Data Scorecard and Action Plan

To: Ms. Jacqueline Annabi
From: Alejandro Reyes, CLM and Project Manager
c: Luke Gervase, CLM
Date: May 2023
Re: Roaring Brook Lake Data Scorecard
Town of Putnam Valley
Putnam Valley, NY
GEI Project No. 2204698

GEI Consultants Inc., P.C. (GEI) is pleased to present this summary of 2022 monitoring and data scorecard.

Summary of Monitoring Events

Building off the 2021 sampling and action plan for Roaring Brook Lake, the lake was monitored for water quality at two stations from April to October 2022. Tributaries were monitored from April to June and then again in October. Aquatic plant sampling also took place in August repeating the methodology used in the 2019 survey.

In-Lake Water Quality Monitoring

Methodology

In-lake monitoring consisted of seven monitoring trips from April to October sampling the south lake main station (Station 1) and the north lake station (Station 2).

At each monitoring station, water clarity data was collected using a viewscope and Secchi disk. Both clarity readings with and without the viewscope are taken to stay consistent with past Citizen Statewide Lake Assessment Program (CSLAP) methodology (without scope) and to provide a more accurate reading (with scope). Temperature and oxygen profiles were taken at 0.5-meter increments from the surface to the bottom of the lake using a Hach LDO 101 probe calibrated to manufacturers specifications.

Nutrient samples were taken at three depths (0.5 meters, 2.5 meters and 4.5 meters) at Station 1 and just at the surface and bottom of Station 2. Samples were analyzed for total phosphorus (TP), total nitrogen (TN), and ammonia. Cyanobacteria samples were taken using a 3-meter integrated hose sampler and zooplankton samples were taken using a 63 micro mesh Wisconsin sampler towed from 1 meter off the bottom to the surface at a speed of approximately 1 meter per second.

Evaluating Lake Water Quality Status

While state standards for TP and Secchi disk readings exist, these standards represent the worst case, do not exceed values, and are not directly relevant to Roaring Brook Lake. The lake does not come close to exceeding each value throughout the season, so a more conservative evaluation system specific to Roaring Brook is needed.

GEI is proposing a three-part water quality evaluation system for each key parameter. This is intended to take advantage of all the past data collected in the lake and to examine long-term trends, not only single values. The proposed system is as follows:

- Each parameter receives a score out of 3 at the end of the field season. One point is awarded if the seasonal average does not exceed the established upper threshold value. When parameters exceed the threshold value, lakes are at risk for high algal abundance and frequent desired use impairments such as swimming closures, etc.
- One point is awarded if the seasonal average for the parameter exceeds, or is at, the optimal value, which is a value that we would ideally like to see the lake maintain. These optimal values are indicative of extremely low algae favorable conditions, where harmful algae blooms are not expected to be present at all.
- One point is awarded if the trend is not increasing over a 5-year period. This is intended to capture declines in water quality that do not reach to the level of the upper threshold. Declines in water quality parameters are not good signs for the lake, even if the values themselves are not of concern individually. A 5-year timeframe is used to account for yearly differences in precipitation and weather. For cyanobacteria cell counts, we used the average of total cyanobacteria cell counts (table collected throughout the season to determine if a point is awarded for the long-term trend).
- For example, for a given year if water clarity averages 2.5 meters over the summer season, and the values have not been decreasing over a 5-year period, the water clarity year's score would be a 2/3. One point was awarded because the seasonal average was greater than 2 meters and one point was awarded because there was no decrease in values over the 5-year period. Since the value was not greater than the optimal value, a third point was not awarded.

The parameters included in this measure include:

Table 1. Parameters included in the optimal and threshold value matrix for evaluating lake status.

Parameter	Optimal Value	Threshold Limit
Water Clarity	> 3 meters	< 2 meters
Surface Total Phosphorus	< 10 µg/l	> 20 µg/l
Surface Total Nitrogen	< 200 µg/l	> 600 µg/l
Cyanobacteria Cell Counts	< 2,000 cells/ml	> 20,000 cells/ml

Scores across all parameters can be summed to give the lake an overall score for the year. This score can be tracked over time to evaluate how the lake have been faring in terms of water quality. The Town of Putnam Valley (TOPV) and Roaring Brook Lake Property Owners Association (RBLPOA) monitoring scheme for future years should aim to continue to adequately sample for all these parameters at least monthly or on a more frequent basis.

While these values are a great starting point for evaluating the water quality of Roaring Brook Lake, a professional lake manager or limnologist should still inspect the data on an annual basis to determine if there are any additional factors to consider that would adjust the optimal and threshold values. There are more potential signs that lakes are experiencing a problem that are not captured in the above matrix, such as spikes in values throughout the season not linked to precipitation, or visually observing poor water quality not taking place during a monitoring event.

Results

Data Scorecard

Table 2. Data Scorecard for Roaring Brook Lake in 2022.

Parameter	Seasonal Average at or Better than Optimal Value	Seasonal Average Not Above Threshold Value	Long Term Trend	2022 Score
Water Clarity (m)	0	1	1	**2**
Surface Total Phosphorus (µg/l)	0	1	1	**2**
Surface Total Nitrogen (µg/l)	0	1	1	**2**
Cyanobacteria Cell Counts (cells/ml)	1	1	1	**3**
Total	**1/4**	**4/4**	**4/4**	**9/12**

Water Clarity

Water clarity in 2022 was desirable throughout the majority of the recreational season (Fig 1), with the greatest clarity measured on July 19th at Station 1 (2.95 meters). Early season clarity from April to August was relatively stable, staying between 2.4 and 2.95 meters. Clarity got more shallow moving into September, increasing to under 2 meters on September 15th.

Mean clarity measured in 2022 was higher than recorded in 2021, however for the most part has stayed similar since 2020 (Fig 2). The variation in clarity in 2022 was much lower than what was observed in previous years, especially when compared to 2009 to 2011 and in 2016. Values recorded during CSLAP sampling and from Stations 1 and 2 remained consistent with each other.

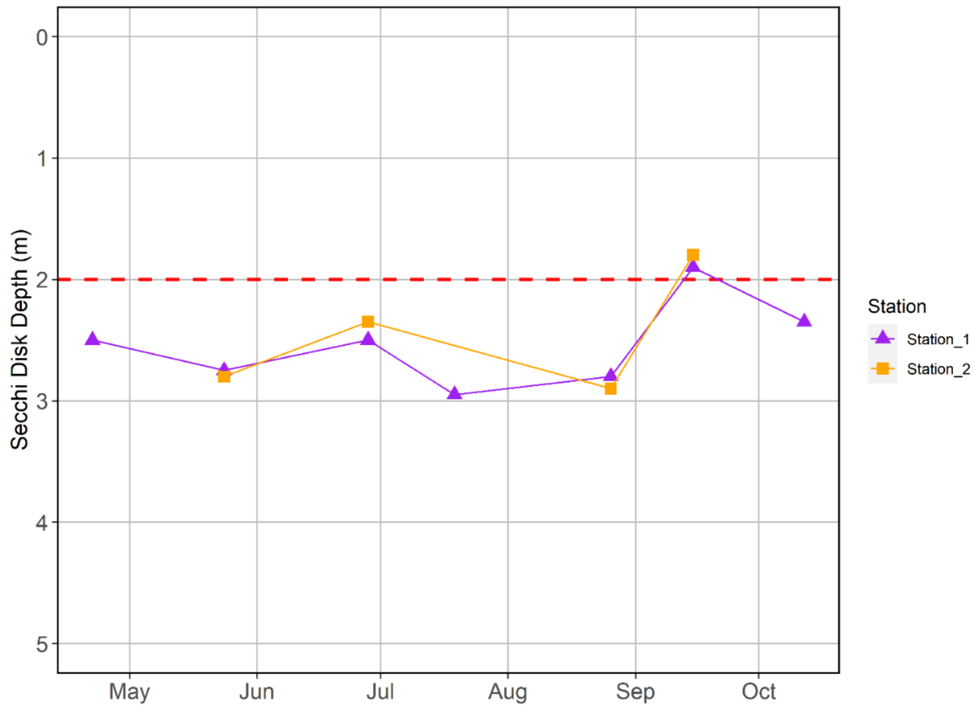


Figure 1. Water clarity measurements (without a view scope) from 2022 at Station 1 (purple triangles) and Station 2 (orange squares). Red dashed line indicates the New York State narrative limit for eutrophic waterbodies at 2 meters.

