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Black Lake Management Plan

Black Lake, Town of Oswegatchie
St. Lawrence County, New York

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Abbreviations and Acronyms

AIS	Aquatic Invasive Species
BLA	Black Lake Association
BLW	Black Lake Watershed
BMP	Best Management Practice
CLM	Certified Lake Manager
CLP	Curly Leaf Pondweed
COC	Black Lake Chamber of Commerce
CSLAP	Citizens Statewide Lake Assessment Program
DASH	Diver Assisted Suction Harvesting
DO	Dissolved Oxygen
EDRR	Early Detection Rapid Response
EWM	Eurasian Watermilfoil
FGC	Black Lake Fish and Game Club
GEI	GEI Consultants, Inc., P.C.
HAB	Harmful Algae Bloom
IRLC	Indian River Lakes Conservancy
ITRC	Interstate Technology and Regulatory Council
LCI	Lake Classification Inventory
LIISMA	Long Island Invasive Species Management Area
NEAR	Northeast Aquatic Research, LLC
NEIWPCC	New England Interstate Water Pollution Control Commission
NRCS	Natural Resources Conservation Service
NYSDEC	New York State Department of Environmental Conservation
NYSFOLA	New York State Federation of Lake Assocaitions
PIRTRAM	Point Intercept Rake Toss Relative Abundance Method
PRISM	Partenrship for Regional Invasive Species Management
SLELO	St. Lawrence and Eastern Lake Ontario
SLN	Special Local Need
TAC	Technical Advisory Committee
USACE	United States Army Corps of Engineers
WSS	Web Soil Survey

MEASUREMENTS

C	Coefficient of Conservation
°C	Degrees Celsius
°F	Degrees Farenheit
Ft	Feet
M	Meters
Mg/L	Milligrams per Liter
µg/L	Micrograms per Liter

1. Executive Summary

This plan was prepared by GEI Consultants Inc., P.C. (GEI) in conjunction with Northeast Aquatic Research, LLC (NEAR) for the Town of Oswegatchie (the town), the Black Lake Chamber of Commerce, and the Black Lake Association for Black Lake in St. Lawrence County, New York. It summarizes and documents field survey work completed in 2021 including aquatic plant distribution and abundance, water quality measurements, and harmful algal bloom observations. The report is designed to guide future management priorities and actions on Black Lake, particularly concerning aquatic invasive species. Further, recommendations are proposed for adaptive management strategies to preserve the freshwater ecosystems of Black Lake. The goal of the plan is to help guide management decisions, facilitate cohesiveness and stewardship amongst the nearby community, and to provide practical and efficient strategies to promote a functional and balanced aquatic ecosystem.

2. Introduction

2.1 Organizational Structure

Black Lake is unique in that it provides multiple towns, counties, and groups access to the waterbody. There are six towns on the shore of Black Lake: Rossie, Hammond, Morristown, Oswegatchie, DePeyster, and Macomb. The watershed spans through the New York Counties of St. Lawrence, Jefferson, and Lewis. Active organizations on the lake include the Black Lake Chamber of Commerce (COC), Black Lake Association (BLA) and the Black Lake Fish and Game Club (FGC). There is also a boat launch in Morristown that provides public access owned and operated by the New York States Parks Office of Parks, Recreation, and Historic Preservation. The Indian River Lakes Conservancy (IRLC) is an additional stewardship group that aims to protect the resources of the Indian River watershed for the benefit and enrichment of present and future generations (https://indianriverlakes.org/). The Indian River lakes system consists of 18 lakes which includes Black Lake. The St Lawrence Eastern Lake Ontario Partnership for Regional Invasive Species Management (SLELO PRISM) is one of eight NYSDEC designated partnerships throughout the state to combat invasives species and is the PRISM in which Black Lake resides. All these towns and groups are stakeholders of Black Lake and should strive to maintain and improve the ecological state and recreational value of Black Lake while understanding that different groups may not have identical interests. It is recommended that these groups collaborate with one another as much as possible for the overall improvement of Black Lake. As of 2021, the St. Lawrence County planning office initiated an effort to unite the stakeholders and improve communication and cohesiveness amongst the invested community of Black Lake.

2.2 Historical Efforts

Due to the size of Black Lake and its importance to the community, there have been several studies and reports completed in the past. The BLA has participated in a program through NYSDEC, and the New York Federation of Lake Associations (NYSFOLA) called the Citizens Statewide Lake Assessment Program (CSLAP). CSLAP provides a statewide standardized program to assess lakes within New York state over time and assesses factors including but not limited to the aquatic plant community, water quality, nutrient concentrations, water clarity, and algae populations. Black Lake has reports from 1989 and 1996 to 2019 (https://nysfola.org/cslap-report-search/). In July 2008, the "Black Lake Eurasian Watermilfoil Management Plan" was prepared by Quantitative Environmental Analysis, LLC of Liverpool, NY for the Black Lake Invasive Weeds Committee of Hammond, NY (QEA 2008). This document outlined the history of Black Lake, management objectives, management techniques, and monitoring actions. In February 2013, the "Reconnaissance Report Aquatic Plant Control Program Black Lake, New York" was prepared by the Buffalo District of the U.S. Army Corps of Engineers (USACE). This report provided insight into aquatic invasive species (AIS), particularly aquatic plants, and management strategies. At the time of construction of this report it is unclear as to how many of these recommendations or strategies from past documents were implemented. Additionally, there have been several studies or monitoring efforts conducted by the SLELO PRISM and faculty and students from St. Lawrence University. Black Lake was listed as an impaired waterbody in New York State's Section 303(D) list of impaired waters requiring a Total Maximum Daily Load (TMDL) or other strategy in 1998. The suspected pollutant causing the impaired designation was phosphorus from agriculture (NYSDEC 2020). Although a full TMDL study was not conducted for the lake. NYSDEC is currently in the process of completing a TMDL for Black Lake as of June 2022.

There have been many efforts to prioritize the understanding and management of invasive species in Black Lake which are outlined below (Extracted from Tenbusch 2021).

- Sporadic mechanical harvesting in the 1970s and 1980s.
- In 2012 a report was written to USACE by Dr. Brad Baldwin of St Lawrence University identifying the need for proper lake management.
- 2018 CSLAP report listed the lake as impaired noting Harmful Algae Blooms (HABs), Eurasian watermilfoil (EWM) and curly leaf pondweed (*Potamogeton crispus*).
- In 2020 and 2021 the BLA financially supported a channel to be cut down the middle of the northern end of the lake to allow for safe recreational boating. The target species to be cut was EWM.
- SLELO has conducted biannual surveys of invasive species in Black Lake starting in 2021.
- In 2021, GEI conducted a lake wide aquatic plant survey to assess the distribution and abundance of EWM, other aquatic invasive plants, and the presence of desirable native plants.

3. Site Description

3.1 Site Characterization

Black Lake has an area of approximately 7,855 acres and a watershed of approximately 359,925 acres. Land use is dominated by other lakes and wetlands, agricultural development, forest, and residential development. Black Lake's main inlet is the Indian River on the southwestern end of the lake and its outlet is the Oswegatchie River which eventually discharges into the St. Lawrence River (**Figure 1A**). The northern and southern ends of the lake are distinct from one another. The northern end can be characterized as a riverine lake system with a shallower average depth (approximately 6 feet) and nearly all its area is littoral zone[1] while the southern end is more characteristic of other glacial lakes in the region with limited littoral zones and deeper depths in the middle basins. The southern portion of the lake still has many bays and habitat for dense aquatic plant growth but not nearly as extensive as the northern end. The large surface area and shallow mean depth of approximately 8 feet (**Table 1**) make Black Lake especially susceptible to excessive aquatic plant growth. For comparison, nearby Millsite Lake has a mean depth of 42 feet (Gervase 2018). Prior to GEIs field effort it was known that several aquatic invasive species (AIS) exist in the lake including Eurasian watermilfoil (*Myriophyllum spicatum*), curly leaf pondweed (*Potamogeton crispus*), zebra mussels (*Dreissena polymorpha*), and common carp (*Cyprinus carpio*). An invasive species is described as a plant, animal, fungi, or pathogen that is non-native to an area and has adverse impacts on the environment, ecology, and in some cases human health (NYSFOLA 2009). During 2021 sampling efforts, other invasive species recorded included common reed (*Phragmites australis*), water chestnut (*Trapa natans*), and purple loosestrife (*Lythrum salicaria*) (**Table 8**).

[1] **Littoral zone:** The area of a lake in which light can penetrate to the sediment and therefore enables viable plant growth.

Table 1: Physical parameters and descriptors of Black Lake.

Lake Parameter	Value
Mean Depth	8 Feet (NYSDEC 2008)
Maximum Depth	40 Feet (NYSDEC 2008)
Shoreline Length	63.7 miles (NYSDEC 2008)
Lake Area	7,855.8 Acres (NYGIS Clearinghouse 2008)
Watershed Area	359,925.5 Acres[2]
Watershed to Lake Area Ratio	45.8:1
NYSDEC Classification	B (NYSFOLA 2019)

The NYSDEC protection of waters program, Article 15 6NYCRR Part 608, provides classifications for waterbodies within New York State. Black Lake has the designation of a Class B Lake which means that its best usage is for swimming and other contact recreation, such as boating and fishing, but not for drinking water. Black Lake is a premier fishing lake and generates large revenue for all the surrounding towns and St. Lawrence County. The total output of anglers alone in 2017 was $16,116,631 (Responsive Management 2019). Many properties along the shoreline of the lake serve as tourist campgrounds and cabin rentals to promote the recreational use of the Lake.

The watershed of a lake can be defined as an area of land in which all water eventually channels into one system, in this case Black Lake (**Figure 1**). The Black Lake Watershed (BLW) is 359,925.5 acres with a watershed to lake area ratio of 45.8 to 1. A larger watershed to lake ratio tends to lead to an increase in water quality problems because there is more stormwater, nutrients, and sediment accumulating in its final basin. Of the total watershed area, 49.28% is covered by forest, 22.9% is covered by wetlands or vegetation, and under 5% is developed land. These percentages are desirable because there is less impervious substrate in the watershed meaning that stormwater runoff and associated impacts to the lake are reduced. Approximately 16% of the watershed is Hay/Pasture or cultivated crops which is a significant amount of agricultural cover within the watershed particularly within the northwestern area of the lake shoreline (**Table 2, Appendix F)**.

[2] Calculated using ArcGIS from watershed polygon extracted from https://streamstats.usgs.gov/ss/

Table 2: Land use of the BLW, surface area and percentage of each classification (USGS 2011) and associated pie chart illustrating land use coverage.

Land Use	Area (square meters)	Area (acres)	Percent Cover of Watershed
Open Water	74,519,100	18,413.42	5.14%
Developed, Open Space	32,719,500	8,084.88	2.26%
Developed, Low Intensity	17,488,800	4,321.42	1.21%
Developed, Medium Intensity	9,181,800	2,268.79	0.63%
Developed, High Intensity	3,306,600	817.05	0.23%
Barren Land	1,294,200	319.79	0.09%
Deciduous Forest	572,743,800	141,523.05	39.53%
Evergreen Forest	118,250,100	29,219.20	8.16%
Mixed Forest	23,006,700	5,684.88	1.59%
Shrub/Scrub	56,111,400	13,864.94	3.87%
Herbaceous	60,649,200	14,986.21	4.19%
Hay/Pasture	207,741,600	51,332.25	14.34%
Cultivated Crops	34,761,600	8,589.47	2.40%
Woody Wetlands	215,079,300	53,145.37	14.84%

An initial desktop evaluation was conducted in the spring of 2021 by GEI's staff ecologist and Certified Lake Manager (CLM). The purpose of this evaluation was to determine the extent of any AIS populations within the BLW. GEI had personal communication with staff of the SLELO PRISM discussing any prior efforts or knowledge regarding the lake. Additionally, GEI utilized the iMapInvasives (iMap) database to conduct research on any other previously reported invasive species within the BLW. GEI's research found that there was a total of 153 AIS observations reported within iMap including ten species in the BLW, which are listed in **Appendix D**. While this data provides a baseline and background for AIS in the watershed, it is not all encompassing; there is a possibility due to survey and data limitations that additional invasive species exist within the BLW.

