination of salt marsh and intertidal areas through excavation, filling, or loss of tidal connection, would result in a direct loss of valuable habitat area. Construction of shoreline structures, such as docks, piers, bulkheads, or revetments in areas not previously disturbed by development (*i.e.*, natural beach, tidal flat, or salt marsh), may result in the loss of productive areas which support the fish and wildlife resources of Lake Montauk. Alternative strategies for the protection of shoreline property should be examined, including innovative, vegetation-based approaches. Control of invasive nuisance plant species, through a variety of means, may improve fish and wildlife species use of the area and enhance overall wetland values.

Also, the increasing resident mute swan population in this area may contribute to nutrient loading in small or enclosed waterbodies, and may affect usage by other waterfowl species. Mute swan control or removal may be beneficial to native waterfowl use of these waterbodies.

KNOWLEDGEABLE CONTACTS:

Habitat Unit
NYS Department of State
Division of Coastal Resources
41 State Street
Albany, NY 12231
Phone: (518) 474-6000

NYSDEC—Region 1
State University of New York, Building 40
Stony Brook, NY 11790-2356
Phone: (631) 444-0354

Wildlife Manager
NYSDEC—Region 1
State University of New York, Building 40
Stony Brook, NY 11790
Phone: (631) 444-0310

Bureau of Marine Resources
NYSDEC
205 N. Belle Meade Road, Suite 1
East Setauket, NY 11733
Phone: (631) 444-0430

Finfish and Crustaceans
NYSDEC
205 N. Belle Meade Road, Suite 1
East Setauket, NY 11733
Phone: (631) 444-0436

New York Natural Heritage Program
Wildlife Resources Center
700 Troy-Schenectady Road
Latham, NY 12110
Phone: (518) 783-3932

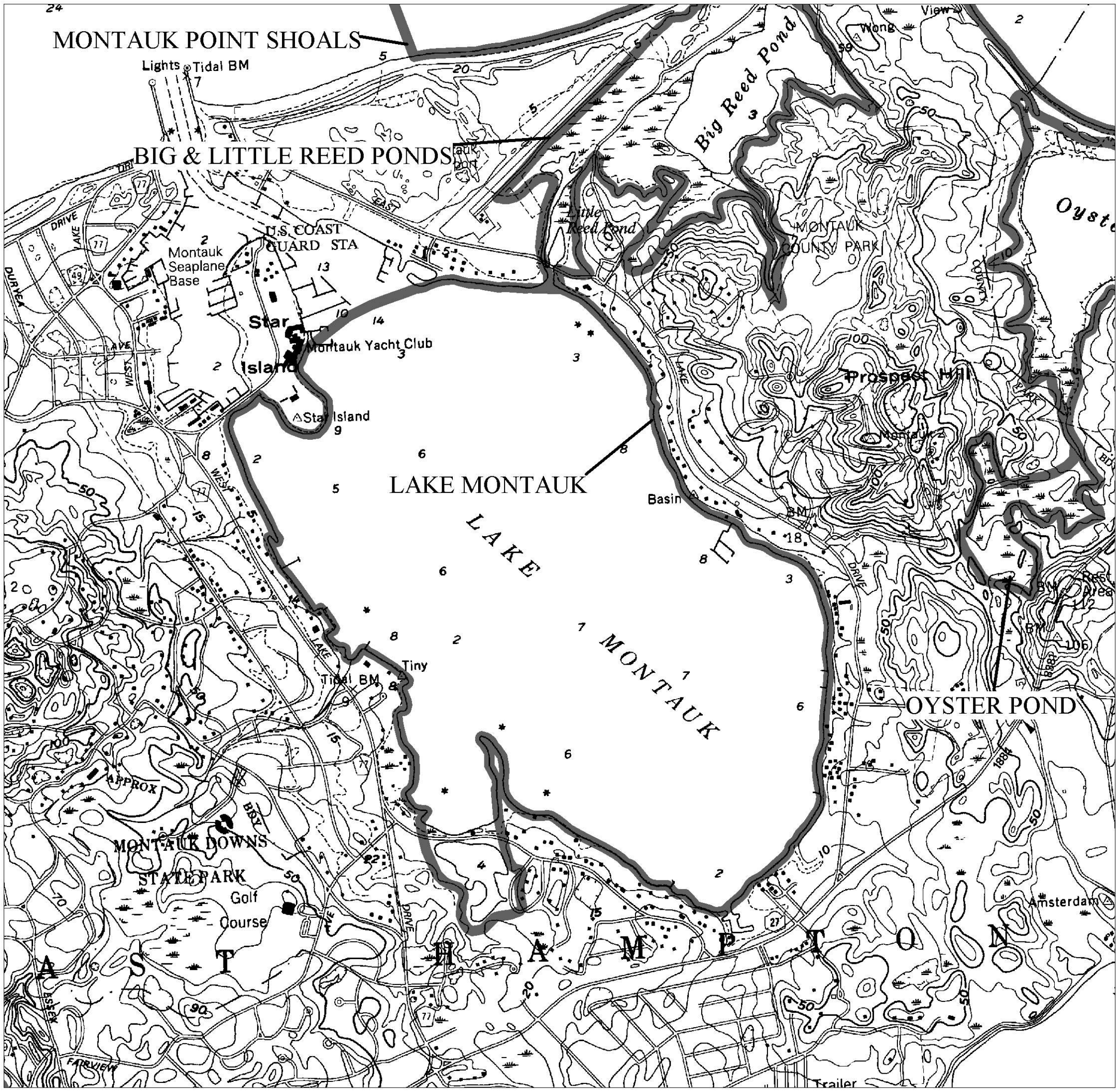
The Nature Conservancy
Long Island Chapter
250 Lawrence Hill Road
Cold Spring Harbor, NY 11724
Phone: (631) 367-3384

Group for the South Fork
P.O. Box 569
Bridgehampton, NY 11932
Phone: (631) 537-1400

East Hampton Dept. of Natural Resources
Town of East Hampton
300 Pantigo Place, Suite 105
East Hampton, NY 11937-2684
Phone: (631) 324-0496

East Hampton Baymen's Association
P.O. Box 498
Amagansett, NY 11930
Phone: not available

Office of Ecology
Suffolk County Dept. of Health Services
Bureau of Environmental Management
County Center
Riverhead, NY 11901
Phone: (631) 852-2077



Significant Coastal Fish and Wildlife Habitats

New York State
Department of State
Division of
Coastal Resources

Lake Montauk
Big and Little Reed Ponds (In part)
Montauk Point Shoals (In part)
Oyster Pond (In part)

0 2000 feet

COASTAL FISH & WILDLIFE HABITAT ASSESSMENT FORM

Name of Area:	**Big and Little Reed Ponds**
Designated:	**March 15, 1987**
Date Revised:	**May 15, 2002**
County:	**Suffolk**
Town(s):	**East Hampton**
7½' Quadrangle(s):	**Montauk Point, NY**

Assessment Criteria

Ecosystem Rarity (ER)--the uniqueness of the plant and animal community in the area and the physical, structural, and chemical features supporting this community.

ER assessment: Relatively large wetland complex containing a transition from brackish to freshwater communities; rare on Long Island. 16

Species Vulnerability (SV)--the degree of vulnerability throughout its range in New York State of a species residing in the ecosystem or utilizing the ecosystem for its survival.

SV assessment: Northern harrier (T) and least bittern (SC) nesting; blue-spotted salamander (SC) and spotted turtle (SC) breeding; bald eagle (T), short-eared owl (E), and osprey (SC) feed and overwinter in the area. Calculation: 36 + (25/2) + (25/4) + (16/8) + (16/16) = 57.8

Human Use (HU)-- the conduct of significant, demonstrable commercial, recreational, or educational wildlife-related human uses, either consumptive or non-consumptive, in the area or directly dependent upon the area.

HU assessment: Recreational fishing use of regional significance. 9

Population Level (PL)--the concentration of a species in the area during its normal, recurring period of occurrence, regardless of the length of that period of occurrence.

PL assessment: One of only 4 major documented alewife spawning streams in Peconics region. Concentrations of blue-spotted salamanders are also unusual in the region. 9

Replaceability (R)--ability to replace the area, either on or off site, with an equivalent replacement for the same fish and wildlife and uses of those same fish and wildlife, for the same users of those fish and wildlife.

1.2

R assessment: Irreplaceable

Habitat Index = [ER + SV + HU + PL] = 91.8 **Significance = HI x R = 110.2**

NEW YORK STATE
SIGNIFICANT COASTAL FISH AND WILDLIFE HABITAT
NARRATIVE

BIG AND LITTLE REED PONDS

LOCATION AND DESCRIPTION OF HABITAT:

Big and Little Reed Ponds are located northeast of Montauk Harbor, on the south fork of Long Island, in the Town of East Hampton, Suffolk County (7.5' Quadrangle: Montauk Point, NY). The fish and wildlife habitat is approximately 200 acres in size, and includes a large freshwater pond (Big Reed Pond), extensive cattail marsh, a brackish pond and marsh (Little Reed Pond), and surrounding wetlands and woodlands. Big Reed Pond supports a rich population of submerged aquatic vegetation, and Little Reed Pond supports beds of widgeon grass. A small stream flows from Big Reed into Little Reed Pond, which is connected to Lake Montauk by a tidal creek channel. Most of the habitat is located within undeveloped County parkland. The area is bordered on the west side by a landing strip for small aircraft.

FISH AND WILDLIFE VALUES:

Big and Little Reed Ponds comprise a relatively uncommon ecosystem type on Long Island. Big Reed Pond is one of only three areas on Long Island that have been designated as National Natural Landmarks by the National Park Service. The cattail marsh adjoining Big Reed Pond is one of the largest contiguous areas of emergent freshwater wetland in the region, whereas Little Reed Pond is an undeveloped brackish wetland area. Together, Big and Little Reed Ponds represent an unusual example of the natural transition between these habitat types, and contain a relatively diverse assemblage of fish and wildlife species.

Bird species breeding in this area include northern harrier (T), least bittern (SC), Canada goose, mallard, and American black duck. Red-shouldered hawk (SC) historically bred in this area, but has not been documented recently. Immature bald eagles (T) use the area, and short-eared owls (E) frequently overwinter here. Big and Little Reed Ponds serve as valuable feeding areas for these species, as well as for osprey (SC), redhead, hooded merganser, herons, egrets, and many passerine birds.

Blue-spotted salamanders (SC) have been reported breeding in the moist wooded swales draining into Big Reed Pond. This is one of the few locations on Long Island where this species is known to occur. The populations of this species in Montauk are unique because they are comprised of non-hybridized, sexually-reproducing animals. Most mainland populations of blue-spotted salamander have hybridized with Jefferson salamander. Spotted turtles (SC) are found in the ponds and adjacent wetlands. The adjacent wetland and upland areas are valuable as hunting areas for northern harrier and red-shouldered hawk. In addition, the rare coastal heathland cutworm moth (Abagotis crumbi benjamini) is found at this site.

Big and Little Reed Ponds also comprise a significant warmwater fisheries habitat. This area contains one of only four major documented spawning streams in the Peconics region for alewives, which migrate from the ocean to spawn in shallow freshwater in spring. Recreational fishing opportunities in Big Reed Pond, primarily for largemouth bass, attract residents from throughout Long Island to the area.

The New York Natural Heritage Program has documented several rare plant species in this area, including clustered bluets (Hedyotis uniflora, T), sandplain wild flax (Linum intercursum, T), pine-barren sandwort (Minuartia caroliniana), southern arrowwood (Viburnum dentatum), and the best example of water-pennywort (Hydrocotyle verticillata, E) in New York State.

IMPACT ASSESSMENT:

Any activities that would degrade water quality, increase turbidity, or alter water depths would have a significant impact on fish and wildlife species inhabiting Big and Little Reed Ponds. All species may be affected by water pollution, such as chemical contamination (including food chain effects resulting from bioaccumulation), oil spills, excessive turbidity, waste disposal (including boat wastes), and stormwater runoff. Warmwater fish species would be most sensitive from April 1 through July 30, when spawning takes place. Barriers to fish migration, whether physical or chemical, would have a significant effect on the biological resources of this area. Passage into Big Reed Pond is difficult and intermittent, and removal of debris and other impediments should be considered for enhancement of migratory fish habitat.

Wildlife species would be most sensitive during the breeding season, which generally extends from April 1 through August 30. Collection of amphibians and reptiles from this area or adjacent areas could have a significant impact on an important population of blue-spotted salamanders. The introduction of exotic, non-native fish, wildlife or plant species should be prohibited.

Any substantial alteration or human disturbance of the wetland and upland vegetative communities, such as changes to wetland or stream hydrology or configuration, filling, introduction of invasive or exotic species, and/or reduction or fragmentation of woodland buffer areas within or adjacent to the habitat may adversely affect wildlife species in the area. The cattail marsh in this habitat area is the largest on the South Fork and is notable in being largely free of Phragmites australis. Control of invasive nuisance plant species, through a variety of means, may improve fish and wildlife species use of the area and enhance overall wetland values. Expansions or alterations to the existing air strip could impact wildlife species and their habitat at this site.

Access to the area during appropriate time periods for compatible recreational uses of fish and wildlife should be maintained.

KNOWLEDGEABLE CONTACTS:

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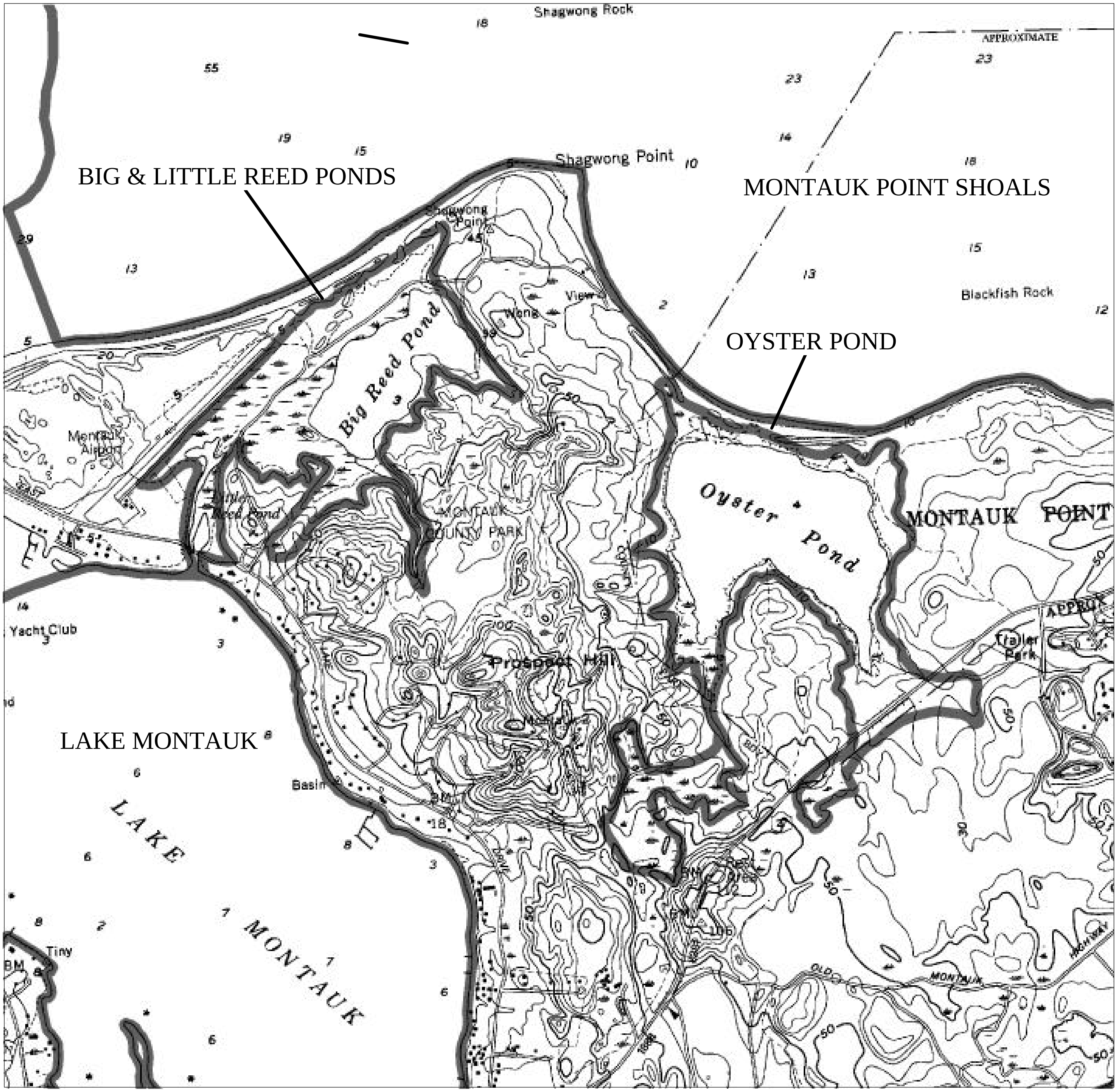

Significant Coastal Fish and Wildlife Habitats

New York State
Department of State

Division of
Coastal Resources

Big and Little Reed Ponds
Oyster Pond
Lake Montauk (In part)
Montauk Point Shoals (In part)

0 *2000*
feet

COASTAL FISH & WILDLIFE HABITAT ASSESSMENT FORM

Name of Area:	**Culloden Point**
Designated:	**March 15, 1987**
Date Revised:	**May 15, 2002**
County:	**Suffolk**
Town(s):	**East Hampton**
7½' Quadrangle(s):	**Montauk Point, NY**

Assessment Criteria

Ecosystem Rarity (ER)--the uniqueness of the plant and animal community in the area and the physical, structural, and chemical features supporting this community.

ER assessment: Complex perched kettle and stream course system draining to Block Island Sound; marshy meltwater depressions at seaward end of watercourse system. Rare on Long Island. 25

Species Vulnerability (SV)--the degree of vulnerability throughout its range in New York State of a species residing in the ecosystem or utilizing the ecosystem for its survival.

SV assessment: Blue-spotted salamander (SC) and eastern box turtle (SC). Northern harrier (T) probable breeder. Calculation: 16 + (16/2) = 24

Human Use (HU)-- the conduct of significant, demonstrable commercial, recreational, or educational wildlife-related human uses, either consumptive or non-consumptive, in the area or directly dependent upon the area.

HU assessment: Recreational fishing use of regional significance. Nature study, hiking, fishing from shore, of county-level significance. Access for offshore diving.
Calculation: 9 + (4/2) = 11

Population Level (PL)--the concentration of a species in the area during its normal, recurring period of occurrence, regardless of the length of that period of occurrence.

PL assessment: Very large concentrations of blue-spotted salamander and eastern newt, significant on Long Island. 9

Replaceability (R)--ability to replace the area, either on or off site, with an equivalent replacement for the same fish and wildlife and uses of those same fish and wildlife, for the same users of those fish and wildlife.

R assessment: Irreplaceable. 1.2

Habitat Index = [ER + SV + HU + PL] = 69 **Significance = HI x R = 82.8**

NEW YORK STATE
SIGNIFICANT COASTAL FISH AND WILDLIFE HABITAT
NARRATIVE

CULLODEN POINT

LOCATION AND DESCRIPTION OF HABITAT:

Culloden Point consists of 222 acres located on Block Island Sound and Fort Pond Bay in northern Montauk in the Town of East Hampton, Suffolk County (7.5' Quadrangle: Montauk Point, NY). This tract was subdivided and developed in the early 1990s, resulting in the creation of 54 residential lots and 188.3 acres of protected land in a contiguous block. The protected block is a Town of East Hampton, Suffolk County, and New York State preserve, encompassing all of the property's wetlands. The fish and wildlife habitat at this site consists of varied knob and kettle terrain with a surface area consisting of about 20% wetlands and 80% uplands. The wetlands are of the riparian and kettlehole type. The uplands are vegetated with alternating areas of oak-hickory hardwoods and brushy downs grasslands.

FISH AND WILDLIFE VALUES:

The Culloden Point area is a relatively uncommon ecosystem type on Long Island. The varied knob and kettle terrain provides an excellent habitat for several species of fish and wildlife.

The fern covered stream banks and regularity of stream flow (running to Block Island Sound) make this an ideal habitat for certain amphibians, particularly the blue-spotted salamander. A very large group of blue-spotted salamander (SC) lives in the stream system. Forty-five individuals were found occupying one small breeding hole in 1985. A 1992 herpetological survey in the area encountered 18 individuals. Other species observed were: Four-toed salamander, spring peeper, bull frog, green frog, gray tree frog, snapping turtle, painted turtle, eastern box turtle (*Terrapene carolina*, SC), eastern ribbon snake, and eastern garter snake. The eastern newt occupies several kettleholes including the largest freshwater pond, Culloden Pond.

The habitat area is also important to several species of birds for feeding and nesting. A 1993 breeding bird survey found 25 species of breeding birds here, and is an especially important site for yellow-billed cuckoo, blue-grey gnatcatcher, American goldfinch, and blue-winged warbler. Nest density reached 137 nests per 100 acres. Great horned owls breed in the Culloden Point habitat area; northern harrier (T) is a probable breeder but is not confirmed. Colonies of bank swallows nest in the coastal bluff faces of the area, and wild turkeys and ruffed grouse are found at this site. The littoral zone of Culloden Point is a prime feeding area for the common loon (SC) which overwinters in large numbers (several hundred) in the inshore waters between Montauk Point and Napeague Harbor each year. Other overwintering species observed in the area include Canada goose, common eider, white-winged scoter, bufflehead, red-breasted merganser, oldsquaw, and mallard.

A variety of mammals occupy the area, most notably the gray fox which is quite rare on Long Island.

The long, undisturbed coastline is an important area in the winter months as a haul-out area for harbor seals that feed in Block Island Sound and Fort Pond Bay.

The New York Natural Heritage Program has documented several listed and rare plants at this site, including scotch lovage (*Ligusticum scothicum*, E) and southern arrowwood (*Viburnum dentatum* var *venosum*).

IMPACT ASSESSMENT:

The fish and wildlife resources of Culloden Point would be affected primarily by major habitat alterations, or modification of public access to the area. Habitat modifications which substantially change the natural character of the area, such as residential, commercial, or industrial developments which would fragment important vegetative communities, clear woodlands, or disturb wetlands vegetation, would have a significant impact on the wildlife species in this area. *Phragmites australis* is encroaching on the wetlands in this area. Control of invasive nuisance plant species, through a variety of means, may improve fish and wildlife species use of the area and enhance overall wetland values.

Any activity that would degrade water quality or increase turbidity in the streams and wetlands of Culloden Point would also have a significant impact on fish and wildlife resources. All species may be affected by water pollution, such as chemical contamination (including food chain effects resulting from bioaccumulation), oil spills, excessive turbidity, waste disposal (including boat wastes), and stormwater runoff.

Collection of amphibians or reptiles from this area, as well as other fauna or flora, could have a significant impact on survival of species of special concern in New York State. Any permanent alteration or human disturbance of the harbor seal haulout area along the coastline of Culloden Point would adversely affect this species.

KNOWLEDGEABLE CONTACTS:

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Office of Ecology
Suffolk County Dept. of Health Services
Bureau of Environmental Management
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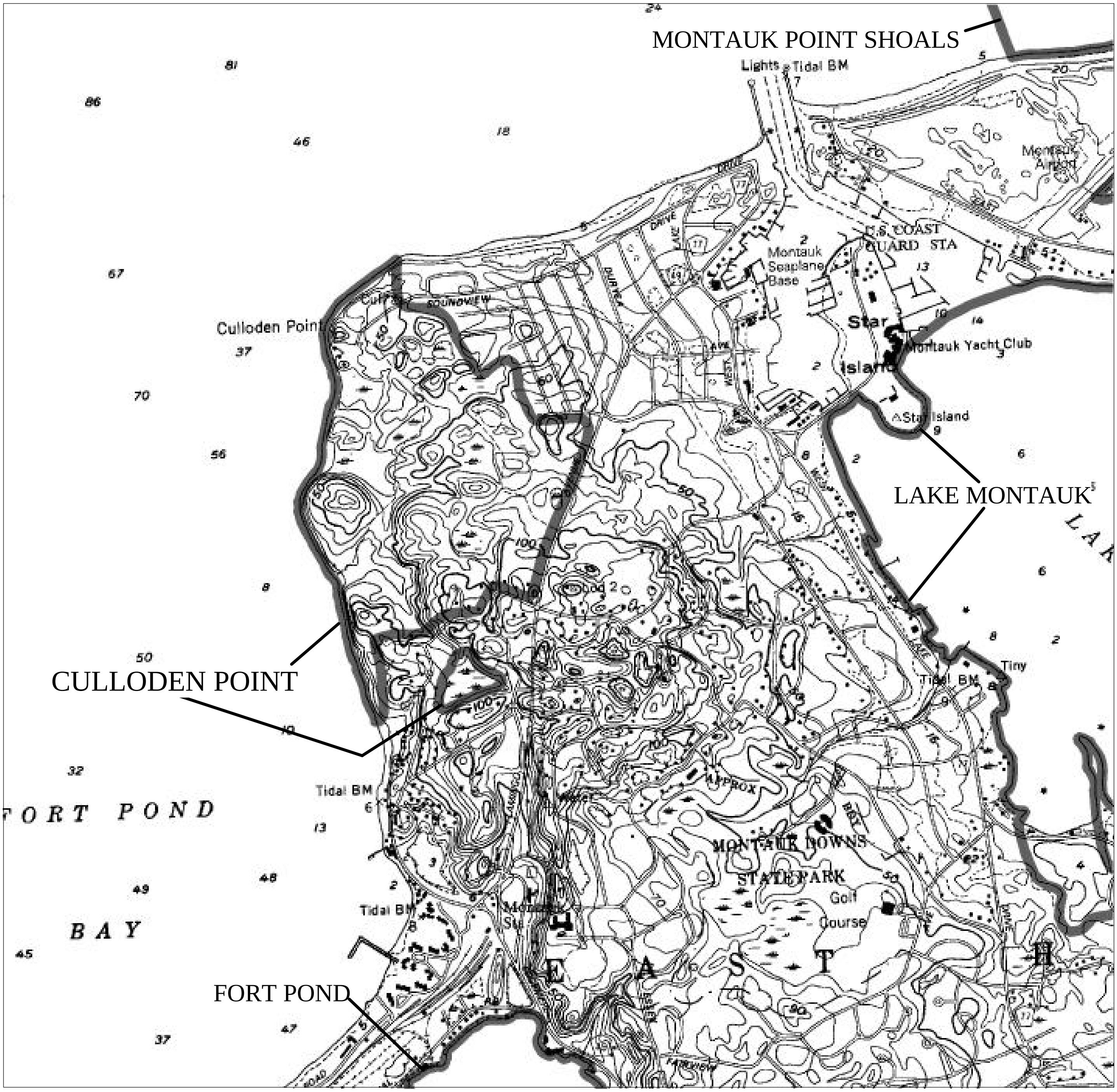

Significant Coastal Fish and Wildlife Habitats

New York State
Department of State

Division of
Coastal Resources

Culloden Point
Fort Pond (In part)
Lake Montauk (In part)
Montauk Point Shoals (In part)

0 *2000*
feet

Appendix J

NYNHP Significant Natural Community Descriptions

Island National Seashore, Suffolk County.

