



Princeton Hydro

LAKE HOPATCONG WATER QUALITY MONITORING ANNUAL REPORT 2015

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1.0 INTRODUCTION

Princeton Hydro, LLC conducted general water quality monitoring of Lake Hopatcong during the 2015 growing season (May through September). This monitoring program represents a continuation of the long-term monitoring program of Lake Hopatcong. While the 2010 through 2012 water quality monitoring programs have been funded with funds awarded to the Lake Hopatcong Commission by NJDEP through the Non-Point Source (319(h) of the Clean Water Act) grant program (Project Grant RP10-087), the water quality monitoring program of 2013 was funded through the Lake Hopatcong Foundation as a monetary match toward the grant. However, remaining funds in the 319(h) grant were made available for the 2014 and 2015 water quality monitoring programs.

The current water quality monitoring program is a modified version of the program that was originally initiated in the Phase I Diagnostic / Feasibility Study of Lake Hopatcong (PAS, 1983) and continued through the Phase II Implementation Projects. Both the Phase I and Phase II projects were funded by the US EPA Clean Lakes (314) Program. The modified monitoring program also continued through the development, revision and approval of the TMDL-based Restoration Plan, as well as through the installation of a series of watershed projects funded through two NJDEP 319 grants and a US EPA Targeted Watershed grant.

The current water quality monitoring program is valuable in terms of continuing to assess the overall “health” of the lake on a year to year basis, identifying long-term trends or changes in water quality, and quantifying and objectively assessing the success and potential impacts of restoration efforts. In addition, the in-lake water quality monitoring program will be an important component in evaluating the long-term success of the implementation of the phosphorus TMDL-based Restoration Plan, which was approved by NJDEP in April of 2006.

2.0 MATERIALS AND METHODS

In-lake water quality monitoring was conducted at the following eleven (11) locations in Lake Hopatcong (represented as red circles in Figure 1, Appendix A) during the study period:

<u>Station Number</u>	<u>Location</u>
1	Woodport Bay
2	Mid-Lake
3	Crescent Cove/River Styx
4	Point Pleasant/King Cove
5	Outlet
6	Henderson Cove
7	Inlet from Lake Shawnee
8*	Great Cove
9*	Byram Cove
10	Northern Woodport Bay
11	Jefferson Canals

* *In-situ* monitoring only

The 2015 sampling dates were 27 May, 16 June, 21 July, 18 August, and 22 September. A Eureka Amphibian PDA with Manta multi-probe unit was used to monitor the *in-situ* parameters: dissolved oxygen (DO), temperature, pH, and specific conductance during each sampling event. Data were recorded at 1.0 m increments starting at 0.25 m below the water's surface and continued to within 0.5-1.0 m of the lake sediments at each station during each sampling date. In addition, water clarity was measured at each sampling station with a Secchi disk.

Discrete water quality samples were collected with a Van Dorn sampling device at 0.5 m below the lake surface and 0.5 m above the sediments at the mid-lake sampling site (Station #2). Discrete samples were collected from a sub-surface (0.5 m) position at the remaining six (6) original sampling stations (Stations #1, 3, 4, 5, 6 and 7) and additionally at the Northern Woodport Bay and Jefferson Canals sites (Stations #10 and #11, respectively) on each date. Discrete water samples were appropriately preserved, stored on ice, and transported to a State-certified laboratory for the analysis of the following parameters:

- total suspended solids
- total phosphorus-P
- nitrate-N
- ammonia-N

- chlorophyll *a*

All laboratory analyses were performed in accordance with *Standard Methods for the Examination of Water and Wastewater, 18th Edition* (American Public Health Association, 1992). Monitoring at the Great Cove (Station #8) and Byram Cove (Station #9) sampling stations consisted of collecting *in-situ* and Secchi disk data; no discrete water samples were collected from these two stations for laboratory analyses. It should be noted that prior to 2005, Station #10 had been monitored for *in-situ* observations only. However, due to observations made at Station #10 by the Lake Hopatcong Commission operations staff, it was decided that this sampling station should be added to the discrete sampling list.

During each sampling event, vertical plankton tows were also conducted at the deep sampling station (Station #2). A 50- μm mesh plankton net was used to sample the phytoplankton, while a 150- μm mesh plankton net was used to sample the zooplankton. The vertical tows were deployed starting immediately above the anoxic zone (DO concentrations < 1 mg/L) and conducted through the water column to the surface.

Additional Water Quality Data Collected in 2015

In addition to the standard, long-term, in-lake monitoring program, supplemental in-lake data were collected as part of the 2015 monitoring program. From 2006 to 2015 some select, near shore, in-lake sampling sites were established and monitored. These additional in-lake sampling sites were located immediately adjacent to drainage areas where a stormwater structure was installed as part of an existing 319(h) grant (SFY05; Grant RP05-080). The three near-shore, in-lake sampling stations included:

1. The southern end of Crescent Cove in the Borough of Hopatcong (NPS-1).
2. Ingram Cove, located in the Borough of Hopatcong (removed from monitoring program).
3. Along the eastern shoreline of the lake, in the Township of Jefferson, just south of Brady's Bridge (NPS-2).

Through the course of implementing the SFY05 319(h) grant, it was determined that no BMP would be installed in the Ingram Cove drainage basin; the Ingram Cove project was dropped from the grant project due to site specific limitations associated with existing utilities. Subsequently, the proposed Ingram Cove project was moved to the Crescent Cove drainage area. However, monitoring of the Ingram Cove sampling station continued through 2008 and was discontinued from 2009 through the 2015 monitoring programs.

For the remaining two supplemental in-lake sampling stations, monitoring occurred during the May through September 2015 in-lake monitoring events. Monitoring included collecting *in-situ* data at 0.5 – 1.0 meters from surface to bottom for temperature, dissolved oxygen, pH and specific conductance. Water clarity was also measured at each station with a Secchi disk. Discrete mid-depth water samples were collected and analyzed for TP and TSS. The Crescent Cove station is NPS-1, while the Township of Jefferson station is NPS-2; both are shown in Figure 1 as yellow circles with an “X” inside (Appendix A).

As part of the SFY10 319 grant, some additional watershed-based restoration projects are being implemented to reduce the NPS pollutant load entering Lake Hopatcong, with an emphasis on TP and TSS. Similar to the SFY05 grant, three near-shore sampling sites were located immediately adjacent to drainage areas that were receiving a structural BMP or MTD as part of the SFY10 319(h) grant (Grant RP10-087). These three nearshore, in-lake sampling stations include:

1. In Ashley Cove in the Township of Jefferson (NPS-3).
2. In King Cove in the Township of Roxbury (NPS-4).
3. Southern end of the public beach at the Hopatcong State Park (NPS-5).

Similar to the SFY05 near-shore sampling program (NPS-1 and NPS-2), *in-situ* monitoring and discrete samples were collected for TP and TSS at the three SFY10 near-shore sampling stations during each of the five 2015 monitoring events. However, discrete samples were also collected for the analysis of chlorophyll *a*, a photosynthetic pigment all algae possess, at the SFY10 sampling stations.

3.0 RESULTS AND DISCUSSION

Thermal Stratification

Thermal stratification is a condition where the warmer surface waters (called the epilimnion) are separated from the cooler bottom waters (called the hypolimnion) through differences in density, and hence, temperature. Thermal stratification separates the bottom waters from the surface waters with a layer of water that displays a sharp decline in temperature with depth (called the metalimnion or thermocline). In turn, this separation of the water layers can have a substantial impact on the ecological processes of a lake (for details see below). Thermal stratification tends to be most pronounced in the deeper portions of a lake. Thus, for convenience, the discussion on thermal stratification in Lake Hopatcong focuses primarily on the deep, mid-lake (Station #2) sampling station.

In-situ measurements during the 2015 growing season were generally consistent with values recorded in previous monitoring programs. By the late May event, Station #2 exhibited thermal stratification with the epilimnion extending to 5.0 m and the thermocline located between 5.0 m and 9.0 m. A similar, yet slightly weaker degree of thermal stratification was also present at the other stations with sufficient depth (i.e. Stations 8 and 9). Stratification persisted throughout the rest of the sampling season with seasonally maximum values observed on 21 July 2015. Shallower stations throughout the lake lacked stratification.

All five 319 sampling sites were generally well mixed from May through late September 2015, with the exception being in May when NPS-5 exhibited some degree of thermal stratification.

Strong and extensive amounts of thermal stratification can effectively “seal off” the bottom waters from the surface waters and overlying atmosphere, which can result in a depletion of dissolved oxygen (DO) in the bottom waters. With the exception of a few groups of bacteria, all aquatic organisms require measurable amounts of DO (> 1 mg/L) to exist. Thus, once the bottom waters of a lake are depleted of DO, a condition termed anoxia, that portion of the lake is no longer available as viable habitat.

Dissolved Oxygen

Atmospheric oxygen enters water by diffusion from the atmosphere, facilitated by wind and wave action and as a by-product of photosynthesis. Adequate dissolved oxygen (DO) is necessary for acceptable water quality. Oxygen is a necessary element for most forms of life. As dissolved oxygen concentrations fall below 5.0 mg/L, aquatic life is put under stress. DO concentrations that remain below 1.0 – 2.0 mg/L for a few hours can result in large fish kills and loss of other aquatic life. Although some aquatic organisms require a minimum of 1.0 mg/L of DO to survive, the NJDEP State criteria for DO concentrations in surface waters is 5.0 mg/L or greater, for a healthy and diverse aquatic ecosystem.

In addition to a temporary loss of bottom habitat, anoxic conditions ($DO < 1$ mg/L) can produce chemical reactions that result in a release of dissolved phosphorus from the sediments and into the overlying waters. In turn, a storm event can transport this phosphorus to the upper waters and stimulate additional algal growth. This process is called internal loading. Given the temporary loss of bottom water habitat and the increase in the internal phosphorus load, anoxic conditions are generally considered undesirable in a lake.

Station #2 was well oxygenated during the May event from surface to 10.0 m with DO concentrations varying between 6.07 and 9.4 mg/L. The bottom of the lake exhibited conditions

below the recommended State threshold but were still “oxic” (with oxygen) with concentrations above 1.0 mg/L. However, by 16 June 2015, anoxic conditions (DO concentration < 1 mg/L) were established at Station #2 within the bottom meter of the water column (DO concentration of 0.75 mg/L). Station #2 was the only site that exhibited anoxic conditions during the month of June.

The month of July continued this trend, displaying anoxic conditions at Station #2 from 8.0 m to the sediments. On 18 August 2015, anoxic conditions continued to exist at Station #2 in the hypolimnetic (below the thermocline) zone of the lake. Station #9 exhibited anoxic conditions within the bottom meter of the lake during both July and August, while Station #5 was also anoxic immediately above the sediments but only in August 2015. All other sampling stations remained oxygenated throughout the growing season. By 22 September 2015 anoxic conditions in Station #2, were limited to depths of 11.0 meters or deeper.

All five of the NPS sampling stations were well oxygenated (DO > 5 mg/L) from surface to bottom during all five 2015 monitoring events. In addition, DO concentrations were frequently greater than 100% saturation, particularly during the months of May and July. Such conditions of super-saturation indicate the presence of high densities of algal and aquatic plant biomass and hence elevated rates of photosynthesis, which generates DO. Such super-saturation was particularly high throughout the season (as high as 160.1%) in NPS-1 (Crescent Cove), not once dropping below 100% saturation.

Overall, a depression of DO was mainly limited to the hypolimnion of Station #2, with instances of anoxic conditions in the bottom meter of Stations #5 and #9. Thus, the majority of the lake had a sufficient amount of DO to support a diverse and healthy aquatic ecosystem (Appendix B).

pH

The pH is defined as the negative logarithm of the hydrogen ion concentration in water. When pH values are greater than 7 they are termed alkaline while those less than 7 are acidic; a pH value of 7 is neutral. The optimal range of pH for most freshwater organisms is between 6.0 and 9.0. However, the NJDEP State water quality standard for pH is for an optimal range between 6.5 and 8.5.

Throughout the lake in May 2015, most pH values were generally acceptable, with the exception being Stations #3 and #5, where maximum values were 9.71 and 9.79 respectively. Also noted, Station #4 had a high of 9.1, just over the general optimal range. Several stations (#3, #4, #5, and #10) were above the NJDEP State standards. By 16 June 2015, the pH decreased across the

whole lake, with values in the 7's, as well as a few in the low 8's. This was largely a result of removing a large portion of the existing aquatic plant / mat algae biomass through the mechanical weed harvesting program during early June.

By 21 July, the pH throughout the lake ranged from mid to high 7's to high 8's, with the exception of Station #3 which experienced a high of 9.1. Overall July pH values were elevated from the last month, but mostly remained within optimal range. Stations #3, #9 and #10 had values above 8.5, which was above the standards for the NJDEP. It should be noted that the elevated pH levels (9.1) and supersaturated DO levels (132%) indicate that Station #3 (Crescent Cove/River Styx) was experiencing an algal bloom and/or high densities of aquatic vegetation (plants and mat algae).

