Restorative Lake Sciences™

Duck Lake 2021 Aquatic Vegetation, Water Quality, and 2022 Management Recommendations Report

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Section 1

Duck Lake 2021 Aquatic Vegetation, Water Quality, and 2022 Management Recommendations Report

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 late summer of 2021. The water clarity ranged from 15.5-22.0 feet in 2021 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 and at the lake bottom.

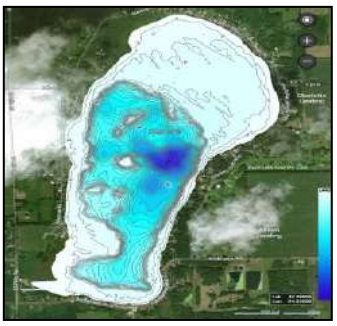
Invasive species such as Eurasian Watermilfoil (EWM) are able to grow in moderate nutrient waters and thus are a challenge to the Duck Lake ecosystem. In 2021, there was a seedbank re-emergence of EWM that necessitated a moderate-size treatment. The initial post-treatment survey in August demonstrated excellent control of the EWM. Another survey will be needed in the spring of 2022 to determine if any EWM survived winter ice cover and would require further treatment. RLS recommends use of the new systemic herbicide ProcellaCOR® in 2022 to reduce tolerance of the EWM with triclopyr and 2,4-D. Treatment of the EWM in the canal may also be recommended. Protection of the twenty-five 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 June 13, 2021. 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.

Section 2

Duck Lake Water Quality Data (2021)



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-µS/cm), total dissolved solids (mg/L), Secchi transparency (feet), total phosphorus and total nitrogen (both in mg/L), chlorophyll-*a* (in µg/L), and algal species composition. Water quality was measured in the deep basin of Duck Lake on June 13, 2021.

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. 2021 water quality data for Duck Lake is shown below in Table 2.

Table 1. Lake trophic classification (MDNR).

Lake Trophic Status	*Total Phosphorus ($\mu g\ L^{-1}$)*	*Chlorophyll-a ($\mu g\ L^{-1}$)*	*Secchi Transparency (feet)*
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 (June 13, 2021).

Depth (m)	*Water Temp ºF*	*DO mg/l*	*pH S.U.*	*Cond. µS cm^{-1}*	*Turb. NTU*	*Total Kjeldahl Nitrogen mg/l*	*TP mg/l*	*TSS mg/l*
0	75.0	8.0	8.5	327	0.5	<0.5	0.010	<10
3	72.0	8.0	8.5	327	0.9	--	--	--
6	70.5	7.2	8.4	333	0.9	--	--	--
9	66.3	2.9	8.4	339	1.0	<0.5	0.030	<10
12	63.8	1.8	8.2	339	1.8	--	--	--
15	61.9	0.9	8.0	339	2.0	--	--	--
16	61.5	0.2	7.9	387	3.0	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 2021 (12-22.0 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 ≤3.0 NTU's and ≤ 98 mg L^{-1}, respectively during the 2021 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 ≤0.010 mg L^{-1} at the surface to 0.060 mg L^{-1} at the bottom during the June sampling event.

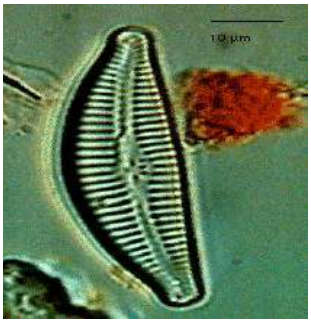
pH

Most Michigan lakes have pH values that range from 6.5 to 9.5 with typical being slightly basic (pH>7.0). Acidic lakes (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 7.9-8.5 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.

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 327-387 µS/cm which is within a similar range of previous years. Severe water quality impairments in freshwater lakes do not occur until values exceed 800 µS/cm and are toxic to aquatic life around 1,000 µS/cm.

