OWASCO LAKE, NEW YORK:
WATER QUALITY & NUTRIENT SOURCES, A 2012 UPDATE.

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INTRODUCTION

Since the initial Finger Lakes Institute water quality survey of seven eastern Finger Lakes in 2005, which revealed relatively poor water quality in Owasco Lake compared to the other surveyed lakes, Owasco Lake and its watershed has been the focus of additional research. The goals were to establish consistent and comprehensive monitoring to document spatial and temporal trends in pertinent water quality parameters; bring particular focus to the extent and source of nutrients from the watershed to the lake; and, promote the development of effective and comprehensive watershed management policies to improve water quality in Owasco Lake. This work was supported by the Fred L. Emerson Foundation, Auburn, NY, New York State secured by New York Senator Michael Nozzolio, the Owasco Lake Watershed Association (OWLA), the Town of Fleming, and most recently Cayuga County. The late Dr Joe Wasileski was a major instigator for these efforts. His immense love of and momentous drive to improve water quality in Owasco Lake was infectious to everyone around him.

The results of these earlier efforts were:

- Owasco Lake is a borderline oligotrophic – mesotrophic ecosystem.
- Phosphorus is the limiting nutrient in Owasco Lake, and any additional inputs of phosphorus would thus stimulate algal growth and degrade water quality.
- Nutrient and sediment flux data indicated that fluvial inputs are significant in the nutrient budget for the lake, especially during major precipitation/runoff events. The largest fluxes are from the two largest tributaries, Dutch Hollow Brook and Owasco Inlet.
- Sources for the nutrients and suspended sediment are point sources including wastewater treatment facilities and onsite wastewater (septic) systems, and non-point sources including, agricultural activities (both animal and crop agriculture), soil erosion, stream bank erosion, fertilized lawns, roadside ditches and construction activities.
- The lake, and especially the southern end of the lake, was less impaired in 2007 than other years. The improvement was due to a DEC mandated reduction in phosphorus loading by the Groton Wastewater Treatment Facility, adoption of best management practices in the watershed, establishment and follow through on recommendations by the newly established Watershed Inspector, and most importantly, significantly lower rainfall in 2007, and thus lower runoff of nutrients and suspended sediments to the lake.
- In recent years the lake has experienced blooms of blue green algae. Blue green blooms are a concern due to their affiliation with impaired water bodies and the toxicity of some (not all) blue green species to warm blooded animals.

The 2011 research was especially noteworthy because it, for the first time, included bi-weekly seasonal sampling of Dutch Hollow Brook and Owasco Inlet and event *versus* base flow, detailed analysis of nutrient and sediment loading from Dutch Hollow Brook.

- Seasonal sampling of Dutch Hollow and the Inlet revealed larger spring and fall phosphorus and suspended sediment loads compared to the summer months, and indicated that the earlier, pre-2011, fluxes, based only on summer samples, underestimated the actual annual loads to the lake.
- The event *versus* base flow, detailed analysis of Dutch Hollow Brook by "R_2D_2" highlighted the dominance of precipitation induced runoff events of non-point sources to the delivery of nutrients and suspended sediments to the lake.
- A preliminary phosphorus budget for Owasco Lake estimated:
  - an input of over 16 metric tons of phosphorus per year,
  - a loss of 4.4 metric tons of phosphorus per year, and
  - the net (input – output) addition of roughly 12 metric tons of phosphorus to the lake in 2011 that stimulated additional algal growth and a decline in water quality/clarity.
- The report concluded with a recommendation to establish more stringent Best Management Practices (BMPs) in the Owasco Watershed to reduce the input of phosphates from non-point sources to the lake, while at the same time monitoring downstream of BMPs and other remediation projects to assess their effectiveness. However the financial burden to install the BMPs cannot be placed solely on the farmer, and everyone must work together to find local, county, state and federal dollars to make this happen.

Here, we report on our 2012 results that continued seasonal and event *versus* base flow, detailed analysis initiated in 2011. Specifically, the 2012 effort proposed to continue monitoring water quality in the lake, nutrient sources in the Dutch Hollow Brook and Owasco Inlet, seasonal-scale variability in nutrient loads from both watersheds, and precipitation/runoff event *versus* base flow variability in nutrient loads from Dutch Hollow Brook to substantiate and build on the 2011 eye-opening results. This study was made possible through the continued support by the Cayuga County Legislature.

METHODS

The sites and methods used in 2012 were for the most part identical to the 2011 program.

Owasco Lake: The 2012 lake survey sampled Sites 1 and 2 on a monthly basis (Table 1, Fig. 1). The specific survey dates were: 4/19, 5/1, 5/22, 6/19, 7/17, 8/14, 9/29, 10/25, and spanned the spring, summer and fall seasons. These two sites have been sampled since the initial study in 2005, as they were shown to be representative of the open water limnology in Owasco Lake during years of extensive sampling at up to eleven lake sites.

The field and laboratory methods were identical to our earlier lake research. A CTD water quality profile, secchi disk depth, horizontal and vertical plankton tows (80-μm mesh), and surface and bottom water samples were collected at each site. The CTD electronically gathers water column profiles of temperature (°C), conductivity (specific conductance, μS/cm, proportional to salinity), dissolved oxygen (mg/L), pH, turbidity (NTUs), photosynthetic active radiation intensities (PAR, $\mu E/cm^2$-s), and fluorescence (a measure of chlorophyll-a, μg/L) using a SeaBird SBE-25 CTD. The CTD was lowered from the surface to ~1m above the lake floor, collecting data every 0.5 seconds (~0.2 meters) along the downcast. The plankton were preserved in an alcohol-formalin solution until identification and enumeration back in the laboratory. Water samples were analyzed onsite for temperature (°C), conductivity (specific conductance, μS/cm), pH and alkalinity (mg/L, $CaCO_3$) using hand-held probes and field titration kits, and analyzed back in the laboratory for total phosphate (μg/L, P), dissolved phosphate (SRP, μg/L, P), nitrate (mg/L, N), chlorophyll-a, and total suspended solids (mg/L) concentrations. Water samples were stored at 4°C until analysis.

Table 1. Site locations and water depths.

Site Name	Latitude	Longitude	Water Depth
Site 1	42° 52.4' N	76° 31.35' W	34 m
Site 2	42° 49.15' N	76° 30.45' W	52 m

Owasco Streams: The 2012 stream survey sampled Dutch Hollow Brook and Owasco Inlet at 17 sites, and for the first time the small tributary at the very end of Fire Lane 20. Sites were visited monthly, specifically on: 3/30, 4/27, 5/30, 6/26, 7/24, 8/21, 9/23, and 10/27 to perform onsite analyses and collect samples for additional analyses in the laboratory. Dutch Hollow Brook and Owasco Inlet have been continually studied since 2005 to investigate the source of nutrients and suspended sediments entering the lake, because earlier data has shown that these two watersheds delivered more nutrients and suspended sediments to a lake than the other tributaries. Both watersheds also drain critical examples of point and nonpoint sources of nutrients and suspended sediments, e.g., municipal wastewater treatment facilities and agricultural areas. Dutch Hollow Brook drains the 2nd largest subwatershed area (77 km^2) in the Owasco watershed (523 km^2) and drains an agriculturally-rich landscape (64% agricultural, 33% forested) of both crop agronomy and animal husbandry. The Owasco Inlet drains the largest portion (299 km^2) of the Owasco watershed, includes a mixture of agricultural (46%) and forested (49%) landscapes, and contains two municipal wastewater treatment facilities.

Stream Segment Analysis & Nutrient Sources: Segment analysis delineates point and non-point sources and is facilitated by sampling multiple sites along a major stream and its major tributaries. The segment analysis concept is simple. The concentration of any pollutant increases downstream from the source. Thus, if the concentration of a pollutant increases between any two adjacent sites or at a tributary, then the source of that pollutant is somewhere between those two sites or within the tributary drainage. Calculating fluxes quantifies the transport of that parameter and differentiates if the upstream source(s) significantly impact(s) loading to the lake.

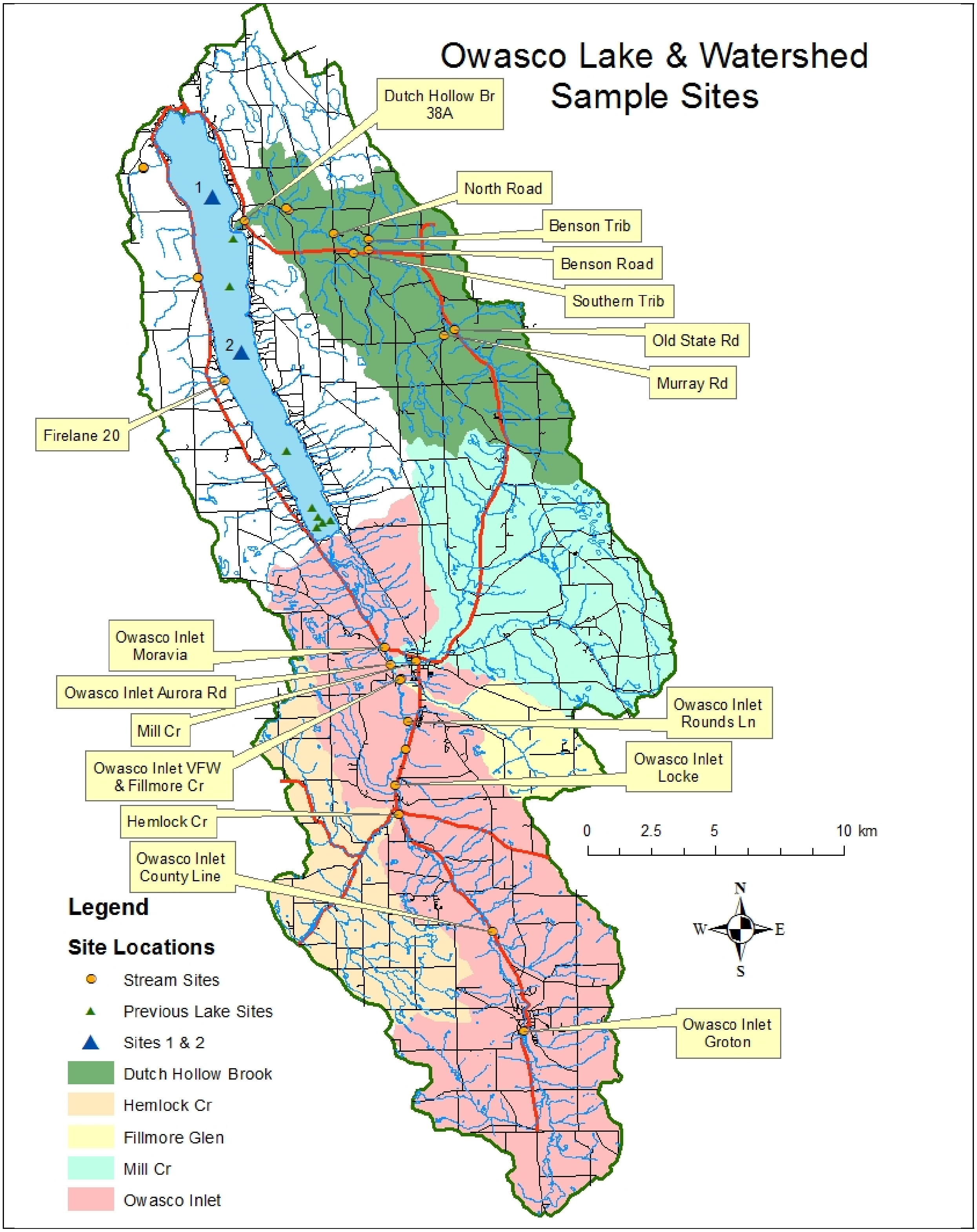


Fig. 1. The 2012 lake and stream sites. Dutch Hollow Brook drains the second largest area (77 km^2) in the Owasco watershed. The Owasco Inlet drains the largest area (299 km^2) in the Owasco watershed. Fire Lane 20, Murray Rd Trib (Dutch Hollow subwatershed) and Locke (Owasco Inlet subwatershed) Sites were added in 2012 at the expense of Suckerport Ln and the two Barski Rd. sites sampled in 2011.

Dutch Hollow Brook was sampled at four successive upstream sites in 2012 (Figs. 1 & 2). Proceeding upstream, sites were at Rt 38A, North St, Benton Rd, and near Old State Rd. Three unnamed tributaries were also sampled just upstream of their confluence with Dutch Hollow Brook. The Southern tributary joined Dutch Hollow between the North St site and the Benson Rd site. It drained the agriculturally-rich land to the south. Benson Trib joined Dutch Hollow between the Southern tributary confluence and the Benson Rd site and it drained a large farm. The site was located on Benson Rd at the golf course. Finally, the tributary at Murray Rd joins Dutch Hollow just southwest of the Old State Rd site. It was added to the sites surveyed in the Dutch Hollow watershed in 2012, because it drains a predominantly forested region to the southwest. The previously surveyed Barski Rd sites were discontinued because the 2011 data did not add any new insights to the nutrient and suspended sediment loading “problems”.

Owasco Inlet was sampled at seven successive upstream sites (Figs. 1 & 2). Proceeding upstream along Rt 38, sites were just downstream of Moravia on Rt 38, Auburn St in Moravia, VFW fairgrounds, Rounds Ln, Locke, County Line, and just upstream of Groton (near Spring St). The site selection bracketed two municipal wastewater treatment facilities. The Groton facility is located between the Groton and County Line sites. The Moravia facility is located between the VFW and Aurora sites. Three major tributaries, Mill, Fillmore and Hemlock Creeks, were also sampled just upstream of their confluence with Owasco Inlet. Mill Creek joined the Inlet between the Rt 38 and Aurora sites, Fillmore Creek just down stream of the VFW site, and Hemlock Creek between Locke and County Line sites. Of these three tributaries, Fillmore Creek is the smallest and most forested (16 km^2, 70% forested, 29% agricultural), Hemlock Creek is the most agricultural (47 km^2, 57% forested, 41% agricultural), and Mill Creek is the largest with a near even split of agricultural and forested land (77 km^2, 51% forested, 47% agricultural). In 2012, the Suckerport Ln site surveyed in 2011 was replaced with the site at Locke to better differentiate the source of materials along this reach of the Inlet.

The tributary at Fire Lane 20 was sampled for the first time in 2012 to investigate potential contributions from intense agricultural activity in its headwaters. This tributary is typical of numerous 1st or 2nd order (small) tributaries along the east and west shores of the lake.

At each stream site, stream discharge, onsite water quality analyses and water samples were collected for additional analyses back in the laboratory. Stream discharge (the volume of water per unit time flowing past a site) was calculated for each site on each visit from measured stream width, depth and velocity data (using a 30 m tape, wading rod and Marsh-McBirney flow meter). Both velocity and depth were measured at five or ten equally distributed locations across and aligned perpendicular to stream flow. The velocity was measured at ~60% of the stream depth to acquire an average velocity. Ten segments were utilized when the stream was wide or more accuracy was necessary, e.g., some of the Inlet sites and the Dutch Hollow 38A site. Stream discharge (water volume per unit time) is required for flux (loading) calculations of any substance (e.g., phosphates, nitrates, suspended solids, etc.) because a flux (mass/time) is the stream discharge (volume water/time) times its concentration (mass/volume water). Flux indicates how much of that substance is transported by the stream per unit time. Stream water was measured onsite for temperature, conductivity, dissolved oxygen, pH and alkalinity using hand-held probes or field titration kits. Water samples were also analyzed for total phosphate, dissolved phosphate, nitrate and total suspended solid concentrations in the laboratory. Laboratory samples were stored at 4°C until analysis.

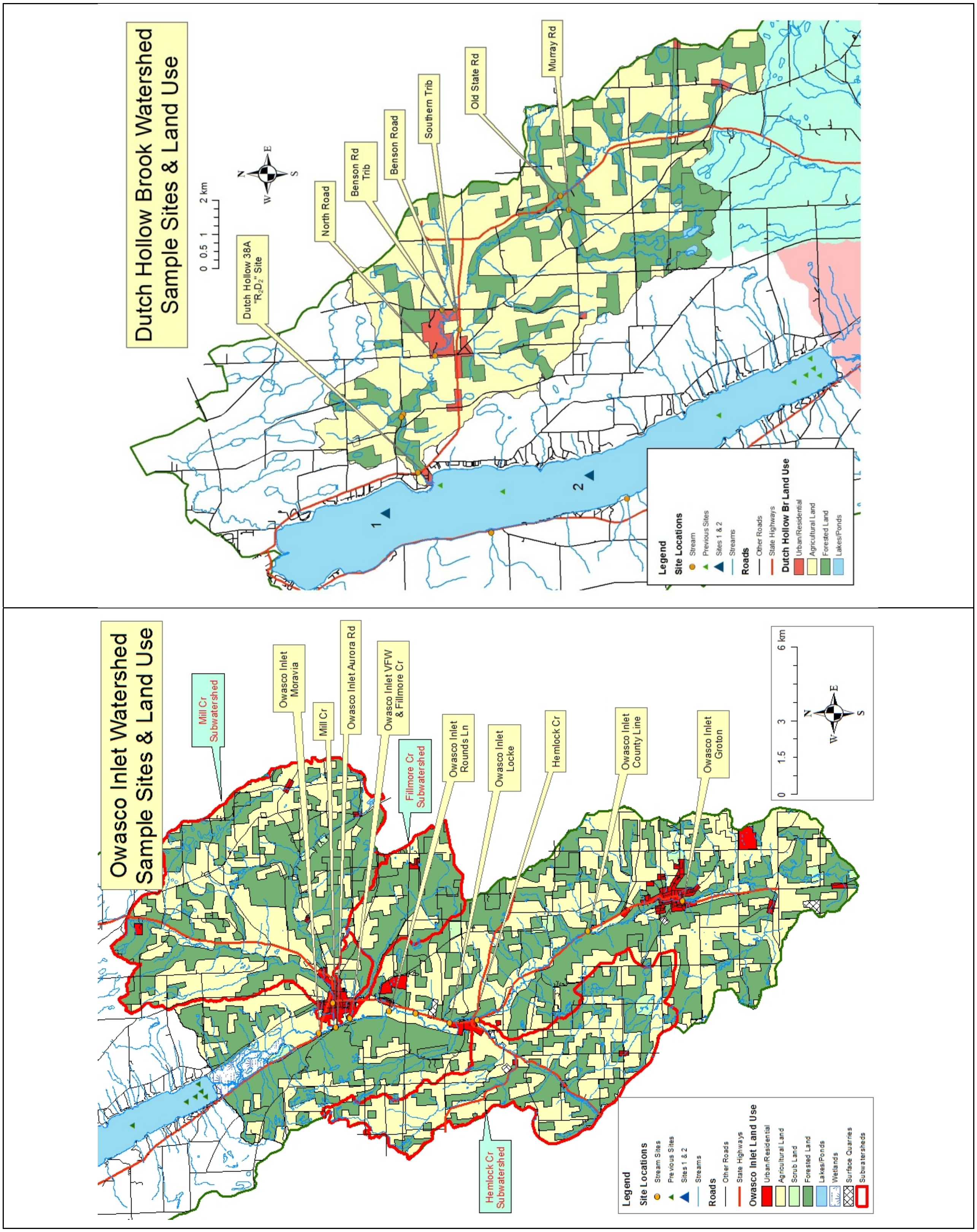


Fig. 2. 2012 site locations along Dutch Hollow Brook and Owasco Inlet watersheds. Land use in each watershed is also shown.

Runoff/Event Flow versus Base Flow Variability: Two stream states are critical to characterize, event flow (storm runoff or peak flow) and base flow (groundwater supported flow). When it rains, runoff quickly adds water to a stream, which swells to an event (peak) discharge (perhaps a flood) a few hours to a day or more after the rainstorm. The response is longer for larger watersheds and/or larger precipitation events. Following the rainstorm, runoff dissipates and the stage peak declines but at a slower rate than the initial increase. Rejuvenated near-surface groundwater flow from the recent infiltration of rain supports the post runoff flow. When the runoff and near-surface rejuvenated groundwater wane, the stream flows at a lower discharge, its base flow, fed by groundwater inputs.

Sampling both event and base flow conditions is necessary due to their unique influence on the transport of point and non-point source materials. Event flow samples primarily detect materials from non-point sources that are eroded by the runoff of water across the land. Their stream concentrations increase significantly (10 to 1,000 fold) above base flow concentrations during an event. Typical non-point sources include agricultural and lawn care fertilizers, herbicides and pesticides, and concentrated animal feedlot (CAFO) wastes from farm lots and manure spread on fields. In contrast, base flow samples highlight point sources like effluent from wastewater treatment facilities and industrial plants. It also highlights materials transported by groundwater flow, e.g., nitrates. The total annual flux is typically dominated by the few largest runoff events during any period of time, especially in agriculturally-rich watersheds.

An automated water sampler and data loggers were installed at the Rt 38A site in Dutch Hollow Brook from 3/20/2012 to 11/2/2012 to investigate the impact of event *versus* base flow on the delivery of nutrients and suspended sediments to the lake. This spring, summer and fall deployment was critical because it collected springtime data previously missed in 2011. Two *In-Situ* Aqua-Troll 200 data loggers recorded stream stage (height), temperature and specific conductance every hour to identify runoff events and enable the estimation of stream discharge at this site (Fig. 3a). A *Teledyne* ISCO automated water sampler, called "R_2D_2" by the team, collected 1-L of water every eight hours (Fig. 3b). The timing collected both event and base flow samples in 2011. The water samples were transported back to the laboratory for analysis once a week. Every 8-hr event sample but only daily base flow (4 am) samples were analyzed in 2012, because event concentrations and fluxes revealed quick and substantial sample to sample changes where base flow concentrations revealed minimal sample to sample changes in 2011. The two stage states were differentiated by stream stage data and suspended solid concentrations. Over the 220 day (662 8-hr periods) deployment in 2012, only 4 samples were lost due to power failure (a mouse ate the power cord), and 60 samples (~20 days) were not collected by R_2D_2 due to dry conditions.

Fig. 3a. An *In Situ* Aqua Troll 200 data logger. It logged stream height (proportional to stream discharge),

Fig. 3b. Servicing "R_2D_2" the *Teledyne* ISCO automated water sampler located at the Rt 38A site. It

temperature and specific conductance of the stream on an hourly interval.

automatically collected 1-liter samples at an 8-hr interval and was serviced weekly.

Laboratory Analyses: Laboratory analyses for nutrient, chlorophyll-a, and total suspended solid concentrations followed standard limnological techniques (Wetzel and Likens, 2000). Once back in the laboratory, each sample water was filtered through pre-weighed, 0.45 μm glass-fiber filters. The filter and residue were dried at 80°C for at least 24 hours. The weight gain and filtered volume determined the total suspended sediment concentration. Lake water was also filtered through a Gelman HA 0.45 μm membrane filter. The filtered residue was kept frozen until chlorophyll-a analysis after acetone extraction by spectrophotometer. The filtrate was saved and stored at 4°C for dissolved phosphate, nitrate and dissolved silica colorimetric analyses by spectrophotometer. A third, unfiltered water sample was analyzed for total phosphates by spectrophotometer after digestion of any organic-rich particles in hot (100ºC) persulfate for 1 hour. Laboratory precision was determined by periodic replicate analyses resulting in the following mean standard deviations: total suspended solids ±0.2 mg/L, phosphate ±0.1 μg/L (both TP and SRP), silica ±5 μg/L, and nitrate ±0.1 mg/L. For the plankton enumerations, over 100 individuals were identified to genus level and reported as date averaged relative percentages.