By 18 August 2015, pH values throughout Lake Hopatcong ranged from mid-7's to mid-8's, with only one instance where the State standard was not met (Station #6). The September values also ranged from the mid-7s to mid-8s, however, Crescent Cove/River Styx (ST #3), the Outlet (ST #5) and Henderson Cove (ST #6) were above State thresholds.

The near-shore sampling areas (NPS 1 through 5) sustained higher pH values throughout the growing season when compared to open water stations. This is primarily due to elevated rates of photosynthesis from rooted aquatic vegetation and mat algae, in addition to the free-floating planktonic algae. The 18 August 2015 monitoring event was the time the pH did not exceed the upper limit for pH set by the NJDEP (8.5).

Water Clarity (as measured with a Secchi disk)

Water clarity or transparency was measured at each in-lake monitoring station, during each monitoring event, with a Secchi disk. Based on Princeton Hydro's in-house long-term database of lakes in northern New Jersey, water clarity is considered acceptable for recreational activities when the Secchi depth is equal to or greater than 1.0 m (3.3 ft).

In May 2015, Secchi depths were all equal to or greater than 1 meter or reached the bottom of the sampling site, which was the case for Station #11 where the total depth was 0.8 meters. In both June and July, Secchi depths remained equal to or greater than 1.0 meter. The same pattern was seen in the August and September sampling events. Secchi depth did not drop below the 1.0 meter threshold in open water stations during the growing season at Lake Hopatcong. The sub-optimal water clarity values seen in past years at River Styx / Crescent Cove and Woodport / Northern Woodport were not present in 2015.

Secchi depth among near-shore sampling Sites #2, #4 and #5 remained above the threshold of 1.0 meter or reached the bottom of the lake. The exceptions were NPS-1 and NPS-3 fell below the 1.0 meter criteria, with values of 0.9 m and 0.7 m respectively

Ammonia-Nitrogen (NH₄-N)

Surface water NH₄-N concentrations above 0.05 mg/L tend to stimulate elevated rates of algal growth. Ammonia concentrations measured during the May 2015 event varied from low (0.04 mg/L) at ST-1, ST-2, and ST-3 to high (0.26 mg/L) at ST-7. Bottom water NH₄-N concentrations were very excessive, at 0.72 mg/L, at the ST-2 deep water station, but elevated concentrations of NH₄-N are a natural occurrence in the bottom water of lakes due to the bacterial decomposition of organic material. By mid-June 2015 all NH₄-N concentrations were low throughout the lake (0.01 to 0.03 mg/L), except for deep waters of ST-2 (0.13 mg/L).

By July 2015, surface water NH₄-N concentrations varied from 0.02 mg/L at Stations #4 and #6 to 0.25 mg/L at Station #1. The bottom water concentrations increased to 0.64 mg/L. Stations #1, #5, and #10 were above the threshold of 0.05 mg/L, indicating a possibility for elevated algal growth. Concentrations in mid-August 2015 largely decreased, with surface water concentrations typically being non-detectable to 0.02 mg/L, with the exception of ST-10, with a value of 0.06 mg/L. Deep waters reached a concentration of 0.49 mg/L. In September 2015, NH₄-N concentrations were very low throughout the surface waters (non-detectable to 0.01 mg/L), while the deep waters at ST-2 continued to have a high concentration of NH₄-N (0.75 mg/L).

In summary, the excessively high concentration of NH₄-N in the deep (hypolimnetic) waters at ST-2 was attributed to the depletion of DO and the bacterial decomposition of the organic matter raining to the bottom from the surface waters. Surface water NH₄-N concentrations were consistently low from June through September, with only one spike at ST-1 in July; concentrations were moderate in May 2015. The elevated NH₄-N concentrations throughout the entire lake in the late spring of 2015 are at least partially, attributed to the heavy winter of 2014-2015. However, leachate from near-shore septic systems also attributed to the extremely high NH₄-N concentrations in the surface waters of some stations, such as ST-7 (0.26 mg/L), ST-10 (0.22 mg/L) and ST-11 (0.20 mg/L). The sub-watershed areas immediately adjacent to these sampling stations are known to have high densities of older (some > 50 years old), near-shore septic systems, which frequently contribute elevated pollutant loads (e.g. nitrogen, phosphorus, fecal coliform, and *E. coli*) to the lake.

Nitrate-Nitrogen (NO₃-N)

Nitrate-N concentrations greater than 0.1 mg/L are considered excessive relative to algal and aquatic plant growth. The State and Federal drinking water limit for nitrate-N is 10 mg/L. In May 2015, nitrate-N concentrations varied from non-detectable (ND<0.02 mg/L) to moderate (0.06 mg/L). The exception to this was at ST-2 DEEP, where the measured nitrate-N concentration was 0.14 mg/L. By mid-June 2015, almost all of the nitrate-N concentrations throughout Lake Hopatcong were below the 0.1 mg/L threshold, varying between <0.02 and 0.08 mg/L. The exception to this was once again ST-2 DEEP, where the measured concentration was 0.21 mg/L.

By July 2015, all measured nitrate-N concentrations were below the 0.1 mg/L threshold; however, ST-2 DEEP had the highest measured concentration at 0.08 mg/L. In mid-August 2015, five of the ten stations had non-detectable concentrations (ND<0.02 mg/L) but all sampling stations had nitrate-N concentrations below the 0.1 mg/L. In September 2015 nitrate-N concentrations were low throughout all of Lake Hopatcong, with nine of the ten stations with non-detectable concentrations, while ST-2 DEEP had a concentration of only 0.02 mg/L.

In summary, all in-lake nitrate-N concentrations were consistently below the State and Federal drinking water standard of 10.0 mg/L. Nitrate-N concentrations only exceeded the 0.1 mg/L threshold that stimulates elevated amounts of algal and aquatic plant growth in ST-2 DEEP in May and June. In 2014, exceedances typically occurred in those sections of the lake immediately adjacent to lands that have relatively higher amount of development and/or homes using septic systems (Borough of Hopatcong around Crescent Cove / River Styx; Township of Jefferson around Woodport and in the Canals).

Total Phosphorus (TP)

Phosphorus has been identified as the primary limiting nutrient for algae and aquatic plants in Lake Hopatcong. Essentially, a small increase in the phosphorus load will result in a substantial increase in algal and aquatic plant growth. For example, one pound of phosphorus can generate as much as 1,100 lbs of wet algae biomass. This fact emphasizes the continued need to reduce the annual phosphorus load entering Lake Hopatcong, as detailed in the lake's revised TMDL and associated Restoration Plan.

Studies have shown that TP concentrations as low as 0.03 mg/L can stimulate high rates of algal growth resulting in eutrophic or highly productive conditions. Based on Princeton Hydro's in-house database on northern New Jersey lakes, TP concentrations equal to or greater than 0.06

mg/L will typically result in the development of algal blooms / mats that are perceived as a nuisance by the layperson.

The State's Surface Water Quality Standard (SWQS, N.J.A.C. 7:9B – 1.14(c) 5) for TP in the surface waters of a freshwater lake or impoundment is 0.05 mg/L. This established TP concentration is for any freshwater lake or impoundment in New Jersey that does not have an established TMDL. Lake Hopatcong has established a phosphorus TMDL, which was revised and approved by NJDEP in June 2006. Based on its refined phosphorus TMDL, the long-term management goal is to maintain an average, growing season TP concentration of 0.03 mg/L within the surface waters of Lake Hopatcong.

TP concentrations measured in the surface waters during the May 2015 sampling event ranged from 0.02 mg/L to 0.05 mg/L with a surface water mean concentration of 0.031 mg/L. The deep water TP concentration at Station #2 was 0.02 mg/L.

TP concentrations in the surface waters during the June 2015 event ranged from 0.03 mg/L to 0.05 mg/L with a mean concentration of 0.038 mg/L. ST-2 DEEP remained at 0.02 mg/L. Once again all stations had concentrations equal to or below the State's Surface Water Quality Standard.

The surface water TP concentrations measured during the July 2015 event ranged from 0.01 mg/L to 0.03 mg/L, less than the State's Water Quality Standard. The TP concentration at ST-2 DEEP increased to 0.09 mg/L, but was a result of the depletion of DO immediately over the sediments. In the absence of DO, phosphorus normally adsorbed onto sediment particles, leaches into the overlying waters. However, it should be noted that the mean surface water TP concentration in July 2015 was 0.024 mg/L, which is below (and therefore acceptable) the TMDL established threshold of 0.03 mg/L.

In August 2015, all TP concentrations were below the State's Surface Water Quality Standard of 0.05 mg/L. The highest TP concentration of 0.03 mg/L was measured at ST-10. The TP concentration at ST-2 continued to increase, as anoxic conditions persisted. September 2015 continued this trend, as TP concentrations were consistently low throughout the lake, varying between 0.01 and 0.03 mg/L with an overall surface water mean of 0.02 mg/L. Thus, the mean surface water TP concentrations in August and September 2015 were below the TMDL established threshold of 0.03 mg/L.

Deep water TP concentrations at Station #2 varied between 0.02 and 0.22 mg/L, peaking in August. Again, the deep water TP concentrations increased over the growing season once the bottom waters were depleted of DO.

The mean TP concentration was calculated for each surface water sampling station to determine if they comply with or exceed the concentration of 0.03 mg/L established under the lake's TMDL. Of the nine standard, long-term water quality monitoring stations, all nine complied with the TMDL. That is, they had a mean 2015 growing season concentration at or less than 0.03 mg/L. In recent years, ST-3 (Crescent Cove/River Styx) and ST-10 (Northern Woodport Bay) were out of compliance with the TMDL or the State's Surface Water Quality Standard. As past monitoring data have revealed, these two sections of the lake were in the highest need of restoration efforts in order to move the lake into compliance with its TMDL. These sections of the lake have some of the highest density of residential housing and/or include lots with aged, near-shore septic system, which contributes to the elevated TP loads and concentrations. While the results of the 2015 monitoring program are positive, these sites should continue to be monitored since Lake Hopatcong is not yet in complete compliance with its TMDL for total phosphorus.

As part of the existing SFY05 319 grant, two large Aqua-Filter Manufactured Treatment Devices (MTDs) were installed in the southern end of the Crescent Cove drainage basin to reduce a large portion of the TP and TSS loads that enter the lake from this section of the watershed. The first MTD was installed in November of 2008, while the second was installed in June of 2011. The NPS-1 monitoring station was established in 2006 in order to assess how the implementation of these MTDs, as well as other restoration measures (i.e. sewerage part of the drainage area; more wide-spread use of non-phosphorus fertilizers) have impacted this section of the lake.

The data collected from 2006 to 2008 were prior to the installation of the two large Aqua-Filters, while the data collected in 2009 and 2010 were after the first Aqua-Filter was installed and the data collected in 2011 through 2015 were after the second Aqua-Filter was installed.

As shown in Table 1, before the first Aqua-Filter was installed, the mean growing season (May – September) TP concentration in Crescent Cove was 0.06 mg/L; these mean values are greater than both the State's Surface Water Quality Standard of 0.05 mg/L for standing waterbodies, as well as the targeted TMDL concentration of 0.03 mg/L. However, after the first Aqua-Filter was installed in late 2008, the mean TP concentration declined to 0.045 mg/L (Table 1; 2009 monitoring year). While this value was still greater than the targeted TMDL concentration of 0.03 mg/L, it was below the State's Surface Water Quality Standard of 0.05 mg/L. In addition, only one of four TP measurements in 2009 was above the State standard.

Table 1
The Mean and Range of TP and TSS Concentrations for Crescent Cove
Over the Growing Season of Each Monitored Year

Monitoring Year	TP mean and range	TSS mean and range
2006 (pre-installation)	0.06 mg/L (0.05 – 0.075 mg/L)	10 mg/L (6 – 15 mg/L)
2007 (pre-installation)	0.06 mg/L (0.04 – 0.08 mg/L)	7 mg/L (3 – 11 mg/L)
2008 (pre-installation)	0.06 mg/L (0.04 – 0.08 mg/L)	14 mg/L (1.5 – 48 mg/L)
2009 (post-installation)	0.045 mg/L (0.03 – 0.06 mg/L)	7 mg/L (1.5 – 8 mg/L)
2010 (post-installation)	0.07 mg/L (0.02 – 0.09 mg/L)	8 mg/L (1 -15 mg/L)
2011 (post-installation)	0.04 mg/L (0.01 – 0.08 mg/L)	5 mg/L (1 – 11 mg/L)
2012 (post-installation)	0.06 mg/L (0.03 – 0.08 mg/L)	6 mg/L (3 – 10 mg/L)
2013 (post-installation)	0.05 mg/L (0.04 – 0.07 mg/L)	7 mg/L (2 – 15 mg/L)
2014 (post-installation)	0.05 mg/L (0.03 – 0.09 mg/L)	8 mg/L (4 – 13 mg/L)
2015 (post-installation)	0.04 mg/L (0.03 – 0.05 mg/L)	4 mg/L (1.5 – 5 mg/L)

In sharp contrast to the 2009 results, during the 2010 growing season, only one of the five sampling events was below the State Standard at NPS-1. The mean TP concentration at NPS-1 in 2010 was 0.07 mg/L greater than the mean values measured prior to the installation of the Aqua-Filter (2006-08). These conditions were in spite of the fact that 2010 had a relatively dry growing season. More than likely, these elevated TP concentrations indicated that the first Aqua-Filter needed to be maintained. Specifically, the filter pillows needed to be replaced and the Aqua-Swirl portion of the structure needed to be cleaned out. At a minimum, the Aqua-Filter should be inspected quarterly and accumulated material in the Aqua-Swirl should be vacuumed out several times a year. This would allow the structure to at least continue to remove accumulated sediments and the phosphorus adsorbed onto such particles. However, to maximize its phosphorus removal capacity, the filter pillows should be replaced as well.

