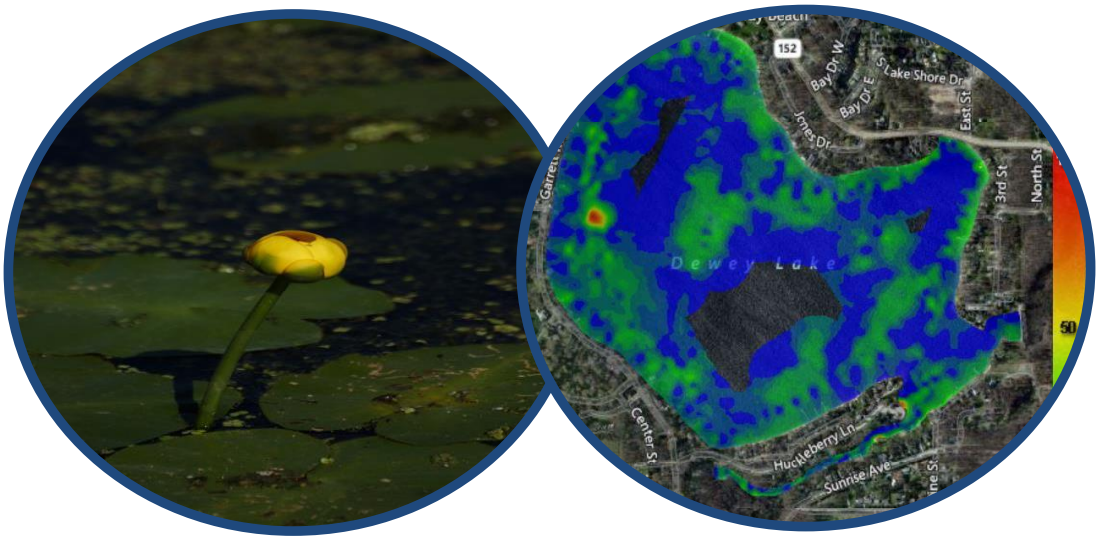
Restorative Lake Sciences™

Dewey Lake 2016 Aquatic Vegetation & Water Quality Report & 2017 Management Recommendations



October, 2016

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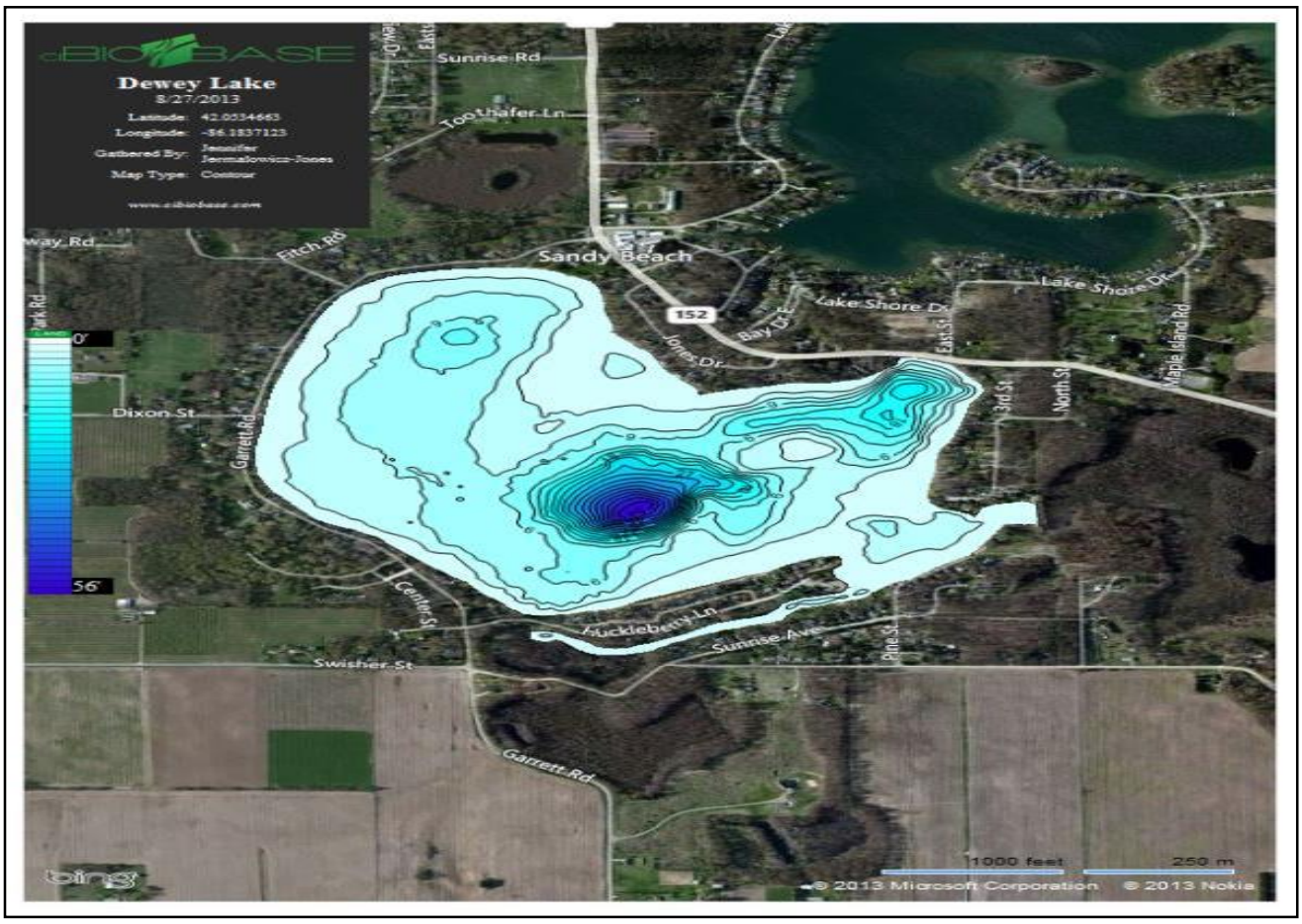