3.2 Lake Management Concerns

3.2.1 Macrophytes

Macrophytes, also known as aquatic plants, can have beneficial and detrimental impacts to a lake. They are required to keep the ecosystem balanced, utilize nutrients that can otherwise be used by algae, stabilize sediments, and provide fish habitat and spawning grounds. When at nuisance levels, aquatic plants can cause severe oxygen depletion, species can shade out and outcompete separate desirable species, and they can severely impede recreation. There is evidence that the economic value of property decreases on lakefront properties that have AIS present within the lake. For example, EWM has shown evidence of decreasing lakefront property by 19% (Olden and Tamayo 2014). Black Lake is a large economic driver for the surrounding area that primarily generates revenue through fishing and recreational boating activities (Responsive Management 2019). EWM and other AIS pose a significant threat to the perceived and actual value that these activities provide. Invasive aquatic plants can displace valuable fisheries habitat such as spawning and feeding grounds, outcompete desirable native plants, cause water quality issues such as hypoxia[3], spread across the water's surface preventing boating and recreational activities, and even promote algae blooms.

EWM, and other AIS like curly leaf pondweed, purple loosestrife, water chestnut, and European frogbit (*Hydrocharis morsus-ranae*) are discussed further in **Section 5.3** (**Table 8**). There were also beneficial plants found such as water marigold (*Bidens beckii*), which is a state listed rare plant, buttercup or white water crowfoot (*Ranunculus aquatilis*) that provides high ecological value, and many native *Potamogeton* species such as Robbins pondweed (*P. robinsii*) that offers desirable cover and foraging opportunities for Northern pike (*Esox lucius*) (Borman et al. 1997). Aquatic plant management attempts to achieve balance while managing dense monocultures of invasive plants and promoting growth of desirable native plants at moderate levels to favor recreation and ecological synergy.

3.2.2 Harmful Algae Blooms (HABs)

Cyanobacteria, also known as blue-green algae, are a group of photosynthetic bacteria that are found naturally in all aquatic systems. Under particular conditions, cyanobacteria can become very abundant and cause HABs. A HAB occurs when certain algae species form colonies that grow out of control and can produce harmful or toxic impacts on humans and animals. Cyanobacteria can produce cyanotoxins[4] which when present in excessive amounts can cause harm to wildlife, domestic animals, aquatic ecosystems, and human health (ITRC 2020). Cyanobacteria are natural in systems and do even offer ecosystem benefits in some cases. However, with increasing human development and excess nutrients entering freshwater systems, the frequency of HABs throughout New York State has increased and

[3] **Hypoxia:** Depleted oxygen within the water column, usually in the range of 2-3 mg/L and unable to functionally support aquatic organisms.
[4] **Cyanotoxin:** Toxins produced by cyanobacteria that can have adverse impacts on wildlife and humans.

has garnered more attention. When a HAB is present the cyanobacteria causing the bloom *may* be producing cyanotoxins at that time. It is impossible to know just from observing if the bloom is producing toxins without laboratory analysis.

HABs have been observed in Black Lake every year since at least 2012 when NYSDEC began tracking blooms (NYSDEC 2019). During the 2021 field effort there were multiple areas in which significant HABs of different genera were observed (**Figure 2W**). Three genera of cyanobacteria, the type of algae that cause HABs, were identified during the field effort. The three genera observed were *Lyngbya*[5], *Microcystis*[6], and *Gloeotrichia*[7] (**Appendix E, Photos 5-27**). The *Lyngbya* was identified in the field while the *Gloeotrichia* and *Microcystis* was confirmed via microscopy. These genera of cyanobacteria are known to produce cyanotoxins which can have a multitude of effects on human health including skin rashes, headache, sore and scratchy throat, gastrointestinal issues, fever, in more extreme prolonged cases lead to neurological implications, and have harmed or even kill pets or livestock (EPA, n.d.). It is important to note that cyanobacteria exist in all ponds and lakes but become problematic when they reach nuisance levels and are producing cyanotoxins; not all cyanobacteria produce the toxins at any given time. This group of algae usually blooms when there is excessive nutrient input into a lake and when other conditions line up favorably for the organisms. A sample of the *Microcystis* bloom observed in the lake was sent to a lab for toxin analysis to inquire if the algae was producing cyanotoxin at the time. A total of 18.8 µg/L microcystin[8] was present in the sample collected on July 22, 2021. It should be noted that the sample was taken inside a thick bloom and may not represent lake-wide conditions however, toxins were still present. The EPA recommends a maximum concentration of 8 µg/L of total microcystin as the threshold for swimming and other recreation that would result in human contact and exposure (EPA 2019) (**Appendix B & G**).

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[5] ***Lyngbya*****:** Pronounced "Ling-be-ya"
[6] ***Microcystis*****:** Pronounced "micro-sis-tiss"
[7] ***Gloeotrichia*****:** Pronounced "glee-oh-tricky-ah"
[8] **Microcystin**: The type of cyanotoxin produced by *Microcystis.*

4. Methods

4.1 Water Quality

Water quality measurements were taken at three separate locations (**Figures 1C, 4-5, Table 3**). At each site water clarity measurements, temperature, and oxygen profiles along with water samples for nutrient analyses were taken. Water clarity was measured using a Secchi disk and a view scope. The view scope blocks out glare and overcast conditions allowing the sampler to get a more accurate picture of the water transparency. A Secchi disk is a black and white disk that is broken up in quarters of the two colors. The disk is tied to a rope and lowered into the water until it can no longer be seen and then raised until it is observed again. The Secchi disk value is the average of those two depths. Temperature and oxygen profiles were taken at 1-meter intervals from the surface to the bottom using a Hach LDO 101 optical sensor probe. Probe was calibrated to manufacturer specifications prior to data collection. The water samples were taken using a horizontal beta opaque sampling bottle at depths of 1 meter and 1 meter off the lake bottom. Samples were transferred to opaque 177ml HDPE sample bottles, put on ice and frozen within 6 hours of collection. Samples were shipped to the Upstate freshwater institute where they were analyzed for Total Phosphorus, Total Nitrogen and Ammonia-Nitrogen (**Table 4**).

Table 3: GPS coordinates of water quality sampling sites (Figure 1C).

Location	Latitude	Longitude
Waypoint 31	44.61299	-75.48044
Waypoint 1039	44.49999	-75.61071
Waypoint 1805	44.46371	-75.63256

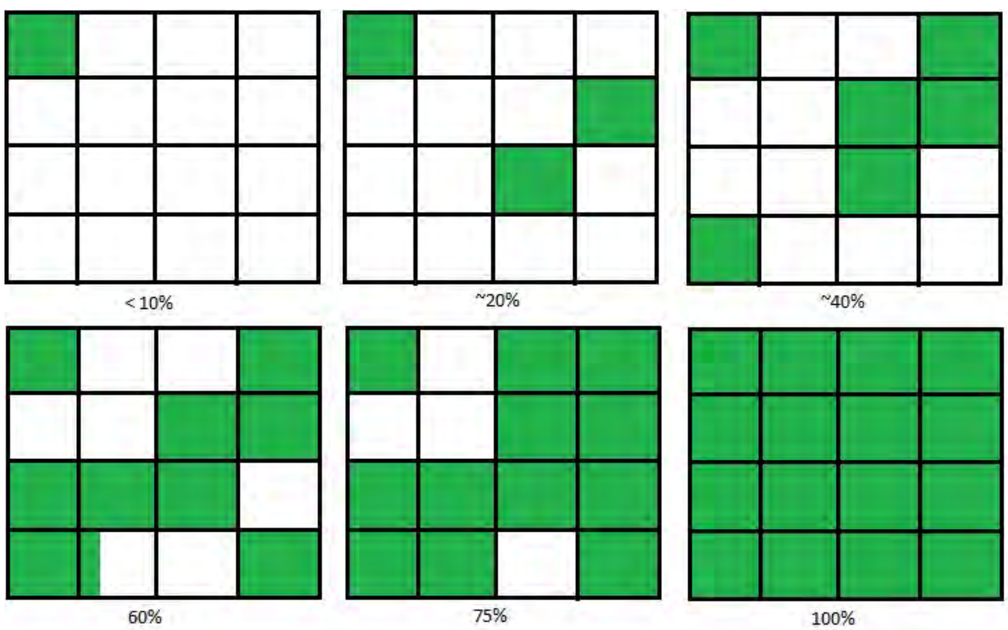
Table 4: Laboratory methods used to analyze water samples collected.

Parameter	**Limit of Quantification**	**Limit of Detection**	**Method**
TP_Auto	4.5 µgP/L	1.5 µgP/L	SM4500-P F-H, 2011
NH3	30 µgN/L	15 µgN/L	SM4500-NH3 H, 2011
TN	75 µgN/L	25 µgN/L	SM4500-N C, 2011

4.2 Aquatic Plant Survey

Aquatic plant surveys were conducted in two separate week-long field events. The first was July 18, 2021, through July 22, 2021, and the second was August 16, 2021, through August 20, 2021. General aquatic plant survey methods involved using a combination of pre-determined waypoints that can be re-visited and supplemental points to add to distribution and abundance information. In the point-intercept survey style, waypoints were pre-determined at fixed intervals (200m) throughout the littoral zone (area where plants can grow based on available light). These points were generated using the ArcGIS 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 diversity of a plant community. To increase survey data accuracy, supplemental points were taken in the field to help complete the inspection of the aquatic plant community. Points were loaded onto a Garmin GPS Map 73 SC for field navigation.

At each waypoint and supplemental point, either a long-handled (~16ft) rake or a 14-tine double-sided garden rake attached to a 10m rope, was used to collect specimens. The water depth and plant density were recorded at each point. Plant coverage was determined using a combination of three methods. The visual density determination method is based solely on what is visible from the surface. This method involves using a hypothetical 10 to 15-foot quadrat where the surveyor visually estimates how much area is covered by the plant in question. Visual estimates are made by a single person during the survey, but survey team members do input their perceived percent cover estimates if the primary surveyor's estimate seems too high or too low. Team collaboration encourages objectivity and more accurate estimates.



Example of hypothetical quadrat that is visualized by the surveyors.

The second 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. A Lowrance Elite FS7 Fish finder was used to collect sonar information. In areas where plants cannot be seen from the surface, the SONAR images become extremely useful for percent coverage estimations, along with weed-rake tosses.

The third 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. 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.

Plants collected during the survey were identified to the lowest practicable taxon. If identifications could not be done in the field, plant samples were placed in a Ziploc bag with water, labeled with the date and waypoint and brought back to the office.
Crow and Hellquist (2006) was the dichotomous key used to identify specimens.

Sonar imagery of plant height during survey. The red circle indicates low growing plants on sonar down scan unit.

C.I. Biobase software was used to estimate plant height throughout the water column. During the survey, SONAR readings were recorded using a micro-SD card at 1-hour intervals to keep files manageable. Sonar settings were consistent with C.I. Biobase's recommendations for recording and analyzing vegetation data. Boat speed during the survey did not exceed 5.5 miles per hour as per C.I. Biobase's specifications. At the end of each survey day, data was offloaded from the micro-SD cards and then uploaded to C.I. Biobase server. Once uploaded, each log is checked for accuracy and applied a depth offset to account for the distance between the transducer to the lake bottom. Once checked, logs were merged to create one complete surface of vegetation biovolume.

5. Results and Discussion

5.1 Water Quality

5.1.1 Temperature

The temperature of a waterbody can have a direct impact on several chemical characteristics and biological factors within the system. While water temperature is mainly influenced by sunlight and air temperature, there are other factors that can influence water column temperature such as depth, abundance of aquatic vegetation, wind, and lake stratification. For example, deeper oligotrophic[9] lakes are usually stratified in the summer months and then completely mixed in the spring and autumn. When lakes are stratified, the changes in temperature with depth creates different densities and results in layers of water that do not get mixed. When the lake goes through a turnover event in the spring or autumn or a severe storm event forces a turnover, nutrients from the sediment-water interface get mixed into the water column and become bioavailable. Alternatively, when waterbodies are constantly mixing it allows any nutrients within the water and sediment interface to be bioavailable throughout the season.