The second Aqua-Filter was operating by the end of June 2011 and the resulting mean 2011 growing season TP concentration for NPS-1 was 0.04 mg/L, the lowest mean value of the entire 2006 - 2015 dataset (Table 1). Of the five 2011 sampling events, only one was above the State standard. In addition, three of the five had TP concentrations at or below the TP concentration targeted under the TMDL (0.03 mg/L). However, by 2012 TP concentrations were again on the rise with a mean of 0.06 mg/L, again above the State threshold (Table 1 and Figure 1). Of the five measurements collected over the 2012 growing season, only two were below the State

threshold. In 2013, the mean TP concentration was 0.05 mg/L (Table 1), with three of the five values at or below the State standard.

The 2014 monitoring data were similar to that documented in 2013. That is, the mean TP concentration was 0.05 mg/L. Additionally, three of the five TP concentrations were below the State's standard.

In 2015, the mean TP concentration once again decreased to 0.04 mg/L, which is within the State standard of 0.05 mg/L. All of the five TP concentrations fell at or below this standard, while only one met the TMDL targeted concentration of 0.03 mg/L (Figure 1). A comparison of the overall pre-installation mean TP concentration (0.06 mg/L; 2006 to 2008) to the overall post-installation mean TP concentration (0.05 mg/L; 2009 to 2015) indicates that the Aqua-Filter stormwater systems have contributed toward an approximately 17% reduction in the in-cove phosphorus concentrations. More importantly, based on input provided by the Borough of Hopatcong, they have been cleaning out the Aqua-Swirl portion of these stormwater structures for at least the last 1-2 years. Thus, the reduction in TP over the last few years is more than likely attributed to this re-initiation of maintaining a portion of these stormwater MTDs.

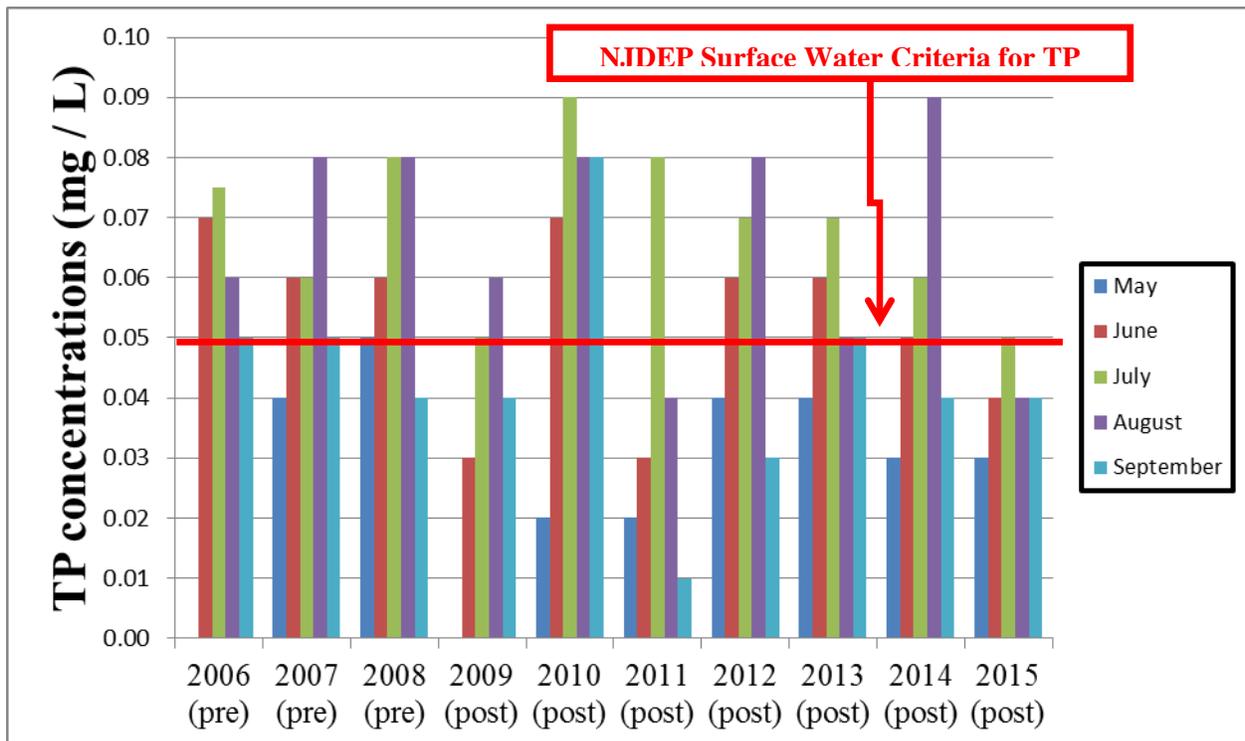
While not discussed in a high level of detail as TP, it should be noted that there has been a measurable decline in total suspended solids (TSS) concentrations once the Aqua-Filters were installed. Prior to their installation (2006 – 2008), TSS concentrations ranged from 1.5 to 48 mg/L, with growing season means ranging from 7 to 14 mg/L. In contrast, after the Aqua-Filters were installed, TSS concentrations ranged from 1 to 15 mg/L, with growing season means ranging from 4 to 8 mg/L (Table 1). A comparison of the overall pre-installation mean TSS concentration (10 mg/L; 2006 to 2008) to the overall post-installation mean TSS concentration (6.4 mg/L; 2009 to 2015) indicates that the Aqua-Filter stormwater systems have contributed toward a 36% reduction in the in-cove TSS concentrations. Thus, in-lake TP and TSS concentrations were lower in the southern end of Crescent Cove, once the Aqua-Filters were installed. However, it is worth repeating that in order to maximize pollutant removal efficiencies, both structures, at a minimum, should be cleaned out at least once a year.

As previously mentioned, based on some conversations over the last years, it is understood that the Borough of Hopatcong has been at least pumping out the Aqua-Swirl portion of the two stormwater structures in the Hopatcong Beach Club's parking lot. Routine clean-outs of these stormwater structures have directly contributed to these reduced TP and TSS concentrations in the southern end of Crescent Cove. However, in order to continue to reduce the concentrations and loads of these pollutants, the following must be conducted:

1. At a minimum, inspect the Aqua-Swirl portion of the Aqua-Filter 2-4 times a year and pump out the Aqua-Swirl portion of each structure at least once a year.
2. Inspect and clean out the Aqua-Filter chambers; in addition, if possible replace the existing filter pillows with new ones (the filter pillows are designed to remove dissolved phosphorus from the stormwater).

Finally, while some reductions in TP and TSS concentrations have been made, there is still more pollutant loading that needs to be addressed in this part of the Lake Hopatcong watershed. Other sources of untreated stormwater and leachate from aged, near-shore septic systems have contributed to elevated concentrations of TP in the River Styx / Crescent Cove part of the lake. Thus, additional restoration measures need to be implemented.

Figure 1
TP Concentrations in Crescent Cove (NPS-1) Over the Growing Season of Each Monitored Year from 2006 to 2015



Chlorophyll a

Chlorophyll *a* is a pigment possessed by all algal groups, used in the process of photosynthesis. Its measurement is an excellent means of quantifying algal biomass. In general, an algal bloom is typically perceived as a problem by the layperson when chlorophyll *a* concentrations are equal to or greater than 30.0 µg/L. Based on the findings of the refined TMDL, the existing average seasonal chlorophyll *a* concentration under current conditions is 15 µg/L, while the maximum seasonal value is 26 µg/L. In contrast, the targeted average and maximum chlorophyll *a* concentrations, once Lake Hopatcong is in complete compliance with the TMDL, are predicted to be 8 and 14 µg/L, respectively.

Chlorophyll *a* concentrations during the May 2015 event ranged from 3.4 µg/L at Station #3 to 12.7 µg/L at Station #11 with a mean concentration of 8.5 µg/L. The mean value for May 2015 was only 0.5 µg/L over the targeted average, while the maximum value was below the suggested maximum. The mean in May of 2015 was the minimum concentration found in the May of 2014, while the maximum was half the value that was produced in the May of 2014 (26.2 µg/L). Thus, the spring algal bloom of 2014 was substantially larger than the spring algal bloom of 2015. No 2015 values exceeded the targeted maximum concentration.

Chlorophyll *a* concentrations increased at six of the nine sampling stations, yet decreased at the other three by the mid-June 2015 event, with concentrations ranging from 3.7 µg/L at Station #6 to 16.0 µg/L at Station #1 with a mean concentration of 10.3 µg/L. The mean is above the targeted average value and the maximum value is just 2 µg/L units above the targeted maximum concentration. Of the nine June 2015 concentrations, only three (Stations #1, #10 and #11) exceeded the targeted maximum concentration under the TMDL.

Chlorophyll *a* continued to increase by the July event with concentrations ranging from 4.1 µg/L at Station #7 to 19.0 µg/L at Station #10 with a mean concentration of 12.1 µg/L. The mean July concentration exceeded the targeted mean of 8 µg/L, while the maximum threshold concentration was exceeded in three of the nine sampling stations and included the Outlet, Northern Woodport Bay, and Jefferson Canal sampling stations (Stations #5, #10 and #11).

In mid-August chlorophyll *a* concentrations varied between 3.6 µg/L at Station #7 to 13.0 µg/L at Station #10 with a mean concentration of 8.2 µg/L, decreasing from the previous month. Five of the nine sampling stations exceeded the targeted TMDL mean, while none of the stations exceeded the maximum threshold of 14 µg/L.

In September 2015 chlorophyll *a* concentrations decreased even further, varying from 3.3 µg/L at Station #7 to 11.0 µg/L at both Stations #1 and #2 with a mean concentration of 6.0 µg/L. In September, three of the nine sampling stations had concentrations that exceeded the targeted mean concentration (Stations #1, #2 and #10). None of the sampling sites in September 2015 were above the maximum threshold concentration.

Chlorophyll *a* concentrations at the NPS-3 station remained low throughout the growing season, ranging from a low of 2.8 µg/L in September and a high of 6.4 µg/L in August, all below the targeted mean and maximum threshold. NPS-4 was lowest during the May event with a concentration of 1.6 µg/L, increasing to above the mean threshold in both June (8.4 µg/L) and July (9.4 µg/L). By August, the chlorophyll *a* concentration decreased to 7.2 µg/L, ultimately declining to 3.1 µg/L by September. NPS-5 remained below the targeted mean during all months, except August where it increased to 13 µg/L. All concentrations remained below the maximum threshold.

Phytoplankton

Phytoplankton are algae that are freely floating in the open waters of a lake or pond. These algae are vital to supporting a healthy ecosystem, since they are the base of the aquatic food web. However, high densities of phytoplankton can produce nuisance conditions. The majority of nuisance algal blooms in freshwater ecosystems are the result of cyanobacteria, also known as blue-green algae. Some of the more common water quality problems created by blue-green algae include bright green surface scums, taste and odor problems and the generation of cyanotoxins.

Table 1 lists the dominant phytoplankton identified in Lake Hopatcong during each water quality monitoring event in 2015. Algal diversity was moderately high during the 27 May 2015 event with a documented bloom of *Tabellaria*. Diatoms *Asterionella* and *Fragilaria* were relatively common as well.

Total algal abundance increased to 12 separate genera identified during the 16 June 2015 sampling event. Several diatoms (*Asterionella*, *Fragilaria* and *Tabellaria*) and blue-green algae (*Aphanizomenon* and *Oscillatoria*) were relatively common during this sampling event. Various green algae, diatoms, cryptomonads and dinoflagellates were also present.

The 21 July 2015 sampling event algal abundance was similar to the previous event, yielding 11 genera. Blue-green algae (*Aphanizomenon* and *Oscillatoria*) were quite common during this sampling event. Various green algae, chrysophytes and diatoms were also present.

By 18 August 2015 algal abundance was moderate with 12 genera identified and the dominant group again being the blue-green algae. Three genera were identified as common (*Aphanizomenon*, *Oscillatoria* and *Anabaena*). Four genera of green algae, including *Chlorella*, *Chlamydomonas*, *Scenedesmus* and *Pediastrum*, were all identified as moderate numbers.

Total algal abundance and diversity were highest during the 22 September 2015 sampling event with 18 different genera identified. The dominant algae were the diatom *Tabellaria* and the blue-green alga *Oscillatoria*. A bloom of *Tabellaria* was seen at this time. Eight genera of green algae were identified, along with diatoms, blue-greens, dinoflagellates, chrysophytes and cryptomonads.

