11.8 Monitoring Results

The figures on the following pages show the trends in surface dissolved oxygen in the locations sampled by SCDHS. Figure 11-18 shows surface dissolved oxygen concentrations at the East Mill and West Mill Pond SCDHS stations. Releases from East Mill Pond are generally above 4.8 mg/L. The West Mill Pond discharge experienced frequent low dissolved oxygen conditions beginning in 2007. These may be due to the death and decay of the extensive algal mats observed in the pond.

Figure 11-19 shows the surface dissolved oxygen concentrations at the frequently monitored SCDHS creek stations, with the exception of Wills and Poospatuck Creek. Dissolved oxygen in Old Neck Creek showed frequent low dissolved oxygen in 2006 and early 2007. Conditions appear to have improved in recent years. The remaining creek stations had observed dissolved oxygen above 4.8 mg/L. Figure 11-20 shows the surface dissolved oxygen concentrations at duck farm releases. It can be seen that dissolved concentrations below Titmus Farms (Barnes Road) were above 4.8 mg/L. Observations below Jurgielewicz Farms had three low dissolved oxygen readings in 2006. Monitoring data from 2007 to present were not available.

Surface and bottom dissolved oxygen measurements were collected by SCDHS in Wills Creek, Poospatuck Creek, the middle Forge River, and lower Forge River. Dissolved oxygen data for these stations are shown in

Figure 11-21 through Figure 11-24. Each of these stations realized frequent low dissolved oxygen concentrations. While many of these measurements are from bottom depths, where dissolved oxygen is more likely to be low due to stratification, lower algal production and microbial oxygen demand, many low measurements are also from the surface. The maximum saturation level of dissolved oxygen is in the range of 12.0 to 14.5 mg/L depending on ambient temperature and salinity. Numerous measurements of dissolved oxygen exceeded saturation. These high concentrations most likely occur from photosynthesis during algal blooms.

Both Wills Creek and Poospatuck Creek show headwater inflows with dissolved oxygen less than 4.8 mg/L. The inflows to these creeks show elevated levels of nitrogen, possibly from poorly functioning septic systems. The high nitrogen may be driving algal growth (both phytoplankton and macroalgae like *Ulva*), which leads to high biological oxygen demand (BOD) from the microbial decay of this algal production. Finally, deposition of

other organic matter to the sediments like leaf fall and material carried by stormwater can be a source of sediment oxygen demand.

The middle Forge River experiences the most frequent periods of low dissolved oxygen. This part of the river receives much of the nitrogen load, supports high algal productivity, and has limited exchange with Moriches Bay. Review of the data collected in the lower Forge River show less frequent low dissolved oxygen, likely due to improve mixing and exchange with Moriches Bay. Data was also collected by SCDHS within Moriches Bay. These data are shown in

Figure 11-25. Dissolved oxygen concentrations are above 4.8 mg/L with the exception of one bottom depth observation.

Maps of the average dissolved oxygen were prepared to provide a spatial perspective to the analysis. Besides nitrogen supply, algal growth is light and temperature dependent. In addition, dissolved oxygen is temperature dependent with solubility being lower at higher temperatures. For these reasons, dissolved oxygen is presented on a seasonal basis. The seasonally averaged results are shown in Figure 11-14 through Figure 11-17.

During the winter, low water temperatures increase the solubility of oxygen. Algal growth is also low due to the colder temperatures and limited sunlight. As shown in Figure 11-14, the observations generally reflect the high dissolved oxygen concentrations. Of note are the higher number of violations seen at the headwaters of Poospatuck Creek and Ely Creek. Only one of seven dissolved oxygen measurements in Ely Creek was below the NYSDEC's standard of 4.8 mg/L, indicating a limited problem. However, five of seven measurements on Poospatuck Creek were below 4.8 mg/L during the winter, indicating a significant problem.

Conditions during the summer are similar, with Old Neck Creek and Wills Creek having a moderate number of violations and Poospatuck Creek having frequent violations. Stations in the main branch of the Forge River above Ely Creek also experience frequent violations as shown in Figure 11-16.

The frequency of dissolved oxygen violations during the fall is less than ten percent at all stations (Figure 11-17). Review of the seasonal violation maps shows persistent low dissolved oxygen in Poospatuck Creek and somewhat less so in Wills Creek and Old Neck Creek. The main branch of the Forge River is moderately impacted above Ely Creek with conditions improving in the lower reaches, due likely to the mixing and flushing from Moriches Bay.

The frequent violations in Poospatuck Creek, even during winter, suggest that algal blooms are only partially to blame for low dissolved oxygen measurements. Inflows to the creek may have low dissolved oxygen or the dissolved oxygen demand from sediments in this part of the system may be so large that dissolved oxygen consistently remains below 4.8 mg/L. Poor circulation may limit tidal exchange as well.

