2011/2012 Annual Water Quality Report

Water Quality Monitoring Program

Prepared in 2013 for

Friends of the Bay • P.O. Box 564 • Oyster Bay, New York 11771
www.friendsofthebay.org

This *2011/2012 Annual Water Quality Report* was produced in 2013. It presents and describes data and observations that were recorded by the Friends of the Bay Water Quality Monitoring Program during the sampling year as well as information regarding other activities and accomplishments since 2011.

Who We Are

Friends of the Bay (FOB) – a widely respected, not-for-profit organization with thousands of supporters – is dedicated to the protection of the Oyster Bay/Cold Spring Harbor estuary and the surrounding watershed. FOB's advocacy efforts enable the estuary to continue as an unsurpassed scenic, ecological and economically-productive resource.

Our Mission

FOB's mission is to protect, preserve and restore the ecological integrity and productivity of the Oyster Bay/Cold Spring Harbor estuary and the surrounding watershed.

What We Do

- Help to maintain clean waters that sustain a vital ecosystem, a wide range of recreation and a thriving shellfishing aquaculture business.
- Monitor water quality within the estuary.
- Create awareness of the need to preserve water quality and marine life.
- Confront unsound development proposals.
- Promote responsible development and land use planning.
- Partner with residents, organizations, and local businesses.
- Work with government at all levels.

How We Are Perceived

In June 2011, Friends of the Bay completed a Watershed Action Plan for the Oyster Bay/Cold Spring Harbor Estuary and surrounding watershed. The Watershed Action Plan is a comprehensive management plan to protect and restore water resource conditions throughout the Oyster Bay/Cold Spring Harbor Watershed. The plan recommends continuation of the ongoing monitoring programs to monitor changes in the harbor conditions as a result of changing watershed conditions and implementation of plan recommendations. Additional data collection is also recommended to refine the current understanding of water quality impairments in the estuary complex, particularly pollutants for which previous monitoring results have demonstrated the potential for water quality impairment but which are not currently identified by NYSDEC as a listed cause of impairment (e.g., sediment, nutrients, dissolved oxygen.)

A State of The Watershed Report was completed in October of 2009. This report summarizes existing environmental and land use conditions in the watershed. It is a comprehensive document that integrates many environmental indicators to assess the current health of the watershed and potential future threats. The report provides a baseline assessment of watershed conditions, which can be updated periodically to to evaluate changes in the watershed and help direct watershed management planning.

In April of 2009 Friends of the Bay was awarded the Region 2 Environmental Quality Award by the Environmental Protection Agency for its water quality monitoring program. This award recognizes individuals and organizations that have significantly contributed to improving environmental quality during the prior year; have demonstrated a high level of achievement; and have created unique or location-specific benefits, produced results that are sustainable or reproducible, or increased public involvement in environmental action.

In 1997, we became one of the few East Coast groups ever to receive the prestigious Walter B. Jones Memorial and NOAA (National Oceanic and Atmospheric Administration) Excellence Award in Coastal and Ocean Resource Management presented to the "Non-Governmental Organization of the Year." In 1999, the New York Chapter of the American Planning Association honored FOB with an Award for Meritorious Achievement. Friends of the Bay was selected in the "Best Environmental Organizations" category of the *Long Island Press'* Best of Long Island 2013 issue.(This is the sixth year the readers of the *Long Island Press* selected us as their choice in this category.)

More importantly, our cooperative planning efforts are models for local governments and other environmental groups around Long Island Sound that seek to prepare watershed management plans to protect their embayments and reap the benefits of a cleaner Sound.

Our History

FOB was formed in 1987 by a small group of citizens who were concerned about the impact of a proposed development on the Oyster Bay waterfront at the former Jakobsen Shipyard site. After defeating the environmentally destructive proposal, FOB led an extraordinary public process that resulted in the "Land Use Plan for the Oyster Bay Western Waterfront." Today, the Water Front Center for Marine Education is located on that site.

Since our founding, we have grown into a powerful voice representing approximately 3,000 members. The New York Times has identified Friends of the Bay as one of the most effective environmental organizations around Long Island Sound. In 1997, we received the prestigious Walter B. Jones Memorial and National Oceanic and Atmospheric Administration Excellence Award for Coastal and Resource Management as the "Non-Governmental Organization of the Year".

In 2009 FOB was awarded a Region 2 Environmental Quality Award by the Environmental Protection Agency for its citizen water quality monitoring program.

Today, FOB in addition to conducting water quality monitoring in Oyster Bay and Cold Spring Harbor, we also sponsors community events on the water and beach and works with citizens and local government for wetland restoration and habitat protection. We are monitoring progress on Eastern Waterfront planning, involving land owners, town and state governments and continuing to involve citizens in the process.

Table of Contents

2011/2012 Annual Water Quality Report
Water Quality Monitoring Program
Friends of the Bay

Table of Contents

2011/2012 Annual Water Quality Report
Water Quality Monitoring Program
Friends of the Bay

Tables **Page**

Figures **Page**

Table of Contents

2011/2012 Annual Water Quality Report
Water Quality Monitoring Program
Friends of the Bay

Appendices

Acknowledgements

Friends of the Bay would like to thank the individuals and organizations that make our Water Quality Monitoring Program possible.

National Fish and Wildlife Foundation – Provided a portion of the funding necessary to conduct our Water Quality Monitoring Program.

Frank M. Flower and Sons, Inc. – Dwight and Dave Relyea and Joseph Zahtila, owners of Frank M. Flower and Sons, Inc. have provided dock space, use of boats, and logistical support for Friends of the Bay's monitoring program since 1992.

Oyster Bay Marine Center – Donates fuel for the Baywatch II each year.

Bridge Marina – Richard Valicenti and his staff continuously provide support to Friends of the Bay through repairs, parts, service, and advice for our vessel, the "Baywatch II".

Nassau County Department of Health – Nassau County Department of Health donates laboratory testing services for bacteria samples collected by FOB.

Analytical Chemists Laboratory LLC – Donates their laboratory services for the testing of nitrates, nitrites, total nitrogen, ammonia-N, and organic nitrogen once per month as part of our Water Quality Monitoring Program.

Boat Captains:
Hank Kasven (Syosset)
Scott Sayer (Northport)

Citizen Scientists:
Jonathan Belz
Terri Felske
Ken Guenther
Terry Kattleman
Lorna Mann
Carla Panetta
Christine Pfoertner (SUNY Stonybrook)
Barbel Polansky
Denise Wurtz

Locust Valley High School Students and Teachers:
Chris Hoppner (teacher)
Christine Boutros (student)
Kendall Christian (student)
Kevin Placillo (student)
Preston Tansill (student)
Sarah White (student)

FUSS & O'NEILL

Executive Summary

Friends of the Bay's Water Quality Monitoring Program is an important component of our efforts to protect the Oyster Bay/Cold Spring Harbor estuary and the surrounding watershed while serving to increase public awareness of local threats to water quality. This program was developed in cooperation with the United States Fish and Wildlife Service, United States Environmental Protection Agency, New York State Department of Environmental Conservation, local governments, and other volunteer monitoring groups around Long Island Sound.

Friends of the Bay (FOB) conducts water quality monitoring in accordance with a Quality Assurance Project Plan (QAPP) approved by the Environmental Protection Agency (EPA). The QAPP formalizes the quality assurance procedures for the data collection portions of our open water body monitoring program, and will ensure that our data can be used by EPA and other government agencies. The QAPP includes many procedures that were already implemented by Friends of the Bay, and introduces a few new quality assurance steps as well.

During 2011 and 2012, FOB continued data collection in support of the long-term open water body monitoring program. Once a week since 2000, from spring through fall, FOB has collected water quality data in Mill Neck Creek, Oyster Bay Harbor, and Cold Spring Harbor. In 2011, FOB collected samples during 24 separate monitoring events between April 4th and October 31st (21 Mondays, 2 Tuesdays, and 1 Wednesday; 5 planned monitoring dates were cancelled for all locations due to inclement weather conditions), collected numerous samples that were analyzed for bacteria (471 samples each for fecal coliform and enterococci) and nitrogen pollution (approximately 88 samples for each parameter), recorded hundreds of measurements each of dissolved oxygen, temperature, pH, and salinity (averaged 449 measurements), and measured water clarity 464 times.

In 2012, FOB collected samples during 29 separate monitoring events between April 2nd and October 29th (23 Mondays, 5 Tuesdays, and 1 Sunday; 7 planned monitoring dates were cancelled for all locations due to inclement weather conditions), collected samples that were analyzed for bacteria (approximately 360 samples each for fecal coliform and enterococci) and nitrogen pollution (approximately 100 samples for each parameter), recorded hundreds of measurements each of dissolved oxygen, temperature, pH, and salinity (averaged 330), and measured water clarity 360 times.

FOB monitored 19 open water body locations within Cold Spring Harbor (FB-1 through FB-4), Oyster Bay Harbor (FB-5 through FB-12), and Mill Neck Creek (FB-13 through FB-19). Each site was monitored in the morning once per week, weather and tide permitting, for dissolved oxygen, bacteria pollution, salinity, temperature, pH, and clarity. Nitrogen samples were collected approximately five times during the monitoring season.

In July 2010, FOB added three monitoring locations in Laurel Hollow (LH-1, LH-2, and LH-3) to the open water body monitoring program at the request of the Village of Laurel Hollow and Nassau County Department of Health (NCDH). The Laurel Hollow locations were sampled in 2011 but not in 2012.

Three major water quality parameters were monitored in 2011 and 2012: bacteria levels, dissolved oxygen levels, and nitrogen concentrations. Analysis of the 2011 and 2012 open water body monitoring data provided useful insights into the estuary's water quality.

As observed in previous years, bacteria levels in Mill Neck Creek and Cold Spring Harbor were generally higher than in Oyster Bay Harbor. In both 2011 and 2012, bacteria levels exceeded the fecal coliform standard at FB-1, FB-2, FB-3, FB-7, FB-8, FB-10, FB-13, FB-14, FB-15, FB-16, FB-17, FB-18, FB-19, LH-1, LH-2, and LH-3 (Laurel Hollow stations were only sampled in 2011). These results are encouraging, since the majority of Oyster Bay Harbor met the standard for fecal coliform (FB-1, FB-2, and FB-3 are located in Cold Spring Harbor, FB-7 is located in the center of Oyster Bay Cove, FB-8 is located just west of Oyster Bay Cove, FB-10 is located near Beekman Creek, FB-13 through FB-19 are located in Mill Neck Creek, and LH-1 through LH-3 are located in Laurel Hollow). Oyster Bay Harbor is where the majority of shellfishing occurs in the estuary.

Geometric mean levels of fecal coliform decreased in Cold Spring Harbor in 2011 and 2012. In Mill Neck Creek, the geometric mean levels increased significantly in 2011 and then decreased significantly in 2012. The levels were similar to past years in Oyster Bay Harbor. All locations experienced increased geometric means from fecal coliform levels reported in 2006 (area's average lowest level on record), although the 2012 levels are the lowest reported since 2006. The enterococci geometric means followed a similar trend recorded for fecal coliform in 2011 and 2012 – Cold Spring Harbor remained similar to 2011, although it decreased from 2010 geomean concentrations, Mill Neck Creek increased significantly in 2011 and then decreased significantly in 2012, and Oyster Bay remained constant from 2010 levels.

The nitrogen monitoring results for 2011 and 2012 indicate that none of the monitoring locations would have met the nitrogen guideline for salt water that New York State applies to the Peconic Bay estuary (Total Nitrogen greater than 0.5 mg/l), if that guideline were applied to Oyster Bay. Conversely, with the exception of FB-12 during the 2012 monitoring season, all monitoring locations had ammonia levels well below the State standard (0.23 mg/l). In the case of station FB-12, a single elevated sample value caused the seasonal average to exceed the standard; the average of 2012 events without this high value was 0.025 mg/l, well below the standard. The seasonal average for all locations was 0.08 mg/l in 2011 and 0.05 mg/l in 2012.

A $10.6 million advanced wastewater treatment facility serving the Oyster Bay Sewer District (OBSD) went online in December 2005. Microorganisms used to seed the plant were delivered in mid-January 2006, and the plant was fully operational in March 2006. The facility, a Sequencing Batch Reactor, is achieving the 2014 nitrogen limits imposed by the New York State Department of Environmental Conservation. The upgrade has reduced daily nitrogen discharges by as much as 75%. With the completion of this plant, the Friends of the Bay nitrogen monitoring data provide a valuable baseline in evaluating the effect of reduced nitrogen loading on the estuary. The upgrade represents an important improvement in infrastructure available to the public, which should improve water quality of the estuary.

Dissolved oxygen (DO) data was collected throughout the estuary during the open water body monitoring season. In 2011 and 2012, as well as in past years, DO trends indicate that the waters of the estuary are enriched with nutrients consistent with the nitrogen monitoring observations, since dissolved oxygen levels decrease steadily from spring through late summer, and then begin to increase in late summer. Nutrient enrichment can result from inadequately treated sewage discharges, polluted stormwater runoff, over-fertilization of lawns and gardens, agricultural runoff, and atmospheric deposition of air pollutants. Long-term reductions in nitrogen inputs should reduce the occurrence of extremely low DO conditions in the bottom of the harbor.

Friends of the Bay also continued to implement a stream and outfall monitoring program in 2011. The goal of the stream and outfall monitoring program is to establish current baseline water quality conditions, identify water quality impacts from potential point and non-point pollution sources, develop a water quality database for the watershed to guide environmental decision-making, and measure the progress toward meeting water quality goals in the estuary watershed. A QAPP has been approved for this monitoring program. This monitoring program, initiated in 2007, includes the sampling of 10 major discharges (OBS 1-10) into the Oyster Bay/Cold Spring Harbor estuary. These discharges include streams, ponds, a formerly untreated sewage discharge ("The Birches"), and a 'rotating' outfall that can change for each event in an effort to identify other pollutant sources.

"The Birches" is a 49-home Locust Valley community that has been dealing with a failing sewage treatment system for over 40 years. In 1983, a chlorination tank was installed to reduce bacteria contamination to Mill Neck Creek, but the treated wastewater continued to not meet NYSDEC standards. In 2009, it was announced that the Town of Oyster Bay, Nassau County, and NYSDEC would be initiating a joint $13.2 million improvement project to remedy the problem. The construction of this sewer remediation project was initiated in April 2009. As of April 2011, sewage infrastructure upgrades have been completed and all the homes in the Birches residential subdivision have been connected to the Glen Cove sewage treatment plant. The average bacteria levels recorded at Mill Neck Creek monitoring locations decreased significantly (>50% for both fecal coliform and enterococci) from the 2011 to the 2012 sampling seasons. These reductions are an early indicator of the potential water quality improvements resulting from the sewage infrastructure upgrades. Additional monitoring data is necessary to verify these observations and document water quality trends. Friends of the Bay will continue to monitor these sites to continue documenting improvements to the water quality in Mill Neck Creek.

Although stream and outfall monitoring has been conducted as eight discrete events over five years (no samples collected in 2012), some initial observations can be made. Overall, DO values have remained fairly consistent over the sampling period since 2007 and are in the range of 6-14 mg/l. Samples were collected for *E.coli* and fecal coliform during one of the two monitoring events in 2011. The results of this event were within the range of values observed since 2007. Continued monitoring is necessary to further evaluate the presence of potential trends. pH values remain relatively consistent and within a desirable range. Specific conductivity measurements remain relatively consistent over time and at all stations. In general, ammonia levels were observed above the reporting limit in 2011, consistent with past years. The maximum reported ammonia concentration in 2011 compared to other years. Nitrate levels were consistently elevated at The Birches (OBS -1), and the highest metals values were observed at that station in 2008 and 2010. Additional data will help to further identify potential pollution sources associated with the streams and outfalls and their respective drainage areas.

In June 2011, Friends of the Bay completed a Watershed Action Plan for the Oyster Bay/Cold Spring Harbor Estuary and surrounding watershed. The Watershed Action Plan is a comprehensive management plan to protect and restore water resource conditions throughout the Oyster Bay/Cold Spring Harbor Watershed. The plan recommends continuation of the ongoing monitoring programs to monitor changes in harbor conditions as a result of changing watershed conditions and implementation of plan recommendations. Additional data collection is also recommended to refine the current understanding of water quality impairments in the estuary complex, particularly pollutants for which previous monitoring results have demonstrated the potential for water quality impairment but which are not currently identified by NYSDEC as a listed cause of impairment (e.g., sediment, nutrients, dissolved oxygen).

Friends of the Bay looks forward to working with citizen scientists, government agencies, and fellow not-for-profit organizations in future monitoring seasons. Together, FOB and its partners will continue to improve and expand their monitoring efforts. These efforts will provide a link to show how investment in water quality protection is affecting the quality of water in Mill Neck Creek, Oyster Bay Harbor and Cold Spring Harbor.

1 Introduction

Friends of the Bay (FOB) is a widely-respected non-profit environmental organization located on the North Shore of Long Island. The mission of FOB is to protect, preserve, and restore the ecological integrity and productivity of the Oyster Bay/Cold Spring Harbor estuary and the surrounding watershed[1]. *Appendix A* presents a fact sheet for the estuary.

The Oyster Bay/Cold Spring Harbor estuary complex consists of a unique ecosystem in close proximity to New York City. Consider:

- Oyster Bay (Mill Neck) is among the 33 Inaugural Stewardship Areas listed within the Long Island Sound Stewardship Initiative 2006 Atlas.[2]
- The U.S. Fish & Wildlife Service maintains a 3,209 acre National Wildlife Refuge (NWR) within the Oyster Bay/Cold Spring Harbor Estuary Complex.[3]
- Two State-designated Significant Coastal Fish and Wildlife Habitat areas exist within the Oyster Bay/Cold Spring Harbor Estuary Complex.[4]
- More than 80 commercial baymen annually harvest up to 90% of New York State's oyster crop[5] and 33% of hard clams[6] from the Oyster Bay NWR.
- The Harbor Complex is home to the Cold Spring Harbor Fish Hatchery & Aquarium. The Hatchery is proud to have the largest living collection of New York State freshwater reptiles, fish, and amphibians.
- Oyster Bay is a designated New York State "historic maritime area."
- The oldest traditional shellfish farmer in New York State, Frank M. Flower and Sons (est. 1887), operates out of Oyster Bay. Frank M. Flower and Sons is the only traditional oyster company still in operation on Long Island (C.Blair, Newsday.com).
- Oyster Bay is designated as an Important Bird Area by the National Audubon Society.

The FOB Water Quality Monitoring Program was initiated to continue data collection efforts that would have been terminated due to budget cuts by Nassau County. This program was developed in cooperation with the United States Environmental Protection Agency (EPA), New York State

---

[1] Friends of the Bay Mission Statement as of 2005

[2] The Stewardship Initiative identifies places with significant biological, scientific, or recreational value throughout Long Island Sound and works to develop a strategy to protect and enhance those special places. The Stewardship Initiative has five specific goals: 1) Preserve native plant and animal communities and unique habitat types; 2) Improve recreation and public access opportunities; 3) Protect threatened and endangered species in their natural habitats; 4) Preserve sites that are important for long-term scientific research and education; and 5) Promote efforts to plan for multiple uses. For additional information, visit http://longislandsoundstudy.net/stewardship/stewardship_atlas06.pdf

[3] http://refuges.fws.gov/profiles/WildHabitat.cfm?ID=52563

[4] http://www.nyswaterfronts.com/waterfront_natural_narratives.asp; For almost two decades, there have been three State designated Significant Coastal Fish and Wildlife Habitats within the Oyster Bay/Cold Spring Harbor Estuary: Cold Spring Harbor, Oyster Bay Harbor, and Mill Neck Creek Wetlands (these habitat designations originated in 1987). On October 15, 2005, The New York State Department of State recommendations to consolidate these designations became effective. The two habitats now include 1) Mill Neck Creek, Beaver Brook, and Frost Creek, and 2) Oyster Bay and Cold Spring Harbor.

[5] http://refuges.fws.gov/profiles/index.cfm?id=52563

[6] 2004 New York Annual Shellfish Landings, New York State Department of Environmental Conservation

Department of Environmental Conservation (DEC), local governments and other volunteer monitoring groups around the Long Island Sound. Friends of the Bay considers this program a necessary component in the effort to preserve the Oyster Bay/Cold Spring Harbor ecosystem and hopes to increase public awareness of local threats to water quality. The water quality program of Friends of the Bay is being conducted to:

1. Provide high quality data to continue the dissolved oxygen-testing baseline established by the Nassau County Department of Health in 1972.
2. Screen for water quality impairments.
3. Monitor the estuary in support of the Total Maximum Daily Load (TMDL) for pathogens that has been established for Oyster Bay and Mill Neck Creek[7].
4. Determine long-term water quality trends.
5. Document effects of water quality improvements.
6. Educate and involve citizens and public officials about water quality protection.
7. Watchdog activity within the watershed and harbor.
8. Assist local, State, and Federal agencies in harbor management by providing data.

This program enables trained citizen scientists working alongside Friends of the Bay staff to monitor various components of the marine ecosystem. Citizen scientists track a number of parameters in the estuary including water temperature, pH, clarity, salinity, dissolved oxygen, nitrogen, enterococci bacteria, and fecal coliform bacteria. Measuring these parameters enables Friends of the Bay to better understand changes within the local marine ecosystem. The design of the program was reviewed and approved by the EPA in May of 2006 through Friends of the Bay's *Open Water Body Water Quality Monitoring Program Quality Assurance Project Plan* (QAPP).

A Memorandum of Understanding exists between Friends of the Bay and the U.S. Fish and Wildlife Service as well.[8] In this agreement, Friends of the Bay supplies collected data to the Fish and Wildlife Service. The objectives of this cooperative effort are to support long-term water quality monitoring within Oyster Bay Harbor, Mill Neck Creek, and Cold Spring Harbor, and waterways contained within the Oyster Bay National Wildlife Refuge in addition to cooperative efforts on environmental education, interpretation, and outreach projects.

This Annual Water Quality Report summarizes the data collected during the 2011 and 2012 monitoring seasons as well as the results of the stream and outfall monitoring program, which was initiated in 2007. This report was produced in 2013 as part of Friends of the Bay's continuing commitment to study the complex factors that impact water quality within the estuary and the surrounding watershed.

2 Watershed Management

In June 2011, Friends of the Bay completed a watershed management plan for the Oyster Bay/Cold Spring Harbor Estuary and surrounding watershed. The watershed management plan was developed in

[7] *Pathogen Total Maximum Daily Loads for Shellfish Waters in Oyster Bay Harbor and Mill Neck Creek*. NYSDEC (2003)

[8] Under the authority of the *U.S. Fish and Wildlife Coordination Act,* as amended, (16 U.S.C. Section 661) and Section 7 of the *Fish and Wildlife Act of 1956* [16 U.S.C. 742F(a)(4)], and the *Interior and Related Agencies Appropriation Act of 1992* (PL 102-154, Title 1, 105 Stat. 995.)

two phases – a State of the Watershed Report and a Watershed Action Plan – following an approach endorsed by the U.S. Environmental Protection Agency (EPA), the NYSDEC, and the New York State Department of State (NYSDOS) Division of Coastal Resources for developing watershed-based plans.