While blue-greens were present throughout the entire 2015 growing season, high density, bloom proportions were not seen. Often listed as present or common, and the absence of nuisance cyanotoxin blooms, indicates that overall water quality conditions were improved in 2015, in particular when compared to conditions observed in 2014.

Zooplankton

Zooplankton are the micro-animals that live in the open waters of a lake or pond. Some large-bodied zooplankton are a source of food for forage and/or young gamefish. In addition, many of these large-bodied zooplankton are also herbivorous (i.e. algae eating) and can function as a natural means of controlling excessive algal biomass. Given the important role zooplankton serve in the aquatic food web of lakes and ponds, samples for these organisms were collected at Station #2 during each monitoring event. The results of these samples are provided in Table 2.

The zooplankton community identified during the 27 May 2015 sampling event showed co-dominance of the copepod *Cyclops* and the small-bodied cladoceran *Bosmina*. The herbivorous cladoceran *Daphnia* and the rotifer *Keratella* were also identified, but in lower densities. Only four genera were identified at this time.

During the 16 June 2015 sampling event, zooplankton abundance and diversity increased, yielding 8 different genera of cladocerans, copepods and rotifers. The most abundant zooplankton were the rotifer *Keratella* and the cladoceran *Bosmina*.

Similar zooplankton abundances and diversity were seen during the 21 July 2015 sampling event. The cladoceran *Bosmina* was most common zooplankter during this event. The community also consisted of four rotifers (*Keratella*, *Asplanchna*, *Polyarthra* and *Conochilus*), three copepods (*Cyclops*, *Nauplii*, and *Diaptomus*), and the cladoceran *Ceriodaphnia*.

Generally low zooplankton densities were noted during the 18 August 2015 sampling event where *Bosmina* was most common. Only five genera were identified at this time, including two copepods (*Cyclops* and *Nauplii*) and two rotifers (*Keratella* and *Polyarthra*)

During the 22 September 2015 sampling event zooplankton abundance was high and included three rotifers (*Asplanchna*, *Keratella* and *Polyarthra*), two cladocerans (*Ceriodaphnia* and *Bosmina*) and three copepods (*Cyclops*, *Diaptomus* and *nauplii*). The cladoceran species, *Bosmina*, was the dominant genera of this sampling event.

Similar to past monitoring years, herbivorous zooplankton were present in Lake Hopatcong, but in low densities during spring. Such conditions are indicative of a fishery community dominated by a large number of small, zooplankton-feeding fishes (e.g. golden shiners, alewife, young perch), where large-bodied zooplankton cannot exert a high degree of algal control through grazing.

Table 1
Phytoplankton in Lake Hopatcong
during the 2015 Growing Season

Sampling Date	Phytoplankton
27 May 2015	Algal abundance was moderate, but diversity was low. A bloom of <i>Tabellaria</i> occurred at this time. Other common algae included the diatoms, <i>Fragilaria</i> and <i>Asterionella</i> . Various green algae, blue-greens, euglenoids, and dinoflagellates were listed as present.
16 June 2015	Total algal abundance was moderately high. Common zooplankton were the blue-green algae <i>Aphanizomenon</i> and <i>Oscillatoria</i> and the diatoms <i>Asterionella</i> and <i>Fragilaria</i> . In addition, a variety of other diatoms, green algae, cryptomonads and dinoflagellates were present.
21 July 2015	Algal abundance was moderate, with the most common genera being the blue-green algae <i>Aphanizomenon</i> and <i>Oscillatoria</i> . Several green algae, cryptomonads, diatoms and other blue-green algae were present in varying densities.
18 August 2015	Algal abundance was moderate with the most common genera being the blue-green algae <i>Anabaena</i> and <i>Oscillatoria</i> . Four genera of green algae were identified as present. <i>Dinobryon</i> , <i>Ceratium</i> , <i>Tabellaria</i> and <i>Aphanizomenon</i> were also present. A few <i>Phacus</i> were seen during this event.
22 September 2015	Abundance was high with a bloom of the diatom <i>Tabellaria</i> . The chrysophyte <i>Dinobryon</i> and the blue-green alga <i>Oscillatoria</i> were also common. In addition, several genera of green algae, dinoflagellates, blue-greens and diatoms were identified as present.

Table 2
Zooplankton in Lake Hopatcong
during the 2015 Growing Season

Sampling Date	Zooplankton
27 May 2015	Zooplankton numbers were high, yet had low levels of diversity (4 genera were identified) and co-dominance was exerted between the copepod <i>Cyclops</i> and the small-bodied cladoceran <i>Bosmina</i> . <i>Daphnia</i> was also present, but was not as prolific as the other zooplankters.
16 June 2015	Zooplankton abundance was low to moderate with high diversity (8 genera were identified). The cladoceran <i>Bosmina</i> and the rotifer <i>Keratella</i> were common. A variety of rotifers (<i>Asplanchna</i> , <i>Polyarthra</i> and <i>Conochilus</i>), copepods (<i>Cyclops</i> and <i>Diaptomus</i>) and the cladoceran <i>Ceriodaphnia</i> were also present.
17 July 2014	Zooplankton abundance was low to moderate, with a high diversity. The cladoceran <i>Bosmina</i> was common during this event. Present were four rotifers (<i>Asplanchna</i> , <i>Keratella</i> , <i>Polyarthra</i> and <i>Conochilus</i>), three copepods (<i>Cyclops</i> , <i>Diaptomus</i> , and <i>Nauplii</i>) and the cladoceran <i>Ceriodaphnia</i> .
15 August 2014	Low zooplankton abundance and diversity were noted during this event with only 5 genera recorded. <i>Bosmina</i> was common during this event. Two genera of rotifers (<i>Keratella</i> and <i>Polyarthra</i>) and two genera of copepods (<i>Cyclops</i> and <i>Nauplii</i>) were identified as present.
1 October 2014	The zooplankton community exhibited moderate abundance. The dominant zooplankton was <i>Bosmina</i> . Seven other genera were listed as present, including three rotifers (<i>Keratella</i> , <i>Asplanchna</i> and <i>Polyarthra</i>), three copepods (<i>Cyclops</i> , <i>Diaptomus</i> , and <i>Nauplii</i>) and the cladoceran <i>Ceriodaphnia</i> .

Recreational Fishery and Potential Brown Trout Habitat

Of the recreational gamefish that reside or are stocked in Lake Hopatcong, trout are the most sensitive in terms of water quality. For their sustained management, all species of trout require DO concentrations of at least 4 mg/L or greater. However, the State's designated water quality criterion to sustain a healthy, aquatic ecosystem is a DO concentration of at least 5 mg/L.

While all trout are designated as coldwater fish, trout species display varying levels of thermal tolerance. Brown trout (*Salmo trutta*) have an optimal summer water temperature range of 18 to 24°C (65 to 75°F) (USEPA, 1994). However, these fish can survive in waters as warm as 26°C (79°F) (Scott and Crossman, 1973), defined here as acceptable habitat. The 2015 temperature and DO data for Lake Hopatcong were examined to identify the presence of optimal and acceptable brown trout habitat. As with previous monitoring reports, this analysis focused primarily on *in-situ* data collected at the mid-lake sampling station (Station #2).

For the sake of this analysis, sections of the lake that had DO concentrations equal to or greater than 5 mg/L and water temperatures less than 24°C were considered optimal habitat for brown trout. In contrast, sections of the lake that had DO concentrations equal to or greater than 5 mg/L and water temperatures between 24 and 26°C were considered carry over habitat for brown trout.

Optimal brown trout habitat was identified from the surface waters down to a depth of 10.0 meters at Station #2 during the May 2015 sampling event. By June 2015, the optimal habitat decreased to depths between 3.0 to 7.0 meters with carry over habitat was found from the surface to 2.0 meters.

In July 2015 carry over trout habitat was limited to depths of 4.0 and 5.0 meters as temperature increased over the summer season; no optimal habitat was not present in July. Similar habitat conditions were identified in August 2015, with carry over conditions ranging from 4.0 to 6.0 meters. By mid-September 2015, the optimal brown trout habitat was re-established from the surface waters to depths of 8.0 meters.

In 2014, varying levels of optimal and acceptable brown trout habitat occurred. However, optimal brown trout habitat was found throughout the entire growing season, although it was limited in July to depths of 5 to 6 meters. The persistence of optimal brown trout habitat through the entire 2014 growing season was attributed to the relatively cool conditions of 2014. The *in-situ* data showed both optimal and acceptable brown trout habitat during the 2015 growing season in Lake Hopatcong. Optimal trout habitat was not present during two of the five sampling events, while carry over habitat was present throughout the entire 2015 growing season.

Mechanical Weed Harvesting Program

Many of the more shallow sections of Lake Hopatcong are susceptible to the proliferation of nuisance densities of rooted aquatic plants. Given the size of Lake Hopatcong, the composition of its aquatic plant community, and its heavy and diverse recreational use, mechanical weed harvesting is the most cost effective and ecologically sound method of controlling nuisance weed densities. Thus, the weed harvesting program has been in operation at Lake Hopatcong since the mid-1980's with varying levels of success. However, one consistent advantage mechanical weed harvesting has over other management techniques, such as the application of aquatic herbicides, is that phosphorus is removed from the lake along with the weed biomass. In fact, based on a plant biomass study conducted at Lake Hopatcong in 2006 and the plant harvesting records from 2006 to 2008, approximately 6-8% of the total phosphorus load targeted for reduction under the established TMDL was removed through the mechanical weed harvesting program.

In sharp contrast to the 2006 – 2008 harvesting years, only 1.2% of the phosphorus load targeted for reduction under the TMDL was removed through mechanical weed harvesting during the 2009 growing season. This substantial reduction in the amount of plant biomass and phosphorus removed in 2009 was due to severe budgetary cuts that resulted in laying off the Commission's full time Operation Staff and late start up date. In turn, this resulted in only 1.2% of the plant biomass harvested in 2009. However, the 2010 harvesting season resulted in the estimated removal of approximately 6% of the phosphorus load targeted for reduction under the TMDL, similar to the percentages removed in 2006 – 2008.

In contrast to the 2012 growing season, the mechanical weed harvesting program ran longer in 2013 through 2015. This was primarily due to the fact that the program was initiated earlier in these years relative to 2012. NJDEP has directly overseen the operation of the weed harvesting program for the last three years and each year displays a higher rate of removal, which was attributed to becoming more familiar with the operations and lake-specific conditions. In addition, the operations staff has been excellent at maximizing high rates of efficiency during harvesting operations.

The mechanical weed harvesting program at Lake Hopatcong over the 2015 growing season, from early June through the end of September, resulted in the removal of approximately 2,842 cubic yards of wet plant biomass (slightly more than removed in 2013 and 2014), which resulted in the removal of 60 lbs (27 kg) of phosphorus. In turn, this accounted for 0.83% of the TP load targeted for removal under the TMDL. During the 2011 and 2012 harvesting events these removal rates were 0.3% and 0.6%, respectively, of the TP load targeted for removal under the TMDL. The 60 lbs of TP removed through the 2015 weed harvesting program had the potential to generate up to 66,293 lbs of additional wet algal biomass.

Inter-annual Analysis of Water Quality Data

Annual mean values of Secchi depth, chlorophyll *a* and total phosphorus concentrations were calculated for the years 1991 through 2015. The annual mean values for Station #2 were graphed, along with the long-term, “running mean” for the lake.

The 2015 mean Secchi depth was 2.2 meters, which was higher than the relatively low mean of 1.8 meters of 2014. Additionally, the last time mean Secchi depth was 1.8 meters was 2005 (Figure 2 in Appendix A). The improved water clarity conditions of 2015 contributed to the high amount of aquatic macrophytes (plants and mat algae) in the lake.

Mean algal biomass, measured as chlorophyll *a* concentrations, was 8.7 mg/m³, which was substantially lower than the long-term high mean value of 18.0 mg/m³ measured in 2014 (Figure 3 in Appendix A).

While mean values of Secchi depth and chlorophyll *a* concentrations clearly indicate that Lake Hopatcong experienced substantially larger algal blooms in 2014 and a higher amount of aquatic vegetation in 2015, the mean TP concentrations for both years was 0.017 mg/L (Figure 4 in Appendix A). These results indicate that a large portion of the algal biomass measured in the middle of the lake in 2014 originated from other sections of the lake, primarily the River Styx / Crescent Cove section of the lake where elevated TP concentrations led to a massive blue-green algal bloom in early August 2014. This bloom actually produced cyanotoxin (microcystin-LR) concentrations above the World Health Organization’s recreational threshold. More than likely prevailing winds transported a large portion of this algal bloom into the middle of the lake. Indeed, the chlorophyll *a* concentration at ST-2 in August 2014 was 30.0 mg/m³.

Water Quality Impairments and Established TMDL Criteria

As identified in N.J.A.C. 7:9B-1.5(g)2 “Except as due to natural condition, nutrients shall not be allowed in concentrations that cause objectionable algal densities, nuisance aquatic vegetation or otherwise render the waters unsuitable for the designated uses.” For Lake Hopatcong, these objectionable conditions specifically include both algal blooms and nuisance densities of aquatic vegetation.