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1

Dewey Lake 2016 Aquatic Vegetation & Water Quality Report & 2017 Management Recommendations

The following information is a summary of key lake findings collected in 2016.

The overall condition of Dewey Lake is ranked in the top 25% of developed lakes of similar size in the state of Michigan. The water clarity in late summer of 2016 was around 12.0 feet which was favorable due to the high water temperatures that increased chlorophyll-a concentrations and conductivity. The majority of the clarity is due to coarse bottom sediment that does not create silty, turbid conditions when high wave or boat activity agitates the lake water. Additionally, 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 were slightly lower in 2016 than in 2015, presumably due to less runoff in the spring. Invasive species such as Eurasian Watermilfoil (EWM) and Curly-leaf Pondweed (CLP) are able to grow in moderate nutrient waters and thus are a challenge to the Dewey Lake ecosystem. Protection of the 22 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, White-stem Pondweed).

The lake experienced depletion of dissolved oxygen with depth in late August in the deepest basin but not in the shallower deep basin. Other parameters such as pH and alkalinity were consistent with previous years.

Section

2

Dewey Lake Water Quality Data (2016)

Dewey Lake Sediment Map

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 alkalinity or hardness (measured in mg of calcium carbonate per liter-mg $CaCO_3$/L), total dissolved solids (mg/L), secchi transparency (feet), total phosphorus and total nitrate nitrogen (both in µg/L), chlorophyll-*a* (in µg/L), and algal species composition. **Water quality was measured in the deep basins of Dewey Lake on August 31, 2016.** Table 1 below demonstrates how lakes are classified based on key parameters. **Dewey Lake would be considered mesotrophic (relatively productive) since it does contain ample phosphorus, nitrogen, and aquatic vegetation growth but has excellent water clarity and moderate algal growth.** 2016 water quality data for Dewey Lake is shown below in Tables 2-3.

Table 1. Lake trophic classification (MDNR).

Lake Trophic Status	*Total Phosphorus (µg L^{-1})*	*Chlorophyll-a (µg 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. Dewey Lake water quality parameter data collected in deep basin 1 (August 31, 2016).

Depth ft.	*Water Temp 'F*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Turb. NTU*	*ORP mV*	*Total Kjeldahl Nitrogen mg L^{-1}*	*Total Alk. mgL^{-1} $CaCO_3$*	*Total Phos. mg L^{-1}*
0	78.8	8.2	7.9	135	0.6	126.9	<0.5	34	<0.010
25	68.4	8.1	7.9	125	0.6	119.7	1.3	34	0.015
50	54.0	0.4	8.0	121	1.1	102.6	1.2	35	0.021

Table 3. Dewey Lake water quality parameter data collected in deep basin 2 (August 31, 2016).