The State of the Watershed Report, prepared on behalf of Friends of the Bay in November 2009 (Fuss & O'Neill, Inc.), summarized existing environmental and land use conditions within the Oyster Bay/Cold Spring Harbor watershed. The State of the Watershed Report integrated a variety of environmental indicators to assess the current health of the watershed and potential future threats. The report provided a baseline assessment of watershed conditions, which can be updated periodically to evaluate changes in the watershed and help direct watershed management planning. The State of the Watershed Report therefore serves as the basis for the Watershed Action Plan.

This Watershed Action Plan identifies prioritized action items to protect and improve the health of the Oyster Bay/Cold Spring Harbor watershed and estuary. The plan has been developed to address the priorities and issues identified in the State of the Watershed Report, with significant participation by a steering committee of interested stakeholders and the public. The Watershed Action Plan is designed to have the clear potential to affect on-the-ground change within the watershed by recommending specific, measurable actions to protect and improve water resource conditions.

The Watershed Action Plan recommends continuation of the ongoing monitoring programs to monitor changes in harbor conditions as a result of changing watershed conditions and implementation of plan recommendations. Additional data collection is also recommended to refine the current understanding of water quality impairments in the estuary complex, particularly pollutants for which previous monitoring results have demonstrated the potential for water quality impairment but which are not currently identified by NYSDEC as a listed cause of impairment (e.g., sediment, nutrients, and dissolved oxygen).

3 Monitoring Program

3.1 Open Water Body Monitoring

Every Monday[9] morning from April through October 2011 and 2012, Friends of the Bay staff and citizen scientists collected data on water quality and ambient conditions at 22 open water body sites throughout the estuary complex. The parameters measured by Friends of the Bay included dissolved oxygen, salinity, water temperature, pH, water clarity, coliform bacteria, and nitrogen species.

Dissolved oxygen, salinity, pH, and water temperature were measured using a Hydrolab Quanta. The instrument includes a probe that is lowered within the water column to analyze the water's attributes in-place and a handheld datalogger that interprets the probe measurements and displays them for the sampler.

[9] Monitoring is conducted on Tuesday when Monday is a holiday

Water clarity was measured using a Secchi disk, a circular disk with opposing white and black quadrants that is lowered into the water column to the depth at which it can no longer be distinguished by an observer at the surface.

Water samples for coliform bacteria and nitrogen measurement were also collected by Friends of the Bay and analyzed by the Nassau County Department of Health (NCDH) and Analytical Chemists, respectively.

Field measurements collected and observations made at the time of sampling were recorded on field water quality monitoring sheets, which are presented in *Appendix C*. The following is a summary of the water quality testing locations and methods. These methods are consistent with the Standard Operating Procedures and Quality Assurance Project Plan that were approved by the EPA in May of 2006.

3.1.1 Monitoring Locations

Friends of the Bay monitored a total of 22 open water body sites throughout the Oyster Bay/Cold Spring Harbor estuary, including locations FB-5 through FB-12 in Oyster Bay Harbor, FB-1 through FB-4 in Cold Spring Harbor, FB-13 through FB-19 in Mill Neck Creek, and LH-1 through LH-3 in Laurel Hollow. A map identifying the approximate location of each site and a table of coordinates (latitude/longitude) for each station are included in *Appendix B*. The Laurel Hollow sites were added at the request of the Nassau County Department of Health and the Incorporated Village of Laurel Hollow to evaluate potential causes of high coliform levels leading to beach closures at the Village of Laurel Hollow.

The Oyster Bay/Cold Spring Harbor estuary station locations and identifiers were revised in 2003, so care should be used when comparing results from 2003 through 2012 to results presented in the 2002 monitoring report.

3.1.2 Monitoring Methods

Friends of the Bay monitored each open water body site for the following water quality parameters:

- **Dissolved Oxygen, Water Temperature, and pH** – Dissolved oxygen (DO), water temperature, and pH were measured at 22 monitoring sites using the Hydrolab Quanta datalogger and sonde. At each station, dissolved oxygen readings were taken at approximately one half-meter above the bay bottom, one-half meter below the water surface, and one meter below the water surface (depth permitting). The DO data was measured and recorded in milligrams per liter (mg/l), which is equivalent to parts per million (ppm). The measured values are then compared to ranges that describe the effect of dissolved oxygen on aquatic life, which are well established. In general, dissolved oxygen levels above 5 mg/l are preferred. Levels between 4 and 5 mg/l can cause harm to some species of organisms, especially the larvae of crustaceans such as lobster and crabs. Levels between 2 and 4 mg/l can cause harm to many organisms if exposure is prolonged. When dissolved oxygen levels decline below 2 mg/l, many organisms can be harmed quickly. Few organisms can survive exposure to levels below 1 mg/l for more than very short periods.
- **Salinity** – Salinity is the measurement of the concentration of dissolved salts in the water. Friends of the Bay monitored salinity with the Quanta meter, which measures specific

conductivity (a direct measurement of the ease with which electricity passes through water) and converts that measurement to salinity. In earlier years, Friends of the Bay monitored salinity with a hydrometer, an instrument used to measure the specific gravity of liquids.

- **Water Clarity** – Friends of the Bay measured water clarity with a Secchi disk. The 8-inch diameter disk is divided into alternating black and white quadrants. The disk is lowered into the water with the sun at the citizen scientist's back. The point at which the disk becomes completely obscured is noted. The disk is then raised and the point at which the disk becomes visible again is noted. The average of these two numbers is the Secchi Depth, recorded to the nearest tenth of a meter (decimeter).
- **Bacteria** – Water samples were collected by Friends of the Bay in sterile bottles approximately one foot below the water surface. The bottles, supplied by NCDH, are then stored in a cooler with ice and transported immediately to the NCDH laboratory in Hempstead for analysis. The NCDH uses the Multiple-Tube Fermentation Technique - Method No.9221 (Standard Methods for the Examination of Water and Wastewater, 1995), which uses a 5-tube decimal dilution test. The level of fecal coliform bacteria and enterococci in a water sample is expressed as the most probable number per 100ml (MPN/100ml). A trip blank, supplied by the NCDH laboratory, is used to ensure that proper temperature standards are met. It is placed in the cooler with the ice and, upon arrival at the NCDH laboratory; the trip blank temperature is immediately recorded. If the trip blank exceeds 6°C, NCDH laboratory personnel flag the results on the chain of custody form and then Friends of the Bay flags the data in the electronic database.
- **Nutrients** – Nitrogen species water samples were collected at the Oyster Bay/Cold Spring Harbor estuary stations from the water surface in plastic bottles prepared byAnalytical Chemists. The bottles contain sulfuric acid and are placed into a cooler with ice packs. Once filled, they are transported to Analytical Chemists, located in Farmingdale, New York. The water samples are analyzed for common forms of nitrogen, including nitrate/nitrite, ammonia, and organic nitrogen, collectively called nitrogen species. The techniques used for analysis include the following methods from APHA and AWWA (1995): Nitrate/nitrite-N (mg/l) 4500-NO_3 -E & 4500-NO_2-B, Total Kjeldahl Nitrogen (mg/l) 4500-N_{org}-B, Ammonia-N (mg/l) 4500-NH_3-D. Total Kjeldahl Nitrogen (TKN) measures oxidizable nitrogen, including organic and ammonia nitrogen concentrations collectively. Organic nitrogen levels are then calculated as the difference of TKN and ammonia. Total nitrogen can be calculated by adding TKN and nitrate/nitrite results.
- **Other Parameters** – Other information collected at the sites include: the time the sample was collected; qualitative description of rainfall in the previous 24 hours; tidal stage (scale of 1-4), air temperature (°C); wind direction (1 of 8 directions); wind speed (estimated in 5-mph increments); wave height (subjective, on a scale of 0-5); weather conditions (on a predetermined 1-6 scale); water color (subjective color, e.g. yellow-brown), cloud cover (0-5 scale) and any unusual conditions (i.e., odors, fish kills, debris).

3.1.3 Quality Assurance and Control

The 2006 season was the first in which Friends of the Bay implemented a QAPP that was prepared for the open water body monitoring project. The QAPP was prepared with assistance from Fuss & O'Neill, approved by the EPA, and was implemented by Friends of the Bay in June 2006. Friends of the Bay performed many of the tasks required by the QAPP in earlier years, but the QAPP provides a procedural framework to ensure that the data collected meets EPA standards. Friends of the Bay continued to implement the QAPP during the 2011 and 2012 monitoring seasons. The QAPP includes:

- Formalized monitoring locations and standard parameter list.
- Defined sampling analysis procedures.
- Required collection of duplicate samples.
- Validation of field data through calibration checks and validation with other measurement methods.

The QAPP can be viewed at Friends of the Bay's office in Oyster Bay and is posted on their website at www.friendsofthebay.org.

It should be noted that data generated by the water quality meter was not consistently validated through calibration checks (e.g., titration) and when the titrations were completed the QA/QC readings were found to be outside of the acceptable range (deviate more than 0.5 mg/l) for approximately 29% of the checks performed in 2011 (12% were 2 or more failed titrations per sampling event, 3 total checks per event) and 24% of the checks performed in 2012 (18% were 2 or more failed titrations per sampling event, 3 total checks per event), such that some of the collected data does not meet QA/QC requirements of the QAPP. It should be noted that some of the titration failures were close to the acceptance criterion (deviations of between 0.5 and 1.0 mg/l). Friends of the Bay is working to improve the quality of data collected through citizen scientist training to reduce QA/QC discrepancies.

3.2 Stream and Outfall Monitoring Program

A stream and outfall monitoring program was initiated in 2007 to establish current baseline water quality conditions in the watershed, identify water quality impacts from potential point and non-point pollution sources, develop a water quality database for the watershed to guide environmental decision-making, and measure the progress toward meeting water quality goals in the Oyster Bay/Cold Spring Harbor estuary watershed.

3.2.1 Monitoring Locations

Friends of the Bay monitored a total of 10 major discharges (OBS 1-10) into the estuary in 2011. These discharges included streams, ponds, an untreated sewage discharge, and a 'rotating' outfall that can change for each event in an effort to identify other pollutant sources. A map identifying the approximate location of each site and a table of coordinates (latitude/longitude) for each station are included in *Appendix B*.

3.2.2 Monitoring Methods

Friends of the Bay monitored each stream and outfall site for the following water quality parameters:

- **Field Parameters** – Dissolved oxygen (DO), water temperature, and pH were measured at 10 monitoring sites using the Hydrolab Quanta datalogger and sonde. The DO data was measured and recorded in milligrams per liter (mg/l), which is equivalent to parts per million (ppm).

- **Salinity** – Salinity is the measurement of the concentration of dissolved salts in the water. Friends of the Bay monitored salinity with the Quanta meter, which measures specific conductivity (a direct measurement of the ease with which electricity passes through water) and converts that measurement to salinity.
- **Bacteria** – Water samples are collected by Friends of the Bay in sterile bottles approximately one foot below the water surface. The bottles, supplied by NCDH, are then stored in a cooler with ice and transported immediately to the NCDH laboratory in Hempstead for analysis. See *Section 1.1.2* for additional description regarding the bacteria sampling and analysis techniques used.
- **Nutrients** – Nitrogen species water samples are collected in plastic bottles prepared by South Malls Analytical Labs containing sulfuric acid and placed into a cooler with ice packs. They are then transported to South Mall Analytical Labs located in Plainview, New York. The water samples are analyzed for common forms of nitrogen, including nitrate/nitrite, ammonia, and organic nitrogen, collectively called nitrogen species. See *Section 1.1.2* for additional description regarding the nutrient sampling and analysis techniques used.
- **Metals** – Samples were collected in plastic bottles prepared by South Malls Analytical Labs containing nitric acid and analyzed for hardness (mg/l), lead (mg/l), copper (mg/l), and zinc (mg/l).
- **Other Parameters** – Other information collected at the sites include: the time the sample was collected; air temperature (°C); qualitative description of rainfall in the previous 24 hours, water color (scale of 0-3), water odor (scale 0-3), particulates (scale 0-3), and floatables (scale 0-3).

3.2.3 Quality Assurance and Control

The 2007 season was the first monitoring season in which Friends of the Bay implemented a QAPP for the stream and outfall monitoring program. The QAPP was prepared with assistance from Fuss & O'Neill, approved by EPA, and was implemented by Friends of the Bay in November 2007. The QAPP includes:

- Formalized monitoring locations and standard parameter list.
- Defined sampling analysis procedures.
- Required collection of duplicate samples.

4 Results, Analysis, and Discussion

4.1 Open Water Body Monitoring

With the help of citizen scientists, Friends of the Bay monitored water quality at a total of 22 open water body locations on 25 monitoring dates (22 Mondays, 2 Tuesdays, and 1 Wednesday; 5 planned monitoring dates were cancelled for all locations) from April through October, 2011 and 29 monitoring dates (23 Mondays, 5 Tuesdays, and 1 Sunday; 7 planned monitoring dates were cancelled for all locations) from April through October, 2012. Four sites are located in Cold Spring Harbor, eight are located in Oyster Bay Harbor, seven are located in Mill Neck Creek, and three are located in Laurel Hollow. Data collected during this season was analyzed both spatially (differences between areas in the estuary) and temporally (changes throughout the season) and compared to results recorded during previous seasons. The estuary was considered as a whole, and in terms of the four primary water bodies that comprise the estuary: Cold Spring Harbor (monitoring locations FB-1 through FB-4), Oyster Bay Harbor (FB-5 through FB-12), Mill Neck Creek (FB-13 through FB-19), and Laurel Hollow (LH-1 through LH-3)

These major water bodies are distinguished by hydrographic separations and differ in terms of physical characteristics, use, watershed features, and tidal influence (see Monitoring Locations Map in *Appendix B* and Tide Charts in *Appendix D*). Relatively narrow constrictions separate each water body. Plum Point separates Oyster Bay Harbor from Cold Spring Harbor, and the narrows at the Bayville Bridge divide Oyster Bay Harbor from Mill Neck Creek. Mill Neck Creek is shallow and likely to be more influenced by tributary inflows than the other hydrographic areas. Oyster Bay Harbor contains a large mooring area and industrial facilities, is more densely developed on its south shore, and is somewhat separated from Long Island Sound by Centre Island and the landmass that includes incorporated and unincorporated parts of Bayville. Cold Spring Harbor is open to Long Island Sound and is likely to be most rapidly impacted by tidal inflows and water quality within the Sound. Tributaries flowing into the estuary include Whites Creek, Mill River, Beaver Brook, Spring Lake, Tiffany Creek, Cold Spring Brook, and others.

A long-term data analysis was performed in January 2009. This analysis evaluated the open water body water quality monitoring data that was collected by the Friends of the Bay from 2000 to 2006. The data was evaluated for spatial and temporal trends in order to identify how water quality in the Oyster Bay/Cold Spring Harbor estuary has changed and the progress that has been made as a result of management efforts to address water quality problems in the estuary.

In July 2010, Friends of the Bay added three sites in Laurel Hollow (LH-1, LH-2, LH-3) to the open water body monitoring program and continued to sample them in 2011 at the request of the Village of Laurel Hollow and NCDH. The beaches in this area were being closed by the NCDH's onshore monitoring. However, the high, intermittent coliform levels did not appear to be correlated with high or low tides. Dye testing of cesspools was completed in the area but there were no significant deficiencies found. The NCDH also suspected sewage dumping by recreational boaters may be the source; however, the moorings in the area are for very small vessels – most without onboard sanitary facilities. The NCDH concluded that the exceedences were most likely caused by the Canada geese that frequent the open lawn areas upstream of the beach.

4.1.1 Physical Parameters

Salinity, water temperature, pH, air temperature, and water clarity were measured at each open water body sampling station throughout the 2011 and 2012 monitoring seasons. These physical parameters can impact environmental and ecological conditions within the estuary. *Figure 1* shows air temperature and total rainfall data averaged by sampling season (April through October) in Oyster Bay from 2000 through 2012.

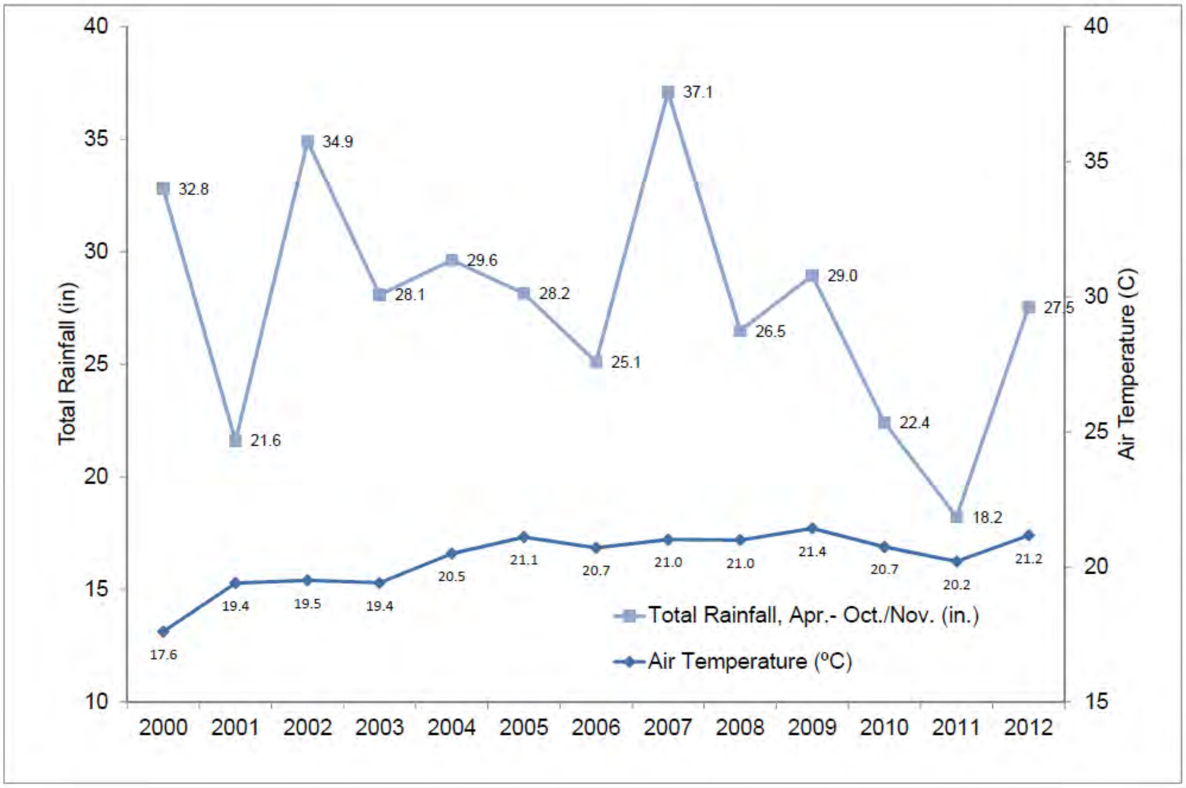

Figure 1. Physical conditions in the Oyster Bay/Cold Spring Harbor Estuary, 2000 – 2012

During the 2011 season, the total rainfall recorded was the lowest of the 13-year monitoring period – 3.4 inches below the next lowest monitoring season (21.6 inches in 2001). At Levittown, Long Island, 18.2 inches of precipitation was recorded during the 2011 monitoring season, which is significantly lower than the average seasonal precipitation from 2000 through 2010 (28.7 inches). The total rainfall during the 2012 monitoring season was 27.5 inches, which is close to the average seasonal precipitation of all eleven prior monitoring seasons (27.8 inches).

The air temperature in the Oyster Bay/Cold Spring Harbor estuary has increased approximately 3 degrees Celsius over the 13-year monitoring period. The 2012 monitoring season was the second warmest over the same monitoring period.

Secchi disk depth is an indication of water clarity. Light that penetrates the surface of the water passes through the water column, reflects off the disk, and passes back through the water column to the eye of the observer. Secchi disk depth is the depth where enough light is scattered (by objects, such as sediment particles) or absorbed (by being converted to heat or chemical energy, such as by algae) within the water column that the light reflected by the disk can no longer return to the surface. Dissolved solids, particulate solids, algae, and other biota can impact clarity in a water column. Secchi disk depths in the Oyster Bay/Cold Spring Harbor complex are generally between 2.5 and 0.5 m (the range was 3.0 to 0.1 m in 2011 and 3.8 to 0.07 m in 2012). Although the cause of the attenuation has not been studied in detail, it is likely to be caused by algal growth fueled by nitrogen inputs to the Bay.

Figures 2 and 3 presents 2011 and 2012 Secchi disk depth results, respectively, as averaged for Cold Spring Harbor, Oyster Bay Harbor, Mill Neck Creek, and Laurel Hollow (for 2011 only). Average Secchi disk depths in 2011 for these areas were 1.54, 1.61, 1.08, and 1.37 m, and 1.27, 1.71 and 1.06 m in 2012, respectively. As was the case in past years, Mill Neck Creek is generally less clear than Oyster Bay Harbor and Cold Spring Harbor, possibly a result of increased biological activity due to it shallow depth, marshy areas, and close proximity to tributary discharges. Secchi disk depths were variable throughout the season, and it is difficult to discern any definitive trends in the 2011 or 2012 data, although the lowest clarity levels seem to occur during mid-summer and the middle of the sampling season (June-July-August) at all locations. See *Appendix E* for additional physical data.