Based on the temperature profiles collected, the lake was fully mixed at the time of sampling at waypoints 1039 on July 22, 2021, and waypoint 1805 on July 22, 2021, while waypoint 31 and 1039 on August 16, 2021, showed evidence of stratification (**Figure 4**). Considering the distance between the waypoints and different environments, it is not surprising to observe the differences in mixed and stratified sections of the lake. Based on this limited information it is possible that Black Lake has areas that mix throughout the summer and others that stay stratified. The hottest temperatures were observed on August 16th at the water's surface reaching a max 27.3 °C (81.14 °F). The coldest water observed was at waypoint 31 at the bottom and was at 18.1 °C (64.58 °F). This is expected because of the sample depth at 6.5 m (21.3 ft) and evidence that this area is stratified. Additionally, colder water can hold more dissolved oxygen. Therefore, when analyzing temperature, it is important to look at its relationship with dissolved oxygen profiles throughout the sampling season. Despite being the coldest water at depth sampled, anoxic[10] conditions were still present below 4.5 m (14.8 ft).

5.1.2 Dissolved Oxygen

Dissolved oxygen (DO) is a measure of the amount of oxygen per liter of water in the water column that is available for uptake/use by aquatic organisms. The minimum dissolved oxygen concentration needed to sustain aquatic organisms is approximately 4 milligrams per

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[9] **Oligotrophic:** A lake with relatively low nutrients and oxygen in bottom waters.
[10] **Anoxia**: Complete depletion of oxygen with the water column, usually in the range of <1 mg/L (Kalff 2002).

liter (mg/L) (NYSFOLA 2009). Dissolved oxygen data collected from the lake showed evidence of hypoxia and anoxia[10] in bottom waters and oversaturation in shallower depths (**Figure 5, Appendix A**). The oversaturation (>100%) of DO in shallower depths indicates a high rate of photosynthesis and dense algae populations (**Appendix A**). This data helps to support the high density of algae blooms and populations that were observed by eye, even in the deepest parts of the lake.

DO concentrations at the bottom of the lake were recorded lower than 2 mg/L at waypoint 31 and waypoint 1805, which is lower than the requirement to sustain aquatic life. It is common to see lower DO concentrations at lower depths due to the lack of an air to water interface and decomposition of organic materials at the sediment-water interface, but when DO readings are also low at the surface and throughout the water column, there is cause for concern. The major causes of the low DO levels observed throughout the warmer summer months were the shallow lake depths and the abundance of AIS and HABs. Aquatic plants photosynthesize during the day and produce oxygen, but at night they respire and utilize the oxygen within a waterbody. Additionally, when plant biomass dies off bacteria break down the biomass and heavily respire (utilize oxygen) which can correspond to plummets in DO levels. The large populations of AIS in the lake can be problematic for any aquatic animals and invertebrates due to their effect of lowering DO levels. For example, on August 20, 2021, an immense die-off of snails was observed (**Appendix E, Photos 43 to 46**). While it cannot be confirmed, this large die-off was likely a result of anoxic conditions in the lakes bottom waters which are supported by the DO data recorded. In contrast to temperature, which is a result of an uncontrollable environmental factor, there are methods to improve DO.

5.1.3 Specific Conductivity

Specific conductivity measures the electrical current that can pass through the water. Current is carried by ions in solution as inorganic substances. “Soft” water lakes have few dissolved ions and therefore a low conductivity, while “hard” water lakes have comparatively more dissolved ions than “soft” water. Conductivity should remain relatively constant throughout the year and any drastic changes can be attributed to a precipitation event or nutrient loading from outside the waterbody (NYSFOLA 2009). Specific conductivity averaged 192.9 microsiemens per centimeter (µs/cm) throughout the sampling effort, suggesting the lake has an intermediate hardness rather than distinctly hard or soft. Increases were observed near the sediment and water interface which is expected as the sampling probe gets closer to the sediment. Based on long term data the conductivity of Black Lake water has slightly increased since 1988 (NYSFOLA 2019). The largest values were observed at waypoint 31 which is anticipated since that site is more riverine than other sites observed (**Appendix A**).

5.1.4 Water Clarity

Recording water clarity throughout the growing season and over a long-term period can indicate certain trends in water quality such as turbidity and suspended solids or algae blooms. Secchi disk transparency can also be used to indicate the trophic state of a waterbody. Oligotrophic systems generally exhibit Secchi depth values greater than 5 meters (16.4 feet), mesotrophic[11] systems generally exhibit a Secchi depth range of 2-5 meters (6.56 feet to 16.4 feet), and eutrophic[12] systems generally exhibit Secchi depth values less than 2 meters (6.56 feet). The average Secchi depth reading of the 4 sites assessed was 1.3 m (4.3 feet). This value, while limited by sample size, is below the long-term average of 1.6 m (5.2 feet) for water clarity in Black Lake (NYSFOLA 2019). In conjunction with the observations of the aquatic plant community, HABs occurring during field efforts, and Secchi disk depth values, Black Lake can be characterized as a eutrophic system with problematic water clarity.

5.1.5 Nutrients

GEI collected surface water samples and bottom depth samples at each of the three water quality sites (Waypoints 31, 1039, and 1805). The samples were analyzed by the Upstate Freshwater Institute in Syracuse, NY for concentrations of phosphorous, nitrogen, ammonia, and nitrates (**Table 5**). While still indicative of nutrient occurrence on the day of sampling and consistent with long term trends, it should be considered that since these samples were only taken from chosen sites and not throughout the entire summer, the analysis of the results is limited. Phosphorous and nitrogen are considered the two limited nutrients in waterbodies, with phosphorous often more limited in freshwater systems. When phosphorous and nitrogen levels are elevated, they provide additional nutrients to accelerate the growth of aquatic plants and in some cases, HABs. It is common to see nitrogen and phosphorous increase in waterbodies in the fall as ponds and lakes are going through a turnover event. Typical phosphorus levels for lakes greater than 250 acres in central NY, the Adirondacks, or the finger lakes region in NY range from 5 to 15 micrograms per liter (µg/L) (NYSFOLA 2009). All nutrient samples taken from Black Lake were above that threshold, as well as the 20 µg/L threshold for eutrophic systems, ranging from 37.9 µg/L to 220.5 µg/L with an average of 104.1 µg/L.

Nitrogen concentrations are usually less than 1,000 µg/L in most lakes and the average of the samples collected in 2021 was 716.5 µg/L (NYSFOLA 2009 & 2019). However, the nitrogen to phosphorus ratio in a lake can be very telling of potential issues that can arise. N:P Ratios of around 30:1 suggest that phosphorus is in short supply while a ratio of around 5:1 suggests that Nitrogen is short supply. This can be problematic since cyanobacteria that cause HABs can proliferate from the higher amounts of phosphorus but more importantly,

[11] **Mesotrophic**: A lake with an intermediate level of nutrients and water clarity.
[12] **Eutrophic**: A lake with high levels of nutrients and productivity.

cyanobacteria can secure nitrogen from the atmosphere at the air to water interface when nitrogen is in shorter supply in the water (NYSFOLA 2009). Based on the samples taken in 2021 there is plentiful phosphorus available for use by algae and cyanobacteria. When phosphorus is bountiful it sometimes makes nitrogen the more limiting nutrient and the lower supply of nitrogen creates an environment favorable for HABs which was also supported through observation.

Ammonia is a form of nitrogen that exists in aquatic environments. Unlike some of the other forms, ammonia can be toxic to aquatic life and can serve as an indicator of severe hypoxia and even anoxia (NYSFOLA 2009 and EPA 2013). It is also a readily available form of nitrogen that can be utilized by cyanobacteria and ultimately result in HABs. Ammonia can also be an indicator of high nitrogen loading from poorly treated wastewater (Effler et al., 2001). When low DO concentrations are present at deeper depths increases in ammonia concentrations are commonly observed (NYSFOLA 2009). The average of ammonia samples taken was 213.3 µg/L which is well below the EPA recommended aquatic life water quality criteria standard of 1,900 µg/L (EPA 2013).

Table 5: Nutrient data collected and analyzed from the 2021 field effort at the three water quality sites TP- Total Phosphorus, TN- Total Nitrogen, tNH3- Ammonia, NOx- Nitrate+Nitrite.

Station	Depth (m)	Sampling Date	TP (µg/L)	TN(µg/L)	tNH3(µg/L)	NOx (µg/L)
WPT 031	1.0	7/22/2021	73.7	838.5	136.1	82.8
WPT 031	5.5	7/18/2021	220.5	627.9	397.5	4.7
WPT 1039	1.0	7/18/2021	37.9	602.1	51.5	66.5
WPT 1039	4.6	7/22/2021	55.4	549.0	268.2	24.3
WPT 1805	1.0	8/19/21	62.1	789	N/A	N/A
WPT 1805	6.3	8/19/21	175.2	893	N/A	N/A
Average	--	--	**104.1**	**716.5**	**213.3**	**44.6**

5.2 Aquatic Plant and Lake Management Strategies

GEI has developed the following list of recommended invasive species and general lake management practices for Black Lake. These strategies are based on the management goals desired by the stakeholders of Black Lake and professional opinion and research.

5.2.1 Invasive Species Prevention Zones

An Invasive Species Prevention Zone (ISPZ) is an area that may have desired native plant species, natural plant communities that successfully reproduce, or desired plant habitat and species composition that provide preferred habitat for fauna. The main goal and concept of establishing ISPZs is to maintain or even enhance the viability of the identified areas. This tactic has led to success within the Long Island Invasive Species Management Area

(LIISMA) PRISM. ISPZs are not necessarily made up of just native species. It is possible that some invasive species exist within the area. However, if invasives like EWM do exist with desirable species such as water marigold or buttercup then these areas should be regarded as both an ISPZ and a priority management area (PMA). Although EWM and other AIS are widespread throughout Black Lake, it should be a priority to maintain the identified ISPZs outlined in **Figure 3** to prevent potential degradation of these suitable habitats. ISPZs help to focus on realistic goals and preserve the limited beneficial habitat that already exists.

A benefit of establishing these ISPZs, and monitoring them over a long period, is that it allows stakeholders to practice Early Detection and Rapid Response (EDRR). EDRR is a practice which allows for control and eradication of a target invasive species before it reaches a level of ecological nuisance and high economic impact. While EDRR can and should always be occurring, establishing ISPZs allows for protection and long-term management of valuable species like water marigold and native *Potamogeton* species valuable to the spawning of game fish species (**Section 5.2.3**).

One aspect of the ISPZs established in Black Lake should involve the annual monitoring for water chestnut to ensure this plant does not establish within the lake. Considering the proximity of known populations in the Oswegatchie River this is an important concern. Although only a single rosette of water chestnut was observed and removed, this species should not be allowed to establish itself within Black Lake. Black Lake has many favorable conditions for water chestnut, and it can have extremely detrimental impacts should this highly invasive plant be given an opportunity to flourish. If herbicide treatments are employed on Black Lake, they should be done on the boundaries of the suggested ISPZs to prevent any AIS from entering or overtaking these conserved habitats.

Figure 3 outlines a suggested template for ISPZs. The ISPZs were determined based on the presence of water marigold and buttercup. The proposed ISPZs include 11 zones totaling approximately 88.87 acres. The two species were selected as the primary driver for the ISPZ determination due to their state status and ecological value. Additionally, **Figure 6** shows PMAs based on native aquatic vegetation that supports successful reproduction of game fish species and is further outlined in **Section 5.2.3**.

5.2.2 Harmful Algae Blooms

In the case of organisms that photosynthesize, algae and plants, all need sufficient light, heat, and nutrients. Light and heat are not going to limit algae growth because they are in plentiful supply. Nutrients like phosphorus and nitrogen naturally exist in lakes in low concentrations. Small increases, particularly in phosphorus, can lead to exponential growth of algae or cyanobacteria populations. Common sources of phosphorus include stormwater resulting from impervious surface or agricultural land or on-site wastewater inputs. Both nitrogen and phosphorus are commonly used in fertilizers and are byproducts of natural waste from humans and livestock. In Black Lake, nutrient management should be a priority due to the shallow depth and the relationship between nutrients to HABs and AIS.