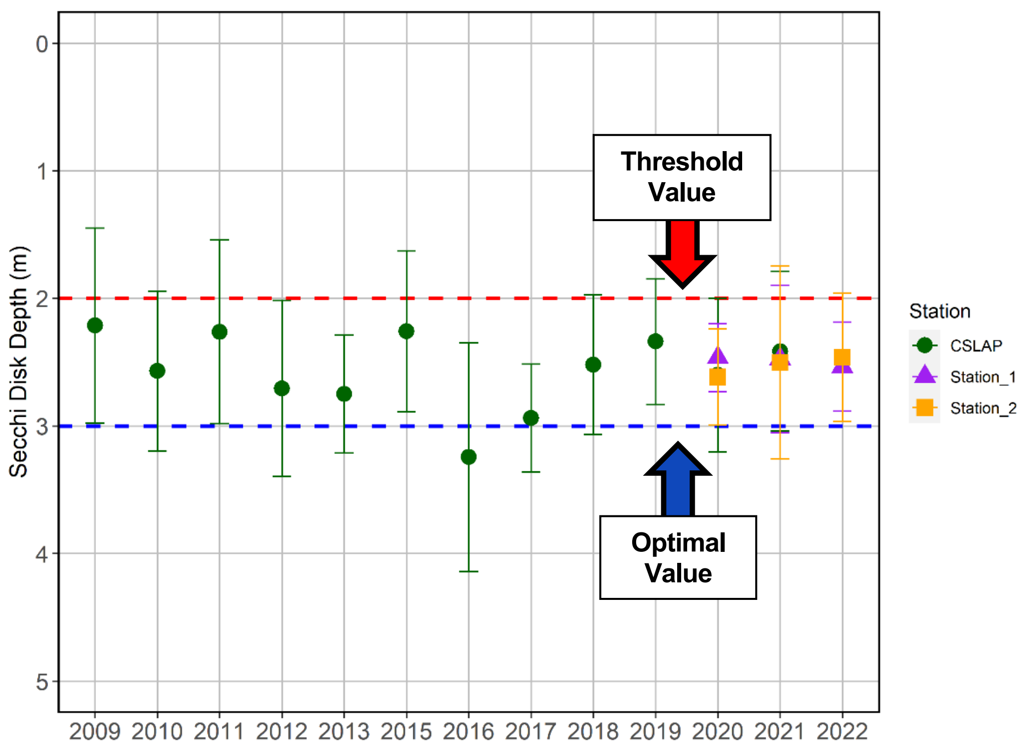


Figure 2. Water clarity measurements (without a viewscope) for all historical data collected on Roaring Brook Lake. Data sources include CSLAP Data (green circles), NEAR Station 1 (purple triangles) and Station 2 (orange squares). Red dashed line indicates the threshold limit (2 m), and the blue line indicates the optimal value (3 m). Error bars represent one standard deviation.

Temperature

Surface temperature data shows a typical warming pattern from June to October, with the highest recorded value being observed on July 23rd at 2pm (88.1 °F). Temperatures fluctuated, but remained steady for the first part of June, with a rapid decrease in temperature starting on June 17th. This drop in temperature was observed for all depths from 0.5 to 3 meters. The increase in temperature at the 3.5-meter depth logger indicates that most of the water column was mixed at this time. The very bottom waters (4.5-meter depth logger) temperature during this timeframe increased but was still cooler than the 0.5-to-3-meter logger temperatures, indicating there was still a thermocline established at this time. That partial mixing event was most likely due to the cool evening temperatures from the 19th to the 21st, with air temperatures at night being less than 50s°F. Starting at the end of July, water temperatures increased at all depths until the beginning of August, when temperatures became uniform from the surface to the bottom, indicating mixed conditions throughout.

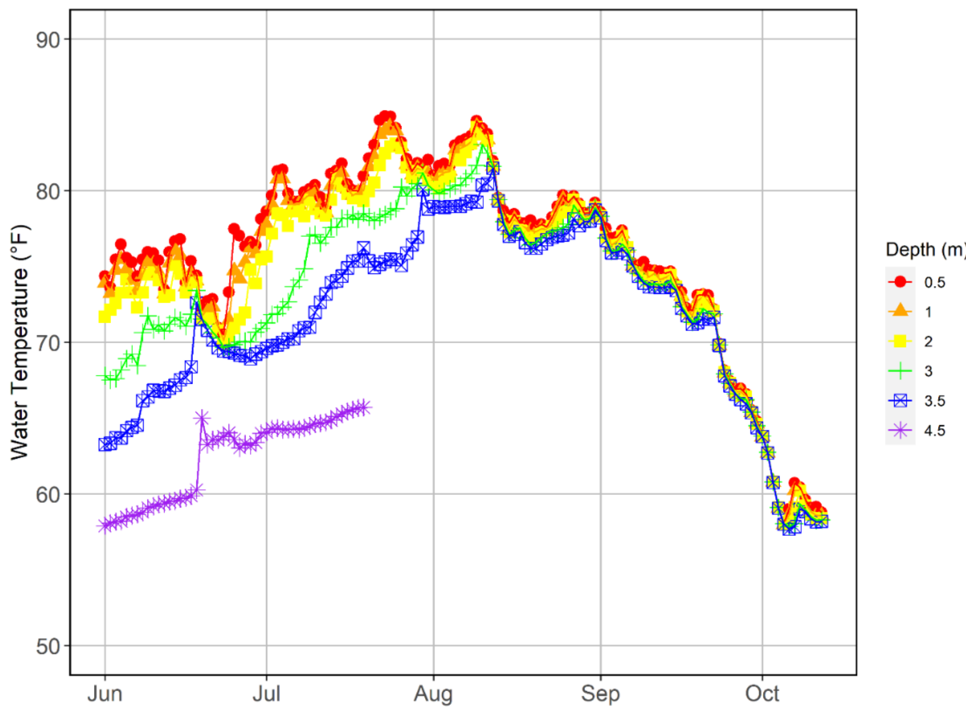


Figure 3. Water temperature measurements from the data loggers in 2022. Note that data was not available at the 4.5-meter depth after July 19th.

Dissolved Oxygen

Higher surface and bottom dissolved oxygen (DO) concentrations were observed at Station 1 in 2022 (8.8 and 3.9 mg/L, respectively) as compared to 2021 (8.6 and 2.9 mg/L, respectively; Fig 4). Station 2 had slightly lower surface and bottom DO concentrations in 2022 than in 2021. All surface concentrations were higher than the 5.0 mg/L minimum daily average standard set by the New York State Department of Environmental Conservation (NYSDEC). Bottom DO concentrations in 2022 were anoxic (less than 2 mg/L), particularly during June, July, and August, which has been noted in previous years.

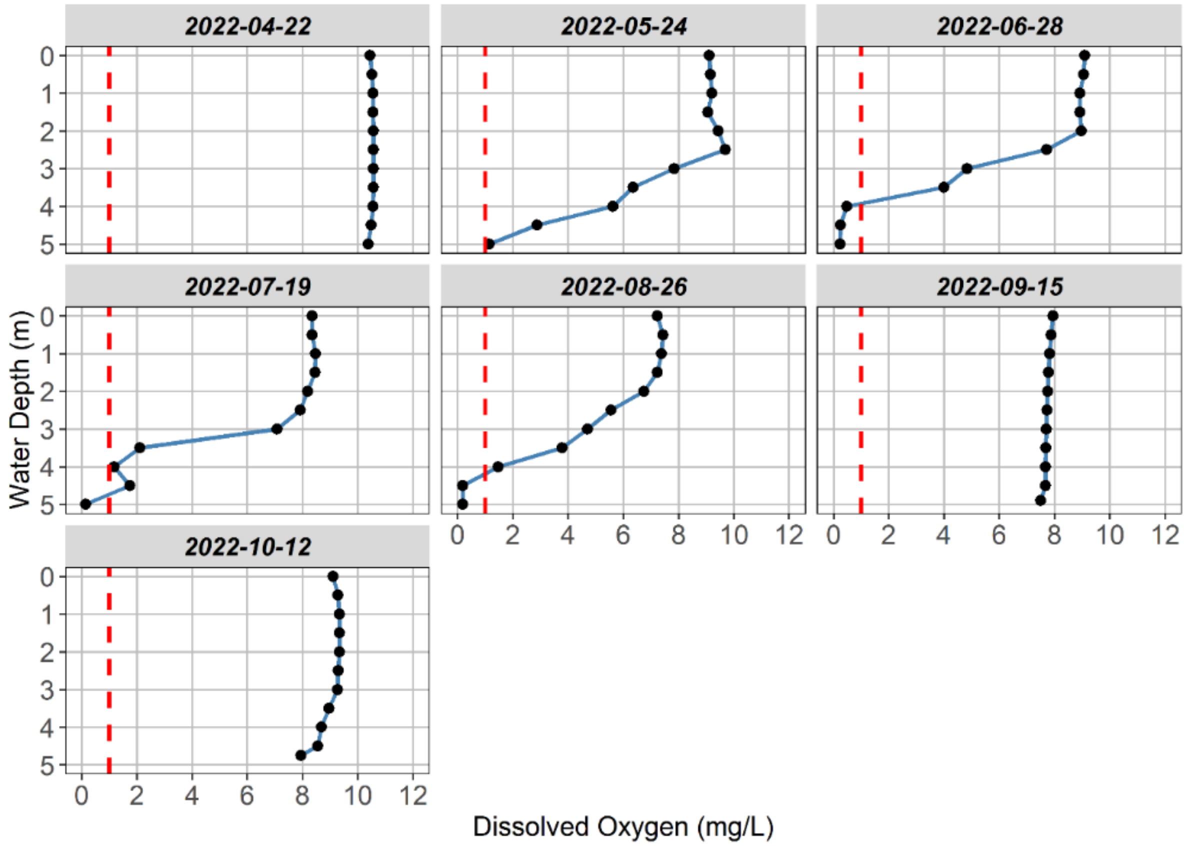


Figure 4. DO profiles from Station 1 in 2022. Values left of the red dashed line indicate anoxic (less than 1 mg/L conditions).

The anoxic boundary in 2022 generally tracked with previous years outside of July, where the boundary decreased down to 4.75 meters (Fig 5). It is important to track the anoxic boundary over time as this is an indicator of the severity of the internal nutrient load. The higher the boundary in the water column, the more sediment area is exposed to anoxic conditions, increasing the area that can release phosphorus and nitrogen into the water column. The lower boundary observed in 2022 may indicate that internal loading of nutrients was much lower than compared to previous years.