Depth ft.	*Water Temp 'F*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Turb. NTU*	*ORP mV*	*Total Kjeldahl Nitrogen mg L^{-1}*	*Total Alk. mgL^{-1} $CaCO_3$*	*Total Phos. mg L^{-1}*
0	78.4	8.1	8.0	125	0.5	133.9	0.8	34	0.010
8	76.9	7.8	7.9	120	0.5	136.7	1.0	34	0.010
17	72.9	7.8	7.9	121	1.3	122.8	1.3	35	0.020

Water Clarity (Transparency) Data

Elevated Secchi transparency readings allow for more aquatic plant and algae growth. **The transparency throughout Dewey Lake in late August of 2016 was adequate (12.0 feet) to allow abundant growth of algae and aquatic plants in the majority of the littoral zone of the lake.** Secchi transparency is variable and 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) and Total Dissolved Solids (measured in mg/L) are correlated with water clarity and show an increase as clarity decreases. **The turbidity and total dissolved solids in Dewey Lake in late August were quite low at ≤1.3 NTU's and ≤50 mg/L, respectively.**

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. Phosphorus may also be released from sediments as pH increases. Fortunately, even though the TP levels in Dewey Lake are moderate, the dissolved oxygen levels are good enough at the bottom until later summer to not cause release of phosphorus from the bottom. **By late August, however, dissolved oxygen concentrations decline to around 0.4 mg L^{-1} at the bottom of the deepest basin and TP can be released from bottom sediments. TP concentrations ranged between <0.010-0.021 mg L^{-1} in late August of 2016.**

Total Alkalinity

Lakes with high alkalinity (> 150 mg L^{-1} of $CaCO_3$) are able to tolerate larger acid inputs with less change in water column pH. Many Michigan lakes contain high concentrations of $CaCO_3$ and are categorized as having "hard" water. Total alkalinity may change on a daily basis due to the re-suspension of sedimentary deposits in the water and respond to seasonal changes due to the cyclic turnover of the lake water. **The alkalinity of Dewey Lake has been very low and indicates a soft water lake system. The low alkalinity is one of the reasons why aquatic herbicides have worked so well on the nuisance aquatic plants in Dewey Lake as they are more effective in softer waters.**

pH

Most Michigan lakes have pH values that range from 6.5 to 9.5. 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). Dewey Lake is considered "slightly basic" on the pH scale. **The pH of Dewey Lake in late August of 2016 was 7.9-8.0 S.U. which is ideal for an inland lake.**

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 in late August, 2016 for Dewey Lake were quite low and ranged from 120-135 µS/cm, which is almost twice as high as in 2015. This may be due to the significantly warmer water temperatures observed in 2016.** Severe water quality impairments 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 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 chlorophyll-*a* concentration in late August of 2016 in Dewey Lake was ≤3.0 μg/L which is quite low for an inland Michigan lake but higher than in 2015 due to the much warmer water temperatures.**

The algal genera were determined from composite water samples collected over the deep basins of Dewey Lake in 2016 were analyzed with the following occurring in order of abundance: The green algae (Figure 1) *Chlorella* sp., *Haematococcus* sp., *Scenedesmus* sp., *Radiococcus* sp., *Euglena* sp., and *Mougeotia* sp.; The Blue-green algae (Figure 2) *Oscillatoria* sp.; The diatoms (Figure 3) Navicula sp., *Fragilaria* sp., *Synedra* sp., *Cyclotella* sp., *Asterionella* 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.

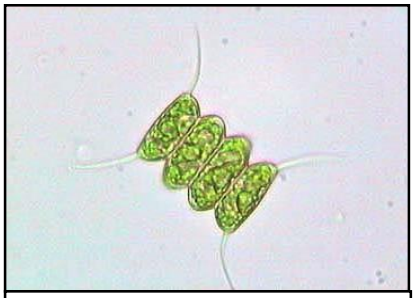

Figure 1. A Green Alga

Figure 2. A Blue-Green Alga

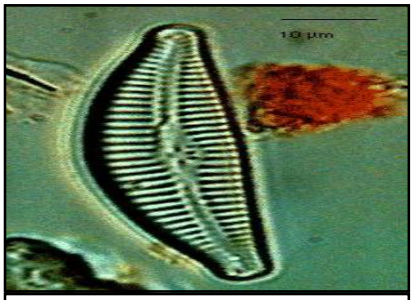

Figure 3. A Diatom

Section 3

Aquatic Vegetation Data (2016)