As outlined in **Section 5.1.5**, Black Lake has overall high total phosphorus and total nitrogen concentrations that contribute to toxin-producing cyanobacteria HABs. Long-term management of Black Lake will require a reduction of anthropogenic and agricultural nutrient sources from the watershed. Many of the strategies presented in **Table 6** represent short term strategies that can result in immediate benefits. HAB management in Black Lake also requires the reduction of phosphorus input from nearby faulty septic systems and/or agriculture. The TMDL or nutrient load study will provide a clearer outlook as to what is coming from direct drainage verse major inlets or sub-watersheds.

In the St. Lawrence County area there are natural limitations to how well septic systems can function based on soil types, depth to water table, depth to bedrock, potential for flooding, and/or slopes. The Natural Resources Conservation (NRCS) Web Soil Survey (WSS) indicates 50.6% (18,996.9 acres) of the area in a one-mile buffer around Black Lake had very limited soils for effective treatment of wastewater effluent. In that total buffer zone, 5.6% (2,103.6 acres) was rated as somewhat limited, and 43.8% (16,457.7 acres) was not assigned a rating (Soil Survey Staff 2022). Approximately half the area not assigned a rating was Black Lake itself, at 7,855.8 acres (**Appendix C**).

In 2015 a total of $400,000 was funded through grants and St. Lawrence County to address deficient septic systems on various waterbodies around St. Lawrence County. Through funding from this program 27 septic systems were replaced on Black Lake. Additionally, in 2019 to 2020 a total of 40 households in St. Lawrence County were assisted with 50% reimbursement to replace faulty septic systems. Seven of those 40 units were in the Black Lake area for a total cost of $93,404 (St. Lawrence County 2022). Due to the limited suitability for septic systems in the immediate area surrounding Black Lake the upkeep, inspection, and evaluation of septic systems is a key part of phosphorus management.

GEI was involved with the Interstate Technology and Regulatory Council (ITRC) in creating a comprehensive web based HAB decision tool (ITRC 2020 [https://hcb-1.itrcweb.org/]). Based on the ITRC management criteria tool, and the opinion of GEI, the following management strategies are recommended to limit the impact of HABs.

Table 6: Description of HAB strategies utilizing the HAB management criteria tool. Certain strategies were omitted due to a lack of feasbility at Black Lake (ITRC 2020).

Strategy	Mode of Action	Advantages	Disadvantages	Additional Concerns
Barley and Rice Straw (https://hcb-1.itrcweb.org/ba	As barley straw breaks down in the water, a residue is produced that inhibits	• Prevents HABs and toxin accumulation • Effective on most types of HABs	• Black Lake would require a high amount of straw and effort, only realistic on a local scale	In New York state, barley straw is labeled and regulated as an algaecide but it is not registered as a herbicide meaning certified applicators cannot use barley straw nor can it be sold/marketed as a

Strategy	Mode of Action	Advantages	Disadvantages	Additional Concerns
rley-and-rice-straw/)	cyanobacteria growth. These residues reduce cell viability of HAB species.	• Low cost • Simple installation	• Can present navigation hazards • New York state regulations	form of algae control. Some permits have been approved in the Adirondacks and through communication with NYSDEC thus barley straw *might* be an option. It is also only realistic on a small scale for coves or private docks. The amount needed for a whole lake treatment would be excessive.
Clay and Surfactant Flocculation (https://hcb-1.itrcweb.org/clay-and-surfactant-flocculation/)	Flocculation is the addition of compounds to de-activate HABs. The compounds are added to the water and are effective in settling HABs and associated toxins.	• Effective on most type of HABs • Removes cells and associated toxins if present • Easy spray dispersal	• May require a permit for use, can be costly in large areas • Requires large volumes of surfactants and large pumps • Chance to impact bottom oxygen levels, which are already in peril (**Section 5.1.2**)	This technique is more effective in brackish and even saline environments. If the flocculant is not capped the decomposition of material can lead to hypoxia. With capping, costs can range from approximately $3,648-$8,197 per acre. Without capping, $148-$245 per acre. If ever approved in NYS this method would involve extensive permitting efforts and may have opposition from fisheries groups.
Copper Algaecides (https://hcb-1.itrcweb.org/copper-algaecides/)	There are many types of copper-based algaecides that work by impacting rates of photosynthesis and respiration or break cells and decrease their viability.	• Quick and effective impact, widespread common treatment for algae • Long history of use in the United States • Can be targeted to certain areas or specific genera of algae	• Frequent applications can lead to copper accumulation in sediments • Copper can be toxic to certain fish species and invertebrates under certain conditions	Cost of treatments are variable and dependent on product selected and vendor prices but have been estimated at $933 per acre of treatment in New York. Copper treatments are a commonly used method in New York to manage HABs and require a NYSDEC permit. Herbicide permit applications can be submitted for active ingredients for aquatic plants as well. The variety of copper algaecide formulations offer a wide range of options if chosen. Small scale treatment can be considered initially. Pilot programs for copper treatments are an option when there is public concern about copper-based algaecides.
Peroxide (https://hcb-1.itrcweb.org/peroxide-application/)	Peroxide products for algae control come in a granular or liquid form that is highly	• Hydrogen peroxide (H_2O_2) breaks down into available oxygen (O_2) and water (H_2O)	• Requires access to all surface or benthic area of application (needs to be direct) • Require special handling	Like copper-based algaecides, the application of peroxide products on the scale of Black Lake would require a NYSDEC permit. However, permitting for products like GreenClean tend to be easier

Strategy	Mode of Action	Advantages	Disadvantages	Additional Concerns
	concentrated hydrogen peroxide and works by breaking down cell walls.	• Oxidizes cyanobacteria cells and toxins • Alternative to copper-based algaecides • Commonly used technique	• At extremely high concentrations, may impact zooplankton or fish • More effective in smaller shallow waterbodies	because it is a peroxide-based product. Peroxide based products can become very pricey on large scales and are more suited to smaller areas rather than a whole lake treatment.
Monitored Natural Attenuation (https://hcb-1.itrcweb.org/monitored-natural-attenuation/)	HABs naturally go through boom-and-bust cycles. The idea behind this strategy is to let the blooms naturally progress and avoid recreation if toxins are present.	• Low-cost relative to other strategies • No wastes or byproducts, expertise not needed • Opportunity to educate the public	• May not result in bloom decline • Substantial time and effort required to conduct outreach, place signage, or monitor HABs • Potential for toxins to accumulate opposed to other strategies	Monitoring HABs is an important step in detailing their impact through time. A good monitoring plan includes defining the problem, controlling exposure risks from toxins, monitoring the bloom and locations, and a contingency plan.
Phosphorus Binding Compounds (https://hcb-1.itrcweb.org/phosphorus-binding-compounds/)	The application of phosphorus binding sediments, such as aluminum, iron, or Phoslock control the release of phosphorus into the water column and effectively prevent severe HABs.	• Experienced contractors available in northeast • Low cost, impacts on aquatic life are well understood and can be avoided • EPA has developed water quality criteria	• Currently not permitted for use in New York • Alum can be impractical for large lakes • Longevity and effectiveness are greater for lakes with infrequent mixing. Problematic because there is evidence Black Lake does not stratify (mix) in certain locations and is frequently mixing (**Section 5.1.1**) • Iron will not bind phosphorus if no oxygen is present at depth	Phosphorus binding compounds like Alum has had success in limiting the impacts of HABs. It is a preventative treatment in the method of removing available phosphorus. Since alum treatments are not permitted in New York and it is not registered as an aquatic herbicide, its use is unlikely at Black Lake for the time being. Like other methods presented above, alum is included as an option should it ever be approved for legal use in New York. Not only could it avoid severe HABs, but it can also potentially reduce nuisance plant growth. Phoslock is a product that contains an element that has been effective at preventing HABs through binding available phosphorus. This product is presently **NOT** allowed in New York, but approval may be developed in the future (NYSDEC 2017). (NYSFOLA 2009).

5.2.3 Priority Management Areas for Fisheries

The Black Lake fishery may be the most valuable form of recreation for the economy of Black Lake and the nearby towns. The total economic output of anglers alone in 2017 was $16,116,631 (Responsive Management 2019). Fifteen species of fish were observed during the 2021 survey work at the lake (**Table 7**).

The aquatic plant and emergent shoreline plant community can have a significant impact on the overall state of a fisheries community because aquatic plants provide habitat for nesting, spawning, feeding, and/or coverage from prey (NYSFOLA 2009).

Table 7: Species of fish observed while at Black Lake during field survey efforts. This list is not representative of every fish species present in Black lake, only those observed. *The lamprey observed was deceased and not possible to identify to species level in the field*.

Scientific Name	Common Name
Esox Lucius	Northern Pike
Esox masquinongy	Muskellunge
Micropterus salmoides	Largemouth Bass
Pomoxis nigromaculatus	Black Crappie
Lepisosteus osseus	Longnose Gar
Micropterus dolomieu	Smallmouth Bass
Sander vitreus	Walleye
Lepomis gibbosus	Pumpkinseed
Lepomis macrochirus	Bluegill
Amia calva	Bowfin
Perca flavescens	Yellow Perch
Ambloplites rupestris	Rock Bass
Cyprinus carpio	Common Carp (invasive)
Ameiurus nebulosus	Brown Bullhead
*Petromyzon spp.**	Lamprey species

The establishment of aquatic invasive species such as EWM, CLP, or water chestnut presents an issue when it comes to preferred fish spawning habitat for many game fish species. For example, muskellunge and northern pike are both known to be highly selective with breeding habitat and studies suggest they prefer to deposit eggs on habitats dominated by plants in the

Potamogeton, Chara, Lemna, Elodea, or *Utricularia* genera while showing little to no evidence for using EWM for spawning (McCarraher and Thomas 1972 and Farrell 1991). Additional studies also suggest the vitality of native plant species habitat in spawning of these two valuable fisheries species. Muskellunge selected against vegetation with complex leaves such as EWM (Nohner and Diana 2015), both northern pike and muskellunge more frequently deposited eggs on plants in the *Potamogeton, Lemna*, or *Chara* genera (Farrell et al. 1996), and nursery habitats for muskellunge were generally found to be in shallow areas with vegetation that included spatterdock (*Nuphar variegate),* eelgrass (*Vallisneria americana),* and large leaf pondweed (*Potamogeton amplifolius*) and flat stem pondweed (*P. zosteriformis*), all of which are present in Black Lake (Zorn et al. 1998). All of this considered, the native aquatic plants in Black Lake provide critical spawning and nursery habitat for economically valuable species, and AIS like EWM may even contribute to the eventual degradation of these fisheries. The management of EWM to promote native aquatic plant habitat is a large part of the management of Black Lake. Therefore, priority management areas (PMAs) have been suggested and are outlined in **Figure 7**. The purpose of PMAs is to designate areas that have ecological significance with a high species richness of native plants to support spawning habitat and desirable fisheries populations for generations. Management goals of the PMAs are to maintain the current species richness of native aquatic plants and most importantly to prevent further invasion of additional AIS. The suggested PMAs were made by looking at select native species and comparing the locations to that of dense EWM. Wherever there were pockets of the native species forked duckweed (*Lemna trisulca*), spatterdock, large leaf pondweed, clasping leaf pondweed *(Potamogeton perfoliatus*), white stem pondweed (*P. praelongus*), Robbins pondweed (*P. robbinsii*), flat stem pondweed, common bladderwort (*Utricularia macrorhiza*), or eelgrass and relatively low densities of EWM, a PMA was created. The PMAs and ISPZs created are meant to serve as a baseline for aquatic plant management activities and to guide the decision-making process for priority areas in which to focus management.