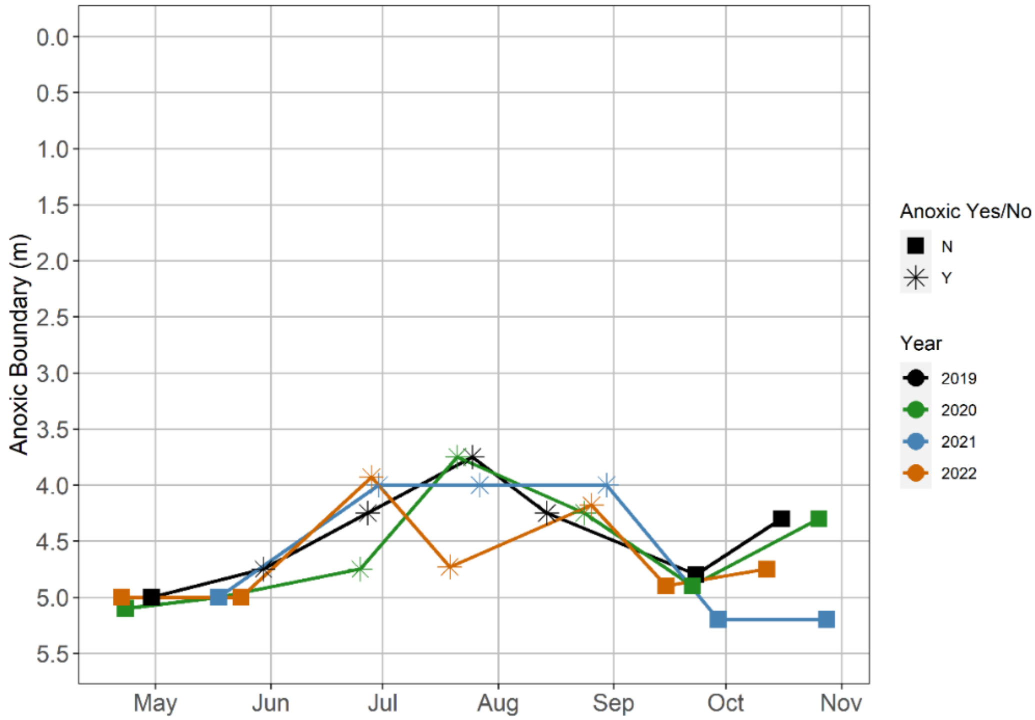


Figure 5. Anoxic boundary at Station 1 in 2019 to 2022. Star and square point shapes indicate either anoxic (star) or oxic (DO concentrations greater than 2 mg/L; square) sampling dates. For example, for the sampling on July 19, 2022, there was anoxic water present at an estimated depth of 4.75 meters, while on September 15, 2022, all DO values were above 1 mg/L, hence no anoxic water (only squares).

Total Phosphorus

In 2022, surface TP concentrations were lower than in 2020 and 2021, averaging 10.3 µg/L (Fig 6). Station 2 TP concentrations were much lower than what was observed at Station 1 with the average concentration being 7 µg/L. Surface TP concentrations over time have varied between 10 and 20 µg/L with recent years having concentrations over 30 µg/L. The low TP concentrations observed over the past few years makes it difficult for the lake to sustain thick, lake wide algae blooms as seen in other local lakes. Cyanobacteria can still grow and proliferate in Roaring Brook Lake, as evident by the infrequent shoreline algae scums that are reported. Low phosphorus concentrations in the surface waters are likely the difference between the scum showing up and going away in a few hours versus sustained, lake-wide blooms that will close swimming for the entire season.

As seen in previous years, there was evidence of internal phosphorus loading in July 2022, however, the rest of the months had low phosphorus concentrations (Fig 7). Middle phosphorus concentrations were similar to surface measurements in 2022, without any anomalous spikes in concentrations as seen in previous years.

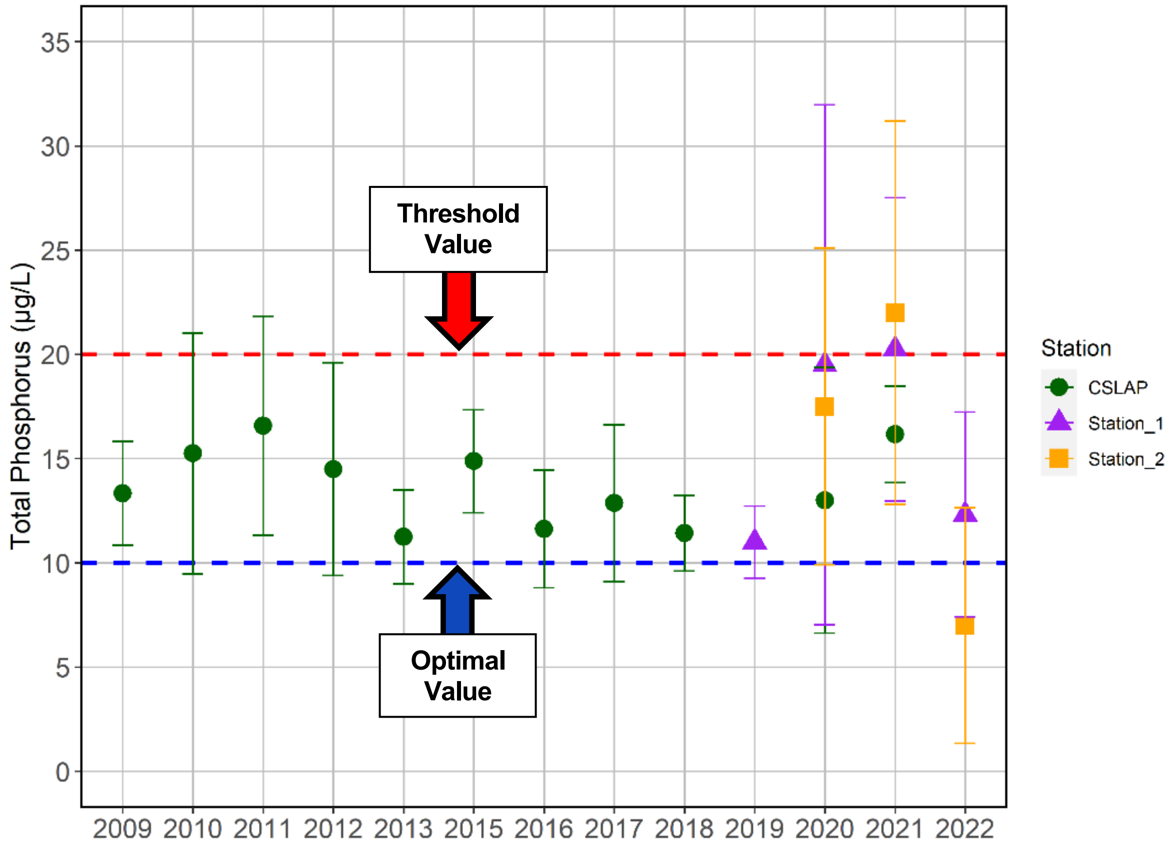


Figure 6. Surface TP for all historical data collected on Roaring Brook Lake during the summer season (June through September). Data sources include CSLAP Data (green circles), NEAR Station 1 (purple triangles), and Station 2 (orange squares). Red dashed line indicates the threshold limit (20 µg/L), and the blue line indicates the optimal value (10 µg/L). Error bars represent one standard deviation.

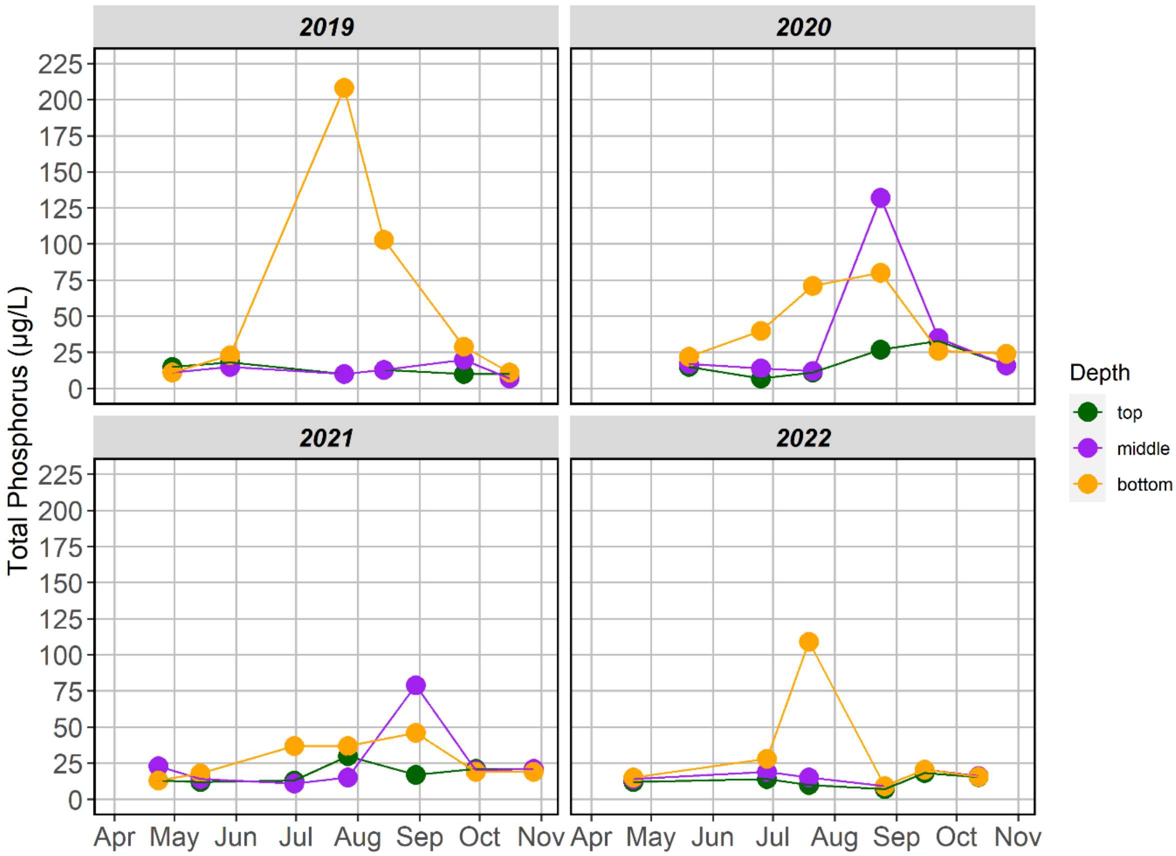


Figure 7. Surface, middle, and bottom TP concentrations on Roaring Brook Lake from 2019 to 2022.