Status of Native Aquatic Vegetation in Dewey Lake

The native aquatic vegetation present in Dewey Lake is essential for the overall health of the lake and the support of the lake fishery. **The whole-lake survey on May 5, 2016 determined that there were a total of 22 native aquatic plant species in Dewey Lake. These include 14 submersed species, 4 floating-leaved species, and 4 emergent species. This indicates a high biodiversity of aquatic vegetation in Dewey Lake.** The overall % cover of the lake by native aquatic plants is low relative to the lake size and thus these plants should be protected unless growing near swim areas at nuisance levels. All of the native aquatic plant species found in Dewey Lake during the survey are shown below in Table 4.

The most common native aquatic plant species included: 1) White-stem Pondweed (Figure 4) which has long, bright green leaves and grows tall into the water column, 2) White Waterlily (Figure 5), which is a lily pad with showy, white flowers, and 3) Robbin's Pondweed (Figure 6), otherwise known as Fern-leaf Pondweed. This plant has leaves that resemble small ferns that lie close to the lake bottom. The lily pads can become a nuisance in the channel, whereas pondweeds are problematic in the main portion of the lake for recreational activities.

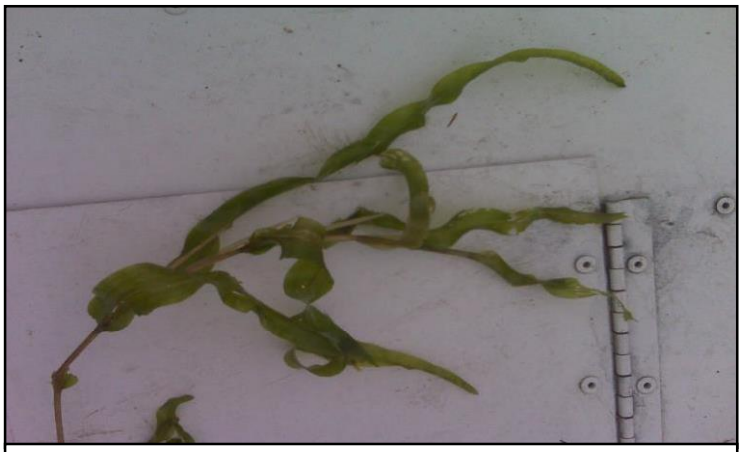

Figure 4. White-stem Pondweed

Figure 5. White Waterlily

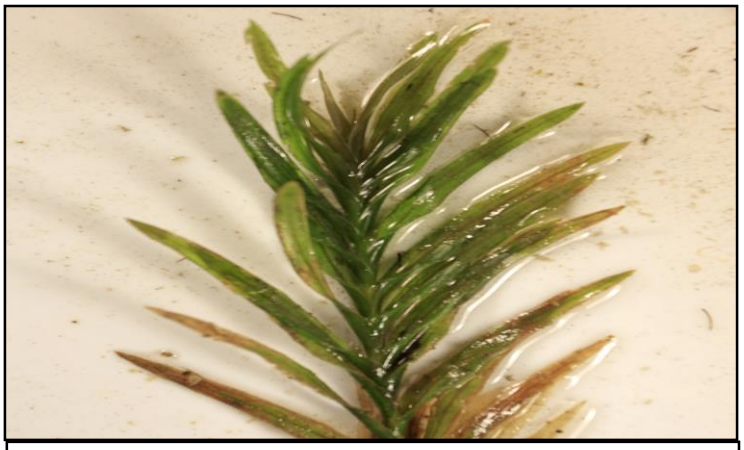

Figure 6. Fern-leaf Pondweed

Table 4. Dewey Lake Native Aquatic Plant Species (May 5, 2016).