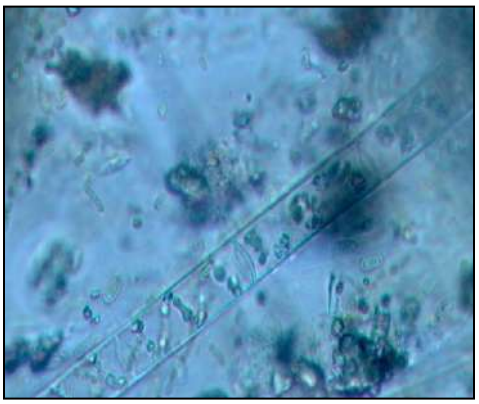
Chlorophyll-*a* and Algal Species Composition



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 µg L^{-1} are found in eutrophic or nutrient-enriched aquatic systems, whereas chlorophyll-*a* concentrations less than 2.2 µg/L are found in nutrient-poor or oligotrophic lakes. The mean chlorophyll-*a* concentrations in June of 2021 in Duck Lake were around 2.1 µg/L which is low for an inland Michigan lake and typical in the summer for the lake. These measurements were collected using a calibrated Turner Designs® *in situ* fluorimeter.

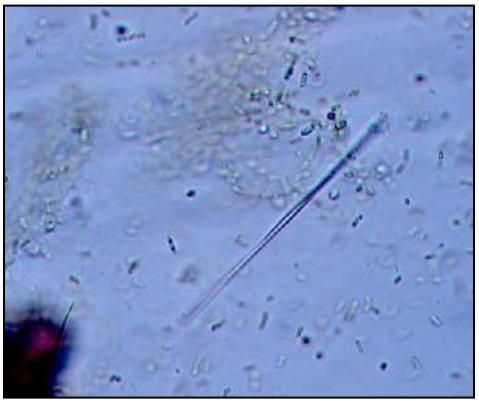
The algal genera were determined from composite water samples collected over the deep basin of Duck Lake in 2021 were analyzed with a Zeiss® compound bright field microscope. The genera present included the Chlorophyta (green algae): *Chlorella* sp., *Mougeotia* sp., *Scenedesmus* sp., *Rhizoclonium* sp., *Cladophora* sp., *Spirogyra* sp., and *Chloromonas* sp. The Cyanophyta (blue-green algae): G*leocapsa* sp., the Bascillariophyta (diatoms; Figure 3)*: Synedra* sp., *Navicula* sp., *Fragilaria* sp., and *Cymbella* 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**

O*scillatoria*-A Blue-Green Algae



***Synedra*-a Diatom**

Section

3

Aquatic Vegetation Data (2021)

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 13, 2021 determined that there were a total of twenty-four native aquatic plant species. These include fourteen submersed species, four floating-leaved species, and 6 emergent species. The most common native aquatic plant species in 2021 included Sago Pondweed (Figure 1) and Illinois Pondweed. The current biodiversity of aquatic vegetation in Duck Lake is ideal to support a healthy fishery.

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

Figure 2. Illinois Pondweed

Table 3. Duck Lake Native Aquatic Plant Species and Relative Abundance (June 13, 2021).

Native Aquatic Plant Species Name	***Aquatic Plant Common Name***	***Abundance in/around Duck Lake***	***Aquatic Plant Growth Habit***
Chara vulgaris	Muskgrass	12.8	Submersed, Rooted
Potamogeton pectinatus	Thin leaf (Sago) Pondweed	20.2	Submersed, Rooted
Potamogeton zosteriformis	Flatstem Pondweed	1.0	Submersed, Rooted
Potamogeton amplifolius	Large-leaf Pondweed	0.9	Submersed, Rooted
Potamogeton gramineus	Variable-leaf Pondweed	4.0	Submersed, Rooted
Potamogeton praelongus	White-stem Pondweed	0.1	Submersed, Rooted
Potamogeton pusillus	Small-leaf Pondweed	0.8	Submersed, Rooted
Zosterella dubia	Water Stargrass	5.5	Submersed, Rooted
Potamogeton illinoensis	Illinois Pondweed	9.9	Submersed, Rooted
Vallisneria americana	Wild Celery	18.7	Submersed, Rooted
Myriophyllum verticillatum	Whorled Watermilfoil	8.7	Submersed, Rooted
Ceratophyllum demersum	Coontail	0.2	Submersed, Non-Rooted
Utricularia vulgaris	Bladderwort	6.0	Submersed, Non-Rooted
Najas guadalupensis	Southern Naiad	2.9	Submersed, Rooted
Nymphaea odorata	White Waterlily	0.7	Floating-Leaved, Rooted
Nuphar variegata	Yellow Waterlily	4.1	Floating-Leaved, Rooted
Lemna minor	Duckweed	0.1	Floating-Leaved, non-rooted
Azolla sp.	Watermeal	0.1	Floating-Leaved, non-rooted
Typha latifolia	Cattails	12.5	Emergent
Scirpus acutus	Bulrushes	6.8	Emergent
Sagittaria sp.	Arrowhead	0.4	Emergent
Pontedaria cordata	Pickerelweed	4.5	Emergent
Decodon verticillatus	Swamp Loosestrife	10.0	Emergent
Iris sp.	Iris	0.5	Emergent