Total Nitrogen

TN in 2022 averaged 346 µg/L between Station 1 and 2, which is in line with 2021 values (Fig 8). Historically, TN has varied significantly between 300 and 500 µg/L. There has not been any consistent increase or decrease in TN trends over the sampling period. While TN is not regarded as important as TP to regulating cyanobacteria growth in lakes, it is an important parameter to track over time. Lakes with high TN concentrations have excessive growth of filamentous algae and floating aquatic plants like duckweed (*Lemna minor*). Fortunately, this has not been documented on Roaring Brook Lake.

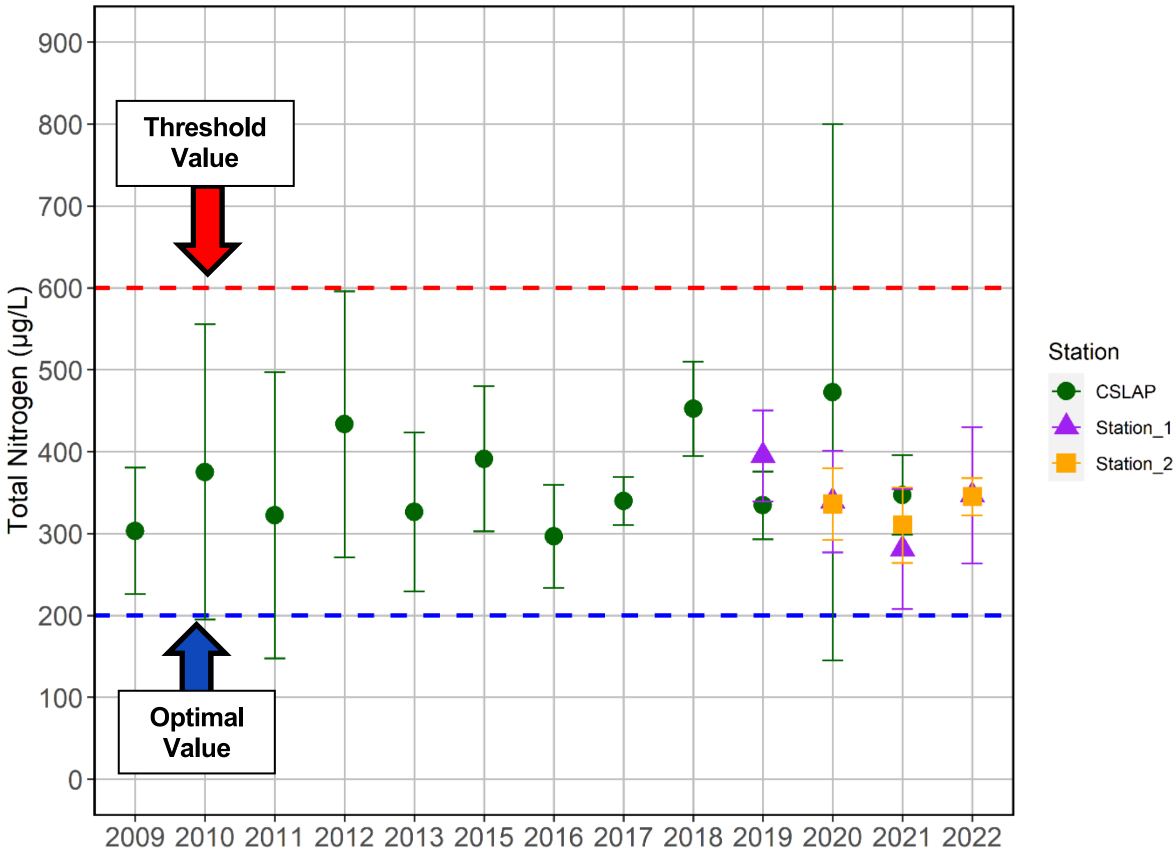


Figure 8. Surface TP for all historical data collected on Roaring Brook Lake during the summer season (June through September). Data sources include CSLAP Data (green circles), NEAR Station 1 (purple triangles), and Station 2 (orange squares). Red dashed line indicates the threshold limit (600 µg/L) and the blue line indicates the optimal value (200 µg/L). Error bars represent one standard deviation.

Algae Cell Counts

Total algae cell counts were low throughout the season, with no single group exceeding 12,000 cells per milliliter (mL). In the beginning of the season, there is a mix of dominant groups, with green algae, golden algae, diatoms, and cyanobacteria shifting to more cyanobacteria dominance from the end of August to the end of October, which is typically seen in New York waterbodies.

Table 3. Algae group cell counts (Cells per mL) for samples collected during the 2022 season.

Sample Date	Cyanobacteria	Green Algae	Diatoms	Golden Algae	Dinoflaggelates	Euglenophytes
4/22/2022	5,831	7,493	3,673	350	0	0
5/24/2022	5,539	1,166	1,020	8,805	0	58
6/28/2022	5,831	0	7,289	6,414	58	0
7/14/2022	2,041	0	4,023	2,041	350	0
8/26/2022	3,790	292	1,399	0	0	0
9/15/2022	11,662	0	729	0	0	0
10/12/2022	8,017	0	0	0	0	0
Average	**6,102**	**1,279**	**2,590**	**2,516**	**58**	**8**

The cyanobacteria community consisted of five different genera, with two genera (*Dolichospermum* and *Planktothrix*) being common bloom formers. *Dolichospermum* is a common genus that can form "pop up" scums that can be windblown to a shoreline. *Planktothrix* does not form scums but can still grow rapidly and discolor the water green or brown. Both genera also can form mid-water column blooms, which can take advantage of the higher nutrient concentrations present at the 2.5 and bottom sample depths.

Table 4. Cyanobacteria cell counts (Cells per mL) for samples collected during the 2022 season.

Sample Date	*Dolichospermum*	*Aphanocapsa*	*Aphanothece*	*Planktothrix*	*Chroococcus*
4/22/2022	0	0	0	5,831	0
5/24/2022	0	292	0	5,284	0
6/28/2022	583	0	0	5,248	0
7/14/2022	2,041	0	0	0	0
8/26/2022	0	0	0	3,790	0
9/15/2022	0	0	0	0	11,662
10/12/2022	437	0	7,580	0	0

Compared to previous years, total cyanobacteria cell counts were similar to 2021 with all cell counts less than 5,000 cells per mL except for May 19, 2021, which contained 22,741 cells per mL of *Anacystis* (Fig 9). The type of genera present between 2022 and past years was vastly different, with no *Planktothrix* present in 2021, *Dolichospermum* at the end of the year being more abundant in 2021. Cells of *Microsystis* and *Woronichinia* were also present in past years as compared to 2022. *Microcystis* and *Woronochinia* are known scum forming cyanobacteria.

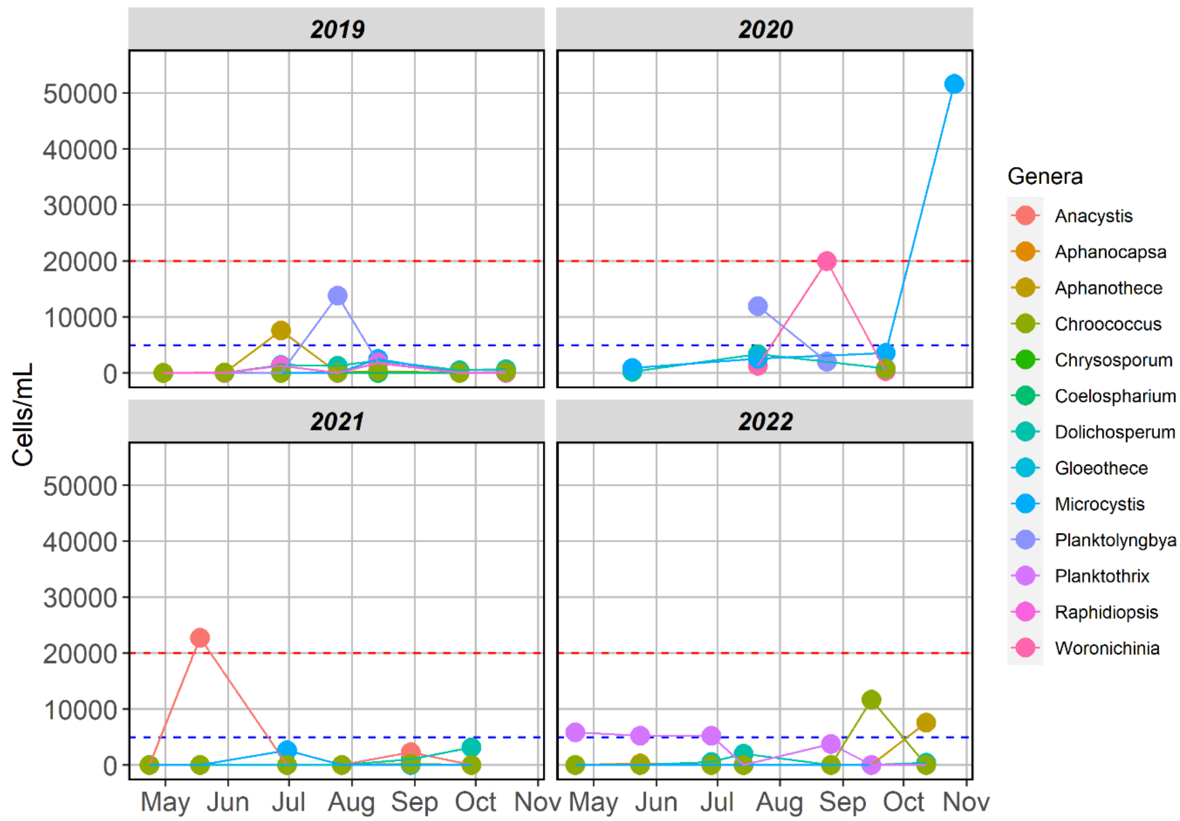


Figure 9. Cyanobacteria cell count data (cells per mL) from 2019 to 2022 at Station 1. Red dashed line indicates WHO recreational guidance for cyanobacteria blooms (20,000 cells mL). Blue dashed line indicates optimal value (5,000 cells mL).

