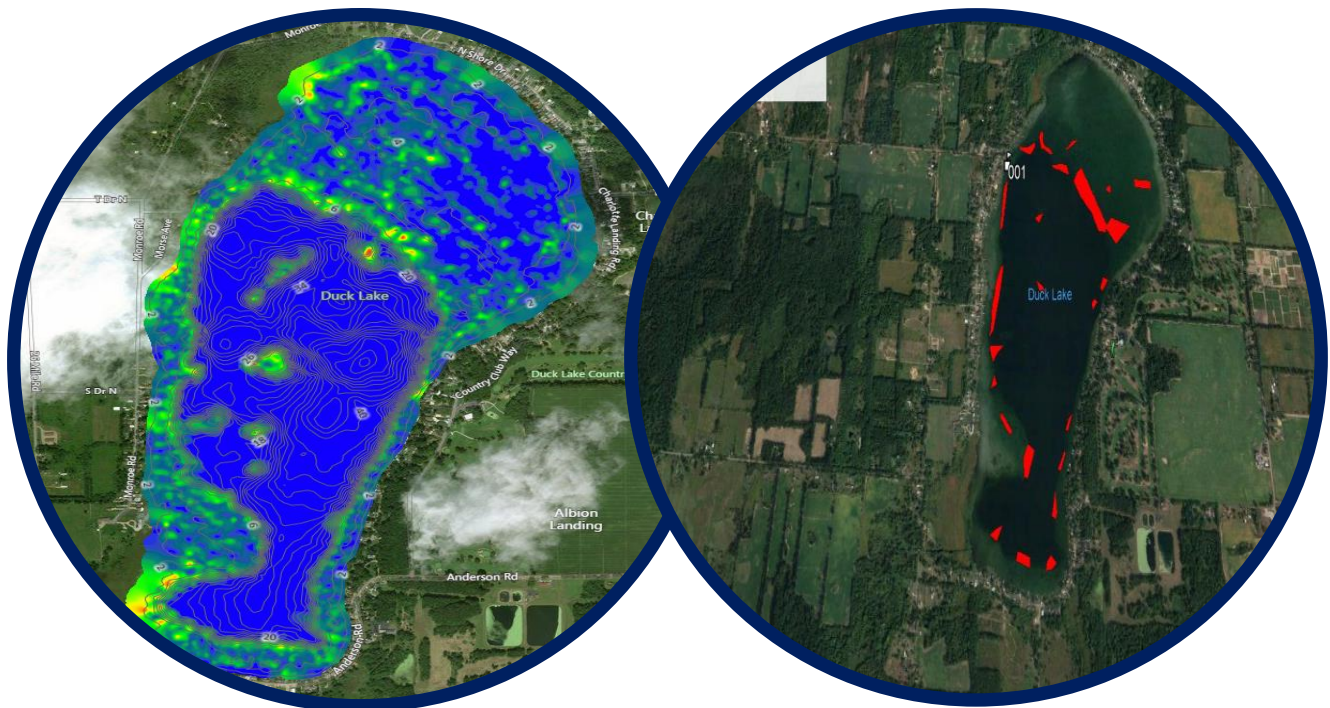


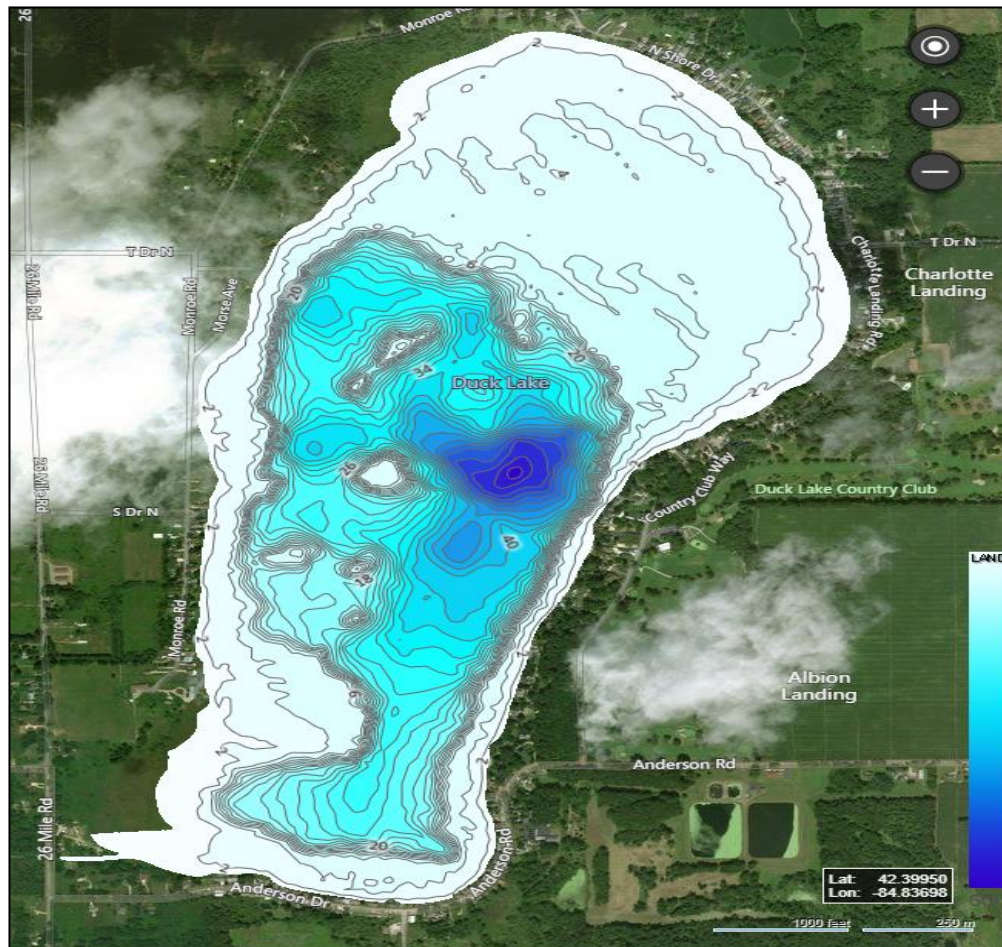


Duck Lake 2020 Aquatic Vegetation, Water Quality, and 2021 Management Recommendations Report



October 2020

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***The following information is a summary of
key lake findings collected during 2020.***

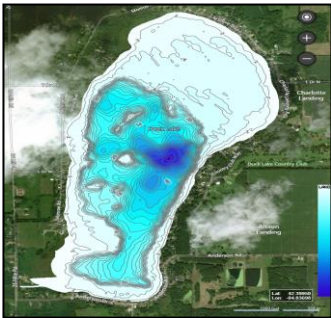
The overall condition of Duck Lake is ranked in the top 20% of developed lakes of similar size in the state of Michigan as measured in the fall of 2020. The water clarity ranged from 15.5-22.0 feet in 2020 which is excellent. Some of this clarity is due to filtration of the water by Zebra Mussels but it may decline during years when heavy spring rains create added runoff and contribute nutrients for planktonic algae in the water column. The lake has enough nutrients (phosphorus and nitrogen) to support some algae and submersed aquatic plant growth, but the nutrient levels are considered moderate and are only elevated in the spring and summer.

Invasive species such as Eurasian Watermilfoil (EWM) are able to grow in moderate nutrient waters and thus are a challenge to the Duck Lake ecosystem. In 2020, there was a seedbank re-emergence of EWM that necessitated a large treatment. The post-treatment survey in August demonstrated excellent control of the EWM. Another survey in the spring of 2021 will be needed to determine if any EWM survived winter ice cover and would require treatment. Treatment of the EWM in the canal may also be recommended. Protection of the 25 native aquatic plant species is paramount for the health of the lake fishery and these plants should not be managed unless they are a nuisance to lakefront property owners and possess navigational and recreational hazards (i.e. lily pads).

The lake was sampled on August 4, 2020. It was stratified and the dissolved oxygen was plentiful at the surface and mid-depth with marked depletion near the lake bottom. Increased loss of dissolved oxygen at the lake bottom were due to increased sediment bacteria respiration with decaying EWM biomass. In addition, the nutrients were quite low at the surface and mid-depth with an increase near the lake bottom. This is a normal event for large deep lakes with ample runoff. Chlorophyll-a concentrations were also moderately low and also correlate with the observed high water clarity throughout the season. Conductivity was moderate and the pH was ideal.

Duck Lake Water Quality Data (2020)

Water Quality Parameters Measured



There are hundreds of water quality parameters one can measure on an inland lake but several are the most critical indicators of lake health. These parameters include water temperature (measured in °F), dissolved oxygen (measured in mg/L), pH (measured in standard units-SU), conductivity (measured in micro-Siemens per centimeter- $\mu\text{S}/\text{cm}$), total dissolved solids (mg/L), Secchi transparency (feet), total phosphorus and total nitrogen (both in mg/L), chlorophyll-*a* (in $\mu\text{g}/\text{L}$), and algal species composition. Water quality was measured in the deep basin of Duck Lake on August 4, 2020.