Status of Invasive (Exotic) Aquatic Vegetation in Duck Lake

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

The amount of EWM (Figure 3) or Curly-leaf Pondweed (Figure 4) present in Duck Lake varies each year and is dependent upon climatic conditions, especially runoff-associated nutrients. There are other aquatic plants that resemble invasive EWM, such as native Whorled watermilfoil (Figure 5) and even the rootless bladderwort (Figure 6).

The May 21, 2021 survey revealed approximately 6.6 acres of Curly-leaf Pondweed and 10.1 acres of EWM were present in the lake. The EWM was treated on June 8 with Sculpin G® a systemic herbicide at 240#/acre offshore and Renovate OTF®, a systemic herbicide at 200#/acre nearshore. Aquathol-K® was used to treat the CLP. An additional survey on July 13, 2021 by RLS determined that 5.0 acres of new EWM necessitate treatment. On July 21, 2021, that EWM was treated with Sculpin G® at a dose of 250#/acre. RLS was present to oversee the treatments. Due to the late season treatment and time needed for the EWM to assimilate the systemic herbicide, the EWM mortality will need to be evaluated in the spring of 2022 by RLS. Figures 7-8 show the distribution of these invasives during the 2021 season.

Figure 3. Eurasian Watermilfoil

Figure 4. Curly-leaf Pondweed

Figure 5. Whorled native watermilfoil in Duck Lake (May, 2021).

Figure 6. Eurasian watermilfoil with native Bladderwort in Duck Lake (May, 2021). Note: the EWM is on the bottom of the photo.