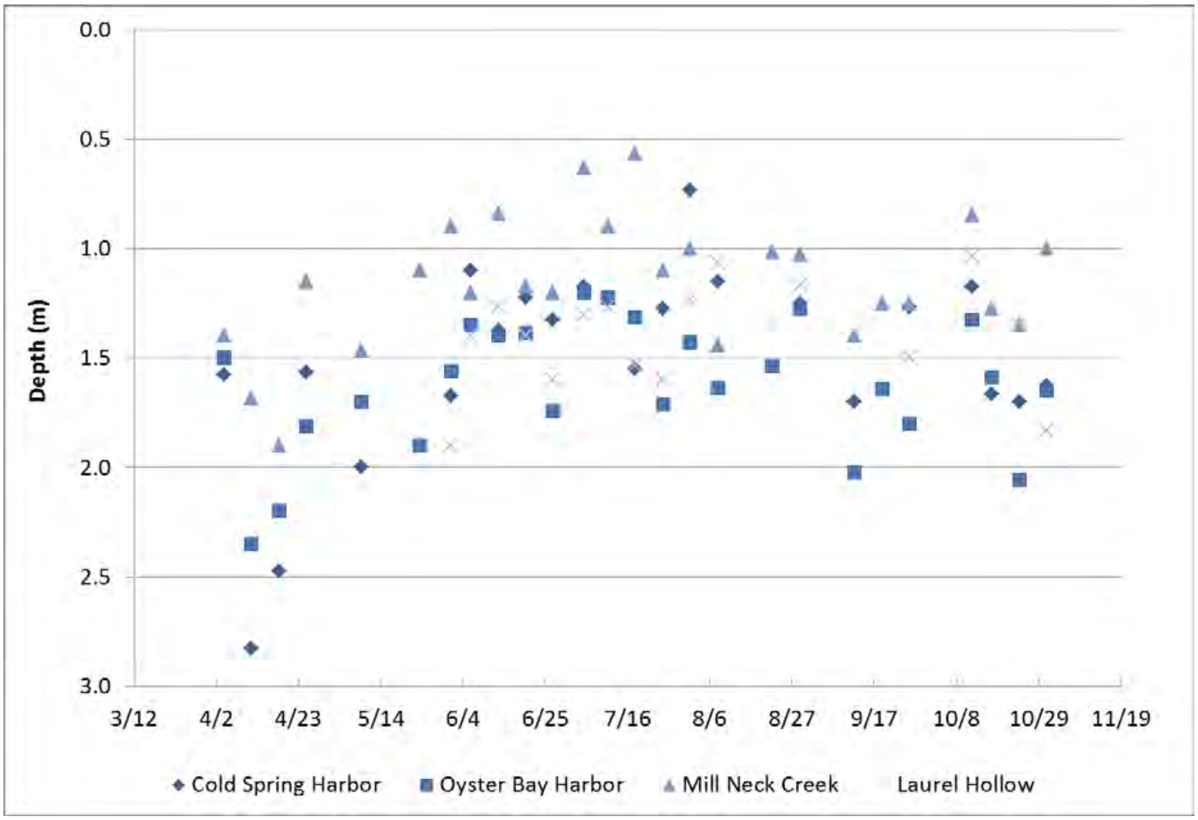

Figure 2. 2011 Secchi disk results, averaged locationally

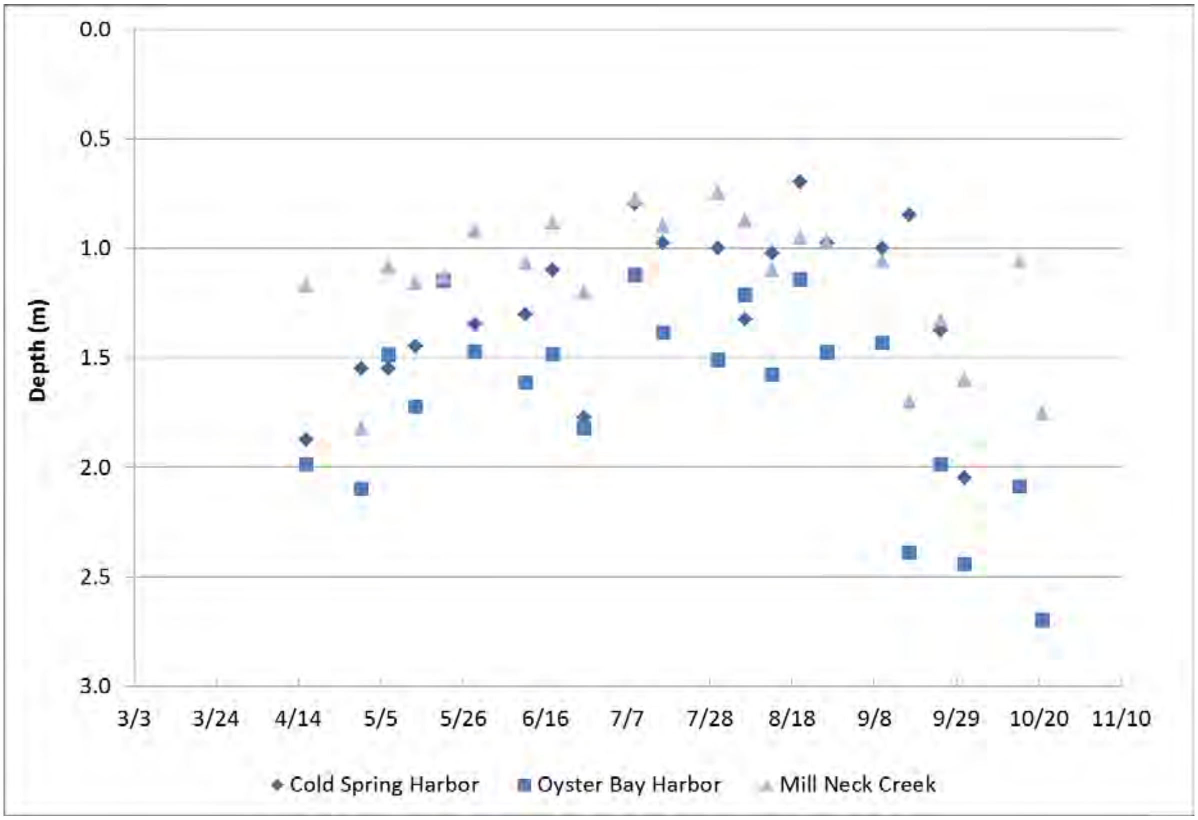

Figure 3. 2012 Secchi disk results, averaged locationally

4.1.2 Bacteria

Bacteria are ubiquitous in the environment. Certain types, however, can be used to indicate the possible presence of human pathogens. Common fecal indicator bacteria include fecal coliform and enterococci. Bacteria are introduced in the marine environment through various point and non-point sources such as surface water runoff, industrial and agricultural discharges or wastewater discharges. The New York Code of Rules and Regulations (NYCRR) specify levels of fecal coliform bacteria that should be met in bodies of water designated for different purposes. Waters used for shellfish cultivation and harvest must meet the most stringent bacteriological criteria.

Coliform bacteria levels are reported as logarithmic average with a 30-day averaging period (also known as the geometric mean, or geomean). Geomeans are often used for regulatory thresholds as they are less prone to influence by outlier values which frequently result during bacterial analysis.

Friends of the Bay collected bacteria data during 24 of 27 weeks monitored during the 2011 open water body monitoring season (5 dates were cancelled completely for all locations due to inclement weather) and 20 of 21 weeks monitored during the 2012 season (7 dates were cancelled completely for all locations due to inclement weather). The completeness of monitoring runs, calculated by dividing the number of runs performed (24, 20) by the number of possible runs (27, 21) and expressed as a percent, is 89%[10] and 95% for the 2011 and 2012 monitoring seasons, respectively. In comparison, completeness of monitoring runs in previous years has ranged from 77% to 96%.

Table 1 summarizes shellfish standards for fecal coliform bacteria that are enforced by New York State (NYS). In 2004, revised beach closure standards were implemented that are based on measured levels of enterococci, an alternate indicator bacteria, and fecal coliform (although a total coliform standard is still included). The standards are summarized in *Table 2*.

Table 1. NYS Coliform Bacteria Standards

	Shellfishing *
Fecal Coliform	LOG AVG <14 MPN/100 ml and If < 10% of samples do not exceed 43 MPN/100 ml

* 6 NYCRR §47.3

Table 2. NYS Coliform Bacteria Standards, effective 2004

	Swimming †
Fecal Coliform	LOG AVG 30 days < 200 MPN/100ml, and no sample greater than 1,000 MPN/100 ml
Enterococci	LOG AVG 30 days <35 MPN/100 ml, and no sample greater than 104 MPN per 100 ml

†10 NYCRR Section 6-2.15 - Water quality monitoring

Fecal coliform and enterococci levels were measured and reported at all twenty-two (22) locations during the 2011 and all nineteen (19) locations during the 2012 monitoring season (Laurel Hollow was not sampled in 2012). Fecal coliform has been measured by Friends of the Bay since the inception of the monitoring program, while enterococci has been measured since 2004.[11] Samples were collected for enterococci as well, but a different laboratory method was used in 2004 than in 2005 and later. The method used in 2004 resulted in elevated values compared to these later years, so 2004 enterococci results are not included for comparison in this report.

Table 3 and *Table 4* present a summary of the season's bacteria results compared to the New York State Shellfishing Standards in *Table 1*. The shaded cells in *Table 3* and *Table 4* indicate that the seasonal geomean and/or the 90th percentile value at that station exceeded the State standard. Although only

[10] Completeness is typically calculated as the number of total datapoints collected divided the number of datapoints planned. However, completeness calculated in this manner is less meaningful for Friends of the Bay, since several monitoring locations cannot be sampled under certain tidal conditions.

[11] The NCDH laboratory, which performs bacterial analysis for Friends of the Bay, changed analysis methods from the 2004 to 2005 season. As such, data from 2004 is not comparable to data from later years.

fecal coliform data were collected in 2011 and 2012, in earlier years of the monitoring program, total coliform exceedances were generally accompanied by exceedances in fecal coliform as well.

Table 3. Comparison of 2011 Monitoring Results to State Shellfishing Standards

	Fecal Coliform		
Station	Seasonal Geomean	90th Percentile	Location
FB-1	110	1240	CSH
FB-2	63	399	CSH
FB-3	14	48	CSH
FB-4	3	9	CSH
FB-5	3	9	OBH
FB-6	3	10	OBH
FB-7	16	62	OBH
FB-8	13	80	OBH
FB-9	8	28	OBH
FB-10	27	228	OBH
FB-11	5	35	OBH
FB-12	5	29	OBH
FB-13	30	186	MNC
FB-14	38	278	MNC
FB-15	565	5840	MNC
FB-16	242	2320	MNC
FB-17	564	4800	MNC
FB-18	14	41	MNC
FB-19	19	50	MNC
LH-1	18	164	LH
LH-2	17	138	LH
LH-3	14	79	LH
Shellfish Standard	14	43	

Table 4. Comparison of 2012 Monitoring Results to State Shellfishing Standards

Station	Fecal Coliform Seasonal Geomean	Fecal Coliform 90th Percentile	Location
FB-1	108	1660	CSH
FB-2	62	422	CSH
FB-3	13	62	CSH
FB-4	2	4	CSH
FB-5	2	6	OBH
FB-6	2	4	OBH
FB-7	15	57	OBH
FB-8	9	48	OBH
FB-9	5	12	OBH
FB-10	41	250	OBH
FB-11	2	13	OBH
FB-12	2	6	OBH
FB-13	17	90	MNC
FB-14	24	173	MNC
FB-15	127	469	MNC
FB-16	68	208	MNC
FB-17	117	596	MNC
FB-18	9	50	MNC
FB-19	12	67	MNC
Shellfish Standard	14	43	

Bacteria levels exceeded the fecal coliform standard at FB-1, FB-2, FB-3, FB-7, FB-8, FB-10, FB-13, FB-14, FB-15, FB-16, FB-17, FB-18, FB-19, LH-1, LH-2, and LH-3. These results are encouraging, since the majority of Oyster Bay Harbor met the standard for fecal coliform (FB-1, FB-2, and FB-3 are located in Cold Spring Harbor, FB-7 is located in the center of Oyster Bay Cove, FB-8 is located just west of Oyster Bay Cove, FB-10 is located near Beekman Creek, FB-13 through FB-19 are located in Mill Neck Creek, and LH-1 through LH-3 are located in Laurel Hollow). Oyster Bay Harbor is where the majority of shellfishing occurs in the estuary. In 1983, the New York State Department of Environmental Conservation closed Mill Neck Creek to shellfishing due to the elevated coliform bacteria levels found there, which was likely the result of the sewage overflows from "The Birches" (also known as Continental Villa) housing development in Locust Valley that have plagued Mill Neck Creek.

This subdivision historically operated its own sewage treatment system, which suffered chronic problems due to cesspool overflows and inadequate treatment of waste, impacting low-lying wetlands and the adjacent creek. Failing and/or low-functioning individual on-site sewage disposal systems located in this area are also believed to have contributed to these chronic problems. As of April 2011, sewage infrastructure upgrades were completed, and all the homes in "The Birches" residential subdivision were connected to the Glen Cove sewage treatment plant. The average bacteria levels recorded at Mill Neck Creek monitoring locations decreased significantly (>50% for both fecal coliform and enterococci) from the 2011 to the 2012 sampling seasons. These reductions are an early indicator of the potential water quality improvements resulting from the sewage infrastructure upgrades. Additional monitoring data is necessary to verify these observations and document water quality trends. Friends of the Bay will continue to monitor these sites to continue documenting improvements to the water quality in Mill Neck Creek.

Figure 4 and *Figure 5* present seasonal geometric means (i.e., May through October) for fecal coliform and enterococci, respectively, for each of the estuary's embayments. Geometric mean levels of fecal coliform decreased in Cold Spring Harbor in 2011 and 2012. In Mill Neck Creek, the geometric mean levels increased significantly in 2011 and then decreased significantly in 2012. The levels were similar to past years in Oyster Bay Harbor. All locations have increased geometric means from fecal coliform levels reported in 2006 (area's average lowest level on record), although the 2012 levels are the lowest reported since 2006. The enterococci geometric means followed a similar trend recorded for fecal coliform in 2011 and 2012 – Cold Spring Harbor remained similar to 2011, although it decreased from 2010 geomean concentrations, Mill Neck Creek increased significantly in 2011 and then decreased significantly in 2012, and Oyster Bay had levels similar to 2010. Although not shown, average enterococci levels in Laurel Hollow were 2 MPN/100 ml and average fecal coliform levels were 16 MPN/100 ml in 2010 and 2011, respectively, which are slightly above the shellfish standard (no data was collected at Laurel Hollow sites in 2012).

Although the shellfish and swimming standards are included on the figures below, the locationally-averaged geomeans cannot be used to directly assess compliance with the standards.

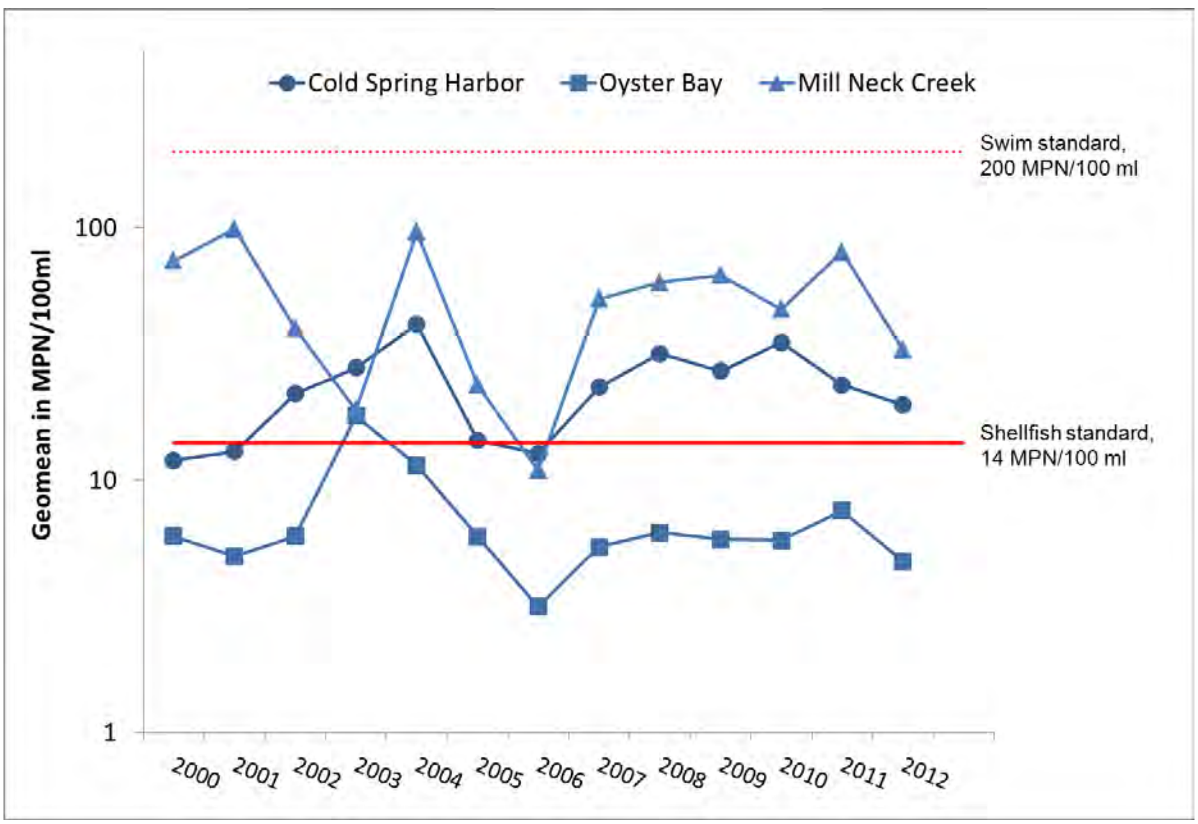

Figure 4. Seasonal geomeans of fecal coliform data by location

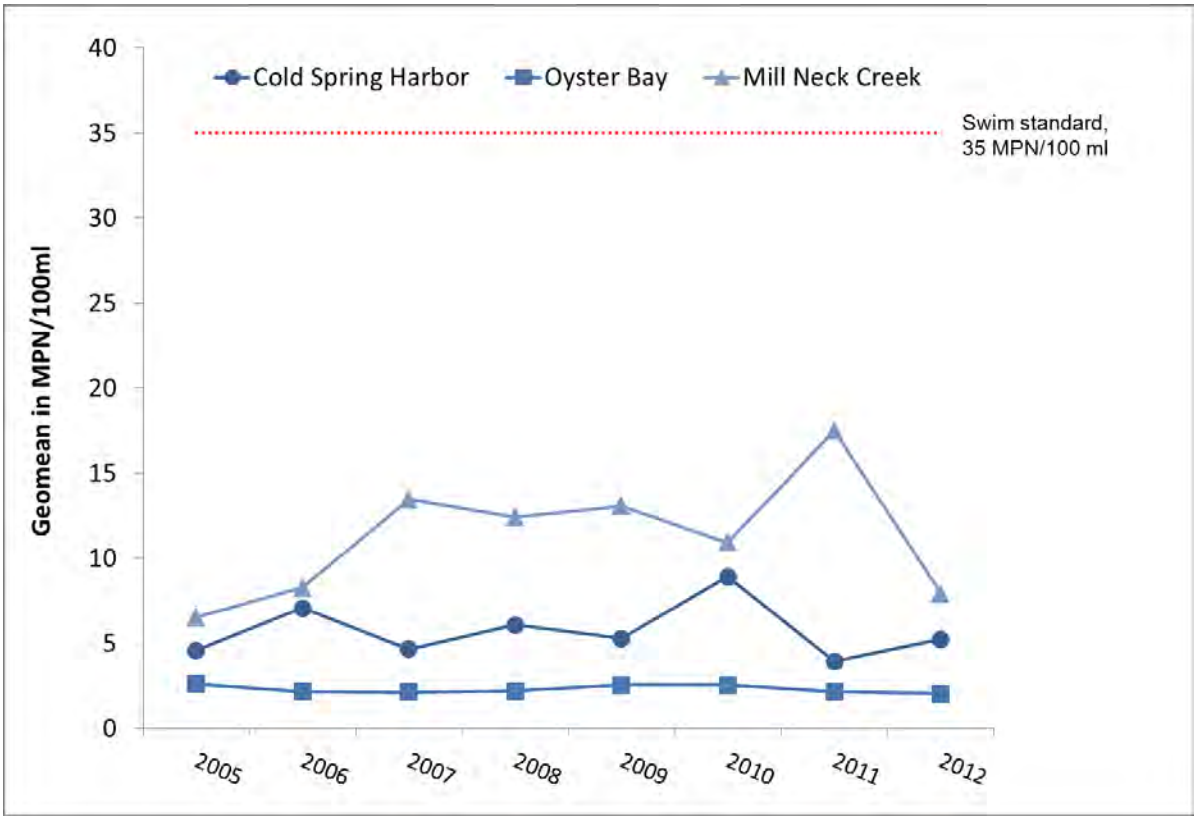

Figure 5. Seasonal geomeans of enterococci data, by location

Figure 6 and *Figure 7* present total monthly precipitation as recorded at a precipitation station in Levittown during the 2011 and 2012 sampling seasons. There was a significant spike in total monthly precipitation during 2011; 11.76 inches were measured in August, while all other months were below 3 inches of recorded monthly rainfall. Total monthly precipitation during 2012 was more evenly distributed. Precipitation quantities ranged from 2.24 inches in October to 6.67 inches in June. The distribution of precipitation through the monitoring season is important since stormwater runoff can transport bacteria pollution to receiving waters. See *Appendix E* for additional bacteria data.