Sources: Andrle and Carroll 1988; Art 1976; Hancock 1995; Johnson 1985; Leatherman 1979; Robichaud and Buell 1983; Zaremba 1990, NYNHP field surveys.

5. Maritime shrubland: a shrubland community that occurs on dry seaside bluffs and headlands that are exposed to offshore winds and salt spray. This community typically occurs as a tall shrubland (2-3 m), but may include areas under 1m shrub height, to areas with shrubs up to 4 m tall forming a shrub canopy in shallow depressions. These low areas may imperceptibly grade into shrub swamp if soils are sufficiently wet. Trees are usually sparse or absent (ideally less than 25% cover).

Characteristic shrubs and sapling trees include shadbush (*Amelanchier canadensis*), bayberry (*Myrica pensylvanica*), black cherry (*Prunus serotina*), arrowwood (*Viburnum dentatum*), and shining sumac (*Rhus copallinum*). Other shrubs and stunted trees include beach-plum (*Prunus maritima*), sand-rose (*Rosa rugosa*), wild rose (*R. virginiana*), eastern red cedar (*Juniperus virginiana*), American holly (*Ilex opaca*), black oak (*Quercus velutina*), and sassafras (*Sassafras albidum*). Small amounts of highbush blueberry (*Vaccinium corymbosum*), sweet pepperbush (*Clethra alnifolia*), red maple (*Acer rubrum*), and black chokeberry (*Aronia melanocarpa*) are found in moister low areas, often grading to small patches of shrub swamp.

Characteristic vines include poison ivy (*Toxicodendron radicans*), Virginia creeper (*Parthenocissus quiquefolius*), greenbrier (*Smilax rotundifolia*), oriental bittersweet (*Celastrus orbiculatus*), and Japanese honeysuckle (*Lonicera japonica*).

The herb layer is very sparse and may contain a few scatttered flat-topped goldenrod (Euthamia graminifolia), wild indigo (*Baptisia tinctoria*), white-topped aster (*Aster paternus*), and little bluestem (*Schizachyrium scoparium*).

Maritime shublands may form a patchy mosaic and grade into other maritime communities. For example, if trees become more prevalent it may grade into one of the maritime forest communities, such as successional maritime forest. If a severe storm reduces shrub cover and deposits sand into the community it may be converted to a maritime dune. This community shares many shrub species with maritime dunes, but typically lacks the maritime dune herb species. More data on possible landscape variants are needed (e.g., maritime shrublands on morainal headland vs. outwash barrier dune).

Birds that may be found in maritime shrublands include black-crowned night-heron (*Nycticorax nycticorax*), fish crow (*Corvus ossifragus*), yellow-breasted chat (*Icteria virens*), and migratory songbirds (especially in fall) (Levine 1998).

Distribution: along the seacoast of the Coastal Lowlands ecozone.

Rank: G4 S4 *Revised:* 2001

Example: Montauk Point, Suffolk County; Fire Island, Suffolk County.

Sources: Clark 1986b; Levine 1998; Robichaud and Buell 1983; Taylor 1923, Thompson 1997; NYNHP field surveys.

6. Maritime heathland: a dwarf shrubland community that occurs on rolling outwash plains and moraine of the glaciated portion of the Atlantic coastal plain, near the ocean and within the influence of offshore winds and salt spray. This community is dominated by low heath or heath-like shrubs that collectively have greater than 50% cover.

Characteristic shrubs include bearberry (*Arctostaphylos uva-ursi*), beach heather (*Hudsonia tomentosa*), blueberry (*Vaccinium angustifolium*), black huckle-berry (*Gaylussacia baccata*), bayberry (*Myrica pensylvanica*), and beach-plum (*Prunus maritima*).

Grasses and forbs are present, but they do not form a turf; characteristic species include common hairgrass (*Deschampsia flexuosa*), little bluestem (*Schizachyrium scoparium*), Pennsylvania sedge (*Carex pensylvancica*), rush (*Juncus greenei*), asters (*Aster dumosum, A. linariifolius, A. solidagineus*), bushy rockrose (*Helianthemum dumosum*), and New England blazing star (*Liatris scariosa* var. *novae-angliae*).

A characteristic bird in winter is yellow-rumped warbler (*Dendroica coronata*). This community intergrades with maritime grassland, and the two communities may occur together in a mosaic.

Distribution: along the seacoast of the Coastal Lowlands ecozone, in eastern Long Island.

Rank: G3 S1 *Revised:* 1990

Example: Napeague Dunes, Suffolk County; Montauk Mountain, Suffolk County.

Sources: Dunwiddie et al. 1996; Thompson 1997; NYNHP field surveys.

7. Maritime grassland: a grassland community that occurs on rolling outwash plains of the glaciated portion of the Atlantic coastal plain, near the ocean and within the influence of offshore winds and salt spray. This community is dominated by grasses that usually form a turf; the grasses collectively have greater than 50% cover. Low heath shrubs may be present, with less than 50% cover.

The dominant grasses are little bluestem (*Schizachyrium scoparium*), common hairgrass (*Deschampsia flexuosa*), and poverty-grass (*Danthonia spicata*).

Other characteristic species include Pennsylvania sedge (*Carex pensylvanica*), rush (*Juncus greenei*), Indian grass (*Sorghastrum nutans*), Atlantic golden aster (*Pityopsis falcata*), bushy rockrose (*Helianthemum dumosum*), hoary frostweed (*H. propinquum*), flat-top goldenrod (*Euthamia graminifolia*), white-topped aster (*Aster paternus*), pussy's-toes (*Antennaria plantaginifolia*), bitter milkwort (*Polygala polygama*), bayberry (*Myrica pensylvanica*), shining sumac (*Rhus copallinum*), and northern dewberry (*Rubus flagellaris*). A characteristic lichen is *Cladina rangiferina*.

Distribution: along the seacoast of the Coastal Lowlands ecozone, in eastern Long Island.

Rank: G2G3 S1 *Revised:* 1990

Examples: Conscience Point, Suffolk County; Shinnecock Hills, Suffolk County; Sayville Grasslands, Suffolk County.

Source: Taylor 1923; Dunwiddie et al. 1996; Thompson 1997; NYNHP field surveys.

8. Hempstead Plains grassland: a tall grassland community that occurs on rolling outwash plains in west-central Long Island. This community occurs inland, beyond the influence of offshore winds and salt spray. Historically this community covered about 15,000 hectares (approximately 38,000 acres) of western Long Island; less than 12 hectares (30 acres) remain today, and most of these are severely degraded.

This community was dominated by species characteristic of midwestern tallgrass prairie: big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), Indian grass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*). These species are present in today's remnants, but they are not always dominant.

Other characteristic species that still occur in this community include rush (*Juncus greenei*), wild indigo (*Baptisia tinctoria*), dwarf cinquefoil (*Potentilla canadensis*), rough goldenrod (*Solidago nemoralis*), early goldenrod (*Solidago juncea*), butterfly-weed (*Asclepias tuberosa*), stargrass (*Hypoxis hirsuta*), fringed violet (*Viola fimbriatula*), bird's-foot violet (*V. pedata*), stiff-leaf aster (*Aster linariifolius*), boneset (*Eupatorium hyssopifolium*), and northern dewberry (*Rubus flagellaris*).

Characteristic birds include vesper sparrow (*Pooecetes gramineus*), savannah sparrow (*Passerculus sandwichensis*), grasshopper sparrow (*Ammodramus savannarum*), and bobolink (*Dolichonyx oryzivorus*).

Distribution: only known from the Coastal Lowlands ecozone, in western Long Island.

Rank: G1Q S1 *Revised:* 1990

Example: Mitchell Field, Nassau County.

Sources: Cain et al. 1937; Seyfert 1973; NYNHP field surveys.

9. Riverside ice meadow: a meadow community that occurs on gently sloping cobble shores and rock outcrops along large rivers in areas where winter ice floes are pushed up onto the shore, forming an ice pack that remains until late spring. The ice scours the meadow, cutting back woody plants. The late-melting ice pack, which is up to 8 ft (2.4 m) deep in late April or early May (in the southern Adirondacks), creates a cool microclimate in late spring, and shortens the growing season. The ice pack deposits organic matter that has accumulated in the ice during the winter, apparently enriching the sandy soils of the cobble and rocky shores. Within this community there is a gradient of two to three vegetation zones that vary with elevation above the river and soil moisture.

Along the river there is often a narrow zone of seepy, wet meadow; characteristic species of this riverside seep include sweet-gale (*Myrica gale*), twig-rush (*Cladium mariscoides*), Canadian burnet (*Sanguisorba canadensis*), stiff willow (*Salix rigida*), silky dogwood (*Cornus amomum*), three-way sedge (*Dulichium arundinaceum*), slender spikerush (*Eleocharis elliptica*), beakrush (*Rhynchospora capitellata*), cranberry (*Vaccinium macrocarpon*), brook lobelia (*Lobelia kalmii*), and rose pogonia (*Pogonia ophioglossoides*).

Where the cobble shores are broad and the soil is coarse and dry, there is a zone of grassy meadow. The dominant grasses include big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), and Indian grass (*Sorghastrum nutans*); in at least one location, nutrush (*Scleria triglomerata*) is codominant. Characteristic species of the dry meadow include

Appendix K

Case Studies

Appendix K-1
Surface Water Aeration Example

Section 319
NONPOINT SOURCE PROGRAM SUCCESS STORY
Vermont

Area Residents Keep Shelburne Beach Open
Unnamed Tributary to Shelburne Beach, VT

Waterbody Improved Bacteria leaking from residential septic systems caused exceedances of Vermont's *E. coli* criteria in a tributary to Shelburne Beach, resulting in occasional beach closures. As a result, Vermont placed the one-mile unnamed tributary on its section 303(d) list for *E. coli* in 1998. The Town of Shelburne identified the potential source of the bacteria, prompting improvements to a number of residential septic systems along the stream. Subsequent monitoring data showed that the stream and beach consistently met water quality standards, and the tributary was removed from the state's 303(d) list in 2004.

Problem

Shelburne Beach is a town swimming beach on a central portion of Lake Champlain in the town of Shelburne, Vermont. The state has classified the beach and the unnamed tributary to the beach as class B waters—a designation defined as "suitable for bathing and recreation, irrigation and agricultural uses; good fish habitat; good aesthetic value; acceptable for public water supply with filtration and disinfection."

The town monitors *E. coli* levels at the beach, including at a station at the mouth of the tributary, about 20 times a year during the swimming season, to check for compliance with Vermont's *E. coli* criteria. The criteria are 77 colony-forming units (cfu) per 100 milliliters for Class B waters. Among other purposes, the *E. coli* standard is designed to protect human health by preventing exposure to harmful levels of pathogens. Monitoring results for a number of years in the mid- to late 1990s indicated occasional exceedances of the *E. coli* standard at the monitoring station at the tributary mouth, causing occasional closures of the beach. The high *E. coli* counts resulted in the state's adding the unnamed tributary to the 303(d) list in 1998.

Coordinated efforts by area residents to control bacteria levels permit the continual enjoyment of Shelburne Beach

Project Highlights

In 1997 the town commissioned a study to find the source of the bacteria in the tributary, and the study identified six residential septic systems along the stream as the most likely source. Based on the findings of the study, the town encouraged the homeowners of concern to correct the deficiencies in their septic systems. Between 1998 and 2001, all six homeowners rebuilt their systems by installing new tanks and leach fields.

Results

The data summarized in Table 1 show that the *E. coli* standard was exceeded occasionally during the years 1996 to 1999. Although data are not available for 2000 and 2001, the data for 2002 and 2003 (following septic system improvements) show that the Vermont water quality standards for *E. coli* were met 100 percent of the time during those years. Accordingly, the state removed the tributary from the 303(d) list in 2004.

Partners and Funding

The restoration work in this case was funded by the Shelburne homeowners, who together spent approximately $90,000 to rebuild their on-site septic systems. The Town of Shelburne supported this work with seasonal bacteria monitoring and funding for the study that identified the bacteria source. Vermont Department of Environmental Conservation staff, funded with section 319 funds, provided some technical assistance to the town during the source-tracking phase.

Table 1. Summary of *E. coli* data at the mouth of the southern tributary to Shelburne Beach

Year	Number of samples taken throughout the season	Number of samples that exceeded Vermont's *E. coli* criterion of 77 CFU/100 mL	Average *E. coli* count for samples that exceeded criterion(CFU/100 mL)	Number of days beach was closed to swimming
1996	31	1	240	1
1997	28	3	197	1
1998	26	3	3,033	4
1999	16	1	130	0
2002	21	0	--	0
2003	21	0	--	0

U.S. Environmental Protection Agency
Office of Water
Washington, DC

EPA 841-F-07-001G
June 2007

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ALBEMARLE REGION, NORTH CAROLINA

PROBLEM

Rivers and streams of the Albemarle Region of North Carolina are nutrient-sensitive and require nutrient input controls such as upgrades for wastewater treatment plants and septic systems. Both strategies are being pursued by state and local officials. Much of the area is unsuitable for conventional gravity-flow individual systems due to low-permeability clay soils and high water tables. In past decades, these limitations prompted the extensive use of sand-lined trench leaching systems in the region. A 1991 study found that 30% of those systems were malfunctioning and posing risks to groundwater and surface water quality.

SOLUTION

Local governments authorized a regional management entity to inventory and monitor individual wastewater systems, improve system management, and develop site-specific design criteria for new and replacement systems incorporating advanced treatment technologies.

Albemarle Environmental Health Department
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OVERVIEW

Individual wastewater system malfunctions, water quality risks, and the explosive growth experienced in the Albemarle Region prompted 11 North Carolina counties to form the Albemarle Septic Management Entity (ASME) in 1993. ASME has instituted a management program that consists of:

- **Routine inspections**
- **Use of advanced treatment system designs for difficult site conditions**
- **Maintenance contract requirements and reminders**
- **Operating permit requirements for advanced units**
- **Alternating drainfields and reserve areas**

MAINTENANCE AND INSPECTION AGREEMENTS

ASME oversees individual and clustered systems in an 11-county area. ASME requires owners of all advanced and innovative systems to enter into inspection and maintenance agreements with the program. In addition, ASME requires that all repaired or replaced systems be included in the system management service area.

ASME works with low-income system owners to identify grant and low-interest loan funding to address repairs and replacements for problem systems using a combination of Community Development Block Grants, the North Carolina Clean Water Trust, and other sources.

ASME inspects systems in its jurisdiction at least annually. The system owner must complete all repair and maintenance activities. If an owner fails to make repairs, ASME is authorized to make the needed repairs and bill the owner and, if needed, place a lien on the property until payment is secured.

OPERATING PERMITS FOR ADVANCED SYSTEMS

ASME allows the use of advanced pressure-dosed systems, which incorporate fixed aerobic film and/or suspended growth pretreatment followed by soil absorption. Advanced systems require an operating permit. The local health department issues operating permits in accordance with state and local rules.

FUNDING SOURCES

The annual budget for the ASME wastewater program is $290,000. The program is sustained through its $300 per home permit fees, annual $50 system inspection fees, and county funds.

RESULTS

Local officials note that the management entity has prevented system malfunctions through more rigorous design, inspection, and operation/maintenance requirements. In the early 1990s, estimates of system malfunctions ranged as high as 30%. During 2007–2008, the program inspected 2,153 of the 4,240 systems under its management purview, and fewer than five of the newly installed systems were found to be malfunctioning.

New system installations and increasing the number of properly functioning systems through inspections will help to reduce nutrient pollution in the Albemarle watershed.

References and Resources

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FAIRFAX COUNTY, VIRGINIA

PROBLEM
During the past three decades, the population of Fairfax County has grown to more than one million people. With sanitary sewers at or near capacity, the number of individual wastewater systems began to multiply, eventually rising to more than 24,000. Inappropriately sited, improperly designed, and/or poorly managed individual systems have the potential to contribute to the pollution and degradation of the county's 900 miles of perennial and intermittent streams and a number of freshwater lakes and ponds.

SOLUTION
Fairfax County adopted an ordinance requiring routine pumping of septic tanks every five years and alternating drainfields and drainfield reserve areas to ensure system performance.

Onsite Sewage and Water
Division of Environmental Health
Fairfax County Health Department
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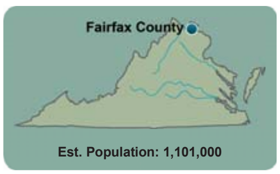

OVERVIEW

Fairfax County's decentralized wastewater management program has evolved since the first measures to improve onsite treatment were enacted in 1928. The program now includes:

- **A treatment system inventory and database**
- **Requirements for alternating drainfields and reserve areas**
- **Tank pump-outs at least once every five years, and pump-out manifests provided to the county health department**

ALTERNATING DRAINFIELDS AND RESERVE AREA

The Fairfax County Health Department issues permits and provides inspections and evaluations for new and existing individual wastewater system repairs and expansions. All new and repaired systems are designed with a flow diversion valve to allow portions of the drainfield to dry out; this improves treatment and avoids soil saturation problems. A suitable reserve area is required in the event that the system needs to be repaired or replaced.

FIVE-YEAR PUMP-OUT AND MANIFEST SYSTEM

An ordinance specifies that septic tanks must be pumped every five years. The service provider and the system owner both provide copies of the pump-out manifests to the county health department which tracks maintenance. The information is maintained in a database and is used to track compliance with the local ordinance. The database generates five-year pump-out reminder notices that the Health Department mails to system owners. The health department also offers $200 individual system inspections if required by a mortgage lender at the time of property transfer.

FUNDING SOURCES

Fairfax County sustains its annual $1.5 million onsite program through user fees and dedicated funds. The fees cover approximately 30% of the program costs. The remainder is financed through dedicated state and local funds.

RESULTS

A recent study found that the average malfunction rate for systems in the county was only 2.1% of the 15,401 systems reviewed. In addition, many systems thought to have outlived their life expectancy are still functioning satisfactorily.

The creation of a database for system inventory has allowed the county to track septic tank pump-outs and categorize all systems according to system type, greatly assisting the enforcement of existing codes and regulations. The use of alternating drainfields has increased the average lifespan of sewage disposal systems.

The five-year pump-out requirement has resulted in better maintained systems and the identification of system malfunctions that would otherwise go undetected. As a result of these measures, fewer owners are facing costly major repairs or system replacements.

Through its program, Fairfax County now better understands and manages its many onsite systems even in light of a fast-growing population.

References and Resources

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Hill, D. 1999. Onsite Waste Management—A Case Study, Fairfax, Virginia. **www.nesc.wvu.edu/nodp/pdf/ffva.pdf**.

The National Onsite Demonstration Program (NODP). Phase 4 Final Report. **www.nesc.wvu.edu/nodp/nodp_index.htm**.

Population data—Census Bureau, State and County QuickFacts, Fairfax County, 2011. **http://quickfacts.census.gov/qfd/states/51/51059.html**

JAMESTOWN, RHODE ISLAND

PROBLEM

Jamestown is a small, island town dependent on private drinking water wells and individual wastewater systems. Poorly maintained onsite wastewater systems on undersized lots with high seasonal water tables were affecting groundwater quality. Studies revealed that 32% of the wastewater treatment systems in the area were contributing to nutrient and pathogen problems in private water wells (Legislative Press and Public Information Bureau, 2006).

SOLUTION

Jamestown adopted an ordinance requiring routine inspections of individual wastewater systems. A High Groundwater Table District also guides future development to protect drinking water quality.

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Jamestown, RI 02835
www.jamestownri.net

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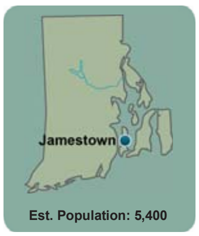

OVERVIEW

Jamestown is located on a small island situated in the middle of Narragansett Bay in Rhode Island. It is approximately nine miles long and one mile wide. In 2001, Jamestown passed an ordinance to better accommodate growth and manage individual wastewater systems to protect its fresh water supplies. The program consists of:

- **Routine inspections**
- **Maintenance reminders**
- **Web-based system database**
- **Siting and installation rules**
- **Designation of a High Groundwater Table District**

MAINTENANCE INSPECTIONS AND WEB-BASED TRACKING

Jamestown's program provides a framework for the inspection, maintenance, and repair of individual wastewater systems. The town conducted an initial round of inspections in 2003 aimed at identifying and evaluating the condition of 1,608 individual systems. Jamestown then began a routine maintenance inspection program in 2006 under which systems are inspected every three or five years based on size, type of system, and water use. Inspectors record the inspection information in the town's web-based database. The town has the authority to pump tanks at the owner's expense and, if necessary, can place liens on property for failure to reimburse the town for the pump-out.

HIGH GROUNDWATER OVERLAY ZONE AND IMPERVIOUS LAYER DISTRICT

Jamestown adopted a High Groundwater Overlay Zone and Impervious Layer District Ordinance in 2003. The ordinance applies to designated areas in the town that have substandard-sized lots served by private wells. Provisions of the ordinance include a total impervious surface area limit of 15% (calculated for individual lots and excluding wetlands), a requirement to control runoff volume—using low-impact techniques—to maintain predevelopment infiltration for a 25-year storm, and a mandate to use advanced wastewater treatment technologies capable of 50% nitrogen removal.

FUNDING SOURCES

Jamestown's program is funded through an annual user fee of $30 paid by system owners. The fee funds the town's part-time wastewater management specialist.

RESULTS

- **To date, 94% of all septic systems have had an initial maintenance inspection.**
- **Of the systems inspected:**
  - **35 failed (2%)**
  - **85 (5%) were found to be substandard systems (e.g., cesspools, systems with steel tanks)**
  - **1,488 passed (93%)**
- **Since 2003, 50 systems have been subject to repair/replacement actions initiated by the town.**

Property owners are responsible for ensuring that their system is operating properly and that it is maintained in good repair. Systems that do not meet applicable performance requirements can be subject to a repair or replacement order. Addressing malfunctioning systems helps to reduce nitrogen and pathogen pollution that pose threats to Jamestown's drinking water sources.

References and Resources

Jamestown Source Water Assessment and Wastewater Needs Analysis. University of Rhode Island Cooperative Extension. **http://www.uri.edu/ce/wq/RESOURCES/dwater/Assessments/PDFs/James_Chapters%203,4.pdf.** Accessed August 9, 2010.

Legislative Press and Public Information Bureau. 2006. Senate passes Paiva Weed bill stemming from Jamestown well contamination. State of Rhode Island, General Assembly. Providence, RI.

Rhode Island Department of Environmental Management. 2008. Rules Establishing Minimum Standards Relating to Location, Design, Construction, and Maintenance of Onsite Wastewater Treatment Systems. Town of Jamestown. High Groundwater Ordinance. **www.jamestownri.net plan/hgwt.html.** Accessed March 31, 2010.

Population data—Town of Jamestown, Rhode Island. **http://www.jamestownri.net/**

KEUKA LAKE WATERSHED, NEW YORK

PROBLEM

Approximately 20,000 residents in the Keuka Lake watershed rely on groundwater and the lake for their drinking water. Nearly all of the residents in the watershed also depend on individual wastewater systems that are densely positioned and that discharge to the soil for treatment. However, testing revealed that poorly maintained individual onsite systems were contributing excessive levels of bacteria to the lake and contaminating drinking water wells.

SOLUTION

Eight municipalities formed a regional watershed cooperative that implemented a uniform permitting and inspection program to identify and repair or replace malfunctioning treatment systems. As a result, Keuka Lake's water quality ranks among the highest of the water bodies in the Finger Lakes region.

Keuka Watershed Improvement Cooperative
1 Keuka Business Park
Penn Yan, NY 14527
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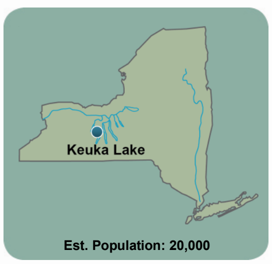

OVERVIEW

In 1994, eight municipalities—Barrington, Jerusalem, Hammondsport, Milo, Penn Yan, Pulteney, Urbana, and Wayne—bordering Keuka Lake formed the Keuka Watershed Improvement Cooperative (KWIC) to better manage individual and decentralized wastewater systems in the region. KWIC has instituted a management program that consists of:

- **Uniform regional ordinances**
- **System inspection requirements based on health and environmental risk factors**
- **Maintenance contract requirements for mechanized units**
- **Operating permit requirements for new or modified systems**

ROUTINE INSPECTIONS AND MAINTENANCE CONTRACTS

Municipalities participating in the KWIC program must adopt a uniform wastewater management ordinance and hire a coordinator to inspect treatment systems in their communities. All 3,000 wastewater systems within 200 feet of Keuka Lake or its tributaries are inspected at least once every five years. Inspection reports are filed with KWIC. Aerobic and advanced treatment systems are inspected annually, at which time the system owner must show evidence of an active maintenance contract. Systems are also inspected when property is sold.

The regional ordinances require a KWIC operating permit for all new or modified individual wastewater systems. A system that is malfunctioning must be repaired to meet specific performance requirements. Additionally, KWIC could require the system owner to upgrade or replace the malfunctioning system using the best available technology.

KWIC utilizes a computerized database to track inspections and system compliance. KWIC reviews lake water quality information and evaluates the performance of advanced systems. KWIC's enforcement authority includes fines and compliance timetables in addition to corrective actions.

FUNDING SOURCES

The KWIC program is financed by permit fees and dedicated funds from each municipality's budget. The program's annual budget is $70,000.