Figure 11-18. Mill Pond Discharge Dissolved Oxygen Time Series

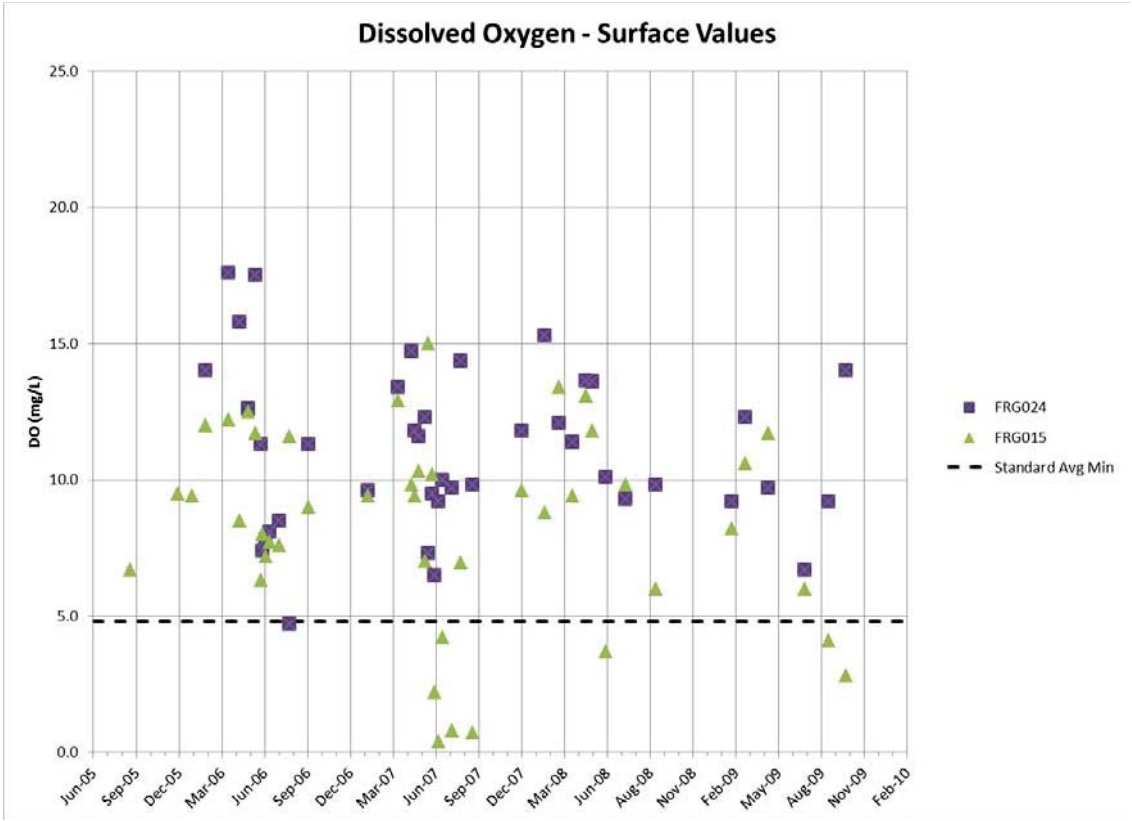


Figure 11-19. Creek Dissolved Oxygen Time Series

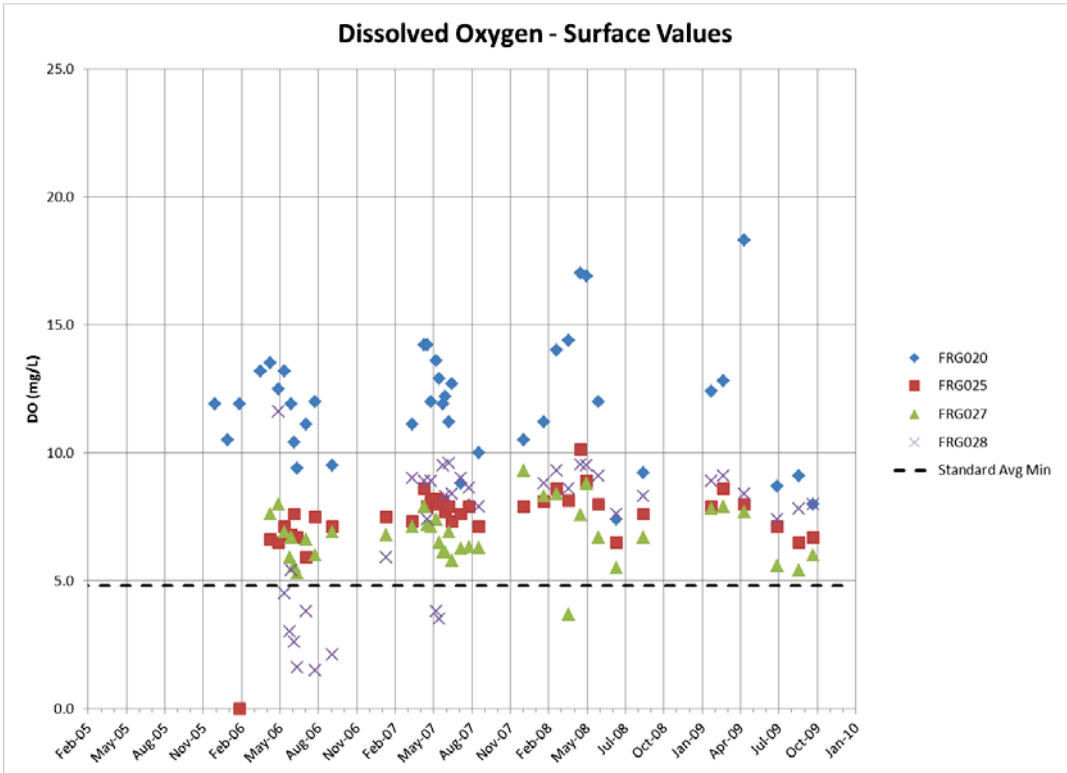


Figure 11-20. Duck Farm Discharge Dissolved Oxygen Time Series

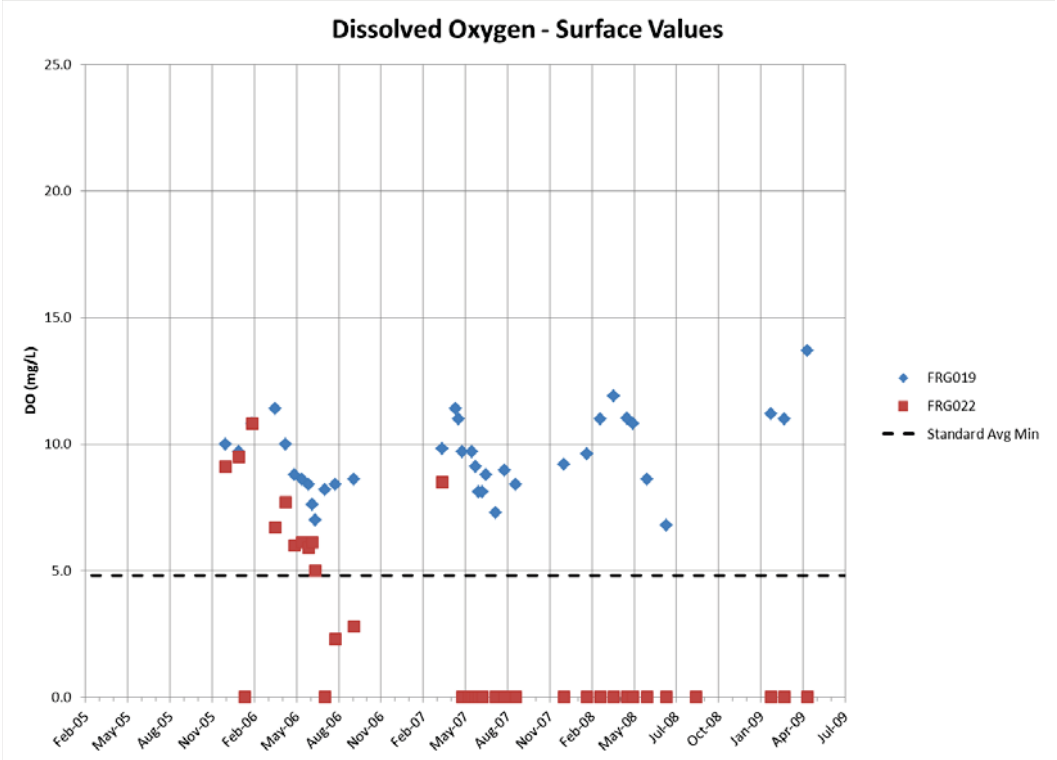


Figure 11-21. Dissolved Oxygen Time Series for Wills Creek

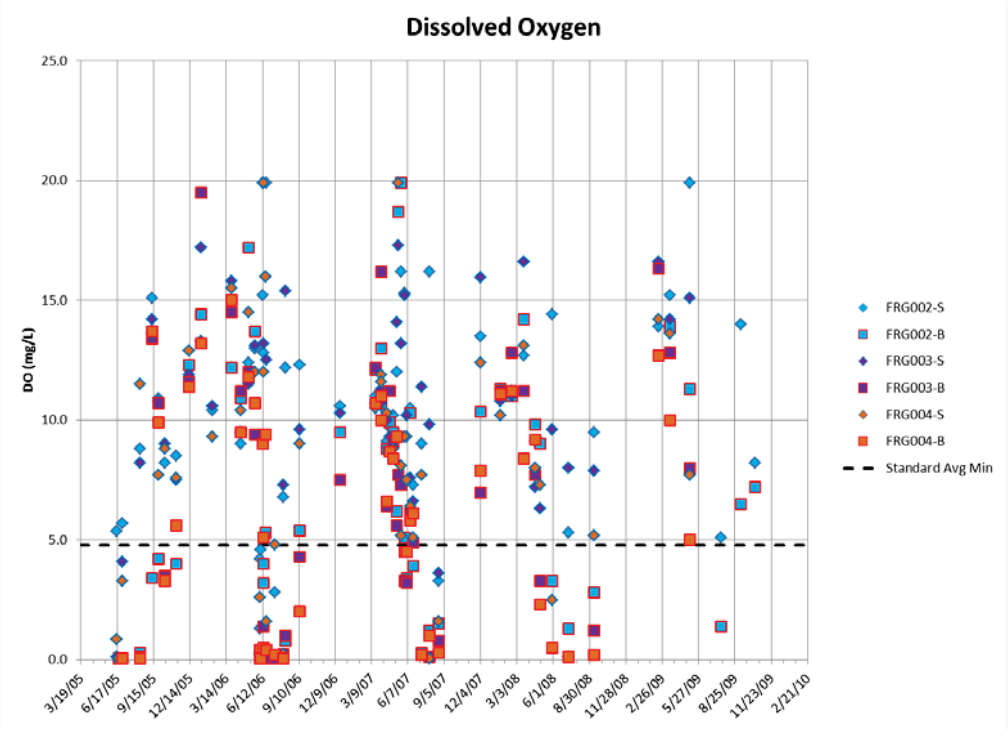


Figure 11-22. Dissolved Oxygen Time Series for the Poospatuck Creek

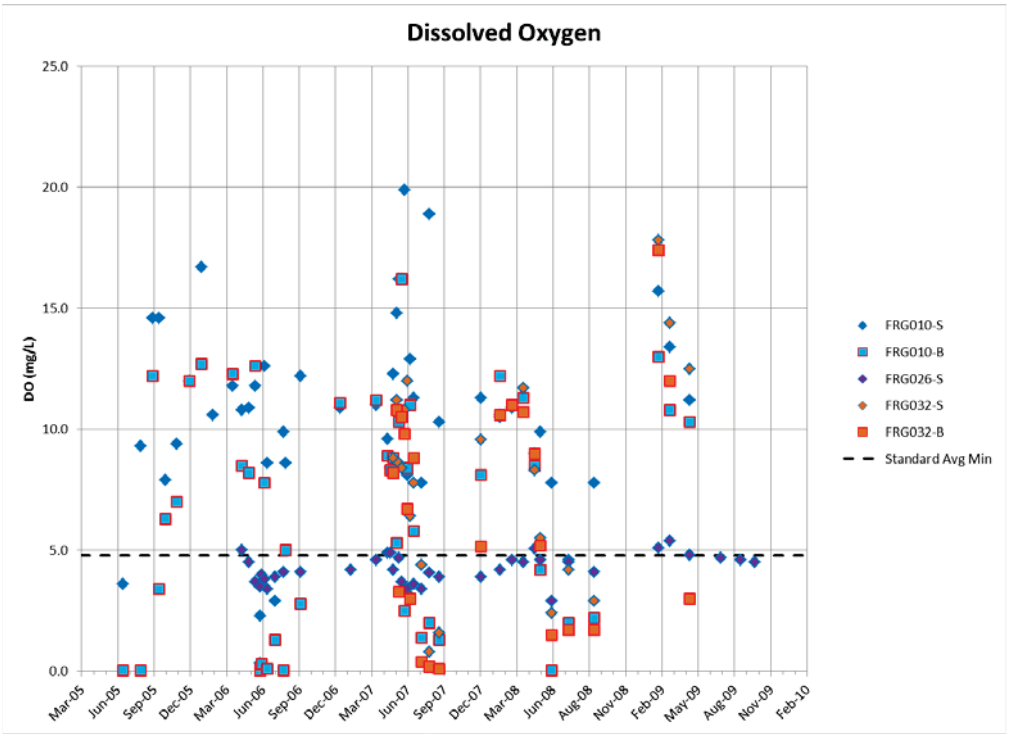


Figure 11-23. Dissolved Oxygen Time Series for the Middle Forge River

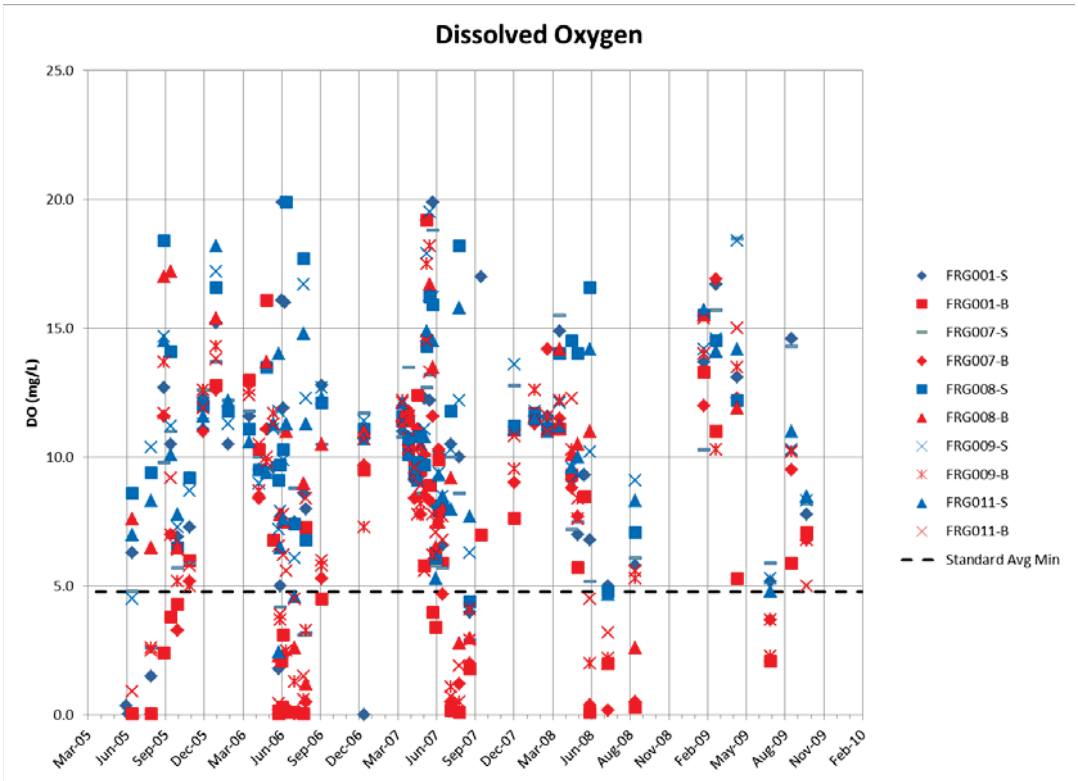


Figure 11-24. Dissolved Oxygen Time Series for the Lower Forge River

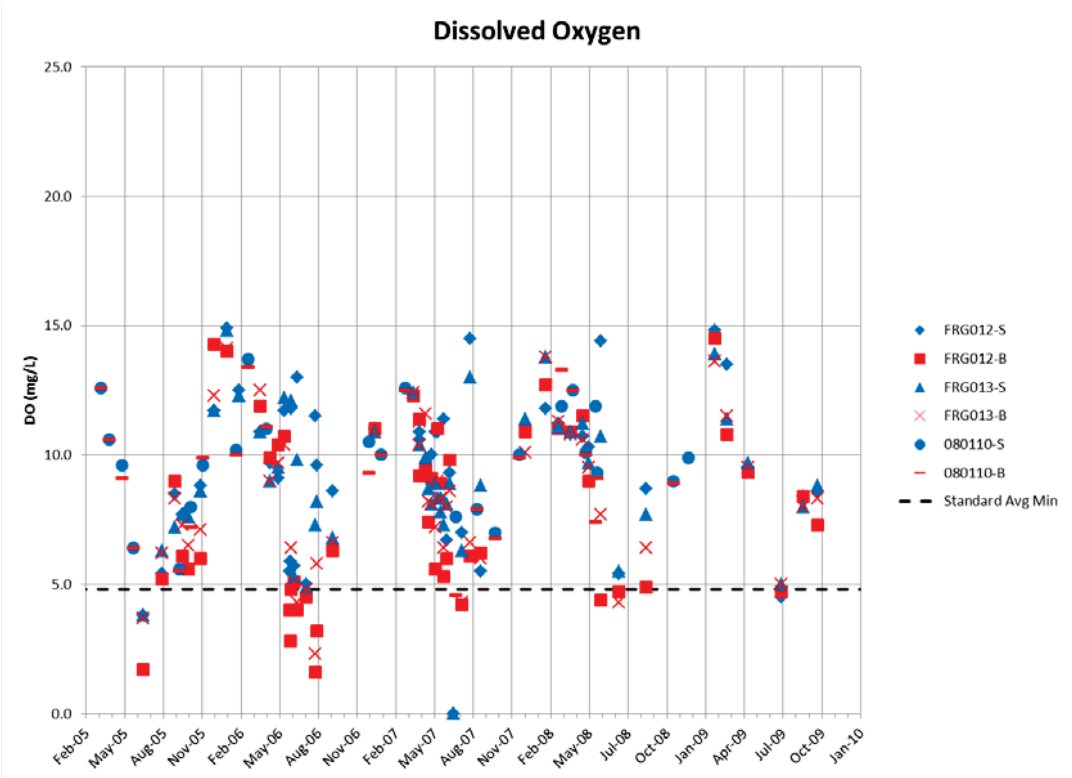
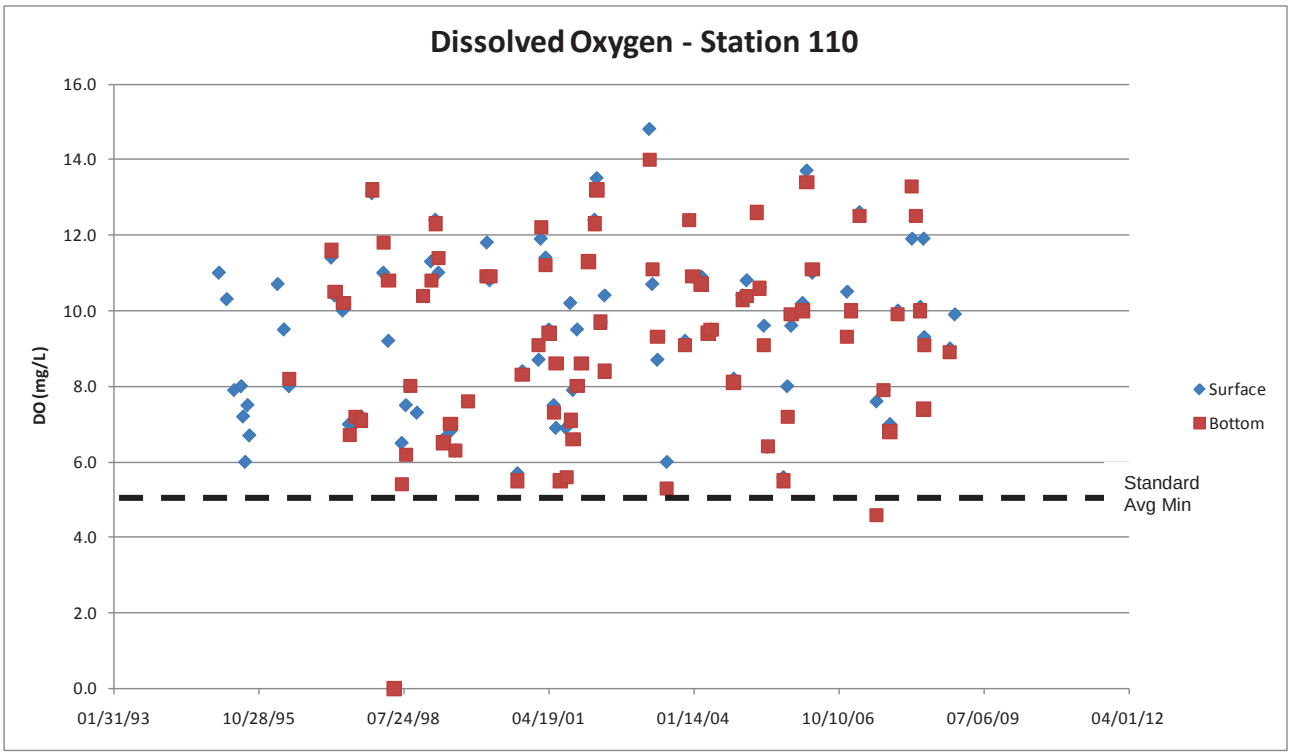