LAKE RESULTS & DISCUSSION

Lake CTD Profiles: The 2012 water temperature profiles were typical for any spring through fall transition (Fig. 4). The first two profiles, 4/19 and 5/1, revealed nearly isothermal conditions, i.e., uniform temperatures throughout the water column at ~ 5 and 7º C, respectively. When the lake is isothermal, the lake mixes vertically throughout the water column (i.e., spring or fall overturn), and homogenizes any concentration differences that developed in nutrients, dissolved oxygen and other parameters during the summer (and winter) stratified seasons. Isothermal profiles were also detected in the April and early March lake surveys in 2011 but not observed previously because surveys were not early enough in the spring (5/20 earliest) to reveal isothermal conditions. Subsequent 2012 profiles revealed the establishment of summertime lake stratification, an increasingly less dense and warmer epilimnion over a constant denser and colder hypolimnion. Epilimnetic temperatures ranged from 15ºC in late-May to just over 25º C in the summer (8/14), and cooled to 13.3º C by the end of the survey (10/31). Starting on 5/1, hypolimnetic temperatures remained a uniform 6 to 7º C through the survey. Since 2009 through 2012, the epilimnion and hypolimnion were slightly warmer (by 1 to 2º C) than pre-2009 temperatures. The long term warming may be related to global warming, annual climatic variability or the distribution of the sample dates.

A thermocline, the depth in the water column that separates the epilimnion from the hypolimnion and defined by the largest decrease in water temperature with water depth, was typically observed at 10 to 15 meters at both sites during the summer. Its mean depth is controlled by the size of storm waves that mix the entire epilimnion. Any changes in its depth from site to site or day to day can be attributed to internal seiche activity, the periodic, see-saw like, oscillation of the thermocline set up by strong axial wind events, or fall cooling. The thermocline deepened in the October profiles during the fall decay through cooling of the epilimnion, until the lake presumably turned isothermal in winter (not observed).

Epilimnetic conductivity data (reported as specific conductance, a parameter proportional to water salinity) ranged from ~310 to 330 μS/cm, and like previous years, it decreased from the largest values in the early spring through the summer and fall seasons. The hypolimnetic specific conductance data were ~340 μS/cm and remained relatively uniform over time and depth except for a slight, ~5 μS/cm, increase near the lake floor in the fall (Fig. 4). The source of the dissolved ions was most likely from the natural weathering of soils, tills and bedrock and human sources like road salt, brought to the lake by runoff and/or groundwater flow. The epilimnetic salinity decline through the year probably was due to the dilution of the epilimnion with less saline rainfall and its associated runoff over time. The 2012 early spring conductivities (330 vs. 340 μS/cm) and the decrease in conductivity through the stratified season (~20 vs. 50 μS/cm) was slightly less than those detected in 2011, but more typical of earlier years. The large decrease in 2011 reflected more rainfall in 2011. The 2012 hypolimnion concentrations were similar in previous years.

Dissolved oxygen (DO) concentrations ranged from nearly 11 mg/L in the cold spring down to just below 4 mg/L in the upper and lower hypolimnion by late summer and into the fall (Fig. 4). The primary source of oxygen is diffusion from the atmosphere to the lake's epilimnion. This source isolates the hypolimnion from additional oxygen throughout the summer stratified season. DO concentrations also respond to three internal forcing functions: water temperature, colder water dissolves more oxygen than warmer water; photosynthesis, algal photosynthesis adds oxygen primarily to the epilimnion with super saturated concentrations of oxygen slowly diffusing back the atmosphere; and, respiration, bacterial respiration consumes oxygen and its removal impacts the isolated hypolimnion, initially just below the thermocline and/or near the lake floor, and if decomposition is intense enough, e.g., in a eutrophic lake, the depletion turns the entire hypolimnion anoxic. Because DO concentrations respond to temperature and biologic activity, DO concentrations are occasionally reported as "percent saturation", the percentage of the actual DO concentration to the theoretical saturated concentration at the water's temperature. Thus, super saturation indicates move photosynthesis than respiration, where under saturation indicates more respiration than photosynthesis.

The epilimnetic DO concentrations in 2012 decreased as epilimnetic water temperatures increased, but typically remained at or near 100% saturation. However, DO was progressively depleted below saturation just below the thermocline and just above the lake floor down to the 4 mg/L (~30 to 40% saturation) threshold for respiratory stress in sensitive organisms as the laqte-spring through summer season progressed. The decrease is interpreted to reflect bacterial respiration and decomposition of dead algae.

Photosynthetic available radiation (PAR), or light intensity, decreased exponentially with water depth in 2012 from a maximum intensity of 100 to a few 1,000 μE/cm^2-s at the surface to 1% of surface light intensities at water depths of 10 to 15 m, a depth still within the epilimnion (Fig. 4). The observed decrease in light reflects the normal exponential absorption and conversion of longer wavelengths of light (infrared, red, orange, yellow) to heat, and scattering of shorter wavelengths of light (ultraviolet, violet, blue) back to the atmosphere. Many of the profiles revealed a marked decrease in light at 2 or 3 meters. It corresponded to the sensor passing through the shadow of the boat. The range in surface intensities reflected the season, the extent of cloud cover, and the turbidity of the water (suspended sediment and/or algal density) on the survey date. The 2012 PAR data were similar to earlier years. The availability of light is critical for algal photosynthesis. The 1% threshold represents the minimum amount of light required for algae to photosynthesize enough biomass to survive. Thus, algal photosynthesis and growth was restricted by light to the epilimnion in Owasco Lake.

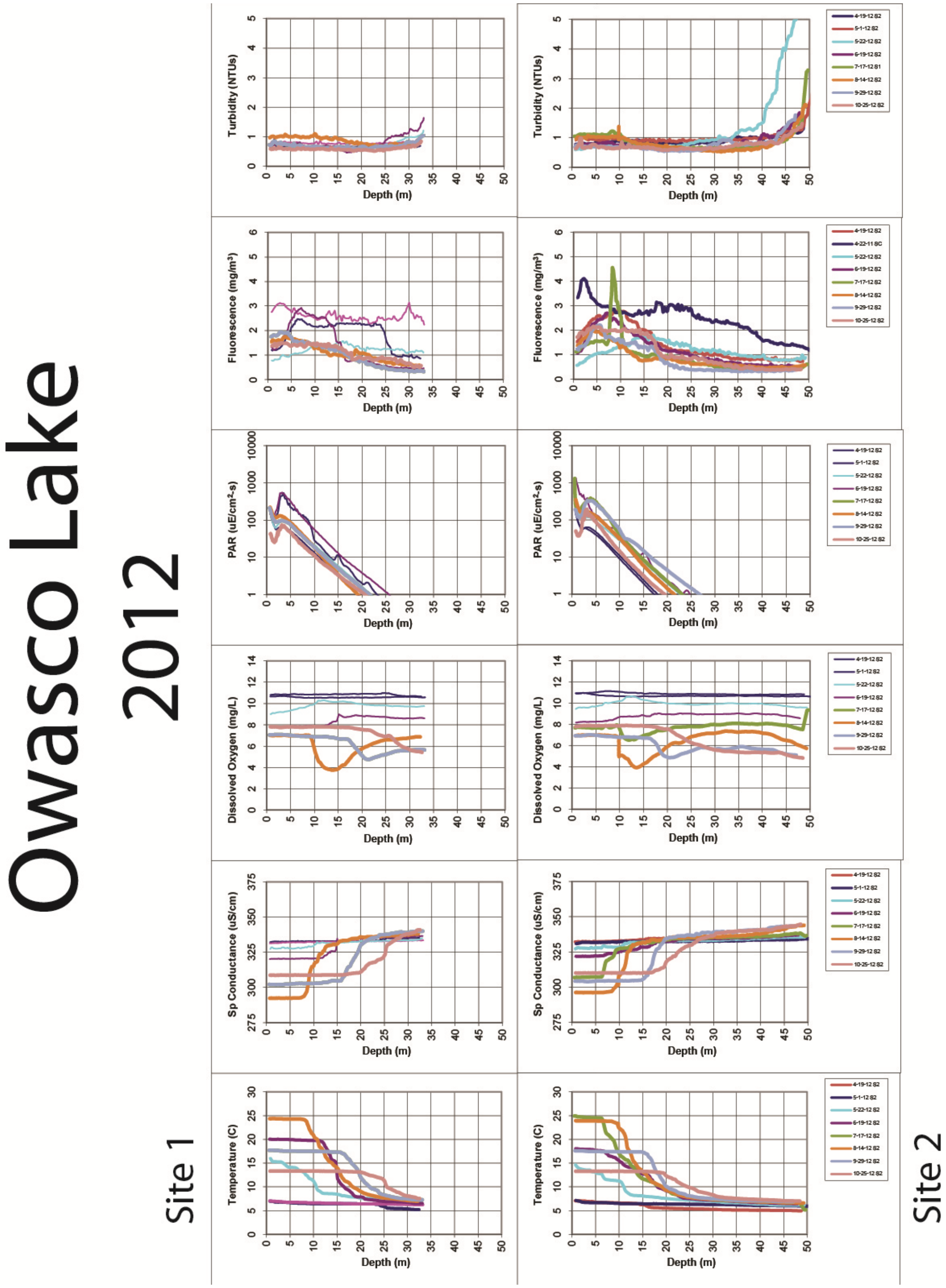


Fig. 4. Owasco 2012 CTD profiles from Sites 1 & 2. The PAR (light) data are plotted on an exponential scale, so that exponential changes with water depth appear as straight lines.

Fluorescence profiles (algal concentrations) revealed algal peaks within the epilimnion during the summer months (Fig. 4). Peak concentrations were up to 3 and occasionally just above 4 μg/L (mg/m^3), but more typically between 1 and 3 μg/L in 2012. Smaller mean peak concentrations were detected in 2012 than 2011, and 2012 was more like profiles from earlier years. Hypolimnetic concentrations were consistently below 1 μg/L. The two earliest sample dates revealed uniform (well mixed, isothermal) profiles up to 3 μg/L. Spring isothermal conditions, i.e., spring overturn, uniformly mixed the algae throughout the water column, whereas the subsequent stratified conditions and depth of available light allowed the algae to survive only in the sunlit epilimnion.

The 2012 turbidity profiles revealed uniform or nearly uniform turbidities at or below 1 NTU down to the lake floor at Site 1 and down to just above (5 to 10 m) the lake floor at Site 2 (Fig. 4). The 2012 summer concentrations were similar or slightly smaller to those collected in previous years, and highlighted algal, fluvial and wave resuspention sources.

Benthic nepheloid layers (bottom-water turbid zones extending from 5 to 10 meters above down to the lake floor) were once again detected at Site 2. A fluorescence peak was not observed at this depth, indicating that the source of the benthic turbidity was inorganic particles. The largest nepheloid layer was detected on 5/2, and was the first survey after a series of early May precipitation events. The sediments were probably the result of runoff events and/or erosion of nearshore/shallow water sediments by waves and currents during high winds and brought to the deepest lake floor by density currents and/or settling. These nepheloid layers were less prevalent in 2007 & 2008 than 2009 and 2010, and were most prevalent in 2011, only to return to earlier values in 2012. The change probably reflected a change in sediment inputs from streams and erosion by waves.

Nutrient, Chlorophyll-a, TSS and Secchi Disk Data: The 2012 secchi disk, chlorophyll, nutrient and suspended sediment data indicated that the lake was not a health threat, as the nitrate concentrations were an order of magnitude (10 times) below the 10 mg/L MCL established by the EPA (Table 2 in appendix, Fig. 5). Neither was the lake impaired, as the total phosphate concentrations were typically below the 20 μg/L total phosphate (TP) threshold established for impaired water bodies by the DEC. The 5/1 and 8/14 TP data were two exceptions with a TP date-averaged lake concentrations of 20.2 and 20.9 μg/L, respectively. Surface chlorophyll-a concentrations ranged from 0.8 to 4.5 μg/L, and averaged 1.7 μg/L. Secchi disk depths ranged from 3.4 to 8.0, averaged 5.4 meters.

A few additional observations about these data were noteworthy. First, the dissolved phosphate to nitrate ratio in the lake, the two nutrients that may limit algal growth, averaged 1:2,275 and never lower than 1:370 in 2012. The P:N ratio required by algae is 1:7 (Redfield Ratio). The difference indicates that phosphate was by far and in every year since 2005 the limiting nutrient in Owasco Lake. Thus, its availability limits continual algal growth, and algae never “run out” of nitrogen. Second, some variability was observed in every parameter from one survey date to the next (Fig. 5) with minimal consistency between parameters in 2012. Third, dissolved nutrient concentrations revealed a small increase and chlorophyll-a a small decrease between the epilimnion and hypolimnion, e.g., annual mean surface and bottom water concentrations for soluble reactive phosphate were 0.2 and 0.6 μg/L, nitrate 0.5 and 0.6 mg/L, silica 1,000 and 1,470 μg/L, and chlorophyll-a 1.7 and 0.5 μg/L, respectively, and reflected the seasonal progression of algal uptake of nutrients and their growth in the epilimnion, and algal decomposition and nutrient release by bacteria in the hypolimnion.

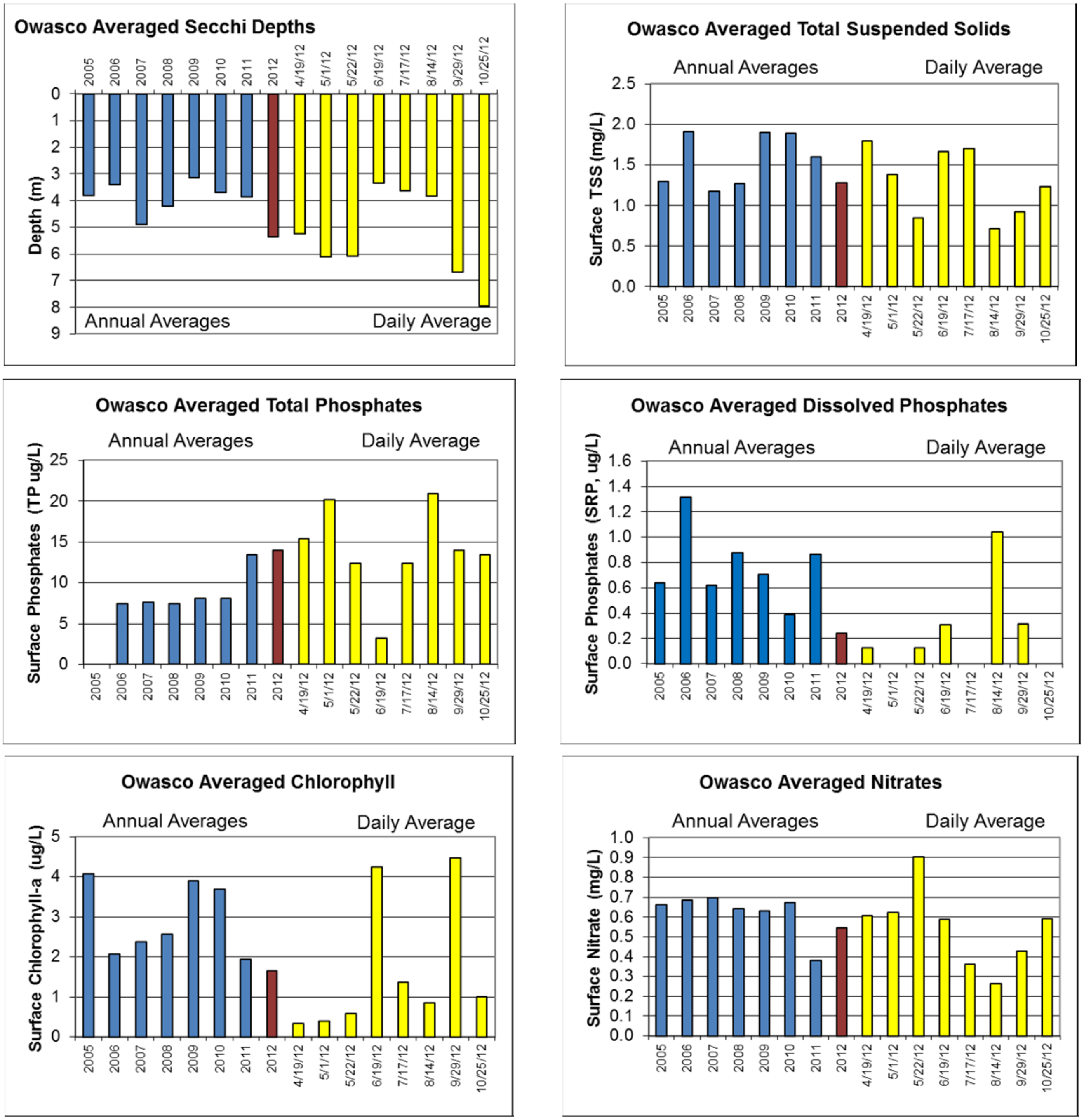


Fig. 5. Annual averaged surface water data (blue bars, dark red for 2012), and date average surface water data from each 2012 survey date (yellow bars).

Annual mean nutrient concentrations typically fluctuated from year to year, yet hinted at a subtle increase from 2005 through 2011 that reversed slightly in 2012 (Fig. 5). Total phosphate concentrations increased slightly from 2006 to 2011 (7 or 8 to 14 μg/L) and remained high 14 μg/L in 2012. Dissolved phosphate concentrations were high in 2006, fluctuated up and down to 2011 but declined in 2012 (0.6, 1.3, 0.6, 0.9, 0.7, 0.4, 0.9 and 0.4 μg/L). Chlorophyll-a and TSS concentrations were larger in 2009 and 2010 than other years (3.9 and 3.7 to ~2 μg/L; 1.9 and 1.9 to ~1.2 mg/L). Secchi disk depths were deepest in 2007 (4.9 m) and 2008 (4.2 m) and again in 2012 (5.4 m) compared to shallower depths detected in the other years (3 to 4 m, Fig. 5). These trends were consistent with increased algal productivity from 2008 to 2009 through 2010 that declined in 2012. The data suggest slightly better water quality in 2012 than 2011. However, the annual average changes were small and within the scatter of the individual data. The spring, summer and fall data in 2011 and 2012 but only summer data in the earlier years or sampling an intense late-summer bloom one year but not the next could shift the annual averages as well. For example, the summer secchi disk depths averaged 4.7 m in 2012 (using the May through September sample dates for the 2012 Finger Lake Survey) but averaged 5.4 m using data from the entire year.

Owasco Trophic Status: The annual Secchi disk depth average placed Owasco Lake in the oligotrophic range (Table 3, Fig. 5). Mean annual nitrate concentrations place Owasco Lake in the oligotrophic range, i.e., below 2 mg/L. The annual mean TP concentrations placed Owasco Lake in the mesotrophic range, i.e., between 10 and 20 μg/L. Algal peak concentrations in 2012 remained below 4 μg/L, below the 4 μg/L threshold between an oligotrophic and mesotrophic lake. The annual average DO concentrations were within the 80 to 20% saturation range for mesotrophic lakes. Thus, the 2012 annual mean hypolimnetic oxygen saturation and total phosphate concentrations were within the mesotrophic range. However, secchi disk depths, chlorophyll and nitrate concentrations were in the oligotrophic range. Thus, Owasco Lake remains borderline oligotrophic-mesotrophic but one step closer to an oligotrophic system in 2012. The mean secchi disk depth was deeper and thus indicated an oligotrophic lake in 2012 from its previous mesotrophic ranking in 2011.

Table 3. Concentration ranges for Oligotrophic (low productivity), Mesotrophic (mid-range productivity), and Eutrophic (high productivity) lakes. The bold entries highlight Owasco Lake's 2012 mean values.

Trophic Status	Secchi Depth (m)	Total Nitrogen (N, mg/L, ppm)	Total Phosphate (P, μg/L, ppb)	Chlorophyll a (μg/L, ppb)	Oxygen (% saturation)
Oligotrophic	**> 4**	**< 2**	< 10	**< 4**	> 80
Mesotrophic	2 to 4	2 to 5	**10 to 20**	4 to 10	**10 to 80**
Eutrophic	< 2	> 5	> 20 (> 30)	> 10	< 10

Plankton Data: The phytoplankton (algal) species in Owasco Lake during 2012 were dominated by diatoms, primarily *Flagillaria* and *Tabellaria*, with smaller numbers of *Melosira*, *Asterionella*, *Rhizoselenia* and *Synedra* (Table 4 in appendix, Fig. 6). For the first time, the diatom *Melosira* was abundant during the spring. Other phytoplankton species included the dinoflagellate *Dinobryon*, with a few *Ceratium* and *Coalcium*. The seasonal succession moved from *Tabellaria* and *Melosira* to *Tabellaria* and *Flagillaria* or *Dinobryon* back to *Flagillaria* and *Asterionella*. Zooplankton species were dominated by rotifers, with some cladocerans, as well as *cercopagis*, the spiny water flea. Zebra and quagga mussel larvae were detected in the plankton tows.

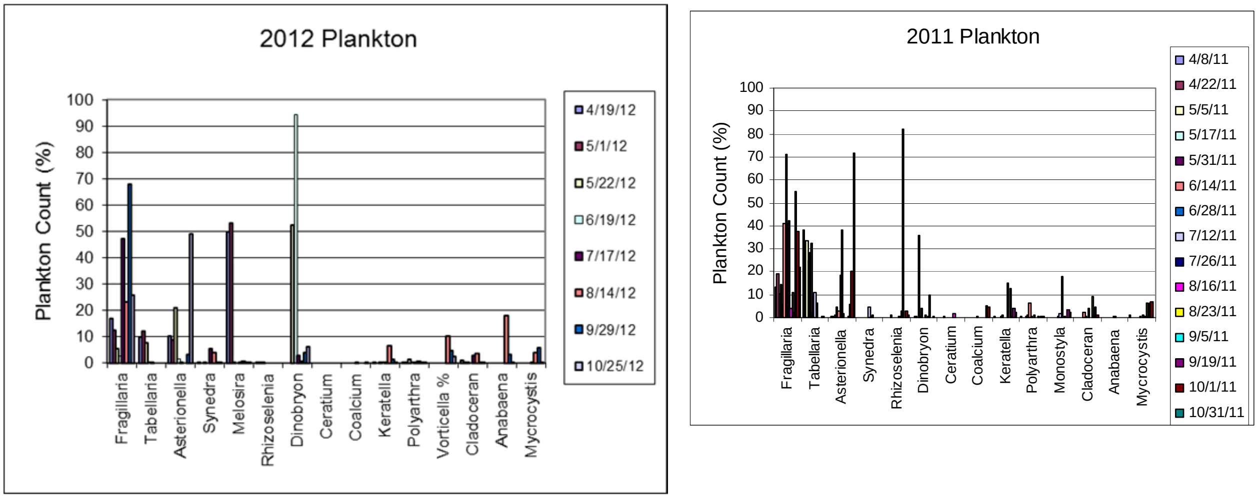


Fig. 6. Date averaged plankton data for 2011 and 2012.