As described in detail in the Lake Hopatcong TMDL Restoration Plan, a targeted mean TP concentration, as well as mean and maximum chlorophyll *a* ecological endpoints, was established to identify compliance with the TMDL. For the sake of this 2015 analysis, the mid-lake (Station #2), Crescent Cover / River Styx (Station #3) and Northern Woodport Bay (Station #10) monitoring stations were reviewed. To provide guidance for this review, the criteria developed under Lake Hopatcong’s TMDL are provided below:

TMDL Criteria for Lake Hopatcong

Targeted mean TP concentration	0.03 mg/L
Targeted mean chlorophyll <i>a</i> concentration endpoint	8 mg/m ³
Targeted maximum chlorophyll <i>a</i> concentration endpoint	14 mg/m ³

The 2015 seasonal mean and single TP concentrations at Station #2 were all consistently below or equal to the targeted mean TP concentration, recognized under the TMDL (0.03 mg/L). The seasonal mean chlorophyll *a* concentration exceeded the targeted mean chlorophyll *a* concentration of 8 mg/m³. None of the single chlorophyll *a* concentrations in Station #2 were greater than the targeted maximum chlorophyll *a* concentration endpoint, only reaching a value of 11 mg/m³.

For Station #3, the mean TP concentration in 2015 (0.026 mg/L) was below the targeted mean of 0.03 mg/L. Only one TP concentration exceeded the established TMDL threshold and that was in June (0.04 mg/L). In addition, the mean chlorophyll *a* concentration was only slightly above the targeted mean, with a concentration of 8.26 mg/m³. All chlorophyll *a* concentrations were less than or equal to the maximum chlorophyll *a* concentration threshold.

At Station #10, the mean TP concentration in 2015 (0.032 mg/L) for Station #10 was slightly above the targeted mean of 0.03 mg/L, only exceeding it by 0.002 mg/L. The mean concentration of chlorophyll *a* (13.24 mg/m³) exceeded the targeted mean concentration of 8 mg/m³. Two of the five sampling events (June and July) were greater than the targeted maximum chlorophyll concentration endpoint of 14 mg/m³.

4.0 SUMMARY

This section provides a summary of the 2015 water quality conditions, as well as recommendations on how to preserve the highly valued aquatic resources of Lake Hopatcong.

1. By late May 2015 the lake was already thermally stratified, but was well oxygenated from surface to 10 meters with DO concentrations greater than 5.0 mg/L. In June, this range of oxygenated water decreased to a depth of 7 meters. From July to September 2015 the lake remained thermally stratified to varying degrees with the anoxic zone reaching a depth between 8 and 11 meters.
2. It has been well documented that phosphorus is the primary limiting nutrient in Lake Hopatcong. That is, a slight increase in phosphorus will result in a substantial increase amount of algal and/or aquatic plant biomass. TP concentrations in the surface waters of Lake Hopatcong typically varied between 0.02 mg/L and 0.04 mg/L, with a few instances of TP concentrations reaching 0.05 mg/L at Stations #1 and #11 (Woodport Bay and Jefferson Canals).
3. None of the nine sampling stations had a mean TP concentration greater than the targeted mean concentration of 0.03 mg/L, as recognized under the TMDL. However, Crescent Cove/River Styx and Northern Woodport Bay should remain closely monitored, as nearby stormwater runoff and septic systems contribute to elevated phosphorus loading.
4. TP and TSS values continued to decrease at NPS-1 to mean concentrations of 0.04 mg/L and 4 mg/L, respectively, under post-installation Aqua-Filter conditions. In order to continue to maximize pollutant removal efficiencies, both structures should be inspected and maintained (cleaned out) between 1 – 4 times per year.
5. Based on the *in-situ* conditions, optimal brown trout habitat was present in May, June, and September 2015. However, carry-over brown trout habitat was present from June through July, ranging from 4 to 6 meters (13 to 20 ft deep). Thus, some type of brown trout habitat was present throughout the 2015 growing season.
6. NJDEP continued to increase its efficiency in mechanical weed harvesting at Lake Hopatcong. During the 2015 harvesting program approximately 2,842 cubic yards of wet plant biomass was removed. This resulted in removing 60 lbs of TP, accounting for 0.83% of the TP targeted for removal under the TMDL. This was a slight increase in the amount of weeds harvested in 2015 relative to 2014 (approximately 198 more cubic yards).

7. From 2014 to 2015 Secchi depths (water clarity) were higher and chlorophyll a concentrations were lower. This increase in water clarity in 2015 due to a lower abundance of algae in the water led to the high densities of submerged vegetation. However, in spite of this the mean, mid-lake TP concentrations were the same in 2014 and 2015. This indicates that the high amount of algae in the surface waters at ST-2 in 2014 were attributed to blooms being transported to the mid-lake section of the lake due to wind and wave action. More than likely these blooms originated from the Crescent Cove / River Styx section of the lake.

8. Finally, it should be noted that a nuisance algal bloom of the blue-green alga *Anabaena* occurred in early August 2014 in the Crescent Cove / River Styx section of the lake and was sampled by NJDEP. This monitoring included an analysis for microcystin-LR, which is a cyanotoxin that has recently been recognized as a pollutant of concern by US EPA. An analysis of near-shore samples collected in 2014 revealed elevated concentrations of microcystin-LR, above the World Health Organization's recreational threshold of 20 ug/L. In response to this Princeton Hydro conducted some near-shore / beach sampling in 2015 for blue-green algae enumeration and the measurement of microcystin-LR with the Abraxis test strip analysis. Samples were collected from six near-shore / beach locations in June, July and August of 2015. The algal enumeration results will be forwarded as an addendum to this report; however, shown below are the results from the microcystin-LR analyses. No measurable concentrations of this cyanotoxin were identified during any of the sampling events or any of the sampling stations in 2015 (see below). Such results are not surprising since algal densities were substantially lower in 2015 relative to 2014; however, with US EPA Health Advisories anticipated to be announced for recreational waterbodies in May 2016, the Lake Hopatcong Commission must be aware of the potential recreational and health-related impacts associated with these cyanotoxins. In turn, the TMDL is designed to reduce the TP concentration in the lake, which in turn, will reduce the amount of blue-green algae in the water (the group of algae that produce cyanotoxins).

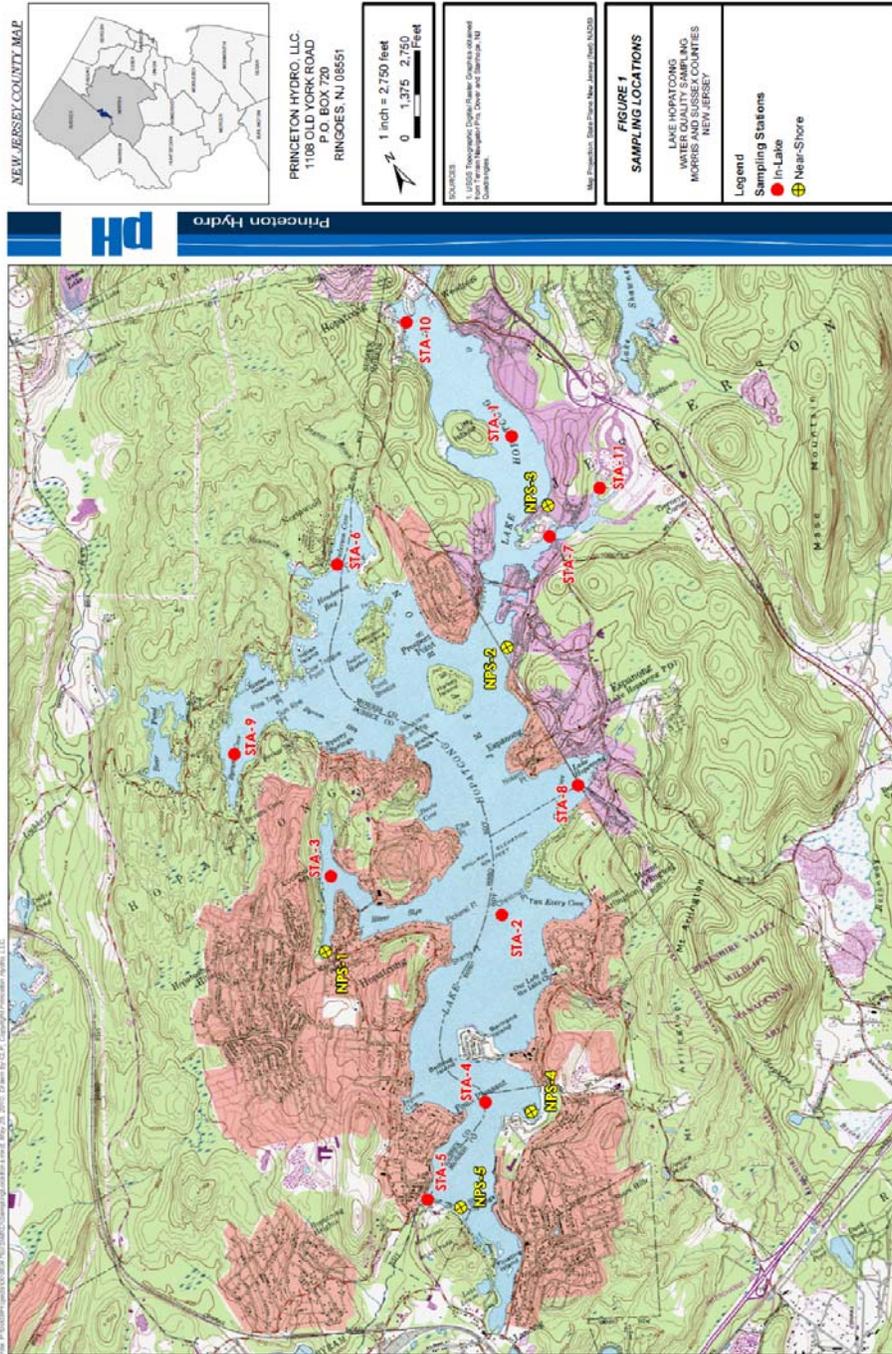
Lake Hopatcong Microcystin-LR Testing for 2015

Near-Shore Sampling Station	6/16/2015*	21-Jul-15	22-Sep-15
Beach in Northern Jefferson (B-1)	0 ppb / 0 ppb	0 ppb	0 ppb
CAPP Beach (B-2)	0 ppb / 0 ppb	0.5 ppb	0 ppb
Western shoreline of Crescent Cove (B-3)	0 ppb / 0 ppb	0 ppb	0 ppb
Borough of Hopatcong Beach (B-4)	0 ppb / 0 ppb	0 ppb	0 ppb
Barnes Bros Beach (B-5)	0 ppb / 0 ppb	0 ppb	0 ppb
Hopatcong State Park Beach (B-6)	0 ppb / 0 ppb	0 ppb	0 ppb

* two microcystin samples were run per collected water sample

APPENDIX A

FIGURES



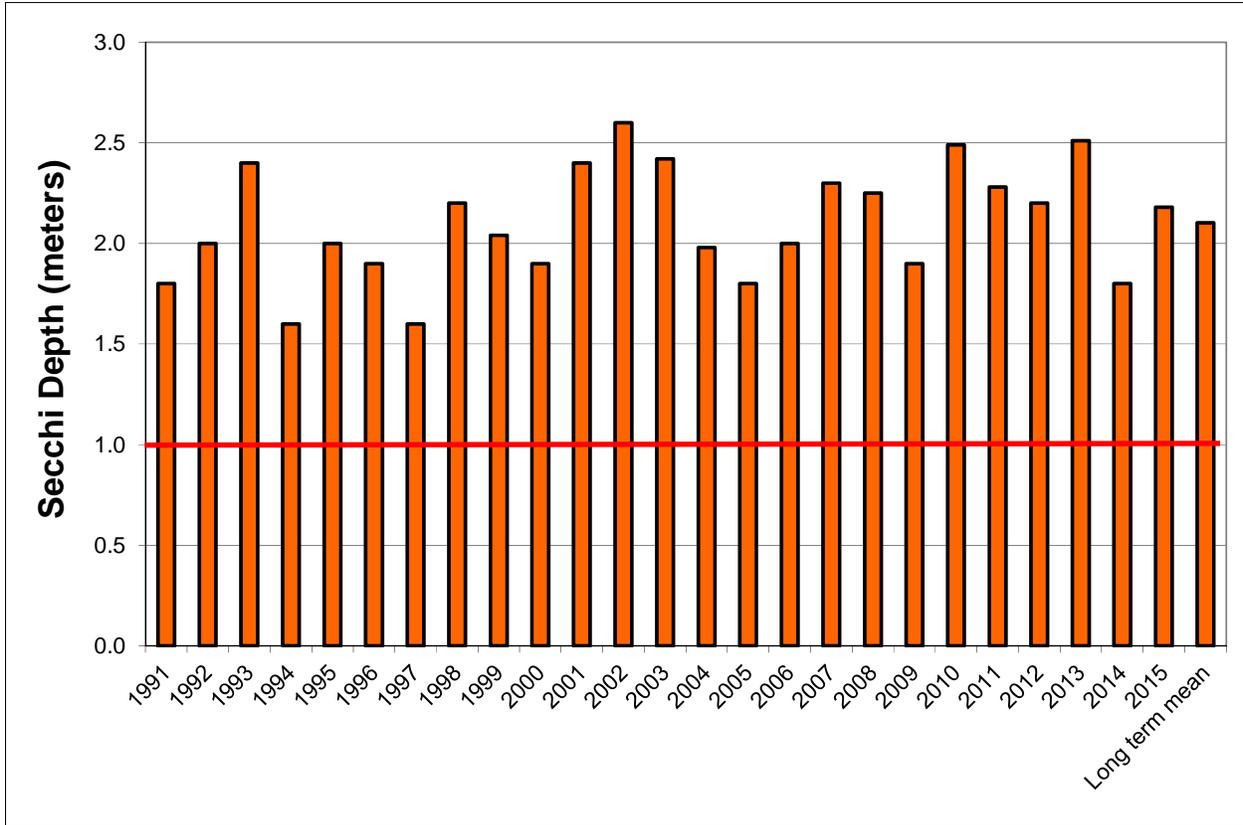


Figure 2 - Lake Hopatcong Long-Term Secchi Depth (meters)