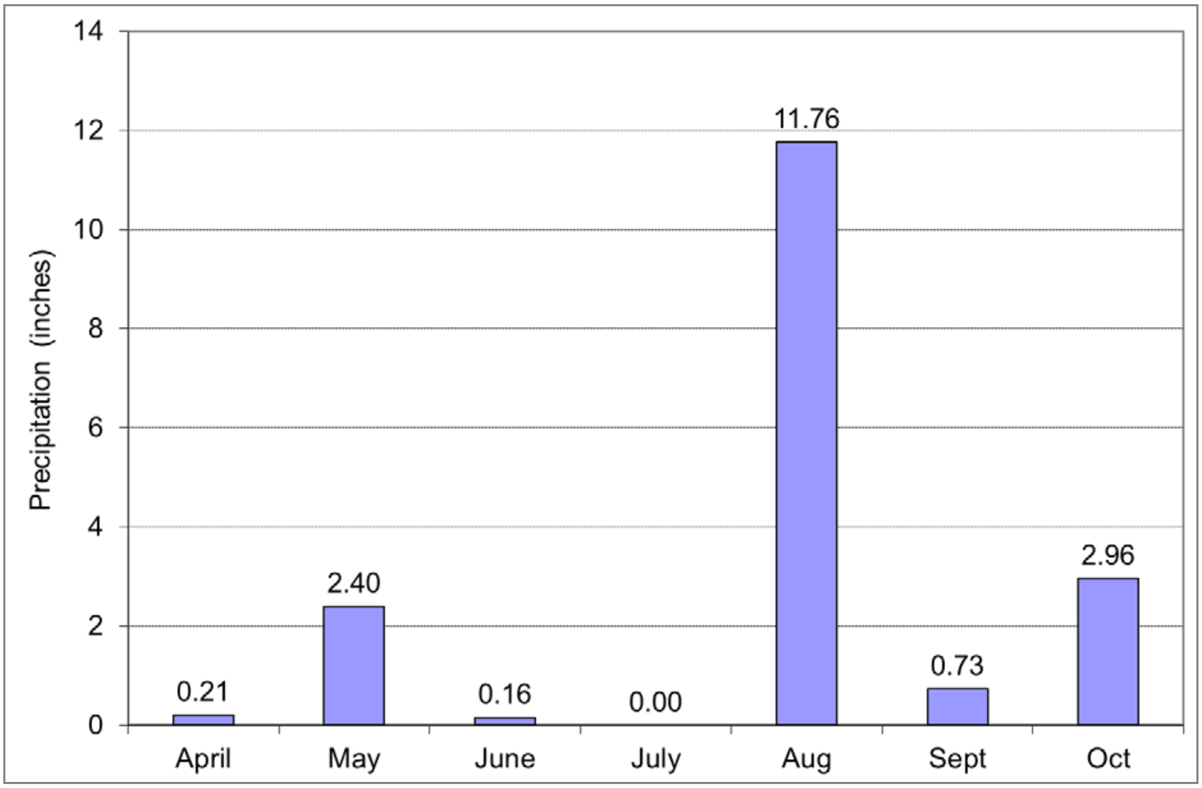

Figure 6. Precipitation recorded at Levittown, Long Island, 2011

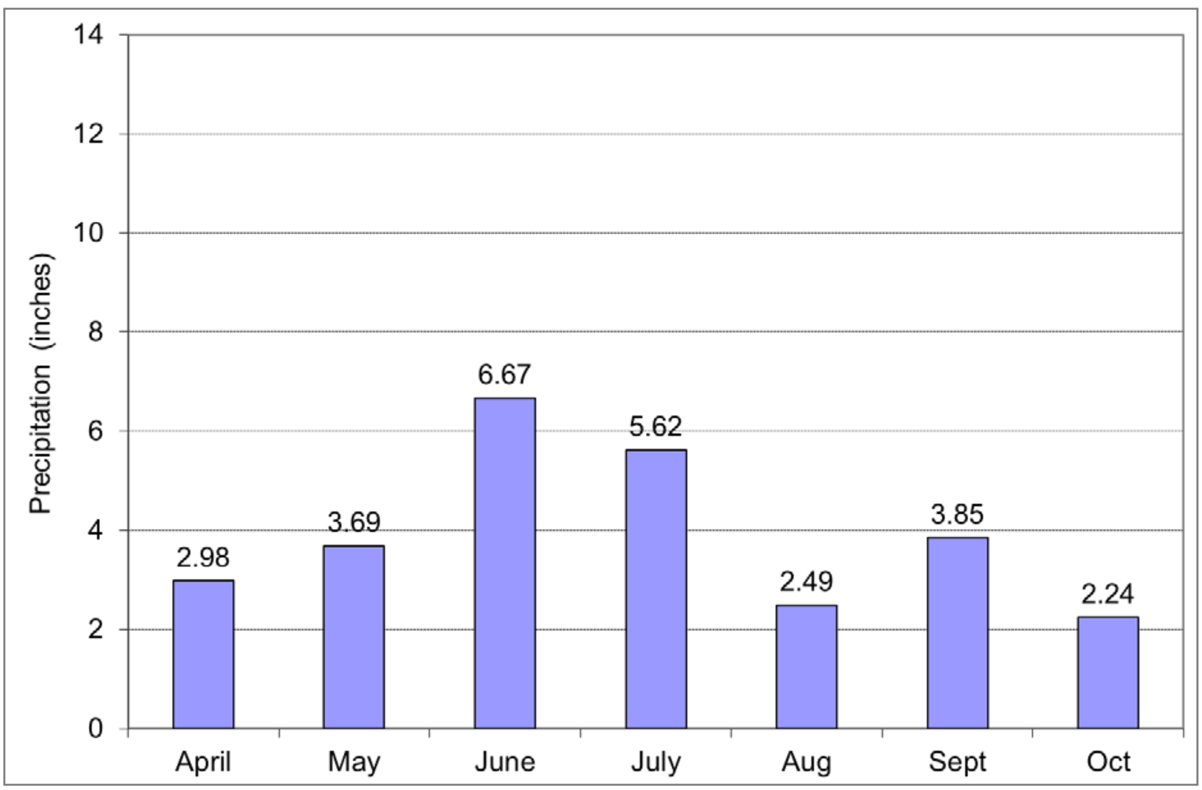

Figure 7. Precipitation recorded at Levittown, Long Island, 2012

4.1.2.1 Cold Spring Harbor Results

Four stations were monitored for fecal coliform and enterococci bacteria in Cold Spring Harbor in 2011 and 2012. *Figure 8* through *Figure 11* present the 2011 and 2012 fecal coliform and enterococci 30-day running bacteria geometric means for each station. In some cases, fewer than two samples were collected in the preceding 30-day period, so some breaks in the line graph are present.

The results for shellfishing are consistent with those presented in *Table 3*; only one station in Cold Spring Harbor (FB-4) met the fecal coliform NYS shellfish geometric mean standard for the duration of the 2012 season. The other three stations exceeded the standard for fecal coliform bacteria for all or portions of the 2011 and 2012 monitoring seasons (FB-4 did not comply during the 2011 season). In 2012, FB-4 met the fecal coliform standard with the highest calculated 30-day mean reaching 8.7 MPN/100ml.

FB-3 met both the fecal coliform and enterococci geometric mean swimming standards for the 2011 and 2012 seasons; however, fecal coliform levels at FB-3 exceeded the shellfish standards (enterococci levels were below the shellfish standard). FB-1 and FB-2, particularly FB-1, exceeded the swimming standards during the majority of the summer season (late June through September).

During the 2011 and 2012 seasons, three fecal coliform samples at the FB-1 location and one at the FB-2 station exceeded the 1,000 MPN/100 ml swimming standard (eight exceedences, total, over the 2-year period). Additionally, the 104 MPN/100 ml single sample standard for enterococci was exceeded once at FB-1 and once at FB-4 in 2011, and three times at FB-1 and two times at FB-2 during the 2012 monitoring season. These results would have resulted in beach closures. See *Appendix E* for bacteria data.

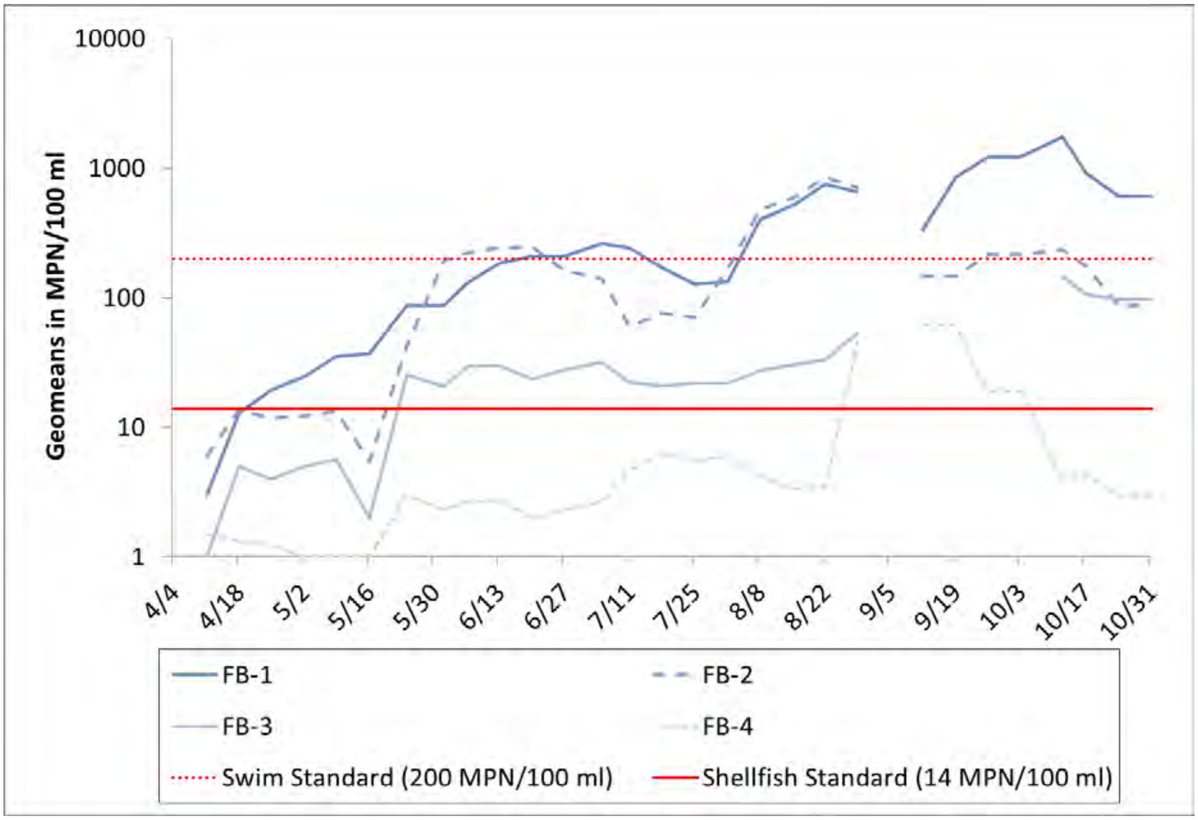

Figure 8. 30-day running geometric mean of 2011 Cold Spring Harbor fecal coliform samples

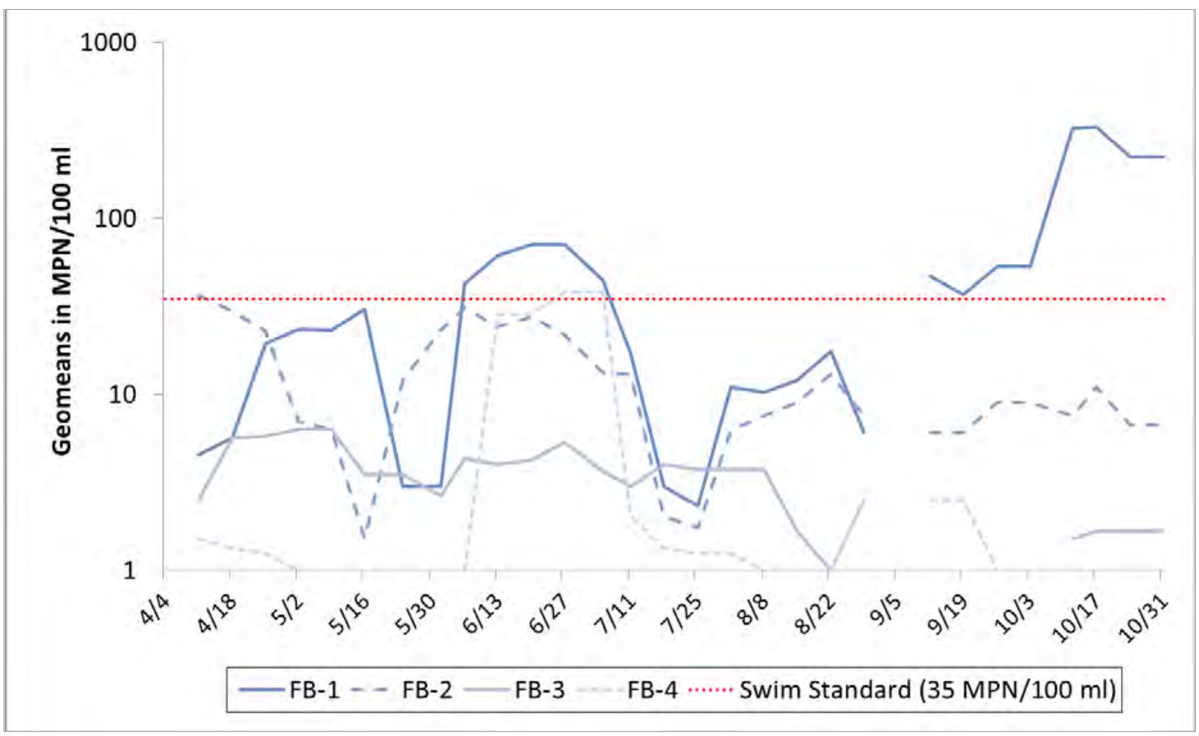

Figure 9. 30-day running geometric mean of 2011 Cold Spring Harbor enterococci samples

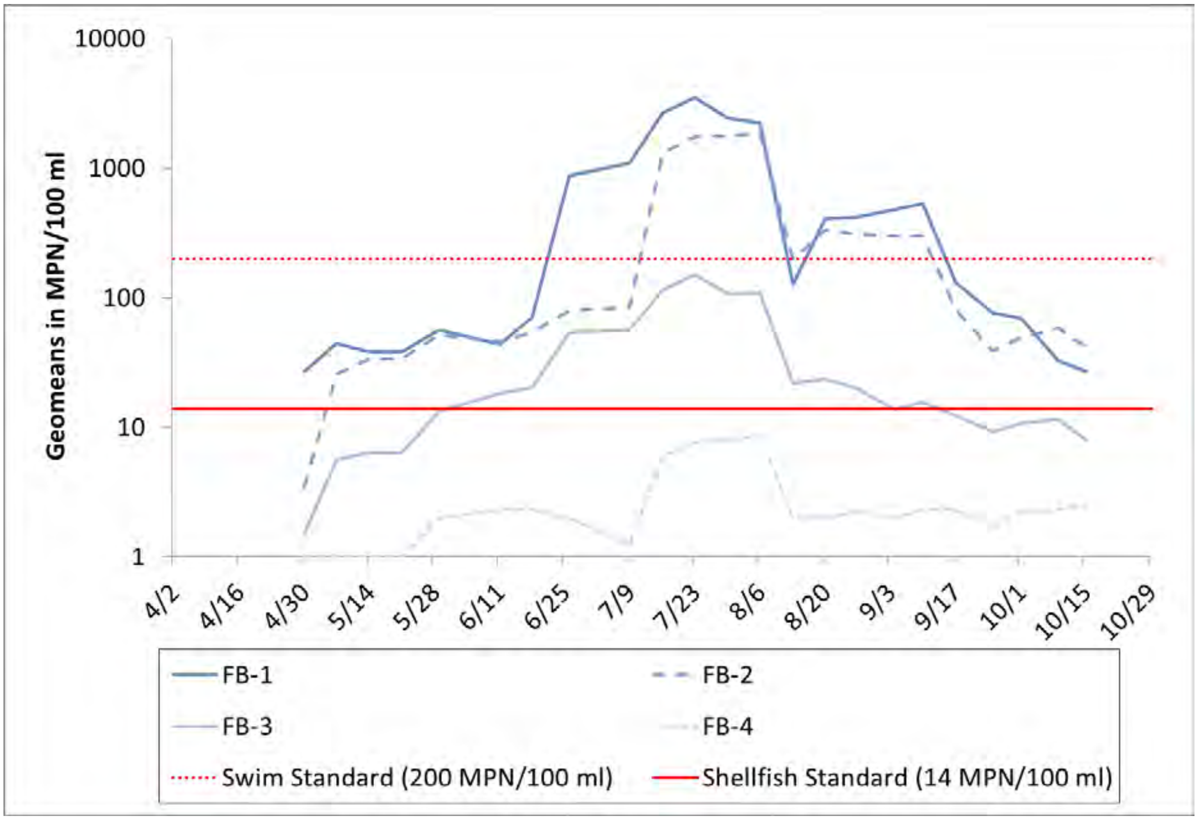

Figure 10. 30-day running geometric mean of 2012 Cold Spring Harbor fecal coliform samples

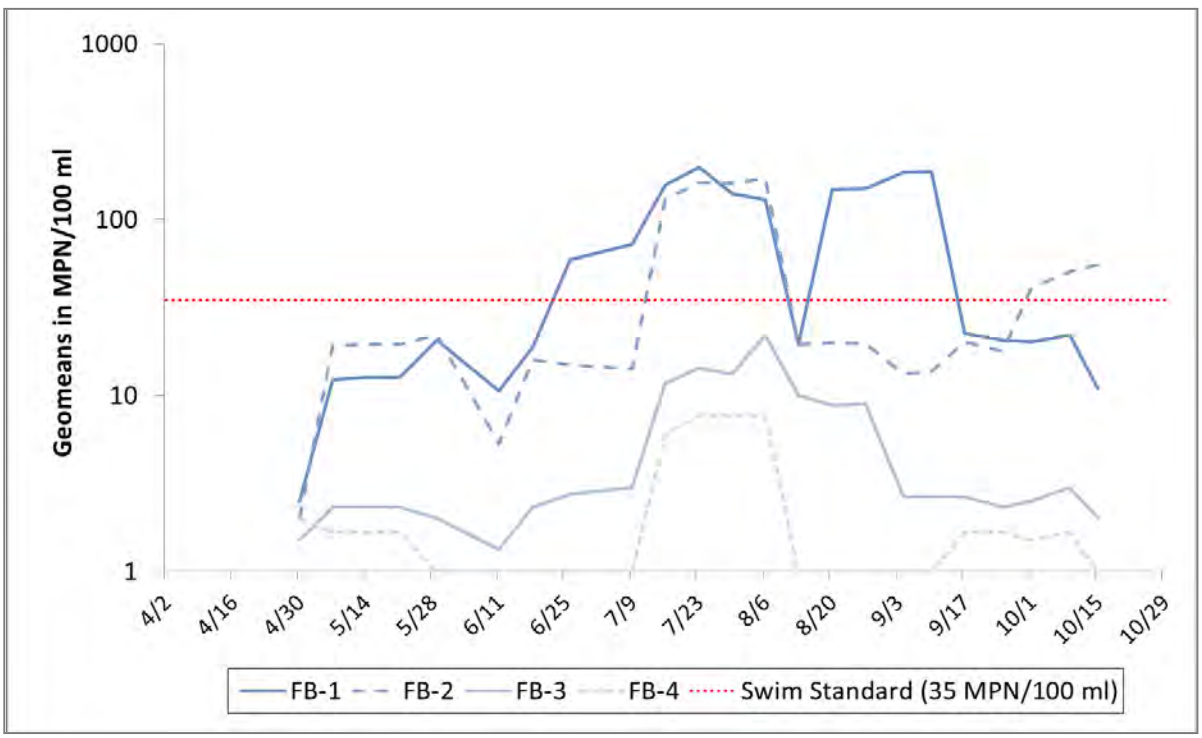

Figure 11. 30-day running geometric mean of 2012 Cold Spring Harbor enterococci samples

4.1.2.2 Oyster Bay Harbor Results

A total of eight stations were monitored for fecal coliform and enterococci bacteria in Oyster Bay Harbor in 2011 and 2012 as depicted in *Figure 12* through *Figure 15*. As shown, the geometric mean of fecal coliform results at many of the stations did not meet the geometric mean standard for shellfishing for the 2011 and 2012 seasons. In 2011, all of the stations exceeded the standard during a portion of the season. In 2012, six of the stations exceeded the standard during a portion of the season.

In 2011, the running 30-day enterococci geometric mean standard for swimming (35 MPN/100 ml) was exceeded in April and May at FB-9 and FB-10, while the 30-day fecal coliform geometric mean standard for swimming (200 MPN/100 ml) was exceeded at FB-8, FB-10 and FB-12 during September and October. In 2012, the running 30-day enterococci geometric mean standard (35 MPN/100 ml) was exceeded May through June at FB-10, while the 30-day fecal coliform geometric mean standard (200 MPN/100 ml) was exceeded at FB-7 (July through August) and at FB-10 (August through September).

The single sample standard of 1,000 MPN/100 ml for fecal coliform was exceeded once in 2011 and in 2012 (both at FB-10) within Oyster Bar Harbor, while the 104 MPN/100 ml enterococci standard was exceeded twice in 2011 (FB-9 and FB-10) and once in 2012 (FB-7). See *Appendix E* for bacteria data.

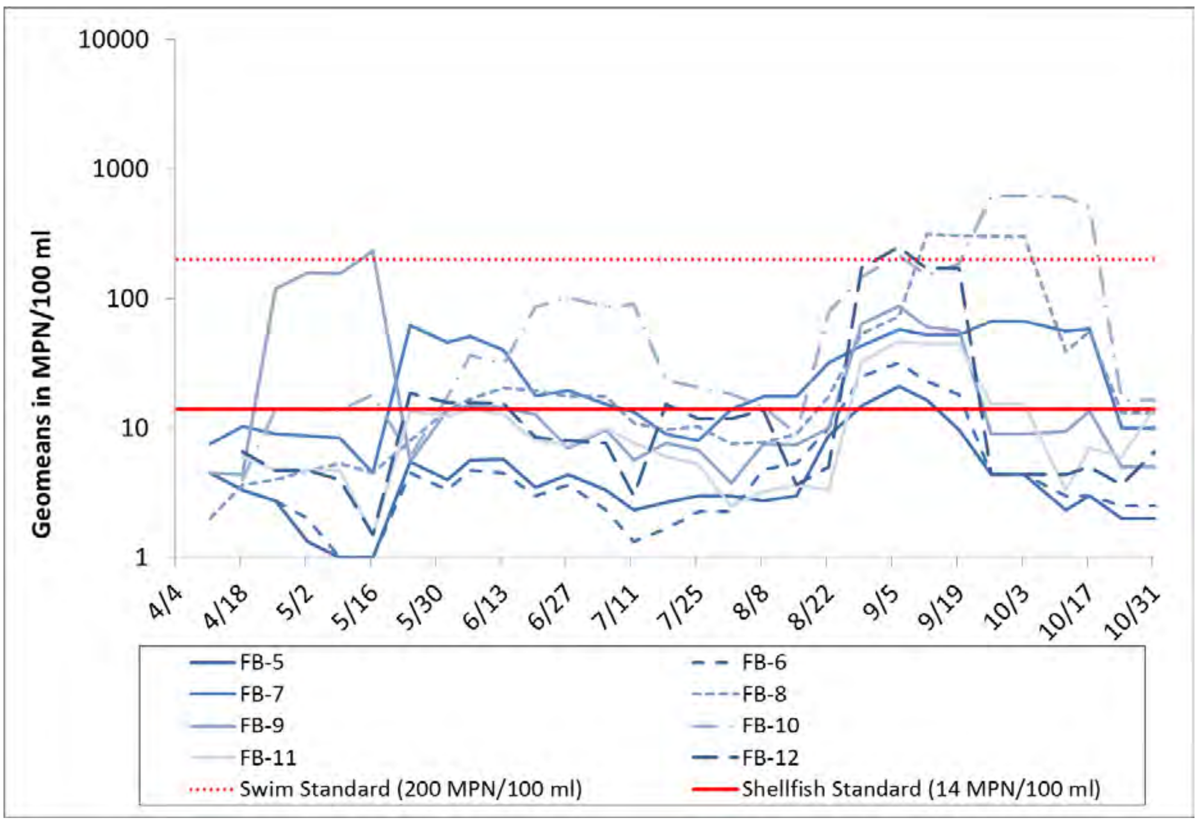

Figure 12. 30-day running geometric mean of 2011 Oyster Bay Harbor fecal coliform samples