5.3 Aquatic Plants of Concern and Management Strategies

The focus of the field effort completed in 2021 was the aquatic plant survey which was conducted on every single day of each visit to Black Lake. Survey methods are outlined in **Section 4.2**. In total, 42 different species of macrophytes were observed including filamentous algae and cyanobacteria. Maps of all species or genera can be found in the **Figure 2** set. Of the 42 species identified, 32 are considered native aquatic species and six are considered invasive by New York State as per NYCRR Part 575 (NYSDEC and NYSDAM 2014) and four are commonly accepted as nuisance species in this area of New York (**Table 8**). The six invasive species identified were EWM, curly leaf pondweed (*Potamogeton crispus*), water chestnut (*Trapa natans*), European frogbit (*Hydrocharis morus-ranae*), purple loosestrife (*Lythrum salicaria*), and common reed (*Phragmites australis*). (**Appendix E Photos 27 to 38**). A composite sample of unidentified *Potamogeton* were brought back to NEAR offices for positive identification. The composite consisted of small pondweed (*P. pusillus*), snail seed pondweed (*P. bicupulatus*), and Berchtold's pondweed (*P. berchtoldii*).

During sampling efforts in 2021 the water level was observed by GEI and NEAR staff to be down about 4 feet (**Appendix E, Photos 49 to 52**) and was also corroborated by numerous stakeholders. The decreased water level can have a significant impact on the aquatic plant community and observed densities. Areas that were topped out with aquatic plants during survey efforts may look different from year to year based on annual water level fluctuation. It is important for Black Lake stakeholders to track water levels over time to aid in future management strategies. Water level fluctuation can cause drastic changes in the observed aquatic plant community as well as influence nutrient dynamics, stratification, and HABs.

Table 8: Species found throughout the aquatic plant field survey effort. Species are referred to in both Latin and common name, some of which are interchangeable. Native or Invasive is noted and if a plant is listed as invasive in NY state, its invasive ranking is shown (Jordan et al. 2008). VH = Very High. *Bidens beckii* is the only listed rare plant in New York state (Young 2001). In Young 2001, each rare plant in the state is assigned a global and state rank as well as state status. *B. beckii* has a secure global rank of G5, a vulnerable rank of S3 in New York, and a New York legal status of "R" for rare meaning is has 20 to 35 extant sites or 3,000 to 5,000 individuals statewide. Coefficients of Conservatism (C) is a value used to create a floristic quality assessment. Any species that was not assigned a value based on the database is provided an "x".

Scientific Name	Common Name	Native (N) or Invasive (I)	Invasiveness Rank	Number of Sites Documented (out of 1,951 sites)	Coefficient of Conservatism
Azolla caroliniana	Mosquito fern	N	x	20	2
Bidens beckii	Water marigold	N	x	48	8
Cephalanthus occidentalis	Buttonbush	N	x	26	7
Ceratophyllum demersum	Coontail	N	x	543	3
Cyanobacteria	Blue green algae	N/I	x	381	x
Decadon virticillatus	Swamp loosestrife	N	x	125	x
Elodea canadensis	Canadien waterweed	N	x	83	2
Elodea nuttallii	Western waterweed	N	x	174	4
Filamentous algae	Filamentous algae	N/I	x	142	X
Hydrocharis morus-ranae	European frogbit	I	VH (86)	32	X

Scientific Name	Common Name	Native (N) or Invasive (I)	Invasiveness Rank	Number of Sites Documented (out of 1,951 sites)	Coefficient of Conservatism
Juncus effusus	Black rush	N	x	35	2
Lemna minor	Lesser duckweed	N	x	7	2
Lemna trisulca	Forked duckweed	N	x	369	4
Lobelia cardinalis	Cardinal flower	N	x	32	7
Lyngbya wollei	Lyngbya	N/I	x	34	x
Lythrum salicaria	Purple loosestrife	I	VH (91)	330	0
Myriophyllum spicatum	Eurasian watermilfoil	I	VH (100)	1,018	0
Najas flexilis	Brittle naiad	N	x	8	3
Najas guadalupensis	Southern naiad	N	x	329	5
Nitella spp.	Nitella	N	x	5	x
Nuphar variegata	Spatterdock	N	x	38	3
Nymphaea odorata	White water lilly	N	x	290	4
Phragmites spp.	Common reed	N/I	VH (92)	5	0
Polygonum amphibium	Water smartweed	N	x	1	5
Pontedaria cordata	Pickerelweed	N	x	104	5
Potamogeton amplifolius	Large leaf pondweed	N	x	44	6
Potamogeton crispus	Curly leaf pondweed	I	VH (80)	42	0
Potamogeton foliosus	Leafy pondweed	N	x	8	4
Potamogeton perfoliatus	Clasping leaved pondweed	N	x	30	5

Scientific Name	Common Name	Native (N) or Invasive (I)	Invasiveness Rank	Number of Sites Documented (out of 1,951 sites)	Coefficient of Conservatism
Potamogeton praelongus	Whitestem pondweed	N	x	184	6
Potamogeton robbinsii	Robbins pondweed	N	x	133	6
Potamogeton zosteriformis	Flat stem pondweed	N	x	159	5
Ranunculus aquatilis	Buttercup	N	x	2	9
Sagittaria latifolia	Arrowhead	N	x	91	3
Spirodela polyrhiza	Greater duckweed	N	x	45	x
Stuckenia pectinata	Sago pondweed	N	x	1	2
Trapa natans	Water chestnut	I	VH (82)	1	0
Typha spp.	Cattail	N/I	N/A	40	2
Unidentified Potamogeton		N	x	4	x
Unidentified Potamogeton 2		N	x	1	x
Utricularia macrorhiza	Common bladderwort	N	x	5	5
Vallisneria americana	Eelgrass	N	x	362	5
Wolffia sp	Watermeal	N	x	112	x
Zosterella dubia	Water stargrass	N	x	44	x

A Floristic Quality Assessment (FQA) is a tool often used by ecologists to assess a study site based on prior assessments from certain regions and lakes. FQAs can be used to identify conservation areas, compare the quality of sites, monitor long term trends, or assess management and restoration techniques (Nichols 1999). Applying FQAs, each plant species is ranked by its common habitat types and assigned a coefficient of conservatism (C). For example, a species found only in disturbed sites with high turbidity and high nutrient concentrations is ranked with a low C (1 to 2), while another species which is native, has a narrow range of ecological tolerances, and is sensitive to disturbance is assigned a higher value (9 to 10) (Freyman et al. 2016). There are multiple ways to calculate an FQA or a floristic quality index (FQI) and the one used for this assessment was accessed through the New England Interstate Water Pollution Control Commission (NEIWPCC) and the universal FQA calculator (https://universalfqa.org/).

The coefficients assigned for the species used in this calculation was based off C values assigned by a group of botanists and ecologists throughout the northeast region recognizing tolerance to environmental stressors and general ecological value (**Table 9**). The higher the number of the C and FQA, the better the quality of the species and aquatic plant community respectively (Borman et al. 1997). The FQA extracted for Black Lake was 21.8. Of the 42 species found, 33 were incorporated into the FQA calculation (2 of the 42 were groups of algae). Species that were omitted from the calculation were those that were never provided C values in this database and are assigned an "x" in **Table 8**. The FQA value is most practical when comparing aquatic plant communities of nearby lakes or analyzing Black Lake surveys from the past of future. If a similar survey effort is repeated, then this tool provides an analytic to assess the improvement or degradation of the aquatic plant community. For example, Millsite Lake in 2000 had an FQI value of 12.85 but after 15 years of aquatic plant management, that value increased to 26.62 (Gervase 2018 and Nichols 1999). It is also possible that an FQA value of a lake may decrease based on the total survey effort or expertise of the surveyors. For instance, if only the northern end of Black Lake were to be surveyed the FQA would be significantly different since certain species may be omitted from the final data set. The best way to analyze a FQA over time is to exactly repeat a previously conducted survey. Of the 33 species used in the analyses, 4 had a C value of 7 or greater and 2 of those 4 were emergent species that exist only on the shoreline. This suggests that despite desirable species richness, only select species provide a high ecological value. 26 of the species had C values of 5 or lower which supports the notion that the aquatic plant community is impaired.

Table 9: C values and evaluation criteria. Extracted from https://neiwpcc.org/.

C Value	Criteria
0	Non-native with a wide range of ecological tolerances. Often these are opportunistic invaders of intact undisturbed habitats.
1 to 2	Native invasive or widespread native that is not typical of (or only marginally typical of) a particular plant community; tolerant of anthropogenic disturbance.
3 to 5	Native with an intermediate range of ecological tolerances and may typify a stable native community but may also persist under some anthropogenic disturbance.
6 to 8	Native with a narrow range of ecological tolerances and typically associated with a stable community.
9 to 10	Native with a narrow range of ecological tolerances, high fidelity to particular habitat conditions, and sensitive to anthropogenic disturbance.

There is no "silver bullet" solution for aquatic plant management. Each lake is its own situation with different AIS, native species, and/or conditions that may influence management techniques. The management strategies outlined in **Table 10** are representative of techniques suitable to Black Lake and the plants that are present. Not every technique or recommendation is the same for every species. Recommendations are discussed in further detail in **Sections 5.3.1-5.3.5** for specific AIS.

Table 10: Aquatic plant management strategies for select AIS present in Black Lake. Certain methods were omitted if not deemed appropriate for use at Black Lake and effectiveness is based on conditions observed at Black Lake as of 2021. Certain techniques may be more applicable in the future depending on populations of the given AIS. "HE" = high effectiveness, "ME" = moderate effectiveness, "LE" = limited effectiveness.

AIS	Herbicide Application	DASH and Benthic Barriers	Cutting or Harvesting	Hand Pulling	Biological Control
Eurasian Watermilfoil	HE	ME	ME	--	--
Water Chestnut	LE	--	--	HE	--
Curly Leaf Pondweed	HE	ME	LE	--	--
Purple Loosestrife	LE	--	--	LE	HE
European Frogbit	ME	--	--	HE	--

5.3.1 Invasive Species of Concern - Eurasian Watermilfoil

5.3.1.1 Plant Ecology

EWM, a prohibited[13] plant in New York (NYSDEC and NYSDAM 2014), is a submerged aquatic plant that was introduced into North America in the 1940s and is now considered the most widespread AIS in the northern half of the U.S. (Gettys et al. 2014). EWM is a plant with compound leaves and 18 to 24 leaflets in whorls of 4. EWM has traits that make it highly invasive which allowed it spread in North America. EWM can be found in depths up to 30 feet in certain light conditions which provides this plant with a wide-ranging viable habitat when compared to other aquatic plants. EWM can grow by fragmentation and therefore can be easily transported and propagated through boat or equipment contamination or aquarium dumping (**Appendix E, Photo 29**). Similarly, when cut by motorized boat traffic an adult plant breaks into fragments which then can establish an additional mature plant. These fragments can also form floating mats which allow the plant to spread even further within a system and can often provide habitat for filamentous algal species in areas they

[13] **Prohibited species**: As defined in Part 575 of the invasive species regulations, "a species that cannot be knowingly possessed with the intent to sell, import, purchase, transport or introduce. In addition, no person (cont.) shall Sell, import, purchase, transport, introduce or propagate prohibited invasive species. Regulated invasive species, on the other hand, are species which cannot be knowingly introduced into a free-living state or introduced by a means that one should have known would lead to such an introduction, although such species shall be legal to possess, sell, buy, propagate and transport." (NYSDEC and NYSDAM 2014).

normally would not be able to survive (**Appendix E, Photo 28**). An additional trait that makes this plant a successful invader is that it can overwinter and can at times be seen growing beneath ice. This factor gives EWM a competitive advantage; once ice thaws and temperatures begin to warm, EWM has already begun growing and can reach the water's surface and shade out other desirable plants. The plant itself can grow up to 20 feet long and even form a dense canopy on the surface. In late summer it develops a flower that breaches the water's surface. The flower itself is elongate and anywhere from 2 to 6 inches above the surface.

Although EWM produces seeds and flowers, its main means of reproduction is through fragmentation, which occurs naturally and as a result of disturbance, and root spread. EWM was widespread throughout Black Lake but there were areas with highly desirable plant communities void of EWM (**Figure 2**). These areas should be protected and monitored to ensure that EWM does not establish.