Figure 11-25. Dissolved Oxygen Time Series for Moriches Bay



11.8.1 Continuous Monitoring Results

Additional dissolved oxygen monitoring was performed by SCDHS using a submerged sonde located near Station 29. This sonde continuously measured dissolved oxygen at 15-minute increments from June 2006 through September 2009. The sonde is tethered above the bottom near Station FRG-029 in the main branch of the Forge River above Ely and Wills Creeks.

The sonde measured temperature, salinity, dissolved oxygen, and chlorophyll-a. This type of data is useful since it provides a more complete picture of how conditions vary on a day to day basis. In addition, the dissolved oxygen response of an algal bloom may lag the bloom by days as the die-off occurs and decay of the resulting organic matter begins. Daily average dissolved oxygen and chlorophyll-a were calculated to evaluate the dissolved oxygen response to algal levels. Dissolved oxygen saturation was also calculated. The calculations for 2007 through 2008 are provided in Figure 11-26.

Figure 11-26 shows that dissolved oxygen falls below 4.8 mg/L for extended periods. High dissolved oxygen periods also occur, indicating super-saturated conditions. Neither extreme is desirable and can have negative effects on aquatic life. Figure 11-27 and Figure 11-28 focus on the summer periods for 2007 and 2008. A consistent pattern of high algal

concentrations and super-saturation followed by a rapid drop in chlorophyll-a and dissolved oxygen can be seen. Sediment oxygen demand is likely to have some impact on dissolved oxygen levels but Figure 11-27 and Figure 11-28 demonstrate that algal blooms play a significant role in the dissolved oxygen cycle seen in the Forge River.

Figure 11-26. Comparison of Dissolved Oxygen, Maximum Dissolved Oxygen Saturation, and Chlorophyll-a

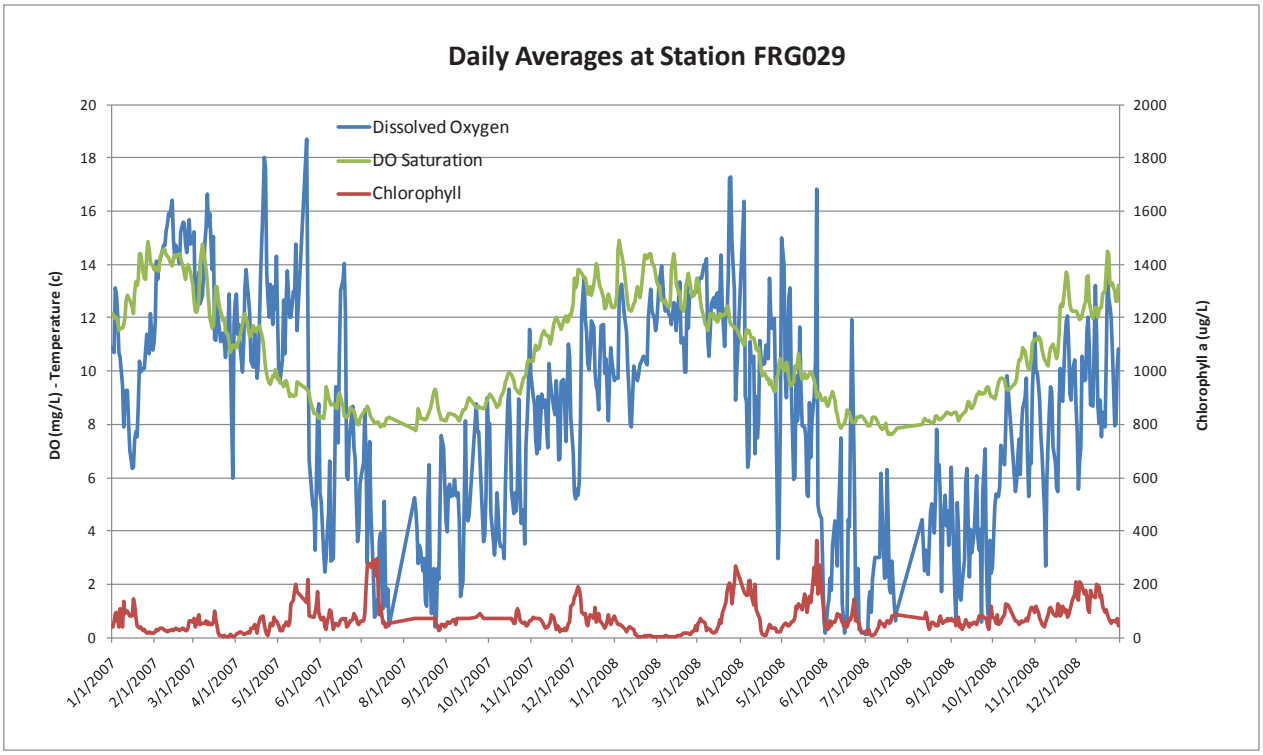


Figure 11-27. Comparison of DO, Maximum DO Saturation, Chlorophyll-a Concentrations – Summer 2007

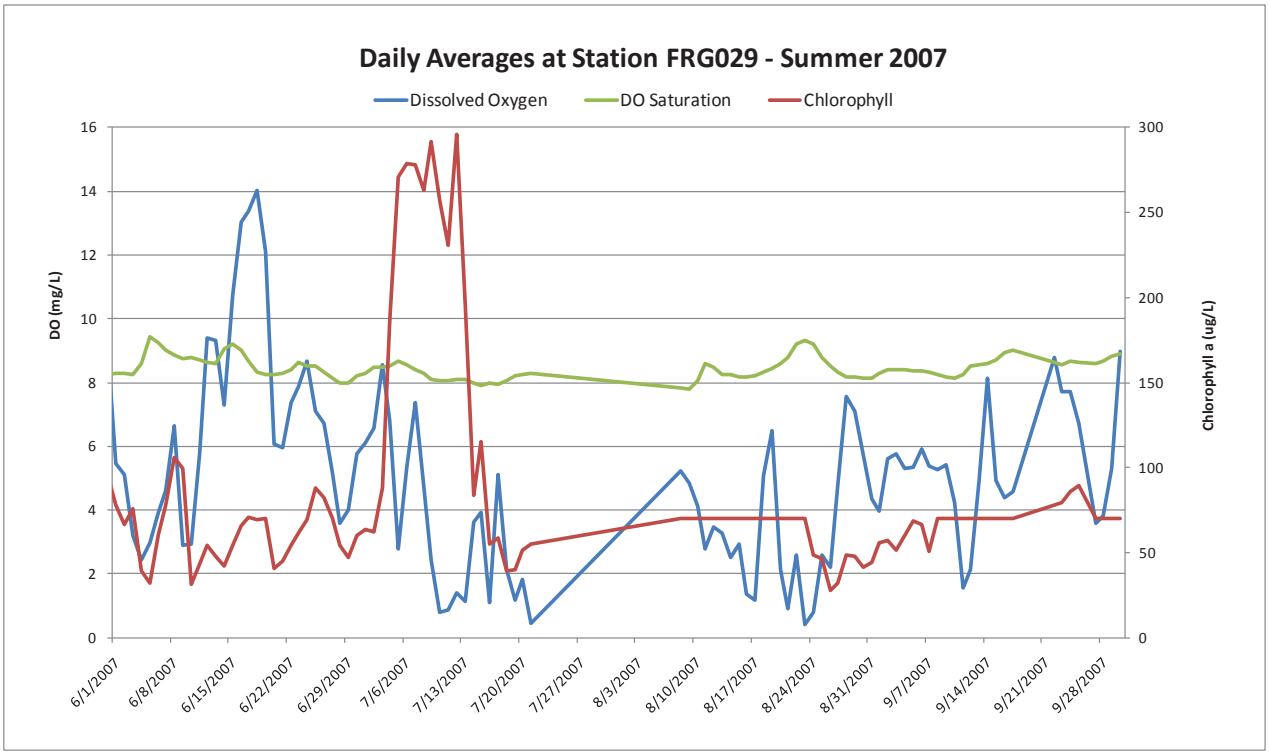
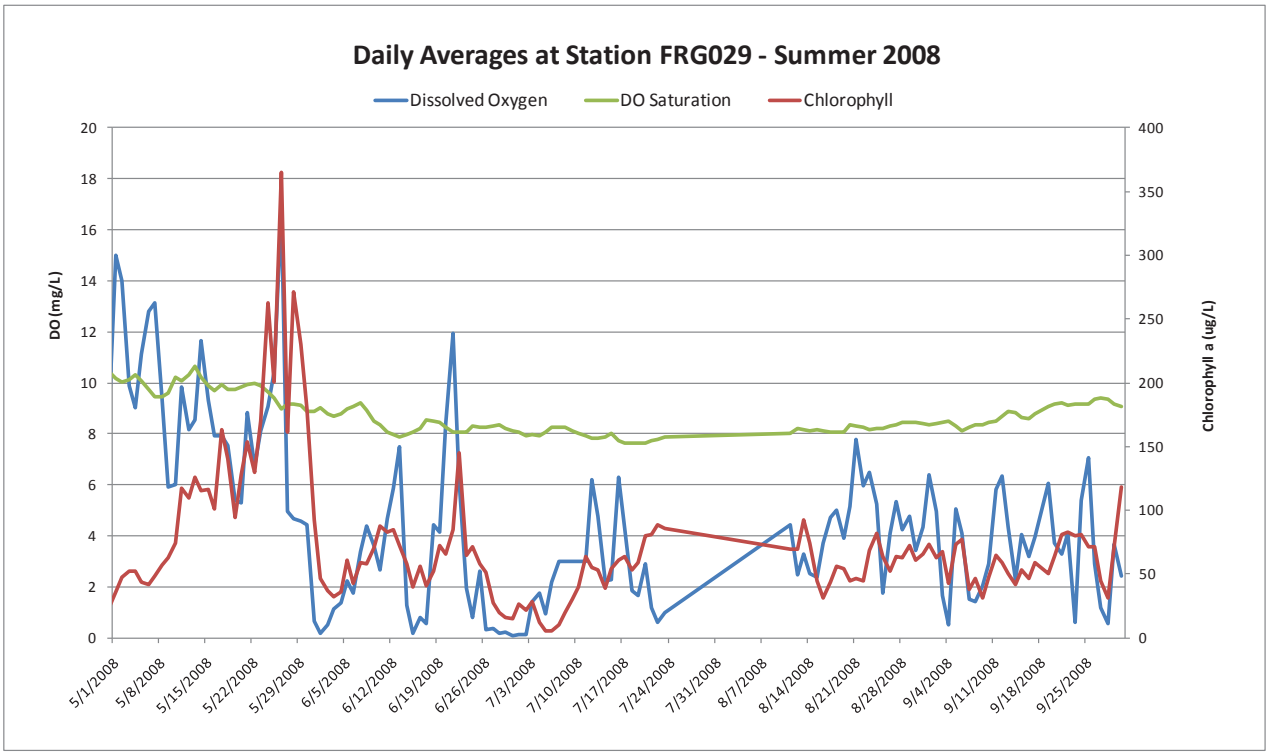


Figure 11-28. Comparison of DO, Maximum DO Saturation, Chlorophyll-a Concentrations – Summer 2008.