This past year, similar to 2019 and 2020 had no public beach closures on any of the health department regulated beaches on Roaring Brook Lake. In addition, the number of blue green algae reports submitted to the NYSDEC decreased from 19 reports in 2020, eight in 2021, to five reports in 2022. While there is considerable variation in reporting frequency and beach closures, the lower reports and no beach closures is a good sign for Roaring Brook Lake and is consistent with the low overall cell counts and type of cyanobacteria genera present in 2022.

Inlet Monitoring

GEI sampled inflowing inlets into Roaring Brook Lake in April and May 2022. Figure 10 below details the sampling results for 2022. Overall, TP concentrations within the streams were low, with not one single sample exceeding 50 µg/L. Compared to previous years, TP concentrations in the inlets in 2022 was lower than 2019 but in line with 2020 and 2021 (Fig 10). TN concentrations were similarly low across all stream locations in 2022 and generally lower compared to past years (Fig 11). The lowest TN concentrations have been consistently documented at Inlets 3 and 4, which happen to be streams with very limited development within their sub-watersheds (Appendix A, Maps). Inlets 1, 5, 6, and 7 all have a higher density of homes within their watershed and all either cross or contain more than one road.

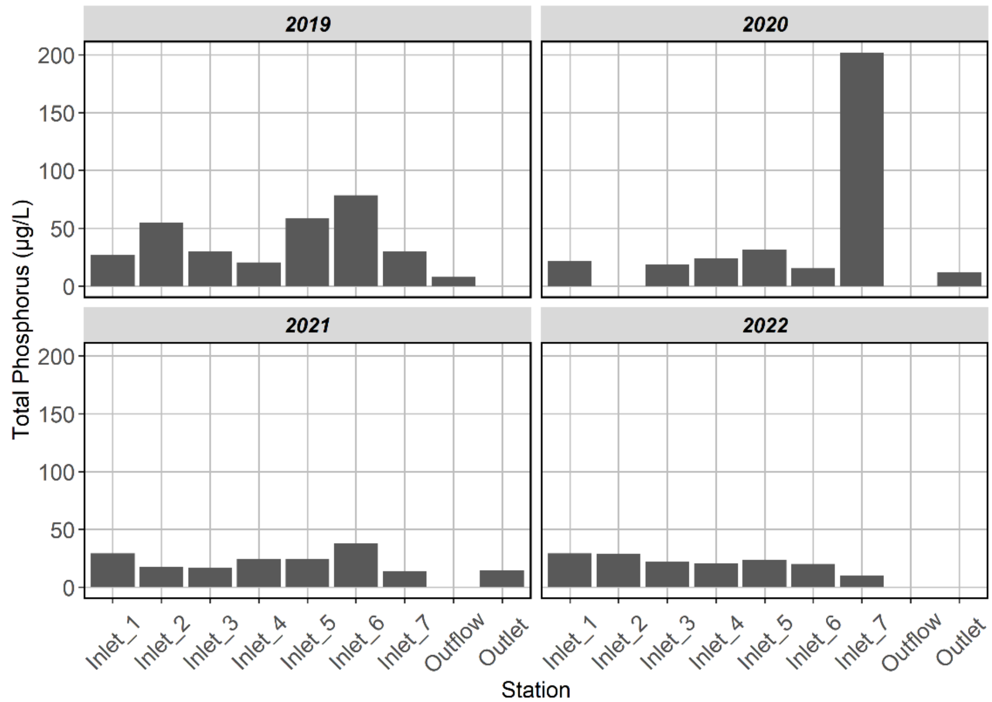


Figure 10. Mean TP stream concentrations for inlets 1 to 7 and outlets from 2019 to 2022.

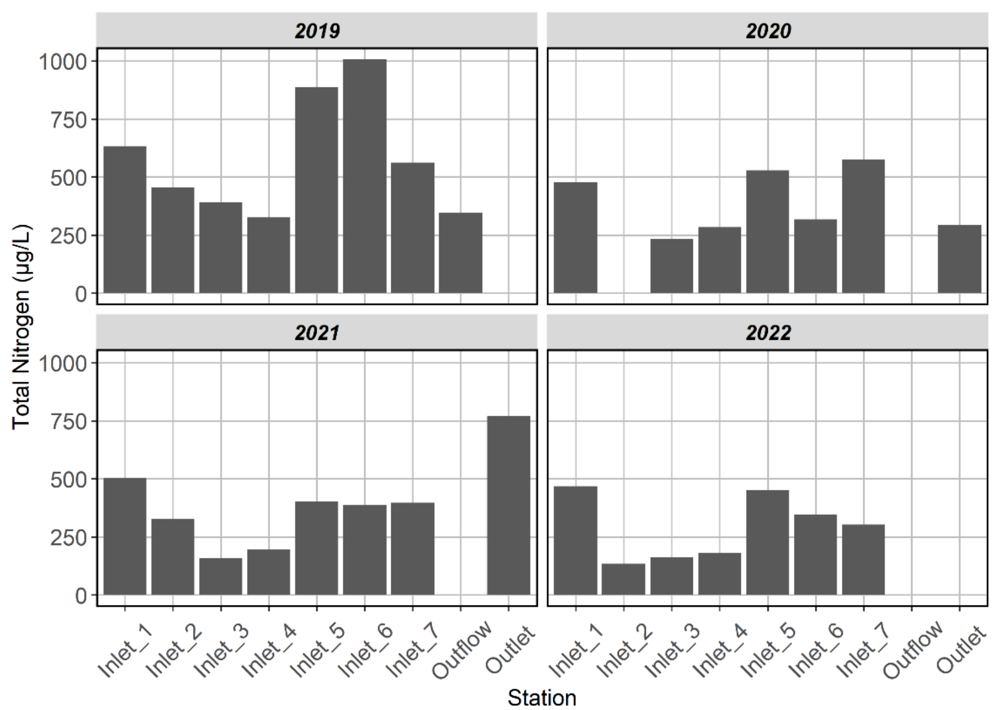


Figure 11. Mean TN stream concentrations for inlets 1 to 7 and outlets from 2019 to 2022.

Water Quality Recommendations

Water quality in Roaring Brook Lake in 2022 had improvements compared to previous years. Water clarity, DO, TP, TN, and cyanobacteria cell count data were either similar to or better than 2021, 2020 and 2019. The lack of beach closures and Harmful Algae Bloom (HAB) reports on the lake further support the notion of desirable water quality.

As stated in previous consulting reports, a focus on the watershed inputs to Roaring Brook Lake for nutrient reduction should be the focus of the TOPV and the RBLPOA's efforts. Currently, while the internal load may be important for future nutrient control, the lake's condition does not warrant such immediate and intensive action. Improvements in the watershed nutrient load will help reduce the frequency and duration of potential algae blooms.

As part of the focus of reducing watershed nutrient inputs, GEI staff installed phosphorus filtering media into Roaring Brook Lake to remove soluble reactive phosphorus (SRP), a form of biologically available phosphorus. Pre and post monitoring will take place throughout 2023 to measure phosphorus capture efficiency and determine if the filter bags can be used in different inlet streams effectively.

GEI also recommends that residents continue to implement best management practices on their properties. The 2021 monitoring report detailed best management strategies for residents to continue such as septic system maintenance, construction best practices, or reducing the amount of runoff that comes off impervious surface on individual properties:

Rainfall Management

For rainfall that hits the roof and runs off, it is important to have gutters installed and maintained correctly, as well as ensuring that once that water leaves the gutter, it does not flow onto an impervious surface. This can be done by either directing gutters into a natural wooded or vegetated area, installing a rain barrel to capture water and re-use for gardening/general irrigation, or install a rain garden and plant saturation-tolerant vegetation.

Driveways and roadways are one of the largest sources of impervious surface in the Roaring Brook Lake watershed. Residents should be encouraged to consult the RBLPOA on new driveway repair/construction to ensure that stormwater runoff is properly treated before entering the roadways and catch basins. This involves proper curbing and diversion of water into wooded areas and when possible, using sensible grading and/or drain placement.

Lawn Care

For lawn care, using little to no fertilizer is suggested, especially in areas directly next to the road or the lake. Storms can flush the fertilizer into the drain system. If fertilizer is desired, use of slow-release nitrogen fertilizer is suggested, as this allows the vegetation to uptake nutrients in a fashion that minimizes wash off. Grass clippings and leaves should never be blown onto roads or into drainpipes. These clippings can decay in the lake and drain system, adding more organic material and nutrients. Only phosphorus free fertilizers should be used.