Table 1 below demonstrates how lakes are classified based on key parameters. Duck Lake would be considered mesotrophic (relatively productive) since it does contain ample phosphorus, nitrogen, and aquatic vegetation growth but has good water clarity and moderate algal growth. 2020 water quality data for Duck Lake is shown below in Table 2.

Table 1. Lake trophic classification (MDNR).

<i>Lake Trophic Status</i>	<i>Total Phosphorus ($\mu\text{g L}^{-1}$)</i>	<i>Chlorophyll-<i>a</i> ($\mu\text{g L}^{-1}$)</i>	<i>Secchi Transparency (feet)</i>
Oligotrophic	< 10.0	< 2.2	> 15.0
Mesotrophic	10.0 – 20.0	2.2 – 6.0	7.5 – 15.0
Eutrophic	> 20.0	> 6.0	< 7.5

Table 2. Duck Lake water quality parameter data collected in the deep basin (August 4, 2020).

<i>Depth (m)</i>	<i>Water Temp °C</i>	<i>DO mg/l</i>	<i>pH S.U.</i>	<i>Cond. µS cm⁻¹</i>	<i>Turb. NTU</i>	<i>Total Kjeldahl Nitrogen mg/l</i>	<i>TP mg/l</i>	<i>TSS mg/l</i>
0	24.2	8.2	8.7	323	0.7	<0.5	0.010	<10
3	24.1	8.2	8.7	322	0.7	--	--	--
6	18.8	6.6	7.8	365	0.7	--	--	--
9	12.5	1.8	7.7	375	0.7	<0.5	0.020	<10
12	10.8	0.1	7.7	383	0.9	--	--	--
15	10.6	0.1	7.6	392	1.4	--	--	--
16	9.9	0.1	7.6	392	2.2	1.0	0.060	<10

Water Clarity (Transparency) Data

Secchi transparency is a measure of water clarity using a weighted disk with black and white markings. The depth is recorded as a mean of the depth at which the disk disappears and reappears. Elevated Secchi transparency readings allow for more aquatic plant and algae growth. The transparency throughout Duck Lake was adequate in 2020 (15.5-22.0 feet; RLS data) to allow abundant growth of algae and aquatic plants in the majority of the littoral zone of the lake. Secchi transparency depends on the amount of suspended particles in the water (often due to windy conditions of lake water mixing) and the amount of sunlight present at the time of measurement. Other parameters such as turbidity (measured in NTU's) are correlated with water clarity and show an increase as clarity decreases. The turbidity and total dissolved solids in Duck Lake were quite low at ≤ 2.2 NTU's and ≤ 94 mg L⁻¹, respectively during the 2020 sampling event.

Total Phosphorus

Total phosphorus (TP) is a measure of the amount of phosphorus (P) present in the water column. Phosphorus is the primary nutrient necessary for abundant algae and aquatic plant growth. TP concentrations are usually higher at increased depths due to higher release rates of P from lake sediments under low oxygen (anoxic) conditions and due to mineralization.

Phosphorus may also be released from sediments as pH increases. In summer, the dissolved oxygen levels are lower at the bottom and likely cause release of phosphorus from the bottom. TP concentrations ranged from $\leq 0.010 \text{ mg L}^{-1}$ at the surface to 0.060 mg L^{-1} at the bottom during the August sampling event.

pH

Most Michigan lakes have pH values that range from 6.5 to 9.5 with typical being slightly basic ($\text{pH} > 7.0$). Acidic lakes ($\text{pH} < 7$) are rare in Michigan and are most sensitive to inputs of acidic substances due to a low acid neutralizing capacity (ANC). Duck Lake is considered “slightly basic” on the pH scale. The pH of Duck Lake ranged from 7.6-8.7 S.U. which is ideal for an inland lake. pH is usually lower at the lake bottom and can increase when aquatic vegetation is actively growing due to photosynthesis. The lower pH observed near the lake bottom was likely due to increased respiration by sediment bacteria to decompose dying, treated EWM.

Conductivity

Conductivity is a measure of the amount of mineral ions present in the water, especially those of salts and other dissolved inorganic substances. Conductivity generally increases as the amount of dissolved minerals and salts in a lake increases, and also increases as water temperature increases. The conductivity values for Duck Lake were moderate and ranged from 322-392 $\mu\text{S/cm}$ which is within a similar range of previous years. Severe water quality impairments in freshwater lakes do not occur until values exceed 800 $\mu\text{S/cm}$ and are toxic to aquatic life around 1,000 $\mu\text{S/cm}$.

