INDEPENDENT THIRD-PARTY MONITOR FOR CHAUTAUQUA LAKE MACROPHYTE MANAGEMENT – 2019 HERBICIDE TREATMENT PROGRAM

CHAUTAUQUA LAKE WEED MANAGEMENT CONSENSUS STRATEGY – MEMORANDUM OF AGREEMENT (MOA)

CHAUTAUQUA COUNTY, NEW YORK

SEPTEMBER 2019

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FUNDING/PARTNERSHIP ACKNOWLEDGEMENT

This project was funded in partnership between the County of Chautauqua and the Chautauqua Lake and Watershed Management Alliance in support of the Chautauqua Lake Weed Management Consensus Strategy Memorandum of Agreement (MOA). Thank you as well to the Alliance Members, MOA participants, and other lake and watershed stakeholder groups and individuals who participated in the project.

EXECUTIVE SUMMARY

The Chautauqua Lake and Watershed Management Alliance commissioned Princeton Hydro, LLC to provide third party monitoring services related to satisfying the Chautauqua Lake Weed Management Consensus Strategy Memorandum of Agreement (MOA) related to herbicide treatments conducted for five (5) municipalities (Towns of Ellery, Ellicott, and North Harmony; and Villages of Celoron and Lakewood) by Solitude Lake Management in May 2019. This third-party monitoring included pre- and post-treatment macrophyte surveys, *in-situ* water quality testing and discrete laboratory testing for herbicides in selected treatment, drift and control zones. The herbicide application of Navigate (2,4-D) and Aquathol K (dipotassium salts of endothall) was conducted by Solitude Lake Management on 15 May through 17 May 2019 under regulatory permits and oversight by New York State Department of Environmental Conservation (NYSDEC).

The primary objectives of the independent third-party monitoring, and the resulting conclusions and recommendations, are summarized below and detailed herein. The Statement of Objectives for this project are to:

1. Evaluate potential risk to local drinking water supplies through water quality testing (Stations: Chautauqua Institution (CUD) and Chautauqua Lake Estates (CWD #2))
2. Provide third-party verification of applicator-collected water samples and applicator-contracted laboratories
3. Provide a third-party assessment of potential herbicide drift into non-target locations and potential impacts to non-target species
4. Evaluate the apparent efficacy of herbicide treatments
5. Evaluate apparent effects of herbicide treatments on ambient water quality

Water quality data showed no acute impacts related to temperature, dissolved oxygen, pH, specific conductance, or clarity in relation to the treatment.

There was concern over potential drift of the applied herbicides used out of the treated zone and into the drift and control zones. For the sake of this study, drift zones were established relatively close to and “downgradient” of the treatment zones. For the Chautauqua Lake ecosystem, downgradient refers to the general movement of water from the northern basin, into the southern basin and out of the Chadakoin River. Control areas were also established where it was expected to be unlikely that any potential drift of herbicide would occur. Chemical data showed some drift of herbicide outside of treatment areas into the drift and control zones approximately 7 to 14 days after the treatment. Samples separately collected and analysis by Princeton Hydro and Solitude were in general agreement.

It should be noted samples of raw (untreated) water collected near potable water intakes by the PWS Operators, split by the County Health Department and provided to Princeton and Solitude for analyses were all well below the NYSDEC Permit Consumptive Threshold of 50 ppb. Consumptive use restrictions were not removed until follow-up testing showed concentrations to be below the permitted threshold. Discrete chemical split-samples analyzed by Princeton Hydro- and Solitude-contracted laboratories were in agreement.

The herbicide treatment program was designed to substantially reduce the targeted invasive species curly-leaf pondweed (*Potamogeton crispus*) and Eurasian watermilfoil (*Myriophyllum spicatum*) with little to no impacts to

native species. Based on a comparison between pre-treatment and post-treatment conditions, community-wide species richness increased and this was statistically significant.

Between pre- and post-treatment conditions, curly-leaf pondweed displayed a statistically significant decrease in the treatment areas while Eurasian watermilfoil also displayed a decrease but this was not statistically significant. In contrast, four of the more common native species all increased from pre- to post-treatment conditions. The only exception to this was a decrease in elodea in the drift zone but note this was not statistically significant.

Relative to plant biomass, total biomass declined at the treatment zones with a marked reduction in the two invasive species. However, none of these declines in biomass were statistically significant. Reductions in native plant biomass were noted at DFT1 and DFT3; indicating potential impact of drift on native species biomass. Finally, it should be noted that the adjusted floristic quality index showed a significant increase from pre- to post-treatment conditions. Thus, while the targeted invasives species declined, overall community diversity and value (native species) increased with the treatments.

As this was the first year of treatment under the MOA, additional treatments in the future may occur under greater coordination between applicators and third-party consultants in terms of adjusting sampling stations to better document potential herbicide drift and to allow for more direct comparability between results such as those obtained via the split-samples collected by the County Health Department at the drinking water plants which were analyzed by two separate labs (PH- and Solitude-contracted). Specifically, better coordination of sampling station location, sampling station nomenclature, and advanced coordination will likely result in more power for interpreting potential drift dynamics. We also recommend further evaluation of potential herbicide drift and its dynamics, including possible northward drift, by collecting additional paired macrophyte and chemical samples to not only assess presence/absence of chemical drift but also significance as it relates to impacts on macrophyte growth.

Future treatments, if possible, should occur at some of the same areas as in 2019 in addition to new areas. Such an approach would allow for the determination of impacts or benefits from multiple years of treatment. Please note, NYSDEC makes the final determination on areas which may be treated in 2020 and beyond. Inter-annual analysis of areas that receive multiple year treatment should be included in any future third-party reports.

Third-party evaluation of the plant community should possibly include a mid- to late-summer event in order to evaluate the plant community later in the growing season. Such an event should provide a more thorough assessment of the response of Eurasian watermilfoil.

Overall, the treatment was successful at its intent, and data pertaining to this project showed adverse impacts to be minimal.

1.0 – INTRODUCTION

Chautauqua Lake, located within Chautauqua County, New York, is an approximately 13,000-acre natural lake with a length of approximately 17-miles. Distinct in shape, the lake consists of a large and moderately deep northern basin and slightly smaller but much shallower southern basin. The watershed of Chautauqua Lake encompasses approximately 180 square miles of mixed land use while the overall flow direction through the lake is in a generally southerly direction into the Chadakoin River. Historically, Chautauqua Lake has been affected by dense stands of native and non-native aquatic macrophytes (plants), which have served to impact the lake's recreational and aesthetic conditions while altering the ecology of the waterbody.

The County of Chautauqua, on 27 March 2019, finalized the Memorandum of Agreement (MOA) for the Chautauqua Lake Weed Management Consensus Strategy. The purpose of the MOA was to effectively bring together lake stakeholders to work together to properly manage the invasive or otherwise nuisance aquatic vegetation and algal blooms in Chautauqua Lake. One of the central tenets of the MOA, as will be described herein, is for third party monitoring for aquatic macrophyte management activities. This monitoring is intended to provide objective data pertaining to this management that may be utilized in a transparent manner to make science-based decisions for the management of the lake.

The herbicide application and application-based monitoring was conducted by Solitude Lake Management under field oversight by New York State Department of Environmental Conservation (NYSDEC). Herbicide applications were commissioned directly by local Municipalities with treatment areas as described in Table 1.1.

Table 1.1: Chautauqua Lake – Herbicide Application Areas

Chautauqua Lake - Herbicide Application Areas			
Application Area	Treatment Date	Permitted Acres	Treated Acres
Ellery / Bemus Point	5/17/2019	29.7	29.7
Ellery / Arnold Bay	5/17/2019	63.1	54
Ellery / Greenhurst North	5/16/2019	17.7	17.7
Ellery / Greenhurst South	5/16/2019	15.4	15.4
Ellicott / Fluvanna	5/16/2019	51	33.8
Ellicott 60-61	5/15-16/2019	44.2	51.2
Nav Channel	5/16/2019	7.5	7.5
N Harm Woodlawn		19.3	0
N Harm Stow	5/17/2019	35	35
N Harm Hadley Bay	5/15/2019	30.2	18
N Harm Cheney Point		13.1	0
N Harm Bly Bay	5/17/2019	48.1	3
N Harm Sunrise Cove		25.5	0
Celoron	5/15/2019	48.2	48.2
Lakewood 026	5/17/2019	14.9	14.9
Lakewood 66-67	5/17/2019	18.1	18.1
Lakewood 60-62	5/16-17-2019	41.5	41.5
Total		**522.5**	**388**

Herbicide application included the utilization of either Aquathol K® (Dipotassium salt of endothall) and/or Navigate® (2,4-Dichlorophenoxyacetic acid) for the control of curly-leaf pondweed (*Potamogeton crispus*) and/or Eurasian watermilfoil (*Myriophyllum spicatum*). Herbicides were applied at zones previously approved by NYSDEC from 15 May 2019 through 17 May 2019. As part of the herbicide application Solitude collected water samples for the herbicides of interest at several stations throughout the lake.

The overall objectives of the third-party monitoring, which was conducted by Princeton Hydro, LLC, were to:

1. Evaluate potential risk to local drinking water supplies through water quality testing (Stations: Chautauqua Institution (CUD) and Chautauqua Lake Estates (CWD #2))
2. Provide third-party verification of applicator-collected water samples and applicator-contracted laboratories
3. Provide a third-party assessment of potential herbicide drift into non-target locations and potential impacts to non-target species
4. Evaluate the apparent efficacy of herbicide treatments
5. Evaluate apparent effects of herbicide treatments on ambient water quality

A key tenet of the third-party observation protocol was to observe and document the applicators and NYSDEC but to not direct treatments or interfere in any way. The overall scope of work conducted by Princeton Hydro included the following tasks (Table 1.2):

Table 1.2: Chautauqua Lake – Third Party Monitoring Tasks

Chautauqua Lake - Third Party Monitoring Tasks	
Task	Description
1.1	Review Memorandum of Agreement (MOA)
1.2	Review NYSDEC Permits
1.3	Develop Third-Party Sampling and Observation Plan
1.4	Develop Compliance Checklist
1.5	Collect Pre-Treatment Samples in Accordance with 1.3
2.1	Review Treatment Schedules
2.2	Observe Permitees and their Contractor(s) During Treatment
2.3	Collect Samples and Observations in Accordance with 1.3
3.1	Collect Post-Treatment Samples and Observations in Accordance with 1.3
4.1	Provide Timely Input and Recommendations to Alliance

The interim results of the data collection efforts were summarized and forwarded by Princeton Hydro to the Alliance as a preliminary document on 25 July 2019. In accordance with the written scope of work, the interim results were not distributed publicly because they were preliminary in nature. This report represents the final, publicly available deliverable, which provides all data collected as part of this project and our interpretation of these results.

Princeton Hydro is uniquely suited to conduct the third-party monitoring of this effort as our staff consists of a mixture of licensed aquatic pesticide applicators and academically trained limnologists and ecologists. Several staff within Princeton Hydro hold doctoral-degrees in aquatic ecology or hold accreditation as Certified Lake Managers (CLM) through the North American Lake Management Society (NALMS). Since 1998, Princeton Hydro has provided rigorous, scientific-based consulting for well over 300 private and public waterbodies throughout the mid-Atlantic and New England regions.

2.0 – METHODOLOGY

The following section details the methodology of the work items discussed in Section 1.0.

2.1 MOA REVIEW

Princeton Hydro developed a review of the MOA which entailed reviewing this document and providing a summary report of our thoughts regarding each of the tenets contained within this Agreement. Overall, we were in agreement with the MOA and felt the rationale provides a transparent, documented process for managing the lake. The environmental safeguards identified within the MOA are appropriate and the science-based decision-making process is to be applauded. The review of the MOA is provided in Appendix I.

2.2 PERMIT REVIEW

Similar to the MOA review, Princeton Hydro's certified pesticide applicators reviewed and commented on the pesticide application permits which were issued by NYSDEC. Initial permits were issued by NYSDEC for Celoron, Ellery, Ellicott, Lakewood, and North Harmony on 29 April 2019. NYSDEC issued a letter of clarification on 6 May 2019 and finalized permits were issued by 8 May 2019. Princeton Hydro reviewed these permits and developed an overview and response letter which is provided in Appendix I. The permits issued by NYSDEC provided reasonable environmental safeguards in terms of pre-application notifications, identification and exclusion of sensitive areas, procedural guidance for application, and post-application monitoring.