RESULTS

Water quality monitoring results indicate very good lake conditions, though runoff from stormwater and agricultural sources after storm events can result in high bacteria levels. The relatively clear water in the lake contains low nutrient levels and supports excellent fisheries. Monitoring results from 2005–2009 show lake water quality improving or holding steady for nearly all parameters. The local lake association attributes this progress, in part, to the septic system inspection program.

References and Resources

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Landre, P. 1995. The creation of Keuka Lake's Cooperative Watershed Program. Clearwaters Magazine, Summer 1995, 28-30.

Smith, J.C. 1995. Protecting and Improving the Waters of Keuka Lake. Clearwaters Magazine, Summer 1995, 32-33.

Population data—Keuka Lake Association. **http://www.keukalakeassoc.org/**

Appendix K-2
Alternative Wastewater Options

National Decentralized Water Resources
Capacity Development Project





Creative Community Design and Wastewater Management

University of Rhode Island Cooperative Extension
Kingston, Rhode Island

March 2004

See Full Document: http://www.uri.edu/ce/wq/NEMO/Publications/PDFs/WW.CreativeDesignAndManagement.pdf

4 ALTERNATIVE SYSTEMS FOR INDIVIDUAL LOTS

This chapter presents examples where design principles and alternative technologies described in the main community case studies are applied on individual lots. Use of alternative systems for individual lots supports the principles of creative community design by permitting compact development and in-filling, which minimizes sprawl and promotes pedestrian-friendly, distinctive neighborhoods. A community's character emerges from the sum of the look and feel of its individual lots. These real-world examples show how alternative systems permit a greater use of yard, buffers, and green space to maintain and enhance the sense of community within individual neighborhoods.

Case Studies of Alternative Systems for Individual Lots

Several of the case study systems were constructed as demonstration systems under an EPA-funded National Onsite Wastewater Demonstration Project-Phase II project in 1998. Since then, many other landowners have installed alternative technologies for either new construction or repairs in sensitive coastal areas and other resource protection zones. These examples explore selection factors related to treatment performance, environmental protection, and site constraints. Although site design and system selection are highly dependent on site conditions, checklists are provided as basic guides to system design on individual lots with factors to consider in evaluating use of individual versus cluster systems.

The reasons to select a particular system over another are many. They include:

- Space limitations
- Treatment requirements
- Reliability and risk of hydraulic failure or inadequate treatment
- Availability and ease of support from companies supplying treatment components
- Aesthetics
- Life cycle costs (not just initial installation cost) including maintenance, repairs, and energy costs over a several year period

In most examples presented here, the treatment objective was to protect pathogen- and nitrogen-sensitive coastal waters and, in some cases, protect private drinking water wells.

A High Water Table, Stony-Soil Coastal Site with a Town Water Supply

The use of an alternative treatment system on this real-world site maintained distinctive natural and architectural features of the neighborhood while protecting public and environmental health. This one-third acre site located in a nitrogen- and pathogen-sensitive coastal watershed is almost completely surrounded by a wetland, has wet glacial till soils, many stones and large boulders, and groundwater at the surface for several months during the wet season. The home on the site and the surrounding neighborhood is serviced by a town water supply.

The existing system for this site, which was pumped four times a year, consisted of an approximately 500-gallon cesspool and auxiliary drainfield line. Shallow ponded water was present over the existing cesspool area during wet times and would flow through a neighboring lot and then into the nearby coastal wetland.

A typical size filter for a three-bedroom home is 8 feet by 20 feet. The typical conventional septic system fix would completely alter the yard and most of the yard area would be required (Figure 4-1). Boulders would need to be excavated and trees removed, 4 feet of gravel fill would be brought in to raise the drainfield above the water table, and a pump would be installed to pump septic tank effluent up to the raised drainfield. Without a level area 25 feet surrounding the drainfield, retaining walls would need to be constructed to contain the fill material. Because of all this excavation and fill material, the cost of this system would far exceed the cost of the alternative system. This type of work often drastically alters stormwater movement in the immediate neighborhood and aggravates already wet site conditions.

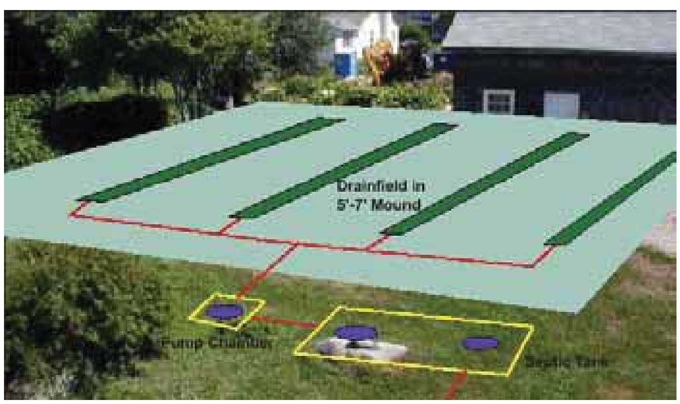


Figure 4-1
Typical Conventional Septic System

To overcome these problems, a recirculating media filter was selected as the treatment unit, with a bottomless sand filter drainfield to provide additional treatment. This system provides a minimum of 50 percent nitrogen removal to help protect nearby coastal waters. As shown in Figure 4-2, wastewater from the house flows into a septic tank with two pumps controlled by separate timers (A). One pump recirculates effluent to a media filter (B), and the other disperses this blended effluent to the raised bottomless sand filter, that is located on the highest point in the yard (C).

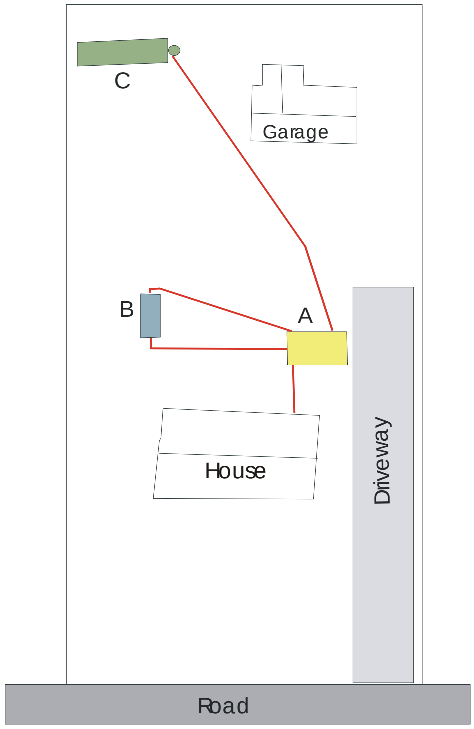


Figure 4-2
Layout of the High Water Table, Stony-Soil Coastal Site Treatment System

The media filter was selected for its small footprint and nitrogen reducing performance. The bottomless sand filter (Figure 4-3) was the only drainfield option available for this high water table site that provided bacterial reduction and avoided large amounts of fill material. This system significantly minimized site disturbance and surface topography changes that would have altered stormwater movement; at the same time it achieved a high degree of nitrogen reduction and moderate levels of bacterial reduction.

Figure 4-3
Bottomless Sand Filter Before the Final Cover of Peastone

The alternative system fits into the landscape, amid boulders and trees while providing a much higher level of treatment than a conventional system (Figure 4-4).

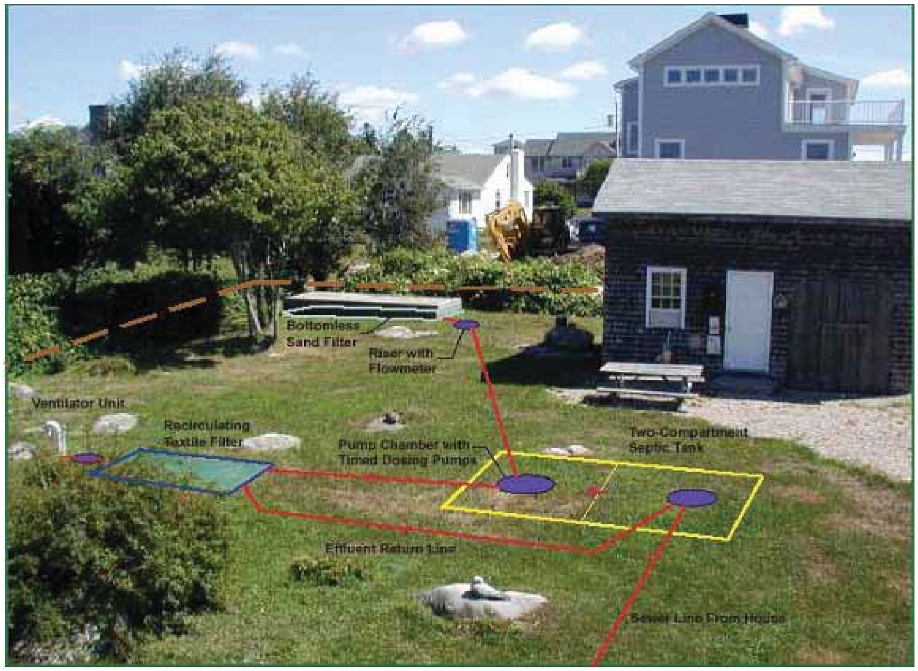


Figure 4-4
The Alternative Treatment System's Layout Fits into the Landscape

Small Flat Coastal Plain Lot with Nearby Private Wells

In this real-world example of a working class summer resort neighborhood, the creative design goal was to maintain the architectural and natural elements of the neighborhood by avoiding large obtrusive raised fill-type wastewater treatment system that would detract from the sense of community and compound stormwater problems. Homes in this low-lying sandy soil coastal plain area are largely seasonally occupied but often experience intense summer use. This entire community relies on wells, many of which are shallow-dug wells that rely on thin freshwater lenses floating above the heavier saltwater. This home, like most of the older homes in the neighborhood, is 1950s- to 1970s-vintage on a small lot (5,000 square foot is common), where well and septic system setbacks are rarely met. Wells on both the case study site and a neighboring lot were approximately 50 feet from a failed cesspool. Obviously nitrogen and pathogen removal are essential to protect groundwater supplies as well as the nearby poorly flushed coastal pond.

To save limited space, a modular recirculating media filter was placed under a cantilevered room of the house, leaving the remaining 15-foot by 50-foot usable space in the back yard for the septic tank and shallow narrow drainfield.

Figure 4-5 shows the final system layout for this flat coastal-plain site with nearby shallow wells. The system included a septic tank (A), media filter (B), and drainfield (C).

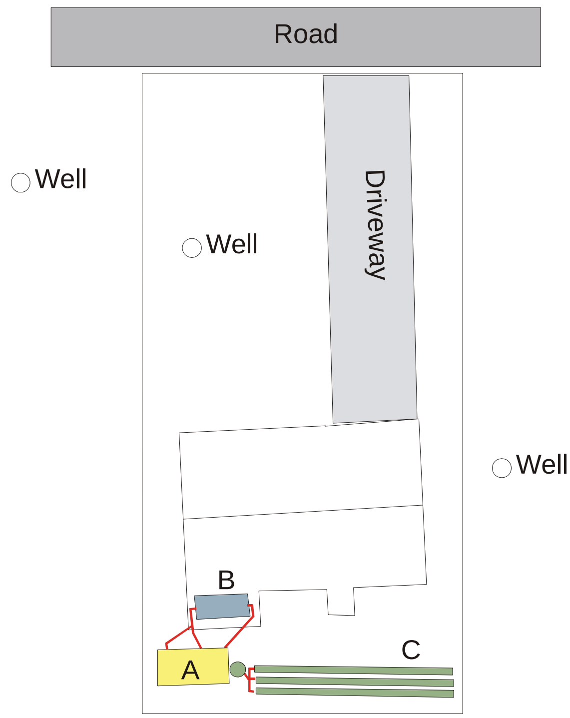


Figure 4-5
Final Treatment System Layout

Wastewater from the home enters the septic tank, where it then recirculates to the media filter in the crawl space, then is dosed to the shallow narrow drainfield where additional treatment occurs (Figure 4-6). The coastal pond can be seen in the background of Figure 4-6, approximately 300 feet away. The recirculating media filter fits in the crawl space under the cantilevered room of the house (Figure 4-7). The owners of the white building seen beyond the outdoor stairs in Figures 4-6 and 4-7 later installed a similar system.

Figure 4-6
Locations of the Final System Components

Figure 4-7
Recirculating Media Filter Under a Cantilevered Room

A Sustainable and Healthy Home Landscape

Maintaining a sustainable home landscape by removing nitrogen was a prime objective on this real-world one-third-acre lot located in a flat coastal plain with sandy soils and eight-foot-deep water table. Homes in this area are typically 1950s vintage, with about half occupied year-round. Typical of the area, the existing system consisted of a cesspool that had hydraulically failed and was surfacing. A conventional system could have easily been accommodated, but with little nitrogen treatment.

One of the homeowner’s main concerns was maintaining a vigorously growing turf on his landscaped lawn. To satisfy the owner’s request, the system selected for this site was a septic tank followed by a pump tank that dosed a drip-irrigated field. The drip irrigation tubing was installed six inches below ground surface to maximize nutrient and moisture use by grass. Although the yard was large enough to accommodate most any technology, the drip irrigation fit well on the site because there was sufficient level space to accommodate the required amount of drip tubing. Figure 4-8 shows the location of the system components.

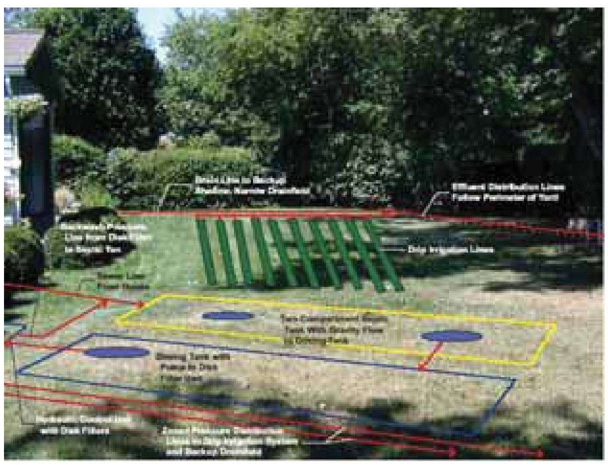


Figure 4-8
Drip-Irrigation System Layout for Turf and Landscape Maintenance

Figure 4-9 shows a diagram of the layout for the drip-irrigation system. In this system, wastewater from the home enters the septic tank (A) where solids settle. Effluent flows to the dosing tank (B) and is pumped through disc filters that remove fine organic particles that might clog the drip irrigation lines (C). A sand-lined shallow narrow drainfield (D) was also installed as a backup to the drip field but has not been used.

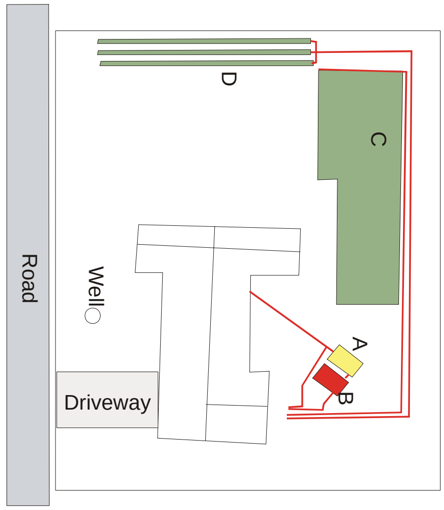


Figure 4-9
Layout of a Drip-Irrigation System

Site with a Nearby Private Well and Unique Wetlands

Maximizing pathogen and phosphorus removal were the treatment concerns on this real-world one-half-acre sandy soil lot relying on well water and having a small, yet environmentally important, vernal pool nearby. Several homes in this portion of the community have these natural vernal pools that are a unique habitat for threatened species of amphibians. The existing bed-type drainfield for this site had failed and was threatening the vernal pool. The somewhat rolling local topography with a high water table at about three feet, lent itself to using a buried single-pass sand filter with a shallow narrow drainfield. This system was used to provide maximum bacterial removal on the three-foot water table site, protect the drinking water well, and maintain the greatest setback from the vernal pool approximately 60 feet from the drainfield.

A generic single-pass sand filter was selected for this site because it is a reliable pathogen removal technology used for more than 100 years to treat water and wastewater. The single-pass sand filter is more effective in removing bacteria than a recirculating filter, which excels in nitrogen reduction. In addition, single-pass sand filters are larger than recirculating media filters and space was available at this site. The shallow narrow drainfield can be expected to provide additional nitrogen and pathogen removal to protect groundwater, and phosphorus treatment to protect the vernal pool from nutrient enrichment.

Figure 4-10 shows the system layout. Wastewater from the home enters the septic tank (A) and this effluent is then dosed to the single pass sand filter (B). Final treated effluent is then dispersed to a shallow narrow drainfield (C).

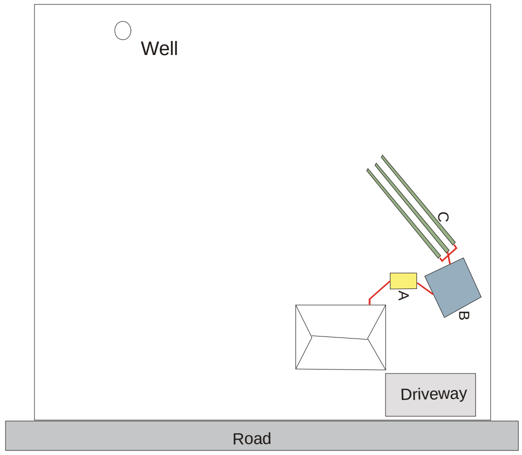


Figure 4-10
Layout for the Single-Pass Sand Filter System

This system required little site alteration, which prevented disruption of the wetland buffer and enabled existing landscaping to remain, including a small tree and several shrubs (Figure 4-11). The conventional septic system option would have required clearing, regrading, and filling to adjust for slopes and to raise the drainfield at least two feet to achieve the required separation to groundwater.

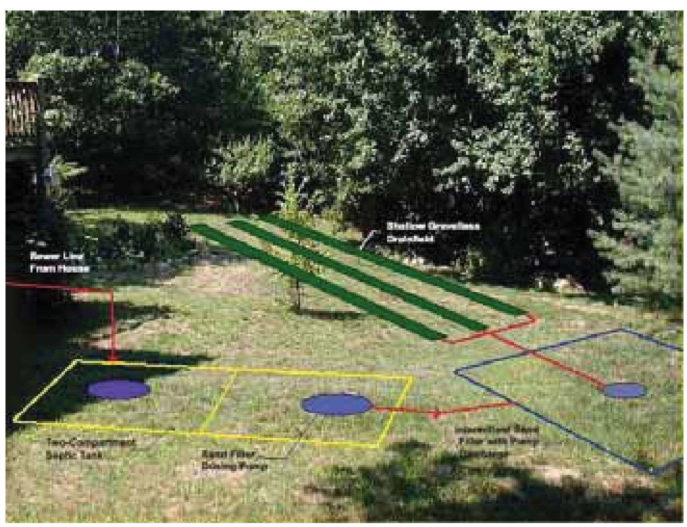


Figure 4-11
Location of System Components

Sandy Shorefront Lot with Limited Space

This real-world example site is located directly on the shore of a nitrogen-sensitive coastal pond that has been closed to shellfishing due to high bacteria levels. Nutrient enrichment at the shoreline of this property has caused an overabundant growth of nuisance algae (Figure 4-12).

Figure 4-12
An Overabundant Growth of Nuisance Algae Caused by Nutrient Enrichment

The creative community design goal in this case study was to maintain a sense of community character and charm while protecting the coastal pond and nearby well from nitrogen and bacteria. With a total land area of 5,000 square feet, the site has extremely limited usable space to fit house footprint, septic system, well, and parking area. The failed system consisted of two 55-gallon steel drums, an approximately 300-gallon steel septic tank, and a 600-gallon cesspool all in series. Located between the house and the pond shore, a dug well drawing from a shallow freshwater lense provided water to the 1950s vintage home.

The system installed on this site consists of a septic tank, a recirculating media filter, and a shallow narrow drainfield. Figure 4-13 shows the system layout. Wastewater from the house enters the septic tank (A) where effluent is then pumped to the recirculating media filter (B). The treated effluent is dosed to a two-zone shallow narrow drainfield (C1 and C2).

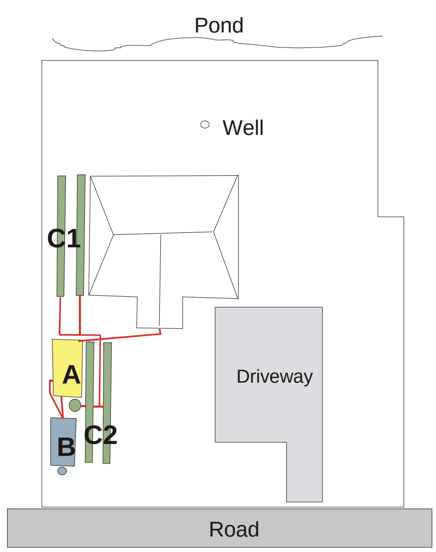


Figure 4-13
Layout for a Recirculating Media Filter System for a Lot With Limited Space

Figure 4-14 and Figure 4-15 show various views of the recirculating media filter system for this tight lot. One-half of the shallow narrow drainfield is located under the clothes line in between the home and the fence at the lot line (Figure 4-15).

Figure 4-14
Recirculating Media Filter System on a Small Lot

Figure 4-15
The System's Drainfield is Located Between the Home and the Fence

Until a few years ago, the conventional option for such small lots with deep sandy soils would have been a septic tank followed by deep concrete leaching chambers. This type of system has an extremely small footprint (4-foot by 12-foot drainfield) but provides little treatment. Shallow concrete leaching chambers could have been installed in the driveway, but again little treatment would have resulted.

Sloping Landscaped Site in a Sensitive Coastal Watershed

This real-world sloping one-half-acre lot has rocky glacial-till soils, well-established landscaping, and many obstacles that render the site with little usable space in which to fit a conventional septic system repair. Although the site has a fairly deep water table and municipal water service, the adjacent coastal pond roughly one block away is sensitive to nitrogen and bacterial inputs. Using alternative technology on this site eliminated extensive filling and regrading of the existing lot and maintained the natural elements of the landscape.

Whatever technology that was chosen for this site needed to fit into an area under an existing raised deck on the house to save space and fit the existing landscaping (Figure 4-16).

Figure 4-16
The Existing Raised Deck

The technology selected was a septic tank with a pump dosing a single-pass modular media filter. Figure 4-17 shows the system layout. Wastewater from the house enters the septic tank (A) where effluent is dosed to the single-pass media filters (B) located under the deck. Treated wastewater flows through an ultraviolet light disinfection unit (C) and then is dosed to the shallow narrow drainfield (D) adjacent to an existing fern garden (Figure 4-18).

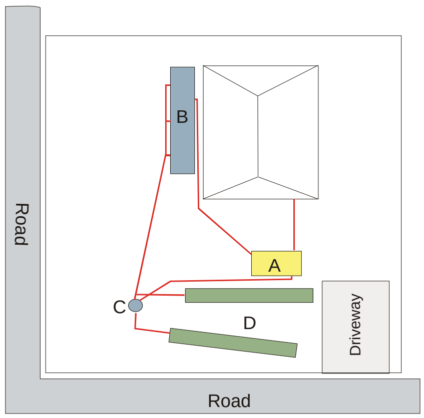


Figure 4-17
System Layout for a Sloping Site Where Bacteria Removal is Important

Figure 4-18
Locations of System Components on the Site

The media filters come in pre-packaged modular units that provide flexibility in siting, simplify installation, and enable limited site disturbance to the lot during construction (Figure 4-19). The UV light disinfection unit provides an additional level of bacterial removal to help reduce the pollution risk from this system. Due to the slope on this lot, a conventional system would have required extensive clearing with large amounts of machine time and gravel fill to enable level areas for drainfield lines, all with little nitrogen removal.

Figure 4-19
Modular Single-Pass Media Filters

A System for Tiny Waterfront Lots

Tiny waterfront building sites are lots that really should never have been built upon. They are grandfathered postage-stamp-sized lots with homes that had little impact on water quality back when first built. But now, with years of infill development and the shift to year-round use, the former summer cottage neighborhood has hastened the loss of recreational and commercial use of a waterbody for fishing and shellfishing.

This example is one such lot (Figure 4-20), located on the shore of a poorly flushed coastal pond that is permanently closed to shellfishing due to bacterial levels and is also showing signs of nitrogen enrichment. This example illustrates the use of alternative technology to maintain the quaint charm of a neighborhood and enable the landowner to renovate and revitalize his home. This roughly 4,000-square-foot-lot has unusually limited space, and a conventional system would neither fit on the site nor would it protect the beleaguered pond. Even most advanced treatment systems would not fit in the available space on this lot.

Figure 4-20
The Existing House Was Originally a Seasonal Home with a Building Footprint of Less Than 600 Square Feet

With remodeling, the footprint was slightly enlarged (Figure 4-21). The number of bedrooms remained the same, keeping potential occupancy at the same level and preventing an increase in nutrient loading.

Figure 4-21
Remodled House with a Slightly Enlarged Footprint

To meet the space and treatment demands of this site, a system incorporating fixed activated sludge technology was installed. This is a space-saver system because the treatment unit itself actually rests within the septic tank (Figure 4-22), eliminating the need for separate space to fit the treatment unit.

Figure 4-22
The Treatment Unit

Figure 4-23 shows the system layout. Wastewater from the house enters the septic tank (A) and flows through the fixed activated sludge system (B). Treated wastewater flows through an ultraviolet light disinfection unit (C) and then is dosed to the shallow narrow drainfield (D). Figure 4-21 also shows the location of system components.

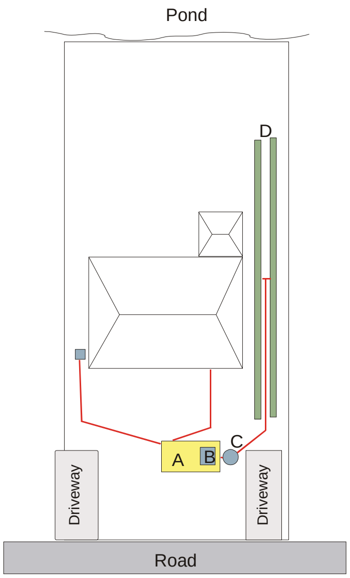


Figure 4-23
The Treatment System Layout

A recirculating media filter would have also been appropriate for this site, but would have used more space. This technology minimizes inputs of nitrogen and bacteria from this particular lot, protects the receiving waterbody, and has the smallest footprint possible.