Landscape Practices

Reducing the number of short grasses and increasing shrubbery and mulch will also help keep nutrients on site. The idea of a beautiful landscape is not restricted to short grass extending directly to the shoreline. A mosaic of tall-growing grass, low growing native plants, mulched shrubbery, and trees can provide both an aesthetically pleasing view and protection against stormwater runoff.

Construction on Property

New or ongoing construction should adhere to all proper protocols for stormwater prevention, especially the use of silt fences and other erosion control devices. If a new driveway or patio is being planned, using alternatives to impervious materials such as pavers or porous pavement will help reduce runoff. These materials infiltrate the rainwater into the ground instead, rather than allowing the water to run directly into the lake. It is also important to mention stormwater prevention and mitigation practices to the contractors prior to construction and before the design phase. It is much easier to build proper drainage and stormwater practices into the design of a project, than to adapt after the fact.

Septic System Maintenance

All septic systems should be pumped out and inspected on a rotating 3-year basis. The town already has a 5-year septic system pump-out regulation in effect for Roaring Brook Lake, which is a great starting point. GEI suggests that pump outs be conducted on a 3-year basis by homeowners, as more frequent inspections will assist in catching problems with the tank earlier on. It is also a good idea to ask the septic contractor to inspect the leach field for any signs of capacity issues or ponding of water. Most inspections only involve the integrity of the tank, which can only catch a portion of the issues.

Aquatic Plant Sampling

The RBLPOA requested an updated aquatic vegetation survey to compare baseline conditions from 2019 to 2022. Roaring brook is engaged in two aquatic plant management techniques: The annual ~4 ft drawdown and the remaining grass carp from the 2011 stocking event. As per the fisheries survey in 2021, grass carp are still present in the lake.

Methods

Aquatic plant survey methods involved using a combination of pre-determined waypoints from the 2019 survey that can be re-visited and adding supplemental points to contribute to distribution and abundance information. In the point-intercept survey style, waypoints were pre-determined at fixed intervals (~150 ft) throughout the littoral zone (area where plants can grow based on available light). These points were generated using the ARC GIS fishnet tool. Pre-determined waypoints can be used for replication in future years, to assess changes over time, or in response to plant management actions. However, pre-determined waypoints may underestimate true plant coverage, in that they can sometimes underestimate the true heterogeneity of a plant community. Supplemental points made in the field can help provide an accurate description of the aquatic plant community.

Plant coverage was determined using a combination of three methods. The first method was at each waypoint, a 14-tine double-sided garden rake attached to a 10m rope was tossed to collect specimens of all species at that point. This method involves stopping the boat and throwing the 10m tow line and rake head and/or raking the bottom with the long-handled rake through the plant bed. The water depth and plant density were recorded at each waypoint. The second method is the visual density determination method which is based solely on what is visible from the surface. This method involves using a hypothetical quadrat. The surveyor visually estimates how much area is covered by the plant in question. Surveyors visualized a hypothetical quadrat approximately 15ft X 15ft around the boat, then estimated coverage accordingly. Visual estimates are made by a single person during the survey, but the entire team has input on the final estimate to ensure accuracy.

The final method used to estimate the percent coverage of vegetation is to use the down-imaging SONAR images of the plants as the boat passes above. In areas where plants cannot be seen from the surface, the SONAR images become extremely useful for percent coverage estimations, along with rake tosses. SONAR and visual estimates are corroborated by rake tosses. When possible, all three ways of estimating the percent cover are used at each waypoint, and the resulting estimate is recorded on the datasheet. Using those three measurements in conjunction achieves the most accurate estimate of plant coverage possible during surveying.

Results and Discussion

Maps for dominant aquatic plant species documented in Roaring Brook Lake are presented in Appendix A. Aquatic plants in Roaring Brook Lake were generally less abundant in 2022 as compared to 2019. Points with no aquatic plants observed increased from 65 points in 2019 to 83 points in 2022. The most drastic changes were seen in the common bladderwort and fanwort populations, which saw declines of 23% and 20% in terms of frequency of occurrence. The historical patch of fanwort located just south of the island across from park beach was no longer present, as GEI staff threw multiple rake rosses in this area. Common bladderwort used to be abundant in the 12-to-14-foot range in the middle of the lake south of park beach to the southernmost island in 2019 and was not observed this area.

The largest increases in frequency of occurrence included invasive Eurasian watermilfoil (*Myriophyllum spicatum*) Lyngbya (*Lyngbya wolleii*), Largeleaf pondweed (*Potamogeton amplifolius*) and Eel grass (*Vallisneria americana*). Eurasian watermilfoil was most prevalent in the northern basin, where there were numerous single stalks growing close to the surface. There were also scattered populations along the western shoreline, especially between moon beach and spur beach. Lyngbya was found at 31 more locations than in 2019, being distributed throughout the lake, but at low abundances.

Table 5. Frequency of occurrence of aquatic plants found in 2019 and 2022. Change between surveys colors indicate if the species increased (green plus sign) or declined (red minus sign) from 2019 t0 2022.

Scientific Name	Common Name	2019 Points Found	Freq -- 2019	2022 Points Found	Freq -- 2022	Change Btwn. Surveys
Brasenia schreberi	Watershield	0	0%	2	1%	1% (+)
Cabomba caroliniana	Fanwort	45	21%	2	1%	-20% (-)
Callitriche spp.	Water Starwort	44	21%	26	12%	-9% (-)
Ceratophyllum demersum	Coontail	12	6%	2	1%	-5% (-)
Elatine minima	Small Waterwort	0	0%	9	4%	4% (+)
Eleocharis aucicularis	Needle Spikerush	0	0%	1	1%	1% (+)
Filamentous algae	Filamentous Algae	10	5%	3	1%	-3% (-)
Isoetes spp.	Quillwort	0	0%	1	1%	1% (+)
Lyngbya wolleii	Lyngbya	1	1%	32	15%	15% (+)
Myriophyllum spicatum	Eurasian Watermilfoil	27	13%	61	29%	16% (+)

Scientific Name	Common Name	2019 Points Found	Freq -- 2019	2022 Points Found	Freq -- 2022	Change Btwn. Surveys
Najas flexilis	Slender Waternymph	0	0%	1	1%	1% (+)
Najas minor	Brittle Naiad	8	4%	6	3%	-1% (-)
Najas spp.	Waternymph	1	1%	6	3%	2% (+)
Nitella spp.	Stonewort	62	29%	52	24%	-5% (-)
Nothing Present		65	31%	83	39%	9% (+)
Phragmites australis	Common Reed	1	1%	3	1%	1% (+)
Potamogeton amplifolius	Largeleaf Pondweed	9	4%	22	10%	6% (+)
Potamogeton epihydrus	Ribbonleaf Pondweed	1	1%	0	0%	-1% (-)
Potamogeton pusillus	Small Pondweed	1	1%	0	0%	-1% (-)
Utricularia gibba	Humped Bladderwort	4	2%	0	0%	-2% (-)
Utricularia macrorhiza	Common Bladderwort	98	46%	49	23%	-23% (-)
Vallesneria americana	Eel grass	0	0%	12	6%	6% (+)

As in 2019, there is a lack of significant plant growth in the shallow, drawdown exposed area. GEI suspects that this is due to the continued transport of fine organic and inorganic materials from the drawdown zone to the deeper waters, limiting the available habitat for expansive aquatic plant growth. This combined with continued grass carp presence and feeding lead to limited aquatic plant growth. The main difference in aquatic plant community is the lack of vegetation at the bottom of the lake in the deeper areas, as noted with the decline of fanwort and common bladderwort. This is most likely due to grass carp feeding, as drawdown does not affect waters deeper than the exposure area of about 0 to 4 feet deep.

Aquatic Plant Recommendations

Currently, the aquatic plant community is limited in distribution and abundance and is not currently affecting desired uses. The only area that may end up becoming an issue in the near term is the northern basin, which has some single stalks of Eurasian watermilfoil that can potentially become problematic. Since the grass carp are still present in the lake, it is not a certainty that this area will become problematic for users immediately, however it warrants close attention to be paid.

If the northern basin does become an issue in terms of Eurasian watermilfoil growth, the RBLPOA and the TOPV can consider the use of diver assisted suction harvesting (DASH) to knock back the plant growth. The goal of this work would be to thin out the population to allow for unimpeded boating and swimming in the northern basin. DASH can get quite expensive (~$2,500 per day) and even the most efficient crews can only cover an acre in ~2 to 3 days, so this should only be done in select areas. If the infestation starts to grow rapidly, then alternative techniques such as aquatic herbicides or another, smaller grass carp stocking should be considered under consultation. Those techniques can handle larger Eurasian watermilfoil infestations more efficiently than DASH.

For the lake as whole, one of the key discussion points in 2019 is that while the aquatic plant community is currently limited in distribution and abundance, this will most likely not stay the case forever. While grass carp have very long lifespans (>25 years) and continue to eat large amount of vegetation as they age, the total number of grass carp will decline over time. There will come a point at where the total amount of grass carp feeding within the lake will not be able to overcome the production of aquatic plants, leading to a rapid increase in aquatic plant biomass. While this change did not happen in 2022, the grass carp are still dying off, meaning their influence will wane over time. It is impossible to predict when the grass carp will fully die off, as annual survival is unknown. GEI recommends that the RBLPOA have a detailed discussion of aquatic plant management techniques, costs, and permit requirements in anticipation of an aquatic plant rebound.