In the past few years, blue green species have increased in abundance, with *Mycrocystis* representing up to 40% of the phytoplankton (2007 & 2010). They were most abundant in week-long blooms during the latter part of the past six summer seasons. An obvious bloom was not sampled in 2012 however it could have been missed by the 2012 monthly monitoring schedule. It suggests that Owasco Lake needs a daily monitoring tool, like the meteorological and limnological monitoring buoy previously deployed by UFI. The onset of *Mycrocystis* blooms is disturbing, because it signals the onset of an eutrophic system. Blue greens contain gas vacuoles that enable them to float at or near the surface of the lake and thus allow them to outcompete other algal species for the available light in a very productive, algal-rich and turbid lake. The resulting surface-water scum of blue-green algae is unpleasant, unsightly, smells, and some species of blue greens are toxic to humans and other warm blooded animals. Unfortunately, only detailed and expensive analyses differentiate between the toxic from other blue green species.

COMPARISON TO OTHER FINGER LAKES

Skaneateles, Otisco and Owasco Lake CTD Comparison: The seasonal progression of cold to warm to cool epilimnion over a colder hypolimnion from the spring through fall seasons was also observed in Skaneateles and Otisco Lakes (Fig. 7). The deeper and larger Skaneateles was a bit colder, and the shallower Otisco was a bit warmer than Owasco Lake both in the epilimnion and hypolimnion. The small variability between lakes is attributed to the difference in maximum depths and volumes of each lake.

Otisco was slightly more saline, and Skaneateles slightly less saline, than Owasco (Fig. 7), but the differences were small, estimated at less than 0.05 ppt. The small variability probably reflected minor differences in the weathering and erosion of the underlying bedrock, glacial till and soils, and/or the use of road salts in these three watersheds. The specific conductance comparison also revealed the smallest decline in epilimnetic salinity through the summer in Skaneateles and largest in Owasco Lake (Fig. 7). These differences probably reflected both the size of the lakes, and lake volume to watershed area ratios.

Skaneateles dissolved oxygen (DO) concentrations in 2012 were saturated or close to saturation throughout the water column (Fig. 7). In contract, Otisco hypolimnetic DO concentrations were depleted to anoxic conditions by mid-July. Owasco hypolimnetic DO depletions were between these extremes. The difference reflected their relative size and the amount of algal productivity, which dictates the volume of oxygen available for bacterial decomposition, and the availability of dead algae for bacterial decomposition in the hypolimnion (2011 report).

The fluorescence profiles from 2012 revealed more algae in Otisco (from 1 to 5 μg/L) than Owasco (0.5 to 3 μg/L) and both lakes had considerably more algae than Skaneateles (consistently below 1 to 2 μg/L, Fig. 7). The water depth of the algal peak was within the epilimnion in Otisco just above the thermocline in Owasco, and below the thermocline in Skaneateles. Less algae in Skaneateles allows for deeper light penetration as confirmed by the PAR profiles and allowed algae to propsper at deeper depths. The concentrations and depth ranges indicate that these three lakes span a range of trophic (algal productivity) states from the less productive and oligotrophic Skaneateles to the intermediate, borderline oligotrophic-mesotrophic Owasco, to a more productive and borderline eutrophic Otisco.

The 2012 turbidity profiles also revealed small differences between the three lakes (Fig. 7). Turbidities were smaller in Skaneateles, and progressively larger in Owasco and Otisco, from below 1 to above 1 and nearly 2 NTUs, respectively. The difference parallels the change in fluorescence results, suggesting that the bulk of the turbidity in these lakes is due to algae. Benthic nepheloid layers were not as well developed in Skaneateles and Otisco Lakes as at Site 2 in Owasco Lake. This may also be attributed to differences in lake volume to watershed area, with more sediment laden runoff impacting Owasco.

In summary, the biologically related CTD parameters, fluorescence, dissolved oxygen, and PAR (light penetration), revealed the borderline oligotrophic-mesotrophic state of Owasco Lake, in between the oligotrophic Skaneateles and borderline eutrophic Otisco. It indicates that smaller lakes become eutrophic more easily than larger lakes. It also highlighted the significant effort, both in time and money, to reduce nutrient loading to Skaneateles Lake from its watershed. Thus, Skaneateles remains oligotrophic, and as a consequence, is one of a handful of surface water supplies in the US that delivers drinking water without filtration.

Finger Lake Water Quality Ranks: Water quality in Owasco Lake was still one of the worst of the eight easternmost Finger Lakes since 2005 (Table 5 in appendix, Figs. 8 & 9). Owasco was similar to Seneca but slightly better that Honeoye, Otisco and Cayuga. Honeoye was the worst lake in the survey. Canandaigua, Keuka and Skaneateles Lakes revealed the best water quality. These ranks were based on annual average secchi disk depths, and surface water concentrations of chlorophyll-a, total and dissolved phosphate, nitrate and total suspended sediment. Bacteria counts were included in the initial 2005 ranking but not measured since, thus excluded from the 2012 tabulations available in this report. The omission of bacteria modified Owasco's earlier 2005 rank from the worst lake to one of the worst lakes (behind Cayuga and Honeoye).

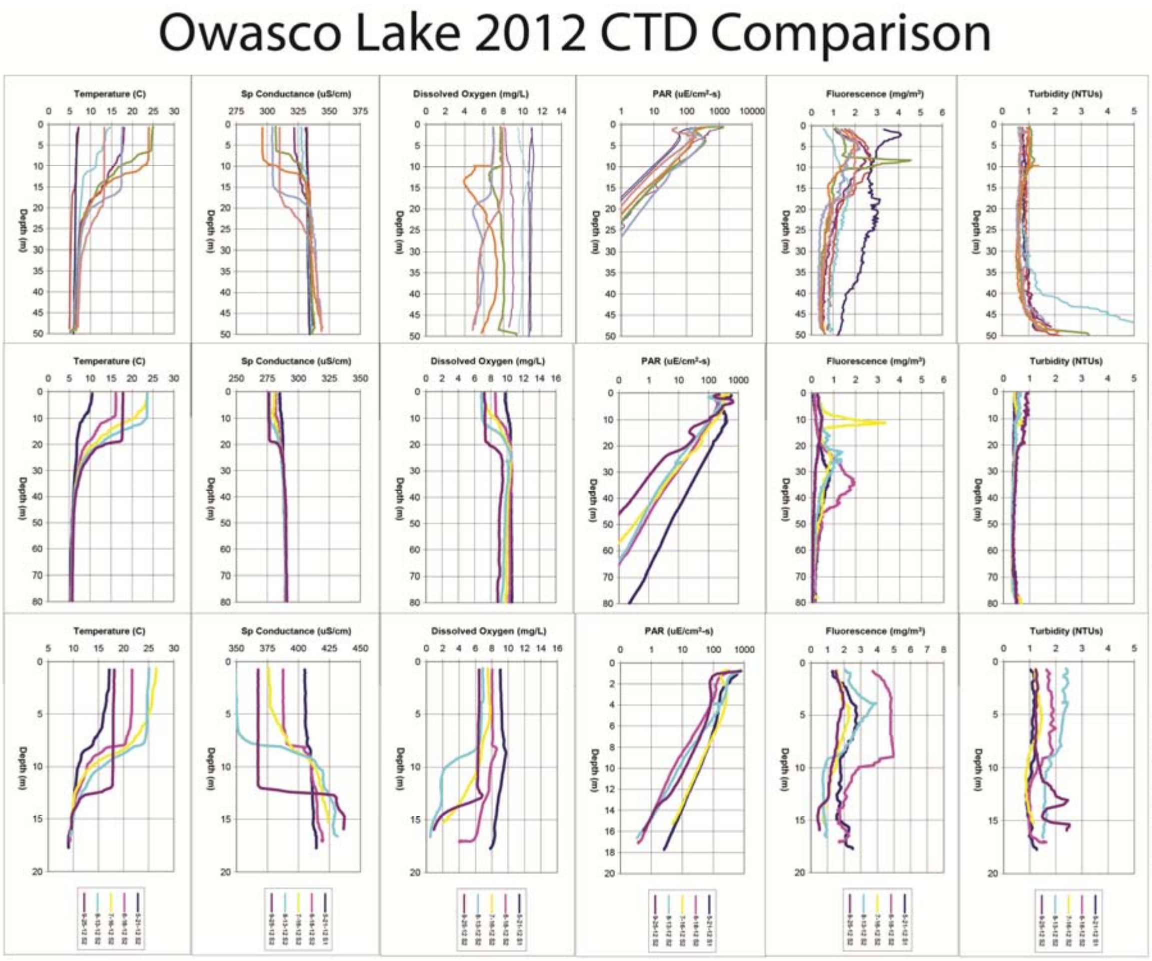


Fig. 7. 2012 CTD Profiles from Owasco (top), Skaneateles (middle) and Otisco (bottom) Lakes. The PAR (light) data are plotted on an exponential scale, so that exponential changes with water depth appear as straight lines.

The change in water quality between lakes is due to a number of factors. The degree of water quality protection legislation and its implementation are important. For example, the Skaneateles, Canandaigua and Keuka watersheds have adopted a number of stringent regulations that protect and maintain the pristine nature of their lakes. The effort appeared to work in Canandaigua and Keuka Lakes, as water quality improved since 2005 until 2011 (a wet year). A previous Owasco Lake report highlighted that the percentage of agricultural land and changes in precipitation from year to year in each watershed influences these ranks. Other factors like population, watershed size and lake volume did not correlate to its water quality rank.

Besides "bottom-up", nutrient loading induced degradation in water quality, exotic species like zebra and quagga mussels, Asian clams and/or *cercopagis*, the spiny water flea, play a "top-down" water quality role as well. Zebra and quagga mussels filter feed on plankton. Thus, they effectively remove algae and other plankton from the lake, and thus "improve" water clarity and water quality. In contrast, Asian clams "pump" phosphorus into the epilimnion from the sediments promoting algal growth and degrading water quality. The spiny water flea also stimulates water quality degradation by feeding on herbaceous (plant eating) zooplankton and thus decreasing algal predation and fostering algal blooms.

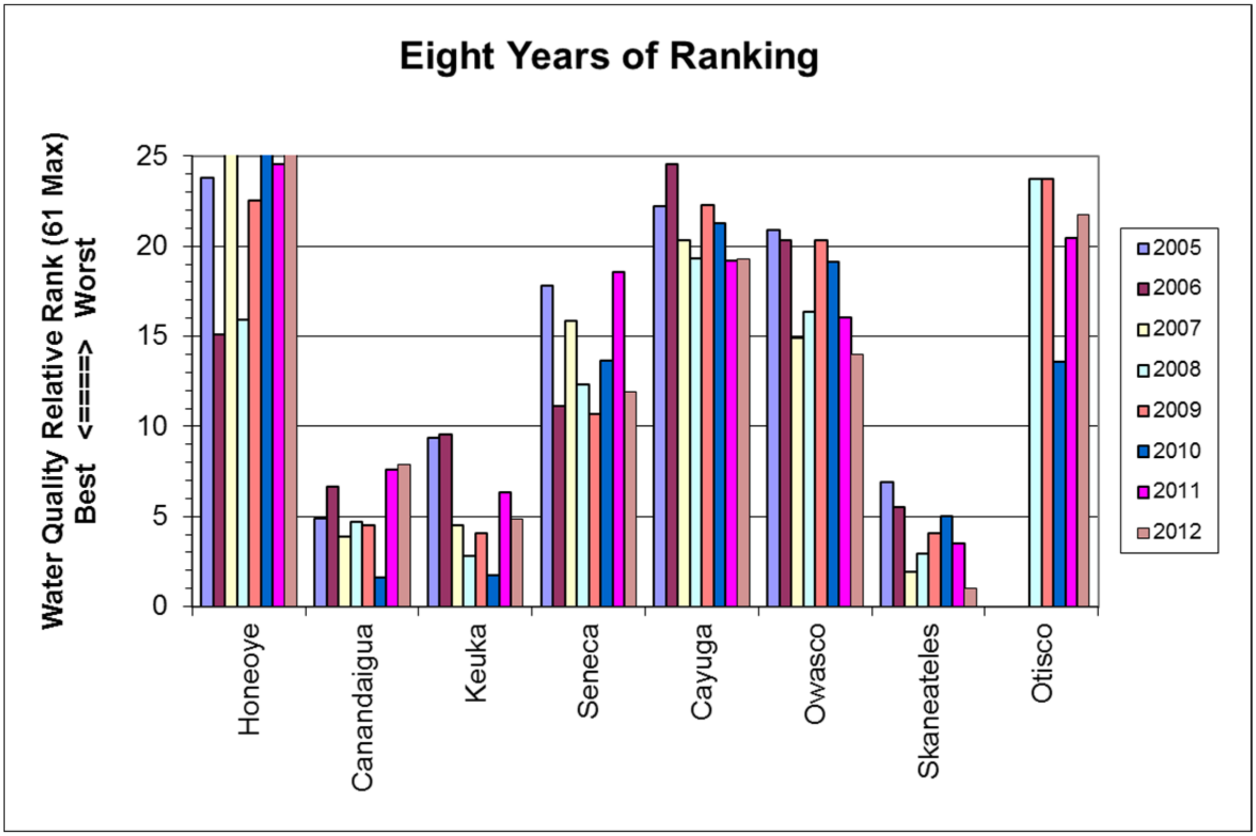


Fig. 8. Annual Water Quality Ranks for the eight easternmost Finger Lakes.

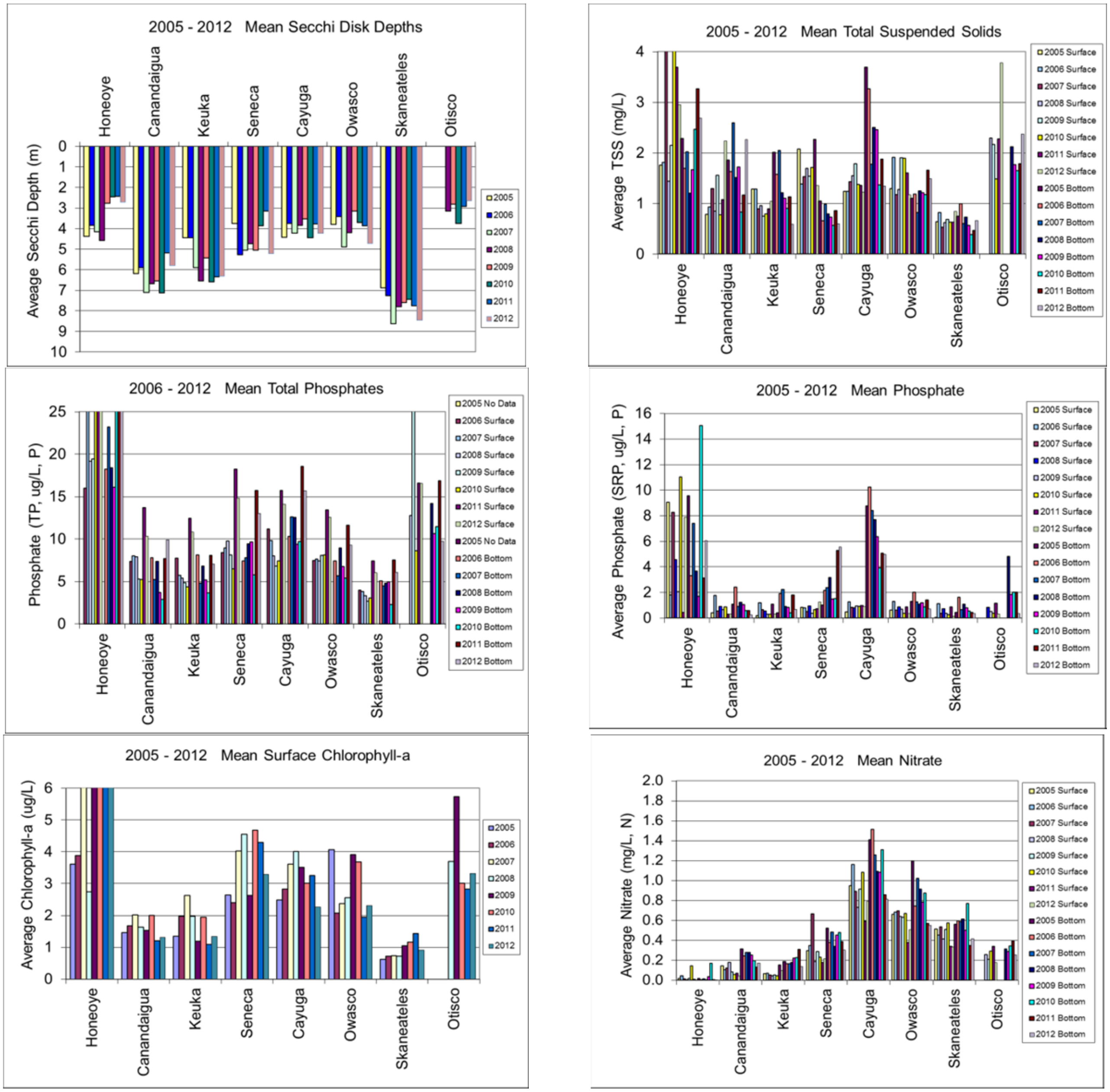


Fig. 9. Annual mean surface and bottom water data from the Finger Lake survey.
The values plotted for Owasco Lake only utilize data from the Finger Lakes survey dates.

STREAM RESULTS & DISCUSSION

Stream Discharge: Stream discharge measurements in 2012 ranged from 0 (dry) at many of the tributaries during the summer to 5.6 m^3/s on Owasco Inlet at Moravia during the spring, and were much smaller than annual discharges in 2011 (Table 6 in appendix, Figs. 10 & 11). Many spatial patterns observed in 2011 persisted in 2012. For example, mean and individual discharge measurements were larger at those sites with a larger drainage basin upstream from the site on any given sample day in 2012 (Fig. 13, $r^2 = 0.95$). The annual mean discharge of Owasco Inlet (523 km^2), Dutch Hollow Brook (77 km^2), Fillmore (17 km^2), Hemlock (47 km^2) and Mill Creeks (78 km^2) were 1.8, 0.4, 0.1, 0.2 and 0.8 m^3/s, respectively (Fig. 12).

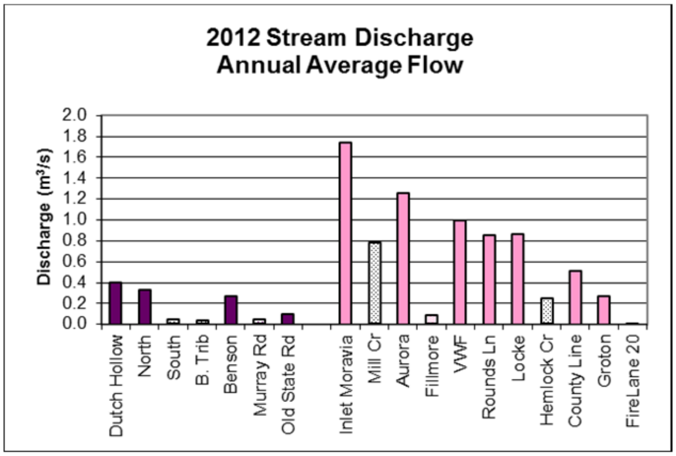


Fig. 10. 2012 annual average stream discharge at each site. Dutch Hollow sites are in purple, Owasco Inlet sites in pink. Tributary sites are stippled. Firelane 20 is in blue. Sites are arranged from downstream to upstream. Note the significant change in scale between 2012 and 2011 (Fig. 11).

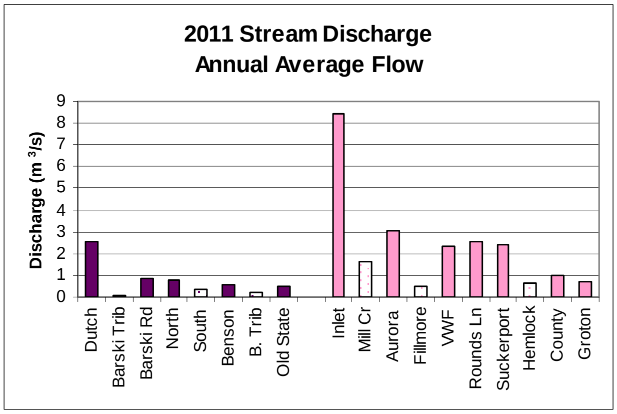


Fig. 11. 2011 annual average stream discharge at each site. Dutch Hollow sites are in purple, Owasco Inlet sites in pink. Tributary sites are stippled. Sites are arranged from downstream to upstream. Note the significant change in scale between 2011 and 2012 (Fig. 10).

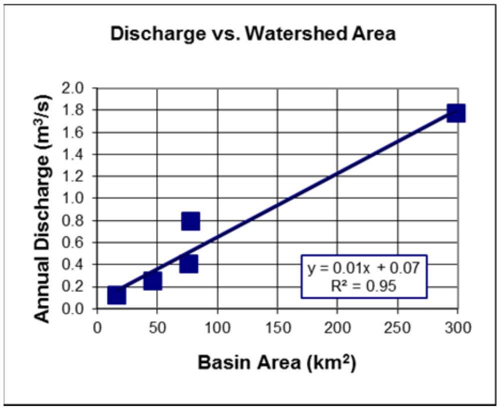


Fig. 12. Discharge vs. basin size.

Within Dutch Hollow Brook, mean annual discharge at each downstream site equaled or was slightly larger than the sum of the discharges at the next upstream site and any tributaries entering along the segment. For example, the sum of the mean annual discharges at South Trib, Benson Trib and Benson Rd sites was similar to the discharge at North St.

Within Owasco Inlet, tributary inputs typically accounted for the observed increases in downstream discharges as well. The sum of the mean discharge at Country Line and Hemlock Creek was close to the discharge at Locke, the downstream increase perhaps also supported by contributions from other smaller creeks flowing into the Inlet along this segment. The mean discharge at Locke, Rounds Lane, VWF, and Aurora, the next four downstream sites, were similar, Aurora gaining some water from Fillmore Creek.

The Aurora Rd to Moravia segment was a notable exception. The average annual discharge observed at Moravia (at Rt 38) was smaller than the combined discharge at Mill Creek, a tributary to Owasco Inlet, and at Aurora St, the next upstream site. Annual averages indicate that approximately 0.4 m^3/s of water (nearly 20%) was lost, presumably to the ground along this stream segment. A similar percentage, but significantly more water, was lost in 2011. Perhaps this segment of the stream intercepts unique glacial geology at the head of the Owasco Flats and is a major groundwater source to the wetland. A portion of the loss could be groundwater withdrawals at the municipal well field that supplies ~0.2 m^3/s to Moravia (Eileen O'Connor, personal communication, 2011).

Seasonal Variability: More rain and less evapotranspiration in the spring generated the largest discharges during the year (3/30, 4/27, 5/30; Fig. 13). Discharges were smallest or zero from the end of May through the fall (6/26 to 10/27), and all but two tributaries were dry from mid to late summer. Even Dutch Hollow Brook was reduced to a trickle in the late summer, and the very low levels prevented collection of some automated samples. The seasonal change in flow paralleled the seasonal change in precipitation (Fig. 14). Monthly precipitation totals were near climatic average "normal" amounts for most of 2012, and significantly below normal in June and July.