2.3 SAMPLING – PLAN, LOCATIONS, & PARAMETERS

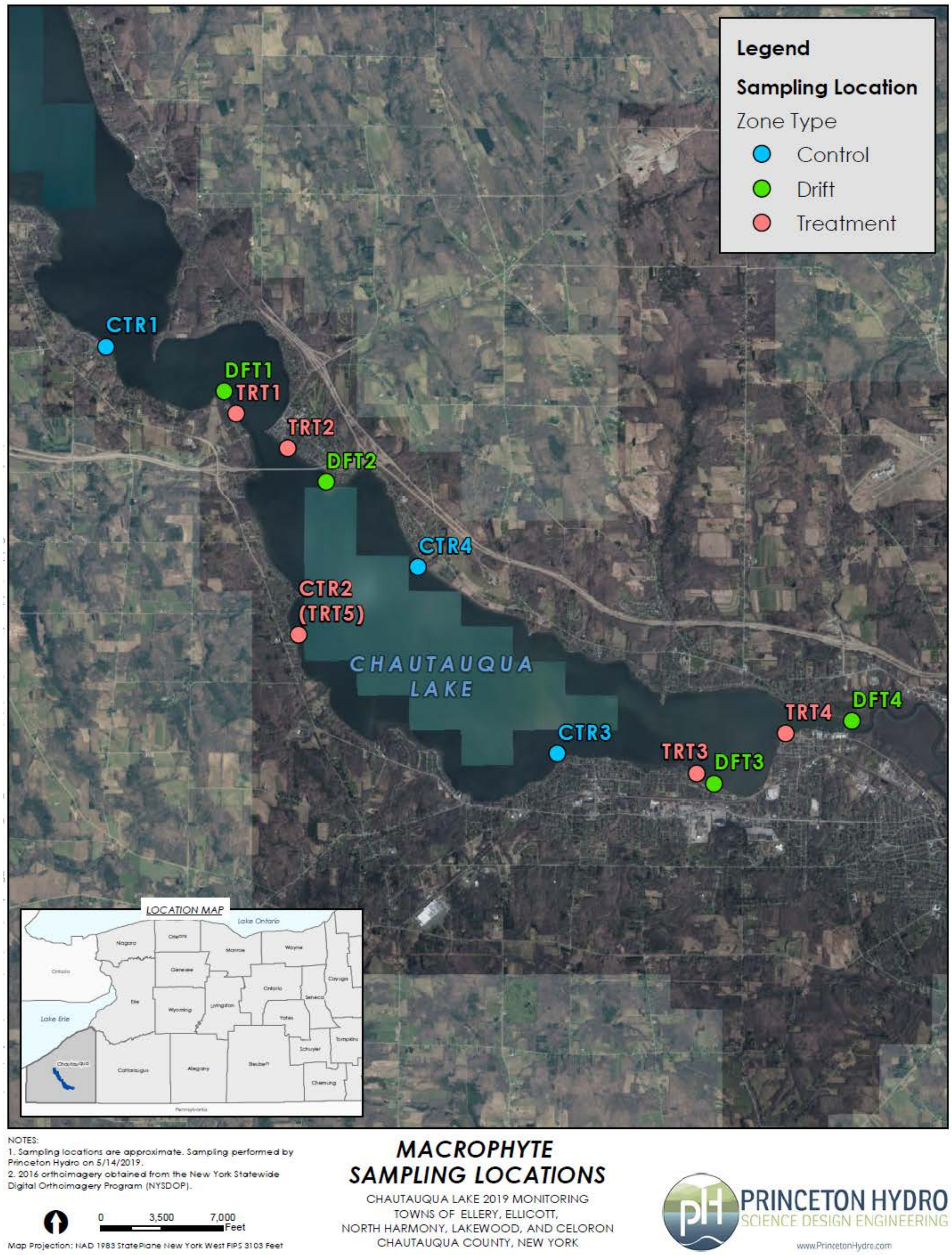
The development of the Sampling and Observation Plan was an iterative process utilizing best practices for the establishment of appropriate monitoring locations and development of scientifically sound monitoring procedure to accurately characterize the *in-situ* water quality, chemical constituents, and macrophyte community in relation to the treatment.

In total, 12 locations were selected for monitoring based on the proposed treatment information available from the Permittees and Solitude at the time the plan was finalized on 13 May 2019. Please note, final permits were not issued by NYSDEC until 8 May 2019 and final determination regarding treatment areas to be paid for by each Permittee were often changed numerous times throughout the development of the Plan, with some changes occurring during the week treatment commenced. The 12 monitoring areas were developed to sample a subset of herbicide Treatment Areas (TRT1-4), Drift Areas (DFT1-4), which represented non-treatment zones that may potentially experience drift due to proximity to the treatment area(s), prevailing wind direction, and general water flow direction within the lake, and Control Areas (CTR1-4), which were selected as non-treatment areas not expected to be susceptible to drift due to distance from proposed treatments in combination with prevailing wind and flow direction. Additional factors considered in the assignment of monitoring points included: range of distances between treatment and drift sites (e.g., Shorter-range: DFT1 and DFT3; Longer-range: DFT2 and DFT4); varied direction of potential drift sites relative to assumed lake flow direction (e.g., Up-lake: DFT1; Down-lake: DFT2, DFT3, and DFT4); and avoidance of areas treated with herbicides in 2017 or 2018.

Please note, station CTR2, a station that was originally designated as a Control, was subsequently chosen to be treated by the Permittee and herbicide application contractor in the latter half of the week of treatment. This station was still sampled according to the Plan but is listed as 'CTR2 (TRT5)' in the sampling figure shown below (Figure 2.1) and on the data tables herein.

Treatment maps provided by the Permittees and/or Solitude are included in Appendix III. These maps were shared with Princeton Hydro and identified as “Final” on 13 May 2019 but were issued prior to the start of the treatment. Therefore, they may not reflect the final representation of the actual treatment of permitted areas (see Table 1.1 for a summary of the actual treatment areas as reported by Solitude).

Figure 2.1: Chautauqua Lake – Third Party Sample Locations



Sampling for *in-situ* parameters of temperature, specific conductivity, dissolved oxygen, pH and clarity occurred along the macrophyte transects at the 40' from shoreline and 100' from shoreline quadrats. Please note, at the beginning of sampling Princeton Hydro intended to measure *in-situ* at each of the quadrats (20', 40', 60', 80' & 100' from shoreline) along each transect. In the field, Princeton Hydro determined that not all field work could be conducted in time with this frequency of data collection. As such, *in-situ* sampling was scaled back to occur at the 40' and 100' mark. No significant variability was observed between *in-situ* parameters along each transect, and we feel this reduced approach was an appropriate modification as based on necessary work load and time constraints. *In-situ* data collection was made according to the methodology laid out in the Sampling and Observation Plan. Daily calibration was conducted of the water quality meter (Hydrolab Quanta) according to manufacturer's specifications. In addition, pH calibration checks were performed every 3 hours by Princeton Hydro. Measurements were made in profile, throughout the water column at 0.5 m to 1.0 m intervals. Water transparency was measured with a Secchi disc. *In-situ* data collection was conducted 'Pre-treatment', 'During-treatment', and 'Post-Treatment'. Samples and observations were collected on 14, 15, 16 & 17 May 2019 and on 12 June 2019. The results of the *in-situ* data are presented in Section 3.1.

Chemical sampling was also conducted for the determination of baseline pre-treatment, approximately 1 day following treatment and then again 7 to 10 days following treatment. Samples for 2,4-D, the active ingredient in Navigate, were collected in 2-liter amber bottles and analyzed by Integrated Analytical Laboratories of Randolph, New Jersey according to the standard methods (FW-846, Method 8151A). Endothall, the active ingredient in Aquathol K, was collected in volatile organic analysis vials preserved with sodium thiosulfate and analyzed according to standard methods (EPA 548.1) by Eurofins Eaton Analytical, of South Bend, Indiana. All samples were appropriately preserved, placed on ice, and shipped overnight to the analytical laboratories for analysis. Third-party sampling was conducted by Princeton Hydro for the lake samples while samples collected at the drinking water plants were collected under the direction of Princeton Hydro by the County Health Department or Drinking Water Plant staff. In addition, other in-lake water samples were collected by Solitude Lake Management, as part of their permitted application process, and distributed to the County Health Department and other involved parties. A full review of all chemical data collected by Solitude from their in-lake stations was beyond the scope of the third-party monitoring. However, data from select Solitude-assigned in-lake sample points were evaluated, and referenced herein, when they provide further context for those data points collected by Princeton Hydro. As such, these data points were evaluated as a third-party, independent check of laboratory results, and to evaluate drift dynamics within the lake. Type and date of collection for chemical analyses are presented in Table 2.1 below (note that not all Solitude samples are listed). The results of the chemical data are presented in Section 3.2. The chemical samples from 21 May 2019 were collected by Alliance staff in direct coordination with Princeton Hydro and were in accordance with the Sampling and Observation Plan (Appendix I).

Table 2.1: Chautauqua Lake – Chemical Sampling for Herbicides

Chautauqua Lake - Chemical Sampling for Herbicides			
Entity	**Type**	**Dates**	**Stations**
Princeton Hydro	Pre-Treatment	5/14/2019	CTR4, DFT4, DFT4 (Dup), TRT4, CUD, CWD2
	Post-Treatment (+1 Day)	5/16/2019	CTR4, DFT4, DFT4 (Dup), TRT4
	Post-Treatment (+1-2 Days)	5/17/2019	CUD, CWD2
	Post-Treatment (+7 Days)	5/21/2019	CTR4, DFT4, DFT4 (Dup), TRT4
	Post-Treatment (+14 Days)	5/28/2019	CUD, CWD2
Solitude	Pre-Treatment	5/14/2019	CUD, NB1, CWD2, NB2
	Post-Treatment (+13-14 Days)	5/27-28/19	CUD, NB1, CWD2, NB2, CEL2, O1, ELL3
	Post-Treatment (+21 Days)	6/4/2019	NB2, CEL2, O1
PWS Operators	Post-Treatment (+8 Days)	5/22/2019	CUD, CWD2

Location or descriptive information for the above sampling sites is provided in the Table (2.2) below.

Table 2.2: Chautauqua Lake – Sampling Station Locations

Chautauqua Lake - Sampling Station Locations			
Station	**Latitude**	**Longitude**	**Description**
CTR4	42.13631°N	-79.363454°W	Princeton Hydro; Control
DFT4 & DFT4 Duplicate	42.112797°N	-79.272164°W	Princeton Hydro; Drift
TRT4	42.110625°N	-79.286287°W	Princeton Hydro; Treatment
CEL2	42.111571°N	-79.28337°W	Solitude; Near TRT4
O1	42.111702°N	-79.269282°W	Solitude; Near DFT4
ELL3	42.129604°N	-79.348771°W	Solitude; Near CTR4
CUD	N/A	N/A	Raw-Water Intake; Chautauqua Institution
NB1	42.211748°N	-79.463422°W	Solitude; Near Intake for Chautauqua Institution (CUD)
CWD2	N/A	N/A	Raw-Water Intake; Chautauqua Lake Estates
NB2	42.2448°N	-79.4669°W	Solitude; Near Intake for Chautauqua Lake Estates (CWD2)

Macrophyte data collection followed the protocol established in the Sampling and Observation Plan (Appendix II). Princeton Hydro established 100' transects at each of the sampling areas (CTR, DFT, & TRT) from the shoreline, or adjacent to the shoreline, extending towards the center of the lake. At zero, 20', 40', 60', 80', & 100' along each transect, Princeton Hydro deployed two rake-tosses. Each rake-toss was assessed for plant species composition with identification typically made to species level. In addition, relative density was ascribed to each plant species according to the following: 'Zero/None' – No plants on the rake; 'Trace' – Approximately 25% of the rake covered; 'Spare' – Approximately 50% of the rake covered; 'Moderate/Medium' – 75% to 100% of rake covered; 'Dense' – Rake entirely covered, over 100% coverage with fragments hanging off of rake. In addition, at one (1) random quadrat, Princeton Hydro harvested both rake tosses (two (2) rake tosses) and measured wet weight biomass at our biological laboratory. Please note, often the transects were not started at the water / upland interface and instead started slightly out from this area. As such, 'zero' feet from shoreline represents the littoral area immediately adjacent to the uplands but still in enough water depth to support plant growth. Plant identifications were made utilizing previous taxonomical knowledge and resources including Skawinski (2014), Crow and Hellquist (2006), and Borman (1997). The results of the macrophyte data are presented in Section 3.3.