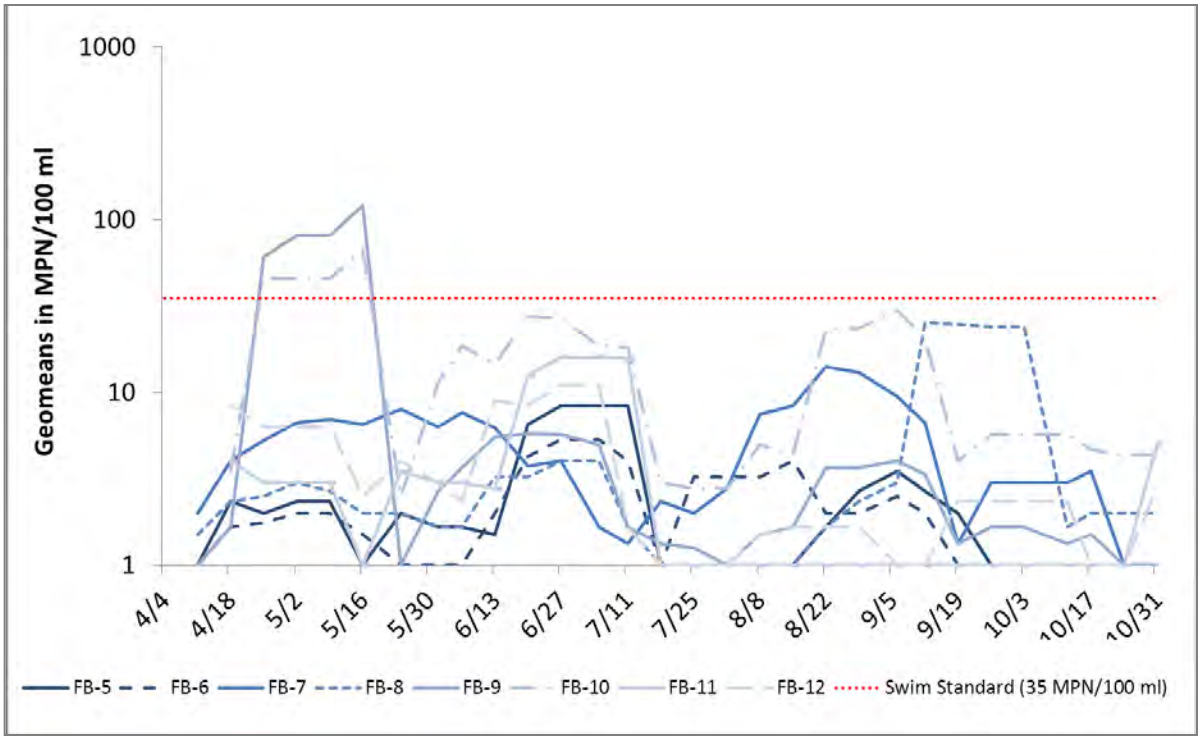

Figure 13. 30-day running geometric mean of 2011 Oyster Bay Harbor enterococci samples

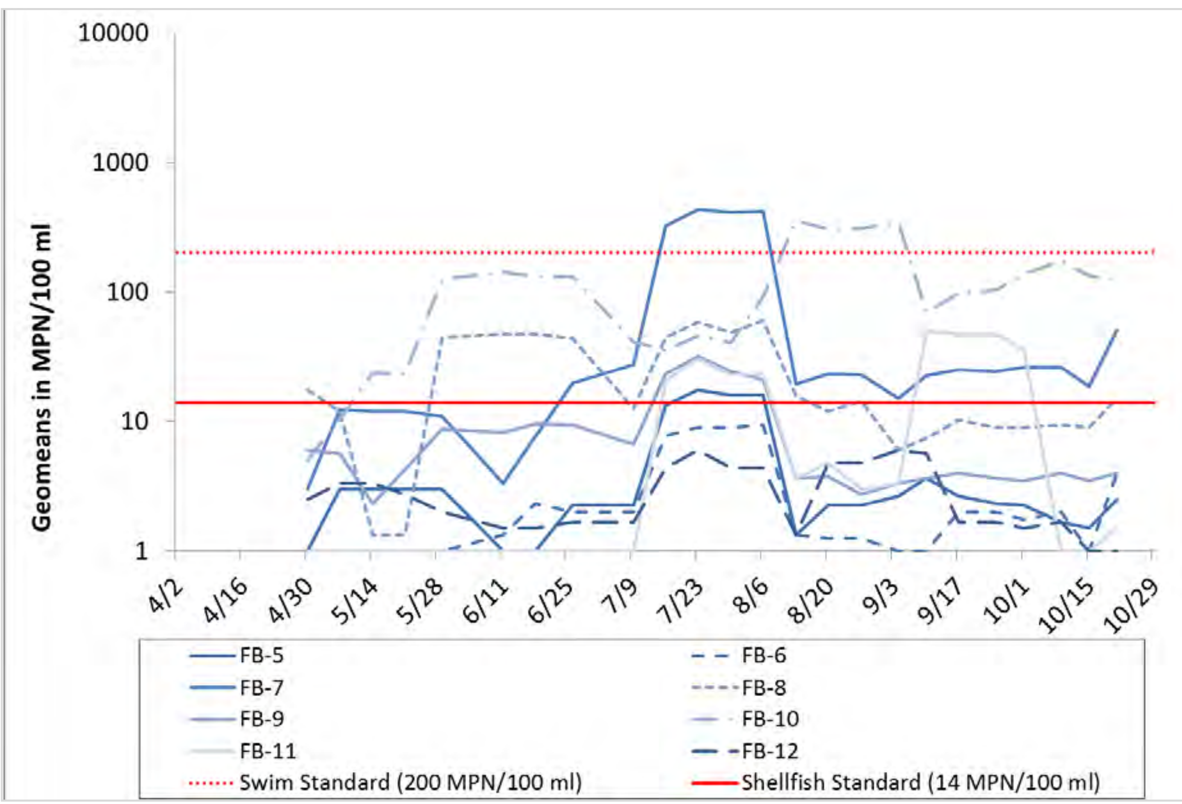

Figure 14. 30-day running geometric mean of 2012 Oyster Bay Harbor fecal coliform samples

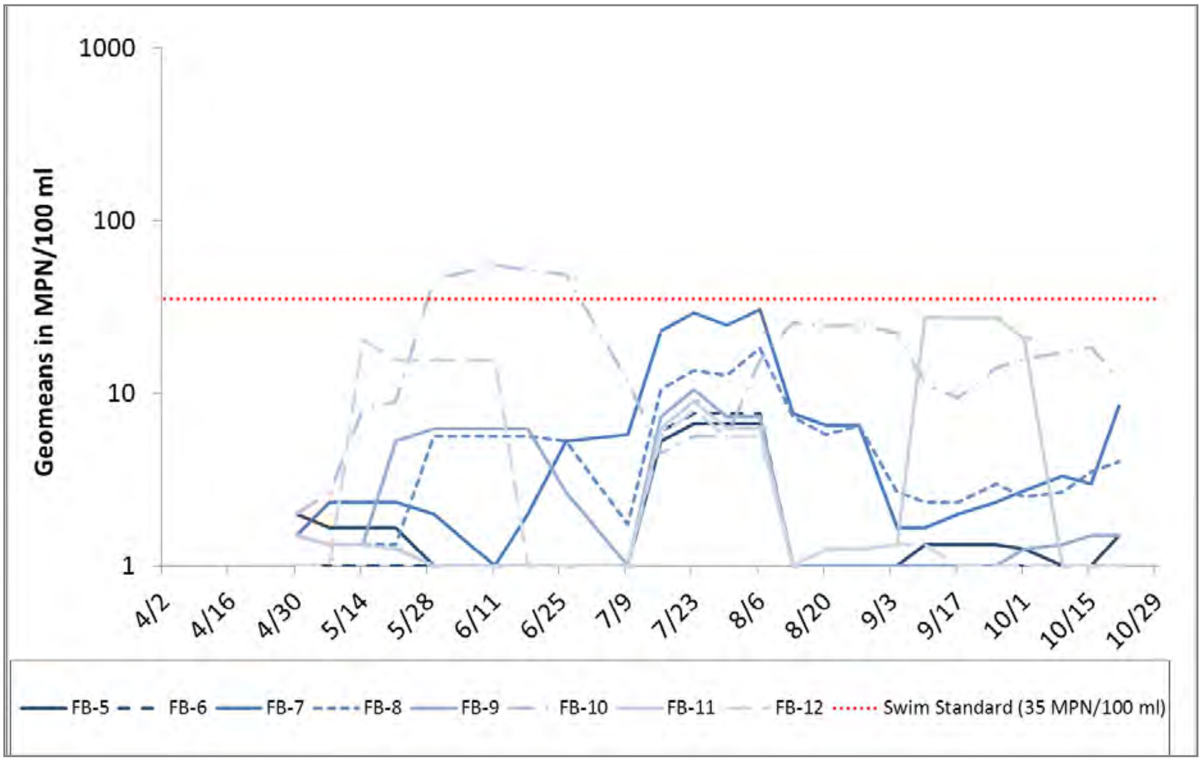

Figure 15. 30-day running geometric mean of 2012 Oyster Bay Harbor enterococci samples

4.1.2.3 Mill Neck Creek Results

In 2011 and 2012, seven stations were monitored in Mill Neck Creek for fecal coliform and enterococci, and monthly geometric means were calculated for the data. *Figure 16* through *Figure 19* present the results of this analysis.

FB-15, FB-16, and FB-17 are difficult to monitor since low tidal conditions often prevent access; FB-15, FB-16, and FB-17 were only successfully sampled on 48%, 52%, and 45% of the monitoring events during 2011, respectively, and 48%, 48%, and 45% of the monitoring events during 2012, respectively. Therefore, the analysis is based on a much smaller data set, which may affect the analysis of the resulting data.

None of the Mill Neck Creek locations met the geometric mean shellfishing standards for the entire 2011 or 2012 monitoring seasons. Locations FB-15, FB-16, and FB-17 did not meet the geometric mean swimming (fecal coliform and enterococci) standards for most of the 2011 season and a significant portion of 2012.

The single sample fecal coliform standard (1,000 MPN/100 ml) was exceeded in 2011 at FB-15, FB 16, and FB-17, five, three and four times, respectively and once each at FB-16 and FB-17 in 2012. Monitoring stations FB-13, FB-14, FB-15, FB-16, and FB-17 exceeded the enterococci standard (104 MPN/100 ml) one, one, seven, three, and four times in 2011, respectively. In 2012, monitoring stations FB-15, FB-16, and FB-17 exceeded the enterococci standard five, two, and three times, respectively. See *Appendix E* for bacteria data.

The highest levels of fecal coliform and enterococci generally occur at FB-15, FB-16, and FB-17. It is notable that FB-15 is located in tidal flats that could accumulate bird droppings during periods of low tide, FB-17 is the closest station to "The Birches" residential subdivision (described above), and FB-16 is at the most northern tidal location sampled of Mill Neck Creek (second closest to "The Birches"). As indicated previously, the average bacteria levels recorded at Mill Neck Creek monitoring locations decreased significantly (>50% for both fecal coliform and enterococci) from the 2011 to the 2012 sampling seasons. These reductions are an early indicator of the potential water quality improvements resulting from the sewage infrastructure upgrades. Additional monitoring data is necessary to verify these observations and document water quality trends.

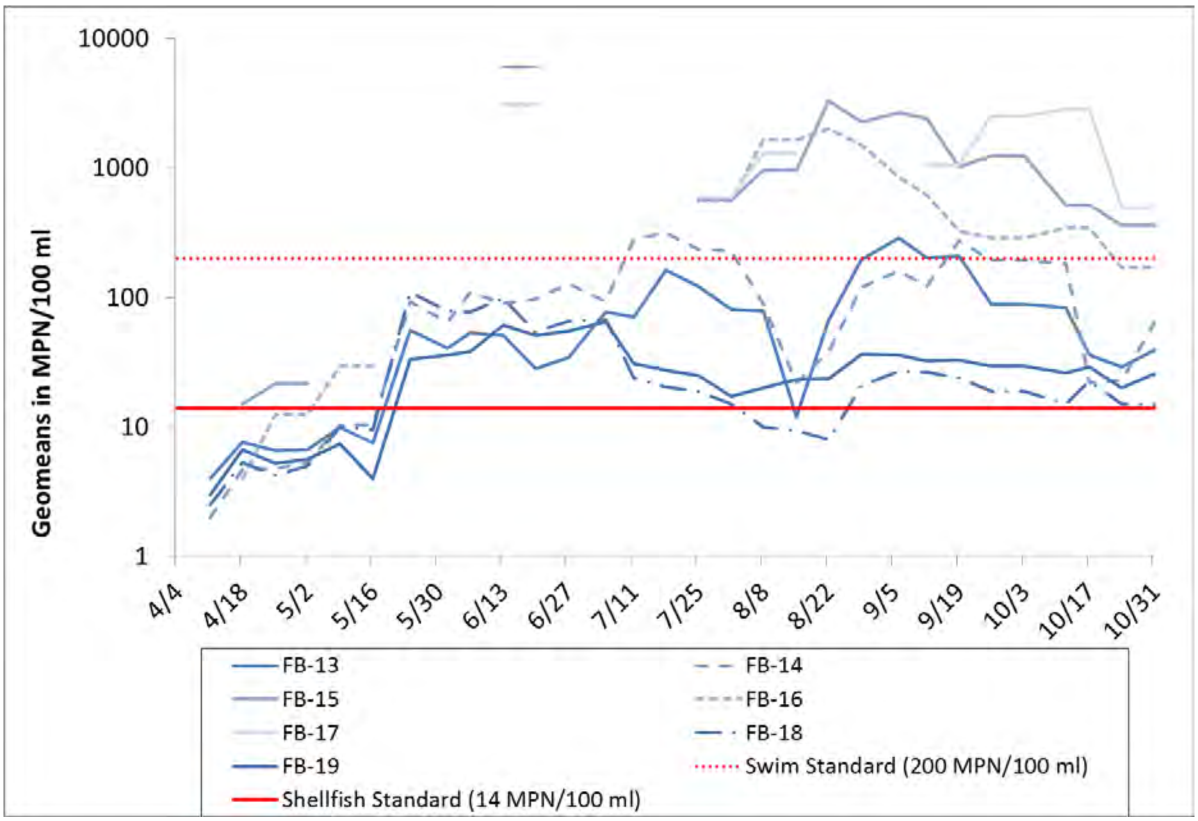

Figure 16. 30-day running geometric mean of 2011 Mill Neck Creek fecal coliform samples

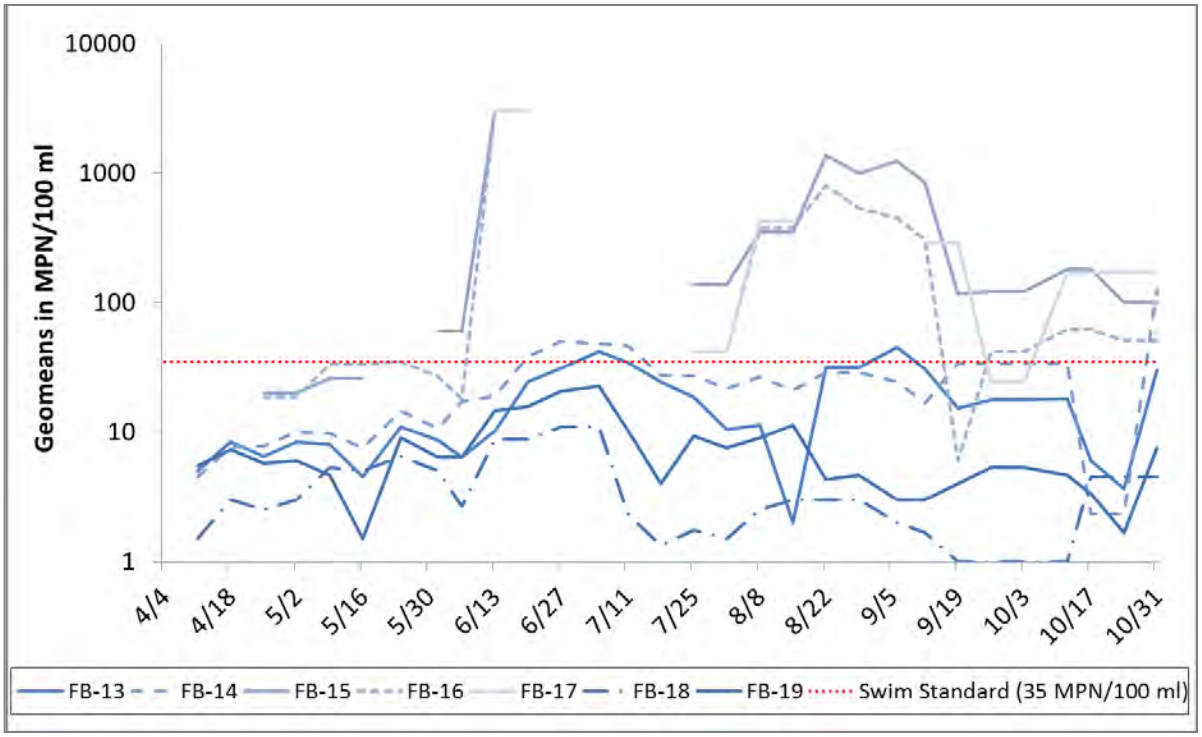

Figure 17. 30-day running geometric mean of 2011 Mill Neck Creek enterococci samples

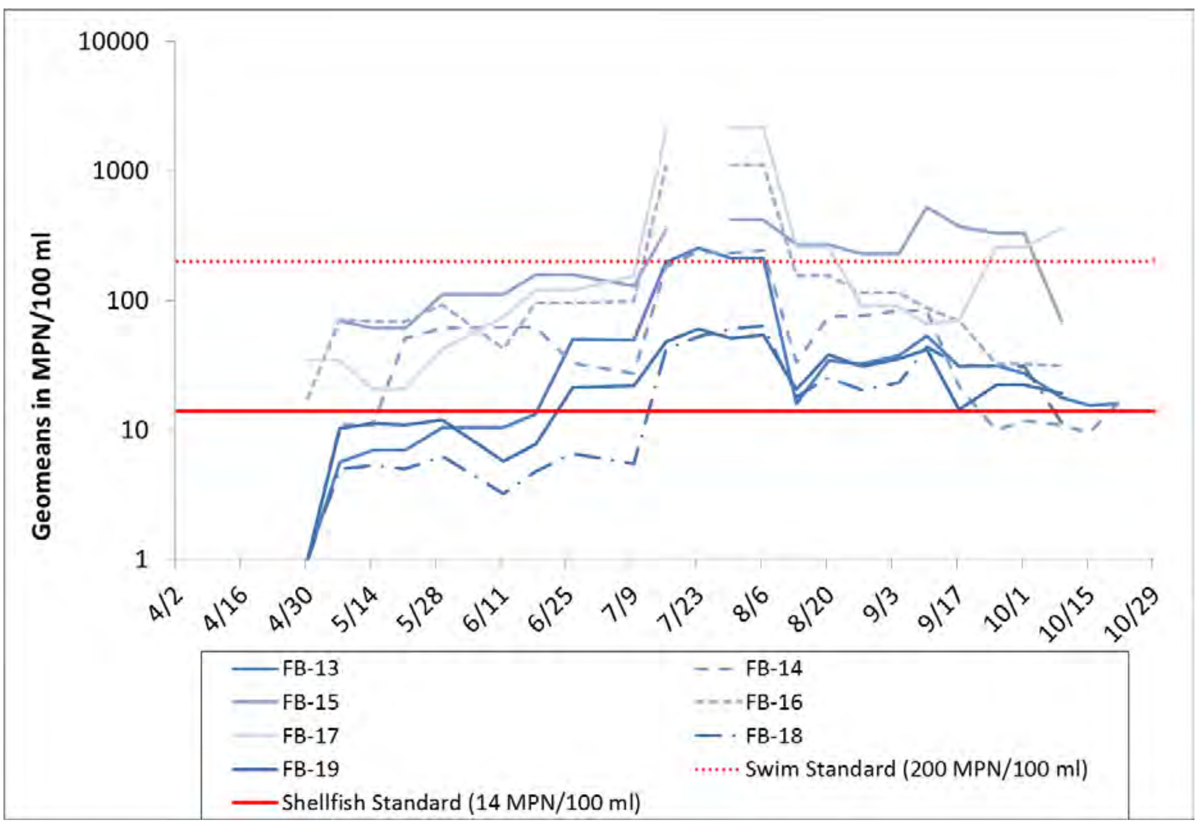

Figure 18. 30-day running geometric mean of 2012 Mill Neck Creek fecal coliform samples

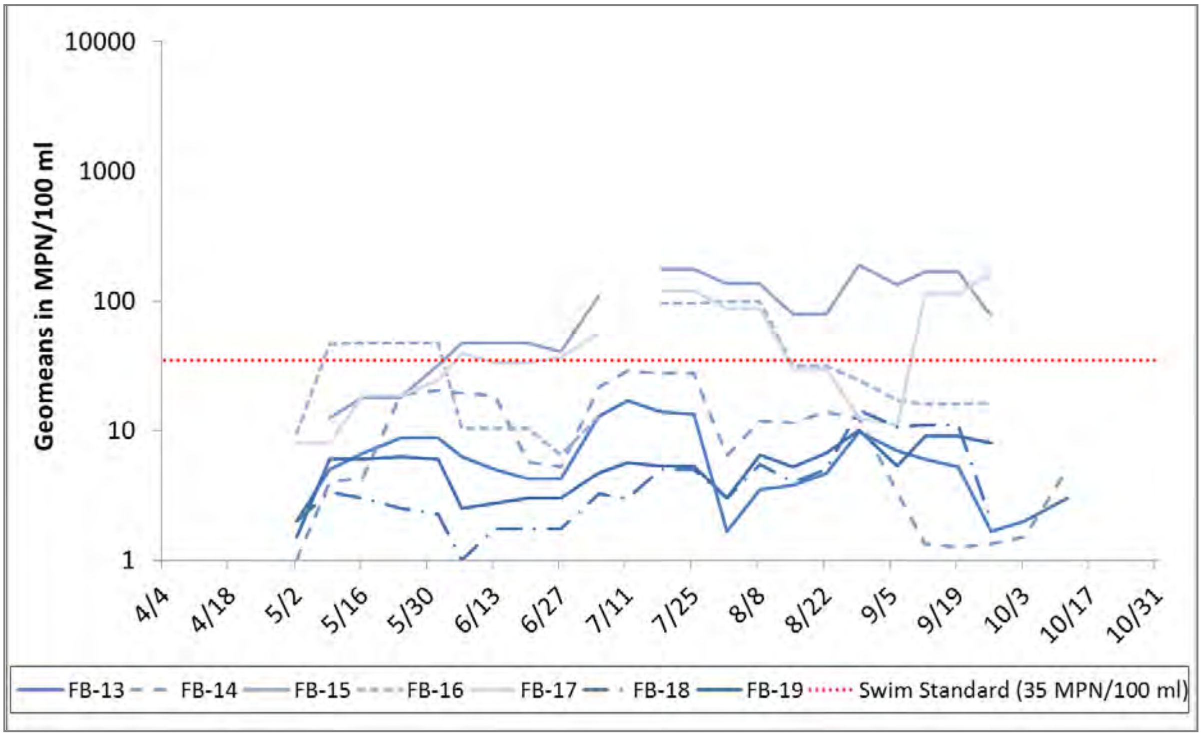

Figure 19. 30-day running geometric mean of 2012 Mill Neck Creek enterococci samples

4.1.3 Nutrient Enrichment by Nitrogen

4.1.3.1 The Nitrogen Cycle

The nutrients nitrogen and phosphorus, as well as other minerals, are essential components for marine organisms. Nitrogen and phosphorus are typically the limiting factor in the quantity of biomass (organisms, such as algae, bacteria, fish, and plants) that can grow in a water body. When nutrient inputs to a water body increase, microorganism populations also increase. These increases are generally first seen in the density of algae, resulting in an algal bloom.