11.9 Nitrogen

11.9.1 Standard

There is no New York State standard value for nitrogen in marine waters. Nitrogen, however, is the primary cause of eutrophication in marine waters and subsequent negative impacts on dissolved oxygen (Swanson, O'Connell, Brownawell, Gobler, & Wilson, 2009). Development of a Total Maximum Daily Load (TMDL) for nitrogen is, therefore, a means of establishing a 'standard' for a particular body of water. The TMDL for nitrogen is that value of nitrogen input that can be absorbed by the waterbody without experiencing significant detrimental effects. A TMDL will be established for the Forge River in the near future.

11.9.2 Monitoring Results

Statistical analyses, time series plots, and loading estimates were used to help define the relationship between nutrient levels and eutrophic conditions. Basic statistics and time series plots for nitrate, total nitrogen, and dissolved oxygen were generated for each of the stations. SCDHS stations were grouped into sets with similar locations or characteristics for the development of the statistics and for time series plots. These groupings include headwater reaches, duck farm discharge, pond discharge, Poospatuck Creek, Wills Creek, the Middle Forge River, and the Lower Forge River. Data for these groupings were plotted to characterize different components of the system (*e.g.*, headwaters, runoff discharge, etc.).

Nitrogen Time Series

The loading evaluation performed by Stony Brook University researchers indicates that the majority of runoff from the Forge River watershed is captured and subsequently released from the East Mill Pond and West Mill Pond. Nitrogen concentrations from these ponds are provided in Figure 11-29. Additional loading from the watershed enters at the creek tributaries to the Forge River. The nitrogen concentrations for the major creeks, with the exception of Wills and Poospatuck Creeks, are shown in Figure 11-30. The pond and creek concentrations reflect both nitrogen in runoff and shallow groundwater contributions. Releases from the Titmus and Jurgielewicz Duck Farms are also discharged to surface waters. The nitrogen concentrations at these two stations are provided in Figure 11-31.

Nitrogen also enters the Forge River from its creeks. Wills Creek and Poospatuck Creek discharge to the middle portion of the Forge River and were monitored frequently. The time series of nitrogen concentrations for Wills Creek and Poospatuck Creek are provided in Figure 11-32 and

Figure 11-33, respectively.

SCDHS monitoring stations in the Middle Forge River reflect the inputs from the East Mill and West Mill Ponds and the duck farms. The time series of nitrogen concentrations for the Middle Forge River monitoring stations are provided in Figure 11-34.

SCDHS stations in the lower Forge River receive nitrogen loadings from upstream but also have an exchange with Moriches Bay. Data indicate lower concentrations than those seen in the creeks or Middle Forge River. The time series of nitrogen concentrations for the Lower Forge River are provided in Figure 11-35.

Average Surface Water Nitrogen

Figure 11-36 shows the distribution of average surface water nitrogen throughout the Forge River estuary. Nitrogen concentrations clearly increase with distance from the mouth of the estuary and near the heads of the tributary creeks. Nitrogen is relatively high even in the main body of the estuary.

Figure 11-29. Pond Discharge Nitrogen Time Series (East & West Mill Ponds)