Aesthetic Hints for Alternative Systems

This section attempts to provide an understanding of some basic system placement, setback, landscaping, and aesthetic issues that often make or break a system in the eyes of the property owner and neighbors. Although it is the designer's responsibility to make sure the system meets all these parameters, it is advantageous for planners to have basic knowledge about how a system should look, how it can fit the home landscape, or how it can blend into a subdivision without looking obtrusive. The following examples illustrate situations where more thought on the aesthetic impacts of a system and its influence on use of the home landscape may have produced a finished product that the system designer, installer, owner, and even neighbors might appreciate.

Simple Changes to Enhance Treatment System Choices

On this small flat coastal plain lot located in the watershed of a nitrogen-sensitive coastal pond, a recirculating media filter was installed to achieve a state-imposed discharge standard of at least 50 percent total nitrogen reduction. Although this technology was a good choice for this area from a treatment and space allocation perspective, the designer insisted on using a conventional (gravity-fed) drainfield. The media filter serves the house on the left in Figure 4-24 (only a corner is barely visible) the fence behind the tank and filter marks the adjoining property boundary with the house in the background.

Figure 4-24
Single-Family Home With a Raised Recirculating Media Filter and Conventional Gravity-Flow Drainfield

The recirculating media filter, which is raised well above the original ground surface and landscaped with native shrubs, uses up more space than actually needed. The raised area effectively limits the owner's use of that portion of the property and creates an aesthetic issue (in this case with several neighbors).

Incorporating the following simple changes would have enabled the homeowner greater use of the yard space. First, tank risers should be trimmed flush with the ground surface so a lawn mower can move directly over them. A second pump could have been used to dose a shallow narrow drainfield rather than using a conventional gravity-fed drainfield. This approach would have required one more pump, but the advantages would be:

- The media filter would be flush with the ground surface and would blend into the existing landscape more easily.
- A shallow narrow drainfield could have been installed easily with minimal disturbance of the yard.
- The shallow narrow drainfield would also provide additional wastewater treatment.

Recent studies show additional nitrogen removal rates in shallow drainfields average 50 percent annually (Stolt et al., 2003).

Paying Attention to the Details

An important consideration when selecting a treatment system is how the system will blend in with surrounding properties. Figure 4-25 shows a site with a demonstration system (foreground) with a shallow narrow drainfield—apparent by the greener grass.

Figure 4-25
A Conscientious Installer Paid Careful Attention to Details and Lined Up the Drainfield Lines on These Two Separate Lots to Produce a More Orderly and Aesthetically Pleasing Look

When the neighbor to the rear decided to replace his system with a similar advanced treatment system, the installer took care to line up the drainfields for a neater look. This is a minor point, but a nice touch from an installer who puts extra thought and effort into system aesthetics.

Options for Placement of System Components

Two adjoining lots in a coastal pond neighborhood upgraded failed septic systems using advanced decentralized treatment systems. Recirculating media filters followed by bottomless sand filter drainfields were used on each lot to achieve nitrogen and pathogen removal, fit on a small lot, and accommodate high water table conditions. The orange line shown in Figure 4-26 marks the property boundary, the treatment unit is outlined in yellow, and the bottomless sand filter is on the right of the pine tree.

Figure 4-26
An Example of Component Placement Options

Unfortunately for the homeowner, the system components became the focal point of the landscape when placed in highly visible, open areas. An alternative placement scenario could have been to site the treatment unit along the property boundary, as shown in the foreground. The bottomless sand filter could have been designed as a long narrow rectangle and sited along the hedge line to the right of the current location, as shown with the dashed blue line. In addition to fitting the site better and opening up more usable space, a long rectangular bottomless sand filter configuration actually functions more effectively, and is easier to install and maintain.

In the adjoining lot (Figure 4-27), similar redesign would have enabled greater use of the property and avoided the need for costly landscaping to camouflage treatment units. The property boundary, as shown by the orange line, extends beyond the photo to the left, with space at the corner of the property, left of the telephone pole, for the treatment unit. The bottomless sand filter, located in front of the shed at the rear of the property, currently blocks the shed door, preventing it from opening fully. The bottomless sand filter could have been designed in a long rectangular shape and sited along the hedge following the property boundary on the left.

Figure 4-27
An Additional Example of Component Placement Options

These examples offer basic helpful tips to help systems blend into the home landscape so system owners and neighbors appreciate the flexibility of the technology and do not view it as an eyesore.

Fitting Alternative Systems into the Landscape

The following checklist provides guidance for fitting alternative systems into the landscape:

- Work with the existing topography, buildings, and vegetation to blend components into the landscape.
- Use grade changes to avoid an additional pump. For example, recirculating systems typically pump effluent from the septic tank to the top of the treatment unit. The treated wastewater exits from the bottom the treatment unit and returns either to the septic tank or a different recirculation tank. When using a recirculating system, locate the bottom of the treatment unit upgradient of the inlet of the recirculating tank, thereby allowing gravity flow back to the tank.

- Treatment units above ground need to fit into the landscape unobtrusively.
- Place components along existing edges such vegetation borders, shrub rows, driveways, or stone walls. Whenever possible avoid putting units in the middle of lawns or other open spaces.
- Conceal vent pipes from general view by siting them behind vegetation, stone walls, or buildings.
- Use natural materials, such as wooden timbers, to encase the sides of treatment units.
- Small modular treatment units can be tucked into crawl spaces and under decks provided access is maintained.
- Where possible, locate treatment units and drainfields away from high-use areas. This consideration becomes more important for larger systems and commercial properties. For example, treatment units should be kept away from restaurant entrances and outdoor patios.
- Electrical panel boxes can be noisy when switches controlling pumps go on and off. Locate these on the outside of utility walls or in high-use areas such as garages, entryways, or kitchens where refrigerators, air conditioners, or other utilities already create some noise.
- Keep in mind the convenience and safety of maintenance providers. Locate the panel box for easy access. Consider locating the panel box outside fenced pet areas for the inspector's convenience and safety.
- Insert activated charcoal pads at the top of drainfield inspection ports if odors are a problem.
- When locating shallow narrow drainfields in playing fields, cover inspection ports with turf for safety, but tag them beforehand with metal markers to easily identify them with a metal detector when maintenance is due.

Selecting Between Individual and Cluster Systems

The decision to use an individual system or a cluster system for two or more homes is highly site specific. Shared systems may cost more or less than several individual systems. Nevertheless, the following factors provide guidance in this decision.

- Consider if a reduction in design flow be allowed with a shared system. With individual systems, enough capacity must be provided for the worst case, maximum flow scenario. With several homes on one system, the risk that all units will experience maximum flow at the same given time is slim, so design flows for each may be lowered because peak flows from some units will be moderated by the group. Reducing peak flows increases cost-effectiveness, but regulators determine if credit is allowed.
- If the lot is too small for a system, try talking with a neighbor who may also need a system fix. The homeowner donating his extra lot as a treatment zone lot for a shared system may qualify for a tax break when the lot is deemed as unbuildable.
- There is no assurance that cluster systems will save costs due to the need to multiply treatment units and the cost of wastewater collection.

- When more than five or six houses are connected, there is potential for greater savings due to reduced design flow, a single treatment unit, and potentially fewer pumps.
- Determine if public property is available for a common treatment and drainfield area. Saving on land acquisition costs can make a shared project much more cost effective.
- Where private wells are located within 100 feet of a soil infiltration system, consider upgrading to advanced treatment to protect drinking water quality.
- Where shallow wells are located within 100 feet of a wastewater treatment system, consider installing a drilled well.
- Collection systems for alternative cluster systems serving anywhere from two homes to a whole village all require piping to carry wastewater from homes to the shared treatment units and drainfields. Typically small diameter (two- to three-inch diameter) pipes are used.
- Compare the cost of a septic tank effluent gravity collection system versus individual system repair.
- Determine if local regulations allow connection of small diameter effluent sewers to a nearby gravity sewer rather than installing a conventional (and generally more costly) traditional pump station.
- Rely on conventional treatment systems using gravity flow in areas of large lots with good soils and where advanced wastewater treatment is not essential to protect public health or environmental quality. With good soil and site conditions, conventional onsite systems generally provide reliable treatment with the least cost and lowest maintenance.
- Use of active systems should be justified with measurable improvements in health and the environment (Tyler, 2000). Active systems that provide only minimal improvements, such as reduced BOD and TSS, and reduced drainfield size, should be carefully evaluated.
- Consider electrical costs, which can add up over the life of a system and offset any minor savings in initial installation cost, especially in island locations where electricity costs are generally much higher than normal.
- When selecting advanced treatment systems of comparable complexity, reliability, and cost, it makes sense to choose the simplest technology.

Appendix K-3

Septic System Inspection/Replacement Case Studies

Lake Restoration

The Problem / Concern:

Why do lakes decrease in water quality and depth?

Development within watersheds has increased greatly in recent years and many lakes have been subjected to an ever-increasing load of nutrients and sediments, resulting in decreased lake water quality, thereby interfering with lake restoration efforts. Increased nutrient loadings are most commonly due to excessive use of fertilizers, malfunctioning septic systems, poor erosion control and improper waste disposal within the watershed. As development continues to increase, the amount of total hard–surfaced area also increases and the volume and velocity of the water moving through the watershed into surface waters is increased. This run-off erodes soils and transports organic materials and nutrients from surface soils. Inorganic materials, in the form of sand, silt, and clay are also transported to receiving waters, resulting in decreased lake water quality and depth.

The US EPA classifies nutrient pollution as one of America's most widespread, costly and challenging environmental problems, and is caused by excess nitrogen and phosphorus in the air and water. As nutrients continue to accumulate, excessive aquatic weed and harmful algae growth starts taking over faster than the ecosystem can handle. Excessive weed growth reduces navigation by boats, limits activities such as water skiing, creates stagnant zones, and reduces natural oxygen transfer due to lack of wave action and circulation. Increases in algae can worsen water quality and acquatic habitats, and decrease the oxygen that fish and other aquatic life need to survive. Large algal blooms can significantly reduce oxygen in the water, leading to increases in bacteria, odors and fish kills. Some blue green algae blooms produce elevated toxins and bacterial growth that in turn can make pets, kids and even adults very sick if they come into contact with polluted water or eat tainted shellfish or fish.

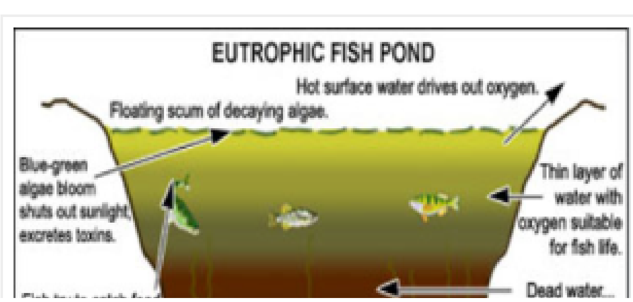
As these plants die either through herbicide applications or season ending die-off, they drop to the bottom of the lake where they decay and add to the organic sediment or muck layer on the bottom. Muck accumulates year after year, increasing available nutrients, reducing the depth of water which increases sunlight penetration, and the cycle continues until the lake favors plant life more than aquatic life.

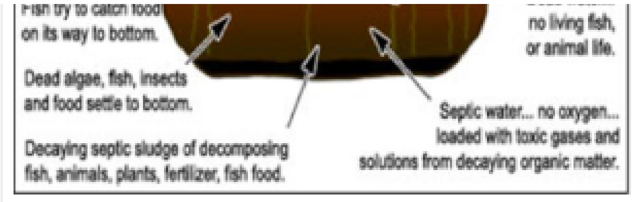
Also in warmer climates, Naegleria fowleri (also known as the "brain-eating amoeba") can be found. In contrast with most pathogenic bacteria, Naegleria fowleri is not adversely affected by the presence of oxygen. This organism thrives on the nutrients in the organic sediment. The level of phosphorus and nitrogen in organic sediment is typically about a thousand times the level found in the water column. When stirred, Naegleria fowleri can invade through the nose and attack the human nervous system and brain, causing primary amoebic meningoencephalitis.

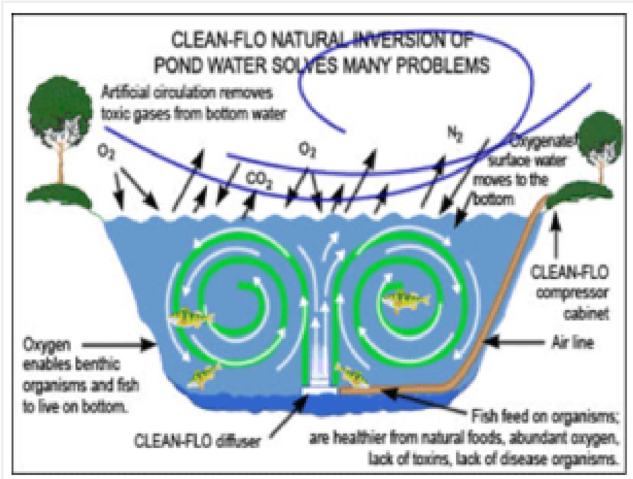
The Solution and Benefits of Lake Restoration

Excessive weeds and algae, lack of dissolved oxygen, odors, fish kills, increased coliform bacteria and Naegleria fowleri are all symptoms of the problem. The cause of these problems is nutrient overloading or eutrophication. The USGS provides this definition of eutrophication "The process by which a body of water acquires a high concentration of nutrients, especially phosphates and nitrates. These typically promote excessive growth of algae. As the algae die and decompose, high levels of organic matter and the decomposing organisms deplete the water of available oxygen, causing the death of other organisms, such as fish. Eutrophication is a natural, slow-aging process for a water body, but human activity greatly speeds up the process. – Art, 1993"

The keystones of our solution are our inversion systems which produce laminar non-turbulent flow in the water and increase oxygen levels throughout the entire water column. Numerous studies have shown that high stable oxygen levels reduce nutrients and minerals in the water column and can keep phosphorus locked into the organic sediments. Here is a simple comparison of a eutrophic lake to a lake with our inversion system operating in it.







Our inversion systems are designed using various sized compressors (based on the application and size – see Custom Design and Build), along with self-sinking airline and micro-porous ceramic diffusers that supply a steady stream of micro bubbles from the bottom to the surface of the water. This non-turbulent flow is capable of moving and circulating large quantities of water, and quickly oxygenates a lake.

Increasing oxygen throughout the water column allows us to start a sequence of events that provide aquatic weed control, improve water quality, reduce organic muck, nutrients, odor, harmful gases, coliform bacteria, nuisance algae growth and at the same time improve the fish growth and health. Natural aerobic bacteria and micro-organisms begin to consume the organic muck and nutrients, aquatic insects feed on the bacteria and increase the natural food source for fish, and water quality improvements provide safer swimming conditions. Reduced organic sediments help aquatic weed control by reducing the nutrient mix they are growing in.

The second step in bringing the proper balance back to a lake is bioaugmentation. This involves the use of aerobic benenficial bacteria and enzymes which break down organic muck similar to a compost pile in your backyard, denitrifying bacteria to reduce nitrogen availability and a blend of minerals which promote healthy diatom growth to clean the water. Consistent use of these products over time will reduce nutrient availability and help keep the water clean and healthy.

A third and final step that can be deployed is our nutrient sponge. Our nutrient sponge is formulated to reduce phosphorus and nitrogen as water passes through the material. Nutrient sponges can be used wherever water flows into the lake to reduce incoming nutrients and can also be used in the lake to help reduce available nutrients. Our staff will recommend a product or combination of products based on the conditions of the lake.

CLEAN-FLO delivers cost effective solutions for your lake, with greater operating efficiency than other aeration providers. We do not pull something off the shelf to try to fit the requirements. We work with you before and after the sale to provide not only the solution to your problems, but results that meet your goals. We look forward to working with you every step of the way.

Successes and Examples of Restored Lakes

Let's hear from a few of our customers:

Village of Scotia, NY – "As you know last summer we were forced to close our lake for swimming due to high fecal bacteria levels. . . Lake Collins is a 55 acre lake with an average depth of 12 feet that has been suffering from the effects of eutrophication for the past three decades. . . A CLEAN-FLO inversion and oxygenation system was installed . . . a significant drop in bacteria levels was observed after a week of operation. The system was turned off a few weeks after installation and bacteria levels rose. When the system was restarted a decrease in bacteria levels was again recorded, suggesting that the CLEAN-FLO system was directly affecting bacteria levels in the lake. . . Thanks for all your guidance and expertise over the past year, the system has performed exactly as we had hoped.

CLE Engineering about a project in Novato, CA – "CLE has completed the pilot study within the Paddleboat Lagoon of the South Lagoon and is reporting that the study was a great success. The water quality has dramatically improved in the past three (3) months since the system was activated. Aeration can dramatically improve the aesthetics of the water quality and reduce the possibility of an algae bloom. By targeting the 'root problem' of the low level of dissolved oxygen due to stratification in the South Lagoon, the beneficial use of the waterways can continue to be a valuable source to the BMK Community."

Appendix L

Sample Details for Select Proposed Improvement Projects

C H A P T E R 9 . 1 0

Standard for Vegetative Filters

Definition

A vegetative filter is an area designed to remove suspended solids and other pollutants from stormwater runoff flowing through a length of vegetation called a vegetated filter strip. The vegetation in a filter strip can range from turf and native grasses to herbaceous and woody vegetation, all of which can either be planted or indigenous. It is important to note that all runoff to a vegetated filter strip must both enter and flow through the strip as sheet flow. Failure to do so can severely reduce and even eliminate the filter strip's pollutant removal capabilities.

The total suspended solid (TSS) removal rate for vegetative filters will depend upon the vegetated cover in the filter strip. Table 9.10-1 below presents the adopted TSS removal rates for various vegetated covers.

Table 9.10-1: Adopted TSS Removal Rates for Vegetated Filter Strips

Vegetated Cover	Adopted TSS Removal Rate
Turf grass	60 %
Native Grasses, Meadow, and Planted Woods	70 %
Indigenous woods	80 %

For filter strips with multiple vegetated covers, the final TSS removal rate should be based upon a weighted average of the adopted rates shown above in Table 9.10-1. This weighted average removal rate should be based upon the relative flow lengths through each cover type. For example, a 50-foot long vegetated filter strip (measured in the direction of flow) that has turf grass in the upper 25 feet and native grasses in the lower 25 feet would have a TSS removal rate of (25/50)(60%) + (25/50)(70%) or 65 percent.

Purpose

A vegetative filter is intended to remove pollutants from runoff flowing through it. Vegetated filter strips can be effective in reducing sediment and other solids and particulates, as well as associated pollutants such as hydrocarbons, heavy metals, and nutrients. The pollutant removal mechanisms include sedimentation, filtration, adsorption, infiltration, biological uptake, and microbacterial activity.

Vegetated filter strips with planted or indigenous woods may also create shade along water bodies that lower aquatic temperatures, provide a source of detritus and large woody debris for fish and other aquatic organisms, and provide habitat and corridors for wildlife.

Condition Where Practice Applies

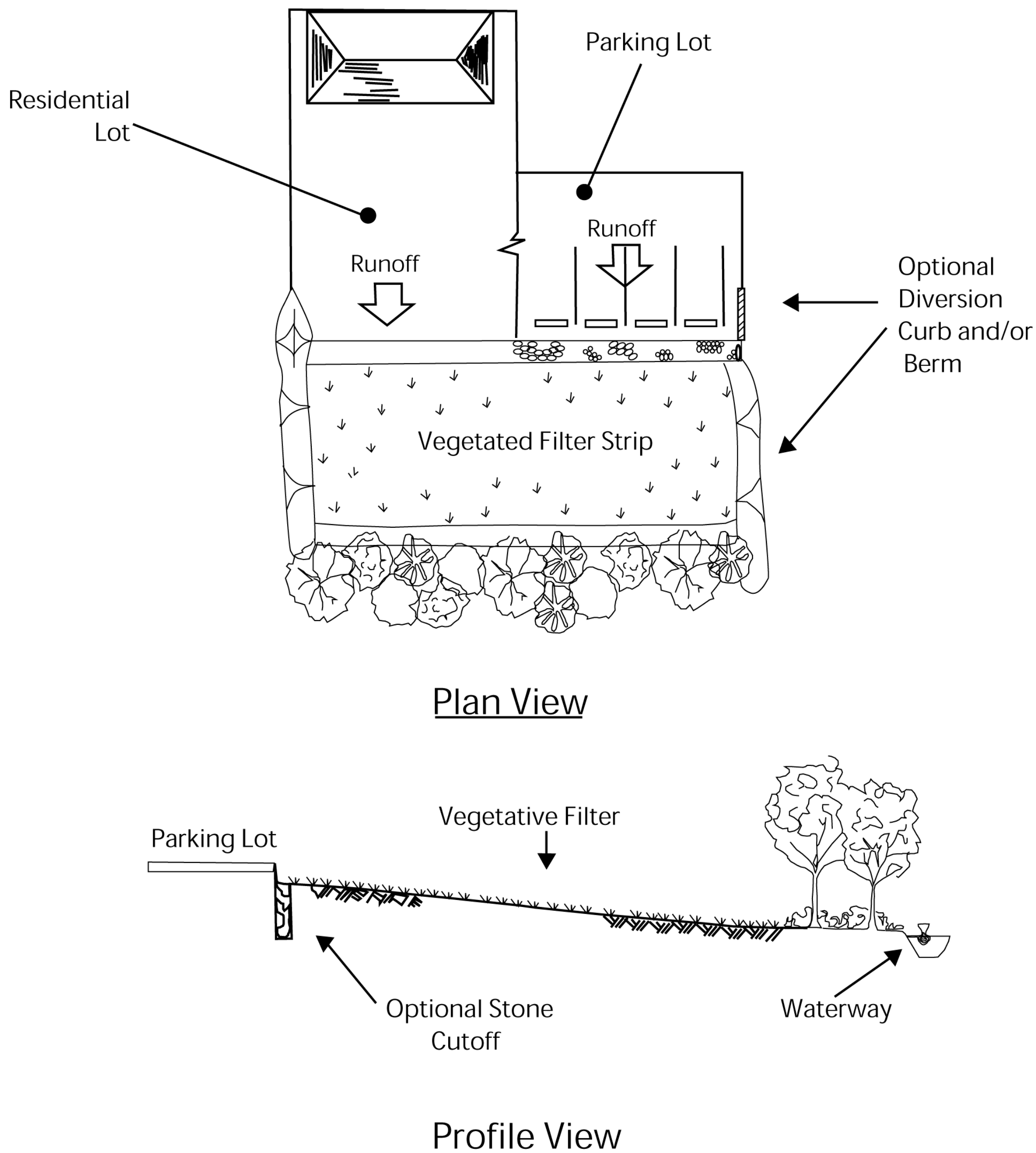
A vegetative filter can be effective only where the runoff entering and flowing through the strip remains as sheet flow and does not concentrate. This sheet flow requirement limits the use of vegetated filter strips in two ways. First, the area used for the filter strip itself must be mildly sloped and uniformly graded to maintain sheet flow or, in the case of indigenous areas, have surface features that retard, pond, and/or disperse runoff generally over the entire filter width. Second, since the runoff to a filter strip must enter the strip as sheet flow, the drainage area to the strip must also be uniformly graded and have a relatively horizontal downstream edge where it meets the upstream end of the filter strip. Such drainage areas may include yards, parking lots, and driveways where runoff flows as sheet flow. As a result, an area with irregular grading and other surface features that cause runoff to concentrate could neither be used as a vegetated filter strip nor have its runoff treated by one. For the same reasons, vegetated filter strips are also not intended to treat concentrated discharges from storm sewers, swales, and channels.

As detailed below in *Design Criteria*, additional factors must be considered. First, the vegetation in all filter strips must be dense and remain healthy and, in the case of planted or indigenous woods, have an effective mulch or duff layer. In addition, a vegetated filter strip must have a maintenance plan and be protected by an easement, deed restriction, or other legal measure that guarantees its existence and effectiveness in the future. Depending upon their TSS removal rate, vegetated filter strips can be used separately or in conjunction with other stormwater quality practices to achieve an overall pollutant removal goal.

Design Criteria

The primary design parameters for a vegetated filter strip are its slope, type of vegetated cover, and the type of soils within its drainage area. These three parameters are then used to determine the standard filter strip length required to achieve the adopted TSS removal rates shown above in Table 9.10-1. In addition, since runoff from the stormwater quality design storm must enter and continue as sheet flow over this length, the peak runoff rate must be sufficiently low and uniformly distributed to ensure such conditions. This peak runoff rate is achieved by limiting the sheet flow length that runoff will flow before entering the filter strip. This length limitation, in turn, limits the size of the drainage area to the filter strip and, consequently, the peak runoff rate. Details of these and other design parameters are presented below. The components of a typical vegetated filter strip are shown in Figure 9.10-1.

Figure 9.10-1 Vegetative Filter Components



Source: Adapted from Schueler and Claytor 1996.

A. Drainage Area and Runoff Characteristics

As noted above, runoff from a drainage area may be directed to flow through a filter strip provided it enters the filter strip and continues through it as sheet flow. In addition, the peak rate and maximum depth of runoff entering the filter strip must be low enough to allow the strip's vegetated cover to serve as an effective filter. As such, the maximum drainage area to a vegetated filter strip will be limited to an area 100 feet long for impervious surfaces and 150 feet long for pervious surfaces. These lengths are to be measured in the direction of flow to the upstream edge of the filter strip.

In addition, the interface of the drainage area and the upstream edge of the filter strip must be as horizontal as possible (perpendicular to the flow direction) so that runoff will be evenly distributed along the upstream edge of the strip. As shown in Figure 9.10-1, a stone cutoff trench, recessed curb, or other measure may be used along the filter's upstream edge to help distribute the runoff and dissipate some of its energy as it enters the filter strip.

As noted above, the required strip lengths are based in part upon the type of soils within the filter strip's drainage area. Table 9.10-2 below lists the various types of soils and their associated Hydrologic Soil Groups that will affect the strip's required length. County Soil Surveys and onsite soil investigations can be used to determine these soil types. Where more than one type of soil exists in a drainage area, the soil with the smallest particle size (and, consequently, the longest filter strip length) should be used in the filter strip's design.