2.4 MACROPHYTE ANALYSIS

Results presented in Section 3.4 show various statistical comparisons between pre-treatment and post-treatment macrophyte data.

Species richness values are depicted which is simply the number (n) of species identified during the two sampling events.

Next, relative density, as identified above ('Zero/None' – No plants on the rake; 'Trace' – Approximately 25% of the rake covered; 'Spare' – Approximately 50% of the rake covered; 'Moderate/Medium' – 75% to 100% of rake covered; 'Dense' – Rake entirely covered, over 100% coverage with fragments hanging off of rake) descriptors were converted numerically as identified in the Sampling and Observation Plan as: (No Plants = 0, Trace = 1, Sparse = 2, Medium = 3, Dense = 4). These numerical indicators of relative density were subsequently statistically analyzed for each sampling station and plant species that was present during both pre-treatment and post-treatment events and analyzed utilizing the Sign Test. The Sign Test is a non-parametric statistical analysis utilized for assessing differences between pairs of observations. This test was also utilized to assess for significant differences in plant biomass (weight) between pre-treatment and post-treatment events.

Finally, Princeton Hydro assessed the sampling stations for the Floristic Quality Assessment (FQA). The FQA is a tool utilized to assess an areas ecological integrity as based on plant species composition. The FQA is conducted through the assignment of a *coefficient of conservatism* (C-value), which ranges from zero to 10 (Table 3.10). A plant species with a higher-score has a lower tolerance to environmental degradation while a lower-score species has a higher tolerance to degradation. FQA is subsequently determined by multiplying the mean C value by the square root of the total number of species. The FQA is presented and also compared between pre-treatment and post-treatment events utilizing the Sign Test. The data tables for the analysis are presented in Section 3.4.

2.5 DEVIATIONS FROM WRITTEN SAMPLING & OBSERVATION PLAN

The following section briefly lists changes from the Sampling and Observation Plan made in the field:

- Field Adjustment 1: Adjustment of location of CTR2 and then subsequent re-characterization of CTR2 to CTR2(TRT5).

- Field Adjustment 2: Limited *in-situ* data collection to 40' and 100' transect locations due to time constraints.

3.0 RESULTS

The following section provides the key data tables or figures related to the data collection effort detailed in Section 2.0. Specifically, this section presents the raw-data for the *in-situ* data, chemical data, and macrophyte data under Pre-treatment, During-Treatment, and Post-Treatment conditions. Section 3.1 includes 'Pre-Treatment' data, Section 3.2 includes 'During-Treatment' data, and Section 3.3 includes the 'Post-Treatment' data. Pertinent thresholds for water quality or chemical parameters, as established by NYSDEC are included as appropriate. Chautauqua Lake South and North Basins are both categorized as 'Class A' waters by NYSDEC and as such are ascribed certain thresholds for pH and dissolved oxygen under 6 NYCRR Part 703. The pH range established by NYSDEC is 6.5 to 8.5 while dissolved oxygen concentrations are not to fall below 5.0 mg/L.

The NYSDEC pesticide permits assigned the chemical thresholds for consumptive use for Aquathol K (Dipotassium salt of endothall) and Navigate (2,4-D) as follows (thresholds were the same for both active ingredients):

- Domestic water use: Must be less than 50 ppb (µg/L) at time of consumption.
- Potable water use: Must be less than 50 ppb (µg/L).
- Irrigation: Must be less than 100 ppb (µg/L).

Reference to an "exceedance" of a particular chemical threshold in this report does not necessarily indicate a human health risk exposure provided that use restrictions were properly put in place and kept in place in accordance with the NYSDEC permits until clearance water samples, collected and reported by the licensed applicator and/or Permittee(s), indicated that the use restrictions could be lifted. In addition, the plant data collected at 'zero feet' does not reference the upland shoreline but instead references the zero point of the transect which were often established several feet out from the water and upland interface where plants or plant habitat were present. Finally, to reiterate, CTR2 was initially established as a Control Station but a decision was made by the municipalities during the week of treatment to treat this area. As such, this station is referenced as CTR2 (TRT5) in this report.

3.1 IN-SITU DATA

In-situ data for Pre-Treatment, During-Treatment, and Post-Treatment events are provided in Tables 3.1 through 3.7. Data discussion for the *in-situ* data is provided in Section 4.0.

Table 3.1: Chautauqua Lake – Pre-Treatment *In-situ* - 5/14/19 (1 of 2)

Chautauqua Lake - Pre-Treatment *In-situ* - 5/14/19 (1 of 2)

Station	Distance from Shore (ft)	Secchi (m)	Total depth (m)	Sample depth (m)	Temp (°C)	DO (mg/L)	DO% (%)	SpC (mS/cm)	pH (units)
NYSDEC Standard For Class A Waterbody:						> 5			6.5 to 8.5
CTR1	40	0.9	0.9	0.1	12.10	9.20	89.7	0.184	7.68
				0.5	12.08	9.47	91.2	0.185	7.70
CTR1	100	1.0	1.0	0.1	11.63	8.79	85.1	0.183	7.52
				0.5	11.63	8.74	85.0	0.185	7.52
DFT1	40	1.0	1.0	0.1	12.63	9.33	90.0	0.182	7.77
				0.5	12.62	9.13	90.4	0.181	7.81
DFT1	100	1.3	1.3	0.1	12.44	9.27	90.6	0.181	7.77
				0.5	12.44	9.24	90.7	0.178	7.81
				1	12.47	9.36	92.7	0.181	7.88
TRT1	40	1.2	1.2	0.1	12.53	10.07	98.8	0.185	7.93
				0.5	12.55	9.93	97.9	0.182	7.98
				1	12.60	9.91	97.0	0.181	8.14
TRT1	100	1.5	1.5	0.1	12.67	10.28	104.5	0.181	8.25
				0.5	12.67	10.62	104.9	0.181	8.34
				1	12.60	10.70	105.8	0.182	8.36
CTR2 (TRT5)	40	1.2	1.7	0.1	13.27	10.27	102.9	0.182	**8.53**
				0.5	13.24	10.16	102.5	0.184	**8.54**
				1	13.25	10.19	101.6	0.184	**8.52**
				1.5	13.25	10.23	102.9	0.185	8.50
CTR2 (TRT5)	100	1.1	2.3	0.1	13.51	10.65	106.5	0.183	8.46
				0.5	13.52	10.52	106.4	0.183	**8.51**
				1	13.55	10.54	105.3	0.182	**8.52**
				1.5	13.41	10.75	105.2	0.183	**8.58**
				2	12.67	9.61	94.5	0.182	8.34
DFT2	40	0.6	0.6	0.1	12.72	10.82	110.6	0.185	7.13
				0.5	12.72	11.27	110.7	0.186	7.93
DFT2	100	0.8	0.8	0.1	12.74	11.57	115.0	0.186	**8.57**
				0.5	12.69	11.57	114.7	0.187	**8.62**
TRT2	0	1.4	1.4	0.1	11.98	8.63	80.6	0.184	**6.48**
				0.5	12.01	8.24	80.2	0.182	6.70
				1	12.01	8.26	80.2	0.182	6.81
TRT2	20	1.6	1.6	0.1	12.01	8.36	81.7	0.181	7.18
				0.5	12.06	8.57	84.1	0.183	7.23
				1	12.06	8.59	84.0	0.181	7.27
TRT2	40	1.7	1.7	0.1	12.07	9.06	86.2	0.183	7.39
				0.5	12.07	8.69	84.6	0.182	7.47
				1	12.07	8.73	85.5	0.183	7.48
TRT2	60	1.9	1.9	0.1	12.08	9.96	88.0	0.181	7.64
				0.5	12.10	9.14	89.1	0.181	7.69
				1	12.08	9.12	88.0	0.183	7.73
				1.5	12.08	9.27	90.0	0.182	7.75
TRT2	80	1.9	1.9	0.1	12.07	9.23	90.4	0.181	7.74
				0.5	12.11	9.46	93.5	0.181	7.79
				1	12.06	10.36	99.8	0.180	7.83
				1.5	12.10	9.31	89.9	0.182	7.88
TRT2	100	2.0	2.0	0.1	12.14	9.78	92.0	0.184	7.84
				0.5	12.14	9.46	93.1	0.182	7.92
				1	12.12	9.39	91.0	0.181	7.90
				1.5	12.08	9.40	91.5	0.180	7.99

Water quality metrics showed slightly elevated pH at various stations highlighted in red above.

Table 3.2: Chautauqua Lake – Pre-Treatment *In-situ* - 5/14/19 (2 of 2)

Chautauqua Lake - Pre-Treatment *In-situ* - 5/14/19 (2 of 2)

Station	Distance from Shore	Secchi	Total depth	Sample depth	Temp	DO	DO%	SpC	pH
	(ft)	(m)	(m)	(m)	(°C)	(mg/L)	(%)	(mS/cm)	(units)
NYSDEC Standard For Class A Waterbody:						> 5			6.5 to 8.5
CTR3	40	1.0	1.0	0.1	12.97	9.32	92.4	0.190	8.11
				0.5	12.98	9.31	92.3	0.193	8.08
CTR3	100	1.6	2.0	0.1	13.05	9.92	95.6	0.189	7.99
				0.5	13.08	9.61	96.3	0.188	8.08
				1	13.09	9.47	95.0	0.189	8.10
				1.5	13.03	9.36	93.7	0.189	8.09
DFT3	40	0.8	1.0	0.1	12.09	9.56	93.5	0.210	8.16
				0.5	11.24	9.83	93.8	0.330	8.14
DFT3	100	1.0	1.0	0.1	12.17	9.64	93.7	0.203	8.18
				0.5	12.15	9.59	93.7	0.205	8.18
TRT3	40	1.0	1.3	0.1	12.27	9.42	92.6	0.197	8.10
				0.5	12.30	9.48	92.5	0.194	8.04
				1	12.34	8.09	92.3	0.194	8.10
TRT3	100	1.1	1.8	0.1	12.42	10.08	94.5	0.190	8.02
				0.5	12.44	9.53	92.6	0.195	8.08
				1	12.43	9.54	94.5	0.194	8.10
				1.5	12.43	9.54	95.2	0.194	8.13
CTR4	40	1.4	1.4	0.1	12.59	9.60	94.0	0.188	8.06
				0.5	12.58	9.53	94.4	0.186	8.03
				1	12.60	9.54	94.3	0.186	8.03
CTR4	100	1.7	2.0	0.1	12.54	9.88	97.9	0.185	8.20
				0.5	12.53	9.90	97.1	0.187	8.20
				1	12.54	9.67	94.6	0.186	8.16
				1.5	12.54	9.59	95.9	0.186	8.14
DFT4	0	0.8	0.8	0.1	11.95	8.70	83.9	0.200	7.77
DFT4	20	0.8	1.0	0.1	12.00	8.76	85.5	0.198	7.05
				0.5	11.67	8.64	82.7	0.210	7.18
DFT4	40	0.8	1.0	0.1	11.64	9.00	83.1	0.204	7.02
				0.5	11.62	8.55	82.1	0.210	7.15
DFT4	60	0.9	1.0	0.1	11.69	8.70	83.4	0.209	7.48
				0.5	11.58	8.57	83.1	0.214	7.53
DFT4	80	0.9	1.2	0.1	11.93	8.93	84.5	0.200	7.63
				0.5	12.01	8.46	83.8	0.198	7.65
				1	11.91	8.37	82.2	0.205	7.66
DFT4	100	0.9	1.2	0.1	11.97	8.75	85.6	0.201	7.74
				0.5	11.96	8.65	83.7	0.203	7.80
				1	11.72	8.55	82.3	0.210	7.73
TRT4	0	0.7	0.7	0.1	11.93	8.93	86.9	0.198	6.84
				0.5	11.93	8.94	80.7	0.198	7.28
TRT4	20	0.7	0.7	0.1	11.94	9.14	88.4	0.198	7.61
				0.5	11.95	9.07	88.2	0.200	7.65
TRT4	40	0.8	0.8	0.1	12.00	9.04	88.3	0.198	7.77
				0.5	12.00	9.01	88.0	1.198	7.77
TRT4	60	0.9	1.0	0.1	12.02	9.11	88.0	0.196	7.81
				0.5	12.03	8.87	87.6	0.198	7.82
TRT4	80	0.9	0.9	0.1	12.09	8.97	87.8	0.195	7.78
				0.5	12.08	8.96	87.3	0.198	7.78
				1	12.08	8.95	87.5	0.196	7.80
TRT4	100	0.9	1.5	0.1	12.11	8.97	87.7	0.196	7.78
				0.5	12.10	8.94	87.0	0.196	7.77
				1	12.04	8.88	86.6	0.197	7.73

No water quality issues were noted at those results listed in Table 3.2.