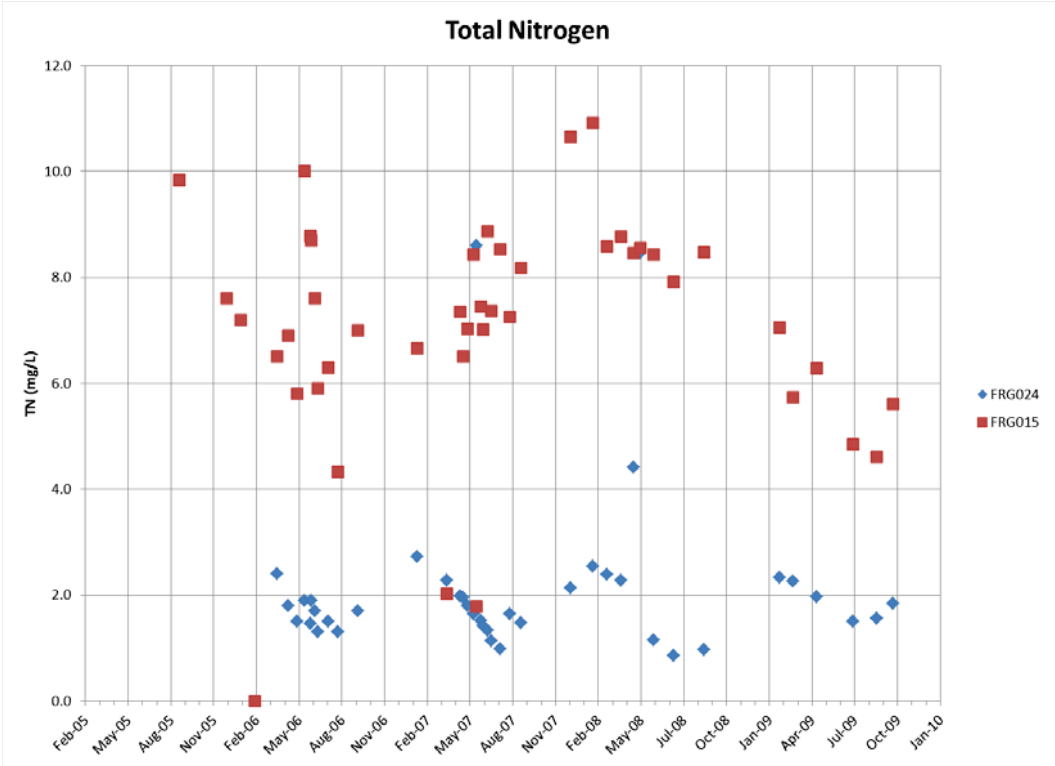


Figure 11-30. Creek Nitrogen Time Series

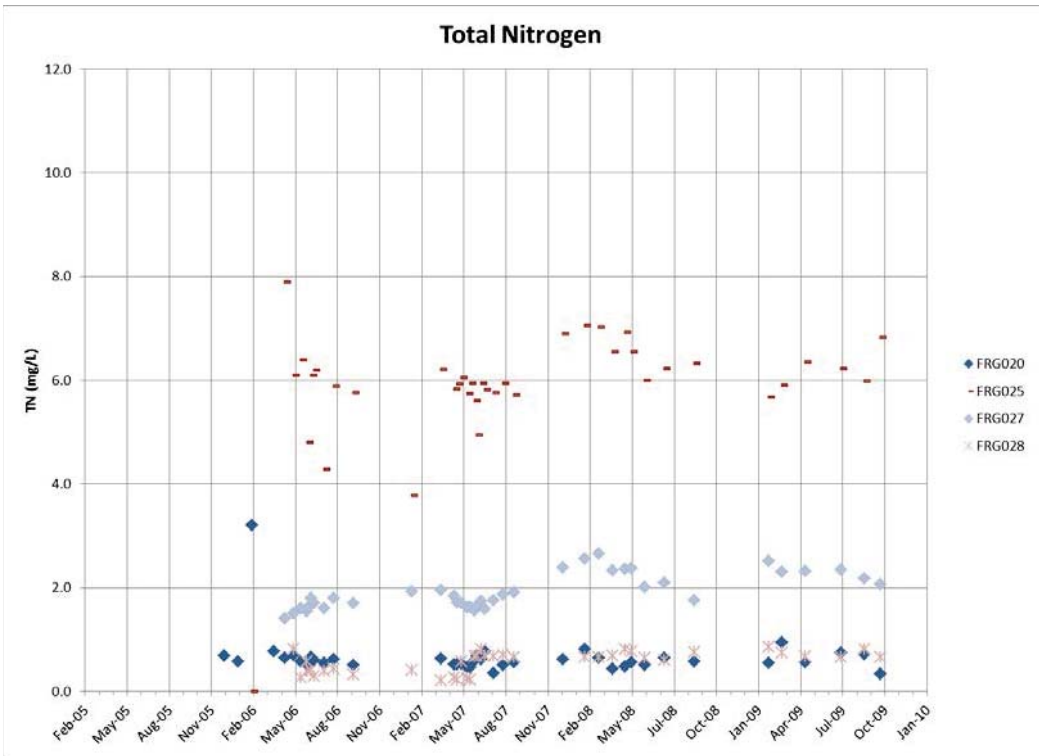


Figure 11-31. Duck Farm Discharge Nitrogen Time Series

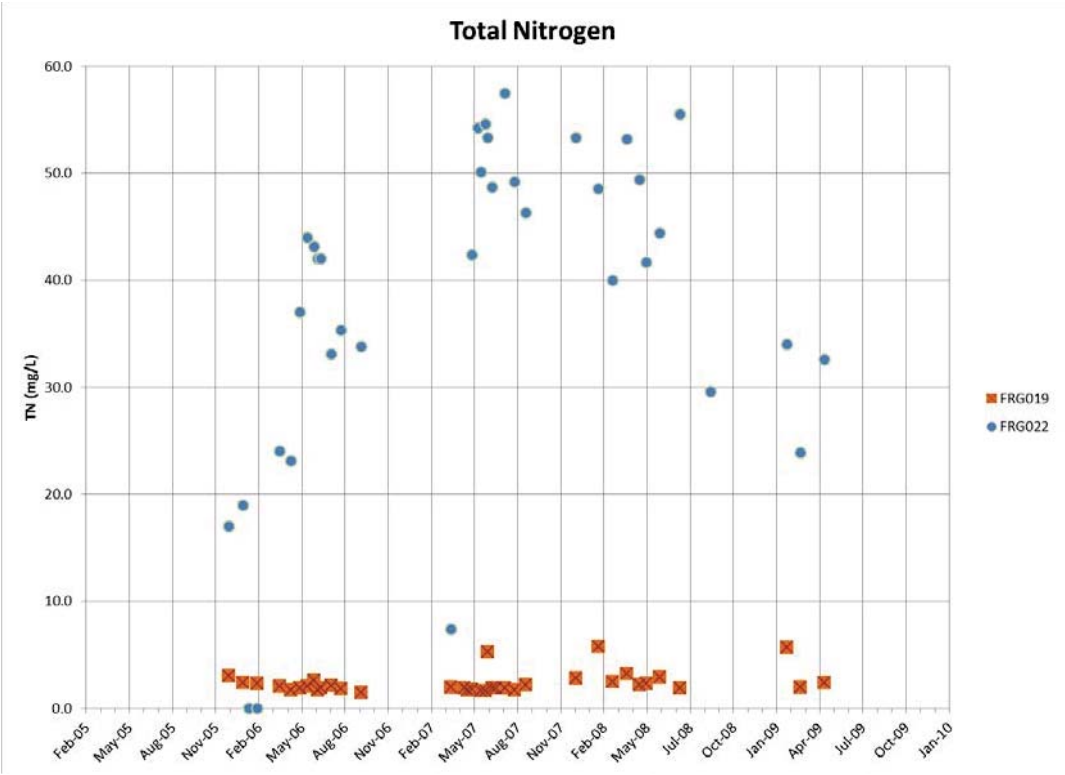


Figure 11-32. Nitrogen Time Series for Wills Creek

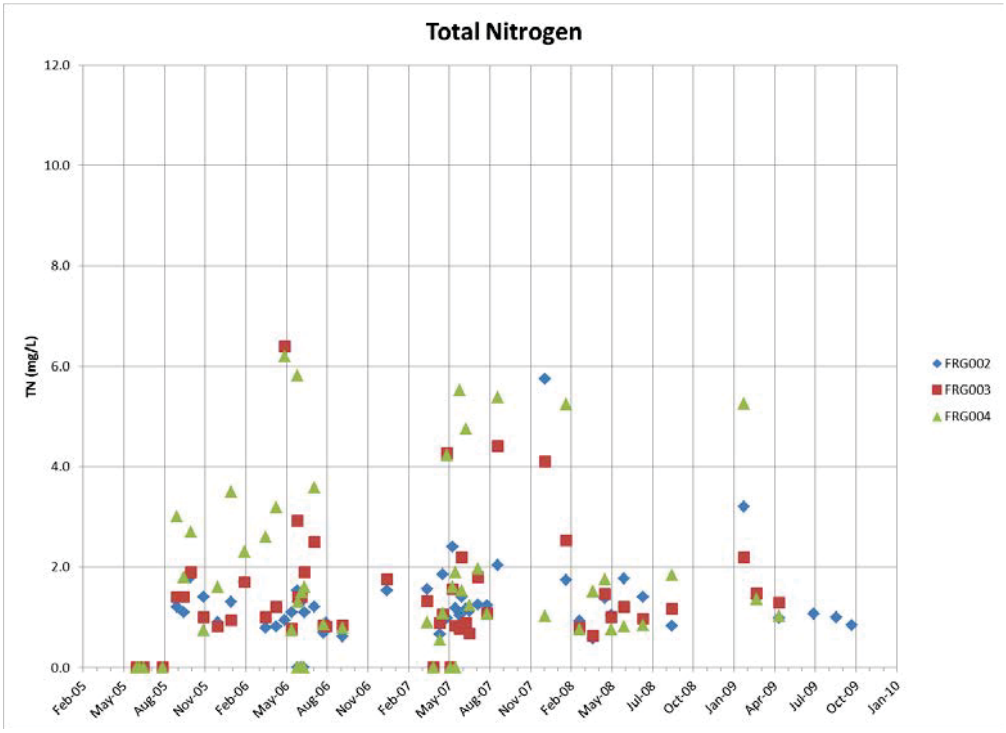


Figure 11-33. Nitrogen Time Series for Poospatuck Creek

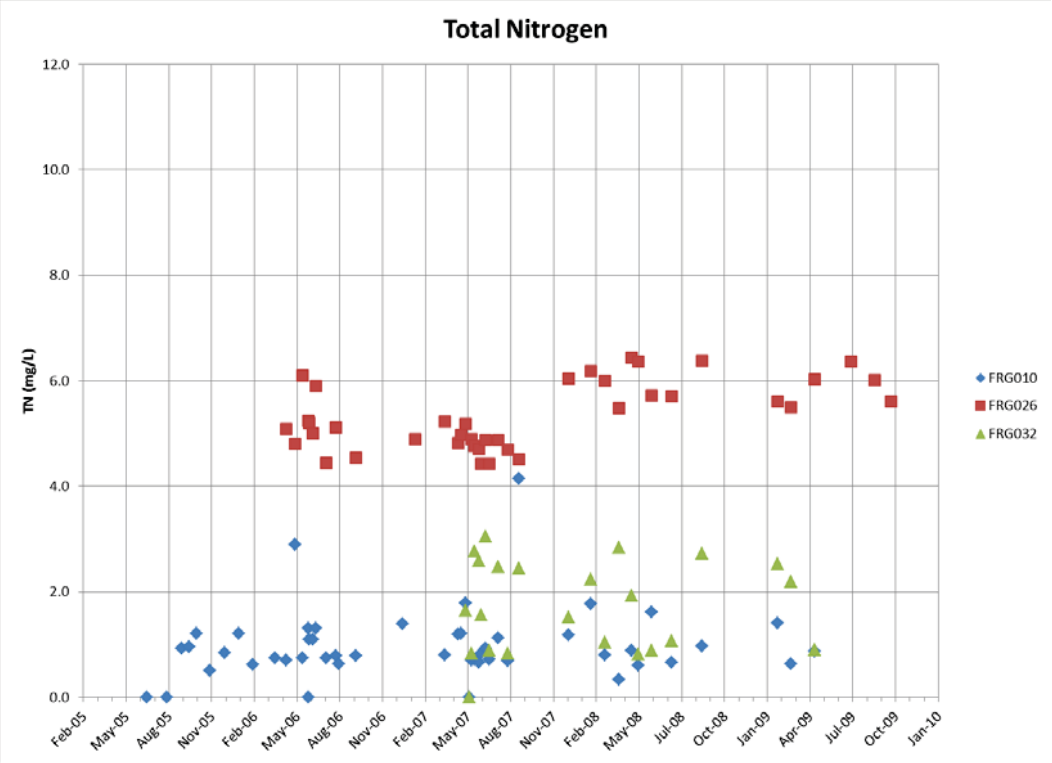


Figure 11-34. Nitrogen Time Series for the Middle Forge River

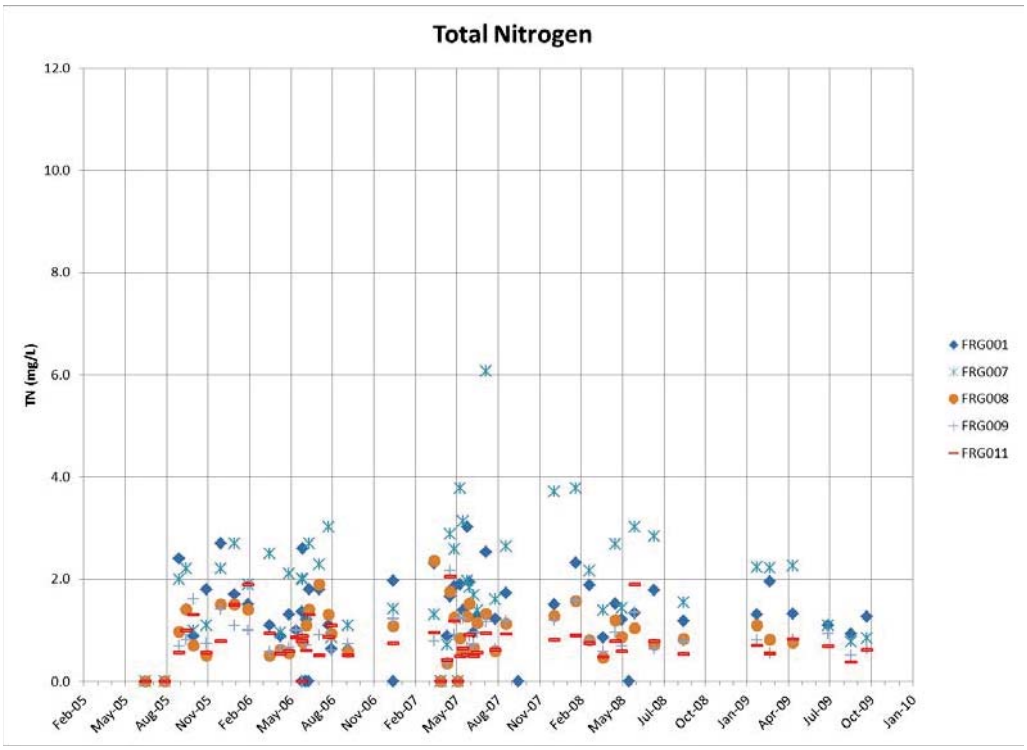


Figure 11-35. Nitrogen Time Series for the Lower Forge River

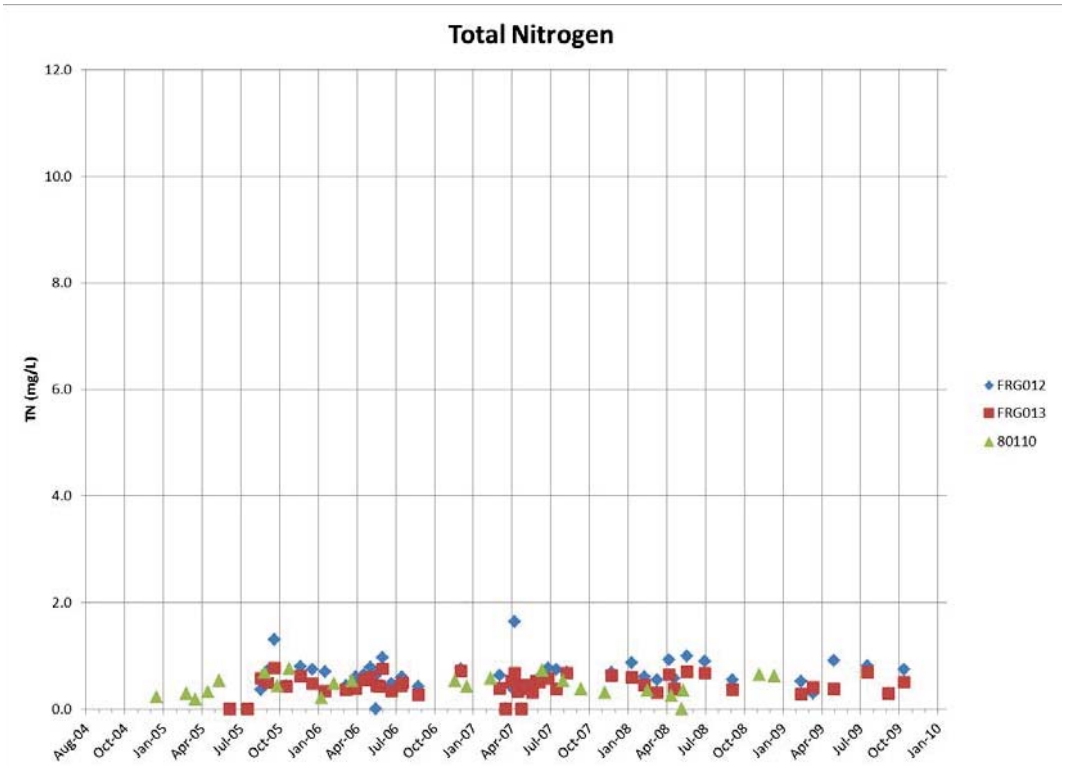
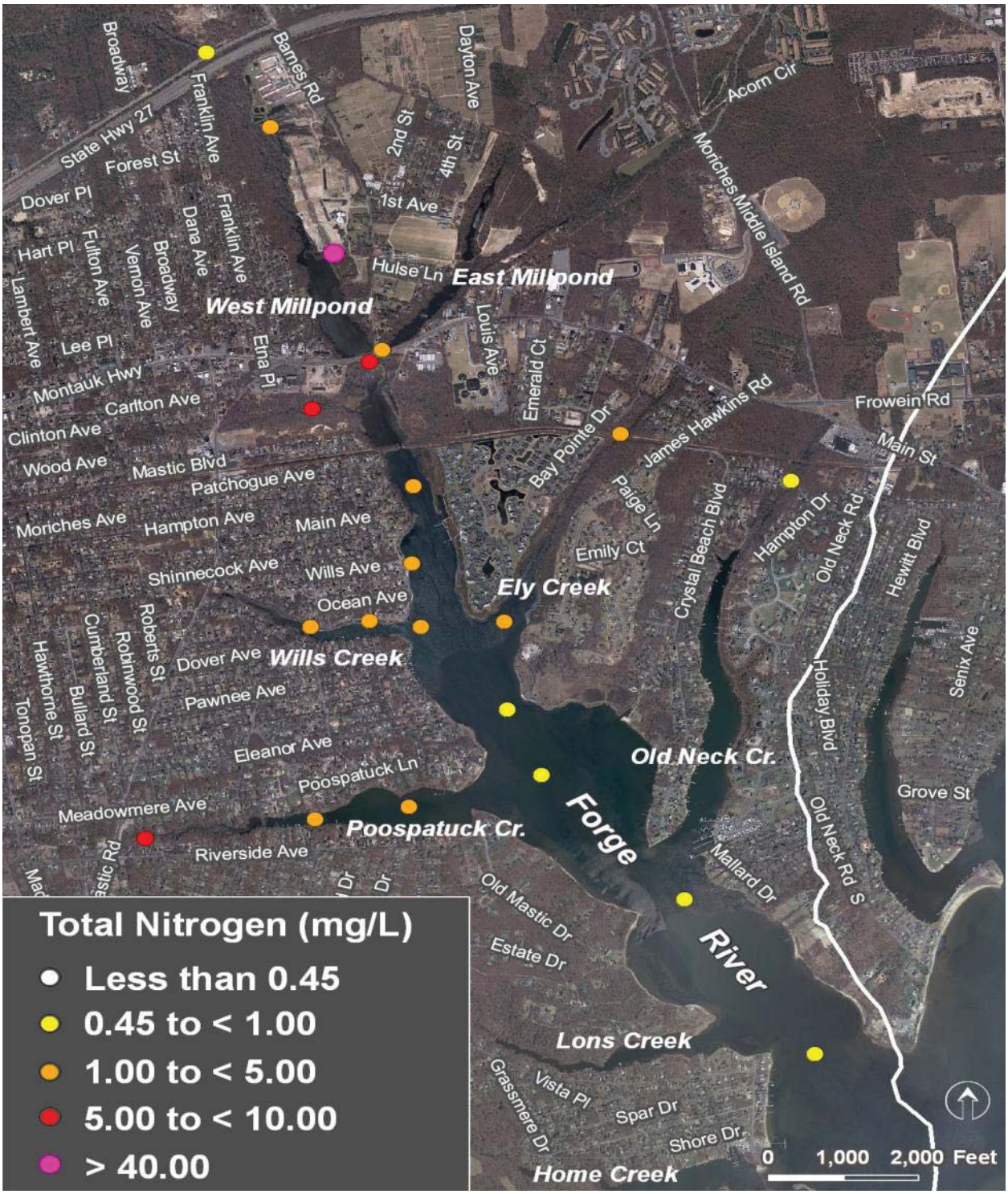


Figure 11-36. Average Nitrogen Concentrations in Forge River Surface Waters.