B. Filter Strip Cover

As noted above, the vegetation in a filter strip can range from turf and native grasses to herbaceous and woody vegetation, all of which can either be planted or indigenous. The type of vegetation used in the filter strip can be very broad, although the best performance is associated with those with dense growth patterns such as turf-forming grasses and dense forest floor vegetation. All vegetation must be dense and healthy. In addition, planted woods must have a mulch layer with a minimum thickness of 3 inches, while indigenous woods must have at least a 1 inch thick natural duff layer.

Further information and references are presented in *Chapter 7: Landscaping*.

C. Filter Strip Grading

As noted above, the area used for a vegetated filter strip itself must be mildly sloped and uniformly graded to maintain sheet flow or, in the case of indigenous areas, have surface features that retard, pond, and/or disperse runoff generally over the entire filter width. As such, indigenous areas such as meadows and woods under consideration as vegetated filter strips should be surveyed and inspected during runoff events to determine runoff flow patterns. Indigenous areas with surface features that obstruct or retard runoff flow, cause ponding, and/or disperse runoff are acceptable, while those with surface features that cause runoff to concentrate are not. It should be noted that such observations must be made with consideration for the proposed volume and peak rate of runoff that the area would receive as a vegetated filter strip.

D. Maximum Filter Strip Slope

In addition to the soils within a vegetated filter strip's drainage area, the soils within the filter strip itself are also important for determining filter strip's maximum allowable slope. Table 9.10-2 below presents maximum filter strip slopes for various vegetated covers and soil types within the filter strip. County Soil Surveys and onsite soil investigations can be used to determine the soil type within a filter strip.

Table 9.10-2: Maximum Filter Strip Slope

Filter Strip Soil Type	Hydrologic Soil Group	Maximum Filter Strip Slope (Percent)	
		Turf Grass, Native Grasses, and Meadows	Planted and Indigenous Woods
Sand	A	7	5
Sandy Loam	B	8	7
Loam, Silt Loam	B	8	8
Sandy Clay Loam	C	8	8
Clay Loam, Silty Clay, Clay	D	8	8

E. Required Filter Strip Length

To achieve the adopted TSS removal rates shown above in Table 9.10-1, the required filter strip length can be determined from Figures 9.10-2 to 6 below based upon the filter strip's slope, vegetated cover, and the soil within its drainage area. As shown in the figures, the minimum length for all vegetated filter strips is 25 feet.

Figure 9.10-2: Vegetated Filter Strip Length
Drainage Area Soil: Sand HSG: A

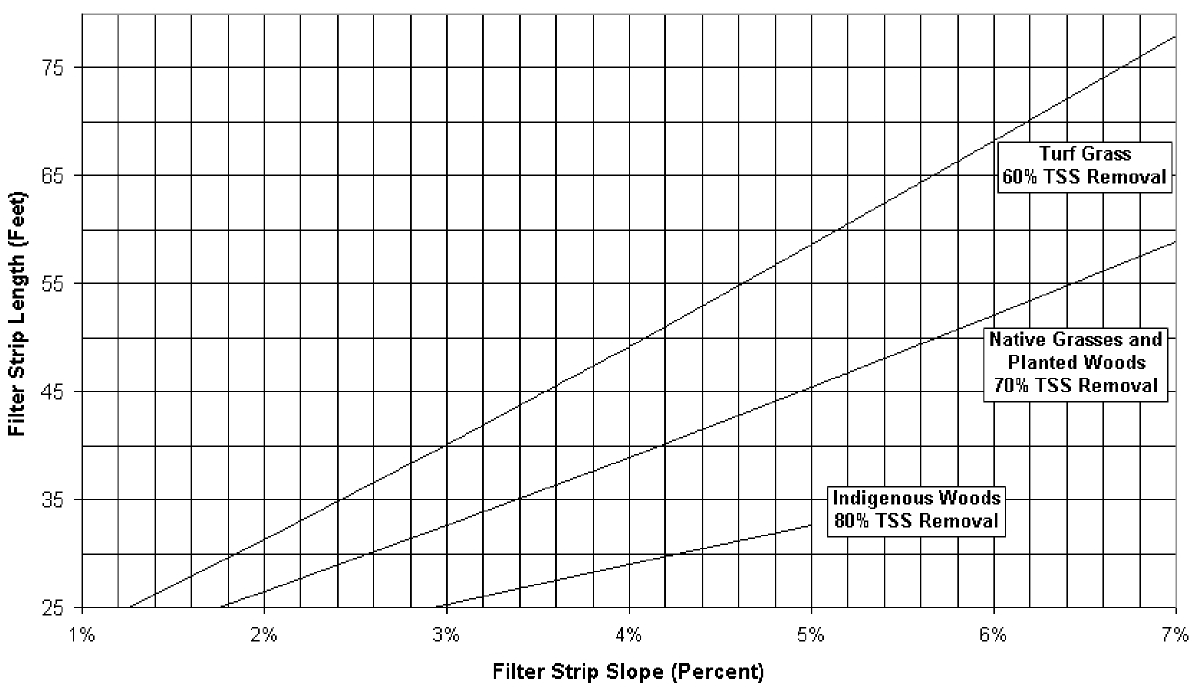


Figure 9.10-3: Vegetated Filter Strip Length
Drainage Area Soil: Sandy Loam   HSG: B

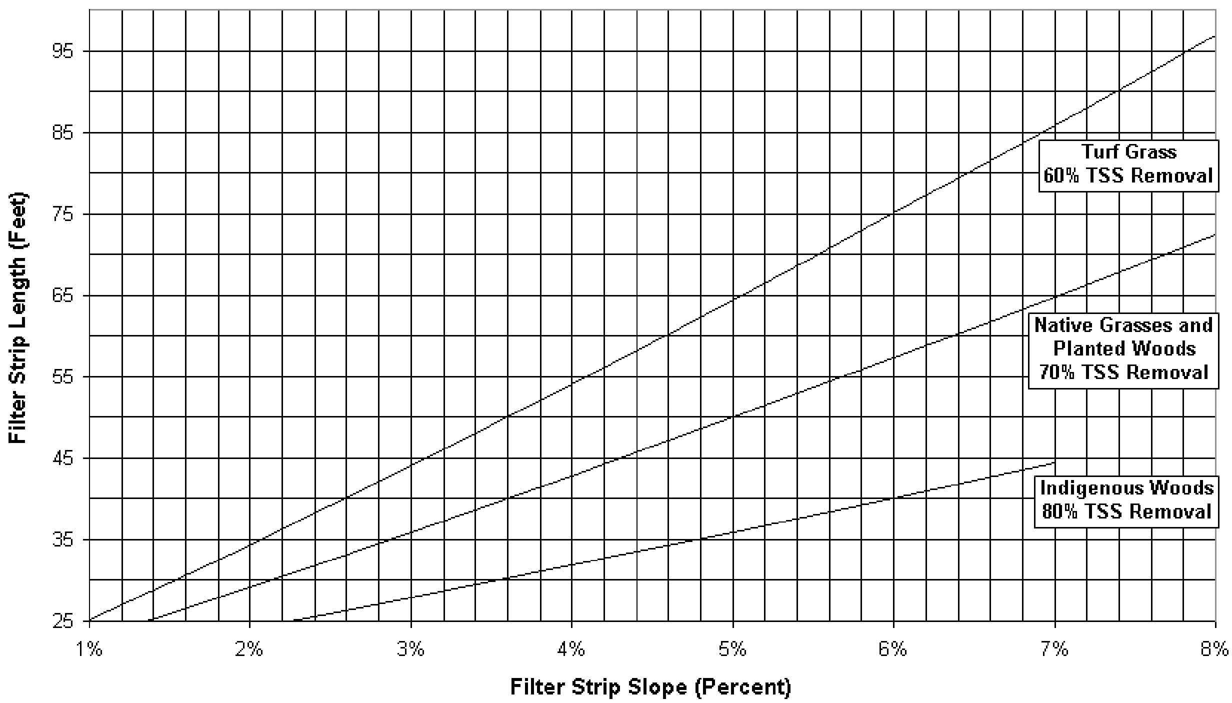


Figure 9.10-4: Vegetated Filter Strip Length
Drainage Area Soil: Loam, Silt Loam   HSG: B

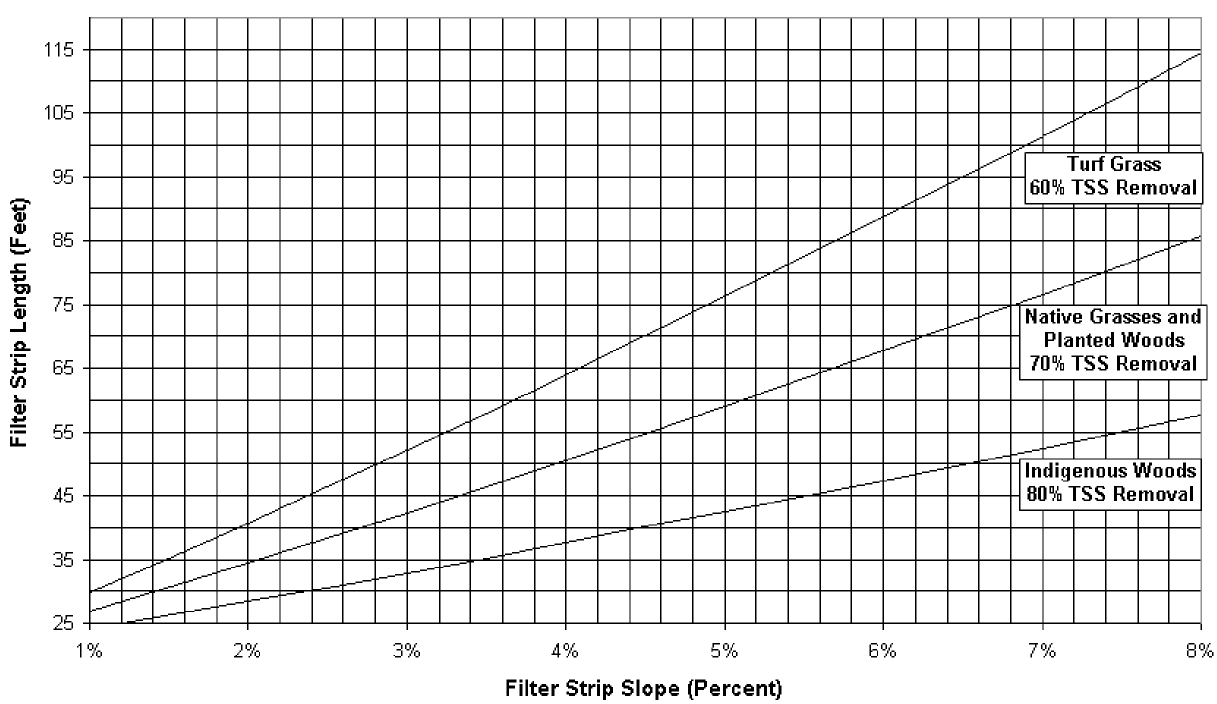


Figure 9.10-5: Vegetated Filter Strip Length
Drainage Area Soil: Sandy Clay Loam HSG: C

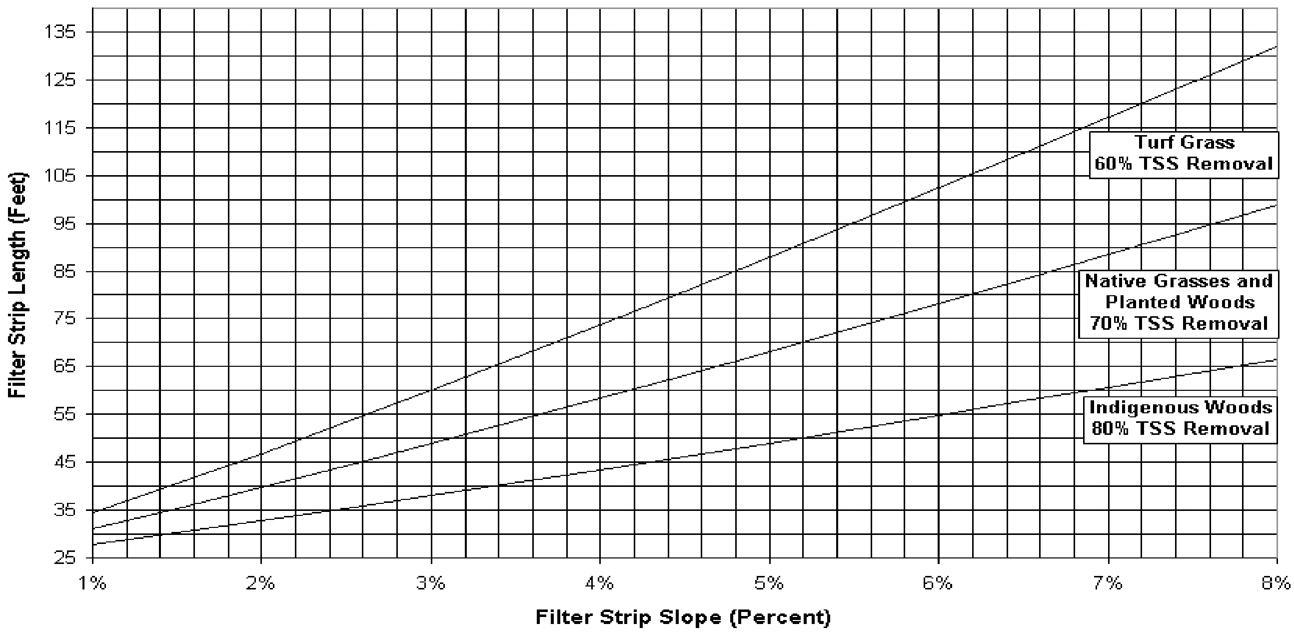
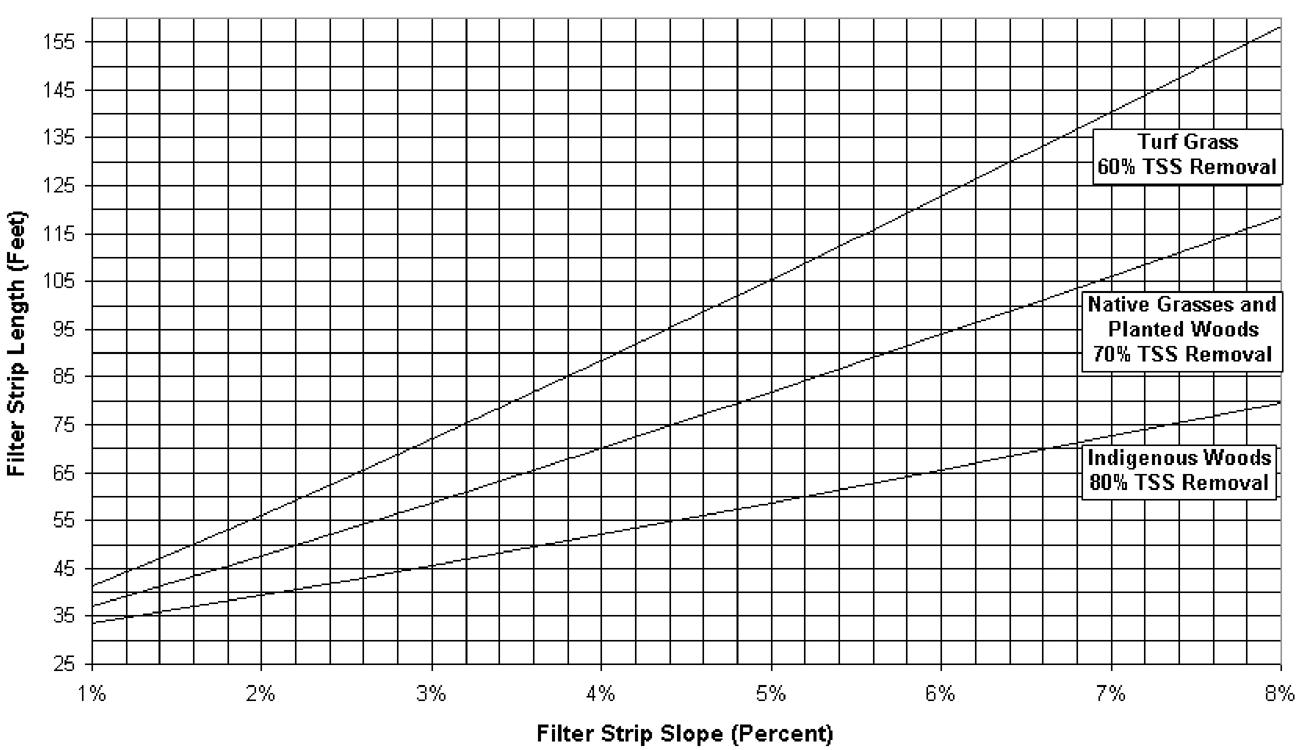


Figure 9.10-6: Vegetated Filter Strip Length
Drainage Area Soil: Clay Loam, Silty Clay, Clay HSG: D



Example 9.10-1: Computing Required Vegetated Filter Strip Length

A vegetated filter strip is to be installed at a uniform 5 percent slope to treat the runoff from a drainage area consisting of a paved parking lot and turf grass lawn. Runoff from the parking lot and lawn will enter the filter strip as sheet flow. The maximum sheet flow lengths across the parking lot and lawn do not exceed 100 and 150 feet, respectively. The soil in the drainage area is a silt loam. Compute the required filter strip length if the strip is to be vegetated with turf grass.

1. Determine the Hydrologic Soil Group of the drainage area soil. From Table 9.10-2, a silt loam is in Hydrologic Soil Group B.
2. Determine the maximum slope of the filter strip. Also from Table 9.10-2, the maximum slope of a turf grass filter strip with Hydrologic Soil Group B soils is 8 percent, which is greater than the 5 percent slope of the proposed filter strip.
3. Determine the required length of the filter strip. From Figure 9.10-4 for silt loam soils, the required length of a turf grass filter strip with a 5 percent slope is approximately 76 feet. The resultant TSS removal rate for the turf grass filter strip will be 60 percent.

Maintenance

Effective vegetated filter strip performance requires regular and effective maintenance. *Chapter 8: Maintenance and Retrofit of Stormwater Management Practices* provides information and requirements for preparing a maintenance plan for stormwater management facilities, including vegetated filter strips. Specific maintenance requirements for vegetated filter strips are presented below. These requirements must be included in the filter strip's maintenance plan.

A. General Maintenance

All vegetated filter strip components expected to receive and/or trap debris and sediment must be inspected for clogging and excessive debris and sediment accumulation at least four times annually and after every storm exceeding 1 inch of rainfall. Such components may include vegetated areas and stone cutoffs and, in particular, the upstream edge of the filter strip where coarse sediment and/or debris accumulation could cause inflow to concentrate.

Sediment removal should take place when the filter strip is thoroughly dry. Disposal of debris and trash should be done only at suitable disposal/recycling sites and must comply with all applicable local, state, and federal waste regulations.

B. Vegetated Areas

Mowing and/or trimming of vegetation must be performed on a regular schedule based on specific site conditions. Grass should be mowed at least once a month during the growing season. Vegetated areas must be inspected at least annually for erosion and scour. Vegetated areas should also be inspected at least annually for unwanted growth, which should be removed with minimum disruption to the planting soil bed and remaining vegetation.

When establishing or restoring vegetation, biweekly inspections of vegetation health should be performed during the first growing season or until the vegetation is established. Once established, inspections of vegetation health, density, and diversity should be performed during both the growing and non-growing season at least twice annually. The vegetative cover should be maintained at 85 percent. If vegetation has greater than 50 percent damage, the area should be reestablished in accordance with the original specifications and the inspection requirements presented above.

All use of fertilizers, mechanical treatments, pesticides and other means to assure optimum vegetation health must not compromise the intended purpose of the vegetative filter. All vegetation deficiencies should be addressed without the use of fertilizers and pesticides whenever possible.

All areas of the filter strip should be inspected for excess ponding after significant storm events. Corrective measures should be taken when excessive ponding occurs.

C. Other Maintenance Criteria

The maintenance plan must indicate the approximate time it would normally take for the filter strip to drain the maximum design storm runoff volume and begin to dry. This normal drain time should then be used to evaluate the filter's actual performance. If significant increases or decreases in the normal drain time are observed or if the 72 hour maximum is exceeded, the filter strip's planting soil bed, vegetation, and groundwater levels must be evaluated and appropriate measures taken to comply with the maximum drain time requirements and maintain the proper functioning of the filter strip.

Considerations

A number of factors should be considered when utilizing a vegetated filter strip to treat stormwater runoff. Most importantly, an adequate filter area and length of flow must be provided to achieve the desired treatment. Slopes of less than 5 percent are more effective; steeper slopes require a greater area and length of flow to achieve the same effectiveness. Good surface and subsurface drainage is necessary to ensure satisfactory performance. The designer should also be aware of potential ponding factors during the planning stage. Dry period between flows should be achieved in order to reestablish aerobic soil conditions.

Filter strip vegetation must be fully established before incoming stormwater flow is allowed. At least one full growing season should have elapsed prior to strip functioning as part of the stormwater management system. Further information and references on filter strip vegetation are presented in *Chapter 7*. Species must be appropriate for the region, soil, and shade condition. Mulching is required for both seeded and planted filter strips.

Perhaps the most common, naturally occurring filter strips are those upland vegetative stands associated with floodplains or found adjacent to natural watercourses. In some cases, preservation of these upland areas will allow them to continue to function as filter strips. To help ensure the longevity of these natural areas under altered and perhaps increased pollutant loading, a top dressing of fertilizer and supplemental plantings may be necessary.

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VEGETATED BUFFER STRIPS

GENERAL

Buffer strips are densely vegetated areas that collect and slow runoff, filtering out sediments and insoluble pollutants and encourage infiltration. Stormwater flows into a buffer strip over a level spreader, a device that converts concentrated flow into sheet flow. As the runoff flows through the vegetation, its velocity is reduced, releasing its load of suspended solids and promoting infiltration.

Buffer strips are uniformly graded and are located down slope from disturbed or impervious areas or adjacent to waterways. Buffer strips are best used in conjunction with other management practices, however, as they do not significantly reduce peak flows or the volume of runoff.

ADVANTAGES

- Relatively low cost
- Easy to construct and maintain
- Can be aesthetically pleasing if designed properly
- Remove sediment and insoluble pollutants
- Increase the infiltration of runoff
- Can provide habitat for wildlife
- Can help stabilize stream banks

DISADVANTAGES

- Ineffective in areas with high velocity runoff
- Require a large amount of land area
- Ineffective for large drainage areas
- Reduced effectiveness with large storm events
- Best used in conjunction with other management practices

DESIGN

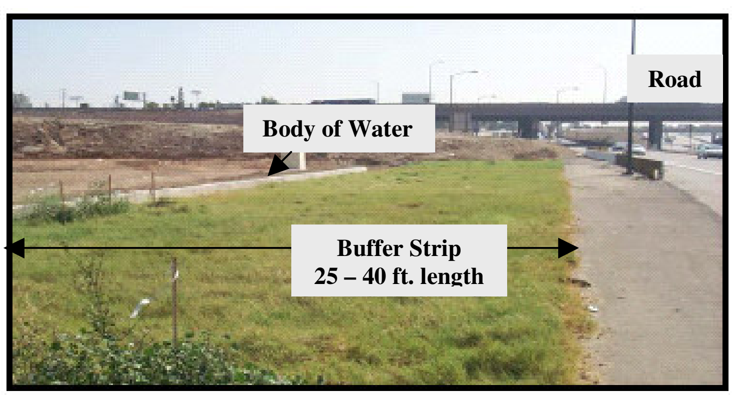
LEVEL SPREADERS AND BERMS

Maintaining sheet flow is critical to the proper operation of buffer strips. To ensure that concentrated flow is eliminated before runoff enters the buffer strip, a level spreader may be constructed at the top of the buffer strip. These devices disperse flows over a wide area, dissipating the energy of the runoff and creating sheet flow.

Common types of level spreaders are curb cuts, concrete weirs, and stone weepers or trenches.

LENGTH, WIDTH, AND SLOPE

Each buffer strip should be sized according to the individual characteristics of the site, taking into account the size of the area to be drained and the slope of the land that they are located on.



An Example of a Vegetated Buffer Strip, Source: Adapted from California Stormwater Quality Association

Buffer strips that border impervious surfaces should stretch the entire width of the surface and have a minimum flow length of at least 25 feet, with a 20-minute detention time. Increased lengths enhance the treatment ability of the practice by increasing detention time. However, lengths greater than 40 feet generally result in channelized flow and require additional flow dissipaters. Regardless of the length, each buffer strip should not drain an area larger than ½ acre. Sites that border bodies of water may have additional requirements beyond this ordinance. For length requirements on this type of site, please contact your local WDNR office.

The length of buffer strips is dependent upon the slope of the site. Slopes of 1-2 percent are recommended and may not exceed 6%. Steeper slopes encourage concentrated flow and may lead to channelization, while slopes flatter than 1 percent may result in ponding. Runoff velocities are determined by the detention time.

VEGETATION

Buffer strips only provide effective erosion control once the vegetation is densely established. "Dense" is defined as a stand of 6-8 inch sod-forming vegetation that uniformly covers at least 90% of a representative 1 square yard plot. As a result, until vegetation is firmly established, it shall under no circumstances be relied upon to prevent soil loss from the site.

Plant species selected for buffer strips should meet the following criteria:

- Native species may be used with careful selection (refer to the Native Grasses section of this Appendix)
- Species should be tolerant to frequent inundation as well as extended dry periods
- Species should be resistant to matting
- Species should form a dense cover
- Avoid exotic, noxious, and invasive species

CONSTRUCTION

- Buffer strips must be established before construction activity begins
- In order to be effective, buffer strips must be densely established

MAINTENANCE

- Grassed vegetation should be cut and removed at least once per year
- Mowing should only be performed during dry periods using lightweight equipment to prevent soil compaction and damage to vegetation
- Buffer strips should be inspected weekly and after all major storm events to ensure they are operating properly and to check for any potential problems, such as the formation of rills and gullies, bare spots, and sediment accumulation
- Buffer strips should be inspected for the accumulation of sediment after all major storm events

METHOD TO DETERMINE PRACTICE EFFICIENCY

Buffer strips filter out sediment and other particles by reducing the flow velocity of runoff. The trapping efficiency of this practice is dependant upon the particle size and the flow length of buffer strip. RUSLE2, when available, has the ability to calculate the approximate efficiency of vegetative buffer strips.