A common rule of thumb is that the ratio of nitrogen to phosphorus in biomass is approximately 7 to 2. This means that, if the nitrogen concentration divided by the available phosphorus is less than 3.5, biological growth will be limited by the amount of nitrogen (Chapra 1997) in the water. If this ratio is greater than 3.5, then phosphorus will limit biological growth (other nutrients, such as silica, are known to limit growth as well in less common instances).

In marine ecosystems, such as the Oyster Bay/Cold Spring Harbor complex, phosphorus is generally abundant. The amount of biological growth that occurs is directly related to the amount of nitrogen that is present in the water. For this reason, Friends of the Bay monitors nitrogen in the estuary since nitrogen is typically the "limiting" nutrient in the marine environment.

Algal blooms may occur during the year, depleting the nutrient concentrations within the water column. When the nutrients are depleted, phytoplankton populations die off and sink to the bottom, contributing to large amounts of organic matter in the water column. This organic matter decays while sinking and is further decomposed by bacteria in the estuarine sediments.

Bacteria consume oxygen while decomposing dead phytoplankton. This depletion of oxygen may result in hypoxia (DO less than 3 mg/l) at the harbor bottom. Typically, hypoxia occurs in summer, when the water column stratification hinders oxygen replenishment in deep water.

Four nitrogen species are common in marine waters: ammonia, nitrate, nitrite and organic nitrogen. *Figure 20* presents a schematic of the interrelationships between these species, showing the processes that impact nitrogen in the marine environment.

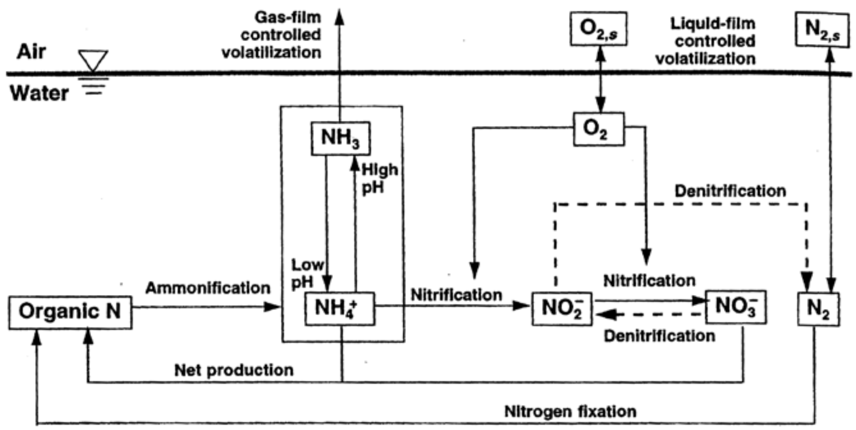

Figure 20. Nitrogen species and processes in marine environments

(Source: Chapra 1997)

Organic nitrogen is present in the form of urea, amino acids, proteins and other compounds (LISS, 1994). It can be bound to organic matter such as plants or algae. Dissolved forms of organic nitrogen come from sewage plants effluent, sewer overflow, failing septic systems and stormwater runoff. Dissolved forms of organic nitrogen are available to bacteria and phytoplankton populations and promote their growth.

Phytoplankton also utilize inorganic forms of nitrogen, including ammonia, nitrate, and nitrite. Organic nitrogen decays through ammonification to ammonia. Nitrates and nitrites are carried into the marine waters by stormwater runoff or result from nitrification of ammonia within the water body. Nitrates and nitrites can be converted to nitrogen gas by bacteria under anoxic conditions, and thus removed from the aqueous environment. High levels of ammonia may pose a danger to aquatic life. With rising temperatures and pH, ammonia ions (NH_4^+) change at increased rates into an un-ionized form of ammonia (NH_3). This form of ammonia is toxic to fish and aquatic plants.

4.1.3.2 Nitrogen Criteria and Standards

In 1989, the U.S. EPA proposed ambient water quality criteria for ammonia (NH_3) in salt water. The criteria are influenced by pH, salinity, and temperature. The EPA recommends that continuous total ammonia levels should not exceed 0.72 mg/l for waters having the following conditions: salinity 20 ppt, temperature 2°C, and pH 8. However, for slightly more alkaline conditions (pH 8.4), the criterion decreases to 0.30 mg/l.

The 1994 Long Island Sound Study (LISS) identified several major sources of nitrogen. These sources include deposition from air pollution, delivery from large tributaries, sewage treatment plants, failing septic systems, and storm water runoff. LISS presented several management options for controlling the nitrogen load into the Sound. Two of these options, including sewage treatment plant upgrades for nitrogen removal and reduction of nitrogen from non-point sources, could potentially result in a 55% reduction of nitrogen load to Long Island Sound.

Nitrogen water quality standards vary across the U.S. Some States follow total maximum daily load (TMDL) criteria. Others use site-specific or waterbody-based ambient nutrient levels (National Research Council, 2000). New York State adopted a revised aquatic life standard for ammonia level in marine waters in 2008. For estuarine waters such as Oyster Bay, the chronic, or long-term aquatic standard for ammonia (un-ionized ammonia as NH_3) is 35 μg/L (0.035 mg/l). The acute ammonia standard is 230 μg/L (0.23 mg/l), meaning that the estuary is considered impaired if measurements exceed this level.

In addition, the NYSDEC has adopted a total nitrogen (TN) guideline of 0.5 mg/l for the Peconic Bay estuary surface water (Suffolk County Department of Health Services, 1999). This guideline is based on the 1988-1990 summer data correlation of the mean TN levels with an occurrence of dissolved oxygen standard violations. The 1999 Comprehensive Conservation and Management Plan for the Peconic Bay Estuary proposed a change of this guideline to 0.45 mg/l based on more recent data (1994-1996). A more stringent criterion of 0.4 mg/l TN is being considered for shallow waters in order to protect eelgrass habitat areas.

LISS established a target of 58.5% nitrogen reduction from the 1990 baseline for cumulative point and non-point in-basin sources (NYSDEC, 2000). This target is to be achieved through maintaining maximum annual loads of nitrogen at 11 management zones. As of 2002, sewage treatment plant upgrades decreased nitrogen loads to the Sound by 28% (EPA 2006). An additional 12% reduction was targeted for completion by August 2004 (it is unknown if this goal was accomplished).

To address this water quality problem, NYSDEC imposed limits to reduce nitrogen discharged from the municipal treatment plants located on the north shore of Long Island. NYSDEC issued a revised discharge permit that required the Oyster Bay Sewer District (OBSD) to reduce nitrogen discharged to Oyster Bay from the treatment plant by 63.8 percent in three 5-year increments by August 2014. With the intent of reducing nitrogen discharges into Oyster Bay and Long Island Sound, the OBSD upgraded its plant in 2006 to provide advanced treatment for nitrogen removal. The OBSD advanced treatment facility is achieving the 2014 nitrogen limits imposed by NYSDEC permit, and the upgrade has reduced the daily nitrogen discharged by as much as 75%.

4.1.3.3 Monitoring Results

FOB began monitoring nitrogen in 2002 with the goal of establishing a baseline of data and identifying possible areas of concern in the estuary. In 2011 and 2012 FOB monitored three species of nitrogen at

22 sites in the Oyster Bay estuary, including ammonia, nitrate/nitrite and TKN. Samples were collected approximately once per month as scheduled. From these analyses, Organic Nitrogen levels (TKN minus ammonia) and total nitrogen (i.e., TKN plus nitrate and nitrite) can be calculated.

Organic nitrogen is typically present in larger quantities in the Oyster Bay/Cold Spring Harbor estuary waters than ammonia and nitrate plus nitrite, generally accounting for more than 50% of total nitrogen at the monitoring sites. In 2011, organic nitrogen accounted for an average of 90% of total nitrogen at estuary monitoring locations and 96% in 2012. Organic nitrogen seasonal averages exceeded 0.8 mg/l at all locations in 2011 and 1.8 mg/l in 2012. In the estuary, ammonia and nitrate/nitrite levels were low compared to organic nitrogen levels.

With the exception of FB-12 during the 2012 monitoring season, all monitoring locations had ammonia levels well below the State standard. In the case of station FB-12, a single elevated sample value caused the seasonal average to exceed the standard; the average of 2012 events without this high value was 0.025 mg/l, well below the standard. The seasonal average for all locations was 0.08 mg/l in 2011 and 0.05 mg/l in 2012.

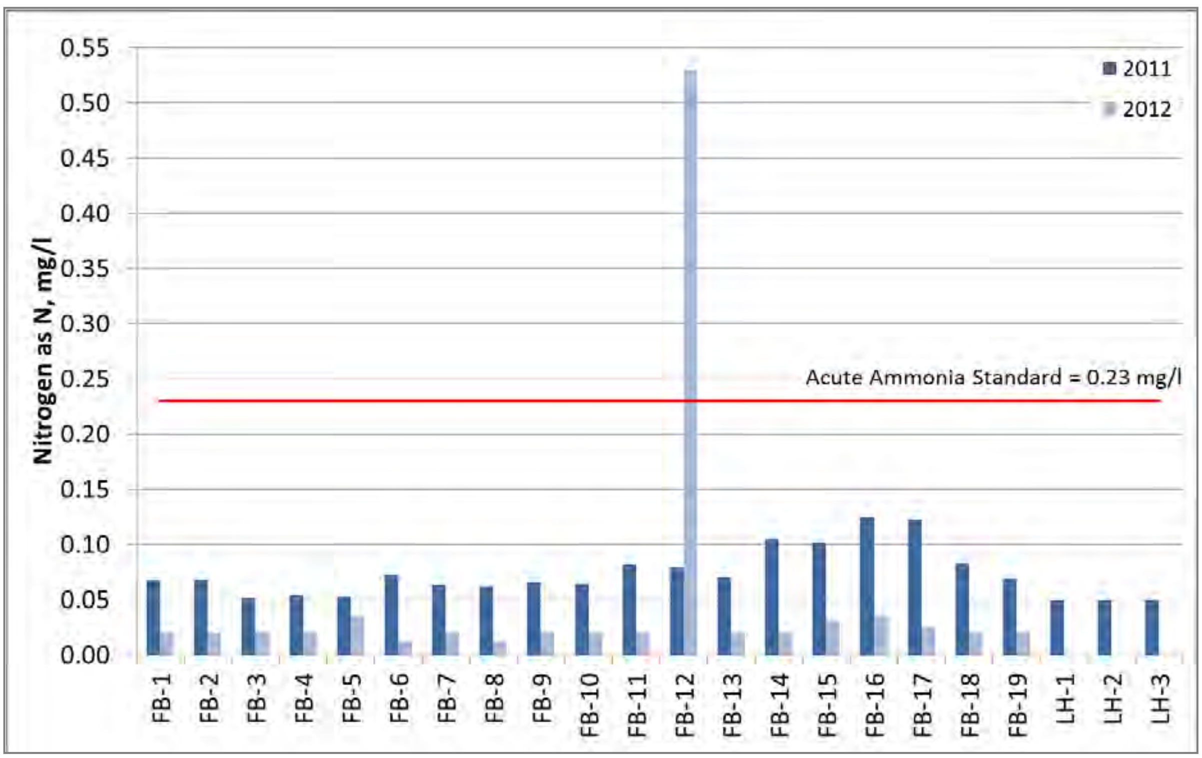

Figure 21. Seasonal average ammonia results for 19 stations in the Oyster Bay/Cold Spring Harbor Estuary, 2011 & 2012

Figure 22 shows locationally-averaged total nitrogen data for the monitored open water body stations in 2011 and 2012. Using the NYSDEC guideline for the Peconic Bay estuary, the seasonal average total nitrogen levels for all of the Cold Spring Harbor, Oyster Bay Harbor, Mill Neck Creek, and Laurel Hollow monitoring locations would have exceeded the total nitrogen guideline of 0.5 mg/l in 2011 and 2012. As a comparison, all 19 monitoring locations have exceeded this guideline since 2005 (in 2002, 2003, and 2004, 17, 11, and 12 locations, respectively, would have exceeded the guideline). The elevated levels were described in Friends of the Bay's 2004 Water Quality Report, but nitrogen samples were only collected on two occasions in that year and the elevated results could not be verified. See *Appendix E* for additional nitrogen data.

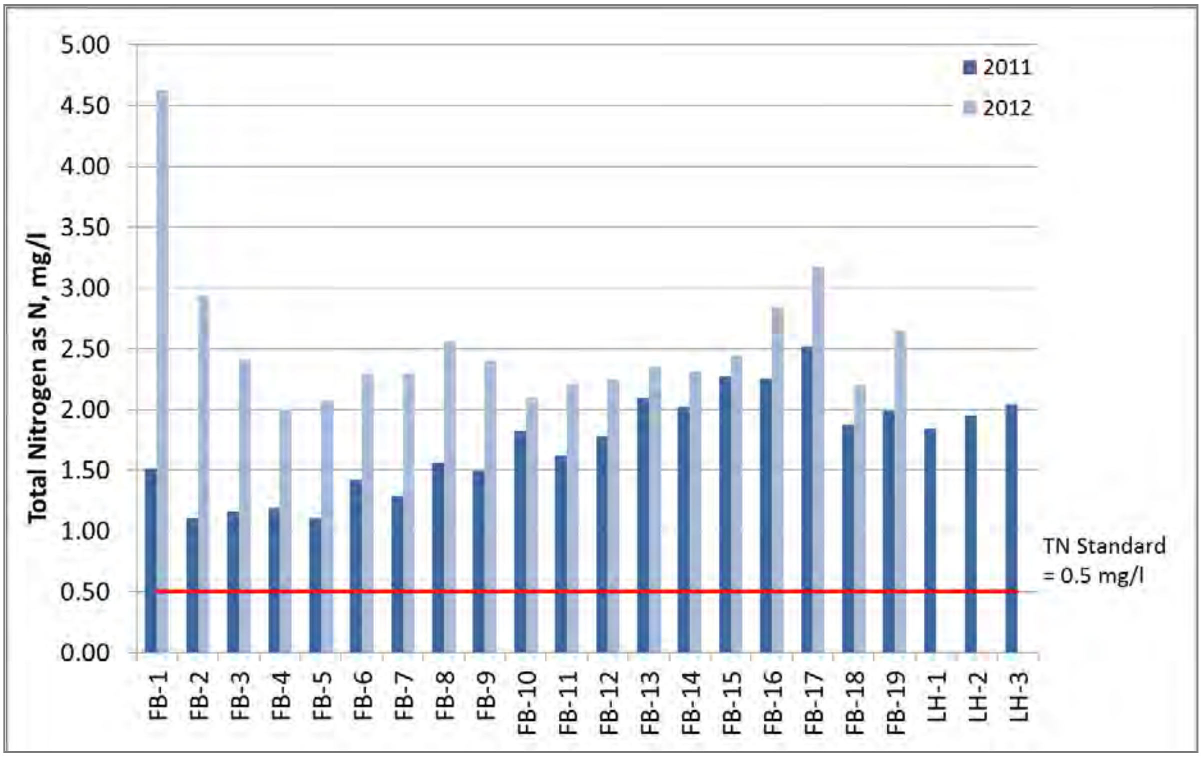

Figure 22. Seasonal average total nitrogen results for 19 stations in the Oyster Bay/Cold Spring Harbor Estuary, 2011 & 2012

As depicted in *Figure 23*, total nitrogen levels measured in the estuary have been generally trending upward since Friends of the Bay began monitoring in 2002. The 2012 monitoring season experienced the second highest total nitrogen levels, while 2011 was closer to the average nitrogen levels measured over all monitoring seasons.

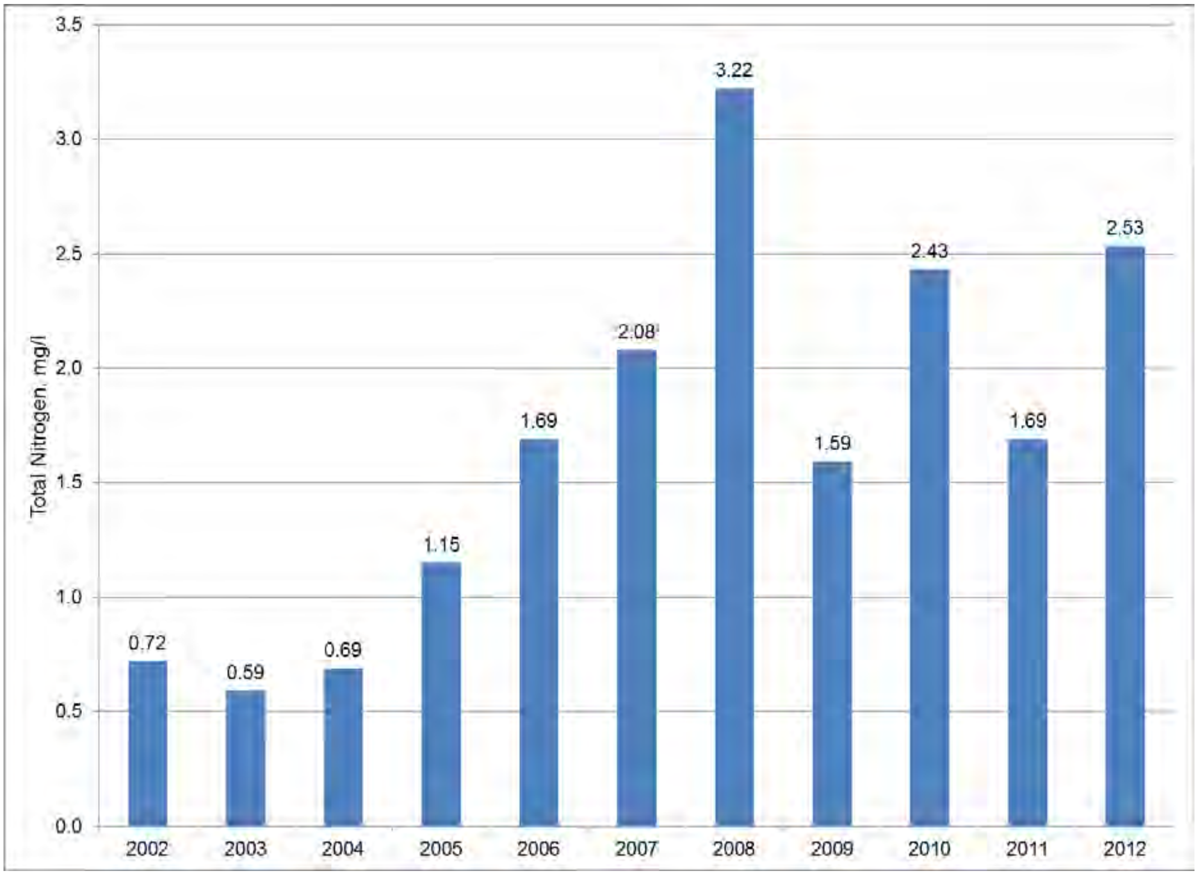

Figure 23. Seasonal averages for total nitrogen

4.1.4 Dissolved Oxygen

LISS (1994) concluded that low dissolved oxygen (hypoxia) poses the most serious threat to the health of the Sound ecosystem. The waters of the western and central portions of the Sound generally exhibit hypoxia during the months of July, August and September. During these months, dissolved oxygen concentrations at the top of the water column are typically 5-8 mg/l (measurement range is approximately 1.4-15.6 mg/l for 2011 and 1.3-11.3 mg/l for 2012) and 3-4 mg/l (measurement range is approximately 0.4-15.0 mg/l for 2011 and 1.3-9.5 mg/l for 2012) at the bottom of the water column.

All aquatic life depends on oxygen availability in the water column. Low levels of oxygen have multiple effects on the marine ecosystems such as a change of species behavior, sensitive species growth impairment and in severe conditions, death of large populations of fish and other species. LISS summarized the effects of different oxygen impairment levels on some organisms of the Long Island Sound. An excerpt of these findings is presented in *Table 5*.

Table 5. Effect of Dissolved Oxygen Concentrations on Selected Organisms. (LISS, 1994)

Dissolved oxygen concentrations above the pycnoline (top of the water column)	
4-5 mg/l	Suitable for many species and life stages, may result in limited biological consequences
3-4 mg/l	25-50% mortality of larval lobsters (based on 4-day long experiments)
2-3 mg/l	50-95% mortality of larval lobsters (based on 4-day long experiments)

Dissolved oxygen concentrations below the pycnoline (bottom of the water column)	
4-5 mg/l	Protective for most biological consequences
3-4 mg/l	Protective for many biological consequences, reduced growth of juvenile Am. Lobster, grass shrimp, summer flounder (12-day experiments)
2-3 mg/l	Impaired finfish habitat (reduced abundance), mortality of larval grass shrimp and mud crabs (12-day experiments)
1-2 mg/l	Impaired lobster and finfish habitat, 10-90% mortality of some non-larval species (4-day experiments)
0-1 mg/l	Many severe consequences, even at short exposures

In bodies of water, oxygen is replenished from the atmosphere and by plant and algal photosynthesis. While aquatic plants and algae produce oxygen during the day, throughout the night photosynthesis does not occur, and consumption of oxygen by bacteria through decay of dead biomass consumes residual oxygen. Thus, the lowest levels of the daily cycle occur in the early morning hours. Several other factors influence the amount of dissolved oxygen found in a particular body of water:

- **Water temperature** - cooler water holds more oxygen; therefore, warm summer waters can be particularly stressful for marine organisms.
- **Salinity** - with increasing salinity the capacity of water to hold oxygen diminishes.
- **Water turbidity** - poor water clarity prevents sunlight from reaching oxygen-producing aquatic plants lower in the water column.
- **Nutrients** - excess nutrients can cause an algal bloom which blocks sunlight from aquatic vegetation lower in the water column. When algae dies and sinks to the bottom, the bacteria involved in decay of the plant material consume a significant amount of dissolved oxygen.
- **Mixing of the waters** - stagnant waters and waters that are stratified hinder transport of oxygen into lower levels of the water column.

Previously, DO levels above 5.0 ppm were considered healthy; DO levels below 5.0 ppm were considered to cause various adverse impacts (related to growth, reproduction, and survival of organisms). The severity of impacts, and threshold DO levels where impacts occur, are strongly species dependent. A revised dissolved oxygen standard was implemented by NYSDEC in 2008. For estuarine waters such as Oyster Bay/Cold Spring Harbor Estuary, the chronic, or long-term DO standard is 4.8 ppm. The standard allows levels to fall below 4.8 ppm for short periods of time; the lower the level, the shorter the time interval allowed (as defined by the equation below).

$$DO_i = \frac{13.0}{2.80 + 1.84e^{-0.1t_i}}$$

where DO_i = DO concentration in mg/l between 3.0 - 4.8 mg/l and t_i = time in days. This equation is applied by dividing the DO range of 3.0 - 4.8 mg/l into a number of equal intervals. DO_i is the lower bound of each interval (i) and t_i is the allowable number of days that the DO concentration can be within that interval. The actual number of days that the measured DO concentration falls within each interval (i) is divided by the allowable number of days that the DO can fall within interval (t_i). The sum of the quotients of all intervals (i …n) cannot exceed 1.0:

i.e., $\sum_{i=1}^{n} \frac{t_i(actual)}{t_i(allowed)} < 1.0$

The DO concentration shall not fall below the acute standard of 3.0 mg/l at any time.