EWM was the most frequently observed plant in Black Lake and present throughout the entirety of the lake (**Figure 2D**). Based on observation of field staff, it mostly did not occupy water depths over 8 feet even though EWM has been known to survive in water up to or more than 20 feet deep. EWM was extremely dominant in open water habitats and still present in lower densities in smaller coves and bays, often was present near valuable species such as water marigold or buttercup, and other valued *Potamogeton* species. EWM mainly existed in monoculture populations or coexisted with southern naiad (*Najas guadalupensis*), coontail (*Ceratophyllum demersum*), or filamentous algae.

In the northern section of Black Lake EWM was distributed ubiquitously from shoreline to shoreline with some bays and coves having lesser densities. There were many large stands of EWM throughout the northern section with a few notable areas such as perpendicular to Demot Road and Oak Point to outside of Lower Big Bay. EWM monocultures were not observed as often in the southern end of the lake due to deeper max depths and steeper rockier slopes in some sections. Black Bay, Mile Arm Bay, Grindstone Bay, and southwest of Emery Island had high frequencies and densities of EWM. The majority of the remaining areas in the southern section of Black Lake such as Big Bay, Lonesome Bay, or Rollway Bay all had observed densities of EWM of moderate or less.

The methods discussed below reflect management strategies that are feasible and best suited to have the most success at Black Lake. Drawdown for example, is a management method in which a lake level is lowered in the winter to freeze the sediment and kill any biomass along the shoreline area and is an effective technique for plants in the *Myriophyllum* genus like EWM. This technique however would not be an option at Black Lake due to the lack of a dam to draw-down water levels. In addition, the lake is too shallow and would require an excessive amount of water to be released to effectively control EWM. Another example of a common aquatic plant management technique used in New York is the stocking of triploid grass carp (*Ctenopharyngodon idella*). Grass carp, which are sterile, are voracious herbivores that are stocked in lakes and ponds to control nuisance vegetation as a biological control agent. Although effective at vegetation control, grass carp do have a pallet and preferentially feed on certain species. EWM is not one of their sought-after plants while many beneficial *Potamogeton* species are preferred (Dibble and Kovalenko 2009). If these fish are overstocked there is also a likelihood that they will over-consume aquatic vegetation which can shift a lake into more frequent HABs. NYSDEC permits are also required to stock grass carp and usually require the ability to keep the stocked fish locked within the target system. This would be near impossible at Black Lake due to the size of the inlets and outlets and the needed migratory pathways for fish that require upstream/downstream habitats for spawning purposes. Therefore, this aquatic plant management option is also not recommended for use at Black Lake.

5.3.1.2 Control Methods: Herbicide Application

The application of EPA registered aquatic herbicides[14] to control EWM and most other AIS is a common practice. While herbicides tend to have a negative connotation for the general public, they can offer a management option that is not only cost effective, but also efficient at controlling the target plant. Herbicides that are labeled for aquatic use go through rigorous testing and analysis prior to getting approved for use. This testing and analysis can span decades and New York State provides a secondary independent review usually reported as a Special Local Need (SLN) label that offers specific information dependent on county and other geographical factors.

There are many factors to consider prior to selecting an herbicide to be used on a target plant. There are selective and non-selective herbicides. Selective herbicides will only impact certain plants through contact while a non-selective herbicide will harm or kill any plant it comes in contact with. Certain active ingredients have different water use restrictions that vary based on water supply, irrigation, agricultural uses, toxicity to aquatic life, and other general water use restrictions (Holdren et. al 2001). By law, these use restrictions must be listed on the product label and strictly adhered to by any applicator. There are also contact or systemic herbicides. Contact herbicides kill whatever part of a plant they come in contact with, while systemic herbicides are translocated throughout an entire plant.

There are several active ingredients for herbicides that are commonly used to treat EWM including florpyrauxifen-benzyl, endothall, 2,4-D (2,4 dichlorophenoxy acetic acid), triclopyr, and fluridone. These are the active ingredients of the herbicide, which may be called by different trade names[15] (Gettys et al. 2014). 2,4-D, florpyrauxifen-benzyl, and triclopyr are systemic herbicides that get translocated throughout the entire plant when applied. They are effective at controlling a variety of floating and submerged plant species and offer fast action after application. They are selective herbicides; but

[14] **Herbicide**: A type of pesticide that targets plants.
[15] GEI does not endorse the use of any particular product, as long as the product is labeled for aquatic use and lists the target plant on the label.

florpyrauxifen-benzyl and triclopyr are known to offer more selectivity in terms of target plants as compared to 2,4-D. 2,4-D can have variable toxicity to aquatic fauna depending on formulation or water chemistry and cannot be used in water supplies. Triclopyr has a 30-day restriction on fish consumption from treated areas (Holdren et al. 2001). If possible, legally and feasibly, the application of both chemicals at the same time or different times of the year can offer the highest control (USACE 2012).

If herbicide applications to control EWM are an option that is considered at Black Lake, applications should be focused on the borders of suggested Invasive Species Prevention Zones (ISPZs) outlined in **Section 5.2.1** and **Figure 3**. Herbicides application must be conducted by a New York State certified pesticide applicator in Category 5A- Aquatic Vegetation. State permits would also be required for any herbicide application to the lake. The applicator chosen must strictly adhere to the label provided on the herbicide.

When herbicides come in contact with aquatic plants and the plant eventually gets broken down by bacteria, there is a risk that this could inadvertently trigger hypoxic conditions and in extreme situations, fish kills. This is more prone to happen in smaller ponds with minimal flow and isn't likely to occur at Black Lake. However, applying herbicides in segments or sections is still a Best Management Practice (BMP). Herbicide choice and application ultimately comes down to the label on the product, which must be adhered to, and the applicator themselves in consultation with the Black Lake stakeholders. If liquid herbicides are applied at Black Lake a surfactant should be utilized to ensure that the applied product has sufficient contact time with EWM to be effective. Additionally, applications near areas with known populations of water marigold or buttercup should be avoided or applied with extreme caution to protect these rare plants.

5.3.1.3 Control Methods: DASH and Benthic Barriers

Diver Assisted Suction Harvesting (DASH) and benthic barriers are two forms of control that offer a localized approach to controlling EWM and other AIS. DASH is a method in which scuba divers educated and proficient with aquatic plant identification either hand pull target plants or use a suction harvester to remove target plants in a defined area. This method can be highly effective but is costly due to specialized diver training, safety considerations and operation of equipment. Additionally, this method can cause turbidity when plants are pulled from the sediment. Caution needs to be taken when the target species is EWM because the plant can proliferate via fragmentation. DASH can be used successfully for management of AIS like EWM when it is confined to localized areas and plants can be specifically targeted. DASH is not a method that is recommended for the entirety of Black Lake. The lake is too large, and it would be too costly to use this method lake wide. However, it is a management method that could be used in smaller areas like ISPZs (**Section 5.2.1**) or public/private docks.

Benthic barriers are a method that installs weighted mats on top of pre-determined areas to shade out target species. NYSDEC general permit GP-0-21-004 'Management of Invasive

Species' is required to install benthic barriers. Like DASH, this method is better suited for smaller areas rather than whole lake use. The mats are limited in that they can only be installed in water that is wadable (~ 3 feet in depth), unless scuba divers deploy the barriers. Unlike DASH, benthic barriers are unselective and will shade out all plants in the area they are installed which is beneficial in areas of EWM monocultures. Benthic barriers involve maintenance because gas bubbles can form below the mats or sediment buildup can occur on top of the mat which allows plants to grow. If selected as a management tool, benthic barriers should be utilized in small areas such as public or private docks or on dense EWM stands surrounding ISPZs. Monitoring is necessary after installation and removal of benthic barriers because the barriers create an "empty space" of habitat which can lead to invasive species recolonizing the area if desirable native plants are not given the opportunity to thrive. The combination of DASH and benthic barriers can be effective for several reasons. One such reason is that the divers can aid in the proper installation of the mats. Another important reason is DASH divers would be given an opportunity to harvest EWM immediately around the area of the benthic mat which would provide desirable natives species a better chance at recolonizing any of the empty space areas.

5.3.1.4 Control Methods: Cutting and Harvesting

Cutting and harvesting are forms of removal that involve the mechanical cutting of target plants using an amphibious vehicle. The main difference between the two methods is that harvesting also includes the collection of the target species for disposal. Both are effective for controlling AIS but have pros and cons. Since EWM is the main target species for AIS control in Black Lake, it is prudent to emphasize that the plant can grow and spread via fragmentation. Even if harvesting is used over cutting, and plant material is collected, it will still leave some fragments behind. However, the method can still be used successfully. In 2021 a private contractor was enlisted to cut and harvest EWM in the northern end of Black Lake to create a navigable recreational channel. Despite the impacts of fragmentation, the harvesting effort proved to be successful since the lake was previously unnavigable. Cutting and harvesting of EWM may not be recommended in all aquatic systems, but in Black Lake the harvesting of EWM to maintain navigable channels is a process that results in a desirable and successful outcome for stakeholders. Harvesting should be continued in the lake to maintain navigable channels, maintain personal docks by request, continue to create fishing lanes and edges in areas where they wouldn't be otherwise, and serve as a complementary technique to the other EWM control methods discussed.

The cutting and harvesting of EWM in Black Lake has led to desirable results but there are ways in which the work can be maximized. Mechanical harvesting is a time and effort intense technique, and it is important to maximize harvest/equipment operation time to capitalize on the task at hand. Establishing multiple designated disposal and launch sites on the shore of Black Lake would allow the operator of the harvester to be much more efficient in carrying out the work. Determining what areas should be harvested and prioritized is another important factor in harvesting at Black Lake. It is recommended to continue harvesting a main navigation channel on the northern end of the lake and adding additional perpendicular lanes as the BLA, COC, or FGC deem appropriate. Creating harvesting lanes that are both parallel and perpendicular to the shoreline will allow for maximum navigation capabilities given the circumstances and access to the main open water channel. The edges will also increase favorable habitat for fishing. Harvesting is not as paramount on the southern end of the lake since it has deeper basins in which there are depths to deep for aquatic plants, although it can and should be utilized for personal docks by request or to maintain fishing areas as deemed appropriate.

5.3.2 Invasive Species of Concern - Water Chestnut

5.3.2.1 Plant Ecology

Water chestnut, a prohibited plant in New York (NYSDEC and NYSDAM 2014), is a rooted floating leaved annual plant that when introduced into waterbodies of the United States can become highly invasive. Water chestnut prefers slow moving, nutrient rich waters and reproduces exclusively by seed. It has feather like submerged leaves but palmate leaves that float on the surface forming the plants' characteristic rosette. Water chestnut produces small white flowers around the middle of June. Each rosette of water chestnut can produce 10 to 15 seeds which can then remain viable in the sediment for 10+ years (Gettys et al. 2014). The seeds are distinctive, with 4 to 5 barbed spikes and appear green and fleshy while on the plant but turn to a deep black later in the year. The seeds can cause an impediment to recreation due to their sharp points and barbed spikes. Since the seeds can remain viable, at least 10 years of monitoring is necessary to ensure the effectiveness of an eradication.

Water chestnut can form dense monocultures that shade out the water surface and block sunlight from reaching the water column. Blocking sunlight can prevent the growth of other desirable native species allowing water chestnut to outcompete most if not all other aquatic plants. Dense monocultures of water chestnut can lead to hypoxic conditions as the plants respire and use up oxygen at night or when they die and get broken down by bacteria. Over time as water chestnut dies and settles into the lake sediment, the organic content and overall depth of the sediment can increase. This can lead to higher turbidity and more intense eutrophication impacts. Water chestnut can also be harmful to fish populations within a waterbody. Reduction of native plants through competition removes plant beds that native fish often depend on as habitat. In addition, the degraded habitat that water chestnut promotes creates habitat more suitable to nuisance fish species such as common carp (Gettys et al. 2014).