Appendix A

Maps

Roaring Brook Lake
Town of Putnam Valley, NY

0 510 1,020

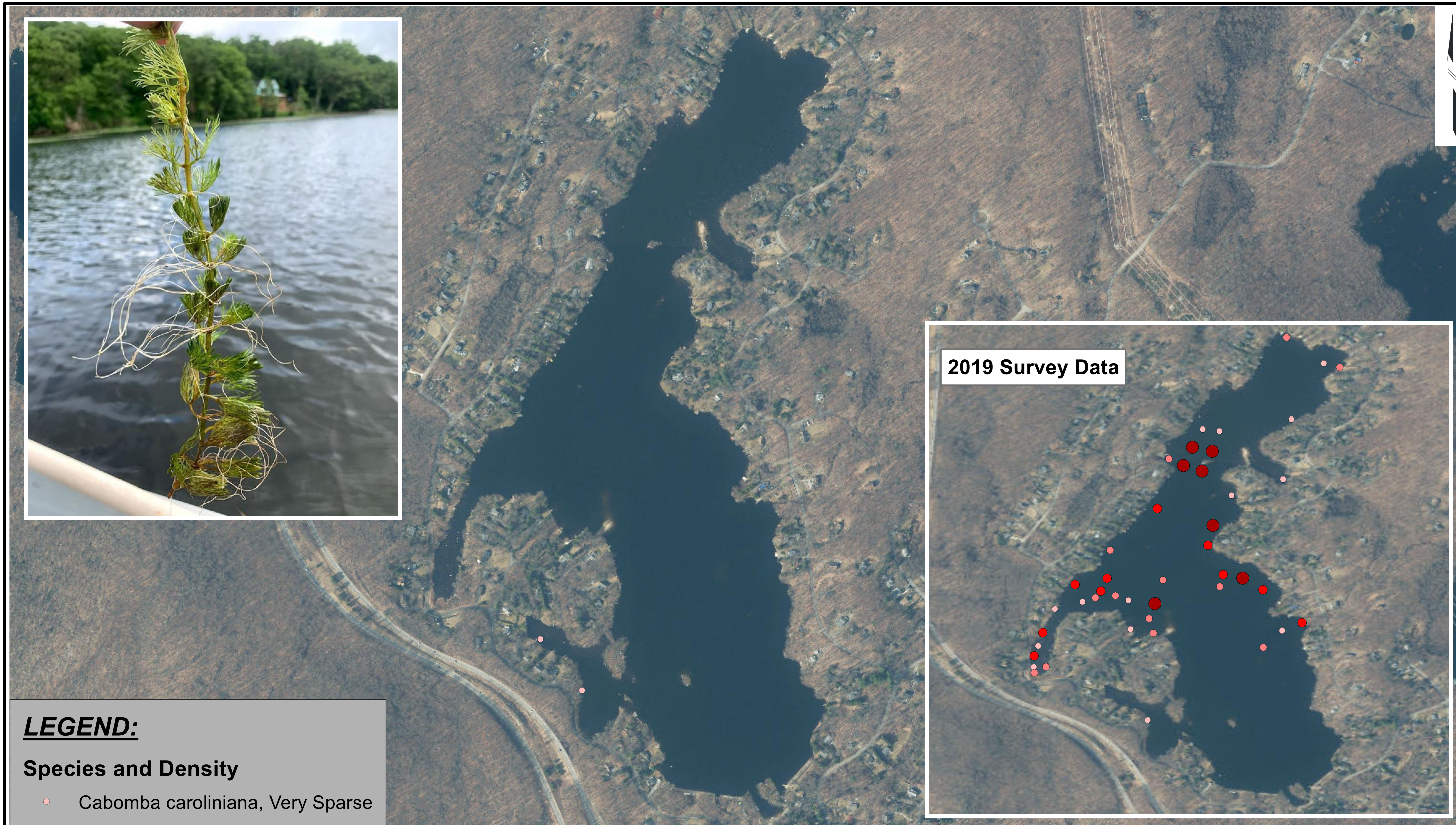
SCALE: 1" = 975'

GEI Consultants

Water Quality Sampling Locations

Project 2204698

May 2023



SOURCE:
1.2022 WORLD IMAGERY ACCESSED VIA ESRI ARCMAP

0 600 1,200
SCALE: 1" = 600'

GEI Consultants

Aquatic Plant Survey & Lake Management
Roaring Brook Lake
Putnam County, NY

Town of Putnam Valley
Putnam Valley, NY

2022 Plant Distribution Map
Fanwort (*Cabomba caroliniana*)

Project 2204698

I:\GIS\Projects\Town of Putnam Valley, Roaring Brook Lake\MXD\Fig. 10 Cabomba.mxd

March 2023

SOURCE:
1.2022 WORLD IMAGERY ACCESSED VIA ESRI ARCMAP
2. Image: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org

0 600 1,200
SCALE: 1" = 600'

GEI Consultants

Aquatic Plant Survey & Lake Management
Roaring Brook Lake
Putnam County, NY

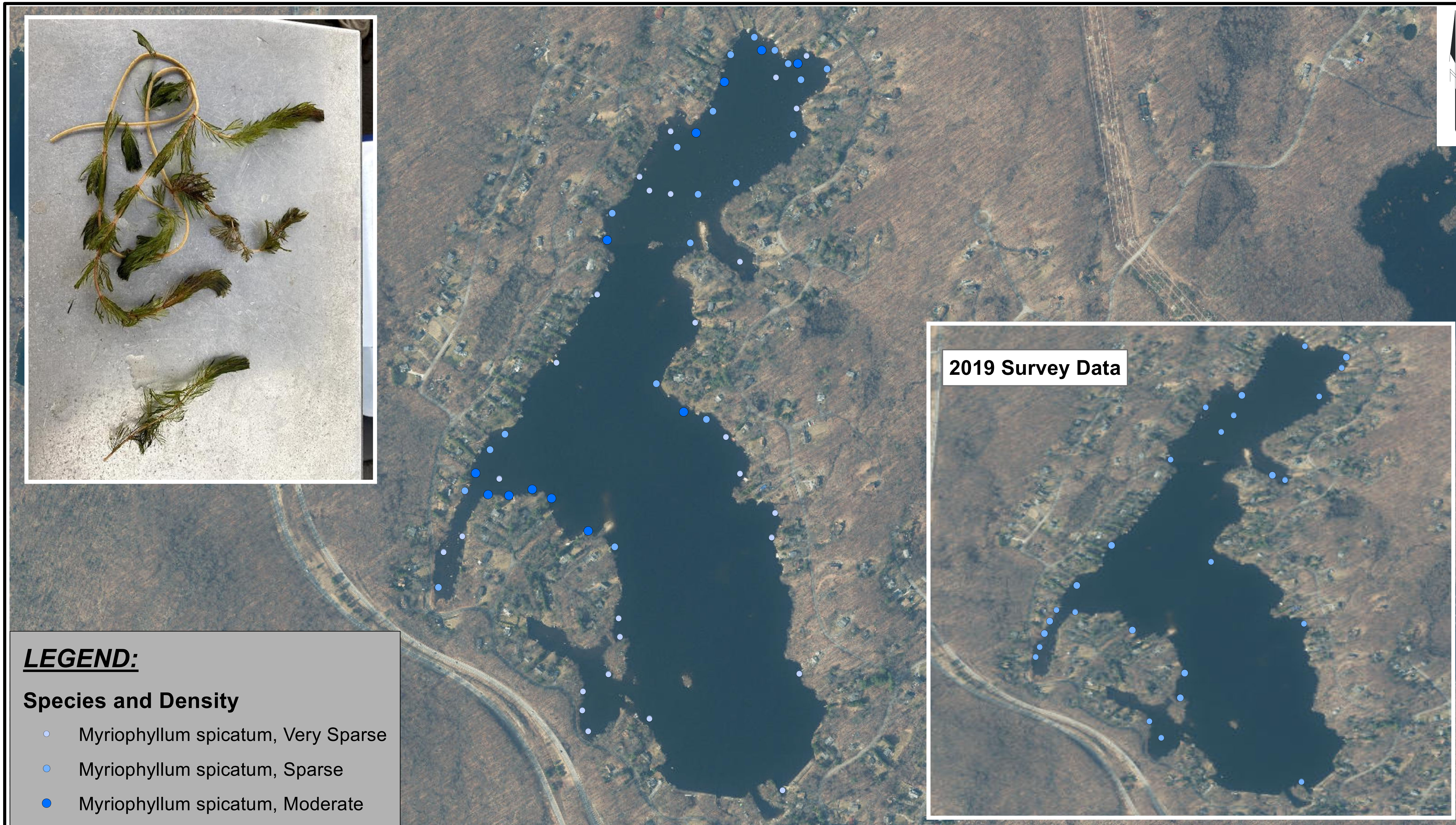
Town of Putnam Valley
Putnam Valley, NY

2022 Plant Distribution Map
Water Starwort Species (*Callitriche spp.*)

Project 2204698

I:\GIS\Projects\Town of Putnam Valley, Roaring Brook Lake\MXD\Fig. 9 Callitriche.mxd

March 2023



SOURCE:
1.2022 WORLD IMAGERY ACCESSED VIA ESRI ARCMAP

0 600 1,200
SCALE: 1" = 600'

GEI Consultants

Aquatic Plant Survey & Lake Management
Roaring Brook Lake
Putnam County, NY

Town of Putnam Valley
Putnam Valley, NY

2022 Plant Distribution Map
Eurasian Watermilfoil (*Myriophyllum spicatum*)

Project 2204698

I:\GIS\Projects\Town of Putnam Valley, Roaring Brook Lake\MXD\Fig. 11 EWM.mxd

March 2023

SOURCE:
1.2022 WORLD IMAGERY ACCESSED VIA ESRI ARCMAP

0 600 1,200
SCALE: 1" = 600'

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Aquatic Plant Survey & Lake Management
Roaring Brook Lake
Putnam County, NY