The acute DO standard is 3.0 ppm, meaning that the estuary is considered impaired if DO measurements fall below this level. For DO concentrations that are equal to or greater than 3.0 ppm and less than 4.8 ppm, the growth and abundance of certain marine species will be affected. The impact of hypoxia on marine life depends on the duration and area over which low DO levels occur; water temperature, salinity, and distribution and behavioral patterns of resident species also play a role in how marine organisms react to hypoxic conditions.

Friends of the Bay monitored dissolved oxygen (DO) levels at the top and bottom of the water column at 22 open water body sites in the estuary complex. The 2011 and 2012 data follow the general trends observed in past years, with the highest DO values occurring in the spring, levels declining through the early summer, and then rising again in late summer and into the fall. *Figures 24* through *Figure 30* present DO data collected at the bottom of the water column throughout the 2011 and 2012 seasons.

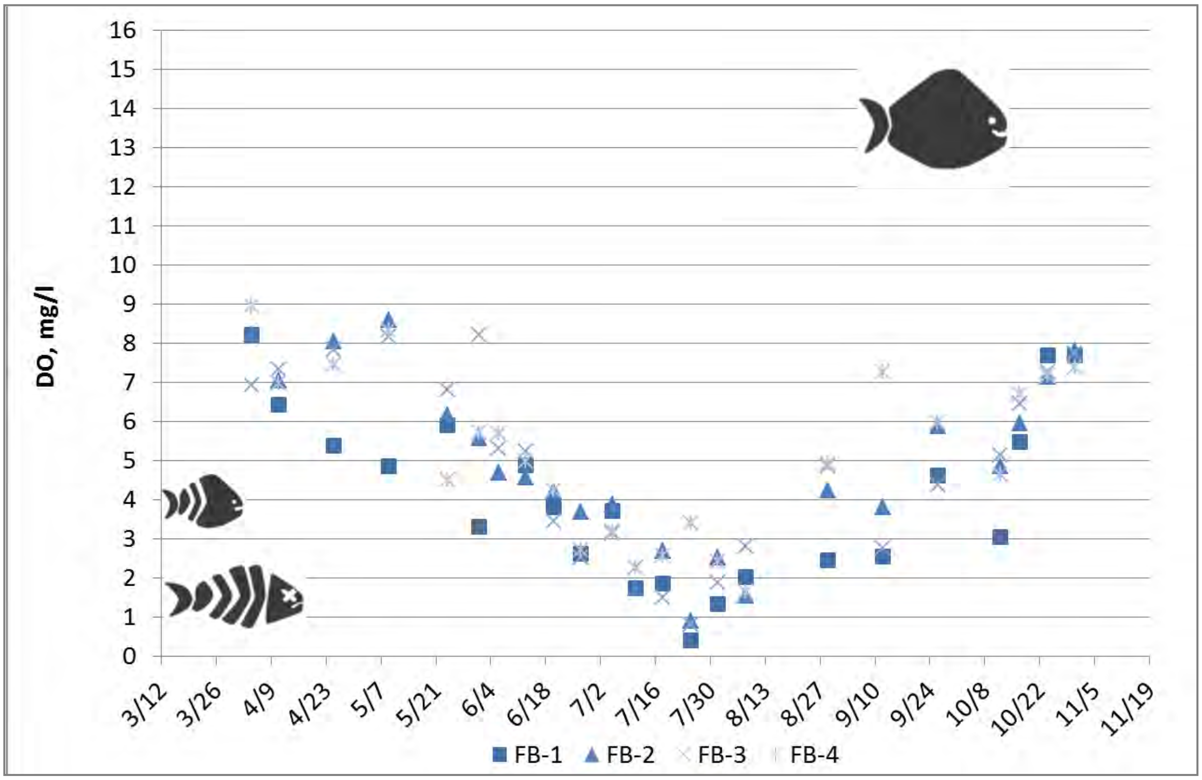

Figure 24. Dissolved oxygen for Cold Spring Harbor monitoring locations, 2011

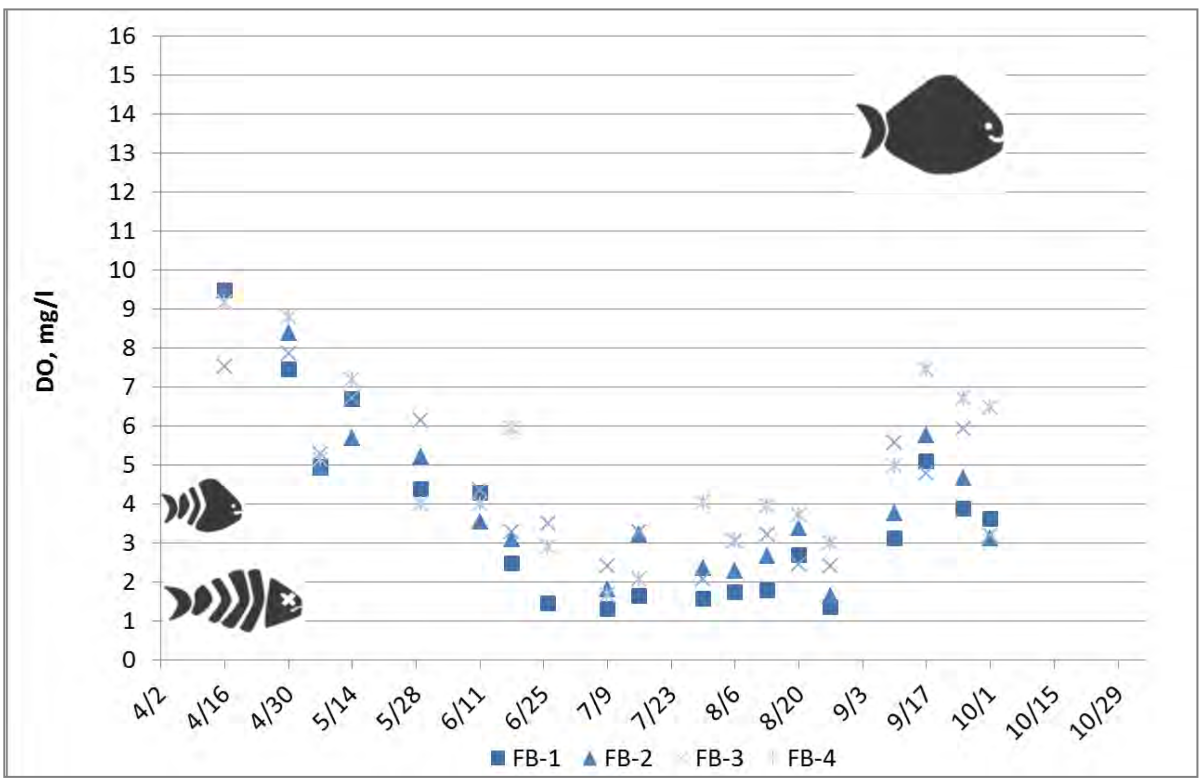

Figure 25. Dissolved oxygen for Cold Spring Harbor monitoring locations, 2012

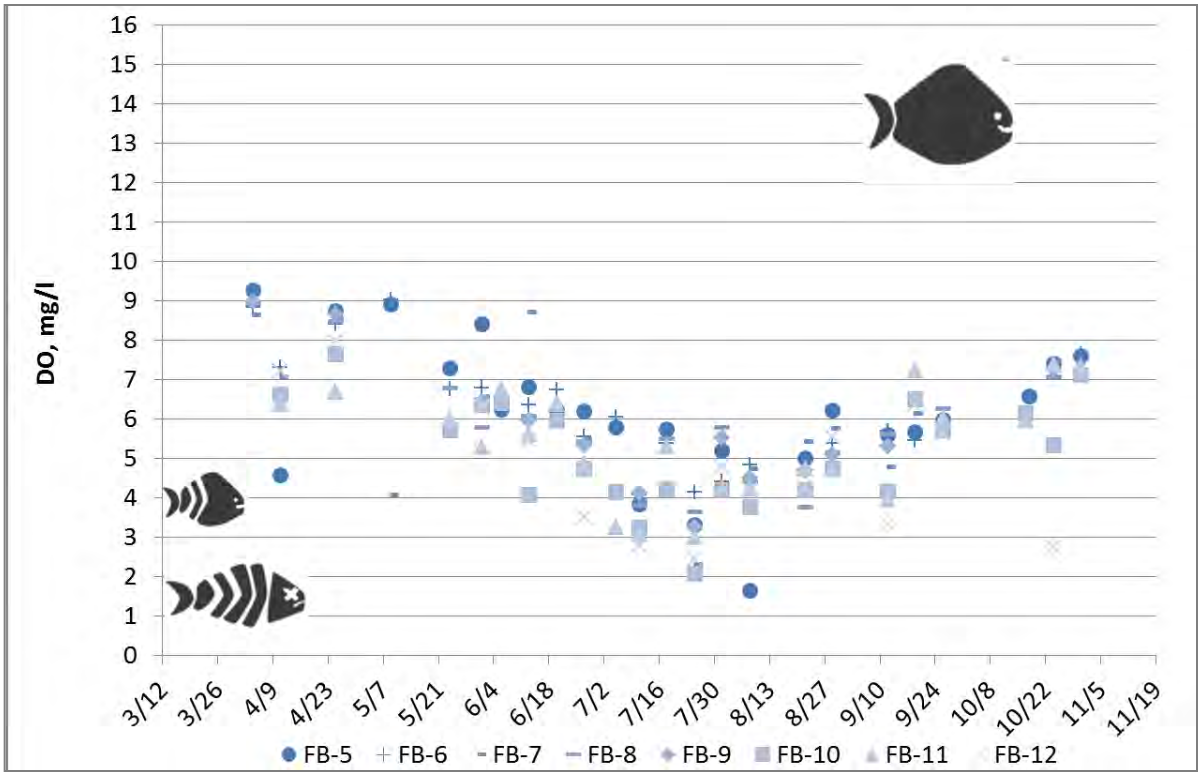

Figure 26. Dissolved oxygen for Oyster Bay Harbor monitoring locations, 2011

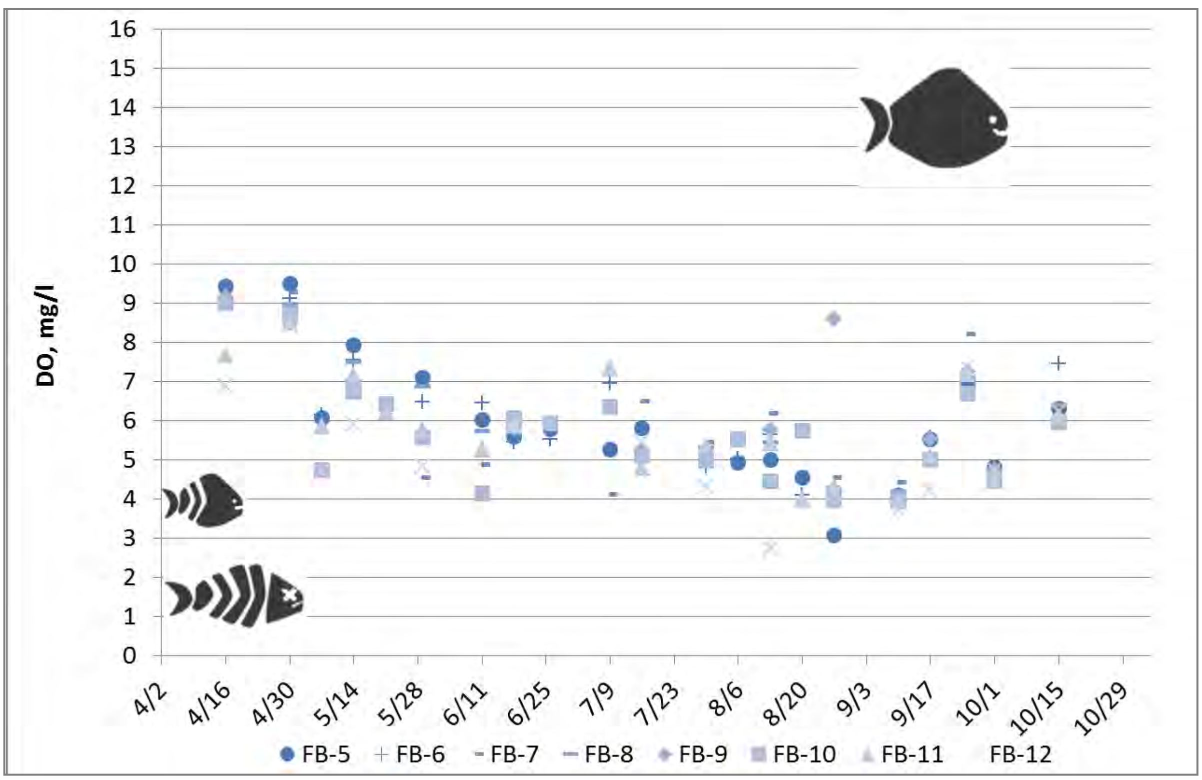

Figure 27. Dissolved oxygen for Oyster Bay Harbor monitoring locations, 2012

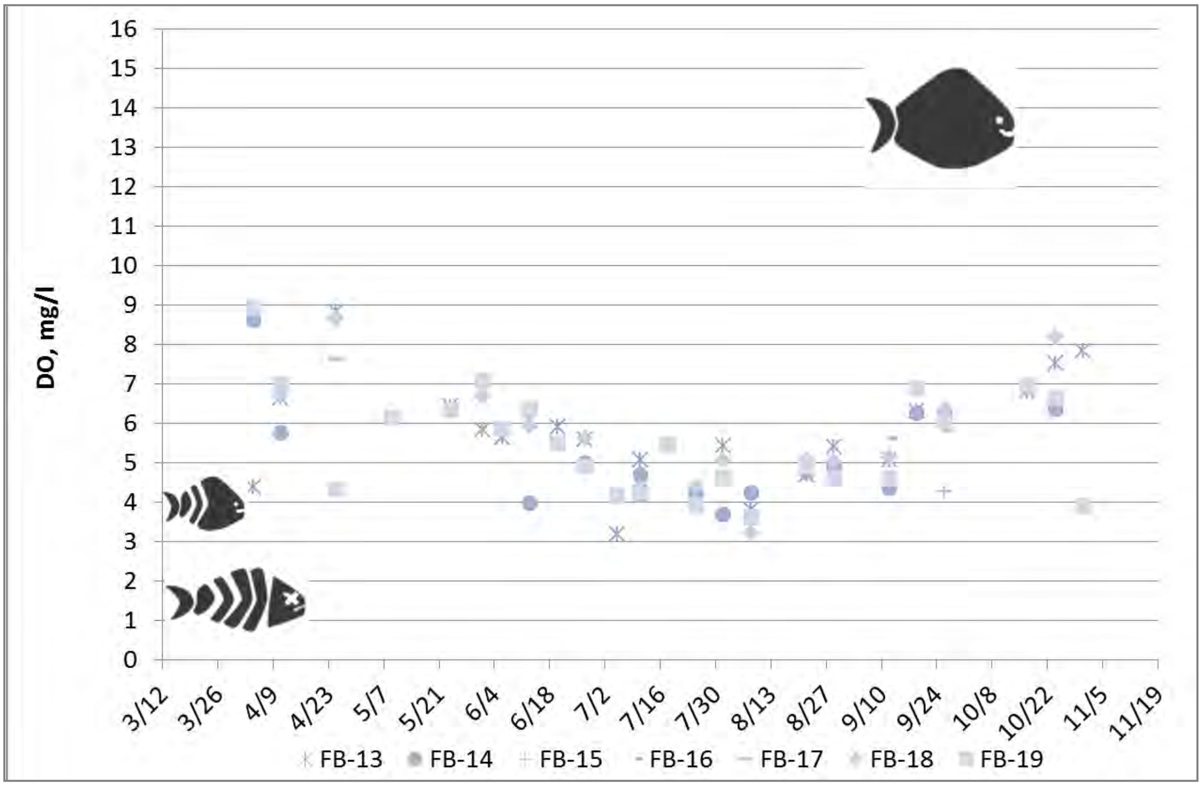

Figure 28. Dissolved oxygen for Mill Neck Creek monitoring locations, 2011

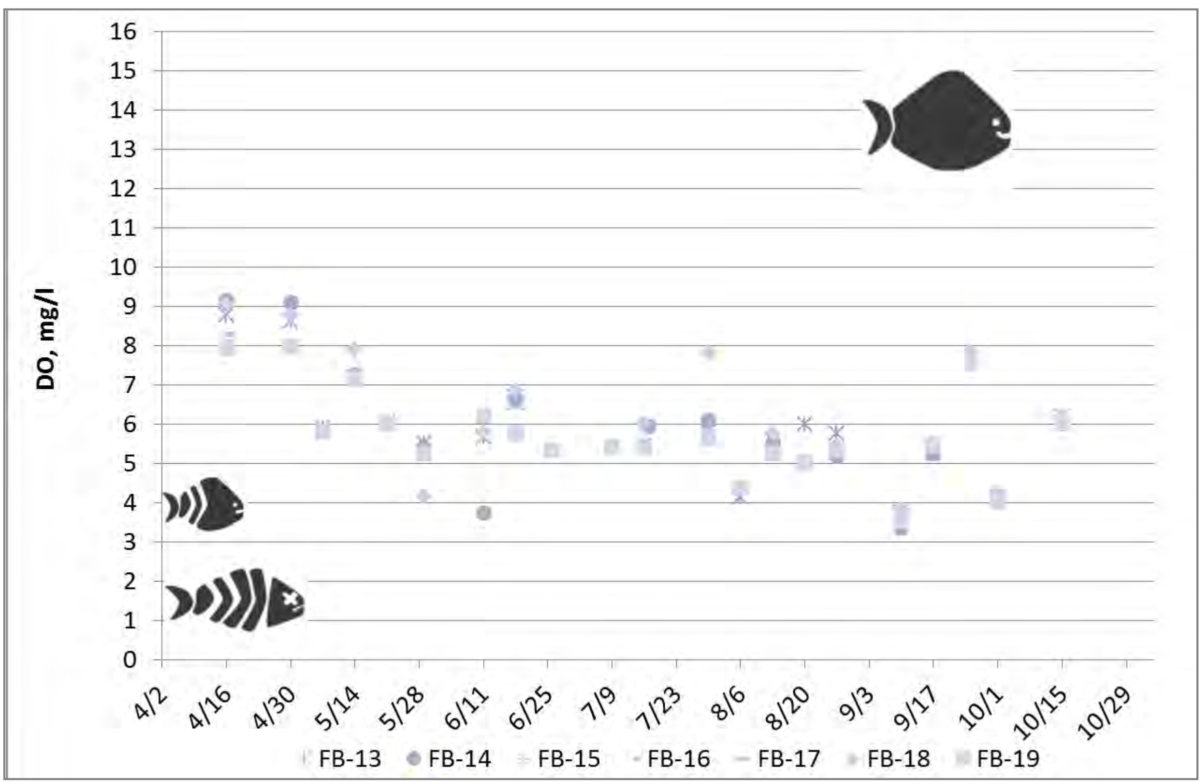

Figure 29. Dissolved oxygen for Mill Neck Creek monitoring locations, 2012

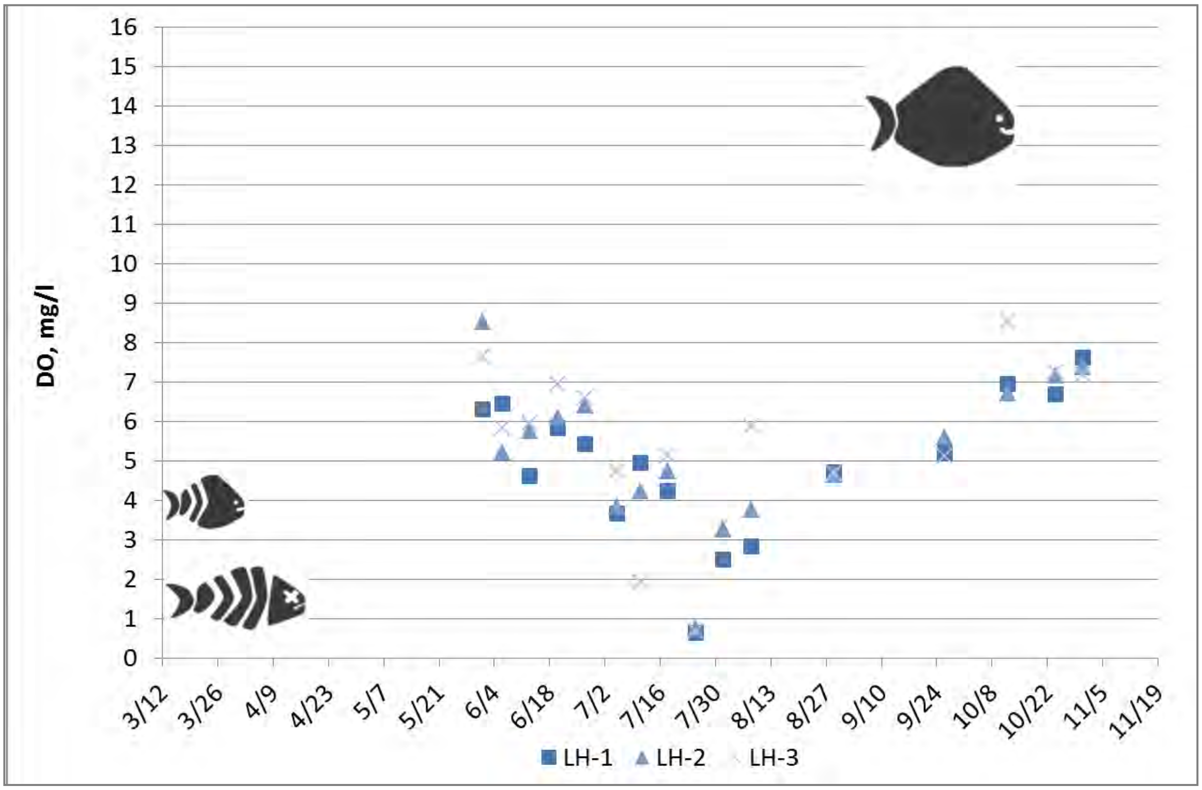

Figure 30. Dissolved oxygen for Laurel Hollow monitoring locations, 2011

Figure 32 and *Figure 33* present boxplots of the DO data collected at the bottom of the water column throughout the 2011 and 2012 seasons. Note, some monitoring stations are not represented in the boxplots as there were not enough samples collected to have an accurate representation. Boxplots have been used to graphically summarize the water quality data. Boxplots provide a succinct, graphical summary of water quality data to allow comparison of water quality conditions at the different monitoring stations. A boxplot consists of a box, whiskers, and outliers. As shown in *Figure 31*, the top of the box is the 75th percentile, the bottom of the box is the 25th percentile, the line dividing the box is the median value (50th percentile), and the diamond is the average. The vertical lines above and below the box are called whiskers and represent the minimum and maximum values of the observed data.