11.9.3 Nitrogen Budget – SoMAS of Stony Brook University

While flows from each of the nitrogen sources are not regularly measured, the School of Marine and Atmospheric Studies (SoMAS) of Stony Brook University estimated flow rates and loadings of nitrogen into the Forge River system (Swanson, O'Connell, Brownawell, Gobler, & Wilson, 2009). The distribution of nitrogen inputs by source is provided in Table 11-6.

Table 11-6. Relative Magnitude of Nitrogen Inputs to the Forge River System

Input	Percent of Input
Creeks	21.8
Atmospheric Deposition	2.6
Direct runoff	2.2
Groundwater	73.5

Source: SoMAS (Swanson *et.al.*, 2009)

These estimates demonstrate that the large majority of nitrogen entering the Forge River is from groundwater. The sources of groundwater nitrogen include releases from on-site wastewater treatment systems, leaching of nitrogen from lawn fertilizer, and leaching of nitrogen from the settling ponds associated with duck farm operations. Figure 11-37 shows groundwater nitrogen concentrations from monitoring wells located near the estuary. Nitrogen concentrations in two of the seven wells (north of Wills Creek) were 12.5-12.7 mg/L. These values are many times higher than average groundwater nitrogen. For example, the USGS reported a median concentration of total nitrogen in shallow groundwater (1946-1996) in Nassau County monitoring wells of 2.2 mg/L (Scorca & Monti, Jr., 2001).

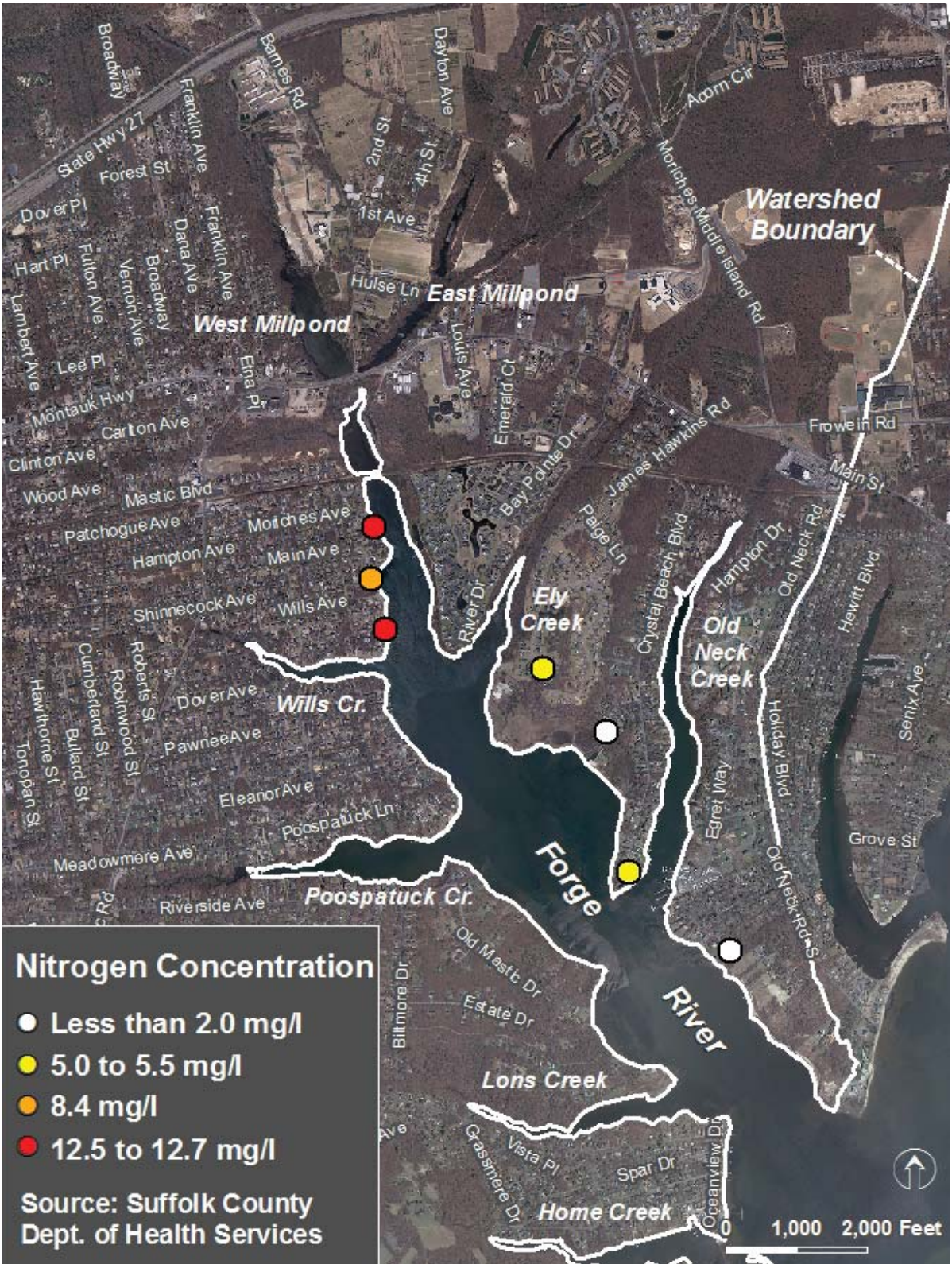
A mass balance of nitrogen for the Forge River system was developed by SoMAS and a summary of their results provided in Table 11-7. The authors estimated that approximately 30 to 50 percent of the nitrogen in the Forge River is derived from recycling of nitrogen from organic matter deposited in the sediments. Thus, according to the SOMAS study, sediment-derived nitrogen may account for one third to almost one half of all nitrogen inputs to the system. The majority of the rest of the nitrogen input is (as described above) from groundwater. Approximately 40 to 50 percent of the nitrogen in the system is removed annually due to exchange and flushing with Moriches Bay (Table 11-7).

Table 11-7. Nitrogen Balance in the Forge River System

Input	Estimated Annual Loading (kg/yr)	Lb/d
Inputs	273,000	1,649
Internal Recycling	122,640 – 245,000	740-1,480
Export	216,600	1,308

Source: SUNY Stony Brook

Figure 11-37. Groundwater nitrogen concentrations



11.9.4 Nitrogen Inputs – Background and Methodology

For the purposes of this watershed plan, a detailed nitrogen budget was prepared to evaluate the different upland sources of nitrogen released into the Forge River. Upland, or external, nitrogen sources are summarized for each subwatershed. This exercise will aid in the selection and prioritization of watershed management strategies that will be proposed as part of this watershed plan. The nitrogen budget also shows the relationship between point sources (*e.g.*, wastewater treatment plants that discharge to surface waters), non-point sources from groundwater underflow (*e.g.*, on-site wastewater treatment systems and wastewater treatment plants discharging to groundwater with long travel times) or surface runoff (*e.g.*, fertilizers and atmospheric deposition that result in immediate nitrogen contribution).

A nitrogen balance was performed to estimate the various nitrogen inputs to the Forge River for existing uses only. Future development (see Section 6.2, Build-out Analysis) was not factored into this exercise. The inputs that were evaluated included on-site wastewater treatment systems (OWTS), fertilizers, atmospheric deposition, wastewater treatment plants (STPs), and benthic flux.

Data from the Town of Brookhaven GIS database was used to identify the following land use categories for each parcel: Agricultural, Commercial/Industrial, Residential, and Vacant. The nitrogen sources were compiled on a per parcel basis with respect to these four land use classes. Table 11-8 shows which of the nitrogen sources were considered for each type of land use.

Table 11-8. Upland Nitrogen Inputs

	OWTS	Fertilizers	Atmospheric Deposition
Agricultural		√	√
Commercial/Industrial	√	√	√
Residential[1]	√	√	√
Vacant			√

[1]Residential parcels not connected to an STP contribute to all three categories. Those residential parcels that are connected to an STP only have a nitrogen contribution from fertilizers and atmospheric deposition.

As described in Section 4.3.2, only six percent of the land in the watershed contributes stormwater runoff into the Forge River; this runoff is discharged untreated (*e.g.*, without partial nitrogen removal through the soil column). Nitrogen inputs from the remainder of the watershed (*i.e.*, 94 percent) enter the Forge River via groundwater after passing through soils where some nitrogen removal occurs from root uptake and microbial action. Each of the nitrogen sources and Forge River loadings is described below including the methodologies used to derive the values.

11.9.5 Nitrogen Inputs- On-Site Wastewater Treatment Systems

Nitrogen contribution from on-site wastewater treatment systems (OWTS) are calculated based on assumptions and parameters derived from design standards and scientific literature. Considering depth to groundwater, a 40 or 50 percent nitrogen removal rate is applied based on literature reviewed (See Section 11.10.3). The lower value (*i.e.*, 40 percent) applies to systems whose depth to groundwater is less than nine feet. The higher value (*i.e.*, 50 percent) is for systems located nine feet or more from groundwater. The nine-foot depth follows from SCDHS regulations that require standard septic systems (*i.e.*, septic tank and leaching pools) to be installed in areas with a depth to groundwater greater than or equal to nine feet. The SCDHS requires installations where the depth to groundwater is less than nine feet to have an alternative design to mitigate the effects of high groundwater. Figure 11-38 reveals that most low-lying OWTS are located along the Wills, Poospatuck, Lons, and Home Creek subwatersheds of the Forge River; given the age of the residences, they are unlikely to support alternative designs and thus induce slightly greater nitrogen loads. Other assumptions for OWTS nitrogen are as follows:

- 3.5 persons per residential household (as per city-data for Mastic, NY)
- 10 lbs of nitrogen per person per year (Long Island Regional Planning Board, 1978)
- 44 gpd per person average water usage (*ibid.*)
- Industrial parcels do not produce process water (process water volumes and concentrations could not be estimated/verified as part of this project)

For the residential calculation, using the information from the first two assumptions, it was inferred that:

$$\frac{10\frac{lbsN}{yr}}{capita} = \frac{0.02740\frac{lbsN}{day}}{capita} X \frac{3.5capita}{household} = \frac{0.0959\frac{lbsN}{day}}{household}$$

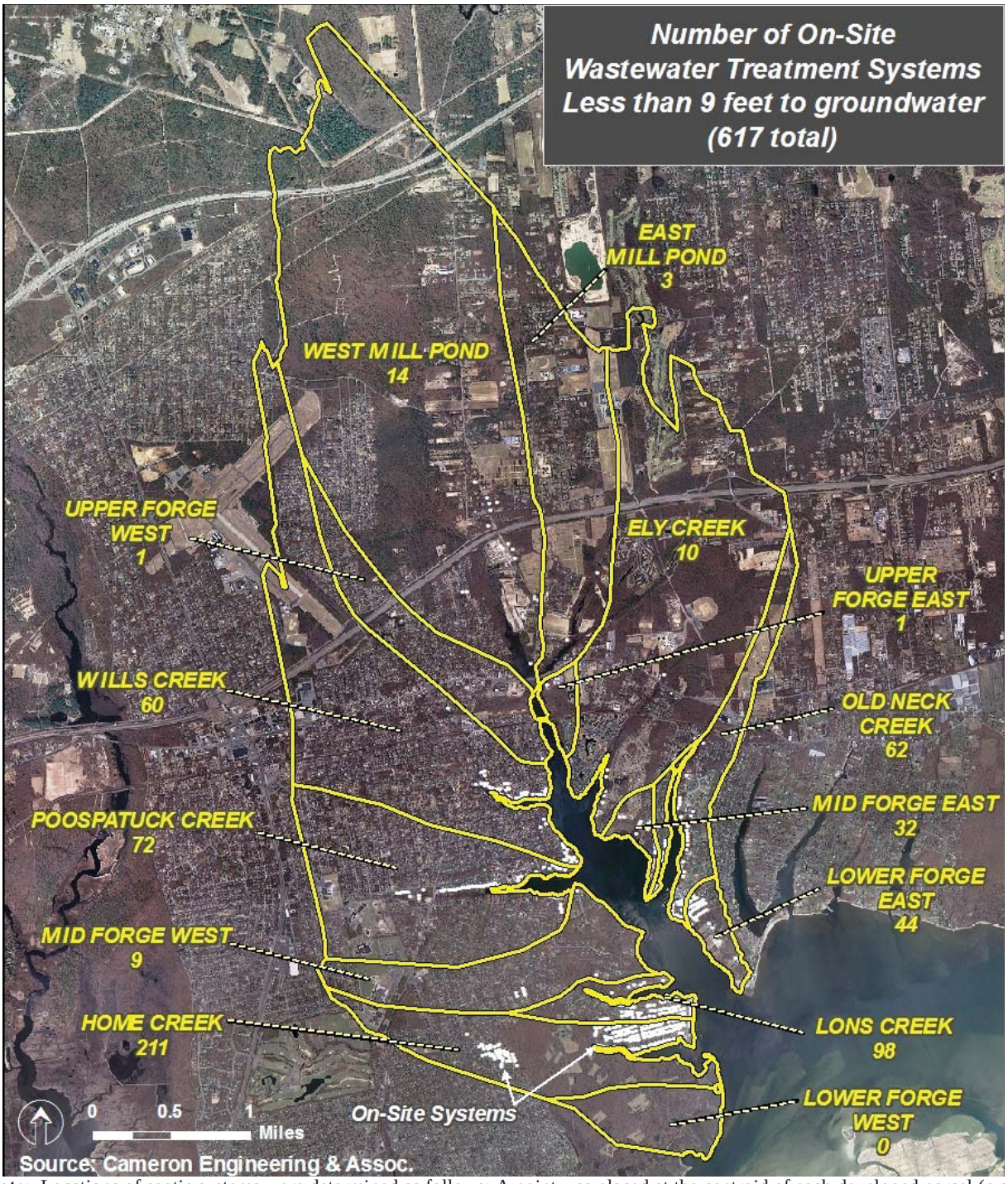
For the commercial/industrial calculation, using the information from the second two assumptions, it was inferred that:

$$\frac{10\frac{lbsN}{yr}}{capita} = \frac{0.02740\frac{lbsN}{day}}{capita} X \frac{day}{44gal} = \frac{0.0006227lbsN}{gal}$$