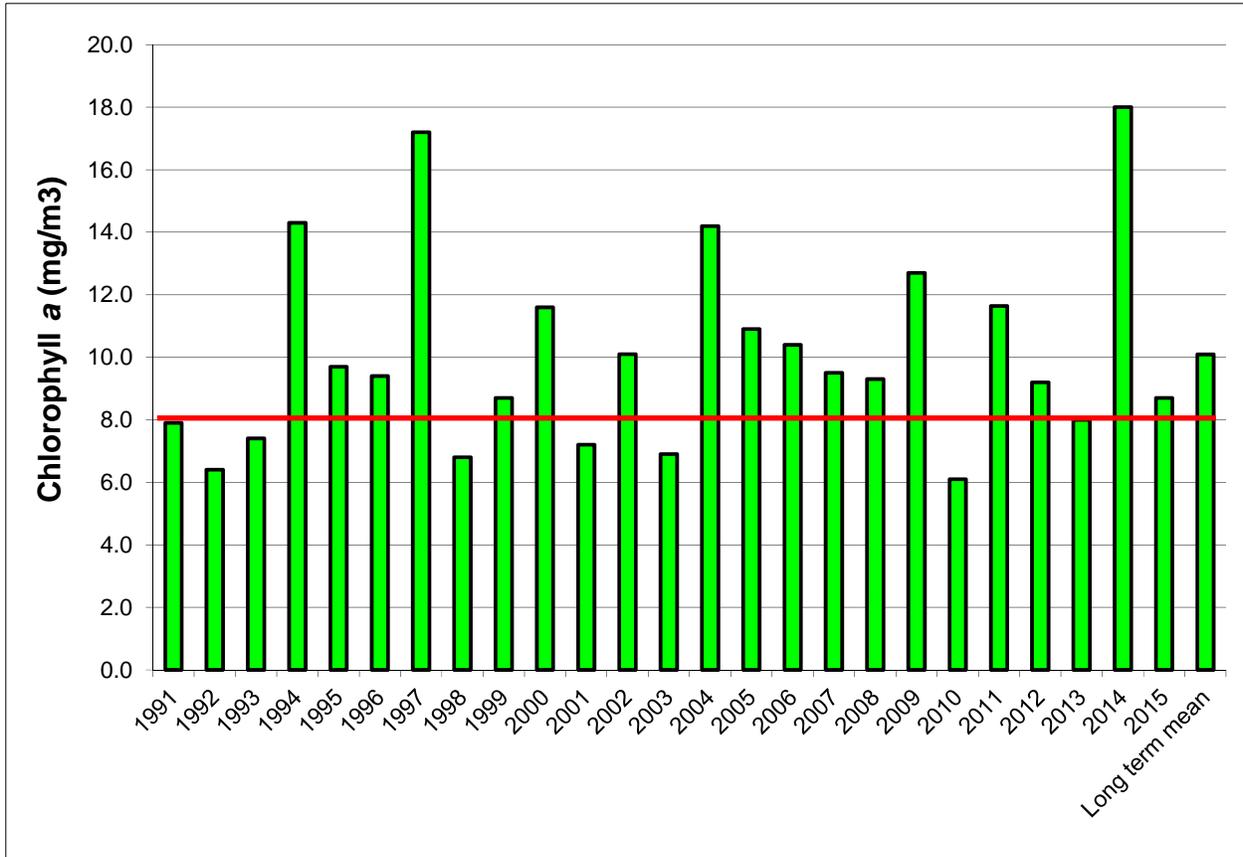


Figure 3 - Lake Hopatcong Long-Term Chlorophyll a Concentrations (mg/m³)

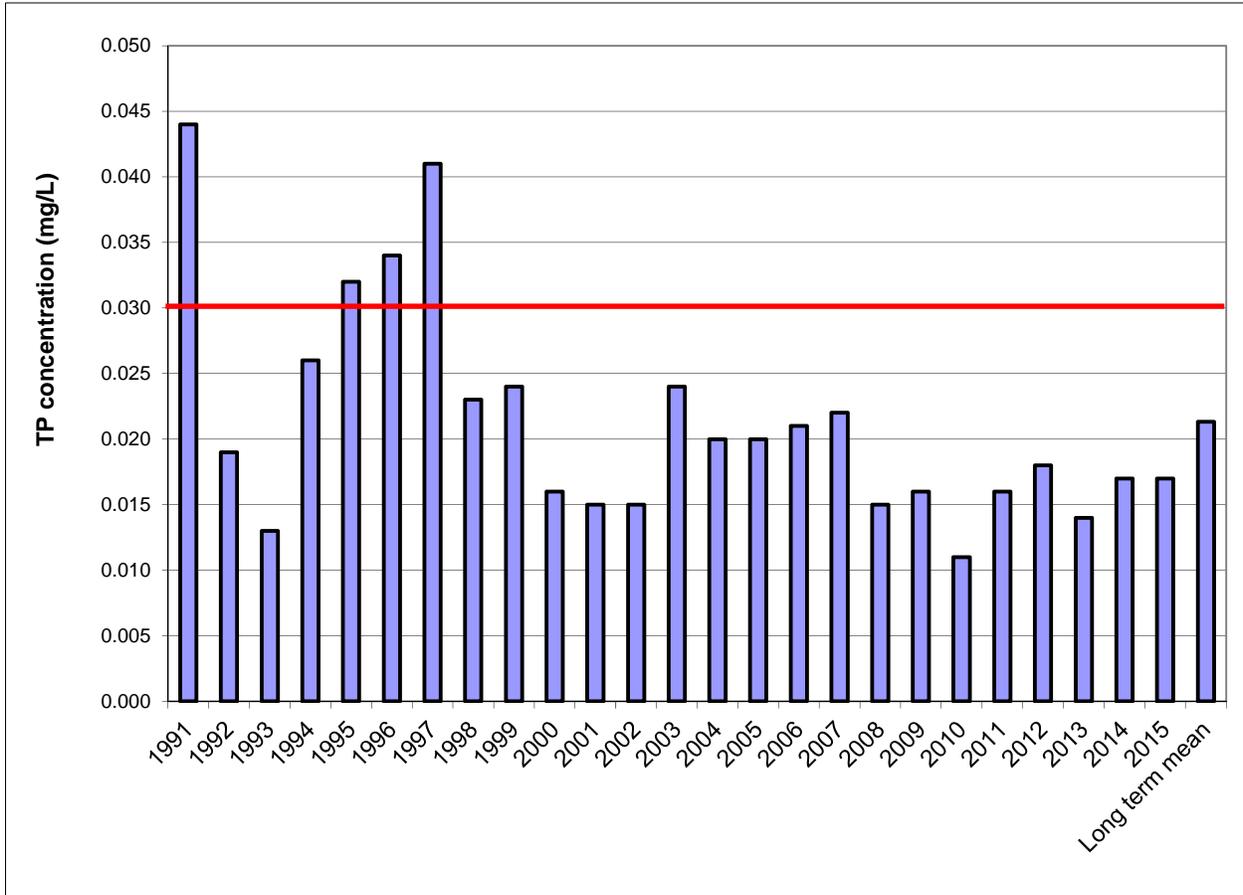


Figure 4 - Lake Hopatcong Long-Term Total Phosphorus Concentrations (mg/L)

APPENDIX B
IN-SITU DATA

In-Situ Monitoring for Lake Hopatcong 5/27/15								
Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	Dissolved Oxygen	pH
	Total	Secchi	Sample	(°C)	(mmhos/cm)	(mg/L)	(%)	(units)
ST-1	1.8	1.5	Surface	21.83	0.529	8.71	100	8.36
			1.0	21.8	0.53	8.73	100.2	8.09
			1.5	21.52	0.535	8.5	97	8.01
ST-2	13.5	1.8	Surface	19.07	0.453	9.4	102.2	8.48
			1.0	19.06	0.453	9.39	102.1	8.29
			2.0	18.99	0.453	9.39	102	8.23
			3.0	18.78	0.453	9.37	101.3	8.21
			4.0	18.45	0.452	9.34	100.3	8.21
			5.0	17.87	0.451	9.31	98.7	8.21
			6.0	16.44	0.449	9.08	93.6	8.19
			7.0	13.99	0.443	8.79	85.9	8.17
			8.0	12	0.441	7.76	72.6	8.12
			9.0	10.81	0.44	6.74	61.3	8.07
			10.0	10.39	0.44	6.07	54.7	8.01
			11.0	10.05	0.44	4.15	37.1	7.9
			12.0	9.8	0.441	4.16	37	7.87
13.0	9.66	0.442	4.04	35.8	7.84			
13.5	9.6	0.465	3.66	32.3	7.73			
ST-3	2	1.5 (SAV)	Surface	22.87	0.721	10.03	117.5	9.53
			1.0	22.46	0.76	10.89	126.7	9.71
			2.0	18.5	1.107	7.71	83.1	8.83
ST-4	3	1.8	Surface	20.1	0.46	9.36	103.9	9.1
			1.0	19.95	0.459	9.39	104	8.84
			2.0	18.18	0.452	9.36	99.9	8.64
			3.0	17.16	0.452	8.43	88.1	8.46
ST-5	3	2.5	Surface	22.18	0.465	9.54	110.2	9.26
			1.0	21.27	0.461	10.44	118.6	9.78
			2.0	18.14	0.454	11.63	124.1	9.75
			3.0	17.09	0.458	12.33	128.7	9.79
ST-6	2.2	1.9	Surface	22.71	0.458	9.03	105.5	8.24
			1.0	22.69	0.458	9.15	106.8	8.07
			2.0	21.69	0.459	7.8	89.3	7.89
ST-7	1.5	1	Surface	23.92	0.409	8.54	102	7.88
			1.0	23.82	0.406	8.48	101.2	7.71
			2.0	23.7	0.401	8.3	98.7	7.66
ST-8	7.2	2	Surface	20.42	0.455	9.24	103.2	8.18
			1.0	20.41	0.455	9.34	104.3	8.04
			2.0	19.72	0.453	9.38	103.4	8.02
			3.0	19.46	0.453	9.39	102.9	8.01
			4.0	19.16	0.453	9.35	101.9	8
			5.0	19.06	0.452	9.29	101	8.01
			7.0	16.7	0.45	8.84	91.6	7.99
ST-9	7.5	2	Surface	21.1	0.455	8.88	100.5	8.16
			1.0	21.03	0.455	9.1	102.9	8.02
			2.0	20.88	0.454	9.24	104.2	8
			3.0	19.77	0.455	9.43	103.9	8.01
			4.0	19.12	0.452	9.48	103.2	8.02
			5.0	18.65	0.453	9.37	101	8.03
			7.0	17.11	0.45	9.41	98.3	8.04
ST-10	1.6	1.6+	Surface	23.43	0.559	8.86	104.9	8.78
			1.0	23.32	0.559	8.97	106	8.62
			1.5	23.15	0.559	8.98	105.8	8.61
			0.5	23.8	0.365	8.87	105.7	7.95
ST-11	0.8	0.8+	Surface	23.8	0.365	8.87	105.7	7.95
			0.5	23.57	0.362	8.69	103.2	7.75