Town of Putnam Valley
Putnam Valley, NY

2022 Plant Distribution Map
Brittle Naiad (*Najas minor*)

Project 2204698

I:\GIS\Projects\Town of Putnam Valley, Roaring Brook Lake\MXD\Fig. 12 Najas minor.mxd

March 2023

SOURCE:
1.2022 WORLD IMAGERY ACCESSED VIA ESRI ARCMAP
2. Image: Nitella — Nitella sp.. Montana Field Guide. Montana Natural Heritage Program. Retrieved on March 2, 2023, from https://FieldGuide.mt.gov/speciesDetail.aspx?elcode=NACHLMT001

0 600 1,200
SCALE: 1" = 600'

GEI Consultants

Aquatic Plant Survey & Lake Management
Roaring Brook Lake
Putnam County, NY

Town of Putnam Valley
Putnam Valley, NY

2022 Plant Distribution Map
Nitella Species (*Nitella spp.*)

Project 2204698

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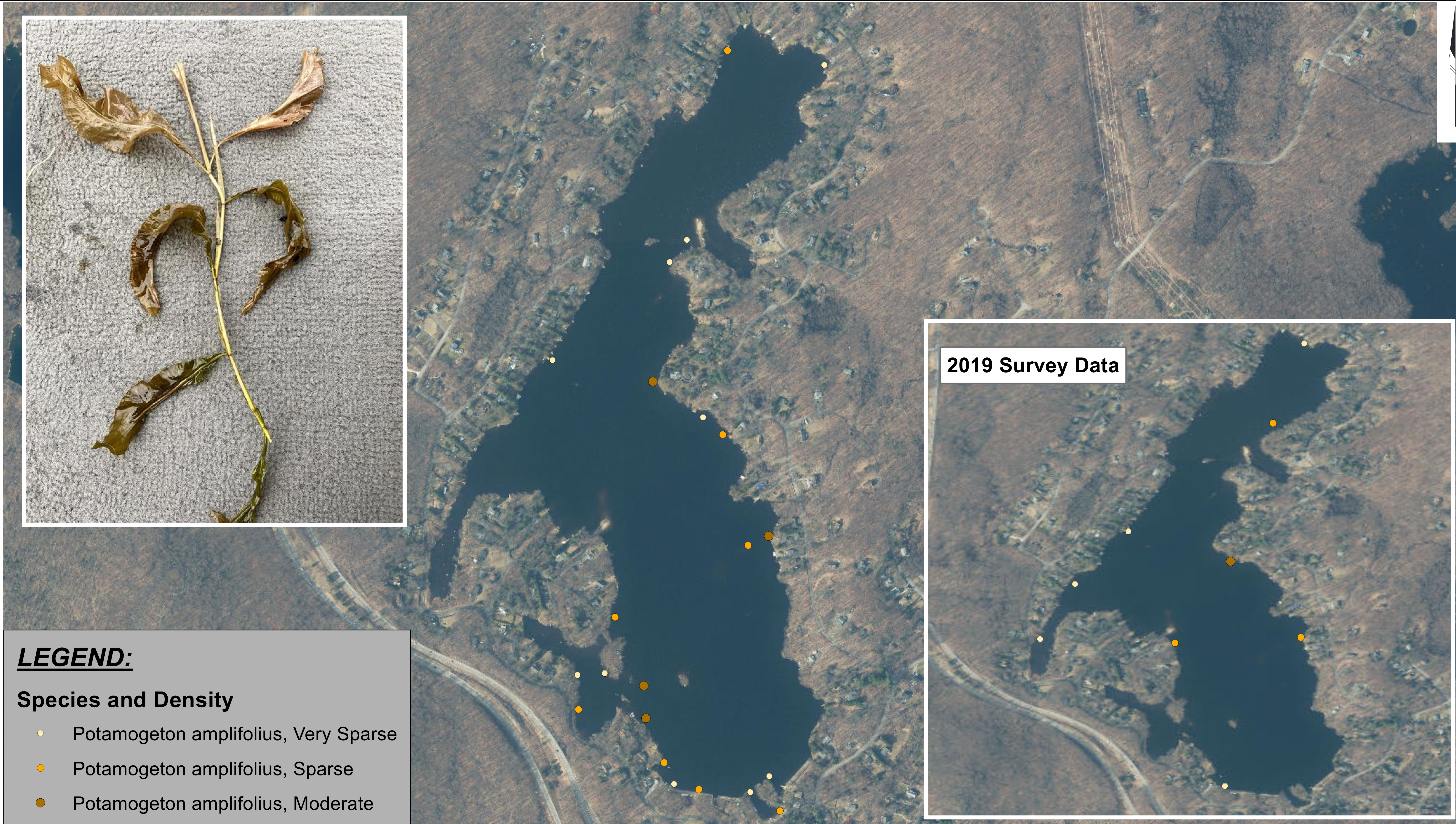
March 2023



SOURCE:
1.2022 WORLD IMAGERY ACCESSED VIA ESRI ARCMAP

0 600 1,200
SCALE: 1" = 600'

GEI Consultants

Aquatic Plant Survey & Lake Management
Roaring Brook Lake
Putnam County, NY

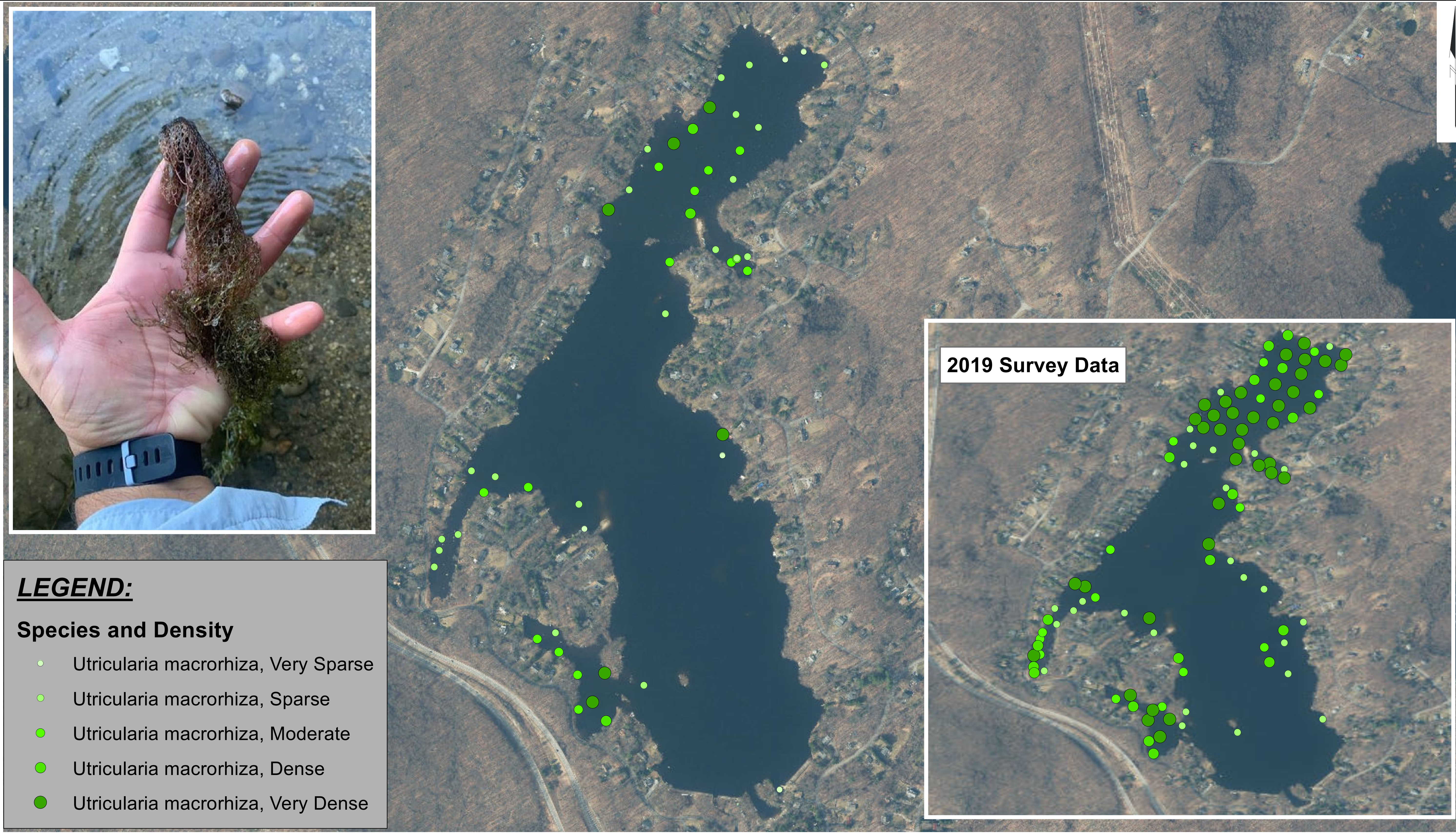
Town of Putnam Valley
Putnam Valley, NY

2022 Plant Distribution Map
Largeleaf Pondweed (*Potamogeton amplifolius*)

Project 2204698

I:\GIS\Projects\Town of Putnam Valley, Roaring Brook Lake\MXD\Fig. 13 P. amplifolius.mxd

March 2023



SOURCE:
1.2022 WORLD IMAGERY ACCESSED VIA ESRI ARCMAP

GEI Consultants

Aquatic Plant Survey & Lake Management
Roaring Brook Lake
Putnam County, NY

Town of Putnam Valley
Putnam Valley, NY

2022 Plant Distribution Map
Common Bladderwort (*Utricularia macrorhiza*)

Project 2204698

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March 2023