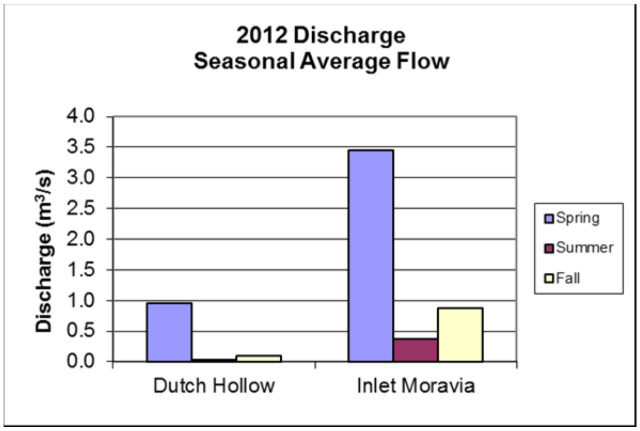


Fig. 13. Seasonal averaged stream discharge for the Rts. 38A and 38 sites, the terminal sites on Dutch Hollow Brook and Owasco Inlet, respectively.

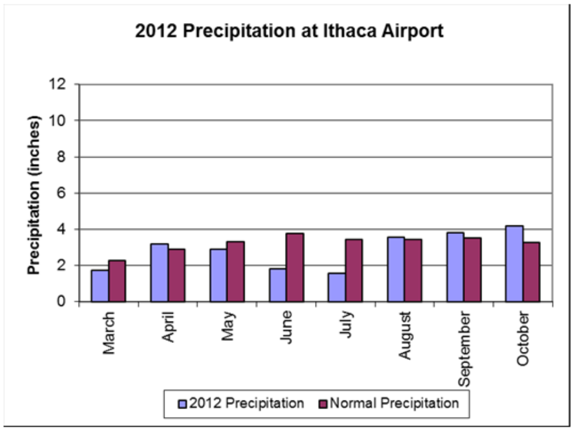


Fig. 14. Monthly 2012 and "normal" precipitation totals for the Ithaca Airport.

Differences to Earlier Years: Annual average stream discharge was much smaller in 2012 than every year since 2006 except for 2007 (Fig. 15). For example, 2011 annual average discharges at the end of Owasco Inlet and Dutch Hollow Brook, were 8.4 and 2.5 m^3/s, respectively, approximately 5 times larger than those in 2012. The difference, 2012 had nearly 50% less rainfall during the eight-month field season than all of the earlier years (Fig. 16). The "normal" rainfall for the March through October field season is 25.9 inches, but was 32.1" in 2006, 15.7" in 2007, 16.4" in 2008, 19.6" in 2009, 15.76" in 2010, 25.8" in 2011 and 13.7" in 2012 (National Weather Service, Ithaca Airport). The 2007 average discharge may be artificially low because it was biased to seasonally low-flow, summer data. Increased summertime losses due to increased evapotranspiration also contributed to the very small summer discharges in 2012 by intercepting a larger percentage of the smaller groundwater flow. Dutch Hollow Brook was also utilized for irrigation (Charlie Green, personal communication). It designates 2012 as the "dry year" end-member and 2011 the "wet" year, and it influenced the concentration and flux data and changes between years presented below.

The USGS stream gauge data on Owasco Inlet (site near Moravia, 4235299) also revealed smaller mean annual discharges in 2012 than earlier years, 3.0 m^3/s in 2012 versus 4.3 and 5.7

m^3/s in 2010 and 2011, respectively (Fig. 17). These daily averages correspond to annual volumes of 135, 180 and 95 million cubic meters in 2010, 2011 and 2012. The total annual flow in 2012 was only 53% of the flow in 2011. Flow during the partial (March through December) record in 2009 was larger than the similar time period in 2012 as well. The seasonal variability in the flow changed as well. Owasco Inlet experienced exceptionally large flows in March and April that is every year except for 2012. The large flows extended into May for 2011.

Similar annual variability was observed for the Owasco Outlet (USGS stream gauge, 4235440). Mean annual outflows were 5.62, 11.38, 8.40 and 8.26 m^3/s in 2012, 2011, 2010 and 2009, respectively. The outflows were larger than the Inlet inflows. The difference is the runoff supplied by the remaining tributaries that drain 45% of the watershed, evaporation from the lake's surface and groundwater interactions. Clearly, 2012 was a dry year for Owasco Lake and its watershed.

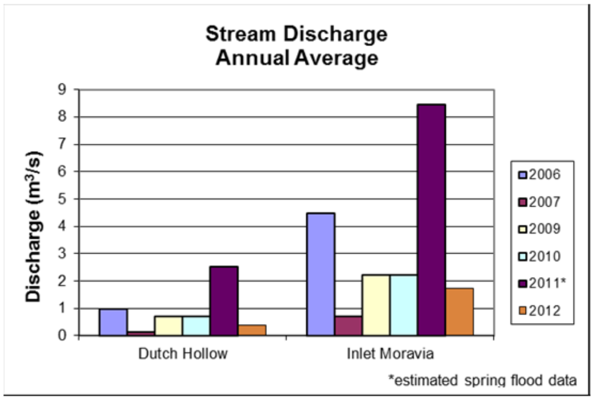


Fig. 15. Annual average stream discharge for the Rts. 38A and 38 sites. Stream data were not collected in 2008.

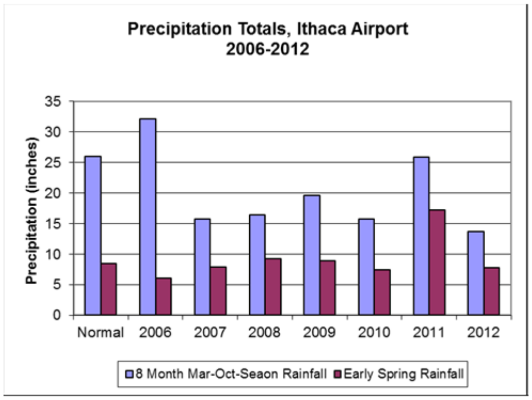


Fig. 16. Annual precipitation totals during the 8-month, March – October, field season at the Ithaca Airport.

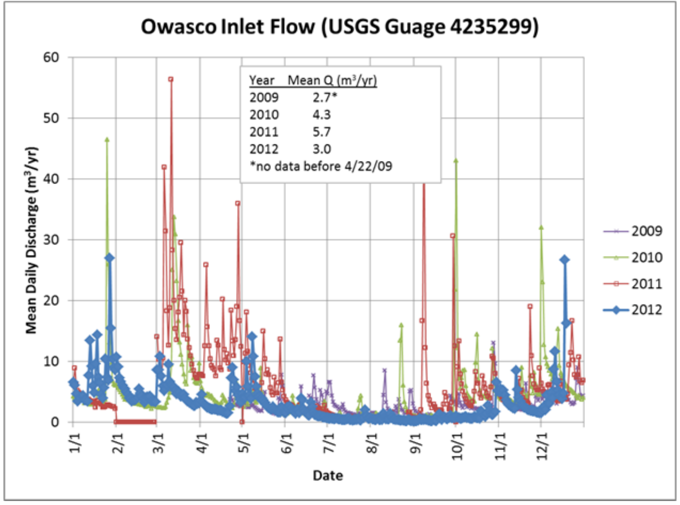


Fig. 17. Annual average stream discharge for Moravia – USGS Stream Gauge 4235299.

Stream Concentration Data: Total phosphate (TP) concentrations ranged from 5 to over 230 μg/L, and averaged 24 μg/L in Dutch Hollow Brook. It ranged from 24 to 135 μg/L, and averaged 24 μg/L in Owasco Inlet (Table 6 in appendix, Fig. 18). In Dutch Hollow, North and Benson Trib sites revealed the largest mean TP concentrations of 44 and 32 μg/L, respectively, whereas the South Trib, Old State Rd and Murray Rd Trib sites along Dutch Hollow Brook revealed the smallest mean TP concentrations (14, 14 and 14 μg/L). Benson Trib was apparently impacted by the agricultural lands upstream like previous years. Other trends are less clear for 2012.

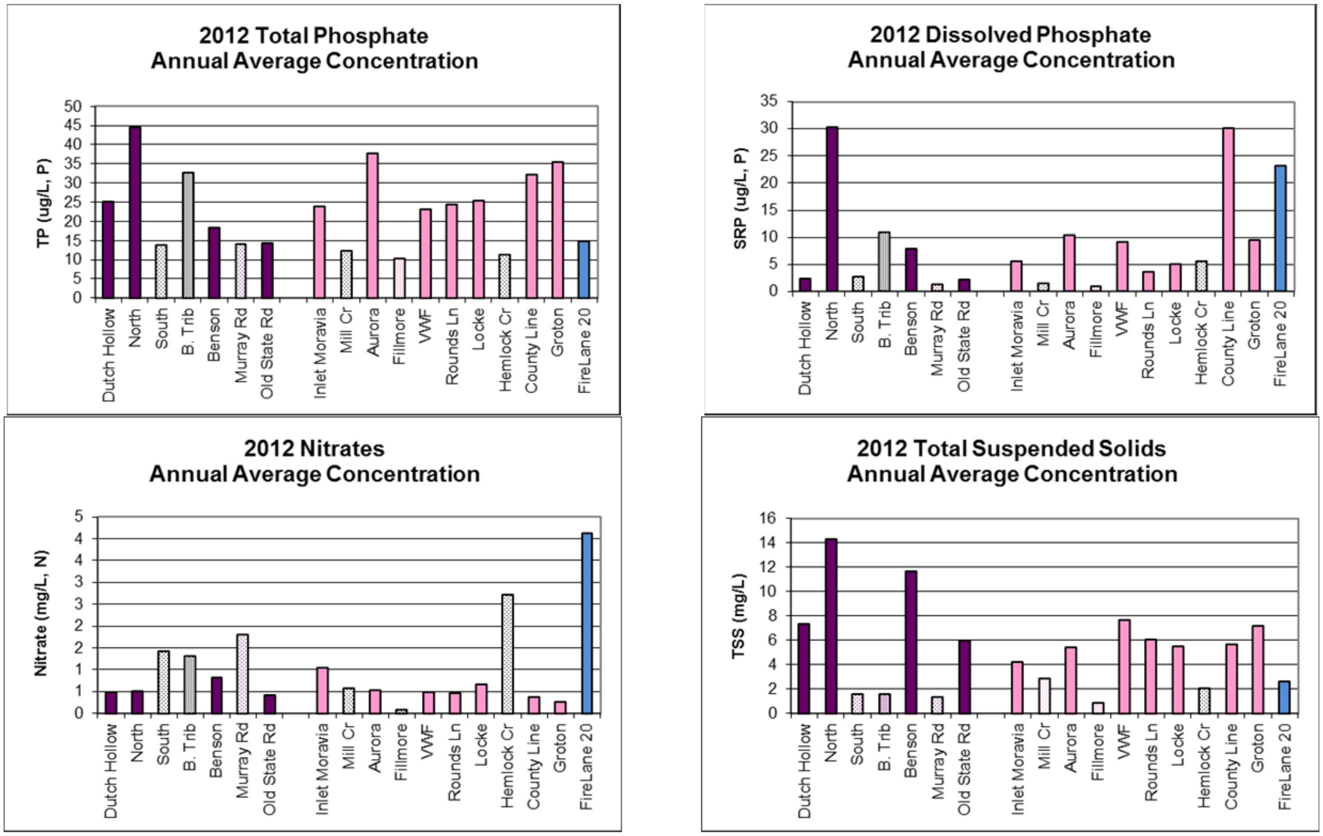


Fig. 18. Site averaged stream and average lake (blue) nutrient and suspended sediment concentrations. Dutch Hollow sites are in purple, Owasco Inlet sites in pink. Tributary sites are stippled. Fire Lane 20 is in blue. Sites are arranged downstream to upstream.

Unlike previous years, the largest annual mean TP concentration was detected at the North site. This mean however was skewed by one very large concentration (230 μg/L) on 7/24. Stagnant stream water during the drought made it difficult to exclude disturbed stream bed sediments in the sample at this and some other muddy stream bed sites. It also enabled microorganisms to flourish (or this date was influenced by an unidentified spill). The next largest measured TP concentrations were 79 μg/L at Benson Trib and 64 μg/L at 38A, both on 7/24, the only other sites with water on 7/24. If the 7/24 results were excluded from the annual averages, then the pattern of TP concentrations become more like the 2011 results.

Elevated dissolved phosphate (SRP) concentrations at Benson Trib indicate that it was impacted by the agricultural lands upstream like previous years. However, the other SRP results like TP were less clear in 2012. North revealed the largest mean SRP concentrations compared to the other Dutch Hollow sites and like TP, it was influenced by a single large concentration (218 μg/L) on 7/24. TSS was largest at North but it was also impacted by a single large concentration (48 mg/L) on 7/24. The next largest measured TSS concentrations were 32 mg/L at Benson and 28 mg/L at 38A, also on 7/24. These three sites are all on the main stream the only sites with flowing water in the Dutch Hollow watershed on this date.

In contrast, patterns in nitrate and conductivity data were different. Conductivity was largest at Benson Trib, similar to previous years, and smallest at Murray Rd Trib perhaps reflecting its forested landscape upstream. The large South Trib and Benson Trib nitrate concentrations reflected the mobilization of nitrates upstream from these sites and the probable input of agriculturally-fed nitrate-rich groundwater. Murray Rd Trib nitrates were also large and inconsistent with its forested land use. However, the tributary was only flowing in the spring and fall when nitrate concentrations were seasonally larger in Dutch Hollow Brook, and it may have artificially skewed the annual averages.

Concentration data from Owasco Inlet were similar to Dutch Hollow Brook. Notable downstream increases in annual mean TP and SRP concentrations along the Inlet were observed at the Aurora (38 & 10 μg/L) and County Line (32 and 30 μg/L) sites, especially late in the summer during low flow conditions. These sites were immediately downstream of the Moravia and Groton wastewater treatment facilities, respectively. It indicates that both facilities were point sources of phosphorus to the Inlet. Presumably, phosphorus in the effluent was not diluted as much by the Inlet during the low flow summer months, as the reported effluent loads were small and relatively consistent through 2012 and their impact on total fluxes will be explored below. The smallest TP and SRP concentrations in the Owasco Inlet were detected at Mill, Fillmore and Hemlock Creeks (TP of 12, 10 & 11 μg/L, respectively). Both Mill and especially Fillmore, drain the least amount of agricultural land in this watershed.

Total suspended solids (TTS) and nitrate concentrations had different trends. TSS concentrations did not vary significantly along Owasco Inlet, but were smallest at the three tributaries, Mill, Fillmore and Hemlock Creeks. Nitrates were largest at Hemlock Creek, perhaps reflecting the agriculturally rich landscapes upstream. Nitrates were once again smallest in Fillmore Creek, a forested watershed, and Mill Creek, a watershed with lesser amounts of agricultural land.

The tributaries at Murray Rd and Fire Lane 20 were new sample sites in 2012. The mean annual concentration of nutrients and suspended sediments at Murray Rd Trib were smaller or near the results of the other Dutch Hollow Brook and Owasco Inlet sites. The small concentrations were presumably related to the forested watershed upstream of the site. In contrast, results from Fire Lane 20 revealed some of the largest SRP and nitrate concentrations than any other site in the 2012 survey. TP and TSS concentrations were mid-range or relatively small. The larger concentrations are presumably due to the agricultural and manure-spreading activities upstream. These trends may also be an artifact that the tributary was dry for most of the summer, and the annual averages only reflecting typically, seasonally larger, spring and fall data.

Stream Fluxes: The Owasco Inlet revealed significantly larger fluxes of nutrients and sediments than Dutch Hollow Brook (TP 3.1 vs. 0.6 kg/day; SRP 0.7 vs. 0.1 kg/day; TSS 900 vs. 250 kg/day; N 135 vs. 40 kg/day, respectively, Fig. 19). The difference can be attributed to the difference in stream discharge which in turn is a function of basin size. The similar concentrations of nutrients and suspended sediments combined with the largest discharge of water down the Inlet resulted in its larger fluxes to the lake.

No one segment along Dutch Hollow Brook provided significantly more nutrients or suspended sediments than any other segment (Fig. 19). Nutrient fluxes steadily increased from the headwaters to the terminus of the stream. No one tributary added a significantly larger flux of nutrients either. For example, the Benson Trib site revealed the largest concentrations of phosphates. However, it also revealed a very small flux of phosphates due to its relatively small discharge. Thus, no segment of this stream was the “primary” source of nutrients and suspended sediments. Instead, Dutch Hollow Brook steadily gained nutrients and sediments along its entire course, a conclusion consistent with the pervasive nature of non-point sources throughout the watershed, including agricultural land, animal feedlot operations, golf courses, suburban homes and other fertilizer dependent or fertilize producing non-point sources. The implications are noteworthy. To remediate Dutch Hollow Brook’s non-point sources will be more challenging than “fixing” a point source like Groton’s wastewater treatment facility because remediation must be applied throughout the entire watershed, influencing and demanding cooperation by everyone in the watershed.

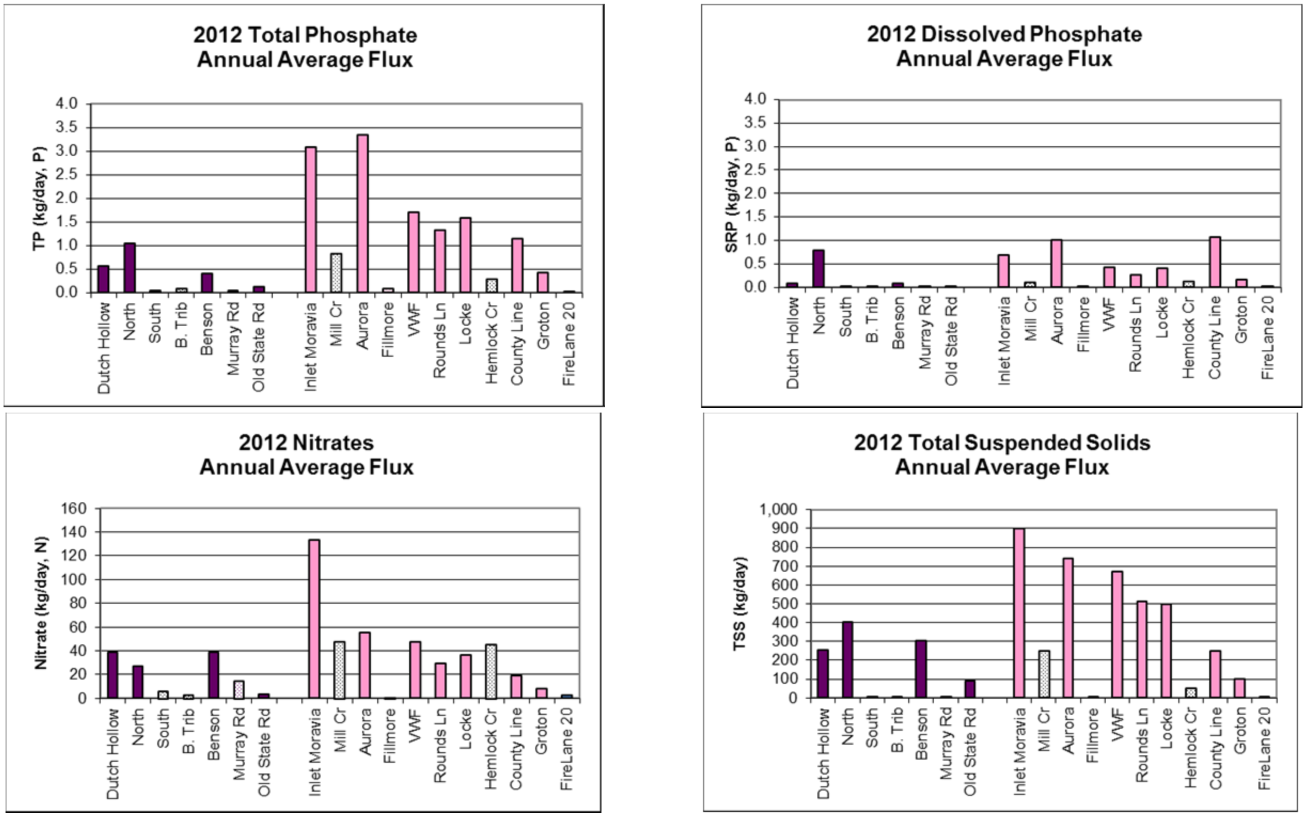


Fig. 19. Site averaged nutrient and suspended sediment fluxes. Dutch Hollow sites are in purple, Owasco Inlet sites in pink, and tributary sites are stippled. Sites are arranged downstream to upstream.

In contrast, the nutrient and suspended sediment fluxes along Owasco Inlet increased in a few discrete steps (Fig. 19). The largest steps for TP and SRP were detected between the Groton and County Line sites, and the VFW and Aurora sites. The segments bracketed the two wastewater treatment facilities. The annual mean TP flux increased by 0.7 kg/day from Groton to County Line, and 1.6 kg/day from VFW to Aurora, after deducting Fillmore’s insignificant contribution. SRP increased along these two segments by 0.9 and 0.6 kg/day, TSS by 149 and 59 kg/day, and nitrates by 11 and 7.3 kg/day, respectively.

Increases at both segments were surprising because the Moravia plant was know for minimal nutrient fluxes (below its TP limits of 0.9 kg/day) in the past, and the Groton facility was recently mandated by NYS-DEC to reduce its nutrient loads to 0.9 kg/day from as high as 5 kg/day in 2003). The Groton effluent was always below its 0.9 kg/day limit in 2012. Reported monthly means averaged 0.17 kg/day, a significant improvement from earlier years (EPA ICIS detailed reports, Fig. 20). Groton's effluent only contributed ~25% of the measured Groton to County Line increase in TP, and more importantly, only 5% of the TP flux past Moravia. This is a significant improvement from 2007, when Groton supplied 87% of the load. The Moravia facility was usually below its 0.9 kg/day limit in 2012 as well, except for a monthly mean of 1.2 kg/day in February 2012. Its EPA reported monthly means averaged 0.5 kg/day through 2012. This facility only contributed ~30% of the measured increase from VFW to Aurora, and only 15% of the TP flux past Moravia.

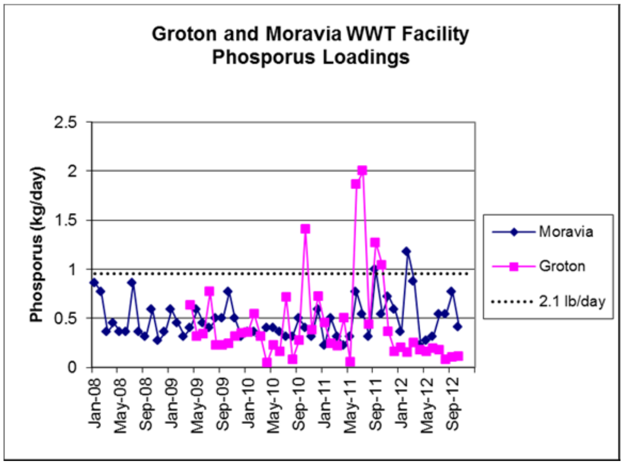


Fig. 20. Total phosphate loading from the Groton and Moravia municipal wastewater treatment facilities (EPA ICIS detailed report). The dotted line is the 0.9 kg/day (2.0 lbs/day) daily discharge limit mandated for both facilities.