This rate was applied to the daily flow rate that was determined by using SCDHS design flow rates for each commercial/industrial establishment.

Using these rates, an assumed percentage of nitrogen removal from OWTS, and additional treatment from the soil column, the nitrogen contribution from all residential OWTS is estimated at approximately 430 lbs of nitrogen per day.

Figure 11-38. On-site Wastewater Systems Less Than Nine Feet from Groundwater



Note: Locations of septic systems were determined as follows: A point was placed at the centroid of each developed parcel (*e.g.*, residential, commercial, industrial, community facility) that uses a septic system (parcel layer provided by the Town of Brookhaven and included land use codes - these land use codes were checked and updated where necessary by the team). For the Poospatuck Reservation – which is not subdivided into lots – a point was created for each structure. Parcels that are connected to a sewage treatment plant, of course, were not included; these included the multi-family developments Waterways at Bay Pointe, Pine Hills South, and Villas at Pine Hills. Sewage flows were estimated for each of the parcels based on land use. The estimate of sewage flows from commercial and industrial uses considered specific uses within their respective land-use categories and building areas. Suffolk County Department of Health Services wastewater generation rates were employed to estimate flow.

11.9.6 Nitrogen Inputs - Wastewater Treatment Plants

Another significant nitrogen input to the Forge River is from the four sanitary wastewater treatment plants in the watershed. Three of the four treatment plants service high-density residential units. Although the wastewater from these residential units is conveyed to and treated at a private wastewater treatment plant, the plants - which discharge to groundwater - have nitrogen limits of 10 mg/L. Data available from the NYSDEC indicated that two of these STPs have, at times, exceeded their permitted nitrogen effluent limit of 10 mg/L (Table 11-9). Fines and consent orders can be imposed on the facilities if their nitrogen concentration exceeds this limit. Information on permitted flow rates and average effluent nitrogen concentrations are from the 2006 EPA Water Discharge Permit data for the residential treatment plants (Source: PCS Query). Duck farm permitted flow rates and average effluent nitrogen concentrations are from NYSDEC data and represent a 2010 average. Table 11-9 summarizes these data.

Table 11-9. Wastewater Treatment Plant Data

Wastewater Treatment Plant	Discharge Location	Permitted Flow (MGD)	Effluent Total Nitrogen as N concentration (mg/L)	Nitrogen- (lbs/day)	Nitrogen Contribution[1] (lbs/day)
Waterways at Bay Pointe	Sub-Surface	0.090	20.0	15.01	7.5
The Villas at Pine Hills	Sub-Surface	0.181	17.5	26.42	13.2
Pine Hills South	Sub-Surface	0.115	8.0	7.67	3.8
Jurgielewicz Duck Farm	Surface Water	0.578	40.5	195.00	195.0
				Total	**219.5 lbs/day**

[1] Assumes 50 percent additional nitrogen removal in soils for sub-surface discharges

Residential Wastewater Treatment Plants

There are three wastewater treatment plants that serve residential subdivision communities inside the contributing area for the Forge River; Waterways at Bay Pointe (0-2-year groundwater contributing area), Pine Hills South (2-5-year groundwater contributing area) and Villas at Pine Hills (10-25-year groundwater contributing area). Each of these plants discharges to groundwater either via leaching pools or recharge basins. Coincidently, all three plants are located inside the Ely Creek subwatershed. The nitrogen contribution from these plants represents approximately 35% of the total nitrogen inputs to the Ely Creek subwatershed. Ely Creek has one of the largest groundwater contributing areas of all of the creeks on the Forge River.

Duck Farm Wastewater Treatment

Two duck farms are located in the West Mill Pond subwatershed area. There is limited information on the Barnes Road Duck Farm, which has a zero discharge permit and four treatment lagoons. That duck farm was purchased by Jurgielewicz Duck Farm. The following discussion focuses on the Jurgielewicz Duck Farm. It has a SPDES permit with different nitrogen limits throughout the year. These limits range from 5 mg/L in the summer to 10 mg/L in the winter. Data from July 2009 through June 2010 are from the NYSDEC. Average flow for this data range is 0.578 million gallons per day (MGD) and the average effluent nitrogen concentration is 40.45 mg/L. Given these values, daily nitrogen generation is estimated at 195 lbs. The duck farm treatment plant's total *effluent* nitrogen concentration is similar to the *influent* concentration at a typical human wastewater treatment plant. A typical residential septic tank (*i.e.* assuming 50 percent nitrogen removal) contributes 0.04795 lbs N per day to groundwater and eventually to the Forge River. Thus, the Jurgielewicz Duck Farm contributes nitrogen to the estuary at a rate equivalent to 4,000 households with properly functioning OWTS. If the duck farm were meeting its effluent nitrogen concentration limit at their discharge limit of 0.6 MGD, it would represent 36.2 lbs N per day to the Forge River (Table 11-10). However, the Duck Farm is not meeting its regulatory limits.

Table 11-10. Jurgielewicz Duck Farm Nitrogen Limits

Months	Nitrogen Limit (mg/L)	Nitrogen Limit (lbs/day)
Jan. thru Feb.	10	50.04
March thru May	8	40.03
June thru Oct.	5	25.02
November	8	40.03
December	10	50.04
	Total	**13,215.56 lbs/year or 36.2 lbs/day**

The Jurgielewicz Duck Farm contribution to the Forge River is 195 lbs N/day.

11.9.7 Nitrogen Inputs - Fertilizer

Fertilizer is applied to agricultural, commercial/industrial and residential parcels. It was estimated from land use data and infrared aerial photography, that 25 percent of agricultural parcels (excluding livestock agriculture) use fertilizer. According to literature from the Center for Environmental Research at Cornell University (Hughes, Pike, & Porter, 1985), (Hughes & Porter, 1983) (Hughes, Porter, & Trautmann, 1983), a fertilization rate of 3.5 lbs N/year/1,000 sq.ft. was assumed for agricultural parcels, with 35 percent of the nitrogen in fertilizers reaching groundwater. Parcels that were not categorized agricultural, residential, or vacant fell into the commercial/industrial category. In a similar manner (based on infrared aerials), it was assumed that 25 percent of

commercial/industrial parcels apply fertilizer. According to New York State Guidelines for Urban Erosion and Sediment Control, turf accounts for an average of 15 percent of the area of a typical commercial or industrial parcel. Using the same Cornell University references as above, 35 percent of applied fertilizer reaches groundwater and the fertilization rate on turf grass is 2.4 lbs N/year/1000 sf. It was also estimated that 25 percent of residential parcels in the watershed apply fertilizer to their turf grass. New York Guidelines for Urban Erosion and Sediment Control assumes 70 percent of a residential parcel's area is turf grass, with 35 percent of applied fertilizer reaching groundwater. The assumed application rate is the same as commercial/industrial parcels at 2.4 lbs N/year/1000 sf.

The total fertilizer contribution to the Forge River is 76.42 lbs N/day.

11.9.8 Nitrogen Inputs - Atmospheric Deposition

The data for atmospheric contribution of nitrogen to the Forge River is from weather station NY96 located at Cedar Beach, Southold, NY. This station is the only one of its kind on Long Island. The sum of the NH_4 and NO_3 average concentrations equals 0.0234 lbs/acre/day (see Appendix B). A 65 percent removal rate (see Appendix B), or 0.0082 lbs/acre/day, due to plant uptake was applied to parcels that have a means of stormwater recharge (*e.g.*, infiltration or piping to recharge basins) prior to it reaching groundwater. This occurs for 8,860 acres of land. It was assumed that 100 percent of precipitation enters the Forge River from the 590 acres of land that does not recharge stormwater.

A total of 87.8 lbs N/day is contributed from atmospheric deposition to the Forge River.

11.9.9 Nitrogen Inputs - Benthic Contribution

The nitrogen contributions from benthic regions of the watershed are attributed to the internal recycling of sediments with enriched organic (decayed) matter that has accumulated in the Forge River and the adjacent creeks and ponds. Nitrogen contributions from benthic flux were estimated using information from several sources (Hughes, Porter, & Trautmann, 1983), (Aller, Brownawell, & Gobler, 2009), (Brownawell, Gobler, & Swanson, May 2009) as well as from conversations with some of the authors, *i.e.*, Dr. Bruce Brownawell and Dr. Robert Aller from Stony Brook University's School of Marine and Atmospheric Sciences (SOMAS). The researchers' measurements of net production rates were obtained in the summertime (22°C/71.6°F) and ranged from 33 to 64 mmol/m^2/day with an average of 45 mmol/m^2/day. The samples that represented extremes of 33 and 64 mmol/m^2/day were taken from the mouth of the Forge River and at Station 2 (located at the end of finger pier off the mouth of Wills Creek), respectively.

Since water-column oxygen content is variable and nitrogen flux is dependent on DO, the researchers suggested that there might be a 30 to 50 percent uncertainty inherent in the calculation of benthic flux annual averages and typical values. To be conservative, therefore, 20 mmol/m^2/day may be a realistic estimate for the year-round average benthic nitrogen flux for the Forge River and its creeks.

Further variability in benthic nitrogen flux (33-64 mmol/m^2/day) is related to location. A value of 10 mmol/m^2/day is appropriate in areas where flushing and mixing are greater (*i.e.* seaward of Old Neck Creek) and 30 mmol/m^2/day for river and areas upstream (*i.e.* Ely and Wills Creeks). This approach produces a fair distribution of the benthic flux across the entire estuary. The nitrogen contribution based on the internal recycling of benthic flux calculated using these boundary conditions is 1,543 lb/day of nitrogen.