Buffer strips help remove suspended sediment from runoff by reducing the flow velocity. As the runoff velocity decreases, the sediment settles out. Buffer strips also help with reducing the amount of pollutants in the runoff since many pollutants are associated with the sediment. Studies have shown a suspended solid removal rate ranging between 40%-90%, with the efficiency of the buffer strip being dependent upon the quantity of runoff, length and steepness of the slope, as well as the vegetation used in the strip and the ability of the soil to infiltrate. Due to the number of variables affecting the performance of buffer strips, it is difficult to determine the exact efficiency of sediment removal for this practice.

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The Chicago Center for Green Technology uses filter strips to convey runoff on-site.

A Citizen's Guide to Permeable Reactive Barriers

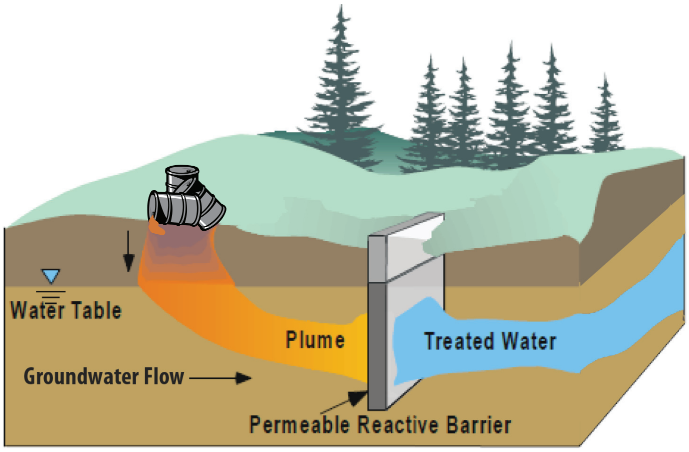
What Are Permeable Reactive Barriers?

A permeable reactive barrier, or "PRB," is a wall created below ground to clean up contaminated groundwater. The wall is "permeable," which means that groundwater can flow through it. Water must flow through the PRB to be treated. The "reactive" materials that make up the wall either trap harmful contaminants or make them less harmful. The treated groundwater flows out the other side of the wall.

How Do They Work?

A PRB is usually built by digging a long, narrow trench in the path of contaminated groundwater flow. The trench is filled with a reactive material, such as iron, limestone, carbon, or mulch, to clean up contamination. Due to limitations of excavation equipment, walls typically can be no deeper than 50 feet. However, a deeper but usually shorter PRB can be built by drilling a row of large-diameter holes or by using fracturing (See *A Citizen's Guide to Fracturing* [EPA 542-12-008]) and other new techniques.

The reactive material selected for the PRB will depend on the types of contaminants present in the groundwater. The material may be mixed with sand to make the wall more permeable so that it is easier for groundwater to flow through it, rather than around it. Side walls filled with an impermeable material such as clay may be constructed at an angle to the PRB to help funnel the flow of contaminated groundwater toward the reactive materials. The filled trench is covered with soil, and is not usually visible at the ground surface.



PRB treats a plume of groundwater contaminants.

Depending on the reactive material, contaminants are removed through different processes:

- Contaminants *sorb* (stick) to the surface of the reactive material. For example, carbon particles have a surface onto which contaminants, such as petroleum products, sorb as groundwater passes through.
- Metals dissolved in groundwater *precipitate*, which means they settle out of the groundwater by forming solid particles that get trapped in the wall. For example, limestone and shell fragments can cause dissolved lead and copper to precipitate in a PRB.
- Contaminants *react* with the reactive material to form less harmful ones. For example, reactions between iron particles and certain industrial cleaning solvents can convert the solvents to less toxic or even harmless chemicals.
- Contaminants are *biodegraded* by microbes in the PRB. Microbes are very small organisms that live in soil and groundwater and eat certain contaminants. When microbes digest the contaminants, they change them into water and gases, such as carbon dioxide. (*A Citizen's Guide to Bioremediation* [EPA 542-F-12-003] describes how microbes work.) Organic mulch frequently is used as reactive media in this type of PRB. Mulch barriers consist of plant-based materials, such as compost or wood chips, and naturally contain many different microbes. Groundwater flow through the PRB also releases organic carbon from the mulch wall, creating another reactive zone for contaminants just beyond the wall.

Over time, reactive materials will fill up with contaminants or treatment products and become less effective at cleaning groundwater. When this occurs the contaminated reactive material may be excavated for disposal and replaced with fresh material.

How Long Will It Take?

PRBs may take many years to clean up contaminated groundwater. The cleanup time will depend on factors that vary from site to site. For example, cleanup may take longer where:

- The source of dissolved contaminants (for instance, a leaking drum of solvent) has not been removed.
- The contaminants remain in place because they are not easily dissolved by groundwater.
- Groundwater flow is slow.

Are PRBs Safe?

The reactive materials placed in PRBs are not harmful to groundwater or people. Contaminated groundwater is cleaned up underground so treatment does not expose workers or others onsite to contamination. Because some contaminated soil may be encountered when digging the trench, workers wear protective clothing. Workers also cover loose contaminated soil to keep dust and vapors out of the air before disposing of it. Groundwater is tested regularly to make sure the PRB is working.

How Might It Affect Me?

During construction of the PRB, nearby residents may see increased truck traffic when materials are hauled to the site or hear earth-moving equipment. However, when complete, PRBs require no noisy equipment. Cleanup workers will occasionally visit the site to collect groundwater and soil samples to ensure that the PRB is working. When the reactive materials need to be replaced, the old materials will have to be excavated and hauled to a landfill.

Why Use PRBs?

PRBs are a relatively inexpensive way to clean up groundwater. No energy is needed because PRBs rely on the natural flow of groundwater. The use of some materials, such as limestone, shell fragments, and mulch, can be very inexpensive, if locally available. No equipment needs to be above ground, so the property may continue its normal use, once the PRB is installed.

Construction of a PRB in Sunnyvale, CA

PRBs have been selected or are being used at more than 30 Superfund sites across the country.

Example

A PRB with iron as the reactive material was installed in 1995 to clean up groundwater at a former semiconductor manufacturing site in Sunnyvale, California. Concentrations of industrial solvents in the groundwater plume were extremely high.

Due to changing groundwater flow directions, low-permeability walls were installed below ground and perpendicular to the PRB to direct the flow of contaminated groundwater toward the PRB. The PRB itself is about 8-feet wide, 40-feet long and 20-feet deep. The objective of the PRB is to reduce solvent concentrations to below the cleanup standards set by the State of California. As of 2009, solvent concentrations in groundwater samples collected within the treatment zone remain below the cleanup standards. Use of a PRB has allowed the metals machining facility currently at the site to continue operating during cleanup.

For More Information

For more information on this and other technologies in the Citizen's Guide Series, contact:

U.S. EPA
Technology Innovation &
Field Services Division
Technology Assessment Branch
(703) 603-9910

Or visit:
http://www.cluin.org/prb

United States
Environmental Protection
Agency

Office of Solid Waste and
Emergency Response
(5102G)

EPA 542-F-12-017
September 2012
www.epa.gov/superfund/sites
www.cluin.org

Low Impact Development strategies use careful site design and decentralized stormwater management to reduce the environmental footprint of new growth. This approach improves water quality, minimizes the need for expensive pipe-and-pond stormwater systems, and creates more attractive developments.

MASSACHUSETTS **LOW IMPACT DEVELOPMENT** TOOLKIT

FACT SHEET #1

BIORETENTION AREAS

Overview

Bioretention is an important technique that uses soil, plants and microbes to treat stormwater before it is infiltrated or discharged. Bioretention "cells" are shallow depressions filled with sandy soil, topped with a thick layer of mulch, and planted with dense vegetation. Stormwater runoff flows into the cell and slowly percolates through the soil (which acts as a filter) and into the groundwater; some of the water is also taken up by the plants. Bioretention areas are usually designed to allow ponded water 6-8 inches deep, with an overflow outlet to prevent flooding during heavy storms. Where soils are tight or fast drainage is desired, designers may use a perforated underdrain, connected to the storm drain system.

Bioretention areas can provide excellent pollutant removal and recharge for the "first flush" of stormwater runoff. Properly designed cells remove suspended solids, metals, and nutrients, and can infiltrate an inch or more of rainfall. Distributed around a property, vegetated bioretention areas can enhance site aesthetics. In residential developments they are often described as "rain gardens" and marketed as property amenities. Routine maintenance is simple and can be handled by homeowners or conventional landscaping companies, with proper direction.

Applications and Design Principles

Bioretention systems can be applied to a wide range of development in many climatic and geologic situations; they work well on small sites and on large sites divided into multiple small drainages. Common applications for bioretention areas include parking lot islands, median strips, and traffic islands. Bioretention is a feasible "retrofit" that can be accomplished by replacing existing parking lot islands or by re-configuring a parking lot during resurfacing. On residential sites they are commonly used for rooftop and driveway runoff.

Management Objectives

- Provide water quality treatment.
- Remove suspended solids, metals, nutrients.
- Increase groundwater recharge through infiltration.
- Reduce peak discharge rates.
- Reduce total runoff volume.
- Improve site landscaping.

Metropolitan Area Planning Council
MAPC

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Above: This bioretention cell at a office park also helps to fulfill site landscaping requirements. *Photo: Low Impact Development Center*

Right: This schematic diagram shows parking lot runoff directed to a bioretention cell, with pretreatment by a grassed filter strip. *Image: Prince George's County (MD) Bioretention Manual*

Cover, top: A rain garden in a Connecticut Subdivision infiltrates rooftop and driveway runoff, and can be marketed as an extra amenity. *Photo: University of Connecticut, Jordan Cove Urban Monitoring Project*

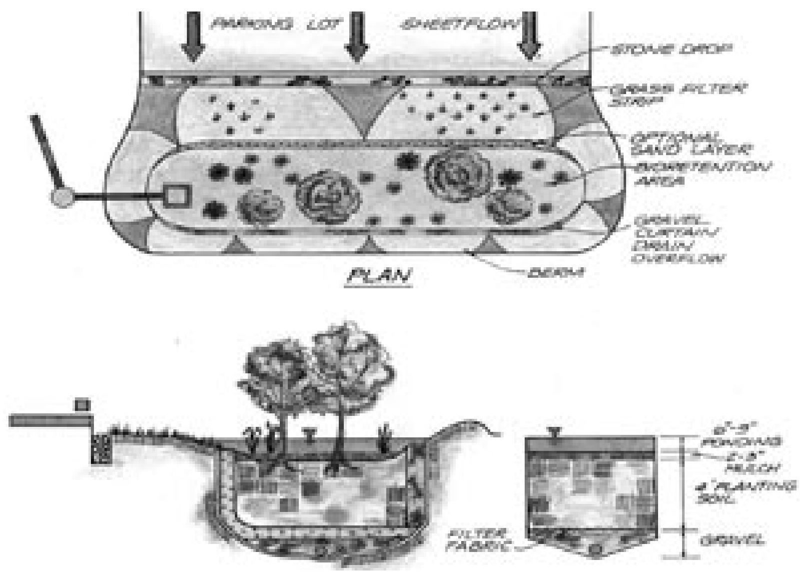
Cover, bottom: A narrow bioretention cell in a parking lot, planted with small trees to reduce the urban heat island effect. *Photo: Low Impact Development Center*

Bioretention cells are usually excavated to a depth of 4 feet, depending on local conditions. Generally, cells should be sized (based on void space and ponding area) to capture and treat the water quality volume (the first 0.5" or 1" of runoff, depending on local requirements.) Some manuals suggest a minimum width of 15', though much narrower bioretention cells have been installed in parking lot islands and are functioning well. Regardless of size, some type of filter should cover the bottom of the excavation. Filter fabric is commonly used but can be prone to clogging; consequently some engineers recommend a filter of coarse gravel, over pea gravel, over sand.

The cell should be filled with a soil mix of sandy loam or loamy sand. The area should be graded to allow a ponding depth of 6-8 inches; depending on site conditions, more or less ponding may be appropriate. The planting plan should include a mix of herbaceous perennials, shrubs, and (if conditions permit) understory trees that can tolerate intermittent ponding, occasionally saline conditions (due to road salt), and extended dry periods. The soil should be covered with 2-3" of fine-shredded hardwood mulch.

In very permeable soils, some bioretention areas can be designed as "off-line" treatment structures (no overflow necessary), but in most situations they will be an "on-line" component of the stormwater management system, connected to downstream treatment structures through an overflow outlet or an overflow drop inlet installed at the ponding depth and routed to the site's stormwater management system. Ideally, overflow outlets should be located as far as possible from runoff inlets to maximize residence time and treatment. In general, bioretention area should be designed to drain within 72 hours. In slowly permeable soils (less than 0.3 inches/hour) a perforated underdrain can be installed at the bottom of the excavation to prevent ponding.

Bioretention areas work best if designed with some pretreatment, either in the form of swales or a narrow filter strip. A stone or pea gravel diaphragm (or, better yet, a concrete level spreader) upstream of a filter strip will enhance sheet flow and better pre-treatment.



Benefits and Effectiveness

- Bioretention areas remove pollutants through filtration, microbes, and uptake by plants; contact with soil and roots provides water quality treatment better than conventional infiltration structures. Studies indicate that bioretention areas can remove 75% of phosphorus and nitrogen; 95% of metals; and 90% of organics,

Above, top: Bioretention cells are designed to allow ponded water six inches deep, which should infiltrate into the ground within 72 hours after a storm.

Above, middle: A large bioretention cell adjacent to a parking lot can reduce or eliminate expenses on storm sewers and detention basins. *Photo: Low Impact Development Center*

Above, bottom: Maintenance of rain gardens can generally be handled by homeowners. *Photo: Low Impact Development Center*

bacteria, and total suspended solids. Bioretention areas qualify as an organic filter according to the Massachusetts Stormwater Policy.

- In most applications, bioretention areas increase groundwater recharge as compared to a conventional "pipe and pond" approach. They can help to reduce stress in watersheds that experience severe low flows due to impervious coverage.
- Low-tech, decentralized bioretention areas are also less costly to design, install, and maintain than conventional stormwater technologies that treat runoff at the end of the pipe. The use of decentralized bioretention cells can also reduce the size of storm drain pipes, a major driver of stormwater treatment costs.
- Bioretention areas enhance the landscape in a variety of ways: they improve the appearance of developed sites, provide wind breaks, absorb noise, provide wildlife habitat, and reduce the urban heat island effect.

Limitations

- Because bioretention areas infiltrate runoff to groundwater, they may be inappropriate for use at stormwater "hotspots" (such as gas stations) with higher potential pollutant loads. On these sites, the design should include adequate pretreatment so that runoff can be infiltrated, or else the filter bed should be built with an impermeable liner, so that all water is carried away by the underdrain to another location for additional treatment prior to discharge.
- Premature failure of bioretention areas is a significant issue that results from lack of regular maintenance. Ensuring long-term maintenance involves sustained public education and deed restrictions or covenants for privately-owned cells.
- Bioretention areas must be used carefully on slopes; terraces may be required for slopes >20%.
- The design should ensure vertical separation of at least 2' from the seasonal high water table.

This parking lot bioretention cell is being constructed with an impermeable liner and a perforated underdrain, to provide retention and treatment of runoff (but not infiltration).

Maintenance

- Bioretention requires careful attention while plants are being established and seasonal landscaping maintenance thereafter.
- In many cases, maintenance tasks can be completed by a landscaping contractor working elsewhere on the site.
- Inspect pretreatment devices and bioretention cells regularly for sediment build-up, structural damage, and standing water.
- Inspect soil and repair eroded areas monthly. Re-mulch void areas as needed. Remove litter and debris monthly.
- Treat diseased vegetation as needed. Remove and replace dead vegetation twice per year (spring and fall.)
- Proper selection of plant species and support during establishment of vegetation should minimize—if not eliminate—the need for fertilizers and pesticides.
- Remove invasive species as needed to prevent these species from spreading into the bioretention area.
- Replace mulch every two years, in the early spring.
- Upon failure, excavate bioretention area, scarify bottom and sides, replace filter fabric and soil, replant, and mulch.

Cost

Bioretention areas require careful design and construction, the price of which will depend on site conditions and design objective. Generally, the cost of bioretention areas is less than or equal to that of a catch basin and underground chambers intended to treat the same area. Additionally, bioretention areas treat and recharge stormwater thereby reducing the amount/size of piping needed and the size of downstream basins and treatment structures.

Design Details

- Where bioretention areas are adjacent to parking areas, allow 3" of freeboard above ponding depth to prevent flooding.
- Determine the infiltrative capacity of the underlying native soil through an infiltration test using a double-ring infiltrometer. Do not use a standard septic system percolation test to determine soil permeability.
- Soil mix should be sandy loam or loamy sand with clay content less than 15%. Soil pH should generally be between 5.5-6.5, which is optimal for microbial activity and adsorption of nitrogen, phosphorus, and other pollutants. Planting soils should be 1.5-3% organic content and maximum 500ppm soluble salts.
- Planting soils should be placed in 1'-2' lifts, compacted with minimal pressure, until desired elevation is achieved. Some engineers suggest flooding the cell between each lift placement in lieu of compaction.
- Planting plan should generally include one tree or shrub per 50 s.f. of bioretention area, and at least 3 species each of herbaceous perennials, shrubs, and (if applicable) trees to avoid a monoculture.
- The bioretention landscaping plan should meet the requirements of any applicable local landscaping requirements.
- During construction, avoid excessive compaction of soils around the bioretention areas and accumulation of silt around the drainfield.
- In order to minimize sediment loading in the treatment area, only runoff from stabilized drainage areas should be directed to bioretention areas; construction runoff should be diverted elsewhere.

Additional References

Design Manual for Use of Bioretiention in Stormwater Management; Department of Environmental Resources, Prince George's County, MD; 1993.

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Bioretention Fact Sheet, Federal Highway Administration www.fhwa.dot.gov/ environment/ultraurb/3fs3.html

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FOR MORE INFORMATION, VISIT: WWW.MAPC.ORG/LID AND WWW.ARC-OF-INNOVATION.ORG.

United States
Environmental
Protection Agency

Constructed Treatment Wetlands

Natural wetland systems have often been described as the "earth's kidneys" because they filter pollutants from water that flows through on its way to receiving lakes, streams and oceans. Because these systems can improve water quality, engineers and scientists construct systems that replicate the functions of natural wetlands. Constructed wetlands are treatment systems that use natural processes involving wetland vegetation, soils, and their associated microbial assemblages to improve water quality.

How do treatment wetlands work?

Natural wetlands perform many functions that are beneficial to both humans and wildlife. One of their most important functions is water filtration. As water flows through a wetland, it slows down and many of the suspended solids become trapped by vegetation and settle out. Other pollutants are transformed to less soluble forms taken up by plants or become inactive. Wetland plants also foster the necessary conditions for microorganisms to live there. Through a series of complex processes, these microrganisms also transform and remove pollutants from the water.

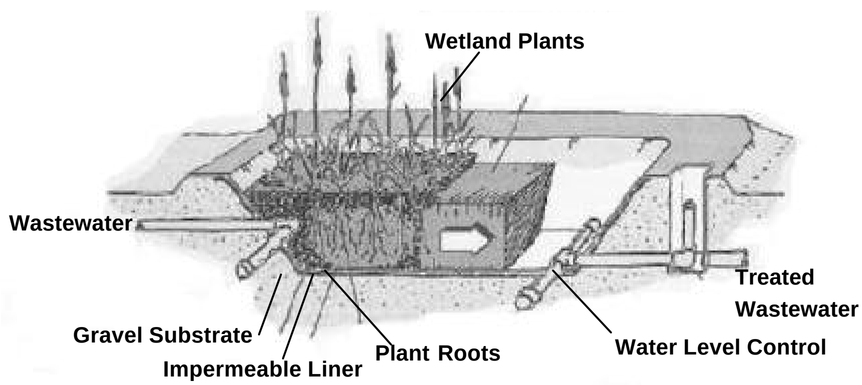
Nutrients, such as nitrogen and phosphorous, are deposited into wetlands from stormwater runoff, from areas where fertilizers or manure have been applied and from leaking septic fields. These excess nutrients are often absorbed by wetland soils and taken up by plants and microorganisms. For example, wetland microbes can convert organic nitrogen into useable, inorganic forms (NO_3 and NH_4) that are necessary for plant growth and into gasses that escape to the atmosphere.

Why build them?

Wetlands are some of the most biologically diverse and productive natural ecosystems in the world. While not all constructed wetlands replicate natural ones, it makes sense to construct wetlands that improve water quality and support wildlife habitat. Constructed wetlands can also be a cost-effective and technically feasible approach to treating wastewater. Wetlands are often less expensive to build than traditional wastewater treatment options, have low operating and maintenance expenses and can handle fluctuating water levels. Additionally, they are aesthetically pleasing and can reduce or eliminate odors associated with wastewater.

A Popular Idea

Designing and building wetlands to treat wastewater is not a new concept. As many as 5,000 constructed wetlands have been built in Europe and about 1,000 are currently in operation in the United States. Constructed treatment wetlands, in some cases involving the maintenance of important wetland habitat, have become particularly popular in the Southwest, where the arid climate makes the wetland habitat supported by these projects an especially precious resource.



Wetland plants and associated microorganisms treat wastewater as it flows through a constructed wetland system.

How are they built?

Constructed wetlands are generally built on uplands and outside floodplains or floodways in order to avoid damage to natural wetlands and other aquatic resources. Wetlands are frequently constructed by excavating, backfilling, grading, diking and installing water control structures to establish desired hydraulic flow patterns. If the site has highly permeable soils, an impervious, compacted clay liner is usually installed and the original soil placed over the liner. Wetland vegetation is then planted or allowed to establish naturally.

Design and Planning Considerations:

If planned and maintained properly, treatment wetlands can provide wastewater treatment and also promote water reuse, wildlife habitat, and public use benefits. Potentially harmful environmental impacts, such as the alteration of natural hydrology, introduction of invasive species and the disruption of natural plant and animal communities can be avoided by following proper planning, design, construction and operating techniques. The following guidelines can help ensure a successful project:

- Construct treatment wetlands, as a rule, on uplands and outside floodplains in order to avoid damage to natural wetlands and other aquatic resources, unless pretreated effluent can be used to restore degraded systems.
- Consider the role of treatment wetlands within the watershed (e.g., potential water quality impacts, surrounding land uses and relation to local wildlife corridors).
- Closely examine site-specific factors, such as soil suitability, hydrology, vegetation, and presence of endangered species or critical habitat, when determining an appropriate location for the project in order to avoid unintended consequences, such as bioaccumulation or destruction of critical habitat.
- Use water control measures that will allow easy response to changes in water quantity, quality, depth and flow.
- Create and follow a long-term management plan that includes regular inspections, monitoring and maintenance.

USDA, Natural Resources Conservation Service

This hog operation in Taylor County, Iowa, uses a wetland system constructed on a series of hillside terraces to filter and purify wastewater. Water quality tests indicated that the effluent from the treatment wetland was cleaner than that required for wastewater treatment plants.

Tres Rios Project Improves Water Quality

In 1990, city managers in Phoenix, Arizona, needed to improve the performance of their 91st Avenue Wastewater Treatment Plant to meet new water quality standards issued by the Arizona Department of Environmental Quality. After learning that upgrading their treatment plant might cost as much as $635 million, the managers started to look for a more cost-effective way to polish the treatment plant's wastewater discharge into the Salt River. A preliminary study suggested that the city consider a constructed wetland system that would polish effluent, while supporting high-quality wetland habitat for migratory waterfowl and shorebirds, including endangered species, and protecting downstream residents from flooding at a lower cost than retrofitting their existing treatment plant. As a result, the 12-acre Tres Rios Demonstration Project began in 1993 with assistance from the U.S. Army Corps of Engineers, the Bureau of Reclamation and EPA's Environmental Technology Initiative and now receives about two million gallons of effluent per day. The demonstration project was so successful that the city and the Bureau of Reclamation asked EPA for help in expanding the project to a full-scale, 800-acre project. For more information on the Tres Rios Constructed Wetlands Project, visit, http://phoenix.gov/TRESRIOS/

EPA 843-F-03-013
Office of Water
August 2004

Wetland Resources

Treatment Wetlands (2004), Robert H. Kadlec and Robert L. Knight, Lewis Publishers, Boca Raton, Fl.

Guiding Principles for Constructed Treatment Wetlands: Providing for Water Quality and Wildlife Habitat (2000), United States Environmental Protection Agency, EPA 843-B-00-003. Available online at www.epa.gov/owow/wetlands/constructed/guide.html

Constructed Wetlands Handbooks (Volumes 1-5): A Guide to Creating Wetlands for Agricultural Wastewater, Domestic Wastewater, Coal Mine Drainage and Stormwater in the Mid-Atlantic Region (1993-2000), United States Environmental Protection Agency. Available online at www.epa.gov/owow/wetlands/pdf/hand.pdf

Handbook for Restoring Tidal Wetlands (2000), Joy B. Zedler, CRC Press, Boca Raton, FL.

Stormwater Retrofit Techniques for Restoring Urban Drainages in Massachusetts and New Hampshire

Small MS4 Permit Technical Support Document, April 2011

Draft NPDES Permits Call for Stormwater Retrofits

The 2010 draft NPDES Small MS4 general permits for Massachusetts and New Hampshire (herein referred to as the draft permits) may require the retrofitting of existing unmanaged and/or inadequately managed stormwater runoff in impaired watersheds as summarized in **Table 1**. While new development is required to manage stormwater on-site, older developments may have been constructed before stormwater management was required or modern criteria were established. Retrofits include new installations or upgrades to existing Best Management Practices (BMPs) in developed areas where there is a lack of adequate stormwater treatment (**Figure 1**). Stormwater retrofit goals may include, among other things, the correction of prior design or performance deficiencies, flood mitigation, disconnecting impervious areas, improving recharge and infiltration performance, addressing pollutants of concern, demonstrating new technologies, and supporting stream restoration activities.

Table 1. References to Retrofit Requirements in the MA and NH Draft NPDES Permits.