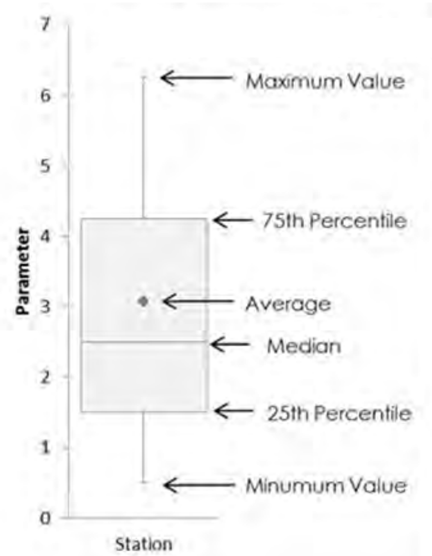

Figure 31. Boxplot Elements

In both 2011 and 2012, FB-1 through FB-4 showed the greatest variability in DO data. In 2011 maximum/minimum DO values were observed at FB-5, FB-6, FB-7, FB-8, and FB-9 and these stations also exhibited the highest mean and median values. In 2011, minimum DO values (<1 mg/l) were recorded at FB-1, FB-2, FB-3 and LH-1, LH-2, and LH-3. Stations FB-10 through FB-19 show the least variability and narrowest range of values in 2011.

In 2012, measured DO values were lower overall, with all values less than 10 mg/l. As in 2011, FB-1, FB-2, FB-3, and FB-4 show the greatest variability and lowest DO values of all stations monitored. The smaller height of the boxes in 2012 compared to 2011 indicates less variability in observed DO concentrations. The mean and median DO values were consistent in 2011 and 2012.

While hypoxic and anoxic conditions are likely to have occurred in the Oyster Bay/Cold Spring Harbor estuary complex based on past experience and trends in the data, it is important to note that no fish kills were reported. The existing ecological community has likely adapted to low DO levels, and actual DO levels are not believed to have deviated beyond typical ranges. Low dissolved oxygen levels are a symptom of over-enrichment by nutrients and not a problem that can be solved directly. Reducing nutrient inputs from the surrounding watershed into the estuary would likely improve water quality and could reduce the occurrence of low DO levels. See *Appendix E* for additional dissolved oxygen data.

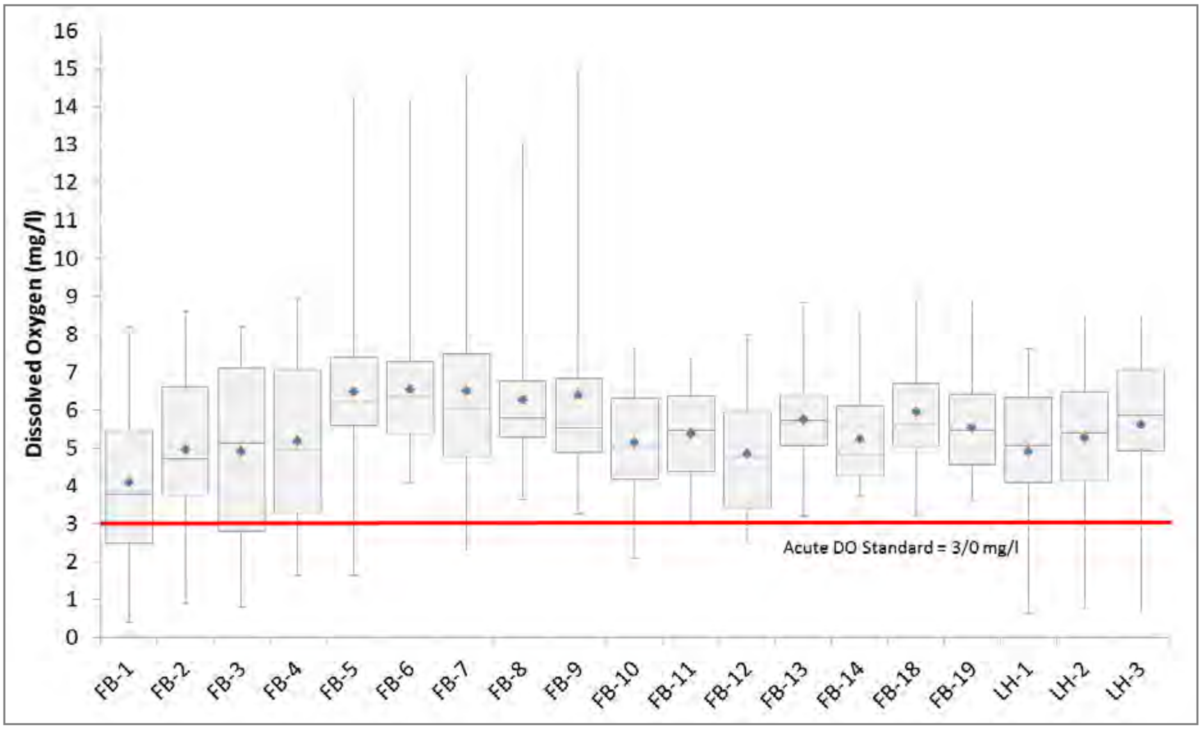

Figure 32. Dissolved oxygen at all monitoring locations, 2011

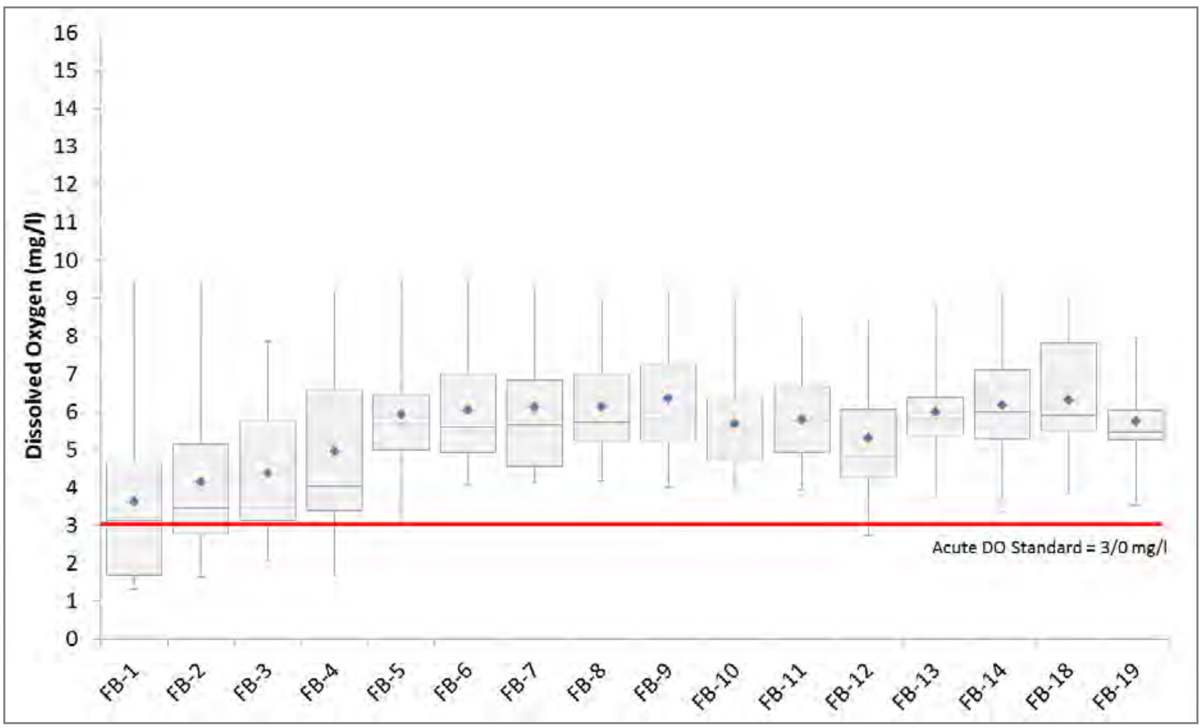

Figure 33. Dissolved oxygen at all monitoring locations, 2012

4.2 Stream and Outfall Monitoring

The Friends of the Bay stream and outfall monitoring program is intended to identify potential upland sources of pollutants and causes of water quality impacts in the Oyster Bay, Cold Spring Harbor, and Mill Neck Creek estuary complex.

The monitoring program includes a "rotating" stormwater or wastewater outfall monitoring location that can change from event to event in an effort to identify pollutant sources given limited resources. Additionally, one monitoring location is upstream of the Mill River discharge to the estuary. This location was selected to examine changes in pollutant contributions within the Mill River watershed. The reach between the upstream and downstream monitoring locations includes an apartment complex, numerous residences, Mill Pond, and freshwater wetlands.

Stream and pond discharge monitoring locations include:

- OBS-2, Beaver Lake Outflow
- OBS-3, Beekman Creek
- OBS-5, Mill River Outflow
- OBS-6, White's Creek
- OBS-7, Tiffany Creek
- OBS-8, DeForest Pond Outflow
- OBS-9, St. John's Pond Outflow

Paired upstream and downstream locations include:

- OBS-4, Upper Mill River
- OBS-5, Mill River Outflow

Wastewater and stormwater discharge monitoring locations include:

- OBS-1, The Birches sewage outfall
- OBS-10, Rotating Outfall

Samples collected at these stations were monitored for dissolved oxygen, specific conductivity, pH, temperature, *E.coli*, fecal coliform, ammonia as N, nitrate as N, TKN, phosphorus as P, BOD, COD, TSS, turbidity, hardness as $CaCO_3$, lead, copper, zinc, magnesium, calcium, and alkalinity as $CaCO_3$ as well as the qualitative parameters of odor, color, particulates, and floatables.

Although stream and outfall monitoring has been conducted as eight discrete events over five years (no samples were collected in 2012), some initial observations can be made. In summer 2010, DO measurements at OBS-8 were very low. These are the lowest observed values of all the stations, but also coincide with summertime measurements. In general, stations OBS-1, OBS-8 and OBS-10 have lower DO values. Overall, DO values have remained fairly consistent since 2007 and are in the range of 6-14 mg/l.

Samples were collected for *E.coli* and fecal coliform during one of the two monitoring events in 2011. The results of this event were within the range of values observed since 2007. Continued monitoring is necessary to further evaluate the presence of potential trends.

pH values remain relatively consistent and within a desirable range (there was an elevated pH reading recorded at OBS-2 during the June 2011 event (10 SU) – a possible anomaly). Specific conductivity measurements remain relatively consistent over time and at all stations. Notably, elevated concentrations were observed at OBS-6 in all sampling events except for December 2008, December 2010, and June 2011. In general, ammonia levels were measured above the laboratory reporting limit in 2011, consistent with past years. The maximum reported ammonia concentration was lower when compared to other years. Nitrate levels were consistently elevated at The Birches (OBS -1). The highest metals concentrations were also observed at OBS-1 in 2008 and 2010. Additional data will help to further identify potential pollutions sources and monitor conditions at the streams and outfalls. Results and preliminary plots of the available monitoring data are included in *Appendix F*.

5 Program Recommendations

5.1 Proposed Changes to Monitoring Procedures

1) Add one open water body location for monitoring stratification within the water column. Prior to 2003, FOB recorded DO at 1-meter intervals throughout the water column. This practice ceased in 2003 due to the excessive number of measurements being recorded each week. However, stratification data can be useful in tracking conditions within the estuary. FOB should consider measuring DO profiles at one of the deep monitoring locations to track the development of stratification throughout the season. If temperature and salinity profiles were also recorded at that location, then the pycnoline (depth interval of steep density gradients) could be tracked via the halocline (depth interval of steep salinity gradients) and thermocline (depth interval of steep temperature gradients).
2) Focus study of pollution problems in CSH and MNC. A focused study of the Cold Spring Harbor inner harbor area and Beaver Lake and Oak Neck Creek in Mill Neck Creek area could provide more insight into pollution sources in these areas of concern. Perhaps a partnership with a research, educational organization, or local municipality would provide necessary insight into the design of such a study.
3) Substitute an alternative monitoring location for "The Birches" Outfall in Stream and Outfall Program. Since this discharge has been eliminated, it no longer warrants monitoring. Other outfalls of concern or another rotating outfall could be monitored instead.

5.2 Continue Partnerships

Friends of the Bay citizen scientists fulfill a multitude of roles by participating in sample collection, data recording and boat operations. Individually they bring intellectual curiosity, diverse skills and compassion for the environment to the program. All the individuals listed in the acknowledgements use their volunteering opportunity to get involved in protecting the estuary. Friends of the Bay citizen scientists have diverse backgrounds and hometowns. They come from as far as the south shore of Long Island and Huntington Harbor, and as close as Bayville and Oyster Bay. All are united in their intellectual curiosity and compassion for the environment.

Friends of the Bay's Water Quality Monitoring Program was made possible by supporting members, businesses and citizen scientists. Partnerships with the Nassau County Department of Health, Analytical Chemists Laboratory, LLC, Frank M. Flower & Sons, Inc., and on boat-citizen scientists were invaluable this monitoring season.

Friends of the Bay has been assisted in water quality monitoring efforts by students and teachers from Locust Valley High School. During the 2011 and 2012 seasons, five (5) students, supervised by their teacher, participated in monitoring during July and August.

5.3 Look to the Future

To further refine the understanding of Cold Spring Harbor, Oyster Bay Harbor, and Mill Neck Creek, Friends of the Bay is considering the following additions to the monitoring program:

- **Improve Understanding of Estuary and Watershed Conditions** – As stated in the Watershed Action Plan, Friends of the Bay would like to:
  - Continue the current Friends of the Bay citizen water quality monitoring program at the in-harbor monitoring locations to continue collecting baseline water quality information and to assess the effectiveness of plan implementation over time.
  - Continue the current Friends of the Bay stream and outfall monitoring program, focusing on priority outfalls and discharges to the estuary complex.
  - Although many users of the harbor have a working knowledge of the various types of marine habitats within portions of the estuary complex, information is limited regarding the actual quality and distribution of benthic (i.e., bottom-dwelling) communities and habitats throughout Oyster Bay/Cold Spring Harbor. A benthic habitat mapping survey is recommended to identify and assess the quality of benthic habitats and biological communities, including those habitats and biological communities that are threatened, missing, or have been extirpated by human activity. This type of information would be used to identify and guide restoration projects such as a shellfish sanctuary, eelgrass restoration, and restoration of diamondback terrapin nesting areas.
  - Current efforts at improving water quality concentrate on reducing pathogen loads to the estuary complex, based on the pathogen Total Maximum Daily Load (TMDL) that was developed for portions of Oyster Bay and Mill Neck Creek. While pathogens are a major threat to water quality, as well as to recreation and the shellfish industry, they are just one of many. Water quality monitoring data collected by Friends of the Bay indicates that low dissolved oxygen and elevated nitrogen concentrations are common in areas of the estuary complex during the summer. Additionally, silt from stormwater runoff can smother otherwise productive shellfish beds and nutrients such as phosphorus can result in harmful algal blooms. Specific recommended actions to evaluate other potential water quality impairments include:
    - Coordinate with the NYSDEC regarding the potential inclusion of Oyster Bay/Cold Spring Harbor for water quality impairments other than pathogens (i.e., low dissolved oxygen, nutrients, sediment) during future listing of impaired waters (303d) list.

        - As a long-term project, develop a linked hydrodynamic and water quality model of the estuary complex to assess the relative influence of watershed sources and Long Island Sound circulation on the water quality of the estuary. In addition to pathogen load reductions, the model could be used to predict the affect of reduced nutrient loads from the watershed on harbor water quality, focusing on specific water quality concerns, such as dissolved oxygen. The model could also be used to predict the impact of other changes on water quality, such as increased rainfall resulting from climate change.
        - Ensure that future management efforts address the full range of water quality parameters and potential sources of water quality impairments.
    - Harmful algal bloom (HAB) monitoring should be conducted within Oyster Bay/Cold Spring Harbor to address these risks and guide water quality management approaches. Specific recommendations include:
        - Coordinate with NYSDEC to expand the NYSDEC Bureau of Marine Resources Shellfisheries Section marine biotoxin monitoring program and/or the Suffolk County HABs monitoring program to Oyster Bay/Cold Spring Harbor.
        - Coordinate HABs monitoring efforts between state, county, and municipal health departments and marine monitoring efforts.
        - Incorporate periodic HAB monitoring into the Friends of the Bay water quality monitoring program and compile results in the proposed Information Resource Center.
        - Coordinate with local government and university researchers regarding ongoing research findings on HABs and implement related water quality management approaches.
- **Bacteria Source Tracking** – Friends of the Bay would like to include Bacteria Source Tracking as part of its water quality monitoring program in future years. FOB continues to monitor grant opportunities to fund the collection of samples for Bacteroides as an indicator of recent human fecal pollution. The QAPP will be modified if funding is acquired to accommodate the additional sampling.
- **Apparent color** – Apparent color is an easy way to get general information about what material is dissolved or suspended in the water, and thus would be a beneficial parameter for FOB to monitor. Water with very little dissolved or suspended material appears blue in color. The presence of dissolved organic matter such as decaying plant matter can result in water color of yellow or brown. The presence of dinoflagellates can produce a reddish or deep yellow color. Water that is rich in phytoplankton and algae appears green. Runoff can result in a variety of colors including yellow, red, brown or gray.
- **Chlorophyll a and/or algal enumeration** – In addition to measuring apparent color, it would benefit the monitoring program to measure chlorophyll levels within the estuary. A chlorophyll test would measure the concentration of algae in the water column, helping to identify if algal blooms are influencing water clarity. Alternatively, algal enumeration by an experienced limnologist can identify the quantity of specific algal species that are present. Varying algal species can be an indicator of changes in a water body from year to year.

6 Conclusion

Since 2000, Friends of the Bay's Water Quality Monitoring Program has developed into a well-conceived periodic monitoring program of several important water quality parameters throughout the Oyster Bay/Cold Spring Harbor estuary complex. In 2011 and 2012, four stations were monitored in Cold Spring Harbor, eight in Oyster Bay Harbor, and seven in Mill Neck Creek. Additionally, 3 stations were sampled in Laurel Hollow in 2011. All waters in the Oyster Bay estuary need protection. However, based on bacterial and nitrogen monitoring results, additional management efforts should be focused on areas of concern such as Cold Spring Harbor, Mill Neck Creek/Beaver Lake and Oak Neck Creek.

Three major water quality parameters were monitored in 2011 and 2012: bacteria, dissolved oxygen and nitrogen. Analysis of the monitoring data provided the following insights:

- As observed in previous years, bacteria levels in Oyster Bay Harbor were lower than in Mill Neck Creek and Cold Spring Harbor, and the majority of Oyster Bay Harbor met the shellfish standard for fecal coliform. This is encouraging since Oyster Bay Harbor is where the majority of shellfishing occurs in the estuary complex.
- Nitrogen monitoring data indicate that all monitoring locations would have exceeded the NYSDEC nitrogen guideline for marine waters that has been established for the Peconic Bay estuary.
- Conversely, with the exception of FB-12 during the 2012 monitoring season, all monitoring locations had ammonia levels well below the State standard.
- A $10.6 million advanced wastewater treatment facility serving the Oyster Bay Sewer District has been fully operational since March 2006. The facility is achieving the 2014 nitrogen limits imposed by the New York State Department of Environmental Conservation. The upgrade has reduced daily nitrogen discharges by as much as 75%. With the completion of this plant the Friends of the Bay nitrogen data collected in 2002 through 2012 and subsequent years will provide a valuable baseline in evaluating the effect of reduced nitrogen loading on the estuary. The upgrade represents an important improvement in infrastructure available to the public, which should improve estuary water quality.
- Dissolved oxygen data continue to indicate that the waters of the estuary are enriched with nutrients. Dissolved oxygen levels decreased steadily from spring through late summer, and then began to increase in late summer. Nutrient enrichment can result from inadequately treated sewage discharges, polluted stormwater runoff, over-fertilization of lawns and gardens, agricultural runoff, and atmospheric deposition of air pollutants. Long-term reductions in nitrogen inputs should reduce the occurrence of extremely low DO conditions in the bottom of the harbor.
- Friends of the Bay continued stream and outfall monitoring in 2011 (no samples were collected in 2012). Observed dissolved oxygen concentrations have remained fairly consistent over the sampling period since 2007 and are in the range of 6-14 mg/L. *E.coli* and fecal coliform were within the range of concentrations observed since 2007. pH values remain relatively consistent and within a desirable range. Nitrate levels were consistently elevated at The Birches (OBS -1), and the highest metals values were observed at OBS-1 in 2008 and 2010. Continued monitoring

is necessary to further evaluate the presence of potential trends. Additional data will help to further identify potential pollutions sources and monitor conditions at the streams and outfalls.

- As recommended in the 2001 Watershed Action Plan for the estuary complex, ongoing monitoring is recommended to monitor changes in harbor conditions as a result of changing watershed conditions and implementation of plan recommendations. Additional data collection is also recommended to refine the current understanding of water quality impairments in the estuary complex, particularly pollutants for which previous monitoring results have demonstrated the potential for water quality impairment but which are not currently identified by NYSDEC as a listed cause of impairment (e.g., sediment, nutrients, dissolved oxygen).

Friends of the Bay will continue to work with citizen scientists, government agencies, and fellow not-for-profit organizations in future monitoring seasons. Together, FOB and its partners will continue to improve and expand their monitoring efforts. These efforts will provide a link to show how investment in water quality protection is improving the quality of water in Mill Neck Creek, Oyster Bay Harbor and Cold Spring Harbor.

7 References

APHA; AWWA; WEF (1995) *Standard Methods for the Examination of Water and Wastewater, 19th Edition.* Washington, D.C.

Chapra, Steven C. (1997) *Surface Water Quality Modeling.* McGraw-Hill, Inc. New York, NY.

Comprehensive Conservation and Management Plan: Peconic Estuary Program, September 1999 Suffolk County Department of Health Services. Office of ecology. Peconic Estuary Program Office. Walter Davydiak. Chapter 3, pp. 8-12, 64-65.

EPA Region 1 (2006) *Long Island Sound Study at EPA New England* <http://www.epa.gov/boston/eco/lis/epane.html>

LISS – Long Island Sound Study. The Comprehensive Conservation and Management Plan. 1994. Published by NYS Department of Environmental Conservation, The Connecticut Department of Environmental Conservation, The EPA Long Island Sound Office.
pp.11-40.

New York Sea Grant Extension. (1990). *Pathogens: Long Island Sound Study Fact Sheet #12*, Stony Brook, NY. 4 pp.

The National Research Council. (2000). Clean Coastal Waters: Understanding and reducing the Effects of Nutrient Pollution, National Academy Press Washington D.C. pp. 67-83, 242-246