Thus both segments required an additional source (or sources) of phosphorus to attain the steps in TP. These sources may include agriculture, on-site (septic) systems, stream bank erosion, lawn fertilizer, roadside ditches, and construction activities. It was heartwarming to report that the wastewater plants have reduced their impact on the stream from previous years, because additional reductions in their TP effluent limits might be economically unfeasible.

Downstream steps in the flux of total suspended solids were detected between the County Line and Locke sites and Rounds Ln and VFW sites. The suspended sediments probably also brought attached phosphates or organic particles, thus was the cause of a small increase in total phosphorus at these two segments as well. It suggests that stream bank erosion, runoff from agricultural activities within the floodplain and other inputs are critical along this segment of the Inlet. Interestingly, dissolved phosphate did not increase along this stream segment, but decreased, suggesting the source did not input dissolved phosphorus or the low flow during 2012 allowed for the biological utilization or absorption of the dissolved phosphorus in the stream.

In summary, the stream segment analyses detected non-point sources in the Dutch Hollow Brook watershed. Both point and non-point sources of nutrients were detected in the Owasco Inlet watershed. TP increases were still apparent from the Groton and Moravia WWT facilities in 2012 but their contribution decreased from earlier years and was only a fraction of the total load. Additional unidentified non-point sources are also important in this watershed, especially between VFW and County Line sites.

Fluxes at the Murray Rd Trib and Fire Lane 20 sites were as small as those at Fillmore Creek and smaller than the other sites in the survey, even though some of the largest concentrations were detected at the Fire Lane 20 site. The small fluxes resulted from the smallest discharges at these sites, and small concentrations at the Fillmore and Murray Rd Trib sites. It follows that smaller watersheds delivered the smallest fluxes and larger watersheds delivered the largest fluxes, and stream discharge plays an important control on the flux of materials to the lake.

Seasonal and Longer-Term Variability: Total phosphate concentrations were larger in the spring than the summer and rebounded in the fall in 2012, a seasonal pattern that dominated all of the parameters in 2011 (Fig. 21). In contrast, 2012 concentrations were largest in the summer for dissolved phosphate and nitrate in Owasco Inlet and for total suspended solids in Dutch Hollow Brook. The unique and inconsistent patterns were most likely due to the low flow, allowing groundwater with its nitrates and other typically less important sources to influence the total concentrations. The dissolved phosphates were probably released from the stream bed by bacterial respiration of the accumulating organic-rich sediments in the slower streams, and nitrate enriched groundwater dominated the summer base flow concentrations. Suspended solids were hampered by unavoidable disturbance of the stream bed on the smallest mid-summer flow sample dates, especially on 7/24.

The 2012 change in seasonal fluxes was similar to those detected in 2011. TP, SRP, nitrate and TSS fluxes were largest in the spring and were smallest in the summer for TP, SRP and TSS and in the fall for nitrates. The seasonality paralleled changes in discharge. The seasonal differences in 2012 were 5 to 100 times less pronounced than those detected in 2011. It suggests again that discharge dictates fluxes of nutrients and sediments to the lake, more so than concentrations, especially for phosphates and suspended sediments.

The reported 2012 fluxes were near or below the fluxes reported for the earlier years, and every year was significantly below the 2011 fluxes (Fig. 22). The difference between 2011 and 2012 was in the amount of rainfall. 2012 was the “dry” year and 2011 the “wet” year. The 2006 fluxes were 2nd largest in the record, and 2006 was another wet year. A direct comparison between 2011 and 2012 to the earlier years is difficult because only these two years sampled the spring and fall seasons, the other years are biased to the summer months. Thus the similarity of the 2012 fluxes to some of the earlier years is probably misleading, and in fact, 2012 would probably be one of the smallest on record if the earlier years had included spring and fall data because 2012 has the least amount of rain.

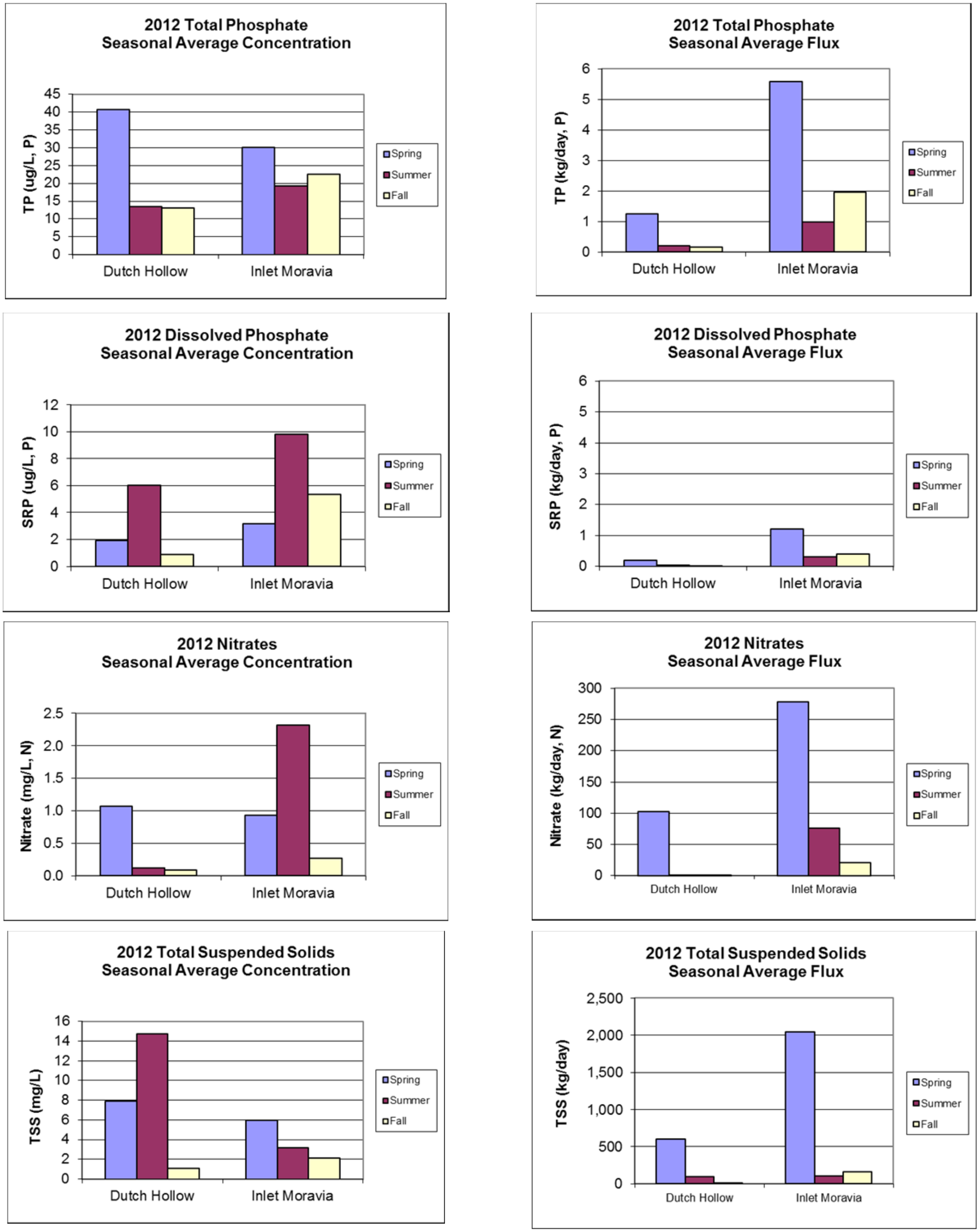


Fig. 21. 2012 Seasonal average concentrations (left) and fluxes (right).

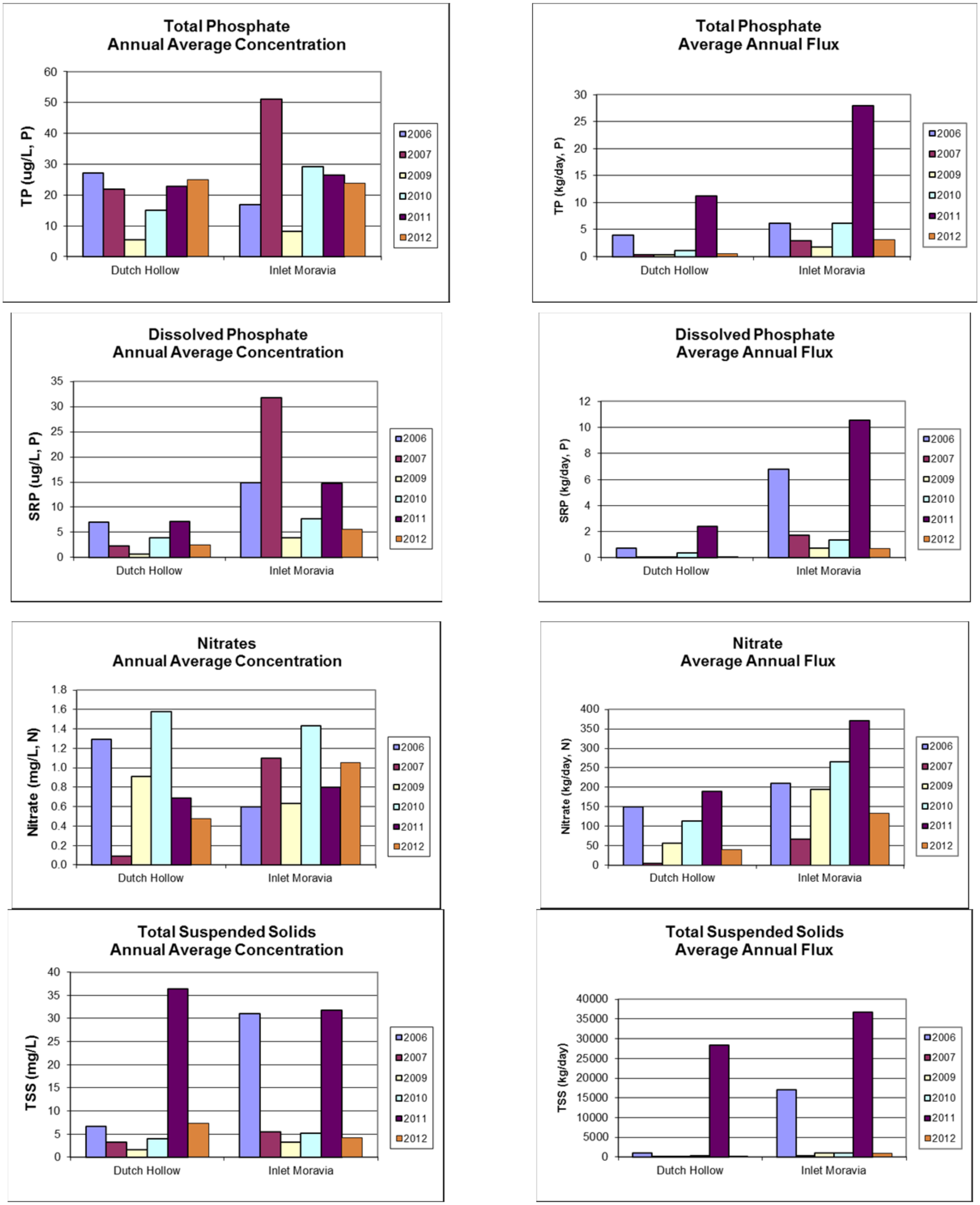


Fig. 22. Annual average concentrations (left) and fluxes (right).

EVENT SAMPLING AT DUTCH HOLLOW BROOK

Detailed Sampling of Dutch Hollow Brook: The data logger stage data revealed textbook perfect responses to precipitation events in both 2011 and 2012 (Fig. 23). Stream stage rapidly increased during rainstorms and peaked just after the bulk of the rain. Larger precipitation events induced taller and longer duration peaks in stage. Once the rain stopped and the bulk of the runoff passed, the stage slowly declined back to base flow conditions. The slow decline reflected the reduction of runoff induced flow and a slower decline in the precipitation rejuvenated near-surface groundwater induced flow, because water moves faster, actually orders of magnitude faster, above ground (runoff and stream flow) than below ground (groundwater flow). Each increase in stage through the 2011 and 2012 field seasons corresponded to a precipitation event. The increase in stage was from 5 to more than 40 cm in 2012, and revealed smaller increases in 2012 than 2011. Not all precipitation events induced a proportional stream response, especially during the summer when increases in stage were smaller for similar sized precipitation events than the other seasons. The low flow, emerging, shallow pools along the stream and thicker vegetation in the summer probably combined to retard the summertime stream response. Over the course of the entire March through October 2012 field season, the stream was mostly in “base flow” mode (67% of the time), not “event” mode. A slightly smaller percentage of time was in base flow during 2011.

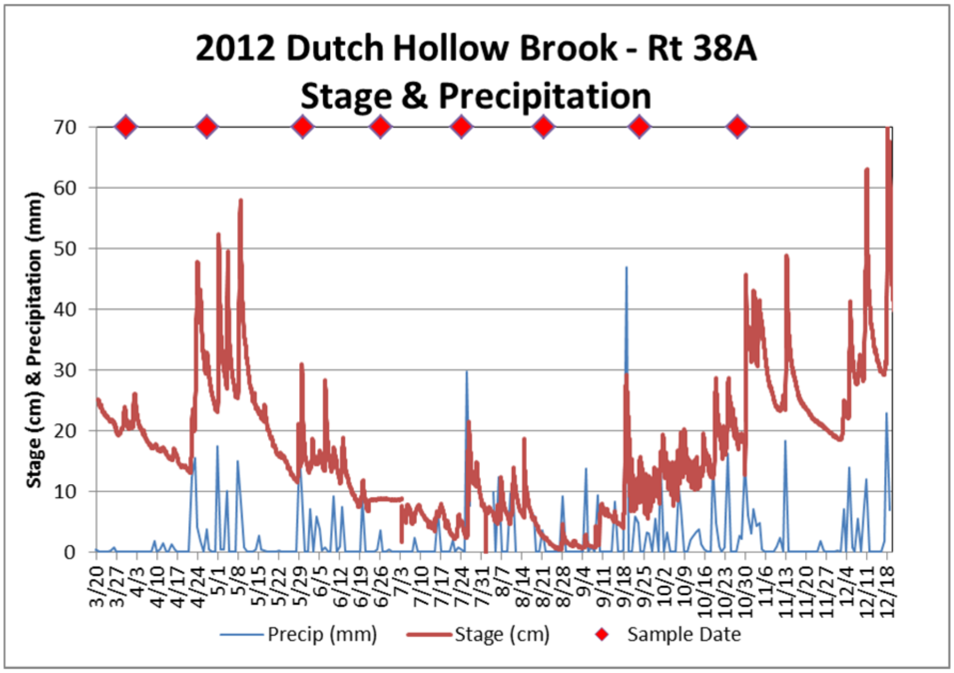


Fig. 23. Data logger stage from Dutch Hollow Brook. Precipitation data was from NY-CY-8, a station within the watershed and part of the Community Collaborative Rain, Hail and Snow Network (CoCoRaHS). On 7/2, declining flow and very low stream levels exposed the data logger sensors in air. The loggers were repositioned, and stage values adjusted accordingly.

Interestingly, the stream stage fluctuated by one or two cm each day in 2012. It was low in the late evening and high around noon. The fluctuation may reflect the daily afternoon photosynthesis (water uptake) and nighttime respiration (water release) by nearby vegetation or the daytime intensification of the evaporation of water from the lake’s surface. The daily cycle was not observed in 2011 and suggests that the weak signal could only impact the very low stream in 2012 but could not impact the higher flow of 2011. Remember, 2012 was the "dry-year" and 2011 was "wet".

The data logger also recorded water temperature and specific conductance (Figs. 24 – 27). Water temperatures rose from ~4° C in the spring to over 30° C by July and back down to ~1° C by the end of November in 2012 as expected (Fig. 24). Water temperature fluctuated from 3° C up to 15° C each day (the rapid up and down "noise" in the record, Fig. 25). The lowest temperature was typically in the early morning around 4 or 5 am, and the warmest temperature was typically in the late afternoon, around 4 or 5 pm. The oscillation probably reflected warming of the stream during the day versus nighttime cooling of the stream by the input of relatively cooler groundwater (10 to 15° C), especially during the summer.

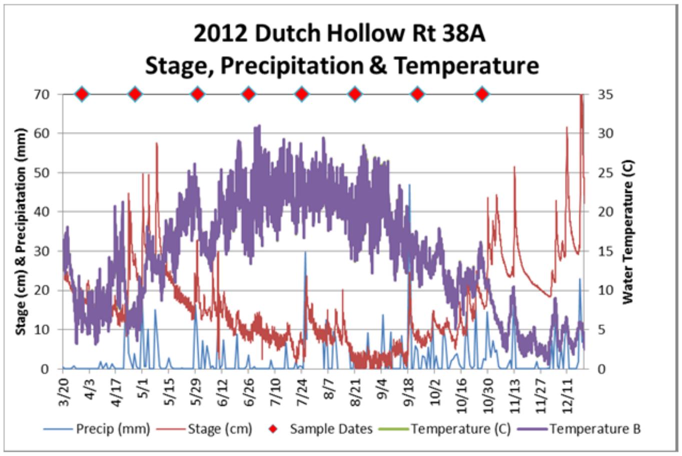


Fig. 24. Data logger water temperature data.

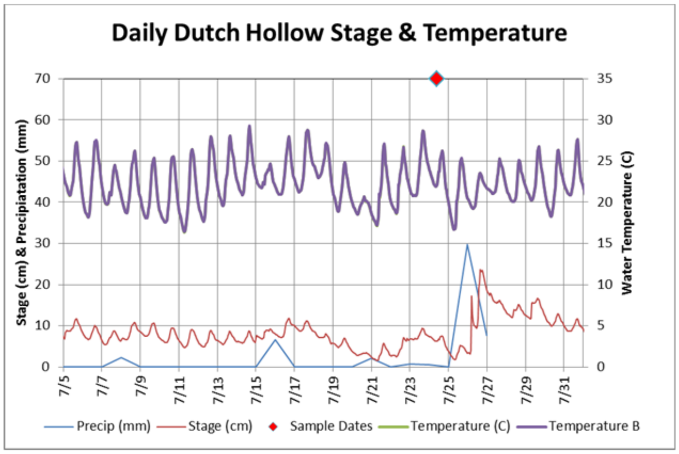


Fig. 25. Daily fluctuations in water temperature.

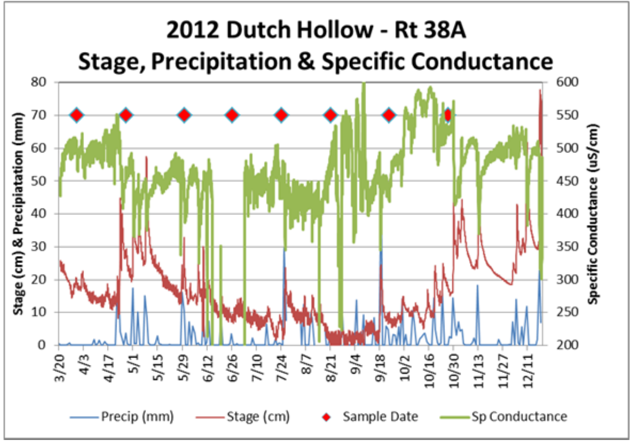


Fig. 26. Data logger salinity data. Salinity decreased to zero when the sensor was dry.

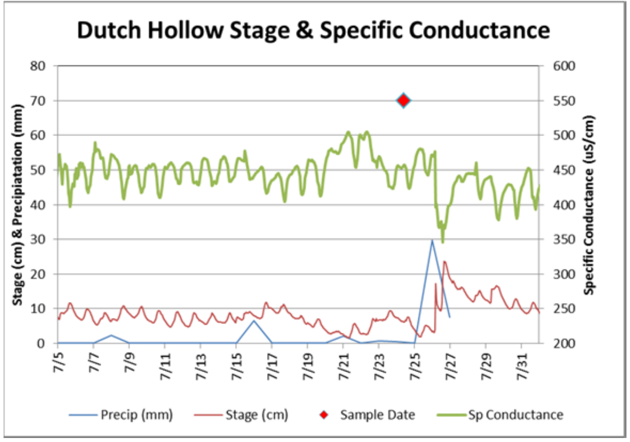


Fig. 27. Daily fluctuations in water salinity.

Specific conductance was noisy. Long term trends revealed a 500 µS/cm to 450 µS/cm decline from the spring to mid-summer but increased to over 550 µS/cm during the late summer and returned to 500 µS/cm in the fall (Fig. 26). The difference is attributed to the relative availability of more rain in the wetter and cooler spring and fall, that would dilute the stream, and more intense evaporation in the warmer and drier summer, that would increase the stream salinity. During precipitation events, stream salinity decreased rapidly by 150 to 200 µS/cm then immediately increased to pre-rain or slightly larger values after the event before slowly declining over time until the next event. These changes in salinity are small, only a few hundredths of a ppt (‰) but they do provide some insight into stream processes. The event dilution suggests that the rain and associated runoff immediately diluted the stream and subsequently initiated a rejuvenated near-surface but slower groundwater flow. Once the dilute surface runoff stopped, near-surface groundwater flow delivered more saline water to the stream until this contribution slowly decreased and salinity stabilized to base flow concentrations. Like stream temperatures, salinity also revealed a daily cycle (Fig. 27). The smallest salinity, by ~50 μS/cm, was in the late afternoon, 4 or 5 pm, and largest salinity in the morning, 2 or 3 am. Perhaps water chemistry was impacted by photosynthesis and respiration as well.

R_2D_2 Results: The event *versus* base flow detailed analysis revealed significant responses to precipitation events throughout the deployment (Fig. 28). TSS increased dramatically from base flow concentrations of 5 to 10 mg/L to an average event flow concentration of 178 mg/L, and rose to a maximum of 495 mg/L during a 15 mm precipitation event on 5/8. These large TSS concentrations were restricted to the runoff portion of the storm event, and declined quickly to base flow turbidities before the stream stage returned to base flow. It indicates that runoff events transported (eroded) soil particles to and impaired water quality in the stream. In contrast, the rejuvenated groundwater flow does not transport particles.