Table 3.3: Chautauqua Lake – During-Treatment *In-situ* - 5/15/19

Chautauqua Lake - During-Treatment *In-situ* - 5/15/19									
Station	Distance from Shore	Secchi	Total depth	Sample depth	Temp	DO	DO%	SpC	pH
	(ft)	(m)	(m)	(m)	(°C)	(mg/L)	(%)	(mS/cm)	(units)
NYSDEC Standard For Class A Waterbody:						> 5			6.5 to 8.5
TRT4	100	0.6	0.6	0.1	14.49	8.79	90.7	0.210	7.17
				0.5	14.42	7.84	82.8	0.208	7.96

Table 3.4: Chautauqua Lake – During-Treatment *In-situ* - 5/16/19

Chautauqua Lake - During-Treatment *In-situ* - 5/16/19									
Station	Distance from Shore	Secchi	Total depth	Sample depth	Temp	DO	DO%	SpC	pH
	(ft)	(m)	(m)	(m)	(°C)	(mg/L)	(%)	(mS/cm)	(units)
NYSDEC Standard For Class A Waterbody:						> 5			6.5 to 8.5
CTR4	100	1.5	1.5	0.1	13.14	8.62	87.4	0.186	7.88
				0.5	13.15	8.51	85.0	0.185	7.88
				1	13.11	8.54	84.8	0.185	7.84
DFT4	100	0.8	1.1	0.1	13.50	9.99	90.1	0.205	6.67
				0.5	13.44	8.64	88.1	0.208	6.87
				1	13.43	8.73	87.9	0.211	7.10
TRT4	100	0.9	1.4	0.1	13.61	8.62	87.5	0.198	7.69
				0.5	13.57	8.51	86.4	0.202	7.68
				1	13.40	8.24	84.5	0.214	7.70

Table 3.5: Chautauqua Lake – During-Treatment *In-situ* - 5/17/19

Chautauqua Lake - During-Treatment *In-situ* - 5/17/19									
Station	Distance from Shore	Secchi	Total depth	Sample depth	Temp	DO	DO%	SpC	pH
	(ft)	(m)	(m)	(m)	(°C)	(mg/L)	(%)	(mS/cm)	(units)
NYSDEC Standard For Class A Waterbody:						> 5			6.5 to 8.5
CTR3	100	1.9	1.9	0	15.36	8.49	88.8	0.193	6.70
				0.5	15.29	8.43	87.9	0.194	7.02
				1	15.47	8.07	86.3	0.194	7.25
				1.5	15.44	7.99	83.4	0.194	7.37
DFT3	100	1.0	1.0	0	15.31	9.01	96.2	0.212	7.47
				0.5	15.18	9.15	95.1	0.224	7.95
TRT3	100	1.3	1.7	0	15.30	9.47	99.6	0.199	8.11
				0.5	15.27	9.58	101.1	0.199	**8.58**
				1	15.19	9.75	100.8	0.200	**8.54**
				1.5	14.52	10.64	109.6	0.200	**9.06**

Slight exceedances for pH were noted at TRT3 during the treatment week.

Table 3.6: Chautauqua Lake – Post-Treatment *In-situ* – 6/12/19 (1 of 2)

Chautauqua Lake - Post-Treatment *In-situ* - 6/12/19 (1 of 2)									
Station	Distance from Shore	Secchi	Total depth	Sample depth	Temp	DO	DO%	SpC	pH
	(ft)	(m)	(m)	(m)	(°C)	(mg/L)	(%)	(mS/cm)	(units)
NYSDEC Standard For Class A Waterbody:						> 5			6.5 to 8.5
CTR1	40	0.9	0.9	0.1	17.77	7.53	82.3	0.197	**6.35**
				0.5	17.75	7.47	81.6	0.196	**6.36**
CTR1	100	0.9	0.9	0.1	18.10	7.66	84.3	0.195	6.65
				0.5	18.09	7.58	83.4	0.195	**6.47**
DFT1	40	1.0	1.0	0.1	18.43	6.79	75.1	0.201	7.08
				0.5	18.43	6.19	68.6	0.199	7.06
DFT1	100	1.3	1.3	0.1	18.39	6.37	70.4	0.199	7.19
				0.5	18.40	6.16	68.0	0.199	7.13
				1	18.40	5.94	65.7	0.200	7.08
TRT1	40	1.2	1.2	0.1	18.92	7.49	83.7	0.202	7.51
				0.5	18.94	7.53	84.3	0.201	7.43
				1	18.93	7.54	84.3	0.201	7.54
TRT1	100	1.4	1.4	0.1	18.95	7.64	85.5	0.200	7.53
				0.5	18.95	7.48	83.7	0.202	7.47
				1	18.93	8.05	90.1	0.201	7.47
CTR2 (TRT5)	40	1.7	1.7	0.1	21.20	8.45	98.9	0.201	7.61
				0.5	21.13	8.41	98.3	0.202	7.58
				1	21.14	8.51	99.5	0.201	7.58
				1.5	21.10	8.41	98.2	0.201	7.58
DFT2	40	0.7	0.7	0.1	20.52	11.72	135.3	0.202	**8.70**
				0.5	20.24	13.21	151.7	0.203	**8.96**
DFT2	100	0.9	0.9	0.1	20.08	10.55	120.7	0.207	7.94
				0.5	19.98	10.32	117.9	0.208	8.24
TRT2	40	0.8	1.4	0.1	19.63	8.15	92.4	0.201	6.70
				0.5	19.69	8.28	94.0	0.201	6.94
				1	19.66	8.20	93.1	0.201	6.99
TRT2	100	1.2	1.5	0.1	19.57	8.40	91.9	0.202	6.74
				0.5	19.58	7.97	90.3	0.202	6.84
				1	19.56	7.94	89.9	0.203	6.76

Slightly low pH values were noted at the control station (CTR1) post-treatment while slightly elevated values were noted at DFT2 (40’) while those at DFT2 100’ where within the range of 6.5 to 8.5.

Table 3.7: Chautauqua Lake – Post-Treatment *In-situ* – 6/12/19 (2 of 2)

Chautauqua Lake - Post-Treatment *In-situ* - 6/12/19 (2 of 2)									
Station	Distance from Shore	Secchi	Total depth	Sample depth	Temp	DO	DO%	SpC	pH
	(ft)	(m)	(m)	(m)	(°C)	(mg/L)	(%)	(mS/cm)	(units)
NYSDEC Standard For Class A Waterbody:						> 5			6.5 to 8.5
CTR3	40	1.1	1.1	0.1	20.86	8.75	101.9	0.201	7.88
				0.5	20.85	8.58	99.7	0.201	7.87
				1	20.59	8.56	99.0	0.202	7.87
CTR3	100	1.6	1.6	0.1	20.94	8.95	104.2	0.199	7.64
				0.5	20.53	8.95	103.4	0.200	7.64
				1	20.48	8.68	100.1	0.199	7.65
				1.5	20.39	8.38	96.4	0.199	7.65
DFT3	40	0.4	0.8	0.1	21.00	7.73	90.1	0.201	7.05
				0.5	19.51	8.49	96.1	0.357	7.05
DFT3	100	0.5	0.8	0.1	20.91	8.17	95.0	0.203	7.55
				0.5	20.91	7.61	88.6	0.202	7.03
TRT3	40	0.4	1.0	0.1	21.03	8.32	97.1	0.218	7.94
				0.5	20.96	8.04	93.5	0.218	7.90
TRT3	100	0.4	1.4	0.1	20.90	8.24	95.8	0.213	7.91
				0.5	20.94	8.29	96.6	0.215	7.89
				1	20.91	8.04	93.6	0.214	7.91
CTR4	40	1.0	1.2	0.1	21.30	9.40	110.1	0.203	**8.62**
				0.5	21.17	9.29	108.7	0.202	**8.58**
CTR4	100	1.0	1.5	0.1	20.79	9.18	106.5	0.203	8.23
				0.5	20.91	9.02	104.8	0.203	8.30
				1	20.84	8.82	102.4	0.203	8.32
DFT4	40	0.7	0.9	0	21.47	6.55	77.0	0.231	6.92
				0.5	21.35	6.65	78.0	0.230	6.93
DFT4	100	0.6	1.1	0	21.27	7.12	83.5	0.227	6.97
				0.5	21.30	6.90	80.9	0.227	6.76
TRT4	40	0.5	1.4	0	21.36	8.65	101.5	0.209	7.42
				0.5	21.35	8.50	99.8	0.210	7.52
				1	21.19	8.33	97.5	0.210	7.54
TRT4	100	0.5	1.5	0	20.99	8.14	94.8	0.209	7.83
				0.5	21.01	8.08	94.2	0.208	7.82
				1	21.04	8.09	94.3	0.208	7.84

Slightly elevated pH values were noted at the control station (CTR4) post-treatment. No strong trends were observed in the *in-situ* data when this data was compared between pre, during, and post-treatment.

3.2 DISCRETE CHEMICAL DATA

The following Table (3.8) displays the chemical data collected by Princeton Hydro during the Pre-Treatment, near term Post-Treatment, and longer-term Post-Treatment events. Exceedances for consumptive use, as established by NYSDEC, of 50 ppb for both parameters are highlighted in red. Please see the note in Section 3.0 above regarding the use of the term “exceedance” in this report. Use restrictions were not lifted until after the 04 June 2019 sampling by Solitude. Final laboratory reports of all third-party data collected by Princeton Hydro are provided in Appendix II.

Table 3.8: Chautauqua Lake – Pre- & Post-Treatment Chemical Data (Princeton Hydro)

Chautauqua Lake - Pre- & Post-Treatment Chemical Data (Princeton Hydro)										
Station	2,4-D ppb (µg/L)					Endothall ppb (µg/L)				
	Pre-treatment	Post-Treatment (1-2 Days)		Post-treatment (7-14 Days)		Pre-treatment	Post-Treatment (1-2 Days)		Post-treatment (7-14 Days)	
	5/14/2019	5/16/2019	5/17/2019	5/21/2019	5/28/2019	5/14/2019	5/16/2019*	5/17/2019**	5/21/2019***	5/28/2019
CTR4	ND < 0.2	ND < 0.2	-	**101.0**	-	ND < 9.0	ND < 9.0	-	**57.0**	-
DFT4	ND < 0.2	**57.7**	-	**69.6**	-	ND < 9.0	16.0	-	**55.0**	-
DFT4 (Duplicate)	ND < 0.2	47.2	-	**60.8**	-	ND < 9.0	14.0	-	Sample broken	-
TRT4	ND < 0.2	**183.0**	-	**85.4**	-	ND < 9.0	18.0	-	ND < 9.0	-
CWD2	0.279	-	ND < 0.2	-	ND < 0.2	ND < 9.0	-	ND < 9.0	-	ND < 9.0
CUD	ND < 0.2	-	ND < 0.2	-	ND < 0.2	ND < 9.0	-	ND < 9.0	-	Sample broken
NYSDEC Permit Consumptive Threshold of 50 ppb (µg/L)						NYSDEC Permit Consumptive Threshold of 50 ppb (µg/L)				
*	Endothall recovery in LFB (32%) outside acceptable limit of 69-136%. Any results are potentially low biased.									
**	Endothall recovery in the LFB (27%) was outside the acceptable limits of 69-136%. Any results are potentially low biased.									
***	Endothall recovery in the MS at 100 µg/L (67%) was outside the accepted limits of 70-142%. Any results are potentially low biased.									

Post-treatment exceedances of the 50 ppb threshold was noted at DFT4 and TRT4 on 16 May 2019 and at all in-lake sites on 21 May 2019 for 2,4-D. Exceedances for endothall were noted on 21 May 2019 at CTR4 and DFT4 but not at the treatment location. The samples marked with *, **, and *** indicated that the matrix spike sample analyzed by the laboratory showed a recovery that was less than expected. As such, these samples may potentially be low-biased. Princeton Hydro did not measure exceedances for 2,4-D or endothall at the water intake locations.

Sampling data conducted by Solitude and the water service operators is hereby provided in Table 3.9.