During 2021 sampling efforts at Black Lake only one water chestnut plant was observed and immediately removed (**Figure 2L**). Water chestnut has been observed historically in Black Lake but has been pulled and removed by CSLAP volunteers and others. If it were not, it would have the chance to be a highly dominant in Black Lake. Finding only one rosette in 2021 is an archetypal example of EDRR in that water chestnut has been found multiple times in Black Lake but has never reached nuisance levels. It is critical that this remain the case because based on the ecology of water chestnut and conditions of Black Lake, this plant would have tremendously detrimental impacts to the overall state of Black Lake. There are large known populations of water chestnut nearby in the Oswegatchie River which presents a close pathway for this plant to continue getting introduced into Black Lake. Due to this, continued monitoring and removal of any water chestnut is highly recommended to prevent any negative impacts from this AIS.

5.3.2.2 Control Methods: Physical and Mechanical Removal

A positive aspect for the control of water chestnut is that it is an annual plant that only reproduces by seed (most other AIS can spread by fragmentation and other methods). Since water chestnut cannot spread by fragmentation, hand pulling or removal by a harvester offers an effective means of control. Hand pulling involves a crew combing the waterbody and pulling as much plant biomass as possible, which is then disposed off-site. Removal of water chestnut should occur from mid-June to mid-July when plants are higher in the water column and before August when seeds mature and drop into the sediment.

Hand pulling is a highly selective and effective technique but is a labor-intensive effort. Hand pulling water chestnut from the entirety of Black Lake would require a large field crew likely assisted by volunteers over a long period of time. Consequently, monitoring for this plant is essential to ensure it does not spread throughout the Lake. Fortunately, only one rosette was found during the 2021 survey (**Figure 2L**). Hand pulling also allows crew members to remove other nuisance plants such as European frogbit at the same time. (**Section 5.3.5**). If hand pulling or any type of physical removal occurs at Black Lake, it is vital to predetermine the ultimate fate of the removed biomass. Options include renting a dumpster to have any plants bagged and removed off site, or temporarily stockpiling the biomass at a NYSDEC approved site to dry out, and then disposing the material through incineration or burial at an approved upland disposal site. Since EWM is already removed using a harvester, any removed plant material can be stockpiled together. Despite being a labor-intensive effort, hand pulling is a process that should be implemented at Black Lake in conjunction with additional management strategies if any water chestnut is found in the future.

Mechanical removal through harvesting is a process in which an amphibious vehicle enters a waterbody and collects and removes the target plant. While renting or purchasing a mechanical harvester can be costly, this control method offers a highly effective technique for managing water chestnut that is not nearly as labor intensive as hand pulling. Water chestnut does not spread via fragmentation and the collection of plants will remove most of the seeds. Note that additional considerations for mechanical harvesting is that the method is a non-selective process and can remove aquatic animals as well as plants and harvesters are limited in areas they can access. Hence, a combination of hand-pulling and mechanical harvesting may offer the most efficient and optimal approach for physical removal of water chestnut at Black Lake should populations increase.

5.3.2.3 Control Methods: Herbicide Application

The basics of this method are outlined in **Section 5.3.1.2**.

There are two active ingredients for herbicides that are commonly used to treat water chestnut, 2,4-D (2,4 dichlorophenoxy acetic acid) and triclopyr. These are the active ingredients of the herbicide, which may be called by different trade names[16] (Gettys et al. 2014). 2,4-D and triclopyr are both systemic herbicides that get translocated throughout the entire plant when applied. Both are effective at controlling a variety of floating and submerged plant species and offer fast action after application. Both are selective herbicides; but triclopyr is known to offer more selectivity in terms of target plants as compared to 2,4-D. 2,4-D, which can have variable toxicity to aquatic fauna depending on formulation or water chemistry and cannot be used in water supplies. Triclopyr has a 30-day restriction on fish consumption from treated areas (Holdren et al. 2001). If possible, legally and feasibly, the application of both chemicals at the same time or different times of the year can offer the highest control (USACE 2012).

Any herbicide application that is considered at Black Lake should be scheduled before water chestnut drops seeds in late July/early August to prevent any reproduction for that year. If herbicides are applied at Black Lake a surfactant should be utilized to ensure that the applied product has sufficient contact time with water chestnut to be effective. As of the 2021 survey, water chestnut is not yet at a population density in which herbicide treatments are recommended but this section is included to provide information in the event water chestnut populations increase.

5.3.3 Invasive Species of Concern - Curly Leaf Pondweed

5.3.3.1 Plant Ecology

Curly leaf pondweed, a prohibited plant in New York (NYSDEC and NYSDAM 2014), is an invasive plant native to Europe, Asia, Africa, and Australia that was first discovered in the United States in 1841. Since its initial discovery, the plant has spread to the lower 48 continental states (Gettys et al. 2014). It is unfortunately a common plant in New York State and three observations were noted within the QCW in iMap Invasives, which is most likely underreported. The plant can be identified by its characteristic curly leaves that have a distinct wavy pattern, which can be described as the edge of lasagna, shells, or crispy bacon. All plants in the *Potamogeton* genus are defined by having a midrib down the center of their leaves. Curly leaf pondweed does indeed have that midrib but is unique in the size of the leaves, which are 1 to 3” in length and attached to the stem in an alternate arrangement, and wavy appearance (Gettys et al. 2014).

Unlike water chestnut and similar to EWM, this plant is a perennial and can reproduce by fragmentation which poses additional management hurdles. Curly leaf pondweed can grow in icy conditions as well as hot summer temperatures. The fact that it can grow in low light, icy conditions during the winter gives it a highly competitive edge over other submerged aquatic plants that begin to grow in the spring and allows the plant to grow up to the water surface. Curly leaf pondweed also has a unique life cycle that gives it a highly competitive advantage over most native submerged aquatic plants. While curly leaf pondweed can reproduce through fragmentation, propagation is mainly done through rhizomes and a structure called a turion. Turions are reproductive buds on the plant that form before the plant dies. A single plant can produce five turions with each one averaging four buds and thus reproduce very rapidly (Gettys et al. 2014). Turions can remain viable in the sediment for multiple seasons.

Curly leaf pondweed dies back in mid to late July, which contrasts with most other submerged aquatic plants that usually grow the full season. This early dieback is problematic because it occurs in the middle of the summer during some of the hottest temperatures when there is a large amount of nutrients that are bioavailable. This can lead to optimal conditions for early season algae blooms. This early season dieback may also have contributed to an underestimate of curly leaf pondweed density within Black Lake since survey efforts began on July 18, 2021. Although it was not seen frequently or in high densities, it was observed from the north end of the lake to the south end suggesting that it may be more widespread than reported. In the future, an earlier season survey may lead to more representative data on the abundance of curly leaf pondweed.

5.3.3.2 Control Methods: Physical and Mechanical

The basics of these methods are outlined in **Section 5.3.2.2**.

Hand removal of curly leaf pondweed is an effective strategy when the population is very small, and precautions are taken to prevent fragmentation. Turions can quickly colonize areas in which plants were recently removed. As discussed, benthic barriers are also a common strategy that may be used and could be an option at Black Lake once populations of water chestnut are under control. Both these methods represent a relatively benign control method but can be high in cost due to labor and maintenance. As noted, benthic barriers are not selective in what plants they control and after their installation and desired outcome it is crucial to repopulate the area with native plants before any invasive species can recolonize the area. The turions of curly leaf pondweed can be problematic in this manner. Even if control is acquired through benthic barriers, the turions can persist unless the barriers remain installed long term and are properly maintained.

Mechanical harvesting is another option for curly leaf pondweed, but this type of control method can promote the spread of turions and fragments. If harvesting is to be implemented to control water chestnut as discussed in **Section 5.3.2.2**, curly leaf pondweed will also be a bycatch product in the effort.

5.3.3.3 Control Methods: Herbicide Application

The basics of these methods are outlined in **Section 5.3.1.2**.

Herbicide application is probably the most common method used for control since there are several active ingredients that are effective at controlling curly leaf pondweed. Those active ingredients include diquat, endothall, flumioxazin, fluridone, penoxsulam, bispyribac, and imazamox. Diquat, endothall, and flumioxazin are contact herbicides and act rapidly while the others are systemic that can require longer contact periods (Gettys et al. 2014). Any active ingredient selected must abide by local and state regulations and/or permit conditions as identified by the applicator and other entities involved.

If herbicide applications are used to control curly leaf pondweed, using different active ingredients throughout the effort could be effective. Plants can often develop resistance to certain active ingredients over time and with repeated use. The application of herbicides to control curly leaf pondweed in early spring is optimal because desirable native plants are not actively growing yet (Gettys et al. 2014). It can also prevent turion regeneration and should lead to a reduction in biomass the following year. However, it is vital that the effort be continued for at least 5 years to ensure that no regeneration has occurred from turions left in the seed bank.

5.3.4 Invasive Species of Concern - Purple Loosestrife

5.3.4.1 Plant Ecology

Purple loosestrife is a prohibited plant in New York (NYSDEC and NYSDAM 2014). It is an invasive emergent perennial plant native to Europe introduced in the early 1800's for ornamental value. This herbaceous plant prefers moist soils and can be found along freshwater shorelines, growing in standing water, and more commonly in roadside ditches. Purple loosestrife can grow as tall as 10 feet high and possesses a large root ball, which makes the plant quite hardy. Purple loosestrife leaves are less than an inch wide and can grow as long as 4 inches. The leaves are opposite and arranged in whorls. The plant has a square stem and hairs along the stem and leaves, which can assist in identification. Purple loosestrife has showy purple flowers arranged on flower spikes that bloom from early July to September, and then go to seed. Each plant can produce up to 3 million seeds per year, which are easily distributed through water or can hitchhike on animals (Gettys et al. 2014).

The seeds of purple loosestrife serve as the main means of reproduction because they are produced in very high numbers, have a relatively high survivability, and can be spread through a multitude of methods. Since purple loosestrife flowers earlier than most native wildflowers, bees and other pollinators are selectively attracted to this plant and will cross pollinate loosestrife plants before many native species have a chance to flower. Purple loosestrife can colonize disturbed and vulnerable areas at a rapid rate due to its seed production and lack of competitors. This species can also alter the chemical parameters of a wetland or lake. The leaves break down quickly after falling in autumn, unlike native species which have leaves that do not typically break down until the following spring. This variable timing can alter food web dynamics within an aquatic ecosystem. Purple loosestrife leaves are also high in tannins, which are acidic and can ultimately reduce the pH of a waterbody and can have a wide range of detrimental impacts. Further, purple loosestrife outcompetes native vegetation and can adversely impact wildlife. It provides little to no value as a food source for herbivores, it can block access to basking areas for turtles, and it outcompetes plant species that would otherwise provide quality habitat for several different birds and mammals (Gettys et al. 2014).

Purple loosestrife was abundant and dense throughout the shoreline of Black Lake and was competing with many other native beneficial emergent species. It was observed frequently near the mouth of the Oswegatchie River, often in moderate densities, but became denser and more frequent while moving south towards the Indian River. Purple loosestrife was also frequently observed on the shores of the numerous islands in Black Lake. Without management purple loosestrife can continue to dominate the emergent plant community on the shores of Black Lake.

5.3.4.2 Control Methods: Biological Control

Biological control is a method that involves introducing a native or non-native species to control an invasive species. The introduced species are thoroughly evaluated to ensure limited to no impacts on any native species. Biological controls are best applied on large populations of an invasive species where methods like herbicides or mechanical removal are not feasible. Biological control is a cost-effective option and the labor required is relatively low. However, results are variable and are reasonably dependent on biological conditions and interactions.

Purple loosestrife biological control agents are species that prey on the target species in its native range. There are currently four insects approved by the USDA for control of purple loosestrife that attack the plant through different methods: *Galerucella calmariensis and Garercucella pusilla* are two leaf feeding beetles, *Nanophyes marmoratus* is a flower feeding beetle, and *Hylobius transversovittatus* is a root-mining weevil. Since all these insects attack the plant in different manners, it is optimal to release a combination of leaf feeders, flower feeders, and root miners. The release of these insects has led to reductions in biomass of purple loosestrife populations of up to 95% (Gettys et al. 2014). Biological control species can usually be acquired through the local county Cornell Cooperative Extension program.