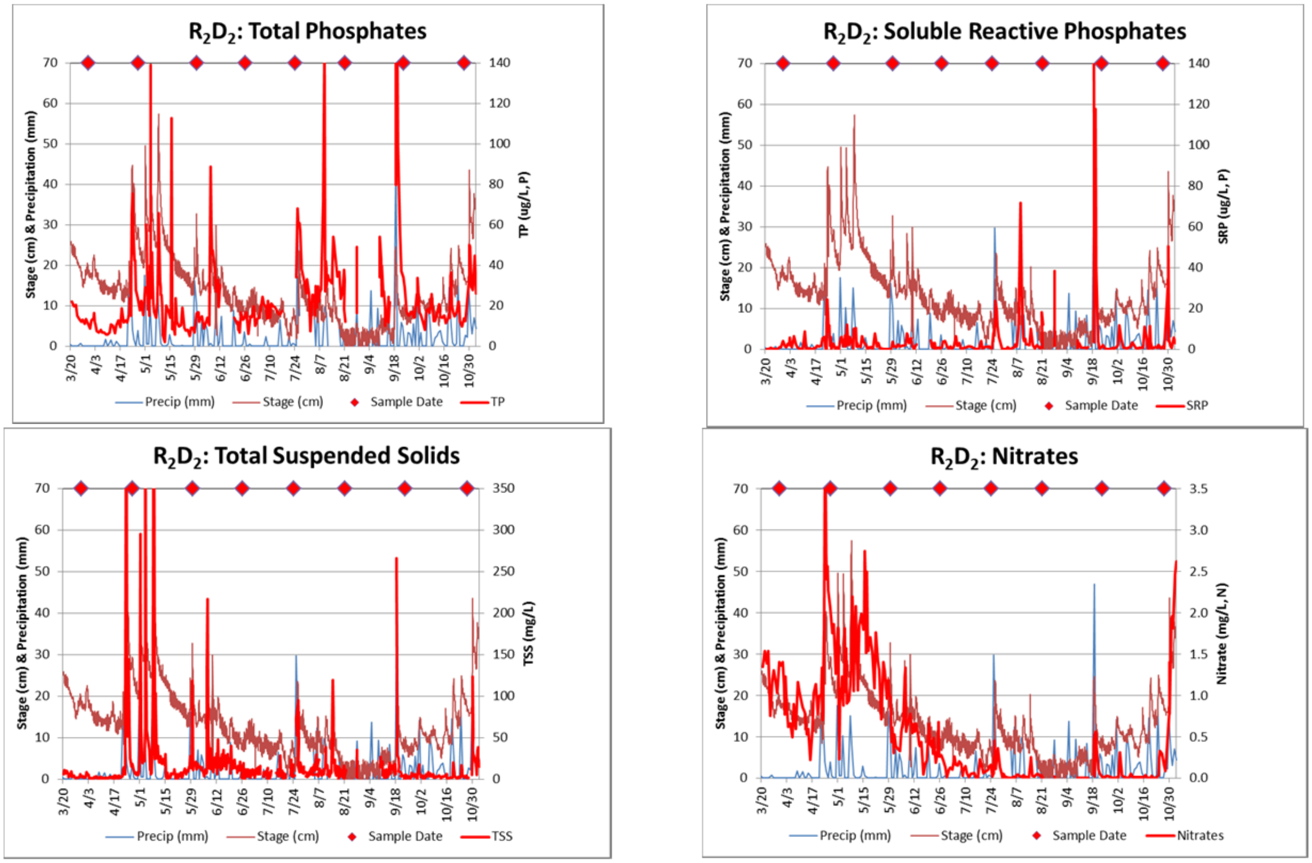


Fig. 28. Autosampler nutrient and suspended sediment concentrations.

Some differences were observed in the TSS results between 2011 and 2012. The peak TSS concentrations were smaller and fewer in number in 2012 than 2011, and reflects the difference in rainfall. Occasionally small events did not transport sediments downstream and the largest events did not transport the most sediment, especially in the middle of the summer. It suggests that summer stands of vegetation, when available, may have retarded the summertime movement of soil particles to the stream. Alternatively, the low flow conditions and minimal precipitation in 2012 may have allowed suspended particles to settle out in emerging, localized, pools along the stream before reaching the 38A site.

The observations suggest remediation practices to reduce TSS impairments. Buffer strips of vegetation alongside each stream course, where the vegetation reduces the velocity of the runoff and allows particles to settle out instead of entering the stream. Installation of gully plugs and retention ponds in low lying areas would provide another mechanism to retard the movement of suspended sediments before the runoff spills into the nearby stream. Both practices however remove tillable acreage from the farmer, and reduce his annual income. Alternatively, farmers could use a winter crop cover, and let this vegetation reduce topsoil erosion from their fields during the fall, winter and spring seasons.

Total and dissolved phosphates revealed similar event responses. Mean TP and SRP event concentrations were significantly larger than base flow concentrations, increasing from base flow means of 40 and 10 μg/L to events means of 105 and 16 μg/L with maximum event concentrations near 220 μg/L for both TP and SRP. The event response was similar between 2011 and 2012, however the number and magnitude of the responses changed. More events happened in 2011 than 2012, and the base flow and event concentrations were larger in 2011 than 2012 over the same June to November time period. The data revealed a direct linkage to and the importance of runoff events for phosphorus loading to the lake. Thus, the remediation steps to reduce phosphate loading would be similar to remediating suspended sediment, i.e., reduce the movement of soil particles from runoff events in the Owasco watershed.

Nitrates revealed a slightly different event response pattern. The largest nitrate concentrations were still stimulated by events with mean event concentrations of 2.4 and base flow concentrations of 1.7 mg/L. The event to base flow change in nitrate concentrations was however not as dramatic as the TSS, TP and SRP changes. The increase to the peak concentration and subsequent decline to base flow conditions took longer as well. It indicates that the runoff provided nitrates to the stream. However, the rejuvenated near-surface groundwater flow contributed groundwater nitrates as well, extending the nitrate response to the event. Nitrates are water soluble and not bound to particles, thus they can enter a stream by runoff and groundwater routes. In contrast, groundwater does not transport TP, SRP and TSS.

Event versus Base Flow Fluxes: Flux calculations for the autosampler data required estimating a stream discharge for every autosampler sample. The discharges were estimated by correlating weekly discharge measurements to the corresponding stage data at Dutch Hollow Brook (Fig. 29, $r^2 = 0.87$). The best-fit linear relationship transformed hourly stage data into discharge data. Comparing the estimated Dutch Hollow discharge to the USGS mean daily discharge measured at the Owasco Inlet (Site ID: 04235299) revealed consistent fluctuations over the field season.

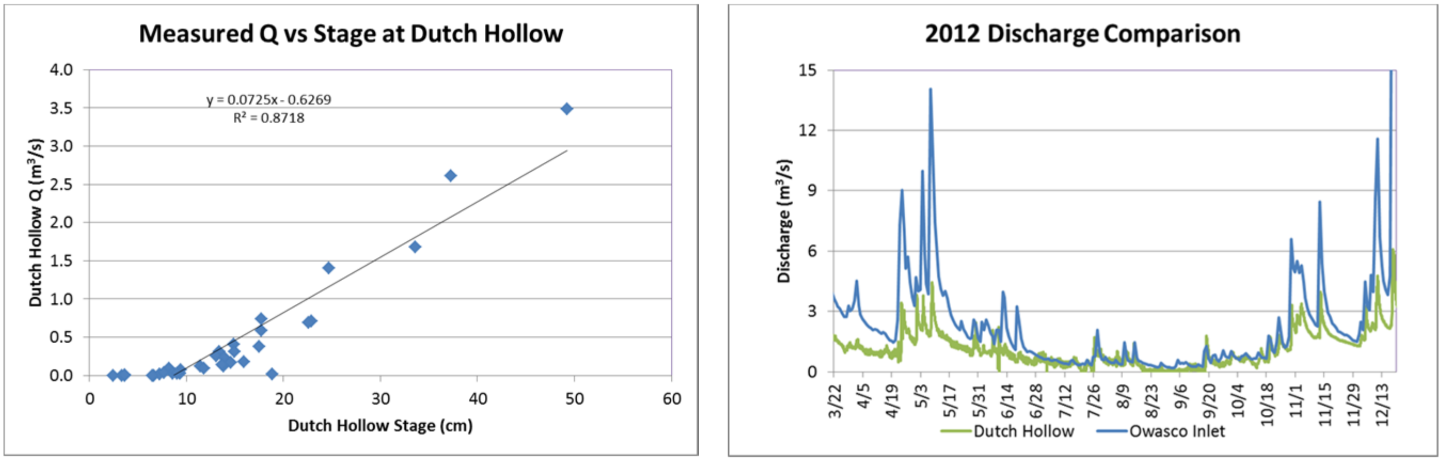


Fig. 29. Estimation of Dutch Hollow Brook 8-hour autosampler discharges from Dutch Hollow Brook stage, weekly discharge measurements, and daily USGS discharge data from Owasco Inlet (Station ID 04235299)

The fluxes of TSS, TP, SRP and nitrates were clearly event dependent in 2012 (Table 7, Fig. 30). TSS event fluxes averaged 6,850 kg/day and base flow fluxes were much smaller, only 2,400 kg/day. TP and SRP event fluxes averaged 4.0 and 0.6 kg/day but base flow fluxes were smaller, only 0.9 and 0.2 kg/day, respectively. During the entire 2012 field season, Dutch Hollow provided 520,000 kg of sediment to the lake during events, and much smaller loads of 28,500 kg during base flow conditions, even though the site was at base flow conditions for the majority of the 2012 field season. In a similar light, events delivered 305 kg of TP and 133 kg of SRP to the lake compared to base flow contributions of 133 kg of TP and 34 kg of SRP over the course of the study. In percentages, events supplied 90 to 99% of the TSS, TP and SRP flux to the lake in 2011, and 70 to 95% of these fluxes in 2012. The percentages for nitrates were slightly smaller (84 and 73%) because nitrates also enter the stream by groundwater flow. The difference between 2012 and 2011 reflects the less frequent and smaller events in 2011.

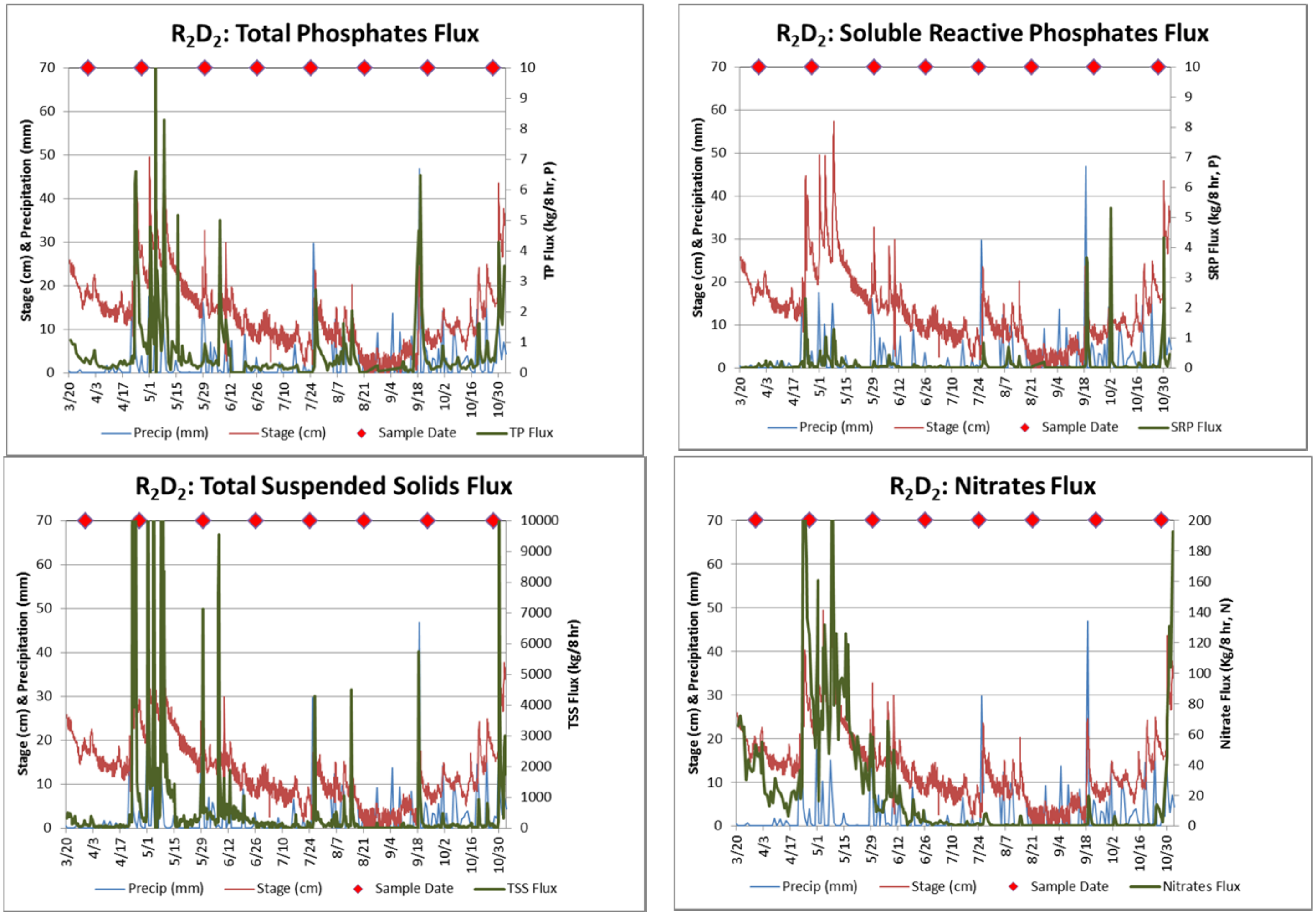
Annual changes were observed. The event fluxes were smaller in 2012 than 2011, even though the autosampler was deployed for three additional months in 2012. The total base flow load was slightly larger in 2012 than 2011, but the longer autosampler deployment in 2011 makes up for the difference. The differences are attributed to the change in annual precipitation. More rain events in 2011 than 2012 made more events with larger fluxes.

The event *versus* base flow, detailed analysis, once again indicated that bi-weekly or longer grab samples may incorrectly estimate fluxes down a stream. If the periodic grabs disproportionally collected event (or base flow) samples, then estimated annual fluxes would be over (or under) estimated. In 2012, the autosampler estimated that the mean flux of sediments was 2,400 kg/day, total phosphates 1.9 kg/day, dissolved phosphates 0.4 kg/day, and nitrates 69 kg/day. The monthly sampling over the same time period estimated the annual mean flux of sediments was 253 kg/day, total phosphates 0.6 kg/day, dissolved phosphates 0.1 kg/day, and nitrates 39 kg/day. Monthly grab samples were biased to base flows to avoid working in the rain.

In conclusion, both 2011 and 2012 revealed a significant increase in event over base flow loads for TSS, nitrates, TP and SRP along Dutch Hollow Brook, and dictate once again the importance to reduce the delivery of nutrient and sediments by runoff events in this watershed (Table 7). It is curious to speculate if the same observations would be detected in the Owasco Inlet, a watershed influenced by municipal wastewater treatment facilities and a smaller percentage of agricultural land.

Table 7: A 2011 and 2012 comparison of estimated autosampler fluxes in Dutch Hollow Brook.

2011 (6/9-11/4)	**TSS**	**Nitrate**	**TP**	**SRP**
Mean (kg/day)	8,700	75	2.7	1.7
Event (kg/day)	24,500	180	6.9	4.5
Base Flow (kg/day)	115	19	0.4	0.1
% by events	99%	84%	90%	96%
2012 (3/20-11/2)	**TSS**	**Nitrate**	**TP**	**SRP**
Mean (kg/day)	2,400	69	1.9	0.4
Event (kg/day)	6,850	150	4.0	0.6
Base Flow (kg/day)	190	28	0.9	0.2
% by events	95%	73%	70%	60%


R_2D_2: Total Phosphates Flux

R_2D_2: Soluble Reactive Phosphates Flux

R_2D_2: Total Suspended Solids Flux

R_2D_2: Nitrates Flux

Fig. 30. Autosampler nutrient and suspended sediment fluxes.

PHOSPHATE BUDGET:

Phosphorus is critical to the health and water quality of Owasco Lake because it limits algal growth. For example, reductions in Owasco Inlet inputs from 2006 to 2007 improved water quality in the southern end of the lake. However, the stream inputs are only one part of the equation. A complete budget must also include other inputs like atmospheric loading, and applied fertilizers and septic systems along the lakeshore. Outputs must be calculated as well to determine the net change in phosphorus in the lake (Fig. 31). The primary outputs include the outflow of phosphorus-rich materials through the Owasco Outlet and their burial into the sediments. Phosphorus will increase in the lake, if inputs exceed outputs, decrease if inputs are less than outputs, or remaining the same if inputs to equal outputs from the lake. To improve water quality, inputs of phosphorus must be smaller than outputs for a number of years, as it would limit algal growth and improve water clarity.

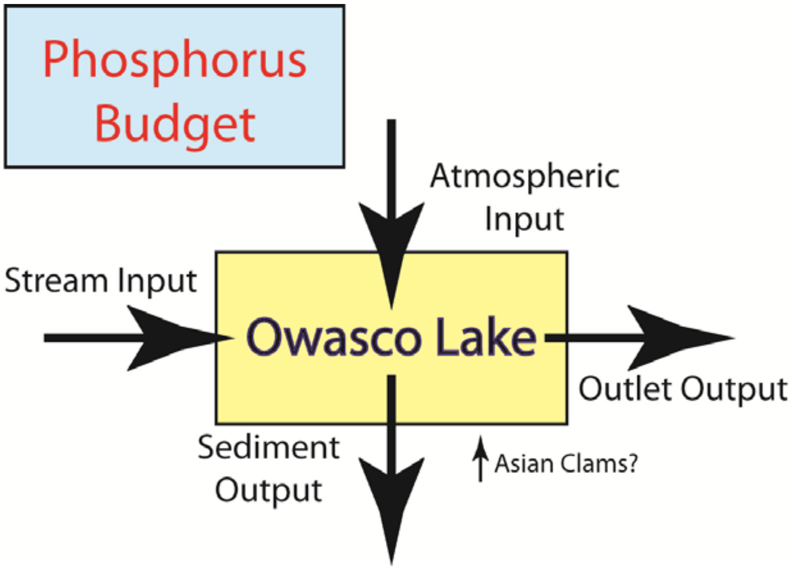


Fig. 31. The Owasco Lake phosphorus budget: Sources and sinks for phosphorus in Owasco Lake. Water quality improves if **inputs are less than outputs**, for a number of years.

The Inputs: The autosampler estimated a mean phosphate flux of 1.9 kg/day from Dutch Hollow Brook in 2012. Owasco Inlet delivered 3.1 kg/day based on the available 2012 monthly stream data. A proportional extrapolation of these two streams to the entire Owasco Lake watershed (using surface areas), estimated that 1.5 metric tons of phosphorus was added to the lake in 2012. The 2012 annual stream load was near the 2007 estimates of 1.5 metric tons but much smaller than the 2006 and significantly smaller than the 2011 estimated of 5 and 15.4 metric tons per year, respectively. But remember, 2006 and 2011 were relatively wet years and 2007 and 2012 were dry. The 2011 report estimated atmospheric and septic system inputs at 0.1 metric tons/year and ~1 metric tons/year. These estimates are used below.

The total 2012 estimated influx of phosphorus was 2.6 metric tons/year in 2012.

The Outputs: Phosphorus is lost from the lake through the Outlet in the form of algae, dissolved organic-rich compounds, organic-rich particulates, and the occasional larger organism (e.g., fish). Approximately 1.6 metric tons of phosphorus flows out the Outlet each year assuming an annual mean total phosphate concentration in the lake of 9.3 μg/L, and the 2012 mean daily discharge of 5.6 m^3/s through the Owasco Outlet (USGS Owasco Outlet flow data, Site ID

04235440). The 2011 report estimated the flux of phosphorus buried in the sediments of a few metric tons of phosphorus each year and this estimate is again used here. The report cautioned that more work was required to firm up this sediment burial estimate, because the flux was based on only a few sediment cores.

The total 2012 estimated efflux was 4.4 metric tons/year in 2012.

The Net Flux: Owasco Lake thus lost approximately 1.8 metric tons of phosphorus from the lake in 2012. This amount was smaller but similar in magnitude to the 8 metric tons of phosphorus in the lake, assuming a mean lake total phosphate concentration of 10 μg/L and a lake volume of 781 x 10^6 m^3. If this loss persists for a number of years, it suggests that water quality in the lake should improve over time. The negative balance was also consistent with a small water quality improvement in the lake during 2012. The difference was small, and would have been difficult to confirm by the casual observer without detailed measurements but is nonetheless a change in the right direction.

In conclusion, a phosphorus mass balance is difficult to estimate because some of the inputs and outputs are tenuous at this time. The largest uncertainties were in the sediment efflux and the septic system estimates. The available 2012 data however suggest that phosphorus inputs were smaller than outputs, and the lake lost phosphorus in 2012. Streams were still the primary source of phosphorus to the lake providing nearly 60% of the total influx, and streams gained the majority of their phosphorus during runoff events. Seeing that streams dominated inputs in both “dry” and “wet” years, it follows that nutrient reduction efforts must focus on the streams, i.e., reducing the major event related sources of phosphorus to streams originating from non-point sources, i.e., agricultural areas. If the reductions occur over a number of years, water quality will improve. However the financial burden to install the remediation practices cannot be dumped on the farmer. Water quality is a watershed-wide issue. Everyone benefits from a cleaner lake. Thus everyone should help support the remediation effort.

RECENT EFFORTS IN THE CONESUS WATERSHED

The 2011 report highlighted a recent study that investigated the impact of Best Management Practices (BMPs) on the delivery of nutrients and suspended sediments to Conesus Lake from its agriculturally-rich watershed. The parallels to Owasco Lake are intriguing so the outcomes of the study are highlighted below again.

- Before the implementation of the BMPs, stream discharge, and nutrient and suspended sediment fluxes responded to events. Over 80% of the nutrient and sediment loss from the watershed occurred within the six largest major precipitation events.
- The BMPs implemented in the Conesus Lake watersheds induced significant reductions in the delivery of nutrients and sediments to the lake.
- The Great Gully watershed, where BMPs controlled the largest percentage of the watershed, revealed the greatest reduction in the delivery of nutrients and suspended sediments to the lake (~50% less sediments, 30% less nitrates, 50% less total phosphates and 60% less dissolved phosphates).
- These reductions yielded a parallel reduction in metaphyton (plankton, 72% reduction), macrophytes (rooted nearshore plants, 30 to 50% reduction) and microbial communities (25% reduction) in nearshore regions of Conesus Lake adjacent to the tributaries with BMPs.

- The nutrient and sediment reductions at Great Gully however, did not decrease to the smaller loadings / hectare from the forested watershed, North McMillian Creek. Even after five years, this agricultural watershed still delivered more nutrients and sediments to the lake than the non-agricultural, forested, watershed.
- Agricultural watersheds with minimal BMPs implementation did not reveal significant changes in nutrient and suspended sediment loads. Thus, the BMPs had an impact on nutrient and sediment delivery to the lake.

In conclusion, BMPs effectively and significantly reduced nutrient and suspended sediments loads to and improved water quality in Conesus Lake. Similar programs should be implemented in the Owasco Watershed. Critical for its success however is the availability of funding to make these BMP improvements. The financial burden cannot be placed solely on the farmer.