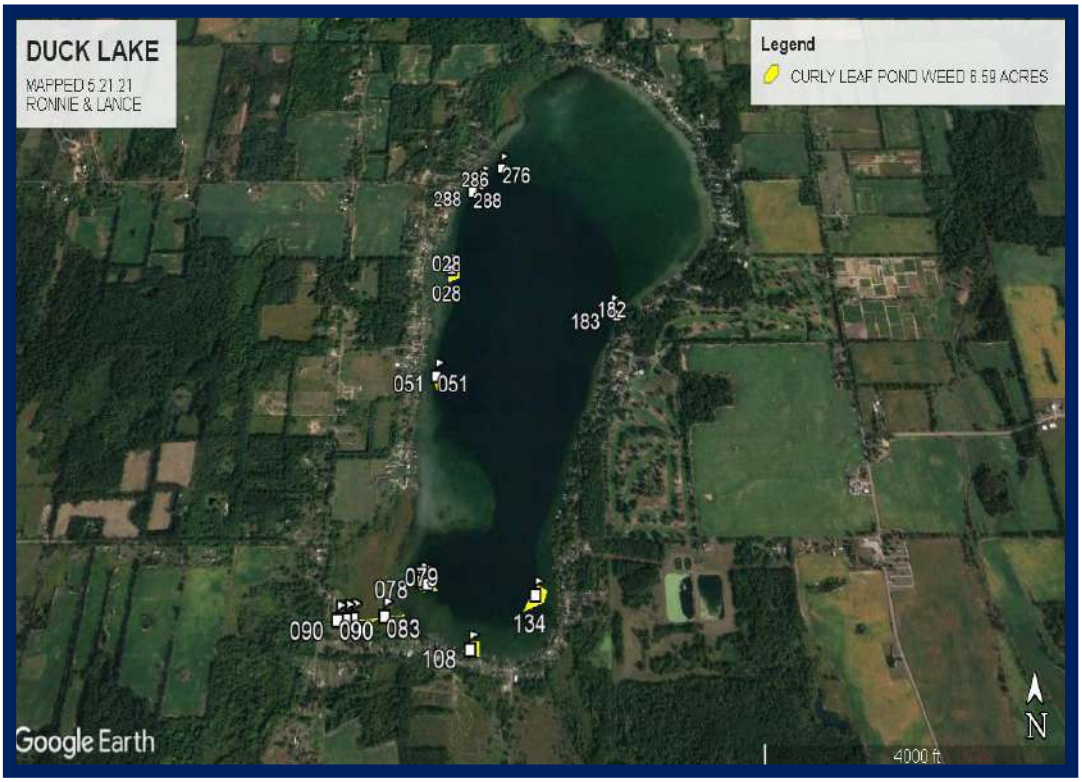


Figure 7. Distribution of CLP in Duck Lake (May 21, 2021).

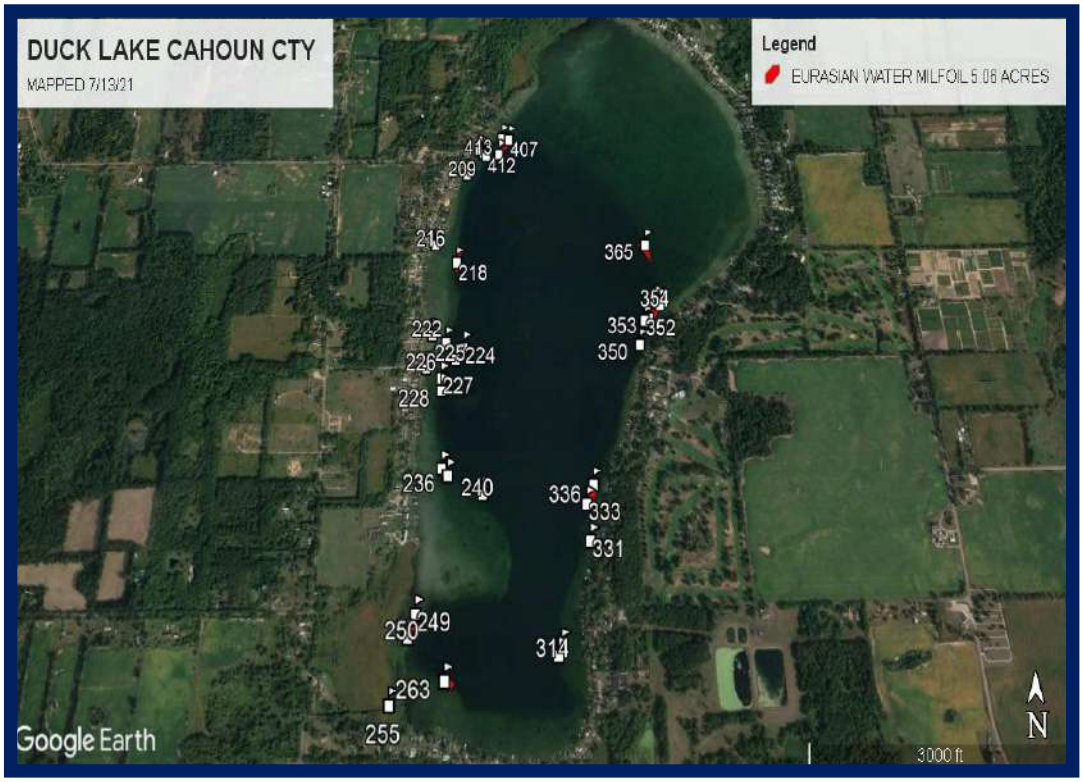


Figure 8. Distribution of EWM in Duck Lake (July 13, 2021).

Section 4

Management Recommendations for 2022

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 as these are critical for the lake fishery and health. These surveys should occur in late-May to early-June and again post-treatment in 2022.

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. The plan for 2022 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. To reduce the probability for tolerance of EWM for triclopyr or 2,4-D, RLS recommends use of ProcellaCOR® systemic herbicide with diquat for EWM control in 2022. Invasive Curly-leaf Pondweed will respond well to Aquathol-K® or diquat at 1-2 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 major lake herbicide treatments.

Water quality parameters in the lake will also be monitored in 2022 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) $CaCO_3$- 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.