In-Situ Monitoring for Lake Hopatcong 6/16/15								
Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	Dissolved Oxygen	pH
	Total	Secchi	Sample	(°C)	(mmhos/cm)	(mg/L)	(%)	(units)
ST-1	1.5	1.5+	Surface	25.59	0.54	8	98.7	7.98
			1.0	25.59	0.539	7.88	97.1	7.76
			1.5	25.58	0.54	7.77	95.8	7.7
ST-2	13.5	2.5	Surface	24.51	0.468	8.67	104.7	7.7
			1.0	24.52	0.467	8.99	108.6	7.8
			2.0	24.52	0.467	9.05	109.4	7.82
			3.0	23.73	0.465	9.17	109.2	7.84
			4.0	22.75	0.466	9.14	106.8	7.83
			5.0	21.19	0.464	9.18	104.1	7.8
			6.0	18.32	0.458	9.24	98.9	7.74
			7.0	15.12	0.453	7.73	77.4	7.66
			8.0	13.89	0.451	4.26	41.5	7.54
			9.0	11.96	0.449	2.82	26.3	7.47
			10.0	11.13	0.449	2.01	18.4	7.41
			11.0	10.62	0.449	1.44	13.1	7.36
			12.0	10.23	0.449	1.29	11.6	7.35
			13.0	9.73	0.455	1.07	9.5	7.31
13.5	9.61	0.484	0.75	6.6	7.25			
ST-3	2	1.1	Surface	25.36	0.771	7.14	87.7	7.72
			1.0	25.09	0.74	6.86	83.9	7.71
			2.0	22.76	0.865	4.52	53	7.33
ST-4	2.8	2.8+	Surface	24.5	0.465	8.78	106	7.41
			1.0	24.5	0.465	8.57	103.6	7.33
			2.0	23.23	0.466	8.63	101.7	7.34
			2.5	22.42	0.467	7.48	86.8	7.26
ST-5	2	2.0+	Surface	24.81	0.463	8.04	97.7	7.4
			1.0	24.78	0.463	7.96	96.7	7.37
			2.0	24.75	0.463	7.18	87.2	7.28
ST-6	2.2	2.1	Surface	25.69	0.456	8.74	107.8	8.22
			1.0	25.71	0.456	8.73	107.8	8.17
			2.0	24.77	0.473	6.85	83.2	7.78
ST-7	1.4	1.4+	Surface	25.94	0.305	7.36	91.2	7.43
			1.0	25.81	0.305	7.21	89.2	7.22
			1.4	25.57	0.321	6.98	85.9	7.01
ST-8	7.3	2.6	Surface	24.42	0.468	9.07	109.3	7.89
			1.0	24.44	0.467	9.07	109.4	7.93
			2.0	24.24	0.465	8.93	107.3	7.84
			3.0	23.94	0.465	8.91	106.5	7.84
			4.0	22.75	0.465	9.05	105.8	7.81
			5.0	21.31	0.465	8.95	101.8	7.8
			6.0	20.35	0.461	8.72	97.3	7.76
			7.0	16.28	0.457	8.85	90.8	7.72
ST-9	7.8	2.5	Surface	25.05	0.462	8.77	107	7.96
			1.0	25.03	0.462	8.95	109.2	7.9
			2.0	24.86	0.464	9.01	109.6	7.87
			3.0	24.48	0.464	8.99	108.5	7.86
			4.0	23.29	0.469	8.99	106.2	7.86
			5.0	19.97	0.46	8.5	94.1	7.84
			6.0	18.52	0.458	8.15	87.6	7.78
			7.0	16.77	0.456	7.18	74.5	7.72
7.5	15.19	0.464	4.91	49.3	7.55			
ST-10	1.2	1.2+	Surface	25.84	0.547	8.57	106.1	8.31
			1.0	25.85	0.547	8.53	105.7	8.28
ST-11	1	1+	Surface	25.38	0.309	6.79	83.3	7.64
			1.0	25.07	0.308	5.6	68.3	7.15

In-Situ Monitoring for Lake Hopatcong 7/21/15								
Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	Dissolved Oxygen	pH
	Total	Secchi	Sample	(°C)	(mmhos/cm)	(mg/L)	(%)	(units)
ST-1	1.8	1	Surface	28.08	0.522	7.84	101	8.13
			1.0	28.08	0.522	7.79	100.4	7.89
			1.5	28.05	0.523	7.76	100.1	7.82
ST-2	13.8	2.5	Surface	26.85	0.477	8.6	108.4	8.2
			1.0	26.81	0.474	8.65	109	8.01
			2.0	26.78	0.474	8.69	107.5	8.05
			3.0	26.5	0.472	8.72	108.9	8.06
			4.0	25.54	0.471	8.59	105.4	7.99
			5.0	24.23	0.468	6.5	78.1	7.67
			6.0	21.7	0.463	4.54	51.1	7.5
			7.0	18.94	0.46	2	18.6	7.35
			8.0	16.1	0.458	<1	7.1	7.32
			9.0	13.12	0.456	<1	7.3	7.32
			10.0	12.14	0.455	<1	2	7.32
			11.0	11.26	0.452	<1	1.3	7.31
			12.0	10.54	0.455	<1	<1	7.33
			13.0	9.9	0.468	<1	<1	7.3
13.5	9.71	0.476	<1	<1	7.33			
ST-3	2.8	1.3	Surface	27.95	0.683	9.77	126.6	9.01
			1.0	27.68	0.631	10.29	132.3	9
			2.0	26.63	0.597	5.82	70.3	7.74
ST-4	2.8	1.5	Surface	27.17	0.477	8.42	106.9	7.85
			1.0	27.09	0.476	8.55	108.3	7.75
			2.0	27.02	0.476	8.55	108	7.74
			2.5	25.44	0.474	7.1	86.5	7.56
ST-5	2.9	1.5	Surface	27.07	0.478	8.46	107.2	7.52
			1.0	27.08	0.478	8.47	107.3	7.53
			2.0	26.24	0.476	7.61	93.8	7.37
			2.5	25.37	0.489	4.51	53.5	6.97
ST-6	2.2	1.6	Surface	27.82	0.465	8.98	115.2	8.36
			1.0	27.76	0.465	9.14	117.3	8.23
			2.0	26.91	0.471	7.14	90.1	7.79
ST-7	1.5	1.5+	Surface	27.87	0.373	8.28	106.4	7.75
			1.0	27.42	0.385	8.04	102.2	7.75
			1.5	26.95	0.375	6.14	73.4	7.2
ST-8	7	2.1	Surface	27.34	0.476	8.55	108.9	8.06
			1.0	27.29	0.476	8.66	110.3	8.05
			2.0	27.13	0.474	8.75	110.8	8.04
			3.0	26.83	0.472	8.71	109.6	8
			4.0	25.56	0.47	8.53	103.9	7.95
			5.0	23.92	0.468	8.17	96.4	7.84
			6.0	22.66	0.465	6.77	79	7.69
			7.0	19.94	0.471	4.53	45.7	7.42
ST-9	7.9	2	Surface	27.07	0.474	9.08	115.2	8.55
			1.0	26.9	0.474	9.31	117.8	8.43
			2.0	26.73	0.474	9.48	119.7	8.45
			3.0	26.01	0.471	9.47	117.6	8.39
			4.0	25.9	0.472	9.26	113.1	8.21
			5.0	24.73	0.472	8.85	106.1	8.09
			6.0	23.01	0.466	7.27	82.8	7.85
			7.0	20.68	0.462	5.16	54.9	7.69
ST-10	1.4	1	Surface	27.69	0.554	8.86	113.4	8.96
			1.0	27.52	0.538	9.23	118.3	8.67
			1.3	27.46	0.538	9.1	116	8.51
			1.1	27.2	0.297	7.44	93.5	7.93
ST-11	1.1	1.1+	Surface	27.2	0.297	7.44	93.5	7.93
			1.0	26.31	0.288	5.85	73	7.4

In-Situ Monitoring for Lake Hopatcong 8/18/15								
Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	Dissolved Oxygen	pH
	Total	Secchi	Sample	(^o C)	(mmhos/cm)	(mg/L)	(%)	(units)
ST-1	1.7	1	Surface	27.62	0.515	7.05	89.4	7.54
			1.0	27.45	0.517	6.86	84.9	7.51
			1.5	26.93	0.523	7.16	89.8	7.5
ST-2	13.8	2.1	Surface	26.24	0.467	8.14	101	7.8
			1.0	26.21	0.465	8.12	101.7	7.71
			2.0	26.21	0.472	8.24	102.1	7.69
			3.0	26.15	0.466	8.28	103.1	7.7
			4.0	25.31	0.467	8.36	102	7.76
			5.0	24.7	0.464	7.6	91.4	7.76
			6.0	24.07	0.467	6.46	75.3	7.71
			7.0	22.29	0.46	3.1	33.6	7.66
			8.0	18.24	0.459	<1.0	6.5	7.61
			9.0	14.71	0.459	<1.0	5.2	7.63
			10.0	12.34	0.461	<1.0	4.2	7.62
			11.0	11.47	0.461	<1.0	3.5	7.59
			12.0	10.87	0.462	<1.0	3.1	7.57
			13.0	10.12	0.474	<1.0	2.8	7.52
ST-3	2	1.2	Surface	28.21	0.603	8.62	113.4	8.05
			1.0	27.51	0.661	9.34	121.6	8.41
			2.0	26.34	0.716	2.25	26.3	8.19
ST-4	2	2.0+	Surface	27.01	0.478	8.26	103.6	7.73
			1.0	26.99	0.47	8.18	102.6	7.62
			2.0	26.4	0.413	8.02	98.2	7.62
ST-5	3	1.4	Surface	26.8	0.469	8.48	101.4	7.77
			1.0	26.78	0.469	8.12	100.8	7.58
			2.0	26.67	0.473	7.7	94.8	7.52
			3.0	25.74	0.482	<1.0	11.2	7.48
ST-6	2.2	2	Surface	27.3	0.467	9.15	116.2	8.26
			1.0	27.17	0.461	9.18	115.6	8.48
			2.0	26.91	0.467	9.56	118	8.58
ST-7	1.6	1.1	Surface	27	0.521	6.44	79.9	7.63
			1.0	26.71	0.523	5.96	73.4	7.4
			1.5	26.55	0.532	5.49	70	7.33
ST-8	7.2	2.5	Surface	26.86	0.471	7.97	99.7	7.74
			1.0	26.88	0.467	8.1	101.1	7.66
			2.0	26.79	0.471	8.17	103.2	7.64
			3.0	26.56	0.47	8.37	102.7	7.68
			4.0	25.22	0.461	8.25	96.7	7.69
			5.0	24.56	0.471	7.56	88.4	7.68
			6.0	23.76	0.467	6.6	72.4	7.65
			7.0	23.08	0.461	4.58	66.8	7.61
ST-9	8	2.2	Surface	26.81	0.467	8.86	108.3	8.36
			1.0	26.49	0.467	8.2	108.5	8.31
			2.0	26.22	0.464	8.77	109.3	8.32
			3.0	26.09	0.464	9	110.9	8.31
			4.0	25.84	0.457	9.08	106.6	8.32
			5.0	25.23	0.463	8.74	104.6	8.23
			6.0	24.23	0.462	8.07	89.8	8.21
			7.0	22.89	0.466	2.59	28.5	8.15
ST-10	1.5	1.1	Surface	27.23	0.523	8.01	98.2	7.8
			1.0	26.75	0.531	7.56	94	7.67
			1.5	26.68	0.526	7.48	94.3	7.63
ST-11	1	1.0+	Surface	25.7	0.528	5.62	66.5	7.56
			1.0	25.2	0.521	5.11	61	7.43

In-Situ Monitoring for Lake Hopatcong 9/22/15								
Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	Dissolved Oxygen	pH
	Total	Secchi	Sample	(°C)	(mmhos/cm)	(mg/L)	(%)	(units)
ST-1	1.3	1.2	Surface	20.73	0.536	7.37	82.1	7.83
			1.0	20.72	0.54	7.36	81.2	7.71
ST-2	13.6	2	Surface	21.57	0.471	6.87	77.8	7.94
			1.0	21.59	0.474	6.81	77.3	7.79
			2.0	21.61	0.468	6.9	78.3	7.75
			3.0	21.61	0.474	6.85	78.1	7.73
			4.0	21.61	0.468	7.22	78.2	7.73
			5.0	21.6	0.474	6.87	78.5	7.7
			6.0	21.6	0.473	6.92	78.8	7.69
			7.0	21.6	0.474	7.03	79.7	7.67
			8.0	21.55	0.473	6.83	77.4	7.66
			9.0	17.85	0.464	2.45	24.5	7.61
			10.0	14.08	0.468	1.3	12.2	7.57
			11.0	11.52	0.477	<1	9.4	7.48
			12.0	10.78	0.483	<1	8.3	7.45
13.0	10.23	0.485	<1	7	7.39			
13.5	10	0.741	<1	6.1	7.26			
ST-3	1.8	1.4	Surface	20.89	0.681	8.53	95.6	8.66
			1.0	20.81	0.691	8.71	97	8.78
			1.5	20.44	0.677	7.04	77.4	8.82
ST-4	2.8	2.2	Surface	20.28	0.478	7.57	83.3	7.99
			1.0	20.28	0.477	7.5	81.8	7.95
			2.0	20.29	0.48	7.43	82.6	7.96
			2.5	20.29	0.475	7.35	81.4	8
ST-5	3	2.5	Surface	20.01	0.48	8.39	89.9	7.69
			1.0	20.03	0.477	7.87	86.3	8.19
			2.0	19.9	0.473	8.07	87.2	8.57
			3.0	19.91	0.474	5.94	57.6	8.48
ST-6	2.1	1.9	Surface	20.93	0.476	8.41	94.3	8.42
			1.0	20.93	0.47	8.44	93.9	8.49
			2.0	20.9	0.47	8.34	90.7	8.56
ST-7	1.3	1.3+	Surface	19.97	0.634	6.46	70.5	7.64
			1.0	19.79	0.625	6.56	71.7	7.52
ST-8	7.5	2	Surface	21.5	0.476	7.19	71.9	7.45
			1.0	21.52	0.475	6.8	76.5	7.39
			2.0	21.53	0.475	6.73	76.4	7.4
			3.0	21.53	0.473	6.86	76.4	7.38
			4.0	21.52	0.471	6.8	77.4	7.4
			5.0	21.48	0.471	6.71	76.1	7.4
			6.0	21.44	0.474	6.72	75.7	7.4
			7.0	21.44	0.474	6.8	74.6	7.4
ST-9	7.7	1.7	Surface	21.99	0.471	7.29	83.5	8.11
			1.0	22	0.47	7.24	82.5	7.98
			2.0	21.97	0.475	7.32	82.6	7.96
			3.0	21.96	0.475	7.36	82.3	7.94
			4.0	21.92	0.475	7.1	81.2	7.92
			5.0	21.92	0.476	7.25	80.9	7.9
			6.0	21.91	0.472	7.26	81.2	7.9
			7.0	21.74	0.476	7.45	81.5	7.88
ST-10	1.2	1.2+	Surface	19.81	0.538	6.93	75.4	7.83
			1.0	19.8	0.547	6.91	76	7.72
ST-11	1	1.0+	Surface	19.06	0.617	6.05	64.3	7.62
			1.0	19.05	0.636	5.73	61.6	7.47