Chlorophyll-*a* and Algal Species Composition

Chlorophyll-*a* is the primary photosynthetic pigment found in all plants and algae. Chlorophyll-*a* is a measure of the amount of green plant pigment present in the water, often in the form of planktonic algae. High chlorophyll-*a* concentrations are indicative of nutrient-enriched lakes. Chlorophyll-*a* concentrations greater than $6 \mu\text{g L}^{-1}$ are found in eutrophic or nutrient-enriched aquatic systems, whereas chlorophyll-*a* concentrations less than $2.2 \mu\text{g/L}$ are found in nutrient-poor or oligotrophic lakes. The mean chlorophyll-*a* concentrations in August of 2020 in Duck Lake were around $2.0 \mu\text{g/L}$ which is low for an inland Michigan lake and typical in the fall. These measurements were collected using a calibrated Turner Designs *in situ* fluorimeter. A localized algal bloom occurred in many nearshore areas during the summer due to increased runoff and associated nutrients. It was determined to be non-toxic, green, filamentous algae.



The algal genera were determined from composite water samples collected over the deep basin of Duck Lake in 2020 were analyzed with a Zeiss® compound bright field microscope. The genera present included the Chlorophyta (green algae): *Scenedesmus* sp., *Rhizoclonium* sp., *Cladophora* sp., *Chlorella* sp., *Mougeotia* sp., *Spirogyra* sp., and *Chloromonas* sp. The Cyanophyta (blue-green algae): *Gleocapsa* sp., the Bascillariophyta (diatoms; Figure 3): *Synedra* sp., *Navicula* sp., *Fragilaria* sp., and *Tabellaria* sp. The aforementioned species indicate a diverse algal flora and represent a good diversity of alga with an abundance of diatoms that are indicative of great water quality. Some photos of the aforementioned algae found in the lake are shown here:



***Scenedesmus*-A Green Algae**



***Spirogyra*-A Green Algae**



***Oscillatoria*-A Blue-Green Algae**



***Synedra*-a Diatom**

Aquatic Vegetation Data (2020)

Status of Native Aquatic Vegetation in Duck Lake

Native aquatic vegetation is essential for the overall health of the lake and the support of the lake fishery. The whole-lake aquatic vegetation survey on June 3, 2020 determined that there were a total of 24 native aquatic plant species. These include 14 submersed species, 4 floating-leaved species, and 6 emergent species. The most common native aquatic plant species in 2020 included Sago Pondweed (Figure 1) and Illinois Pondweed. Figure 2 demonstrates a scan of the entire lake bottom conducted by RLS on June 3, 2020 and shows the aquatic vegetation biovolume. The current layout of aquatic vegetation biovolume is ideal, especially for a large lake.

This indicates a very high biodiversity of aquatic vegetation in Duck Lake. This means that there are a lot of different aquatic plants that serve varying functions in the ecology of Duck Lake. The overall percent cover of the lake by native aquatic plants is low relative to the lake size due to the great mean depth and thus these plants should be protected unless growing near swim areas at nuisance levels. A list of all current native aquatic plant species is shown below in Table 3.



Figure 1. Sago Pondweed

Table 3. Duck Lake Native Aquatic Plant Species and Relative Abundance (June 3, 2020).