Stormwater Retrofit Requirements	Draft NPDES Permit Section	
	NH	MA*
MS4s discharging to impaired waters with an approved TMDL must implement specific BMPs to meet reduction targets**	2.2.1; Appendix F	2.2.1; Appendix G
MS4s discharging to impaired waters without an approved TMDL must identify and implement BMPs to address impairment as part of their Stormwater Management Program (SWMP)	2.2.2	2.2.2
Increased discharges to impaired waters must provide additional BMPs or enhanced control of an existing discharge	--	2.3.1
Inventory and rank MS4-owned properties and infrastructure based on retrofit potential	2.3.6.8(b)	2.4.6.9(c)
Report on MS4-owned properties and infrastructure that have been retrofitted with BMPs	2.3.6.8(d)	2.4.6.9(d)
Design and install stormwater controls at municipal facilities, where needed, as part of the Stormwater Pollution Prevention Plan (SWPPP)	2.3.7.2	2.4.7.2

* MA permit sections listed are from the draft North Coastal Small MS4 General Permit
**Appendices F and G identify waste load targets for those small MS4s for which there are approved TMDLs.

Figure 1. Structural retrofits such as the bioretention, bioswale, and sand filter shown here can be used to capture, treat, and/or infiltrate unmanaged runoff. Public open space and large parking lots are common retrofit locations.

Retrofitting to Meet Total Maximum Daily Load (TMDL) Reductions

MS4s discharging to impaired watersheds with approved TMDLs may now be required to retrofit existing development in order to meet pollutant reduction targets. Draft permit appendices F and G for New Hampshire and

Massachusetts, respectively, provide a listing of small MS4s subject to approved TMDLs and their respective load reduction targets and permit requirements.

Retrofitting the Charles River Watershed
(draft MA North Coastal permit, Section 2.2.1(d))

MS4s within the Charles River or within its tributary watershed must also develop Phosphorus Control Plans (PCPs) that identify, prioritize, and provide design/construction schedules for the structural and non-structural control measures necessary to reduce Total Phosphorous (TP). Structural control measures include practices that reduce or disconnect impervious cover, enhance infiltration, or otherwise treat stormwater. Non-structural measures include pollution prevention and source control activities (e.g., street sweeping). Permittees must also estimate costs and identify third party implementers in the PCP.

Progress on development of the PCP must be reported by the MS4 in the second year NPDES annual report. Implementation of the PCP must start no later than four years from the effective date of the NPDES permit and be completed within 10 years. Beginning one year after implementation of the PCP, the permittee must begin estimating annual TP load reductions based on implementation.

The Stormwater Retrofit Process

A widely accepted approach (Schueler et al., 2007) to stormwater retrofitting at the small watershed scale is summarized in brief below:

1 Evaluate local need and capacity for retrofitting in your MS4. Determine if your jurisdiction falls within the Charles River Watershed or other TMDL watersheds, and identify your pollutant reduction requirements. If there are redevelopment projects in the planning stage, identify any federal, state and local requirements for improving on-site stormwater management. Have you already conducted a retrofit inventory?

2 Using GIS, institutional knowledge and blueprints as appropriate, identify potential retrofit locations at publicly-owned properties (e.g., parks, schools, and municipal maintenance yards), street rights-of-way, culverts/outfalls, and existing detention practices. Target large parking lots, rooftops, or other impervious areas (public or privately-owned) that lack stormwater management and are considered directly connected to the MS4. Identify sites that are prone to flooding, chronic contamination, and/or have a high maintenance burden (**Figure 2**).

3 Conduct a retrofit investigation by visiting each location to verify current conditions and identify potential retrofit treatment options and constraints. Use this opportunity to verify if impervious cover on site is directly-connected to the MS4 or disconnected. Eliminate sites where retrofitting is infeasible or impractical due to existing constraints (e.g., land use, environmental conditions, presence of utilities, or other limitations).

4 Develop an inventory of potential retrofit candidates, with illustrative concept sketches, site photos, and basic drainage calculations (**Figure 3**).

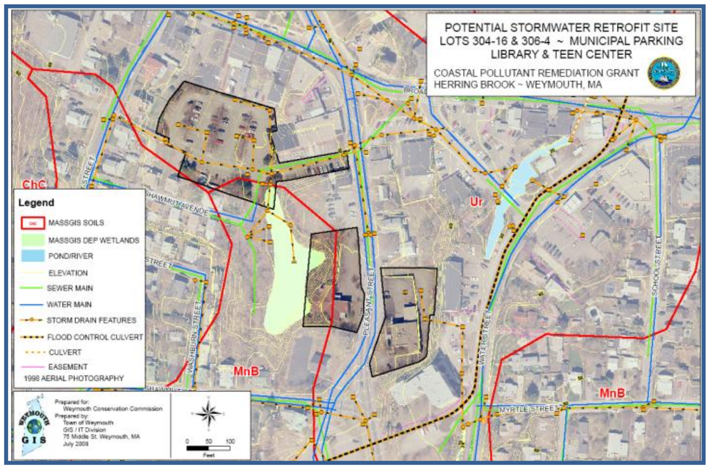


Figure 2. Mapping analysis used to identify potential locations for retrofits in Weymouth, MA showing aerial imagery, parcel ownership, stormwater infrastructure and utilities, topography, soils, and hydrology. The MassGIS and NH's GRANIT websites are good sources of GIS data and can be found at www.mass.gov/mgis/ and www.granit.unh.edu/, respectively.

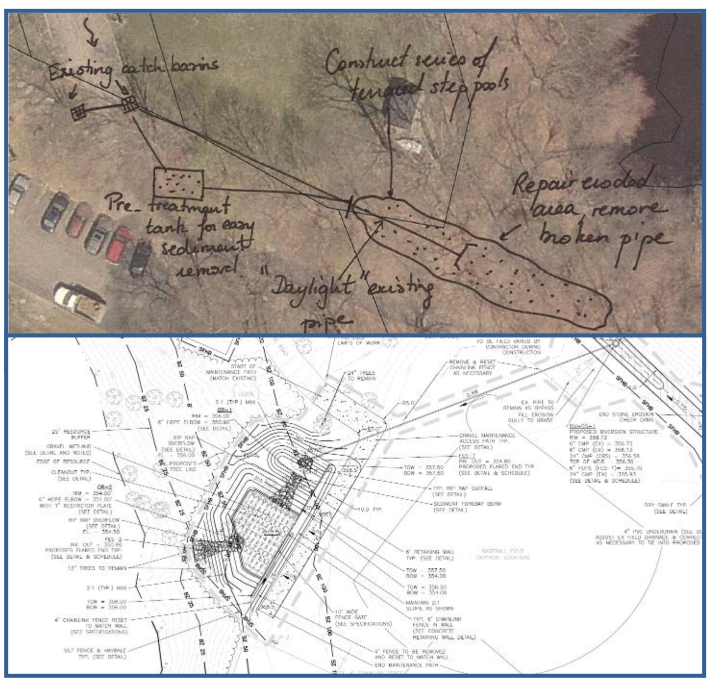


Figure 3. Concept sketches can be done by hand. Once priorities have been identified, concepts can be further advanced to engineering design and construction plans.

5 Evaluate and rank retrofit concepts based on predetermined factors such as pollutant reduction requirements, BMP feasibility and performance, impervious cover disconnection, cost, visibility, property ownership, and community support.

The draft permits require an inventory and ranking of all MS4-owned properties and infrastructure for retrofit potential within two years of the effective date of the permit.

6 Model watershed treatment benefits for various implementation scenarios to help determine the most cost-effective approaches to implementation. There are a number of existing public models that could be used to assist in the evaluation of implementation scenarios, such as the Center for Watershed Protection's Watershed Treatment Model (WTM), Pitt and Voorhees' Source Loading and Management Model (SLAMM), or EPA's new System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) developed by TetraTech. These models can be uploaded at www.cwp.org; www.winslamm.com/; and www.epa.gov/ednnrmrl/models/sustain/index.html.

MS4s in the Charles River Watershed subject to Phosphorous Control Plans must establish 2010 baseline Total Phosphorous Loads, and report annual load reductions based on retrofit implementation pursuant to Sections 2.2.1(vi) and 2.2.1(x) of the draft MA North Coastal permit.

7 Take the top projects to final design and construction stages (**Figure 4**). Allow additional time to complete site surveys, necessary state and local permitting, contractor bidding and specifications, and, in some cases, generate public support. The time required to secure implementation funding will likely vary depending on the primary source of funds (i.e., stormwater utility, general or capital budgets, or grants).

Beginning with the third year annual report, permittees will be required to report on completed retrofit projects. Permittees are encouraged to also report non-MS4 and private sector retrofit projects.

8 Provide inspection and maintenance services for the life of the retrofit (**Figure 5**). MS4 programs should establish a BMP tracking system to ensure long-term maintenance of existing and retrofitted facilities.

Figure 4. As an example of a priority retrofit taken to final design and construction, this shows the installation of a bioretention facility at a nature center in Massachusetts.

Figure 5. Ensuring the long-term maintenance of sand filters, swales, bioretention facilities, and other BMPs is a critical component of a municipal stormwater management program.

Do the Performance Objectives for Retrofits and New Developments Differ?

Yes. In the draft small MS4 general permits for MA and NH, the primary objective for new development is to achieve a condition of pre-development hydrology. As a practical matter, this can be accomplished by preventing a discharge from the 90th percentile storm (about a one-inch rainfall event in Massachusetts and New Hampshire). In contrast, the primary objective for a retrofit is to improve the hydrology of an existing site and reduce the discharge of stormwater as much as possible. In many cases, retrofits provide an opportunity to remedy past design and/or performance deficiencies.

Are Certain Structural Practices Preferred?

Yes. While all retrofit sites are unique and no single solution fits all, in general, preferred practices are those that provide for increased infiltration, evapotranspiration and rainwater harvesting because these practices reduce stormwater runoff volume while also providing water quality benefits. Retrofits that provide for infiltration (e.g., infiltration basins and trenches, bioretention systems, rain gardens, and swales) where little or no infiltration currently exists are likely to improve site hydrology. Infiltration practices also help to recharge groundwater aquifers, although practices located near public drinking water sources should carefully consider the impact of infiltrating stormwater discharges on drinking water sources.

Depending on the water quality/TMDL goals for the watershed, permittees should also consider retrofitting existing BMPs to maximize pollutant removal. The retrofitting of dry detention ponds, for instance, may provide the most cost-effective approach to capture and treat large drainage areas.

Where Can We Find BMP Performance Efficiencies?

Both the Massachusetts and New Hampshire Stormwater manuals include pollutant removal efficiencies for various stormwater practices. These can be found at www.mass.gov/dep/water/laws/policies.htm#storm and des.nh.gov/organization/divisions/water/stormwater/manual.htm, respectively.

Other reliable sources of pollutant removal rates can be found in Appendix D of Schueler et al. (2007), the University of Massachusetts at Amherst, Stormwater Technologies Clearinghouse at www.mastep.net/, or the University of New Hampshire Stormwater Center at www.unh.edu/erg/cstev/.

Where Can I go for More Permit Information?

For more information regarding the new permit requirements for Massachusetts and New Hampshire, go to: www.epa.gov/ne/npdes/stormwater/index.html

Load reduction targets for small MS4s in Massachusetts and New Hampshire that are subject to approved TMDLs are available at:
www.epa.gov/ne/npdes/stormwater/ma/Appendix-G-Small-MS4-MA.pdf

www.epa.gov/ne/npdes/stormwater/nh/Appendix-F-Small-MS4-NH.pdf

Additional Retrofitting Resources

Charles River Watershed BMP Factsheets
www.crwa.org/projects/stormwater/stormwaterBMPs.html

Rhode Island Stormwater Design and Installation Manual. 2010.
www.dem.ri.gov/programs/benviron/water/permits/ripdes/stwater/pdfs/desgnmnl.pdf

Schueler, T., Hirschman, D., Novotney, M., and J. Zielinski. 2007. Urban Watershed Restoration Manual No. 3: Urban Stormwater Retrofit Practices.
www.cwp.org/

USEPA Webcast Series: The Art and Science of Stormwater Retrofitting.
www.epa.gov/npdes/outreach_files/webcast/apr0908/107156_od/107156_od.html

Municipal Retrofit Case Studies

Catskill Watershed Corporation- Stormwater Retrofit Grant Program
www.cwconline.org/programs/strm_wtr/strm_wtr1.html#retro

Center for Landuse Education and Research (CLEAR), University of Connecticut, Eagleville Brook TMDL and Retrofit Project website:
www.clear.uconn.edu/eagleville/Eagleville_TMDL/Home.html

Charlottesville, VA - Stormwater Stewardship on Public Lands Program
www.charlottesville.org/index.aspx?recordid=259&page=635

Massachusetts Institute of Technology (MA) - Stata Center web.mit.edu/environment/ehs/topic/stata.html

Montgomery County, MD - Rainscapes Program
www.montgomerycountymd.gov/dectmpl.asp?url=%5Ccontent%5Cdep%5Cwater%5Crainscapes.asp

Portland, OR - Clean River Rewards Program
www.portlandonline.com/BES/index.cfm?c=edeef

Portland, OR - Downspout Disconnection Program
www.portlandonline.com/BES/index.cfm?c=edaib

Sanitation District No. 1 of Northern Kentucky- Public Service Park. www.sd1.org/

Seattle, WA - Natural Drainage Systems Program
www.seattle.gov/util/About_SPU/Drainage_&_Sewer_System/GreenStormwaterInfrastructure/NaturalDrainageProjects/index.htm

Villanova University - Best Management Practice Demonstration Park www3.villanova.edu/VUSP/

Appendix M

Cost Share Water Conservation Programs
Delaware Department of Natural Resources and Environmental Control
APPOQUINIMINK RIVER POLLUTION CONTROL STRATEGY
November 2010

BMP COST CALCULATIONS

This document describes the cost-effectiveness of urban and agricultural best management practices (BMPs) that reduce nutrients.

On-Site Wastewater Treatment and Disposal System (OWTDS) BMP Cost Calculations

I. Connecting OWTDS to Sewer Districts

According to DNREC's Financial Assistance Branch (personal communication, 2007), the average cost of constructing a sewer system is $8,500 per equivalent dwelling unit (EDU). In the future, this cost is expected to increase to $10,000/EDU. The debt service, or cost of financing these systems, at roughly an average 2% rate is currently $1,867/EDU and will be $2,194/EDU for future septic eliminations and sewer connections. Additionally, system owners must pay for the final septic system pump-out, crushing and filling the tank, and the connection costs associated with building the lateral line running from the building to the right of way. These three expenditures together run approximately $1,000/EDU. Finally, operation and maintenance (O&M), including repair fees, of roughly $200 per EDU per year will also be added to these values for an average 20 year lifespan of a connection (DNREC Financial Assistance Branch, personal communication, 2007) (Table 1).

Table 1. OWTDS Elimination Costs

	Past Conversions	Future Conversions
Construction of sewer system	$8,500/EDU	$10,000/EDU
Debt service	$1,867/EDU	$2,194/EDU
Additional expenditures	$1,000/EDU	$1,000/EDU
Operation and Maintenance (over 20 year lifespan)	$4,000/EDU	$4,000/EDU
TOTAL	$15,367/EDU	$17,194/EDU

II. Holding Tank Inspection and Compliance Program

The cost of pumping-out a 2,800 gallon holding tank averages around $250 per system per pump-out (DNREC Small Systems Branch, personal communication, 2007). As a result of the holding tank inspection and compliance program, they have been shown to be pumped-out roughly 12 times a year. This information reveals that the owner of a single holding tank will spend $3,000 each year. In addition to this cost, there is an annual inspection fee of $60 per system (DNREC Small Systems Branch, personal communication, 2007), so that the total expenditure for holding tank inspection and compliance is $3,060/system/year and over a 20 year lifespan the cost is $61,200/system.

III. OWTDS Pump-outs

The cost of pumping-out OWTDS ranges from $185-200 per system, with an average cost of $192.50 per system (DNREC Small Systems Branch, personal communication, 2007). It is proposed that septic systems be pumped once every three years and inspected during that time period as well. These proposed inspections will be performed by licensed inspectors at an estimated cost that ranges from $200 to $400 with an average cost of $300 at the time of pump-out (DNREC Small Systems Branch, personal communication, 2007). The total cost of the OWTDS inspection and compliance program will cost the system owner $164.17/system/year and over a 20 year lifespan this equals $3,283.33/system.

IV. OWTDS Performance Standards

Licensed installers and members of DNREC's Small Systems Branch (personal communication, 2007) revealed that the installation of best available technologies (BATs) to existing small (<2,500 gallon per day (gpd)) OWTDSs for advanced nitrogen removal would cost between $3,500 and $6,000 per system with an average installation of $4,750. These technologies are believed to last for approximately 20 years. These technologies require a service contract by a certified service provider with an estimated annual cost that ranges from $150 to $300, with an average cost of $225/system/year. In addition, the systems will still require pump-outs, which costs $64/system/year (DNREC Small Systems Branch, personal communication, 2007), and they will need periodic mechanical parts repaired, estimated to cost $50/system/year and the electrical cost of running the systems is likely to also cost about $50/system/year (DNREC Financial Assistance Branch, personal communication, 2007). Taking all of this into account, the total cost of this strategy is $12,530/system.

Stormwater BMP Cost Calculations

I. Wet and Dry Ponds

Typical costs for retention basins were retrieved from Chapter 6.0, “Costs and Benefits of Storm Water BMPs,” of an EPA on-line document (EPA, 1999). In this document, it states that a retention basin treating a 50-acre residential site in 1999 costs about $100,000, such that the cost per unit area was $2,000/acre. All values reported in the document need to be divided by an adjustment factor to account for regional differences. Delaware falls in Region 2, which has a 0.90 adjustment factor (EPA, 1999). Thus, retention basins in Delaware in 1999 cost approximately $2,222.22/acre. Using the average annual federal inflation rate for the time period of 1913-2007 (3.42%), the capital cost of Delaware retention basins in 2009 is $2,982/acre. To this value, the annual operation and maintenance costs over a 25 year lifespan must be added. Operation and maintenance costs for retention basins were determined from New Castle County Department of Land Use’s guidance found in the document “Maintenance (Minor) and Replacement (Major) Costs for Stormwater Management Facilities Preliminary Guidance Version #6” (NCC, 2005). Maintenance costs for wet and dry ponds include the following:

Table 2. Retention Pond Maintenance Costs

	Frequency	Unit Cost for Wet Ponds	Unit Cost for Dry Ponds	Annual Cost for Wet Ponds (40 acres)	Annual Cost for Dry Ponds (20 acres)
Inspection	2 times a year	$800 per inspection	$800 per inspection	$1,600	$1,600
Sediment Removal with Forebay	1 time over 10 years	Based on removal of 0.5 ft of 2,000 sq ft forebay	Based on removal of 0.5 ft of 1,000 sq ft forebay	$2,200	$1,120
Erosion Repair	1 time over 2 years	$4,400	$4,400	$2,200	$2,200
Repair Low Spots in Berm	1 time over 5 years	Based on 20 cy of repair	Based on 10 cy of repair	$1,280	$640
Repair Barrel Leaks	1 time over 5 years	$1,250 per event	$1,250 per event	$250	$250
Mowing	10 times a year	Based on 2 acres mowed @ $300/acre	Based on 2 acres mowed @ $300/acre	$6,000	$6,000

Repair Animal Burrows	1 time a year	$200	$200	$200	$200
Spray for Cattails and Algae (Wet Ponds)	2 times a year	$465		$930	
Invasive Removal (Wet Ponds)	1 time a year	$3,000		$3,000	
Total Annual Cost				$17,660.00	$12,010.00
Total Cost per Acre				**$441.50**	**$600.50**

Including all maintenance costs and dividing by the total acres assumed, the annual cost per acre for wet ponds is $441.50/acre/yr and for dry ponds is $600.50. Adding this to the regionally adjusted construction cost over the 25 year lifespan, the total cost for this strategy is $14,019.50/acre for wet ponds and $17,994.50/acre for dry ponds.

II. <u>Infiltration Structures</u>

The 1999 construction costs of infiltration trenches and infiltration basins treating 5-acre commercial sites were averaged to represent the range of infiltration structures utilized as stormwater BMPs throughout Delaware. These costs were $45,000 for trenches and $15,000 for basins (EPA, 1999), which equates to $9,000/acre and $3,000/acre, respectively, and averages $6,000/acre. Once adjusted for the regional variability in cost (0.90 factor), and inflated to 2009, this value becomes $8,946.67/acre treated by infiltration structures. Annual O&M costs for infiltration structures were determined from New Castle County estimates (NCC, 2005) as follows:

Table 3. Maintenance Costs for Infiltration Structures

	Frequency	Unit Cost for Infiltration Basin	Unit Cost for Infiltration Trench	Annual Cost for Infiltration Basin (20 acres)	Annual Cost for Infiltration Trench (1 acre)
Inspection	2 times a year	$800 per inspection	$200 per inspection	$1,600	$400
Sediment Removal	1 time over 10 yrs with forebay (basin) / 1 time over 2 yrs (trench)	Based on removal of 0.5 ft of 1,000 sq ft forebay	$350 per event	$1,120	$175

Erosion Repair	1 time over 2 years/ 1 time over 3 years (trench)	$4,400	$1,200	$2,200	$400
Repair Low Spots in Berm	1 time over 5 years	Based on 10 cy of repair		$640	
Repair Barrel Leaks	1 time over 5 years	$1,250 per event		$250	
Mowing	10 times a year	Based on 2 acres mowed @ $300/acre	Based on 200 sq ft mowed @ $300/acre	$6,000	$110
Repair Animal Burrows	1 time a year	$200		$200	
Total Annual Cost				$12,010.00	$1,085.00
Total Cost per Acre				**$600.50**	**$1,085.00**

This produces an annual O&M cost of $600.50/acre/yr for infiltration basins and $1,085.00/acre/yr for infiltration trenches. This averages out to $842.75 which when calculated over a 25 year lifespan and added to construction costs equals $30,015.42/acre.

III. <u>Filtering Practices</u>

The EPA on-line document reported that the construction costs for filtering practices in 1999 were $35,000 - $70,000, $60,000 for bioretention facilities, and $9,000 for filter strips for a 5-acre commercial site (EPA, 1999), which when averaged equates to $8,700/acre. Once adjusted for the regional variability in cost (0.90 factor), and inflated to 2009, this value becomes $13,083.31. The O&M costs reported by New Castle County for filtering practices (NCC, 2005) are as follows:

Table 4. Filtering Practices Maintenance Costs					
	Frequency	**Unit Cost for Bioretention**	**Unit Cost for Filter Strips**	**Annual Cost for Bioretention (1 acre)**	**Annual Cost for Filter Strips (1 acre)**
Inspection	2 times a year	$200 per inspection	$200 per inspection	$400	$400
Sediment Removal	1 time over 2 years/ 1 time over 3 years (filter strips)	$350 per event	$350 per event	$175	$117
Erosion Repair	1 time over 3 years	$1,200	$1,200	$400	$400
Mowing	8 times a year		Based on 2000 sq ft mowed @ $300/acre		$110
Soil Amendments	1 time a year	$100	$100	$100	$100
Plant Maintenance	1 time a year	$400		$400	
Total Annual Cost				$1,475.00	$1,127.00
Total Cost per Acre				**$1,475.00**	**$1,127.00**

The maintenance costs for bioretention facilities are $1,475.00/acre and the maintenance costs for filter strips are $1,127.00/acre. The average maintenance costs of these filtering practices are $1,301.00/acre. Calculating the O&M costs over a 25 year lifespan and adding to construction costs provides a total cost of $45,608.31/acre.

IV. <u>Biofiltration</u>

The EPA on-line document reported that the construction costs for biofiltration devices in 1999 were $3,500 for a 5-acre commercial site (EPA, 1999), which equates to $700/acre. This value must also be divided by the 0.90 adjustment factor to account for regional cost differences, which yields $777.78/acre, and then adjusted to the 2009 value, $1,052.68/acre. The annual maintenance costs for bioswales according to New Castle County (NCC, 2005) are as follows:

Table 5. Biofiltration Maintenance Costs			
	Frequency	**Unit Cost for Biofiltration**	**Annual Cost for Biofiltration (10 acres)**
Inspection	2 times a year	$200 per inspection	$400
Sediment Removal	1 time over 3 years	$350 per event	$117
Erosion Repair	1 time over 3 years	$1,200	$400
Mowing	10 times a year	Based on 8000 sq ft mowed @ $300/acre	$440
Soil Amendments	1 time a year	$100	$100
Total Annual Cost			$1,457.00
Total Cost per Acre			**$145.70**

The maintenance costs for biofiltration facilities are $145.70/acre. Calculating the O&M costs over a 25 year lifespan and adding to construction costs provides a total cost of $4,695.18/acre.

Table 6. Stormwater BMP Costs					
	Dry Ponds	**Wet Ponds**	**Infiltration Structures**	**Filtering Practices**	**Biofiltration**
Construction Cost /acre	$2,982.00	$2,982.00	$8,946.67	$13,083.31	$1,052.68
Maintenance Cost /acre	$600.50	$441.50	$842.75	$1,301.00	$145.70
Annual Maintenance/ acre over a 25 year lifespan	$15,012.50	$11,037.50	$21,068.75	$32,505.00	$3,642.50
Total Cost/acre	**$17,994.50**	**$14,019.50**	**$30,015.42**	**$45,608.31**	**$4,695.18**

Open Space Cost Calculations

The costs of the following open space practices have been estimated using data gathered by DNREC's Division of Fish and Wildlife staff. These are estimates, as costs for specific projects may vary.

I. Grassed Open Space

For municipalities and counties to restrict development in grassed open space as part of their development process, it is estimated that it costs $400/acre (personal communication, 2009). With a lifespan of 25 years and average maintenance costs of $35.00/acre/year, the total cost of implementation is $1,275/acre.

II. Riparian Buffers

For municipalities and counties to restrict development in riparian buffer areas as part of their development process, it is estimated that it costs $450/acre (personal communication, 2009). With a lifespan of 25 years and average maintenance costs of $84.00 /acre/year, the total cost of implementation is $2,550/acre.

Agriculture BMP Cost Calculations

The costs of the following agricultural BMPs have been estimated using data gathered by the United States Department of Agriculture (USDA) Natural Resources & Conservation Service (NRCS) staff at the county and state level. These are estimates, as costs for specific projects may vary.