<i>In-Situ Monitoring for Hopatcong 319 Stations 5/27/15</i>								
Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	Dissolved Oxygen	pH
	Total	Secchi	Sample	(^o C)	(mmhos/cm)	(mg/L)	(%)	(units)
NPS 1	1.1	1.1+	Surface	22.87	1.573	11.01	129.4	9.51
			1.00	21.69	1.462	13.94	160.1	10.01
NPS 2	0.8	0.8+	Surface	22.11	0.462	8.55	98.7	8
			1.00	22.12	0.462	8.43	97.3	8.03
NPS 3	0.6	0.6+	Surface	23.26	0.53	9.31	109.9	9.03
			0.50	23.14	0.528	9.86	116.2	9.17
NPS 4	1	1.0+	Surface	21.75	0.502	10.34	118.5	9.26
			1.00	21.48	0.5	10.14	115.6	8.71
NPS 5	2	2.0+	Surface	21.82	0.47	11.07	127.1	10.3
			1.00	21.12	0.464	12.16	137.8	10.15
			1.50	17.83	0.458	9.64	102.2	9.08

<i>In-Situ Monitoring for Hopatcong 319 Stations 6/16/15</i>								
Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	Dissolved Oxygen	pH
	Total	Secchi	Sample	(^o C)	(mmhos/cm)	(mg/L)	(%)	(units)
NPS 1	1.2	0.95	Surface	25.29	1.129	10.02	123	8.8
			1.00	24.33	1.159	10.37	125.2	8.58
NPS 2	0.75	0.75+	Surface	25.65	0.448	7.79	96.1	8.25
			0.75	25.66	0.448	7.49	92.4	8.24
NPS 3	0.5	0.5+	Surface	26.38	0.501	9.02	112.8	9.21
			0.50	26.17	0.501	9.08	113.1	9.12
NPS 4	1.4	1.4+	Surface	24.56	0.489	7.04	85.2	7.33
			1.00	24.56	0.48	6.04	73	7.13
NPS 5	0.5	0.5+	Surface	25.37	0.468	8.5	104.4	7.84

<i>In-Situ Monitoring for Hopatcong 319 Stations 7/21/15</i>								
Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	Dissolved Oxygen	pH
	Total	Secchi	Sample	(°C)	(mmhos/cm)	(mg/L)	(%)	(units)
NPS 1	1.3	1	Surface	27.59	0.929	9.96	127.3	9.01
			1.00	27.11	1.016	10.83	138.6	8.97
NPS 2	1.2	1.2+	Surface	28.18	0.461	7.82	101	7.9
			1.00	28.14	0.463	7.78	100.2	7.84
NPS 3	0.75	0.75+	Surface	28.18	0.506	8.58	110.8	8.86
			0.50	28.17	0.505	9.06	117.5	9.09
NPS 4			Surface	27.98	0.544	9.19	118.3	8.38
			1.00	27.95	0.544	9.39	120.9	8.37
			1.50	27.9	0.546	9.07	116.7	8.17
NPS 5	2.4	1.5	Surface	27.37	0.481	8.44	107.4	7.63
			1.00	27.28	0.48	8.55	108.7	7.7
			2.00	26.14	0.476	7.59	93.7	7.5

<i>In-Situ Monitoring for Hopatcong 319 Stations 8/18/15</i>								
Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	Dissolved Oxygen	pH
	Total	Secchi	Sample	(°C)	(mmhos/cm)	(mg/L)	(%)	(units)
NPS 1	1.1	0.9	Surface	27.4	0.868	8.99	113.5	8.35
			1.00	26.5	0.893	9.1	117.8	8.49
NPS 2	0.8	0.8+	Surface	27.55	0.471	7.37	93.7	7.9
			0.75	27.49	0.479	6.51	82.9	7.85
NPS 3	0.8	0.7	Surface	27.91	0.502	7.1	88.5	7.93
			0.50	27.6	0.498	6.1	76.1	7.66
NPS 4	1.3	1.3+	Surface	27.52	0.5	7.39	91.3	7.8
			1.00	27.53	0.498	7.05	88.6	7.64
NPS 5	2.3	1.3	Surface	27.04	0.478	8.38	105.1	7.88
			1.00	27.04	0.471	8.43	105.3	7.9
			2.00	26.91	0.469	8.14	97.5	7.88

<i>In-Situ</i> Monitoring for Hopatcong 319 Stations 9/22/15								
Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	Dissolved Oxygen	pH
	Total	Secchi	Sample	(⁰C)	(mmhos/cm)	(mg/L)	(%)	(units)
NPS 1	1.1	1.1+	Surface	19.73	0.866	10.96	122.6	9.02
			1.00	19.6	0.887	10.64	125.7	9.22
NPS 2	0.8	0.8+	Surface	19.51	0.505	7.38	79.8	7.54
			0.75	19.5	0.508	7.35	81.1	7.52
NPS 3	0.6	0.6+	Surface	18.95	0.546	8.07	86.6	7.85
			0.50	18.97	0.545	8.18	88.1	7.88
NPS 4	1.1	1.1+	Surface	19.73	0.487	7.25	78.5	7.97
			1.00	19.07	0.492	6.76	72.5	7.96
NPS 5	2	1.6	Surface	20.06	0.476	7.89	86.4	8.52
			1.00	20.06	0.473	7.77	85.2	8.64
			2.00	19.74	0.48	7.75	83.5	8.75

APPENDIX C
WATER QUALITY DATA

HOPATCONG

27-May-2015

STATION	Chl a (mg/m ³)	NH3-N (mg/L)	NO3-N (mg/L)	TP (mg/L)	TSS (mg/L)
ST-1	12.5	0.04	0.03	0.03	ND <3
ST-2	10.7	0.04	ND <0.02	0.02	ND <3
ST-3	3.4	0.04	ND <0.02	0.02	ND <3
ST-4	6.0	0.05	ND <0.02	0.02	ND <3
ST-5	4.2	0.20	ND <0.02	0.03	ND <3
ST-6	5.2	0.08	0.02	0.03	ND <3
ST-7	11.2	0.26	0.05	0.04	ND <3
ST-10	10.2	0.22	0.02	0.04	4
ST-11	12.7	0.20	0.06	0.05	6
ST-2 DEEP		0.72	0.14	0.02	ND <3
MEAN	8.5	0.13	0.04	0.03	2.3

16-Jun-2015

STATION	Chl a (mg/m ³)	NH3-N (mg/L)	NO3-N (mg/L)	TP (mg/L)	TSS (mg/L)
ST-1	16.0	0.01	0.04	0.05	9
ST-2	8.0	0.01	ND <0.02	0.03	ND <3
ST-3	12.5	0.01	ND <0.02	0.04	ND <3
ST-4	7.6	0.02	ND <0.02	0.03	ND <3
ST-5	6.4	0.01	ND <0.02	0.03	3
ST-6	3.7	0.02	ND <0.02	0.03	ND <3
ST-7	7.7	0.02	0.06	0.04	3
ST-10	15.7	0.01	0.03	0.04	5
ST-11	15.4	0.03	0.08	0.05	ND <3
ST-2 DEEP		0.13	0.21	0.02	3
MEAN	10.3	0.02	0.03	0.04	3.0

21-Jul-2015	Chl a	NH3-N	NO3-N	TP	TSS
STATION	(mg/m ³)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
ST-1	12.0	0.25	0.03	0.03	11
ST-2	7.2	0.03	ND <0.02	0.01	3
ST-3	14.0	0.03	0.02	0.03	3
ST-4	9.2	0.02	ND <0.02	0.02	5
ST-5	15.0	0.06	ND <0.02	0.03	6
ST-6	11.0	0.02	ND <0.02	0.02	4
ST-7	4.1	0.04	0.04	0.02	4
ST-10	19.0	0.07	0.03	0.03	7
ST-11	17.0	0.04	0.05	0.03	ND <3
ST-2 DEEP		0.64	0.08	0.09	6
MEAN	12.1	0.12	0.04	0.024	5.0

18-Aug-2015	Chl a	NH3-N	NO3-N	TP	TSS
STATION	(mg/m ³)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
ST-1	11.0	ND <0.01	0.02	0.02	3
ST-2	6.7	ND <0.01	ND <0.02	ND <0.01	ND <3
ST-3	7.3	0.01	ND <0.02	0.02	ND <3
ST-4	8.2	ND <0.01	ND <0.02	0.01	3
ST-5	12.0	0.01	ND <0.02	0.02	ND <3
ST-6	2.9	ND <0.01	ND <0.02	0.01	ND <3
ST-7	3.6	0.01	0.02	0.02	ND <3
ST-10	13.0	0.06	0.02	0.03	6
ST-11	9.1	0.02	0.02	0.02	6
ST-2 DEEP		0.49	0.03	0.22	9
MEAN	8.2	0.02	0.01	0.02	2.8

22-Sep-2015	Chl a	NH3-N	NO3-N	TP	TSS
STATION	(mg/m³)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
ST-1	11.0	ND <0.01	ND <0.02	0.03	5
ST-2	11.0	ND <0.01	ND <0.02	0.02	ND <3
ST-3	4.1	ND <0.01	ND <0.02	0.02	ND <3
ST-4	5.4	0.01	ND <0.02	0.01	ND <3
ST-5	3.7	0.01	ND <0.02	0.02	ND <3
ST-6	3.5	0.01	ND <0.02	0.02	ND <3
ST-7	3.3	0.01	ND <0.02	0.02	ND <3
ST-10	8.3	0.01	ND <0.02	0.02	3
ST-11	4.0	0.01	ND <0.02	0.02	ND <3
ST-2 DEEP		0.75	0.02	0.02	9
MEAN	6.0	0.01	ND <0.02	0.02	2.0

Lake Hopatcong 319(h) Water Quality Sampling for 2015

5/27/2015			
Station	TP (mg/L)	TSS (mg/L)	CHL a (mg/m³)
NPS 1	0.03	ND <3	x
NPS 2	0.02	ND <3	x
NPS 3	0.02	ND <3	5
NPS 4	0.02	ND <3	1.6
NPS 5	0.02	ND <3	6.1
6/16/2015			
Station	TP (mg/L)	TSS (mg/L)	CHL a (mg/m³)
NPS 1	0.04	4	x
NPS 2	0.02	ND <3	x
NPS 3	0.02	4	5.7
NPS 4	0.02	3	8.4
NPS 5	0.02	ND <3	3.4
7/21/2015			
Station	TP (mg/L)	TSS (mg/L)	CHL a (mg/m³)
NPS 1	0.05	3	x
NPS 2	0.02	ND <3	x
NPS 3	0.02	ND <3	4
NPS 4	0.02	ND <3	9.4
NPS 5	0.02	5	7.7
8/18/2015			
Station	TP (mg/L)	TSS (mg/L)	CHL a (mg/m³)
NPS 1	0.04	4	x
NPS 2	0.01	ND <3	x
NPS 3	0.02	4	6.4
NPS 4	0.02	ND <3	7.2
NPS 5	0.02	3	13
9/22/2015			
Station	TP (mg/L)	TSS (mg/L)	CHL a (mg/m³)
NPS 1	0.04	5	x
NPS 2	0.01	ND <3	x
NPS 3	0.01	ND <3	2.8
NPS 4	0.01	ND <3	3.1
NPS 5	ND <0.01	ND <3	2.6