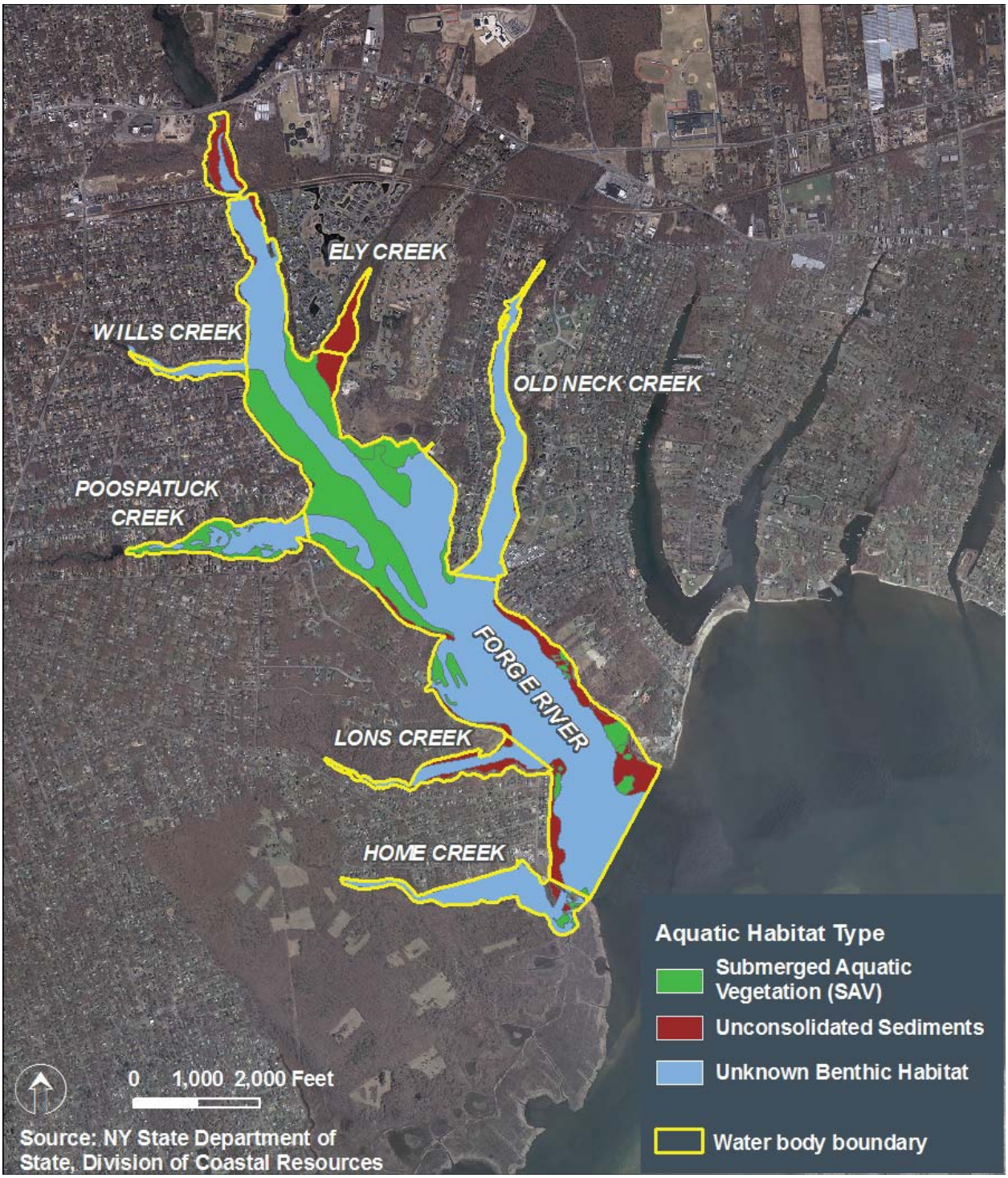
Additional information was available from the New York State Department of State, Office of Coastal, Local Government, and Community Sustainability. Information from this agency included a GIS dataset of polygons representing benthic habitat data; this data set was photogrametrically derived from conventional-color aerial photography of Long Island's south shore bays, acquired in May and June 2002. This dataset is available on the NYS GIS Clearinghouse website and is termed *Benthic Habitats Mapping of the South Shore Estuary of Long Island*. In the Forge River and its contributing creeks and ponds there are only three classifications represented, *Submerged Aquatic Vegetation* (447,167 m^2 or 110.5 acres), *Unconsolidated Sediments* (229,840 m^2 or 56.8 acres) and *Unknown Benthic Habitats* (1,503,634 m^2 or 371.6 acres). This information is mapped in Figure 11-39. Based on this information, the lower value of 10 mmol/m^2/day was applied to the *Submerged Aquatic Vegetation* and the higher value of 30 mmol/m^2/day to the *Unconsolidated Sediments* and *Unknown Benthic Habitats*. The nitrogen contribution based on the internal recycling of benthic flux calculated using these boundary conditions is 1,743 lb/day of nitrogen and is shown in Table 11-11, below.

Table 11-11. Benthic Nitrogen Contributions

	Benthic Contribution	
Waterbody	**lbs N/day**	**% of N in area**
Home Creek	**100.8**	**5.78%**
Lons Creek	63.1	3.62%
Poospatuck Creek	67.6	3.88%
Wills Creek	26.1	1.50%
Ely Creek	28.7	1.65%
Middle Forge East	0.0	0.00%
Old Neck Creek	**129.0**	**7.40%**
Forge River	**1327.8**	**76.17%**
Totals	1743.1	100.00%

A total of 1,743 lbs N/day is contributed from benthic flux to the Forge River.

Figure 11-39. Benthic Contributions



11.9.10 Nitrogen Inputs - Loading Model and Source Share

Each of the upland nitrogen contributions, on-site wastewater treatment systems (OWTS), wastewater treatment plant (WWTP) effluents, fertilizers and atmospheric deposition, were combined and a source share attributed to each subwatershed (Table 11-12). These derived values will support a prioritization of the subwatersheds for the development and implementation of watershed management strategies.

The nitrogen contributions from OWTS were most prevalent in the Wills Creek, Poospatuck, and West Mill Pond subwatersheds (Figure 11-40). This is attributed to the high density of homes and businesses in conjunction with high groundwater and a lack of additional treatment from sub-surface soils. Over half of the total nitrogen input from all of the OWTS in the watershed is produced by these three subwatersheds. The Jurgielewicz Duck Farm, located directly adjacent to West Mill Pond (Figure 11-40), represents the largest nitrogen point source, at 195 lbs N/day.

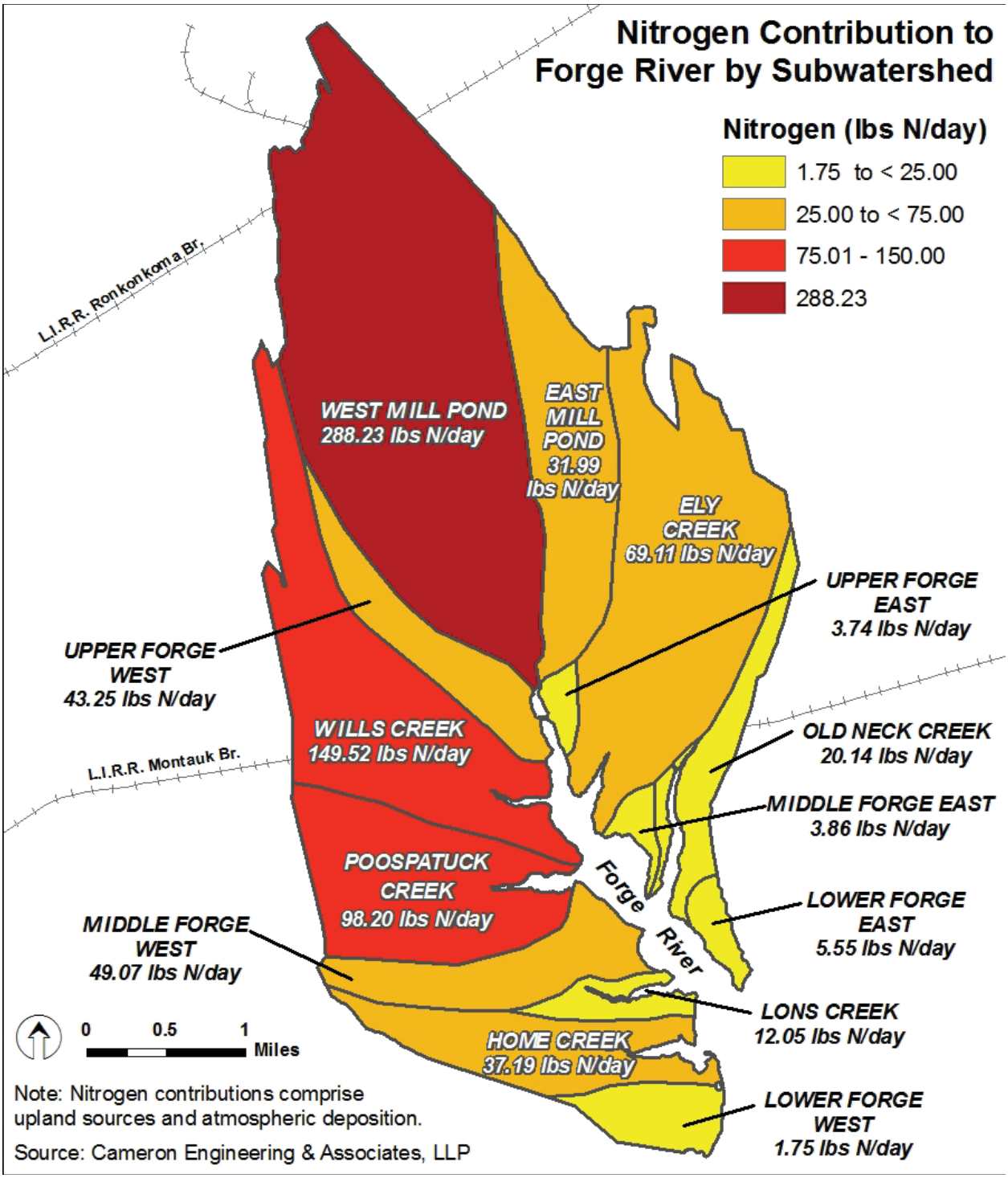
Ely Creek, although smaller than other creeks in the watershed, has the second largest groundwater drainage area. The three private WWTPs that service residential subdivisions are all located in the Ely Creek subwatershed.

Based on the assumptions discussed above, fertilizer usage is most common in the West Mill Pond, East Mill Pond, and Ely Creek subwatersheds, accounting for half of the fertilizer contribution of the entire watershed. The West and East Mill Pond subwatersheds have a large agricultural land use component with significant fertilizers input. The Ely Creek subwatershed also has land uses with high fertilizer requirements such as golf courses and school ball fields.

As atmospheric nitrogen inputs are directly related to subwatershed size, the three largest subwatersheds, West Mill Pond, Ely Creek, and Wills Creek, contribute the greatest quantity of atmospheric nitrogen.

Table 11-5 summarizes the nitrogen load by subwatershed and percent contribution to the entire watershed. A key finding of this nitrogen loading analysis is that 80 percent of all nitrogen from upland sources emanates from five subwatersheds: Mid Forge West, Poospatuck Creek, Wills Creek, West Mill Pond, and Ely Creek as shown in Figure 11-3.

Figure 11-40. Nitrogen Contributions by Subwatershed



Note: The Jurgielewicz Duck Farm ceased operations just prior to the publication of this report. Nitrogen loading will be re-calculated as part of the formulation of the TMDL without the input from the duck farm.

Table 11-12. Subwatershed Nitrogen Contributions
(Listed Highest to Lowest)

	Fertilizer		Atmospheric		On-Site Wastewater		WWTP Effluents		Totals	
Subwatershed	**lbs N/day**	**% of N in subwatershed**	**lbs N/day**	**% of N in subwatershed**	**lbs N/day**	**% of N in subwatershed**	**lbs N/day**	**% of N in subwatershed**	**lbs N/day**	**% of N in watershed**
West Mill Pond	14.73	5.11%	25.63	8.89%	52.86	18.34%	195.00	67.65%	288.23	35.42%
Wills Creek	10.04	6.72%	12.47	8.34%	127.01	84.95%	0	0%	149.52	18.38%
Poospatuck Creek	10.58	10.78%	8.42	8.58%	79.20	80.65%	0	0%	98.20	12.07%
Ely Creek	11.84	17.13%	13.09	18.94%	19.64	28.41%	24.55	35.52%	69.11	8.49%
Mid Forge West	5.48	11.17%	3.63	7.41%	39.95	81.42%	0	0%	49.07	6.03%
Upper Forge West	2.87	6.63%	4.45	10.28%	35.94	83.09%	0	0%	43.25	5.32%
Home Creek	2.87	7.71%	4.92	13.22%	29.40	79.07%	0	0%	37.19	4.57%
East Mill Pond	11.81	36.92%	6.86	21.44%	13.32	41.64%	0	0%	31.99	3.93%
Old Neck Creek	2.91	14.47%	3.40	16.88%	13.83	68.66%	0	0%	20.14	2.48%
Lons Creek	1.29	10.70%	1.35	11.23%	9.41	78.07%	0	0%	12.05	1.48%
Lower Forge East	0.90	16.26%	0.69	12.47%	3.95	71.28%	0	0%	5.55	0.68%
Middle Forge East	0.64	16.59%	0.56	14.62%	2.66	68.79%	0	0%	3.86	0.47%
Upper Forge East	0.46	12.27%	0.57	15.25%	2.71	72.48%	0	0%	3.74	0.46%
Lower Forge West	0.00	0.00%	1.75	100.00%	0.00	0.00%	0	0%	1.75	0.21%
Totals	**76.42**	**9.39%**	**87.79**	**10.79%**	**429.88**	**52.83%**	**219.55**	**26.98%**	**813.64**	**100.00%**