As mentioned above, biological controls are typically more effective with larger populations of a target invasive plant. The population of purple loosestrife found at Black Lake was large and persisted throughout much of the lake shoreline (**Figure 2C**). Purple loosestrife can be manually controlled by hand pulling or digging but there can be a high risk for seed dispersal and plant regrowth using these methods. Biocontrol methods may be beneficial and could provide sufficient management for Black Lake and the surrounding areas, especially considering how widespread the species is on the shoreline of the lake.

5.3.4.3 Control Methods: Herbicide Application

The basics of these methods are outlined in **Section 5.3.1.2**.

Herbicide applications for purple loosestrife provide an impactful method when populations are relatively small and feasible to control chemically. Active ingredients that can be used to control purple loosestrife include: 2,4-D, glyphosate, triclopyr, imazapyr, and imazamox; but it is important to consider collateral damage to any nearby desirable native plants when selecting an active ingredient (Gettys et al. 2014). Local and state regulations or permit conditions may also influence which active ingredient can be used for control. Annual applications are usually required to control the plant due to the hardy root ball and high fecundity of seeds produced. Treatments should be repeated over a multi-year period since one treatment will not control the seeds that might lie dormant in the seedbank. Due to the large population of purple loosestrife at Black Lake, herbicide application would not be an efficient or cost-effective method at controlling this highly invasive species. On a localized level and in smaller areas, herbicide applications could be a feasible control option.

5.3.5 Invasive Species of Concern - European Frogbit

5.3.5.1 Plant Ecology

European frogbit, a prohibited plant in New York (NYSDEC and NYSDAM 2014), is a free-floating aquatic plant that occasionally roots in shallow water. Like water chestnut, it forms a rosette but has tiny round shaped leaves generally under 2 inches long with a reddish underside (**Appendix E, Photo 35**). European frogbit grows one white flower with a yellow middle that blooms most of the summer (**Appendix E, Photo 36**). This plant closely resembles native lilies like spatterdock or white-water lily but is much smaller in size and is free floating, unlike native lilies. Similar to our native lilies and other aquatic floating plants, European frogbit can only thrive in slow moving water such as secluded coves or bays and seems to share habitat with the state listed rare plant, water marigold (**Figures 2A & 2B**). Since European frogbit is a floating plant, it has a high chance of shading out desirable species where they share habitat. Additionally, this plant can spread via stem fragmentation which means that any type of boat disturbance can create additional plants. Like curly leaf pondweed, European frogbit possesses turions that fall off the plant in autumn, go dormant, and then in early spring float to the surface to begin their growth. Proliferation of this plant can occur rapidly once introduced. One plant can create up to 150 turions in a single season (Jacono and Berent 2022).

Due to the habitat limitations of European frogbit and that it needs slower moving waters, the chance for this plant to become truly dominant throughout all Black Lake is relatively low. However, there are many coves and bays that are wetland habitats in which this plant can thrive. For example, it was found frequently in the area east of Big Island and north of Rollway Bay (**Figure 2B**). Otherwise it was not observed all that frequently but was observed from the northern end near the Oswegatchie River to the southern end by Mile Arm Bay.

5.3.5.2 Control Methods: Hand Pulling

The basics of this method are outlined in **Section 5.3.2.2**.

Since there were no dense or higher observations of European frogbit during the survey (**Figure 2B**), hand pulling is an appropriate method for management in Black Lake. Hand pulling of this species offers high selectivity and control on a single season scale due to the production of turions by plants of previous years. If hand pulling is the only method used at Black Lake, it is one that would need to occur for approximately 5 years to be sure that any remaining turions do not lead to new populations. European frogbit populations were widespread throughout the lake, stretching from one end to the other, but were not dense or very dense in any one spot. Hand pulling is a labor-intensive effort that would require a decent sized field crew (approximately 10 people) to perform. However, since European frogbit and water chestnut prefer very similar habitats, hand pulling would allow for the concurrent monitoring for water chestnut. Monitoring of water chestnut is paramount in eliminating the considerable threat to Blake Lake should this plant establish.

5.3.5.3 Control Methods: Herbicide Application

The basics of this method are outlined in **Section 5.3.1.2**.

Populations of European frogbit within Black Lake aren't quite at levels yet that would require herbicide applications but if applications are made targeting EWM, European frogbit can also be targeted since they share common herbicides that are effective at control. Although, EWM tends to be in deep water open habitats when compared to the slower moving coves or wetland habitats preferred by European frogbit. There is limited data about confirmed herbicides for European frogbit and most labels do not include it as a target species. However, herbicides including endothall, diquat, triclopyr, 2,4-D, imazamox, imazapyr, penoxsulam, and flumioxazin have shown evidence at effectively controlling European frogbit in preliminary research (Cahill et al. 2001). Additionally, florpyrauxifen-benzyl has shown evidence of being effective controlling European frogbit in New York state (NYSDEC 2021). European frogbit and EWM share triclopyr, florpyrauxifen-benzyl, diquat, 2,4-D, and endothall as active ingredients effective at control.

6. Recommended Goals and Tasks

6.1 Short Term (2022-2023)

- Create a stakeholder committee with representatives from St. Lawrence County, the COC, BLA, FGC, and any others deemed appropriate. Continue searching for grant funding on the local, state, and federal level using said committee with representatives from each stakeholder group. The main function of the committee is to work together and give each entity a voice to achieve the overarching goal of preserving Black Lake.
    - In addition to a stakeholder committee, a Technical Advisory Committee (TAC) should be formed with select representatives from stakeholder groups, government sector employees, university professors, and/or independent consultants to make any future unbiased informed decisions regarding the management of Black Lake.
- Stakeholders of Black Lake should continue working with the Department of Health and St. Lawrence County staff to catalog and determine age and usage of septic systems.
- Explore developing a seed fund to help defer costs of septic system replacement for property owners around the lake and in the watershed. The fund would function as a reimbursement program where the host organization could pay for a portion of the inspection, repair, or replacement of faulty septic systems.
- A TMDL is being conducted by NYSDEC as of this document being published. Upon completion of the TMDL, stakeholders can attempt to obtain funding for watershed and nutrient management to focus efforts and prioritize areas of concerning nutrient impacts. Expected completion of the TMDL is mid-2023.
- Begin tracking the water level of Black Lake to inform future management operations.
- Coordinate with the SLELO PRISM to provide assistance and support if a new AIS is found and guide stakeholders on EDRR practices to prevent further infestation of select AIS like water chestnut.
- Continue harvesting of EWM to maintain navigable channels for recreation.
- Begin discussing an approach on herbicide applications in the lake to control EWM. If residents are uneasy about herbicide applications, start with a pilot treatment area to

demonstrate the effectives of their use and limited negative impacts when used properly. Questions to consider when selecting herbicide contractors:

  - What time of year will the application be conducted and how many treatment days do you anticipate?
  - Will pesticide signs be displayed around the lake and notifications sent out to the necessary residents?
  - How many crew members will be completing the job?
  - Have you read this management plan and are willing to comply with suggested ISPZs to preserve aquatic plant communities with high diversity and ecologically important species?
  - When do you plan on beginning the permitting process with NYSDEC?
  - Consider if the candidates have experience in treating lakes in this area and of this size, have treated lakes with similar AIS and issues, and/or their location and support staff/equipment.

- Using a similar pilot treatment area approach, use a copper or peroxide-based algaecide to treat HABs.
- Repeat aquatic plant survey to assess the effectiveness of herbicide treatments and other aquatic plant management techniques. Surveying should be done on a semiannual basis which should inform the success of failure of implemented management actions.
- Establish attainable and realistic goals or objectives for EWM management. For example, following the implementation of management activities for EWM and a follow up aquatic plant survey, reduce the number of ‘dense’ and ‘very dense’ sample sites by 10%. In 2022 there were 213 such sites making the goal 192 sites.
- Create an email listserv, mobile app, or similar notification system to alert camp owners, nearby residents, and other stakeholders about any HABs occurring in Black Lake.

6.2 Mid Term (2024-2028)

- Continue and expand on all short-term goals and tasks.
- Create a database or compile all historical data on Black Lake from CSLAP, management documents, NYS Lake Classification Inventory (LCI), and the

NYSDEC regional fisheries unit. The database as well as future data will provide long term trends of Black Lake water quality.

- With a TMDL completed by NYSDEC, explore options for EPA 319 funding.
- Expand herbicide treatments from the pilot treatment area.
- Establish attainable and realistic goals or objectives for EWM management. For example, following additional implementation of management activities for EWM and completing a follow up aquatic plant survey, reduce the number of ‘dense’ and ‘very dense’ sample sites by 25% (goal is 160 sites).
- Survey ISPZs to assess aquatic plant community and determine presence of critical natives or expansion of any AIS.
- Host a Black Lake summit meeting inviting stakeholders to attend an event discussing management efforts and collect public feedback.
- Conduct a bathymetric map survey in late fall when plant biomass has decreased to create an accurate bathymetric map of the lake which will inform additional management decisions.
- Research and develop a strategy to install a water level logger near the Route 58 bridge and long-term water quality data monitoring stations at a pre-determined location.
- Develop best management practice incentives for agricultural properties within the one-mile buffer of Black Lake.
- Develop a list of areas with poor stormwater and erosion control practices around the lake shoreline to create a priority project list for watershed improvements.

6.3 Long Term (2028 and Beyond)

- Continue and expand on all short and mid-term goals and tasks.
- From 2022, have 50% of defunct septic systems inspected repaired, or replaced within the one-mile buffer of the Black Lake shoreline.
- Install a long-term water quality data monitoring station and water level logger.
- Investigate university partnerships to encourage more management-based research on Black Lake. Universities can provide a unique opportunity to collect a significant amount of data and observations on a relatively reasonable budget.

- Repeat the full-lake aquatic plant survey completed as part of the field work done by GEI and NEAR to assess the long-term effectiveness and changes of aquatic plant management techniques. Establish attainable and realistic goals or objectives for EWM management. For example, as a benchmark goal, aim to reduce the number of 'dense' and 'very dense' sample sites between 25 to 50% (goal is more than 106 sites).

7. Conclusion

Despite the substantial population of EWM and other AIS in Black Lake, dedicated long term management of the aquatic plant community can lead to desirable results. While eradication may not be feasible, the possibility of reaching a balanced aquatic plant community and ecological state still exists. Prevention has and most likely will always be the best form of invasive species management and is the most cost effective. While the invasive species observed throughout this project are past that point, the prevention of any new invaders like water chestnut, is also paramount to maintaining an ecological balance and overall desirable state of Black Lake for aesthetics, recreation, and the economic benefit the lake provides.

Funding opportunities for invasive species management projects are becoming more available as invasive species control becomes more of a forefront issue. The NYSDEC and PRISM network have dedicated funds to the effort in the past few years and may provide opportunity for future funding. Pursuing grant funding and utilizing a volunteer network to carry out management and monitoring efforts will aid in achieving the goals desired by the stakeholders of Black Lake that are detailed in this document. There are also programs that are funded through St. Lawrence County to inspect and replace faulty septic systems. Other avenues to pursue include grants through NEIWPCC, the IRLC, or St. Lawrence River watershed opportunities. Establishing a long-term monitoring station in the lake would also provide live real time data that can help to inform management decisions.

Natural resource management is an ongoing process that changes with new environmental conditions, technologies, and/or regulations. Ecosystems are ever-changing, and it is important to remain adaptive to emerging management strategies that may not be outlined in this document. The state of Black Lake will not be remedied with a quick fix and will require coordination, cooperation, and commitment from all stakeholders involved. Successful lake management requires active collaboration and communication between all stakeholders which should be remembered when implementing any management strategies. The strategies outlined in this plan will address select issues that put the lake in peril. Over time these issues may change, become more severe, or disappear entirely. Establishing realistic and feasible goals and achieving those goals with a short term and long-term approach will make the management of Black Lake to a desired state attainable.

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