Table 3.9: Chautauqua Lake – Pre- & Post-Treatment Chemical Data (Solitude or PWS Operators)

Chautauqua Lake - Pre- & Post-Treatment Chemical Data (Solitude or PWS Operators)								
Station	2,4-D ppb (µg/L)				Endothall ppb (µg/L)			
	Pre-treatment	Post-Treatment			Pre-treatment	Post-Treatment		
	5/14/2019	5/22/2019 (+8 Days)	5/27 & 28/2019 (+13-14 Days)	6/4/2019 (+21 Days)	5/14/2019	5/22/2019 (+8 Days)	5/27 & 28/2019 (+13-14 Days)	6/14/2019 (+21 Days)
CUD	< 2.5	< 1.0	< 2.5	-	< 7	< 20.0	7.36	-
NB1	< 2.5	-	8.2	-	< 7	-	< 7	-
CWD2	< 2.5	< 1.0	< 2.5	-	< 7	< 20.0	< 7	-
NB2	< 2.5	-	**56.0**	< 2.5	< 7	-	< 7	-
CEL2	-	-	**108.1**	< 2.5	-	-	24.76	-
O1	-	-	**101.5**	< 2.5	-	-	31.28	-
ELL3	-	-	3.2	-	-	-	< 7	-
NYSDEC Permit Consumptive Threshold of 50 ppb (µg/L)					NYSDEC Permit Consumptive Threshold of 50 ppb (µg/L)			

Solitude noted exceedances for 2,4-D at NB2 (NB = North Basin), CEL2 (Cel = Celoron) and O1 (O = Outlet) during the 27-28 May 2019 events. NB2 was the location near the intake for Chautauqua Lake Estates (CWD#2), CEL2 was in the general vicinity of TRT4, and O1 was in the general vicinity of DFT4. The exceedance at in-lake station NB2 was not corroborated by the raw (untreated) water sample collected from within the drinking water plant during the same time frame (CWD2 was ND < 0.2 ppb on 28 May 2019). An exceedance for 2,4-D at TRT4 (85.4 ppb) was noted on 21 May 2019 by Princeton Hydro, which increased to 108.1 ppb on 27-28 May 2019 based on sampling by Solitude. An exceedance of 2,4-D at 69.6 ppb was noted by Princeton Hydro on 21 May 2019 at DFT4, which also increased to 101.5 at O1 on 27-28 May 2019 based on sampling by Solitude.

3.3 MACROPHYTE DATA

The following Table (3.10) provides a species list of those species encountered during the macrophyte surveys and their associated coefficients of conservatism.

Table 3.10: Chautauqua Lake – Macrophyte Species List

Chautauqua Lake - Macrophyte Species List		
Common name	**Scientific Name**	**Coefficients of Conservatism**
Curly-Leaf Pondweed	*Potamogeton crispus*	0
Small Pondweed	*Potamogeton berchtoldii*	5
Leafy Pondweed	*Potamogeton foliosus*	4
Sago Pondweed	*Stuckenia pectinata*	3
Eurasian Watermilfoil	*Myriophyllum spicatum*	0
Coontail	*Ceratophyllum demersum*	4
Elodea	*Elodea canadensis*	2
Water Stargrass	*Heteranthera dubia*	4
Emergent grass	Un-identified	N/A
Star Duckweed	*Lemna trisulca*	7
White Waterlily	*Nymphaea odorata*	4
Aquatic Moss	*Fontinalis sp.*	N/A
Chara	*Chara sp.*	N/A
Tape Grass	*Vallisneria americana*	5
Slender Naiad	*Najas flexilis*	5

Tables 3.11 through 3.13 provide the pre-treatment macrophyte speciation and relative density data while Table 3.14 provides the pre-treatment macrophyte biomass data for a random quadrat along each transect. Pre-treatment macrophyte data were collected on 14 May 2019.

Table 3.11: Chautauqua Lake – Pre-Treatment Macrophyte Relative Density Data – 5/13-14/19 (1 of 3)

Chautauqua Lake - Pre-Treatment Macrophyte Relative Density Data - 5/13-14/19 (1 of 3)																		
Site	Distance (Ft.)	Rake Toss	Overall Density	Curly-leaf Pondweed	Eurasian Watermilfoil	Coontail	Star Duckweed	Sago Pondweed	Elodea	White Waterlily	Aquatic Moss	Small Pondweed	Leafy Pondweed	Water Stargrass	Unknown Emergent Grass Species	*Chara* algae	Tape Grass	Slender Naiad
CTR1	0	1	NP															
CTR1	0	2	T									T						
CTR1	20	1	T									T						
CTR1	20	2	NP															
CTR1	40	1	T									T						
CTR1	40	2	T									T						
CTR1	60	1	NP															
CTR1	60	2	NP															
CTR1	80	1	NP															
CTR1	80	2	NP															
CTR1	100	1	NP															
CTR1	100	2	T		T													
CTR2 (TRT5)	0	1	T	T														
CTR2 (TRT5)	0	2	NP															
CTR2 (TRT5)	20	1	T	T														
CTR2 (TRT5)	20	2	NP															
CTR2 (TRT5)	40	1	S	S														
CTR2 (TRT5)	40	2	T	T														
CTR2 (TRT5)	60	1	S	S														
CTR2 (TRT5)	60	2	S	S														
CTR2 (TRT5)	80	1	S	S														
CTR2 (TRT5)	80	2	M	M														
CTR2 (TRT5)	100	1	S	S														
CTR2 (TRT5)	100	2	M	M														
CTR3	0	1	T		T													
CTR3	0	2	NP															
CTR3	20	1	NP															
CTR3	20	2	NP															
CTR3	40	1	NP															
CTR3	40	2	T		T													
CTR3	60	1	T		T													
CTR3	60	2	T		T													
CTR3	80	1	S		S													
CTR3	80	2	S		S													
CTR3	100	1	T		T													
CTR4	0	1	T	T					T									
CTR4	0	2	T	T														
CTR4	20	1	T									T						
CTR4	20	2	T	T														
CTR4	40	1	T	T														
CTR4	40	2	T	T														
CTR4	60	1	S	S														
CTR4	60	2	T	T														
CTR4	80	1	S	S														
CTR4	80	2	S	S														
CTR4	100	1	S	S														
CTR4	100	2	S	S														

"NP" = No plants sampled, "T" = Trace (25%), "S" = Sparse (50%), "M" = Moderate (75%-100%), "D" = Dense (>100%)

Table 3.12: Chautauqua Lake – Pre-Treatment Macrophyte Relative Density Data (2 of 3)

Chautauqua Lake - Pre-Treatment Macrophyte Relative Density Data - 5/13-14/19 (2 of 3)

Site	Distance (Ft.)	Rake Toss	Overall Density	Curly-leaf Pondweed	Eurasian Watermilfoil	Coontail	Star Duckweed	Sago Pondweed	Elodea	White Waterlily	Aquatic Moss	Small Pondweed	Leafy Pondweed	Water Stargrass	Unknown Emergent Grass Species	*Chara* algae	Tape Grass	Slender Naiad
DFT1	0	1	S	T					S									
DFT1	0	2	S	T					S									
DFT1	20	1	S	T					S									
DFT1	20	2	S	S		T												
DFT1	40	1	S	S		T												
DFT1	40	2	S	S					T									
DFT1	60	1	M	T		T			M									
DFT1	60	2	S	T		T			S									
DFT1	80	1	M			S			S									
DFT1	80	2	T	T					T									
DFT1	100	1	M	T		S			S									
DFT1	100	2	S	S		T			T									
DFT2	0	1	S	T		T			S									
DFT2	0	2	S	T					S									
DFT2	20	1	S	T					S									
DFT2	20	2	S	T					S									
DFT2	40	1	S			S			S									
DFT2	40	2	S						S					S				
DFT2	60	1	S						S					S				
DFT2	60	2	S						S					S				
DFT2	80	1	S		T	T			S									
DFT2	80	2	T	T		T			T									
DFT2	100	1	M	T					S						S			
DFT2	100	2	NP															
DFT3	0	1	D	S	S	S			S					M				
DFT3	0	2	S			T			T					S				
DFT3	20	1	S	T		T			T					S				
DFT3	20	2	S											S				
DFT3	40	1	S		T	T			T					S				
DFT3	40	2	S		T	T								S				
DFT3	60	1	S	T	T	T			T					S				
DFT3	60	2	S	T		T			T					S				
DFT3	80	1	S			T			T					S				
DFT3	80	2	S		T	T			T					S				
DFT3	100	1	S			T			T					S				
DFT3	100	2	S			S			T					S				
DFT4	0	1	NP															
DFT4	0	2	NP															
DFT4	20	1	NP															
DFT4	20	2	T	T														
DFT4	40	1	NP															
DFT4	40	2	T			T												
DFT4	60	1	NP															
DFT4	60	2	T			T												
DFT4	80	1	T	T	T													
DFT4	80	2	T	T														
DFT4	100	1	T			T			T			T						
DFT4	100	2	T	T								T						

"NP" = No plants sampled, "T" = Trace (25%), "S" = Sparse (50%), "M" = Moderate (75%-100%), "D" = Dense (>100%)

Table 3.13: Chautauqua Lake – Pre-Treatment Macrophyte Relative Density Data (3 of 3)

Chautauqua Lake - Pre-Treatment Macrophyte Relative Density Data - 5/13-14/19 (3 of 3)

Site	Distance (Ft.)	Rake Toss	Overall Density	Curly-leaf Pondweed	Eurasian Watermilfoil	Coontail	Star Duckweed	Sago Pondweed	Elodea	White Waterlily	Aquatic Moss	Small Pondweed	Leafy Pondweed	Water Stargrass	Unknown Emergent Grass Species	*Chara* algae	Tape Grass	Slender Naiad
TRT1	0	1	S			S			S									
TRT1	0	2	S	T		T			T									
TRT1	20	1	S	S					T									
TRT1	20	2	S	T		S			T									
TRT1	40	1	M	T		S			T									
TRT1	40	2	S	T		S			T									
TRT1	60	1	M	T		S			T									
TRT1	60	2	M	S		S			T									
TRT1	80	1	M	T		S			T									
TRT1	80	2	M	T		M			T									
TRT1	100	1	S		T	S			T									
TRT1	100	2	M	S		S			T									
TRT2	0	1	M	M		T			T									
TRT2	0	2	NP															
TRT2	20	1	S	S														
TRT2	20	2	S	S														
TRT2	40	1	S	S														
TRT2	40	2	S	S														
TRT2	60	1	S	S														
TRT2	60	2	M	M														
TRT2	80	1	S	S														
TRT2	80	2	M	M														
TRT2	100	1	S	S														
TRT2	100	2	M	M														
TRT3	0	1	T	T	T													
TRT3	0	2	T	T								T						
TRT3	20	1	S	T	T							T						
TRT3	20	2	S	S	T													
TRT3	40	1	S	S	T													
TRT3	40	2	S	S	T													
TRT3	60	1	S	S	T	T												
TRT3	60	2	M	S	T	T			S									
TRT3	80	1	S	S	T													
TRT3	80	2	S	S	T							T						
TRT3	100	1	S	S	T	T			T									
TRT3	100	2	S	S														
TRT4	0	1	T			T												
TRT4	0	2	NP															
TRT4	20	1	NP															
TRT4	20	2	NP															
TRT4	40	1	NP															
TRT4	40	2	NP															
TRT4	60	1	NP															
TRT4	60	2	T	T														
TRT4	80	1	T	T														
TRT4	80	2	T										T					
TRT4	100	1	T	T		T			T									
TRT4	100	2	T	T									T					

"NP" = No plants sampled, "T" = Trace (25%), "S" = Sparse (50%), "M" = Moderate (75%-100%), "D" = Dense (>100%)

Table 3.14: Chautauqua Lake – Pre-Treatment Biomass – 5/13-14/19

Chautauqua Lake - Pre-Treatment Biomass (grams) - 5/13-14/19																
Station	Distance (Ft.)	Total Mass	Curly-leaf Pondweed	Eurasian Watermilfoil	Coontail	Star Duckweed	Sago Pondweed	Elodea	White Water Lily	Aquatic Moss	Small Pondweed	Leafy Pondweed	Water Stargrass	Unknown Emergent Grass Species	*Chara* algae	Tape Grass	Slender Naiad
CTR1	0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
CTR2 (TRT5)	0	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CTR3	0	3.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CTR4	60	37.0	37.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DFT1	80	612.0	153.0	0.0	122.4	6.12*	0.0	336.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DFT2	60	319.0	0.0	0.0	0.0	0.0	0.0	191.4	0.0	0.0	0.0	0.0	127.6	0.0	0.0	0.0	0.0
DFT3	80	568.0	0.0	14.2	56.8	0.0	0.0	42.6	0.0	0.0	0.0	0.0	454.4	0.0	0.0	0.0	0.0
DFT4	100	3.0	1.1	0.0	0.8	0.0	0.0	0.4	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0
TRT1	100	625.0	140.6	31.3	390.6	0.0	0.0	62.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TRT2	80	302.0	302.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TRT3	100	95.0	85.5	4.8	2.4	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TRT4	60	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
*Plant found in biomass sample but not in field.																