<i>Native Aquatic Plant Species Name</i>	<i>Aquatic Plant Common Name</i>	<i>Abundance in/around Duck Lake</i>	<i>Aquatic Plant Growth Habit</i>
<i>Chara vulgaris</i>	Muskgrass	10.9	Submersed, Rooted
<i>Potamogeton pectinatus</i>	Thin leaf (Sago) Pondweed	15.2	Submersed, Rooted
<i>Potamogeton zosteriformis</i>	Flatstem Pondweed	1.2	Submersed, Rooted
<i>Potamogeton amplifolius</i>	Large-leaf Pondweed	0.2	Submersed, Rooted
<i>Potamogeton gramineus</i>	Variable-leaf Pondweed	2.6	Submersed, Rooted
<i>Potamogeton praelongus</i>	White-stem Pondweed	0.2	Submersed, Rooted
<i>Potamogeton pusillus</i>	Small-leaf Pondweed	2.6	Submersed, Rooted
<i>Zosterella dubia</i>	Water Stargrass	0.1	Submersed, Rooted
<i>Potamogeton illinoensis</i>	Illinois Pondweed	14.2	Submersed, Rooted
<i>Vallisneria americana</i>	Wild Celery	13.5	Submersed, Rooted
<i>Myriophyllum verticillatum</i>	Whorled Watermilfoil	4.5	Submersed, Rooted
<i>Ceratophyllum demersum</i>	Coontail	0.1	Submersed, Non-Rooted
<i>Utricularia vulgaris</i>	Bladderwort	0.9	Submersed, Non-Rooted
<i>Najas guadalupensis</i>	Southern Naiad	2.4	Submersed, Rooted
<i>Nymphaea odorata</i>	White Waterlily	0.6	Floating-Leaved, Rooted
<i>Nuphar variegata</i>	Yellow Waterlily	4.4	Floating-Leaved, Rooted
<i>Lemna minor</i>	Duckweed	0.1	Floating-Leaved, non-rooted
<i>Azolla</i> sp.	Watermeal	0.2	Floating-Leaved, non-rooted
<i>Typha latifolia</i>	Cattails	13.5	Emergent
<i>Scirpus acutus</i>	Bulrushes	6.6	Emergent
<i>Sagittaria</i> sp.	Arrowhead	0.6	Emergent
<i>Pontedaria cordata</i>	Pickerelweed	3.9	Emergent
<i>Decodon verticillatus</i>	Swamp Loosestrife	10.8	Emergent
<i>Iris</i> sp.	Iris	0.6	Emergent