I. Cover Crops

NRCS staff report that the cost of installing cover crops is $49.33/acre. With a lifespan of a year and maintenance costs of $5/acre/year, it costs a total of $54.33/acre to implement. The USDA-NRCS has a cost share program through EQIP for cover crops that covers $37/acre whereas the New Castle Conservation District (NCCD) runs the state cost share program with funding of $50/acre.

II. Ponds

Ponds have an installation cost of $3,758.50/acre and a lifespan of 10 years with maintenance costs of $5/acre/year. This provides a total cost of $3,808.50/acre to implement. Cost sharing levels of capital costs include 50% of the costs with a maximum of $4,500 from the NCCD.

III. Grassed Waterways

Grassed waterways cost approximately $16,404.24/acre to install. With a lifespan of 10 years and maintenance costs of $5/acre/year, it costs a total of $16,454.24/acre. Capital costs are cost shared by the USDA-NRCS through the CRP at 50% the cost and EQIP program at $12,303.18/acre while the New Castle Conservation District cost shares at 75%.

IV. Grass Filter Strips/Wildlife Habitat

These practices are estimated to cost $495.24/acre for installation. This practice has a lifespan of 10 years with maintenance costs of $5/acre/year. Thus, total costs equal $545.24/acre. The installation of these BMPs are cost shared by the USDA-NRCS through the CRP and CREP programs at 50% and through the EQIP and WHIP program at a rate of $371.43/acre. The New Castle Conservation District cost shares these practices at a rate of 75% for EQIP practices and 37.5% for CREP practices.

V. Forested Buffers/Riparian Buffers

The cost of installing a forested buffer is $495.24/acre with a lifespan of 10 years and maintenance equaling $5/acre/year. The cost installing a riparian buffer is $502/acre with a lifespan of 10 years and maintenance equaling $5/acre/year. The total cost of forested buffers equals $535.24/acre and the total cost of riparian buffers equals $552/acre. The installation of forested buffers are cost shared by the USDA-NRCS through the CREP program at 50% and through the WHIP program at a rate of $371.43/acre. The New Castle Conservation District cost shares forested buffers at a rate of 75% for WHIP practices and 37.5% for CREP practices. The installation of riparian buffers are cost shared by the USDA-NRCS through the CREP and CRP programs at 50% and through the WHIP program at a rate of $376.50/acre. The New Castle Conservation District cost shares riparian buffers at a rate of 75% for WHIP practices and 37.5% for CREP practices.

VI. **Wetland Restoration**

Wetland restoration costs $4,374.50/acre. This practice has a lifespan of 10 years and maintenance equaling $5/acre/year. Thus, the total cost of the wetland restoration equals $4,424.50/acre. The installation of wetlands are cost shared by the USDA-NRCS through the CRP and CREP programs at 50% and through the WHIP program at a rate of $3,280.88/acre. The New Castle Conservation District cost shares wetlands at a rate of 75% for WHIP practices and 37.5% for CREP practices.

VII. **Field Border**

Field borders cost $495.24/acre with a lifespan of 10 years and maintenance of $5/acre/year. This equals a total cost of implementation of $545.24/acre. The USDA-NRCS cost shares field borders through the EQIP and WHIP programs at a cost share rate of $215.18/acre and the New Castle Conservation District at a rate of 75%.

VIII. **Critical Area Planting**

The cost of installing critical area plantings equals $7,229.24/acre. When maintenance of $5/acre/year is added over a 10 year lifespan, the total cost of this practice is $7,279.24/acre. The USDA-NRCS cost shares field borders through the EQIP program at a cost share rate of $5,421.93/acre and the New Castle Conservation District at a rate of 75%.

IX. **Conservation Tillage**

Implementing conservation tillage costs $17.33/acre and has a lifespan of 4 years with $5/acre/year of maintenance. This equals a total cost of $37.33/acre. The USDA-NRCS cost shares conservation tillage at a rate of $13/acre.

X. **Nutrient Management Plans (NMPs)**

The cost to develop a nutrient management plan decreases as the acreage in the plan increases. A three year plan for an operation with less than 500 acres costs $5.70 which is the size of the majority of farms in the Appoquinimink watershed.

Table 3. Agriculture BMP Costs				
	Installation Cost / Acre	**Lifespan (years)**	**Total Maintenance Costs over Lifespan**	**Total Costs/ Acre**
Cover Crops	$49.33	1	$5	$54.33
Ponds	$3,758.50	10	$5	$3,808.50
Grassed Waterways	$16,404.24	10	$5	$16,454.24
Filter Strips/Wildlife Habitat	$495.24	10	$5	$545.24
Forest Buffers	$495.24	10	$5	$545.24
Riparian Buffers	$502.00	10	$5	$552.00
Wetland Restoration	$4,374.50	10	$5	$4,424.50
Field Border	$495.24	10	$5	$545.24
Critical Area Planting	$7,229.24	10	$5	$7,279.24
Conservation Tillage	$17.33	4	$5	$37.33
NMP	$5.70	1	-	$5.70

References

ASCE, 2001. *Guide for Best Management Practice (BMP) Selection in Urban Developed Areas.* American Society of Civil Engineers, Reston, Virginia.

DNMC, 2004. *Nutrient Management Planning Claim for Payment*. Delaware Nutrient Management Commission, Dover, Delaware.

EPA, 1999. *Preliminary Data Summary of Urban Storm Water Best Management Practices, Chapter 6: Costs and Benefits of Storm Water BMPs*. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

Lynch, Lori and Robert Tjaden, 2000. *Fact Sheet 774: When a Landowner Adopts a Riparian Buffer – Benefits and Costs.* Maryland Cooperative Extension, College Park, Maryland.

NCC, 2005. *Maintenance (Minor) and Replacement (Major) Costs for Stormwater Management Facilities. Preliminary Guidance Version #6.* New Castle County Department of Land Use, New Castle, Delaware.

SCD, 2003. *FY 2004 Sussex Conservation District Cover Crop Program Fact Sheet*. Sussex Conservation District, Georgetown, Delaware.

Appendix N

USACE Waterway Sign Standards

The Corps sign system has been designed using a selected group of common graphic elements and visual standards. These graphic elements include: the Corps Signature for agency identification, color standards for each type of sign, three weights of the Haas Helvetica typeface for the lettering on sign faces, specifications for letter- and word-spacing, the visual relationship of sign legend to sign panel size, recommended viewing distances for each size of legend typography (page 2-6), and sign placement guidelines (page 2-8 to 2-9).

These standards become the graphic building blocks around which the signs are designed. They have been adopted because they provide a functional base for the graphic format of each sign. These design standards also become one of the visual threads common to the design of each sign in the system.

This section defines the common graphic elements and visual standards and describes how they are to be used. These standards incorporate the principles contained in the Corps Graphic Standards Manual (EP 310-1-6). Each standard, however, has been adapted for application to signage.

Contact the National Sign Program Manager for advice and assistance concerning specialized or unique applications of these Corps design standards as they are applied to signs.

Signature

The Corps Signature is the key graphic element used to identify the Corps to the public. The Signature consists of the Mark and the Corps name set in Helvetica Medium typeface. Both elements are placed flush left.

In applications to signage, the Signature is to be used only on signs where Corps identification is important and integral to the message being communicated. This use is limited to: Standard Identification, Approach Roadway Directional, Boundary (ownership), Construction Project Identification, and Corps Participation Credit signs. Each of these examples is shown in its respective section of this manual.

The two basic forms of the Signature are shown below. The positive version (top) is used on signs with a white or light tone background. The reverse version is used on signs where the Signature is placed on a dark background.

Refer to the *Graphic Standards Manual* (EP 310-1-6) for a complete description of the Mark and Signature. Note the Signature registration symbol ® is not to be used on signs.

The form of the Mark is derived from the traditional Castle symbol used by the Corps since its inception.

The Mark has been redesigned for greater strength and adaptability, both visually and for reproduction purposes. In its new form, the Mark is a simplified contemporary rendering of the traditional symbol.

Do not place the Corps Mark or Signature on Project Roadway Directional, recreation area, informational, safety, or waterway guide signs. Indiscriminate use of the Signature only dilutes the primary communicative intent of the sign on which it is placed.

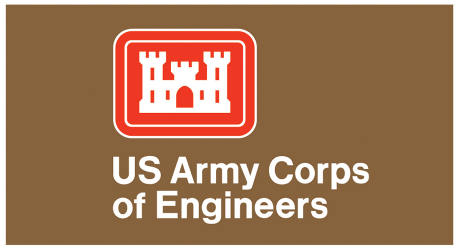
No district, division or other field-operating activity names are to be added to the basic Corps Signature when used on signs (other than sign CID-01 on page 16-2)

US Army Corps
of Engineers

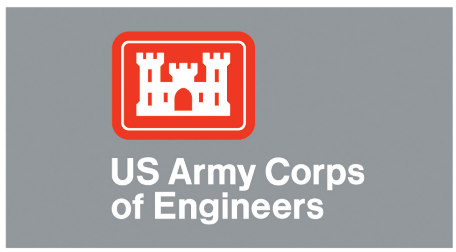
US Army Corps
of Engineers

The illustrations below show the various color configurations possible when using the Corps Signature on signs. Note that there are fewer possible ways to render the Signature on a sign panel than are specified for print applications (see *Graphic Standards Manual*, pages 1-5).

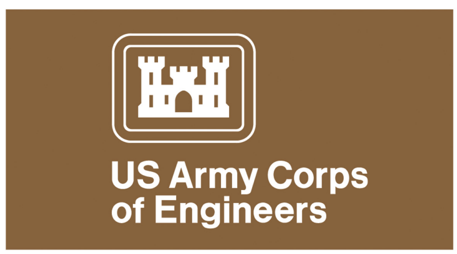
a) The most prominent use of the Signature will be on identification signs. For Standard Identification, post and panel signs, the reverse Signature is used; the Mark is Communication Red, the Signature type is white.



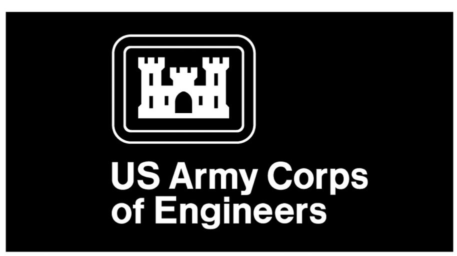
b) For large-scale Standard Identification signs of individual fabricated letters, the positive version is used; the Mark is Communication Red and the Signature typography is white (see page 5-7).



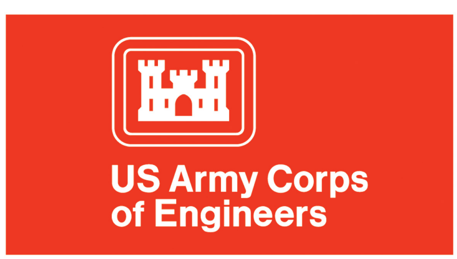
c) The Corps Participation Credit sign uses an all white reverse Signature on a Corps Brown background.



d) The header panels on Building Office Directories use a reverse Signature in white on Dark Grey.



e) Construction Project Identification signs use an all white reverse Signature on a Communication Red background.



f) Boundary signs use the positive Signature in black on a white background.

Within the Corps sign system there are five standard color palettes. Three have been developed by the Corps and include: 1) Recreation Area signs, 2) Lock, Dam and Waterway signs, and 3) Office Interior signs. Two color groups have been adopted from existing standards: 1) Traffic signs (MUTCD) and 2) Workplace Safety signs (ANSI). Each of these is illustrated on the following pages with descriptions for their use. The two-character color code is in parentheses immediately after the color. Additional color application instructions are included in each respective section.

Colors must conform to the standards presented on the following pages when preparing signs.

For many of the colors shown on the next five pages, a corresponding Federal Standard Color number is listed. These numbers refer to color samples contained in a fan deck titled *Federal Standard 595B Colors*. The fan deck is published by the General Services Administration, order number 7690-01-162-2210.

Shown below are the colors for use on Corps identification, directional, and recreation area signs.

Corps Brown (BR): Background for identification, directional, recreation, and symbol signs. The closest Federal Standard Color is 20095.

White (WH): Legend for identification, directional, and recreation signs. Background for boundary signs. The closest Federal Standard Color is 27925, but the match with the 595B fan deck is not exact.

Communication Red (CR): Corps Mark (Castle) on identification signs. The closest Federal Standard Color is 11350, but the match with the 595B fan deck is not exact. The Graphics Standards Manual (EP 310-1-6) specifies Communication Red shall match Pantone Red 032.

Black (BK): Legend and Signature for boundary signs. The closest Federal Standard Color is 17038.

The colors shown below are adopted from the *Manual on Uniform Traffic Control Devices* (MUTCD), Section 2A-11, for use on signs within the right-of-way of all classes of public highways. Adjacent to the color display is a description of the sign types on which it is used. Refer to Section 9 for a description of the standard type of traffic signs used on Corps projects.

Red (RD): Background for Danger Signs (Stop, Do Not Enter, Wrong Way, Yield, etc.). Circle and Slash on Prohibition and No Parking Signs. The closest Federal Standard Color is 11310, but the match with the 595B fan deck is not exact.

Yellow (YL): Background for Warning/road hazard signs. The closest Federal Standard Color is 13637.

Orange (OR): Background for construction and maintenance Warning signs. The closest Federal Standard Color is 12473.

Green (GR): Background for guidance and directional signs. Circle around “P” of Parking sign. The closest Federal Standard Color is 14120, but the match with the 595B fan deck is not exact.

Safety White (WH): Legend for Danger, guidance, and information signs. Background for regulatory signs. The closest Federal Standard Color is 27925, but the match with the 595B fan deck is not exact.

Safety Black (BK): Legend for Warning and Regulatory signs. The closest Federal Standard Color is 17038.

The colors shown below are used on all safety signs as described in Section 11 of this manual.

Safety Red (SR): Federal Standard Color 11310, but the match with the 595B fan deck is not exact. Danger; warning of an immediate hazard.

Safety Yellow (SY): Federal Standard Color 13591, but the match with the 595B fan deck is not exact. Caution; warning of potential hazard.

Safety Green (SG): Federal Standard Color 14109, but the match with the 595B fan deck is not exact. Notice; for safety.

Safety Blue (SB): Federal Standard Color 15092. Information; general.

Black (SK): Federal Standard Color 17038. Directional and all descriptive legends.

White (SW): Federal Standard Color 27875. All sign backgrounds, except for Caution.

Lock, Dam and Waterway Safety and Information Sign Color Standards

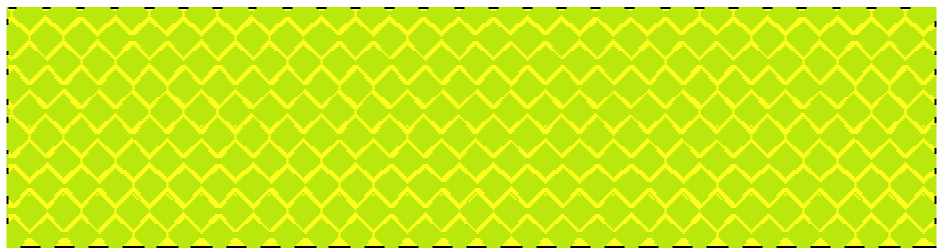
This color group has been developed for all waterway safety and information signs placed around locks and dams, on jetties and breakwaters, and to mark orientation points on lakes. Specifications and illustrations for their use are shown in Section 14 of this manual.

Color shall conform to the chromaticity coordinates as specified by the Corps. The material to be used for the colors below (other than black) is Diamond Grade sheeting. Color reference numbers are available from the National Sign Program Manager. Material specifications are provided on page B-13c-d. Recommended material product numbers are provided in Appendix B.

Lock, dam and waterway signs are used in conjunction with the *Aids to Navigation Marking System* (U.S. Coast Guard).

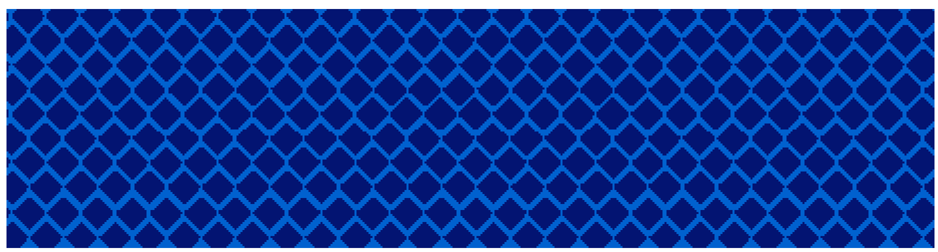
Red (RD): Background for Danger and Restricted signs; denoting an immediate hazard, and identification of restricted areas.

Lemon Yellow (LY): Background for Warning and Caution signs; warning of potential hazards.



Medium Blue (MB): Legend for Lock information/instruction signs; identifies arrival point, locking procedures, and general lock use information.

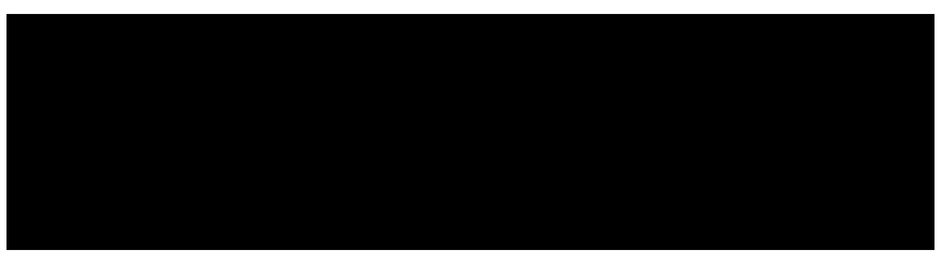
Alternate figure and field color (with white) for Lake Mile Markers and Lake Symbol Guide signs.



White (WH): Background for Lock Information Instruction signs.

Legend for Danger and Restricted signs.

Black (BK): Legend for Warning and Caution signs.



Office Interior signs for Corps buildings use the sign system described in Section 18. Shown below are the standard colors for use in this system. Only one of the standard accent colors (OD, OL, OG or WG) would be selected for a given office area. Color selected should be compatible with the existing office color scheme.

All sign legends are white (WH) and are identified using color number (01).

Office Dark Grey (DG): Background and frame color for identification and information plaques and directories (color number 44).

Office Red (OD): Background and frame color for ceiling-mounted assemblies (color number 24).

Office Blue (OL): Background and frame color for ceiling-mounted assemblies (color number 13).

Office Green (OG): Background and frame color for ceiling-mounted assemblies (color number 27).

Communication Red (CR): Background for safety-related plaques (color number 032). Panel frame to be Office Dark Grey.

Office Warm Grey (WG): Background and frame color for ceiling-mounted assemblies (color number 03).

Three different weights of the Haas Helvetica typeface have been adopted as the standard letter-style to be used on all Corps signs. These include Helvetica Bold, Helvetica Medium, and Helvetica Regular. These alphabets were selected because they are highly legible, contemporary in character, and readily available to manufacturers preparing signs for the Corps.

Shown below is a full upper/lower case display for each weight of the Helvetica letter-style. The comparative diagram on the following page illustrates the designated applications of each different weight.

Do not substitute any other typestyle for use on Corps signs.

Helvetica Bold: The wide stroke width of this letter-style creates a distinctive looking sign with simplicity. The bold letter-forms are ideally suited for signs with short legends. This typeface is used for the primary and secondary legends in identification, recreation area, industrial safety and parking signs.

**ABCDEFGHIJKLMNOPQ
RSTUVWXYZabcdefghij
klmnopqrstuvwxyz
1234567890($?!&-—“”.,;:)**

Helvetica Medium: This medium weight letter-style is used for all roadway and recreation area directional sign legends. This type is ideally suited for signs viewed from a moving vehicle. Its 5:1 letter height to stroke width ratio and large, open, lower case letters make it a very legible typeface. The Helvetica Medium typestyle should not be used on signs where the Helvetica Regular or Helvetica Bold typefaces are used.

**ABCDEFGHIJKLMNOPQ
RSTUVWXYZabcdefghijk
lmnopqrstuvwxyz
1234567890($?!&-—“”.,;:)**

Helvetica Regular: This is a thin stroke letter-style used for selected secondary legends on signs with Helvetica Bold primary legends, such as interpretative signs, and boundary signs. Helvetica Regular is also the typeface used for all interior signs.

ABCDEFGHIJKLMNOPQR
STUVWXYZabcdefghijklm
nopqrstuvwxyz
1234567890($?!&-—“”.,;:)

Designed in 1957 by Edourd Hoffman and Max Miedinger, the Helvetica family of type is registered and copyrighted by the Haas type foundry in Switzerland. Use only versions of this typeface family that have been prepared from Haas originals and licensed for use by Haas on the typesetting method used. Many unauthorized versions exist. Some differ only minutely from the authorized versions. In others, the letter-forms are distorted enough to cause a significant difference in the length of words and, consequently, in panel length. In addition, many versions are not as legible, nor visually pleasing as the correct one.

The examples below illustrate how the three different weights of the Helvetica typeface are used on the various types of signs in the Corps sign program. Although each sign type has been designed for a specific purpose, the shared typographic system gives a cohesive look to these many different types of signs.

The basic sizes of these typefaces (capital letter height) have been predetermined for each type of sign depending on the distance at which they will be viewed (see Viewing Distance Guide, page 2-6).

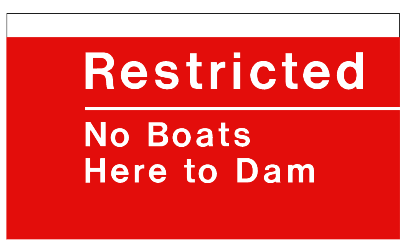
For optimum legibility, a spacing guide has been developed for each type weight (see Appendix D).

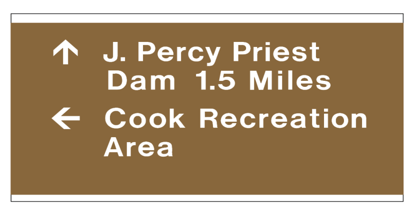
Helvetica Bold is used for all legends on Standard and Secondary Identification signs.

Helvetica Bold is used for all legends on recreation signs and as the support legends for Prohibition Symbol and Area Regulation signs.

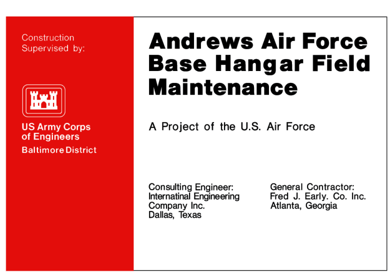
Helvetica Bold is used for all legends on Workplace Safety signs and for support legends on Parking/No Parking signs.

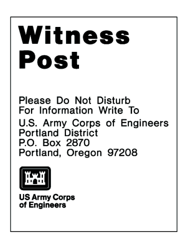
Helvetica Medium is used for all directional and water-viewed signs.





Helvetica Regular is used with Helvetica Bold on Construction Project Identification signs and Property Markers.





Letter-spacing of Typography

Proper letter spacing is critical to the legibility of a sign. Individual letters spaced too closely will cause them to run together, making it difficult to read the word. If the space between letters is too great, it is difficult to distinguish words. For this reason, letter-spacing standards have been established for all Corps signs. A list of typesetting systems that conform to Corps standards is in Appendix D.

In cases where typesetting systems that meet the Corps standards are not available, legends can be prepared using the manual letter-spacing guide described in Appendix D. This guide, while very time-consuming to use, is extremely accurate.

For reference purposes, a display of commonly used words is provided in Appendix D (pages D-18 through D-34) These words can be used to prepare legends or to verify the type and letter spacing provided by a fabricator. Note that the letter-spacing standards for identification, directional and recreation signs use one standard, while safety signs viewed from the water use a more open version to increase legibility.

For more information on letter spacing, consult your district Sign Program Manager.

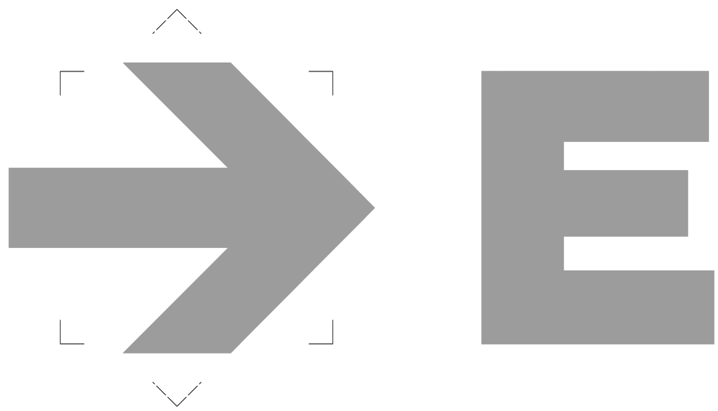
The arrows shown below are for use on Corps signs. Each arrow has been designed to be legible and, at the same time, compatible with its respective typeface.

Arrows may be placed in the directions shown. Position straight-up and left-directed arrows to the left of the legend.

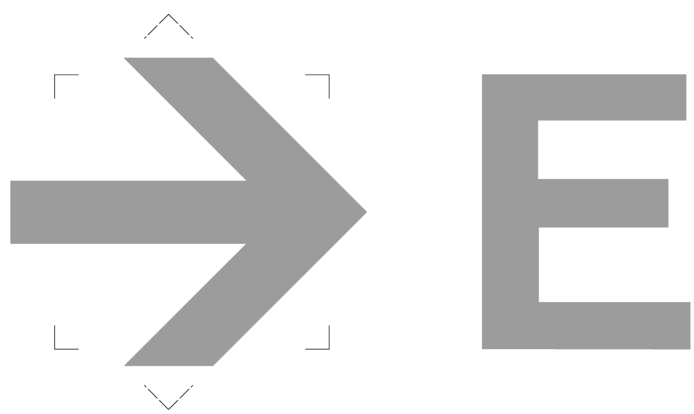
Place right-directed arrows to the right of the legend.

On signs with numerous destinations, a single arrow may be used for a group of destinations with a common direction. Place the arrow alongside the top destination in the group, either left or right of the legend as specified above.

Helvetica Bold Arrow



Helvetica Medium Arrow



Panel illustrates arrow alignment for the five different directions in which arrows may be placed on signs. Reading from left to right, the arrows show the priority of placement on a sign (see page 6-4).