The following Tables provide the post-treatment macrophyte data which were collected on 12 June 2019. Tables 3.15 through 3.17 provide speciation and relative density data while Table 3.18 provides biomass data.

Table 3.15: Chautauqua Lake – Post-Treatment Macrophyte Relative Density Data – 6/12/19 (1 of 3)

Chautauqua Lake - Post-Treatment Macrophyte Relative Density Data - 6/12/19 (1 of 3)

Site	Distance (Ft.)	Rake Toss	Overall Density	Curly-leaf Pondweed	Eurasian Watermilfoil	Coontail	Star Duckweed	Sago Pondweed	Elodea	White Waterlily	Aquatic Moss	Small Pondweed	Leafy Pondweed	Water Stargrass	Unknown Emergent Grass Species	*Chara* algae	Tape Grass	Slender Naiad
CTR1	0	1	T									T					T	
CTR1	0	2	T									T						T
CTR1	20	1	T									T						
CTR1	20	2	T					T				T						
CTR1	40	1	T											T			T	
CTR1	40	2	T	T										T			T	
CTR1	60	1	T	T		T								T				
CTR1	60	2	T	T										T				
CTR1	80	1	T	T								T		T			T	
CTR1	80	2	T									T		T				
CTR1	100	1	T	T										T				
CTR1	100	2	T									T						
CTR2 (TRT5)	0	1	NP															
CTR2 (TRT5)	0	2	NP															
CTR2 (TRT5)	20	1	NP															
CTR2 (TRT5)	20	2	T													T		
CTR2 (TRT5)	40	1	T	T												T		
CTR2 (TRT5)	40	2	T													T		
CTR2 (TRT5)	60	1	S	S					T							T		
CTR2 (TRT5)	60	2	M	M														
CTR2 (TRT5)	80	1	S	S														
CTR2 (TRT5)	80	2	M	M					T									
CTR2 (TRT5)	100	1	S	S														
CTR2 (TRT5)	100	2	M	M														
CTR3	0	1	NP															
CTR3	0	2	NP															
CTR3	20	1	NP															
CTR3	20	2	T		T													
CTR3	40	1	T		T													
CTR3	40	2	S		S													
CTR3	60	1	S		S													
CTR3	60	2	S		S													
CTR3	80	1	S		S													
CTR3	80	2	S		S													
CTR3	100	1	NP															
CTR3	100	2	S		S													
CTR4	0	1	T	T										T				
CTR4	0	2	T											T				
CTR4	20	1	NP															
CTR4	20	2	T	T					T					T				
CTR4	40	1	T	T										T				
CTR4	40	2	T	T										T				
CTR4	60	1	T	T										T				
CTR4	60	2	T	T										T				
CTR4	80	1	T	T										T				
CTR4	80	2	T	T										T				
CTR4	100	1	T	T										T				
CTR4	100	2	T	T										T				

"NP" = No plants sampled, "T" = Trace (25%), "S" = Sparse (50%), "M" = Moderate (75%-100%), "D" = Dense (>100%)

Table 3.16: Chautauqua Lake – Post-Treatment Macrophyte Relative Density Data – 6/12/19 (2 of 3)

Chautauqua Lake - Post-Treatment Macrophyte Relative Density Data -6/12/19 (2 of 3)

Site	Distance (Ft.)	Rake Toss	Overall Density	Curly-leaf Pondweed	Eurasian Watermilfoil	Coontail	Star Duckweed	Sago Pondweed	Elodea	White Waterlily	Aquatic Moss	Small Pondweed	Leafy Pondweed	Water Stargrass	Unknown Emergent Grass Species	*Chara* algae	Tape Grass	Slender Naiad
DFT1	0	1	S		T	S	T		S								T	
DFT1	0	2	M	T	T	S	T		T					T				
DFT1	20	1	S	T	T	S	T											
DFT1	20	2	S	T		T			T					S				
DFT1	40	1	S			S	T		T					T				
DFT1	40	2	M	T		S			S					T				
DFT1	60	1	S	T	T	T	T		S									
DFT1	60	2	S	T		S	T		S					T				
DFT1	80	1	T			T	T		T									
DFT1	80	2	S	T	T	S			S					T				
DFT1	100	1	M	T	S	S			S									
DFT1	100	2	M			M	T		S					T				
DFT2	0	1	T			T			T					T				
DFT2	0	2	T						T	T								
DFT2	20	1	T						T					T				
DFT2	20	2	T			T			T					T				
DFT2	40	1	S						S					T				
DFT2	40	2	S			T			S					S				
DFT2	60	1	S			T	T		S					S				
DFT2	60	2	S			T			S					T				
DFT2	80	1	S			T			S					S				
DFT2	80	2	S			T			S					S				
DFT2	100	1	S			T			S					S				
DFT2	100	2	S			T	T		S					S				
DFT3	0	1	S	T		T			T					S			T	
DFT3	0	2	S	T	T				T					T		T	T	
DFT3	20	1	S	T										S				T
DFT3	20	2	T	T	T	T			T					T				
DFT3	40	1	T											T			T	
DFT3	40	2	M	T		T			T					M			T	
DFT3	60	1	S			T								S				
DFT3	60	2	S	T		T			T					T				
DFT3	80	1	S			T			T					T			T	
DFT3	80	2	T											T				
DFT3	100	1	S	T		T								T			T	
DFT3	100	2	T											T			T	
DFT4	0	1	NP															
DFT4	0	2	NP															
DFT4	20	1	NP															
DFT4	20	2	T								T							
DFT4	40	1	T							T				T				
DFT4	40	2	T								T							
DFT4	60	1	T	T					T					T				
DFT4	60	2	T	T		T								T				
DFT4	80	1	T	T					T					T				
DFT4	80	2	T													T		
DFT4	100	1	T											T		T		
DFT4	100	2	S			T					T			S		T		

"NP" = No plants sampled, "T" = Trace (25%), "S" = Sparse (50%), "M" = Moderate (75%-100%), "D" = Dense (>100%)

Table 3.17: Chautauqua Lake – Post-Treatment Macrophyte Relative Density Data -6/12/19 (3 of 3)

Chautauqua Lake - Post-Treatment Macrophyte Relative Density Data - 6/12/19 (3 of 3)																		
Site	Distance (Ft.)	Rake Toss	Overall Density	Curly-leaf Pondweed	Eurasian Watermilfoil	Coontail	Star Duckweed	Sago Pondweed	Elodea	White Waterlily	Aquatic Moss	Small Pondweed	Leafy Pondweed	Water Stargrass	Unknown Emergent Grass Species	*Chara* algae	Tape Grass	Slender Naiad
TRT1	0	1	S			S			T									
TRT1	0	2	S		T	T			S									
TRT1	20	1	M		T	S			M									
TRT1	20	2	S			S			S									
TRT1	40	1	S			S	T		S									
TRT1	40	2	M	T		S	T		S					T				
TRT1	60	1	S	T		S			S									
TRT1	60	2	S	T		S			S									
TRT1	80	1	S	T		S	T		S									
TRT1	80	2	M	T	T	M	T		S					T				
TRT1	100	1	S			S	T		S					T				
TRT1	100	2	M			M	T		T								T	
TRT2	0	1	T			T	T							T				
TRT2	0	2	T						T					T				
TRT2	20	1	T			T	T							T				
TRT2	20	2	T			T			T					T				
TRT2	40	1	T			T	T							T			T	
TRT2	40	2	T			T			T									
TRT2	60	1	T			T	T							T				
TRT2	60	2	S		T	S			T									
TRT2	80	1	T	T		T			T					T				
TRT2	80	2	T			T	T		T									
TRT2	100	1	T	T		T			T					T				
TRT2	100	2	T			T												
TRT3	0	1	T	T									T			T		
TRT3	0	2	S	S	T									T		T		
TRT3	20	1	S	T	T				T					T				
TRT3	20	2	T	T		T			T							T		
TRT3	40	1	S	T		T			T					T		T		
TRT3	40	2	S	T					T							T		
TRT3	60	1	S	T										S				
TRT3	60	2	S	T		T								T		T		
TRT3	80	1	S	T		T			T					S		T		
TRT3	80	2	S	T	T				T					T		T		
TRT3	100	1	S	T	T	T								T				
TRT3	100	2	T	T	T									T		T	T	T
TRT4	0	1	NP															
TRT4	0	2	NP															
TRT4	20	1	NP															
TRT4	20	2	NP															
TRT4	40	1	NP															
TRT4	40	2	T			T												
TRT4	60	1	T	T		T			T									
TRT4	60	2	T	T														
TRT4	80	1	T	T		T								T				
TRT4	80	2	T	T														
TRT4	100	1	T	T														
TRT4	100	2	T	T		S								T				
"NP" = No plants sampled, "T" = Trace (25%), "S" = Sparse (50%), "M" = Moderate (75%-100%), "D" = Dense (>100%)																		

The following Table (3.18) presents the biomass data collected during the post-treatment event.

Table 3.18: Chautauqua Lake – Post-Treatment Biomass – 6/12/19

Chautauqua Lake - Post-Treatment Biomass (grams) - 6/12/19																
Station	Distance (Ft.)	Total Mass	Curly-leaf Pondweed	Eurasian Watermilfoil	Coontail	Star Duckweed	Sago Pondweed	Elodea	White Waterlily	Aquatic Moss	Small Pondweed	Leafy Pondweed	Water Stargrass	Unknown Emergent Grass Species	*Chara* algae	Tape Grass	Slender Naiad
CTR1	0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.2	0.2
CTR2 (TRT5)	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CTR3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CTR4	60	6.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0
DFT1	80	104.0	2.6	2.6	26.0	5.2	0.0	65.0	0.0	0.0	0.0	0.0	2.6	0.0	0.0	0.0	0.0
DFT2	60	314.0	0.0	0.0	23.6	15.7	0.0	235.5	0.0	0.0	0.0	0.0	39.3	0.0	0.0	0.0	0.0
DFT3	80	43.0	0.0	0.0	3.2	0.0	0.0	3.2	0.0	0.0	0.0	0.0	30.1	0.0	0.0	6.5	0.0
DFT4	100	9.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.2	0.0	0.0	5.9	0.0	2.7	0.0	0.0
TRT1	100	246.0	0.0	0.0	172.2	30.8	0.0	30.8	0.0	0.0	0.0	0.0	6.2	0.0	0.0	6.2	0.0
TRT2	80	18.0	0.9	0.0	7.7	0.9	0.0	5.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0	0.0	0.0
TRT3	100	27.0	14.9	2.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	0.0	0.7	0.7	0.7
TRT4	60	13.0	12.4	0.0	0.3	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

3.4 MACROPHYTE STATISTICS

The following section provides the statistical analyses conducted for the macrophyte relative density and biomass data. This section includes evaluations of species richness change, relative density change of those plants identified in pre-treatment <u>and</u> post-treatment plots, non-parametric data comparisons of biomass, and data pertaining to the adjusted floristic quality assessment. Statistical tests were conducted utilizing the non-parametric Sign Test.

Table 3.19 provides data pertaining to changes in species richness between pre-treatment and post-treatment macrophyte surveys. Species richness is simply the number of species identified between pre-treatment and post-treatment events.

Table 3.19: Chautauqua Lake – Species Richness

Chautauqua Lake - Species Richness			
Site	**Pre-treatment**	**Post-treatment**	**P-value***
CTR1	2	7	0.02
CTR2 (TRT5)	1	2	
CTR3	1	1	
CTR4	3	3	
DFT1	4	7	
DFT2	5	5	
DFT3	5	7	
DFT4	5	5	
TRT1	4	7	
TRT2	3	7	
TRT3	5	8	
TRT4	4	4	
Chara algae, aquatic moss, and the unknown grass species were not included in this assessment. *Sign test - Significant			

As shown above (Table 3.19) there was a significant (Sign-test; p-value < 0.05) increase in species richness between pre-treatment and post-treatment events. The macroalgae *Chara*, aquatic moss (*Fontinalis* sp.), and the un-identified emergent grass was not included for this analysis.