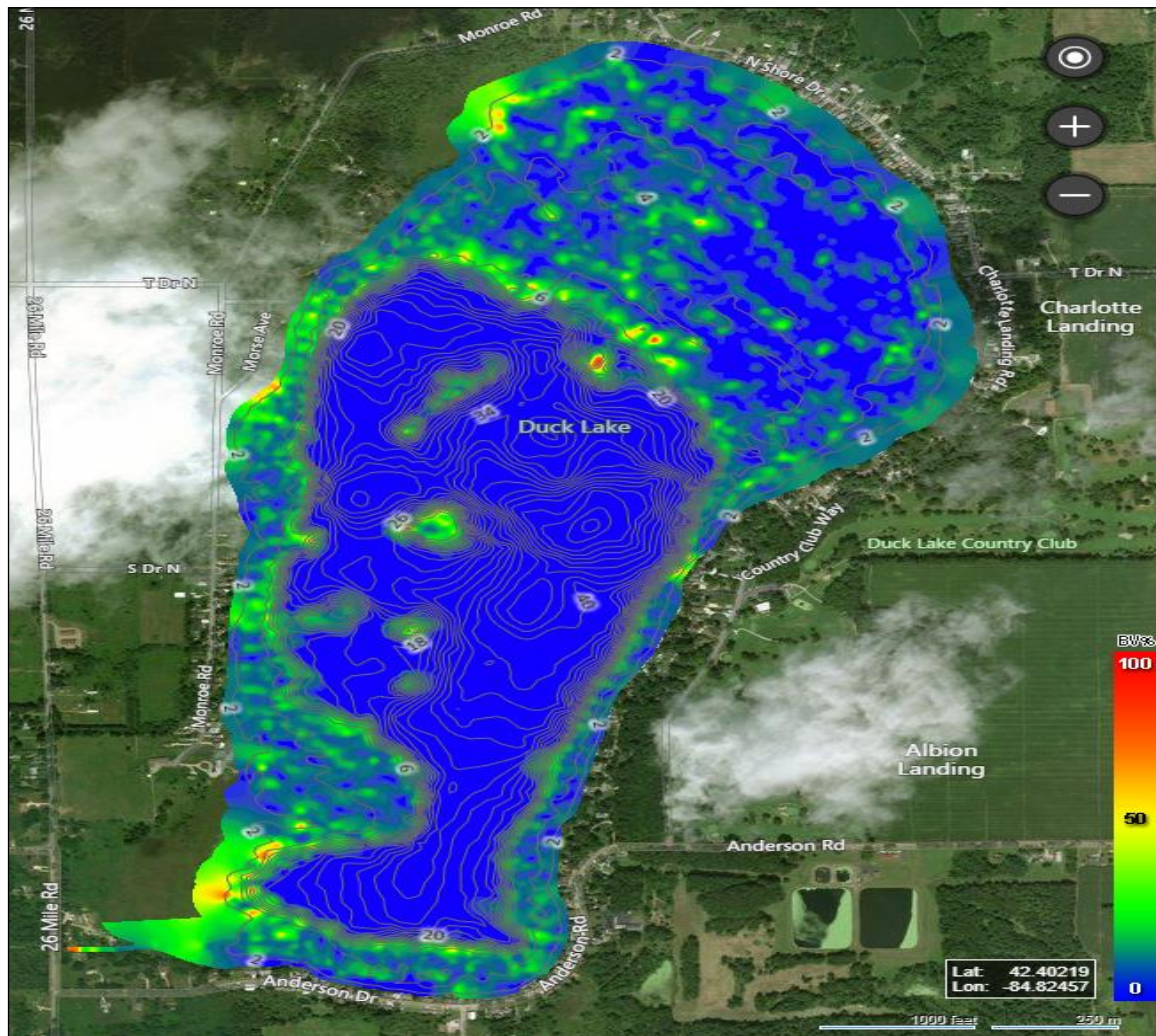


Figure 2. Aquatic vegetation biovolume scan of Duck Lake on June 3, 2020. The blue areas denote a lack of aquatic vegetation. The green areas denote low-lying aquatic plants, and the red and yellow areas denote high-growing aquatic plants.

Status of Invasive (Exotic) Aquatic Vegetation in Duck Lake

Eurasian Watermilfoil (EWM) is an invasive, submersed aquatic plant (Figure 3) that spreads through fragmentation, seed dispersal, and underground stolons. A lake management plan study conducted by RLS in 2015 found that approximately 30 acres infested the lake.

The amount of EWM present in Duck Lake varies each year and is dependent upon climatic conditions, especially runoff-associated nutrients. The June 3, 2020 survey revealed approximately 26 acres of milfoil and 14.8 acres of Curly-leaf Pondweed (Figure 4) in the lake. RLS was present on June 10, 2020 to oversee the treatment with the systemic herbicide Sculpin G. Due to elevated winds on the day of treatment, the treatment was continued on June 16, 2020. RLS inventoried the lake on August 4, 2020 and determined the treatment was very successful. An EWM treatment may also be needed for the canal in 2021 due to low-lying EWM.



Figure 3. Eurasian Watermilfoil



Figure 4. Curly-leaf Pondweed

Management Recommendations for 2021

Continuous aquatic vegetation surveys are needed to determine the precise locations of EWM, Curly-leaf Pondweed (CLP), or other problematic invasives in and around Duck Lake. Protection of the native aquatic plant species in Duck Lake is encouraged. These surveys should occur in late-May to early-June and again post-treatment in 2021.

Due to the great overall depths of Duck Lake and limited areas with native aquatic vegetation in Duck Lake, the treatment of these species with aquatic herbicides is not recommended. Herbicide treatments can be conducted later as well if the EWM is in deeper waters and not a threat to fragmentation. The plan for 2020 includes whole-lake surveys and the use of high dose systemic aquatic herbicides for effective Eurasian Watermilfoil control if EWM is present in the lake and canal. Invasive Curly-leaf Pondweed will respond well to Aquathol-K® at 2-3 gallons per acre if found but should only be treated in dense areas since it naturally dies back in mid to late summer. As in previous years, RLS will be present to oversee the lake herbicide treatments.

Water quality parameters in the lake will also be monitored in 2021 and given in the annual report.

In conclusion, Duck Lake is a healthy lake with excellent aquatic plant biodiversity, high water clarity, moderate/high nutrients (depending on depth and season as these are lower in fall), and a healthy lake fishery. Management of the EWM, Curly-leaf Pondweed and protection of the water quality are paramount for the long-term health of the lake.

Glossary of Scientific Terms used in this Report

- 1) Biodiversity- The relative abundance or amount of unique and different biological life forms found in a given aquatic ecosystem. A more diverse ecosystem will have many different life forms such as species.
- 2) CaCO₃- The molecular acronym for calcium carbonate; also referred to as “marl” or mineral sediment content.
- 3) Eutrophic- Meaning “nutrient-rich” refers to a lake condition that consists of high nutrients in the water column, low water clarity, and an over-abundance of algae and aquatic plants.
- 4) Mesotrophic- Meaning “moderate nutrients” refers to a lake with a moderate quantity of nutrients that allows the lake to have some eutrophic qualities while still having some nutrient-poor characteristics
- 5) Oligotrophic- Meaning “low in nutrients or nutrient-poor” refers to a lake with minimal nutrients to allow for only scarce growth of aquatic plant and algae life. Also associated with very clear waters.