CONCLUSIONS & RECOMMENDATIONS:

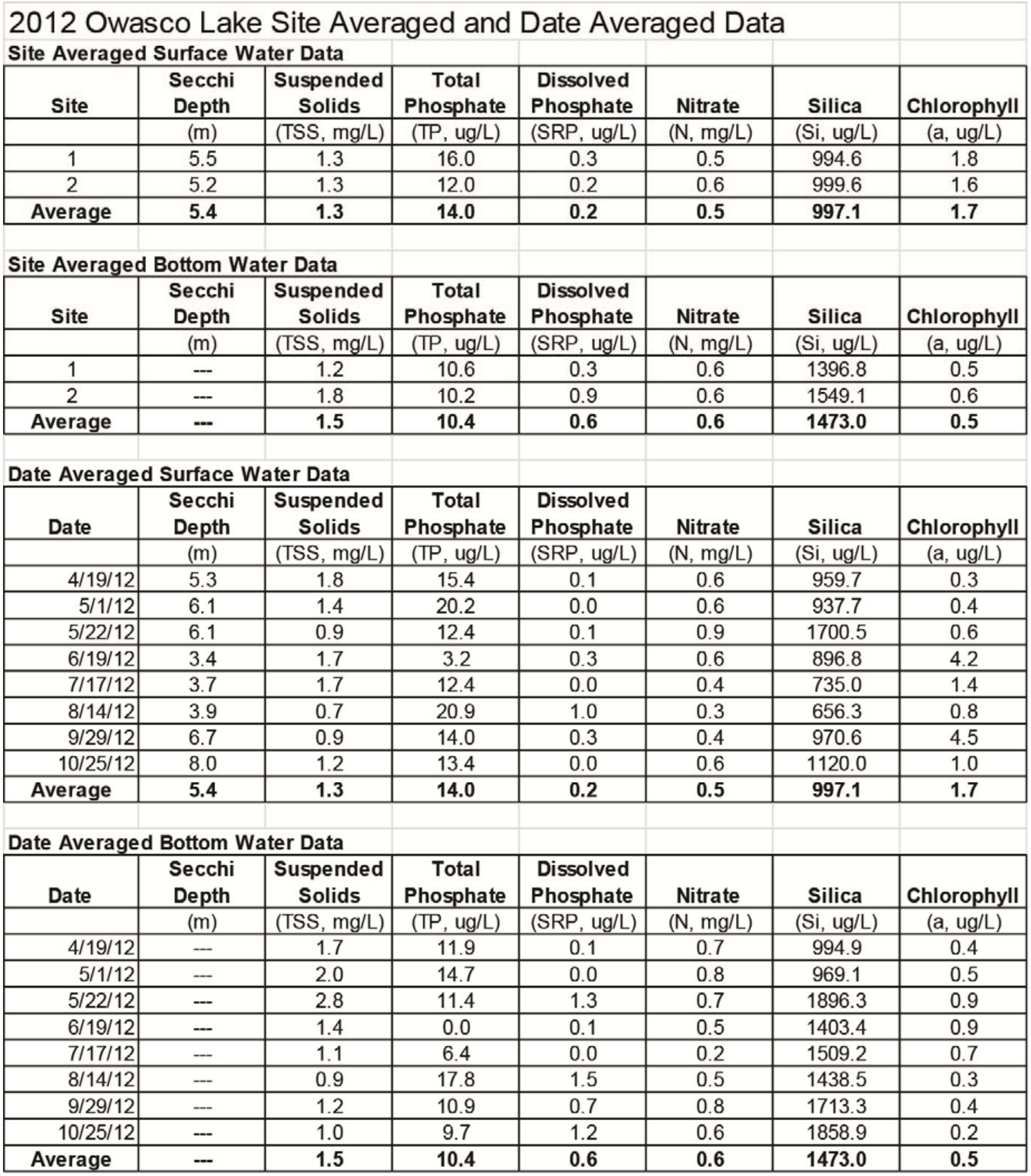
This report confirms and expands on earlier findings.

- As previously observed, Owasco Lake is a borderline oligotrophic – mesotrophic lake.
- Segment analysis highlighted the importance of non-point sources like agriculture and lawn care throughout the Dutch Hollow Brook watershed.
- Segment analysis in Owasco Inlet highlighted the importance of both point and non-point sources. It revealed that both the Moravia and Groton facilities decreased their impact on water quality along the Inlet, and their combined impact was less than the inputs from other unidentified sources. This is good because additional processes to decrease MWTF effluent loads are significantly more expensive.
- Seasonal sampling revealed larger spring loads compared to the fall and summer months, especially for phosphates and suspended sediments. However the differences were not as distinct in 2012, a “dry” year, as in 2011, a “wet” year. Still the seasonal variability suggests that earlier, pre-2011, nutrient fluxes under-estimated the actual annual load to the lake in those years.
- The event *versus* base flow, detailed analysis at Dutch Hollow Brook highlighted the dominance of events and runoff of non-point sources on the delivery of phosphates and suspended sediments to the lake. Loads and differences between events and base flow were smaller in 2012 than 2011 and reflected the change between “dry” and “wet” years.
- The 2012 phosphate budget for Owasco Lake indicated that the inputs of phosphorus from the streams, atmosphere and septic systems along the lakeshore were slightly smaller than the losses out the Owasco Outlet and burial into the deepwater sediments. This negative balance is opposite to the large positive balance estimated in 2011, and reaffirms that water quality in the lake can improve if a concerted effort maintains the reduced nutrient loading to the lake for a number of years.
- Streams were the primary source of nutrients and suspended sediments to the lake, even in the 2012 “dry” year.
- BMPs should be installed to reduce nutrient and suspended sediment loading from agriculturally-rich watersheds in the future, while at the same time monitoring downstream of BMPs and other remediation projects to assess their effectiveness.
- The financial burden to install the BMPs cannot be placed solely on the farmer. Water quality is a watershed-wide issue. Everyone benefits from a cleaner lake. Thus everyone should help support the remediation effort.

ACKNOWLEDGEMENTS

The 2012 research was supported by Cayuga County Legislature. We thank members of the Cayuga County Planning Department, Cayuga County Water Quality Management Agency, Owasco Lake Watershed Management Council, Cayuga County Health Department, Owasco Watershed Lake Association, the Institute for the Application of Geospatial Data, and NYS Department of Environmental Conservation for their help. Numerous individuals helped with many aspects of this study including Senator Mike Nozzolio, Barbara Halfman, Cayuga County Council Chair Steven Cuddeback, Eileen O-Connor, Bruce Natale, Ron Podolak, Bill Graney, Mike Didio, Gary Searing, Ed Wagner, Anthony DeCaro, Katie Jakaub, Charlie Green, Steve Lynch, Judy Wright, and David Eckhardt. Hopefully, I didn't forget to acknowledge anyone, and my apologies to those I omitted. Additional thanks are extended to the following students who helped with the 2012 effort: Ethan Black, Laura Carver-Dionne, Carli Ellis, Molly George, Phillip Hackett, Haleigh Marshall, Yifei Pei and Taylor Weber.

Table 2. 2012 Lake Data.



2012 Owasco Lake Site Averaged and Date Averaged Data

Site Averaged Surface Water Data

Site	Secchi Depth	Suspended Solids	Total Phosphate	Dissolved Phosphate	Nitrate	Silica	Chlorophyll
	(m)	(TSS, mg/L)	(TP, ug/L)	(SRP, ug/L)	(N, mg/L)	(Si, ug/L)	(a, ug/L)
1	5.5	1.3	16.0	0.3	0.5	994.6	1.8
2	5.2	1.3	12.0	0.2	0.6	999.6	1.6
Average	**5.4**	**1.3**	**14.0**	**0.2**	**0.5**	**997.1**	**1.7**

Site Averaged Bottom Water Data

Site	Secchi Depth	Suspended Solids	Total Phosphate	Dissolved Phosphate	Nitrate	Silica	Chlorophyll
	(m)	(TSS, mg/L)	(TP, ug/L)	(SRP, ug/L)	(N, mg/L)	(Si, ug/L)	(a, ug/L)
1	---	1.2	10.6	0.3	0.6	1396.8	0.5
2	---	1.8	10.2	0.9	0.6	1549.1	0.6
Average	**---**	**1.5**	**10.4**	**0.6**	**0.6**	**1473.0**	**0.5**

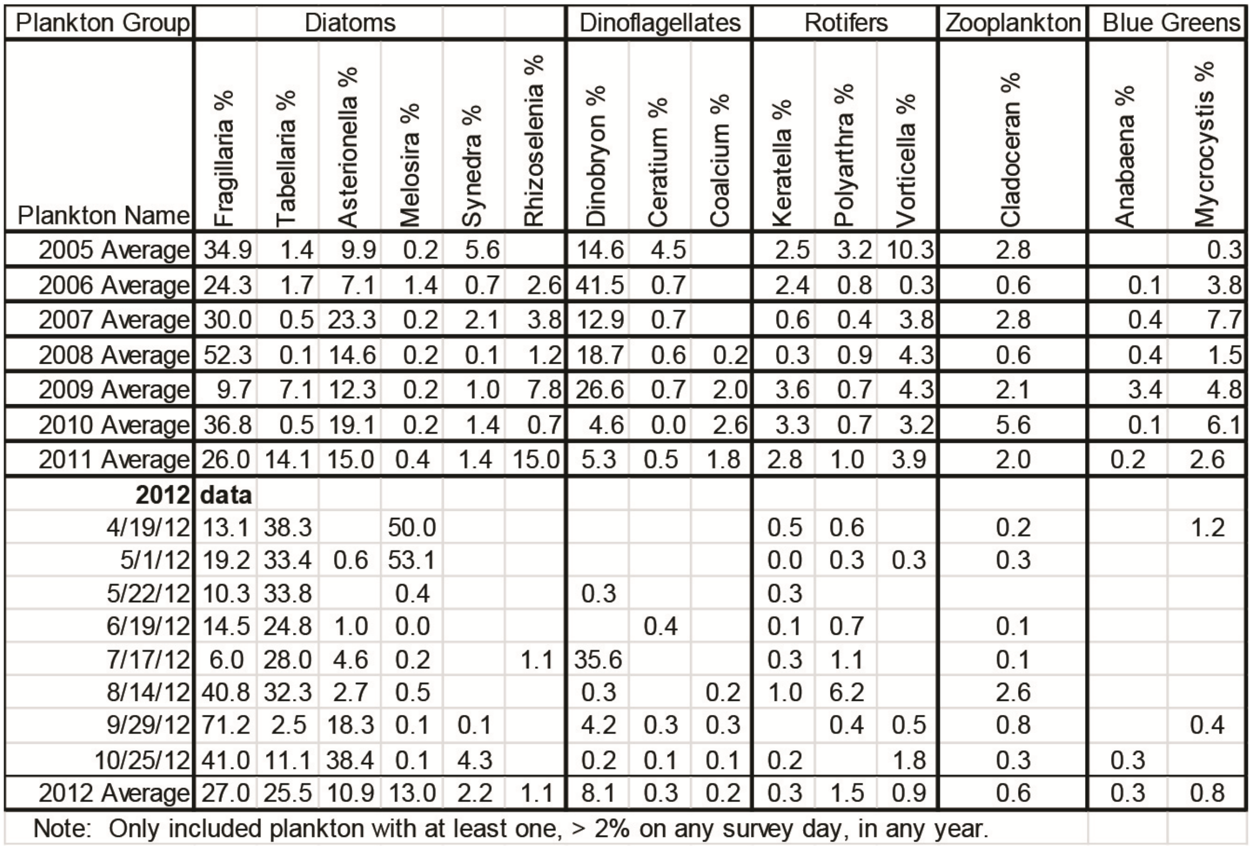
Date Averaged Surface Water Data

Date	Secchi Depth	Suspended Solids	Total Phosphate	Dissolved Phosphate	Nitrate	Silica	Chlorophyll
	(m)	(TSS, mg/L)	(TP, ug/L)	(SRP, ug/L)	(N, mg/L)	(Si, ug/L)	(a, ug/L)
4/19/12	5.3	1.8	15.4	0.1	0.6	959.7	0.3
5/1/12	6.1	1.4	20.2	0.0	0.6	937.7	0.4
5/22/12	6.1	0.9	12.4	0.1	0.9	1700.5	0.6
6/19/12	3.4	1.7	3.2	0.3	0.6	896.8	4.2
7/17/12	3.7	1.7	12.4	0.0	0.4	735.0	1.4
8/14/12	3.9	0.7	20.9	1.0	0.3	656.3	0.8
9/29/12	6.7	0.9	14.0	0.3	0.4	970.6	4.5
10/25/12	8.0	1.2	13.4	0.0	0.6	1120.0	1.0
Average	**5.4**	**1.3**	**14.0**	**0.2**	**0.5**	**997.1**	**1.7**

Date Averaged Bottom Water Data

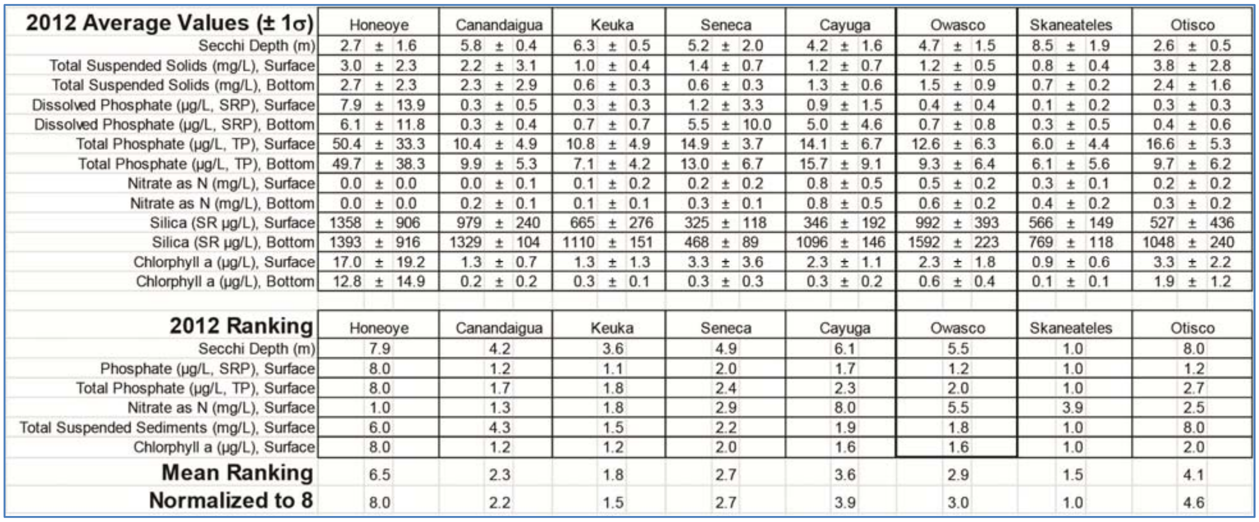
Date	Secchi Depth	Suspended Solids	Total Phosphate	Dissolved Phosphate	Nitrate	Silica	Chlorophyll
	(m)	(TSS, mg/L)	(TP, ug/L)	(SRP, ug/L)	(N, mg/L)	(Si, ug/L)	(a, ug/L)
4/19/12	---	1.7	11.9	0.1	0.7	994.9	0.4
5/1/12	---	2.0	14.7	0.0	0.8	969.1	0.5
5/22/12	---	2.8	11.4	1.3	0.7	1896.3	0.9
6/19/12	---	1.4	0.0	0.1	0.5	1403.4	0.9
7/17/12	---	1.1	6.4	0.0	0.2	1509.2	0.7
8/14/12	---	0.9	17.8	1.5	0.5	1438.5	0.3
9/29/12	---	1.2	10.9	0.7	0.8	1713.3	0.4
10/25/12	---	1.0	9.7	1.2	0.6	1858.9	0.2
Average	**---**	**1.5**	**10.4**	**0.6**	**0.6**	**1473.0**	**0.5**

Table 4. Annual Average Plankton Data from 2005 through 2012, and Daily Average Data for 2012.



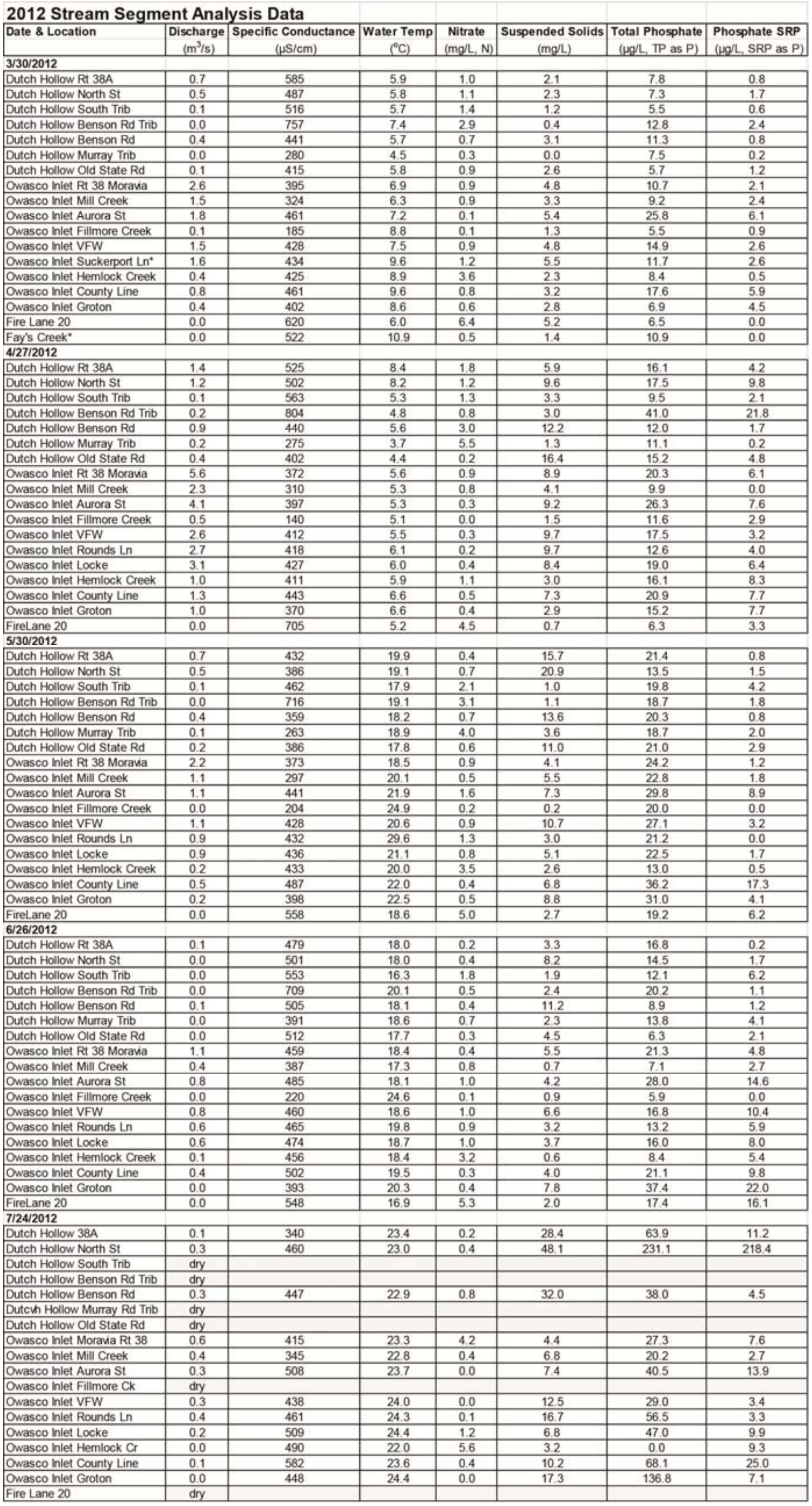
Plankton Group	Diatoms						Dinoflagellates			Rotifers			Zooplankton	Blue Greens	
Plankton Name	Fragillaria %	Tabellaria %	Asterionella %	Melosira %	Synedra %	Rhizoselenia %	Dinobryon %	Ceratium %	Coalcium %	Keratella %	Polyarthra %	Vorticella %	Cladoceran %	Anabaena %	Mycrocystis %
2005 Average	34.9	1.4	9.9	0.2	5.6		14.6	4.5		2.5	3.2	10.3	2.8		0.3
2006 Average	24.3	1.7	7.1	1.4	0.7	2.6	41.5	0.7		2.4	0.8	0.3	0.6	0.1	3.8
2007 Average	30.0	0.5	23.3	0.2	2.1	3.8	12.9	0.7		0.6	0.4	3.8	2.8	0.4	7.7
2008 Average	52.3	0.1	14.6	0.2	0.1	1.2	18.7	0.6	0.2	0.3	0.9	4.3	0.6	0.4	1.5
2009 Average	9.7	7.1	12.3	0.2	1.0	7.8	26.6	0.7	2.0	3.6	0.7	4.3	2.1	3.4	4.8
2010 Average	36.8	0.5	19.1	0.2	1.4	0.7	4.6	0.0	2.6	3.3	0.7	3.2	5.6	0.1	6.1
2011 Average	26.0	14.1	15.0	0.4	1.4	15.0	5.3	0.5	1.8	2.8	1.0	3.9	2.0	0.2	2.6
2012	**data**														
4/19/12	13.1	38.3		50.0						0.5	0.6		0.2		1.2
5/1/12	19.2	33.4	0.6	53.1						0.0	0.3	0.3	0.3		
5/22/12	10.3	33.8		0.4			0.3			0.3					
6/19/12	14.5	24.8	1.0	0.0				0.4		0.1	0.7		0.1		
7/17/12	6.0	28.0	4.6	0.2		1.1	35.6			0.3	1.1		0.1		
8/14/12	40.8	32.3	2.7	0.5			0.3		0.2	1.0	6.2		2.6		
9/29/12	71.2	2.5	18.3	0.1	0.1		4.2	0.3	0.3		0.4	0.5	0.8		0.4
10/25/12	41.0	11.1	38.4	0.1	4.3		0.2	0.1	0.1	0.2		1.8	0.3	0.3	
2012 Average	27.0	25.5	10.9	13.0	2.2	1.1	8.1	0.3	0.2	0.3	1.5	0.9	0.6	0.3	0.8
Note: Only included plankton with at least one, > 2% on any survey day, in any year.															

Table 5: Annual Average 2012 Lake Data from the Finger Lake Survey.