The following Table (3.20) depicts the change in relative density of plant species during pre-treatment and post-treatment.

Table 3.20: Chautauqua Lake – Change in Relative Density (Pre-Treatment vs. Post-Treatment)

Chautauqua Lake - Change in Relative Density (Pre- and Post-Treatment)		
Overall Relative Density		
Site-Types	**Overall Change (based on Average Density)**	**P-value**
Control (CTR)	Increase	0.79
Drift (DFT)	Decrease	1.20
Treatment (TRT)*	Decrease	0.06
All	Decrease	0.39
Curly-leaf Pondweed Density		
Site-Types	**Overall Change (based on Average Density)**	**P-value**
Control (CTR)	Decrease	1.27
Drift (DFT)	Decrease	0.08
Treatment (TRT)*	Decrease	**0.003**
All	Decrease	**0.001**
Eurasian Watermilfoil Density		
Site-Types	**Overall Change (based on Average Density)**	**P-value**
Control (CTR)	Increase	1.31
Drift (DFT)	Increase	1.23
Treatment (TRT)*	Decrease	1.25
All	Increase	1.15
Coontail Density		
Site-Types	**Overall Change (based on Average Density)**	**P-value**
Control (CTR)	Increase	1.00
Drift (DFT)	Increase	0.61
Treatment (TRT)*	Increase	**0.004**
All	Increase	**0.007**
Star Duckweed Density		
Site-Types	**Overall Change (based on Average Density)**	**P-value**
Control (CTR)	None	2
Drift (DFT)	Increase	**0.008**
Treatment (TRT)*	Increase	**0.008**
All	Increase	**0.00003**
Elodea Density		
Site-Types	**Overall Change (based on Average Density)**	**P-value**
Control (CTR)	Increase	1.5
Drift (DFT)	Decrease	0.45
Treatment (TRT)*	Increase	**0.004**
All	Increase	0.19
Water Stargrass Density		
Site-Types	**Overall Change (based on Average Relative Density)**	**P-value**
Control (CTR)	Increase	**0.002**
Drift (DFT)	Increase	0.08
Treatment (TRT)*	Increase	**0.00002**
All	Increase	**0.0000001**
*Treatment sites include CTR2 (TRT5)		
P-values listed in **bold red** indicate a statistically significant change between Pre- and Post-treatment population densities (α = 0.05).		

Of particular interest is the change in overall density and that of the species which were targeted by the herbicide application, curly-leaf pondweed and Eurasian watermilfoil. Please note, the Table above (3.20) is a Sign-Test comparison of the relative densities of pre-treatment data (Tables 3.11 – 3.13) and post-treatment data (Tables

3.15 – 3.17). This Table shows an overall, but not statistically significant, decrease in relative density of all macrophytes. Curly-leaf pondweed showed a significant decrease in relative density between pre-treatment and post-treatment events. Typically, curly-leaf pondweed is an early-growing species and senesces naturally by early to mid-July. Given that the post monitoring occurred in mid-June, we do not associate the decrease in this plant with natural senescence. Eurasian watermilfoil showed an overall increase in relative density but this was not statistically significant. Please note, the relative abundance of Eurasian watermilfoil was low during the pre-treatment sampling event and remained low during the post-treatment evaluation. As appropriate, we also included a Sign Test evaluation of several native species. Those native species which were not identified in both pre-treatment and post-treatment events, or were identified but not of sufficient sample size, were left out of this analysis.

Table 3.21 provides information regarding change in above-ground plant biomass between the pre-treatment and post-treatment events. This table presents change in total biomass, invasive species biomass (i.e., Eurasian watermilfoil & curly-leaf pondweed), native species biomass and change in biomass of the two species that were targeted for treatment; curly-leaf pondweed and Eurasian watermilfoil.

Table 3.21: Chautauqua Lake – Change in Plant Biomass

Chautauqua Lake - Change in Plant Biomass (grams)											
Station	Distance of Sample (ft.)	Total Mass		Invasive Mass		Native Mass		Curly-leaf Pondweed		Eurasian Watermilfoil	
		Before	After	Before	After	Before	After	Before	After	Before	After
CTR1	0	0.5	0.5	0.0	0.0	0.5	0.5	0.0	0.0	0.0	0.0
CTR2 (TRT5)	0	0.5	0.0	0.5	0.0	0.0	0.0	0.5	0.0	0.0	0.0
CTR3	0	3.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0
CTR4	60	37.0	6.0	37.0	3.0	0.0	3.0	37.0	3.0	0.0	0.0
DFT1	80	612.0	104.0	153.0	5.2	459.0	98.8	153.0	2.6	0.0	2.6
DFT2	60	319.0	314.0	0.0	0.0	319.0	314.0	0.0	0.0	0.0	0.0
DFT3	80	568.0	43.0	14.2	0.0	553.8	43.0	0.0	0.0	14.2	0.0
DFT4	100	3.0	9.0	1.1	0.0	1.9	9.0	1.1	0.0	0.0	0.0
TRT1	100	625.0	246.0	171.9	0.0	453.1	246.0	140.6	0.0	31.3	0.0
TRT2	80	302.0	18.0	302.0	0.9	0.0	17.1	302.0	0.9	0.0	0.0
TRT3	100	95.0	27.0	90.3	16.9	4.8	10.1	85.5	14.9	4.8	2.0
TRT4	60	0.5	13.0	0.5	12.4	0.0	0.7	0.5	12.4	0.0	0.0
* = Plant found in biomass sample but not in field.											

As shown above, total biomass generally decreased markedly at the treatment sites with a marked reduction in invasive species. Total biomass for all plants stayed consistent at CTR1 while it decreased at CTR3 and CTR4.

Decreases in biomass at drift sites were noted at all except DFT4 where an increase was noted. Curly-leaf pondweed was markedly reduced at: CTR4, DFT1, TRT1, TRT2, and TRT3. Eurasian watermilfoil biomass was not present in high amounts prior to treatment and was present in even lower amounts post-treatment. A reduction in native species biomass was noted at DFT1 (459.0 g to 98.8 g) and DFT3 (553.8 g to 43.0 g). The dominant native plant species at DFT1 pre-treatment was elodea while the dominant native at DFT-3 pre-treatment was water stargrass. Both native species saw a considerable decline in biomass post-treatment and which may indicate potential herbicide drift and resultant reduction in non-target plant biomass.

Biomass changes for the overall plant community and the invasives of concern, Eurasian watermilfoil and curly-leaf pondweed, are presented below in Table 3.22. It should be emphasized that CTR2 was not included in the control sites but was for the treatment site in this statistical analysis. This was due to the last-minute decision to conduct a treatment at CTR2, which then became CTR2 (TRT5). Thus, CTR2 (TRT5) was under the Treatment site category for the statistical analysis.

Table 3.22: Chautauqua Lake – Change in Plant Biomass – Sign Tests

Chautauqua Lake - Change in Biomass (Pre- and Post-Treatment)		
Overall Biomass		
Site-Types	**Change in Biomass**	**P-value**
Control (CTR)	Decrease	0.50
Drift (DFT)	Decrease	0.63
Treatment (TRT)*	Decrease	0.38
All	Decrease	0.07
Curly-leaf Pondweed Biomass		
Site-Types	**Overall Change (based on Average Density)**	**P-value**
Control (CTR)	Decrease	1.00
Drift (DFT)	Decrease	0.50
Treatment (TRT)*	Decrease	0.63
All	Decrease	0.13
Eurasian Watermilfoil Biomass		
Site-Types	**Overall Change (based on Average Density)**	**P-value**
Control (CTR)	No change	1.50
Drift (DFT)	Decrease	1.50
Treatment (TRT)*	Decrease	0.63
All	Decrease	0.73
*Treatment sites include CTR2 (TRT5)		
P-values listed in **bold red** indicate a statistically significant change between Pre- and Post-treatment biomass (α = 0.05).		

Again, Table 3.22 shows an overall decrease in biomass for the plant community overall and the two invasives of concern. These changes were not deemed statistically significant but still showed a marked decline, especially with curly-leaf pondweed.

Finally, Table 3.23 provides the adjusted Floristic Quality Indices for the pre-treatment and post-treatment plant communities. Again, note CTR2, which then became CTR2 (TRT5) due to the last-minute request to treat this part of the lake.

Table 3.23: Chautauqua Lake – Adjusted Floristic Quality Indices (FQIs)

Chautauqua Lake - Adjusted Floristic Quality Indices (FQIs)			
Site	**Pre-treatment**	**Post-treatment**	**P-value**
CTR1	28.6	30.6	**0.001**
CTR2 (TRT5)	0.0	14.1	
CTR3	0.0	0.0	
CTR4	16.3	28.6	
DFT1	26.0	32.1	
DFT2	25.6	36.0	
DFT3	25.6	30.4	
DFT4	25.6	31.3	
TRT1	17.7	32.1	
TRT2	20.4	32.1	
TRT3	17.8	32.0	
TRT4	26.0	28.6	
Chara algae, aquatic moss, and the unknown grass species were not included in this assessment			
P-values listed in **bold red** indicate a statistically significant change between Pre- and Post-treatment FQIs (a = 0.05).			

The adjusted floristic quality index for the pre-treatment versus post-treatment showed a statistically significant increase with improved quality at all sites evaluated.

4.0 DISCUSSION

The following section provides a discussion of the observations conducted during the treatment and a discussion of the data presented in Section 3.

4.1 OBSERVATION OF TREATMENTS

Princeton Hydro observed the treatments as they occurred on 15, 16, and 17 May 2019. Princeton Hydro was present for the entirety of treatments on 15 and 16 May 2019 and on-water up to 10:00 on 17 May 2019. Treatments had finished by the end of day on 17 May 2019. Princeton Hydro noted that all areas of the Pre-Application Checklist (note, the Pre-Application Checklist can be found in Appendix II) were satisfied by the applicator including:

1. Appropriate notification of regulatory agencies
2. Appropriate posting of signage in accordance with permit
3. Appropriate understanding of permit conditions by applicator
4. Treatment areas were properly delineated
5. Appropriate setbacks from potable water intakes were maintained
6. All personal protective equipment (PPE) was worn by applicators
7. Applicators possessed proper licensure from the State
8. Application equipment was in good working order
9. Application did not occur under unsafe conditions (i.e., excessive wind or wave action)

Princeton Hydro also noted that NYSDEC was present throughout the application process and ensured that all stipulations set forth in the State-issued permits were adhered to. This included treatment zones, product applied, setbacks from potable water intakes or environmentally sensitive areas, and collection of necessary water samples for herbicide concentration. Please note treatments were initiated on 15 May 2019 at Celoron, followed by N Harm Hadley Bay and then Ellicott 60-61, which was completed on 16 May 2019. Following this, on 16 May 2019 Ellicott / Fluvanna, Ellery / Greenhurst North and South were treated. The treatments on 16 May ended with initiating treatments at Lakewood 60-62, which were completed on 17 May 2019. Finally, the remaining treatments were all completed on 17 May 2019 and included Lakewood 66-67, Lakewood 026, N Harm Bly Bay, Ellery / Bermus Point and Ellery / Arnold Bay. More details on these treatments are provided in Table 1.1

4.2 IN-SITU DATA

The *in-situ* data collected by Princeton Hydro, overall, did not show an aberration that would be considered to be attributed to the herbicide application. NYSDEC has prescribed thresholds to dissolved oxygen for concentrations to not fall below 5.0 mg/L. None of the *in-situ* data collected by Princeton Hydro, either pre-treatment or post-treatment showed concentrations fell below this threshold. This pattern is favorable as applications of excessive amounts of herbicides may potentially lead to large-scale die off of macrophytes. This dead plant biomass is then decomposed by aerobic bacteria which have the potential to deplete dissolved oxygen if the treatment is conducted improperly. The areas of treatment prescribed by NYSDEC, in combination with the satisfactory application by the applicator, ensured that this did not occur.

The NYSDEC also defines an acceptable range for pH between 6.5 and 8.5. Several measurements at CTR2 (**TRT5**) and DFT2 slightly exceeded this threshold, and surface measurements at TRT2 were slightly less than this threshold prior to treatment on 14 May 2019. The slightly higher values are expected to be associated with increased primary productivity (i.e., photosynthesis of plants and algae) and are not considered to be a cause for concern.

The lower pH value at TRT2 is likely associated with decreased levels of primary productivity and was similarly not interpreted to be a cause for concern. Princeton Hydro again noted slightly elevated pH values at TRT3 on 17 May 2019, which were again believed to be related to higher levels of primary productivity rather than the herbicide treatment. Measurements at CTR1 during the post-treatment event on 12 June 2019 were slightly low, and those at CTR4 were slightly high; however, neither was considered to be related to the herbicide treatment and therefore was not a cause for concern.

All other water quality metrics (Temperature, clarity, specific conductance) were acceptable and did not indicate acute issues related to the herbicide treatment. Namely, if the treatment was conducted improperly or water quality was impacted by the treatment, we would have expected to have measured a large, wide-spread decrease in oxygen and pH; neither of which occurred.

4.3 DISCRETE CHEMICAL DATA

Discrete chemical data collected by Princeton Hydro showed non-detectable concentrations of both analytes during the pre-treatment at all stations except for a measurement of 0.279 ppb at CWD #2 (raw, untreated water). Given that no treatment had occurred at this point, the extremely low laboratory detection limit, and the very close proximity of the reported concentration to the non-detect limit, this measurement was likely an aberration. In addition, the Solitude-reported results from the analysis of the County Health Department-collected split sample of CWD #2 indicated non-detectable levels of 2,4-D (less than 2.5 ppb).

Potential Exposure to Drinking Water

Post-treatment raw-water (untreated) drinking water samples collected by the Chautauqua County Department of Health from CUD and CWD #2 (analyzed by Princeton Hydro-contracted laboratories) on 17 May and 28 May 2019 were below detection for 2,4-D and endothall. The 28 May 2019 endothall sample for CUD was broken in transport. However, there are two things to note. First, the Pre-treatment and Post-treatment (7-14 days after treatment) endothall concentrations for Princeton Hydro were both < 9.0 ppb, and second, the Solitude Post-treatment concentration (13 – 14 days after treatment) was < 7.0 ppb. Thus, while absence of the results for the endothall sample for CUD after 7-14 days is a data gap, there is a sufficient amount of available data to conclude the endothall did not have any substantial residual impacts.

These results, in addition to below detection post-treatment samples collected by the water supply operators on 22 May 2019 (shared with Princeton Hydro by the Alliance via the Health Department), indicated that the herbicide treatment did not result in unacceptable levels of 2,4-D and endothall reaching the lake's two public water supplies.

Direct Comparison Between Results of PH-Contracted Labs and Solitude-Contracted Labs

Split samples of raw, untreated water were collected by the Chautauqua County Department of Health, in coordination with both Princeton Hydro and Solitude personnel, from the drinking water plants at CUD and CWD#2 and analyzed for 2,4-D and endothall by both Princeton Hydro- and Solitude-contracted laboratories. These direct comparisons between the laboratories subcontracted by the licensed herbicide applicator and an independent third party took place on 14 May 2019 (before treatment began) and again on 28 May 2019. The results indicate agreement between the independent third-party laboratories and the Solitude-contracted laboratories.

Evaluation of Potential Herbicide Drift

Post-Treatment sampling conducted on 16 and 17 May 2019 showed no 2,4-D or endothall in the control zone with as expected measurable concentrations in the treatment zones. Measurable concentrations were also detected in the drift zone (DFT4) and these were noted also in the duplicate (DFT4 duplicate). Concentrations exceeded the potable water intake threshold (50 ppb) for 2,4-D at DFT4 and TRT4 while concentrations for endothall did not exceed this threshold. For reference, the permitted concentrations of 2,4-D and endothall (i.e., the initial concentrations within each treatment zone) were generally 2 to 4 parts per million (ppm) and 3 ppm, respectively (1 ppm = 1000 ppb).

Longer-scale post-treatment data collection on 21 May 2019 showed elevated concentrations of 2,4-D at all in-lake stations with the *highest* concentration at the control station (CTR4 = 101.0 ppb). Endothall measurements from this date again showed the highest concentration at the control station (CTR4 = 57.0 ppb). Concentrations for both 2,4-D and endothall were also above the potable water threshold at the drift station during this event. This indicates that there was some chemical drift outside of the treatment zone. This may be the results of applications which occurred in areas up-lake of CTR4 at TRT1 and TRT2 as the general direction of flow in the lake is in a southerly direction. The appearance of higher herbicide concentration under the longer-scale, post-treatment conditions indicates that these products may have had a potential residual impact. However, based on the plant density / biomass data and statistics, such residual impacts were negligible on native species but might have impacted the invasive species curly-leaf pondweed in the control areas. However, even this potential impact is confounded by the fact that curly-leaf pondweed begins to die off naturally as the seasons move from spring through summer and water temperatures increase.

Solitude noted exceedances for 2,4-D at NB2, CEL2 and O1 during the 27-28 May 2019 events. NB2 was the location near the intake for Chautauqua Lake Estates (CWD#2), CEL2 was in the general vicinity of TRT4, and O1 was in the general vicinity of DFT4. The exceedance for NB2 did not match up with that collected within the treatment facility during the same time frame (ND < 0.2 ppb on 25 May 2019). An exceedance for 2,4-D at TRT4 (85.4 ppb) was noted on 21 May 2019 by Princeton Hydro which increased to 108.1 ppb on 27-28 May 2019 by Solitude. An exceedance of 2,4-D at 69.6 ppb was noted by Princeton Hydro on 21 May 2019 at DFT4 which also increased to 101.5 at O1 on 27-28 May 2019 by Solitude. However, it should be emphasized that the two sampling stations of primary concern, CUD and CWD2, relative to potable water supplies consistently had herbicide concentrations that were below the respective analytical detection limits and thus below the NYSDEC Permit Consumptive Threshold of 50 ppb.

If treatments are to occur in the future, it is recommended that the exact same sampling locations between the licensed applicator and third-party consultant, and dates of sampling are maintained to allow for direct and ease of comparability between stations.

Overall, it does appear that there was some herbicide drift outside of the targeted treatment areas into areas that were not intended to be treated. This is not surprising in a lake environment due to the solubility of these chemicals and inability to discretely cordon off water flow into and out of treatment areas. The routine monitoring of potable water intakes, with restrictions to be lifted after testing negative, is a prudent approach for ensuring the health of consumptive users and should continue as an added layer of precaution.

4.4 MACROPHYTE DATA

The primary evaluation for the macrophyte community related to the third-party monitoring was to document the species composition and biomass and to determine if there were non-target impacts whether in terms of outside of the designated treatment zones or to non-target species.

The macrophyte data showed a relatively high density and occurrence of curly-leaf pondweed prior to treatment in the control, drift and treatment zones. In contrast, Eurasian watermilfoil occurrence and density was low. The occurrence of these species is somewhat attributed to timing as curly-leaf pondweed is an early-season macrophyte, typically beginning vegetative growth in early-April while Eurasian watermilfoil does not begin growing in earnest typically until late-May.

Species richness before treatment ranged from 1 to 5 while post-treatment species richness increased to between 1 to 7 (significant, p value 0.02). This provides evidence that treating for and reducing the amount of invasive species within the treatment areas, allowed more species to grow in those areas. An increase in floristic quality was also noted with increased index values at all treatment, drift and control sites with a significant increase overall (p value = 0.001). This provides evidence that more desirable species (e.g., *Elodea canadensis, Heteranthera dubia, Ceratophyllum demersum*) were established in the areas, regardless if they were treatment or not; thus, the treatments did not negatively impact the floristic quality of the macrophyte community.

Plant biomass changed overall with decreases noted in the targeted invasives Eurasian watermilfoil and curly-leaf pondweed. These decreases were not statistically significant but were sizeable both for plant biomass overall and for curly-leaf pondweed. Eurasian watermilfoil also generally decreased but was not present in sizeable densities prior to treatment as was the case with curly-leaf pondweed. The treatments did exert control over the targeted species of concern: Eurasian watermilfoil and curly-leaf pondweed.

Native species plant biomass did show a reduction pre- and post-treatment at drift stations DFT1 and DFT3. These reductions were sizeable and indicate the potential drift of herbicides into these non-target locations. Additional discrete chemical sampling for herbicides in 2020 may be required to better document drift dynamics in order to ascertain if this was indeed the cause for the reduction in biomass of these native species.

Post-treatment, field observations conducted by Princeton Hydro showed that curly-leaf pondweed, when present, was in trace amounts in the treatment zone while amounts in the control zone were variable with numerous instances of moderate densities. Treatment zone community showed numerous native species including elodea, star duckweed, water stargrass, tape grass, coontail, slender naiad, leafy pondweed and the macroalgae *Chara*.

While this study did not focus on the potential impacts of herbivory as a result of aquatic macroinvertebrates, there was no obvious indication of large densities of these organisms on or around the aquatic macrophytes. Additionally, and again, while not part of this study, there was no observed evidence on the aquatic macrophytes of high amounts of herbivory as a result of resident macroinvertebrates.

5.0 CONCLUSIONS

Princeton Hydro was commissioned by the Chautauqua Lake and Watershed Alliance to provide third-party monitoring services related to the Navigate and Aquathol K treatments conducted by Solitude Lake Management. The monitoring included select *in-situ* water quality, chemical herbicide testing, and macrophyte surveys prior to and following treatment. In addition, Princeton Hydro observed the actual treatment as did NYSDEC.

The treatment was conducted appropriately and within the regulations set forth by the permits as issued by NYSDEC by the contracted applicator, Solitude Lake Management. Princeton Hydro noted that the treatment areas, setbacks, utilization of appropriate protective and application equipment, and application itself met all applicable standards.

A summary of the results is provided below:

- Water quality data showed no acute impacts related to temperature, dissolved oxygen, pH, specific conductance, or clarity in relation to the treatment.
- There was concern over potential drift of the applied herbicides used out of the treated zone and into the drift and control zones. Chemical data showed some drift of herbicide outside of treatment areas into the drift and control zones approximately 7 to 14 days after the treatment.
- The results of split samples analyzed by both Princeton Hydro- and Solitude-contracted laboratories were in general agreement.
- Samples of raw (untreated) water collected near potable water intakes by the PWS Operators, split by the County Health Department and provided to Princeton and Solitude for analyses, were all well below the NYSDEC Permit Consumptive Threshold of 50 ppb.
- The herbicide treatment program was designed to substantially reduce the targeted invasive species curly-leaf pondweed (*Potamogeton crispus*) and Eurasian watermilfoil (*Myriophyllum spicatum*) with little to no impacts to native species. Between pre- and post-treatment conditions, curly-leaf pondweed displayed a statistically significant decrease in the treatment areas while Eurasian watermilfoil also displayed a decrease but this was not statistically significant. In contrast, four of the more common native species all increase from pre- to post-treatment conditions.
- Based on a comparison between pre-treatment and post-treatment conditions, community-wide species richness increased and this was statistically significant.
- Relative to plant biomass, total biomass declined at the treatment zones with a marked reduction in the two invasive species. However, none of these declines in biomass were statistically significant.
- There were potential impacts to native SAV at drift stations DFT1 and DFT3 with a marked reduction in biomass of elodea and water stargrass, respectively
- The adjusted floristic quality index showed a significant increase from pre- to post-treatment conditions. Thus, while the targeted invasives species declined, overall community diversity and value (native species) increased with the treatments.

- Overall, the treatment was successful at its intent, and data pertaining to this project showed adverse impacts to be minimal.

Additionally, we offer the following recommendations for consideration:

- Better coordination of sampling station location, sampling station nomenclature, and advanced coordination will likely result in more power for interpreting potential drift dynamics.
- Third-party evaluations to potentially include a mid- / late-summer SAV survey event to occur sometime between late-July to mid-August to assess the plant community later in the growing season.
- Future treatments should possibly include treating the same areas as in 2019 as well as some new sites. The re-treated sites would be utilized to determine the impact and potential benefits of multiple years of treatment. Please note, NYSDEC, via its permitting process, will be responsible for making the decision as to treatment locations for 2020 and beyond.
- Future reports should begin to re-evaluate macrophyte community changes over the years (For those sites that are treated for more than one year).
- Further evaluation of potential herbicide drift and its dynamics, including possible northward drift, by collecting additional paired macrophyte and chemical samples to not only assess presence/absence of chemical drift but also significance as it relates to impacts on macrophyte growth.

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