2012 Average Values (± 1σ)	Honeoye	Canandaigua	Keuka	Seneca	Cayuga	Owasco	Skaneateles	Otisco
Secchi Depth (m)	2.7 ± 1.6	5.8 ± 0.4	6.3 ± 0.5	5.2 ± 2.0	4.2 ± 1.6	4.7 ± 1.5	8.5 ± 1.9	2.6 ± 0.5
Total Suspended Solids (mg/L), Surface	3.0 ± 2.3	2.2 ± 3.1	1.0 ± 0.4	1.4 ± 0.7	1.2 ± 0.7	1.2 ± 0.5	0.8 ± 0.4	3.8 ± 2.8
Total Suspended Solids (mg/L), Bottom	2.7 ± 2.3	2.3 ± 2.9	0.6 ± 0.3	0.6 ± 0.3	1.3 ± 0.6	1.5 ± 0.9	0.7 ± 0.2	2.4 ± 1.6
Dissolved Phosphate (μg/L, SRP), Surface	7.9 ± 13.9	0.3 ± 0.5	0.3 ± 0.3	1.2 ± 3.3	0.9 ± 1.5	0.4 ± 0.4	0.1 ± 0.2	0.3 ± 0.3
Dissolved Phosphate (μg/L, SRP), Bottom	6.1 ± 11.8	0.3 ± 0.4	0.7 ± 0.7	5.5 ± 10.0	5.0 ± 4.6	0.7 ± 0.8	0.3 ± 0.5	0.4 ± 0.6
Total Phosphate (μg/L, TP), Surface	50.4 ± 33.3	10.4 ± 4.9	10.8 ± 4.9	14.9 ± 3.7	14.1 ± 6.7	12.6 ± 6.3	6.0 ± 4.4	16.6 ± 5.3
Total Phosphate (μg/L, TP), Bottom	49.7 ± 38.3	9.9 ± 5.3	7.1 ± 4.2	13.0 ± 6.7	15.7 ± 9.1	9.3 ± 6.4	6.1 ± 5.6	9.7 ± 6.2
Nitrate as N (mg/L), Surface	0.0 ± 0.0	0.0 ± 0.1	0.1 ± 0.2	0.2 ± 0.2	0.8 ± 0.5	0.5 ± 0.2	0.3 ± 0.1	0.2 ± 0.2
Nitrate as N (mg/L), Bottom	0.0 ± 0.0	0.2 ± 0.1	0.1 ± 0.1	0.3 ± 0.1	0.8 ± 0.5	0.6 ± 0.2	0.4 ± 0.2	0.3 ± 0.2
Silica (SR μg/L), Surface	1358 ± 906	979 ± 240	665 ± 276	325 ± 118	346 ± 192	992 ± 393	566 ± 149	527 ± 436
Silica (SR μg/L), Bottom	1393 ± 916	1329 ± 104	1110 ± 151	468 ± 89	1096 ± 146	1592 ± 223	769 ± 118	1048 ± 240
Chlorphyll a (μg/L), Surface	17.0 ± 19.2	1.3 ± 0.7	1.3 ± 1.3	3.3 ± 3.6	2.3 ± 1.1	2.3 ± 1.8	0.9 ± 0.6	3.3 ± 2.2
Chlorphyll a (μg/L), Bottom	12.8 ± 14.9	0.2 ± 0.2	0.3 ± 0.1	0.3 ± 0.3	0.3 ± 0.2	0.6 ± 0.4	0.1 ± 0.1	1.9 ± 1.2
2012 Ranking	Honeoye	Canandaigua	Keuka	Seneca	Cayuga	Owasco	Skaneateles	Otisco
Secchi Depth (m)	7.9	4.2	3.6	4.9	6.1	5.5	1.0	8.0
Phosphate (μg/L, SRP), Surface	8.0	1.2	1.1	2.0	1.7	1.2	1.0	1.2
Total Phosphate (μg/L, TP), Surface	8.0	1.7	1.8	2.4	2.3	2.0	1.0	2.7
Nitrate as N (mg/L), Surface	1.0	1.3	1.8	2.9	8.0	5.5	3.9	2.5
Total Suspended Sediments (mg/L), Surface	6.0	4.3	1.5	2.2	1.9	1.8	1.0	8.0
Chlorphyll a (μg/L), Surface	8.0	1.2	1.2	2.0	1.6	1.6	1.0	2.0
Mean Ranking	6.5	2.3	1.8	2.7	3.6	2.9	1.5	4.1
Normalized to 8	8.0	2.2	1.5	2.7	3.9	3.0	1.0	4.6

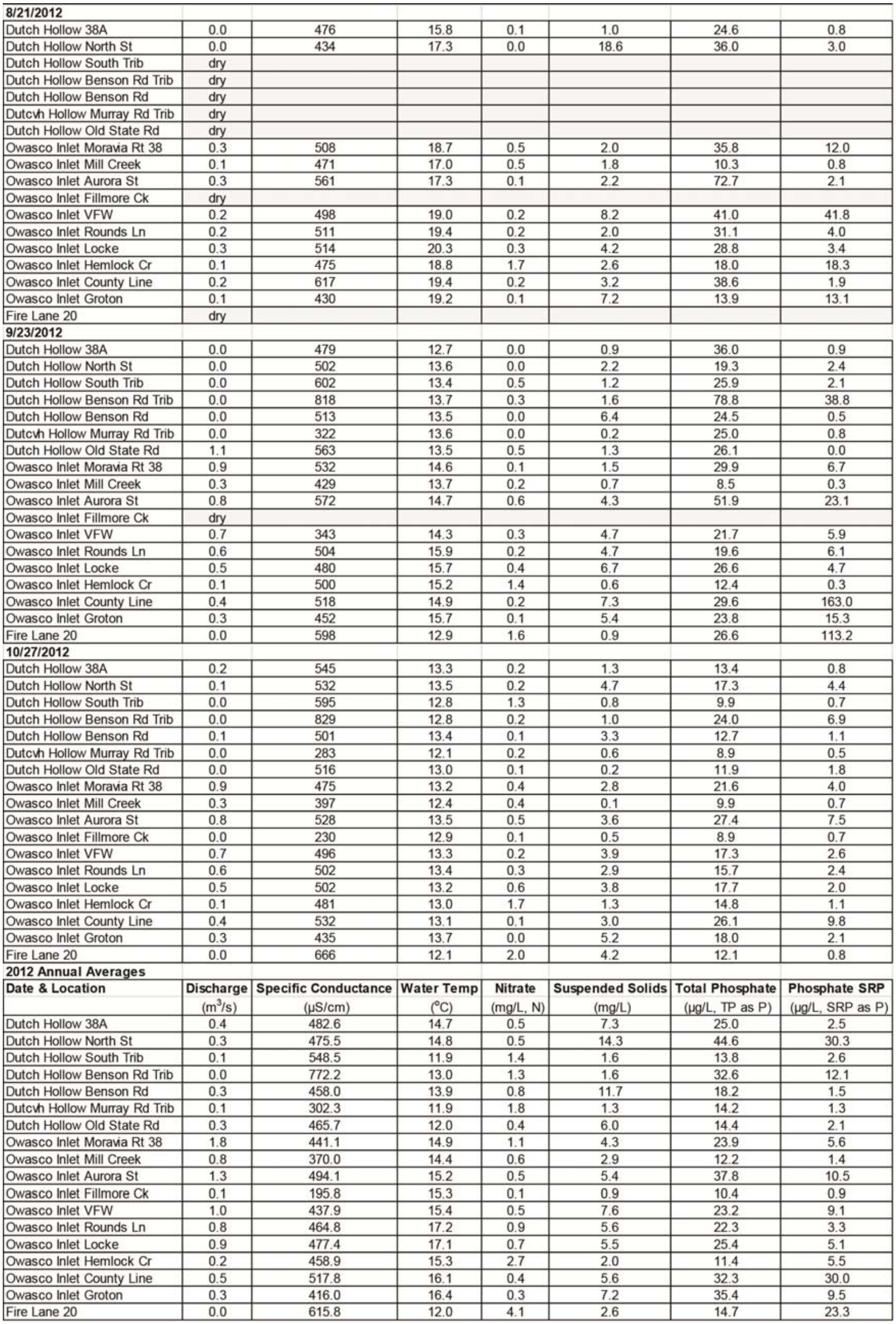
Table 6. 2012 Stream Data.



2012 Stream Segment Analysis Data

Date & Location	Discharge (m^3/s)	Specific Conductance (μS/cm)	Water Temp (°C)	Nitrate (mg/L, N)	Suspended Solids (mg/L)	Total Phosphate (μg/L, TP as P)	Phosphate SRP (μg/L, SRP as P)
3/30/2012							
Dutch Hollow Rt 38A	0.7	585	5.9	1.0	2.1	7.8	0.8
Dutch Hollow North St	0.5	487	5.8	1.1	2.3	7.3	1.7
Dutch Hollow South Trib	0.1	516	5.7	1.4	1.2	5.5	0.6
Dutch Hollow Benson Rd Trib	0.0	757	7.4	2.9	0.4	12.8	2.4
Dutch Hollow Benson Rd	0.4	441	5.7	0.7	3.1	11.3	0.8
Dutch Hollow Murray Trib	0.0	280	4.5	0.3	0.0	7.5	0.2
Dutch Hollow Old State Rd	0.1	415	5.8	0.9	2.6	5.7	1.2
Owasco Inlet Rt 38 Moravia	2.6	395	6.9	0.9	4.8	10.7	2.1
Owasco Inlet Mill Creek	1.5	324	6.3	0.9	3.3	9.2	2.4
Owasco Inlet Aurora St	1.8	461	7.2	0.1	5.4	25.8	6.1
Owasco Inlet Fillmore Creek	0.1	185	8.8	0.1	1.3	5.5	0.9
Owasco Inlet VFW	1.5	428	7.5	0.9	4.8	14.9	2.6
Owasco Inlet Suckerport Ln*	1.6	434	9.6	1.2	5.5	11.7	2.6
Owasco Inlet Hemlock Creek	0.4	425	8.9	3.6	2.3	8.4	0.5
Owasco Inlet County Line	0.8	461	9.6	0.8	3.2	17.6	5.9
Owasco Inlet Groton	0.4	402	8.6	0.6	2.8	6.9	4.5
Fire Lane 20	0.0	620	6.0	6.4	5.2	6.5	0.0
Fay's Creek*	0.0	522	10.9	0.5	1.4	10.9	0.0
4/27/2012							
Dutch Hollow Rt 38A	1.4	525	8.4	1.8	5.9	16.1	4.2
Dutch Hollow North St	1.2	502	8.2	1.2	9.6	17.5	9.8
Dutch Hollow South Trib	0.1	563	5.3	1.3	3.3	9.5	2.1
Dutch Hollow Benson Rd Trib	0.2	804	4.8	0.8	3.0	41.0	21.8
Dutch Hollow Benson Rd	0.9	440	5.6	3.0	12.2	12.0	1.7
Dutch Hollow Murray Trib	0.2	275	3.7	5.5	1.3	11.1	0.2
Dutch Hollow Old State Rd	0.4	402	4.4	0.2	16.4	15.2	4.8
Owasco Inlet Rt 38 Moravia	5.6	372	5.6	0.9	8.9	20.3	6.1
Owasco Inlet Mill Creek	2.3	310	5.3	0.8	4.1	9.9	0.0
Owasco Inlet Aurora St	4.1	397	5.3	0.3	9.2	26.3	7.6
Owasco Inlet Fillmore Creek	0.5	140	5.1	0.0	1.5	11.6	2.9
Owasco Inlet VFW	2.6	412	5.5	0.3	9.7	17.5	3.2
Owasco Inlet Rounds Ln	2.7	418	6.1	0.2	9.7	12.6	4.0
Owasco Inlet Locke	3.1	427	6.0	0.4	8.4	19.0	6.4
Owasco Inlet Hemlock Creek	1.0	411	5.9	1.1	3.0	16.1	8.3
Owasco Inlet County Line	1.3	443	6.6	0.5	7.3	20.9	7.7
Owasco Inlet Groton	1.0	370	6.6	0.4	2.9	15.2	7.7
FireLane 20	0.0	705	5.2	4.5	0.7	6.3	3.3
5/30/2012							
Dutch Hollow Rt 38A	0.7	432	19.9	0.4	15.7	21.4	0.8
Dutch Hollow North St	0.5	386	19.1	0.7	20.9	13.5	1.5
Dutch Hollow South Trib	0.1	462	17.9	2.1	1.0	19.8	4.2
Dutch Hollow Benson Rd Trib	0.0	716	19.1	3.1	1.1	18.7	1.8
Dutch Hollow Benson Rd	0.4	359	18.2	0.7	13.6	20.3	0.8
Dutch Hollow Murray Trib	0.1	263	18.9	4.0	3.6	18.7	2.0
Dutch Hollow Old State Rd	0.2	386	17.8	0.6	11.0	21.0	2.9
Owasco Inlet Rt 38 Moravia	2.2	373	18.5	0.9	4.1	24.2	1.2
Owasco Inlet Mill Creek	1.1	297	20.1	0.5	5.5	22.8	1.8
Owasco Inlet Aurora St	1.1	441	21.9	1.6	7.3	29.8	8.9
Owasco Inlet Fillmore Creek	0.0	204	24.9	0.2	0.2	20.0	0.0
Owasco Inlet VFW	1.1	428	20.6	0.9	10.7	27.1	3.2
Owasco Inlet Rounds Ln	0.9	432	29.6	1.3	3.0	21.2	0.0
Owasco Inlet Locke	0.9	436	21.1	0.8	5.1	22.5	1.7
Owasco Inlet Hemlock Creek	0.2	433	20.0	3.5	2.6	13.0	0.5
Owasco Inlet County Line	0.5	487	22.0	0.4	6.8	36.2	17.3
Owasco Inlet Groton	0.2	398	22.5	0.5	8.8	31.0	4.1
FireLane 20	0.0	558	18.6	5.0	2.7	19.2	6.2
6/26/2012							
Dutch Hollow Rt 38A	0.1	479	18.0	0.2	3.3	16.8	0.2
Dutch Hollow North St	0.0	501	18.0	0.4	8.2	14.5	1.7
Dutch Hollow South Trib	0.0	553	16.3	1.8	1.9	12.1	6.2
Dutch Hollow Benson Rd Trib	0.0	709	20.1	0.5	2.4	20.2	1.1
Dutch Hollow Benson Rd	0.1	505	18.1	0.4	11.2	8.9	1.2
Dutch Hollow Murray Trib	0.0	391	18.6	0.7	2.3	13.8	4.1
Dutch Hollow Old State Rd	0.0	512	17.7	0.3	4.5	6.3	2.1
Owasco Inlet Rt 38 Moravia	1.1	459	18.4	0.4	5.5	21.3	4.8
Owasco Inlet Mill Creek	0.4	387	17.3	0.8	0.7	7.1	2.7
Owasco Inlet Aurora St	0.8	485	18.1	1.0	4.2	28.0	14.6
Owasco Inlet Fillmore Creek	0.0	220	24.6	0.1	0.9	5.9	0.0
Owasco Inlet VFW	0.8	460	18.6	1.0	6.6	16.8	10.4
Owasco Inlet Rounds Ln	0.6	465	19.8	0.9	3.2	13.2	5.9
Owasco Inlet Locke	0.6	474	18.7	1.0	3.7	16.0	8.0
Owasco Inlet Hemlock Creek	0.1	456	18.4	3.2	0.6	8.4	5.4
Owasco Inlet County Line	0.4	502	19.5	0.3	4.0	21.1	9.8
Owasco Inlet Groton	0.0	393	20.3	0.4	7.8	37.4	22.0
FireLane 20	0.0	548	16.9	5.3	2.0	17.4	16.1
7/24/2012							
Dutch Hollow 38A	0.1	340	23.4	0.2	28.4	63.9	11.2
Dutch Hollow North St	0.3	460	23.0	0.4	48.1	231.1	218.4
Dutch Hollow South Trib	dry						
Dutch Hollow Benson Rd Trib	dry						
Dutch Hollow Benson Rd	0.3	447	22.9	0.8	32.0	38.0	4.5
Dutcvh Hollow Murray Rd Trib	dry						
Dutch Hollow Old State Rd	dry						
Owasco Inlet Moravia Rt 38	0.6	415	23.3	4.2	4.4	27.3	7.6
Owasco Inlet Mill Creek	0.4	345	22.8	0.4	6.8	20.2	2.7
Owasco Inlet Aurora St	0.3	508	23.7	0.0	7.4	40.5	13.9
Owasco Inlet Fillmore Ck	dry						
Owasco Inlet VFW	0.3	438	24.0	0.0	12.5	29.0	3.4
Owasco Inlet Rounds Ln	0.4	461	24.3	0.1	16.7	56.5	3.3
Owasco Inlet Locke	0.2	509	24.4	1.2	6.8	47.0	9.9
Owasco Inlet Hemlock Cr	0.0	490	22.0	5.6	3.2	0.0	9.3
Owasco Inlet County Line	0.1	582	23.6	0.4	10.2	68.1	25.0
Owasco Inlet Groton	0.0	448	24.4	0.0	17.3	136.8	7.1
Fire Lane 20	dry						

Table 6. 2011 Stream Data (continued)



8/21/2012							
Dutch Hollow 38A	0.0	476	15.8	0.1	1.0	24.6	0.8
Dutch Hollow North St	0.0	434	17.3	0.0	18.6	36.0	3.0
Dutch Hollow South Trib	dry						
Dutch Hollow Benson Rd Trib	dry						
Dutch Hollow Benson Rd	dry						
Dutcvh Hollow Murray Rd Trib	dry						
Dutch Hollow Old State Rd	dry						
Owasco Inlet Moravia Rt 38	0.3	508	18.7	0.5	2.0	35.8	12.0
Owasco Inlet Mill Creek	0.1	471	17.0	0.5	1.8	10.3	0.8
Owasco Inlet Aurora St	0.3	561	17.3	0.1	2.2	72.7	2.1
Owasco Inlet Fillmore Ck	dry						
Owasco Inlet VFW	0.2	498	19.0	0.2	8.2	41.0	41.8
Owasco Inlet Rounds Ln	0.2	511	19.4	0.2	2.0	31.1	4.0
Owasco Inlet Locke	0.3	514	20.3	0.3	4.2	28.8	3.4
Owasco Inlet Hemlock Cr	0.1	475	18.8	1.7	2.6	18.0	18.3
Owasco Inlet County Line	0.2	617	19.4	0.2	3.2	38.6	1.9
Owasco Inlet Groton	0.1	430	19.2	0.1	7.2	13.9	13.1
Fire Lane 20	dry						
9/23/2012							
Dutch Hollow 38A	0.0	479	12.7	0.0	0.9	36.0	0.9
Dutch Hollow North St	0.0	502	13.6	0.0	2.2	19.3	2.4
Dutch Hollow South Trib	0.0	602	13.4	0.5	1.2	25.9	2.1
Dutch Hollow Benson Rd Trib	0.0	818	13.7	0.3	1.6	78.8	38.8
Dutch Hollow Benson Rd	0.0	513	13.5	0.0	6.4	24.5	0.5
Dutcvh Hollow Murray Rd Trib	0.0	322	13.6	0.0	0.2	25.0	0.8
Dutch Hollow Old State Rd	1.1	563	13.5	0.5	1.3	26.1	0.0
Owasco Inlet Moravia Rt 38	0.9	532	14.6	0.1	1.5	29.9	6.7
Owasco Inlet Mill Creek	0.3	429	13.7	0.2	0.7	8.5	0.3
Owasco Inlet Aurora St	0.8	572	14.7	0.6	4.3	51.9	23.1
Owasco Inlet Fillmore Ck	dry						
Owasco Inlet VFW	0.7	343	14.3	0.3	4.7	21.7	5.9
Owasco Inlet Rounds Ln	0.6	504	15.9	0.2	4.7	19.6	6.1
Owasco Inlet Locke	0.5	480	15.7	0.4	6.7	26.6	4.7
Owasco Inlet Hemlock Cr	0.1	500	15.2	1.4	0.6	12.4	0.3
Owasco Inlet County Line	0.4	518	14.9	0.2	7.3	29.6	163.0
Owasco Inlet Groton	0.3	452	15.7	0.1	5.4	23.8	15.3
Fire Lane 20	0.0	598	12.9	1.6	0.9	26.6	113.2
10/27/2012							
Dutch Hollow 38A	0.2	545	13.3	0.2	1.3	13.4	0.8
Dutch Hollow North St	0.1	532	13.5	0.2	4.7	17.3	4.4
Dutch Hollow South Trib	0.0	595	12.8	1.3	0.8	9.9	0.7
Dutch Hollow Benson Rd Trib	0.0	829	12.8	0.2	1.0	24.0	6.9
Dutch Hollow Benson Rd	0.1	501	13.4	0.1	3.3	12.7	1.1
Dutcvh Hollow Murray Rd Trib	0.0	283	12.1	0.2	0.6	8.9	0.5
Dutch Hollow Old State Rd	0.0	516	13.0	0.1	0.2	11.9	1.8
Owasco Inlet Moravia Rt 38	0.9	475	13.2	0.4	2.8	21.6	4.0
Owasco Inlet Mill Creek	0.3	397	12.4	0.4	0.1	9.9	0.7
Owasco Inlet Aurora St	0.8	528	13.5	0.5	3.6	27.4	7.5
Owasco Inlet Fillmore Ck	0.0	230	12.9	0.1	0.5	8.9	0.7
Owasco Inlet VFW	0.7	496	13.3	0.2	3.9	17.3	2.6
Owasco Inlet Rounds Ln	0.6	502	13.4	0.3	2.9	15.7	2.4
Owasco Inlet Locke	0.5	502	13.2	0.6	3.8	17.7	2.0
Owasco Inlet Hemlock Cr	0.1	481	13.0	1.7	1.3	14.8	1.1
Owasco Inlet County Line	0.4	532	13.1	0.1	3.0	26.1	9.8
Owasco Inlet Groton	0.3	435	13.7	0.0	5.2	18.0	2.1
Fire Lane 20	0.0	666	12.1	2.0	4.2	12.1	0.8
2012 Annual Averages							
Date & Location	**Discharge**	**Specific Conductance**	**Water Temp**	**Nitrate**	**Suspended Solids**	**Total Phosphate**	**Phosphate SRP**
	(m^3/s)	(µS/cm)	(°C)	(mg/L, N)	(mg/L)	(µg/L, TP as P)	(µg/L, SRP as P)
Dutch Hollow 38A	0.4	482.6	14.7	0.5	7.3	25.0	2.5
Dutch Hollow North St	0.3	475.5	14.8	0.5	14.3	44.6	30.3
Dutch Hollow South Trib	0.1	548.5	11.9	1.4	1.6	13.8	2.6
Dutch Hollow Benson Rd Trib	0.0	772.2	13.0	1.3	1.6	32.6	12.1
Dutch Hollow Benson Rd	0.3	458.0	13.9	0.8	11.7	18.2	1.5
Dutcvh Hollow Murray Rd Trib	0.1	302.3	11.9	1.8	1.3	14.2	1.3
Dutch Hollow Old State Rd	0.3	465.7	12.0	0.4	6.0	14.4	2.1
Owasco Inlet Moravia Rt 38	1.8	441.1	14.9	1.1	4.3	23.9	5.6
Owasco Inlet Mill Creek	0.8	370.0	14.4	0.6	2.9	12.2	1.4
Owasco Inlet Aurora St	1.3	494.1	15.2	0.5	5.4	37.8	10.5
Owasco Inlet Fillmore Ck	0.1	195.8	15.3	0.1	0.9	10.4	0.9
Owasco Inlet VFW	1.0	437.9	15.4	0.5	7.6	23.2	9.1
Owasco Inlet Rounds Ln	0.8	464.8	17.2	0.9	5.6	22.3	3.3
Owasco Inlet Locke	0.9	477.4	17.1	0.7	5.5	25.4	5.1
Owasco Inlet Hemlock Cr	0.2	458.9	15.3	2.7	2.0	11.4	5.5
Owasco Inlet County Line	0.5	517.8	16.1	0.4	5.6	32.3	30.0
Owasco Inlet Groton	0.3	416.0	16.4	0.3	7.2	35.4	9.5
Fire Lane 20	0.0	615.8	12.0	4.1	2.6	14.7	23.3