Native Aquatic Plant Species Name	***Aquatic Plant Common Name***	***Abundance in/around Dewey Lake***	***Aquatic Plant Growth Habit***
Chara vulgaris	Muskgrass	2.0	Submersed, Rooted
Potamogeton pectinatus	Thin-leaf Pondweed	1.6	Submersed, Rooted
Potamogeton zosteriformis	Flat-stem Pondweed	0.4	Submersed, Rooted
Potamogeton robbinsii	Fern-leaf Pondweed	3.3	Submersed, Rooted
Potamogeton amplifolius	Large-leaf Pondweed	0.9	Submersed, Rooted
Potamogeton praelongus	White-stem Pondweed	7.8	Submersed, Rooted
Potamogeton pusillus	Small-leaf Pondweed	0.4	Submersed, Rooted
Vallisneria americana	Wild Celery	0.2	Submersed, Rooted
Utricularia vulgaris	Bladderwort	0.2	Submersed, Non-Rooted
Ceratophyllum demersum	Coontail	0.6	Submersed, Non-Rooted
Najas guadalupensis	Southern Naiad	0.4	Submersed, Rooted
Nymphaea odorata	White Waterlily	7.1	Floating-Leaved, Rooted
Nuphar variegata	Yellow Waterlily	0.9	Floating-Leaved, Rooted
Brasenia schreberi	Watershield	0.5	Floating-Leaved, Rooted
Lemna minor	Duckweed	0.2	Floating-Leaved, Non-Rooted
Typha latifolia	Cattails	0.2	Emergent
Scirpus acutus	Bulrushes	0.1	Emergent
Pontedaria cordata	Pickerelweed	0.2	Emergent
Decodon verticillatus	Swamp Loosestrife	0.1	Emergent

Status of Invasive (Exotic) Aquatic Vegetation in Dewey Lake

The amount of Eurasian Watermilfoil (Figure 7) present in Dewey Lake varies each year and is dependent upon climatic conditions, especially runoff-associated nutrients. 2016 was the wettest year on record and many lakes experienced nuisance milfoil and algal outbreaks. **The spring 2016 survey revealed that approximately 1.5 acres of milfoil was found throughout the entire lake. In June of 2016, the milfoil was treated with high dose Triclopyr. The treatment was very successful with no milfoil remaining at the end of the 2016 season.**

In addition to the milfoil, there were approximately 3.0 acres of nuisance Curly-leaf Pondweed (CLP; Figure 8) which is an invasive submersed aquatic plant that can form dense canopies if not treated. These areas were successfully treated with the contact herbicide Aquathol-K®. Treatment maps for each of these invasive species are shown in the maps below.

Figure 7. Eurasian Watermilfoil

Figure 8. Curly-leaf Pondweed

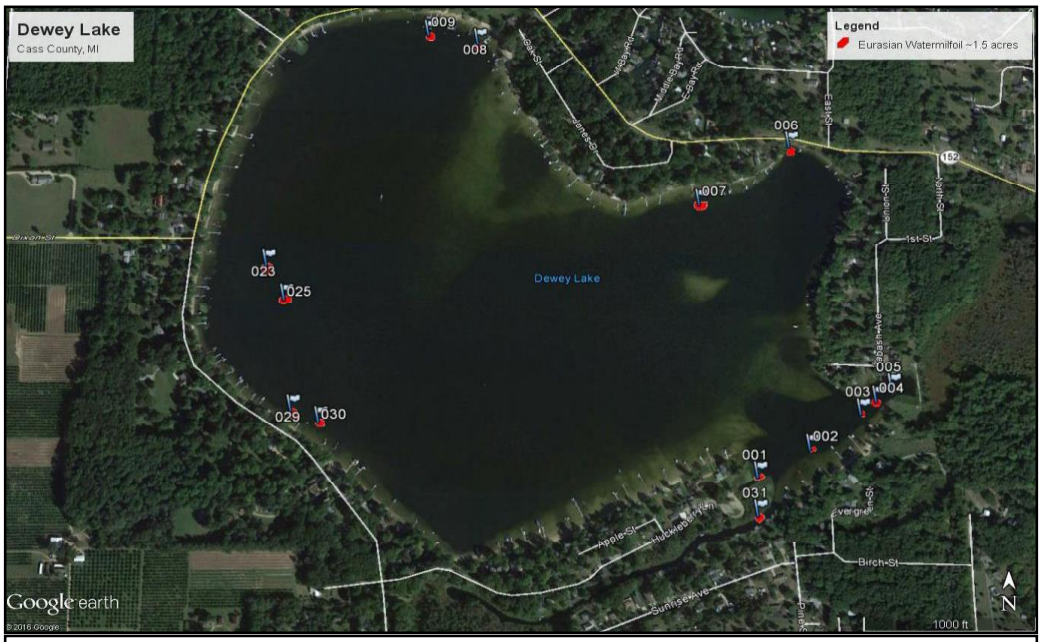

Figure 9. EWM distribution in Dewey Lake (May, 2016).

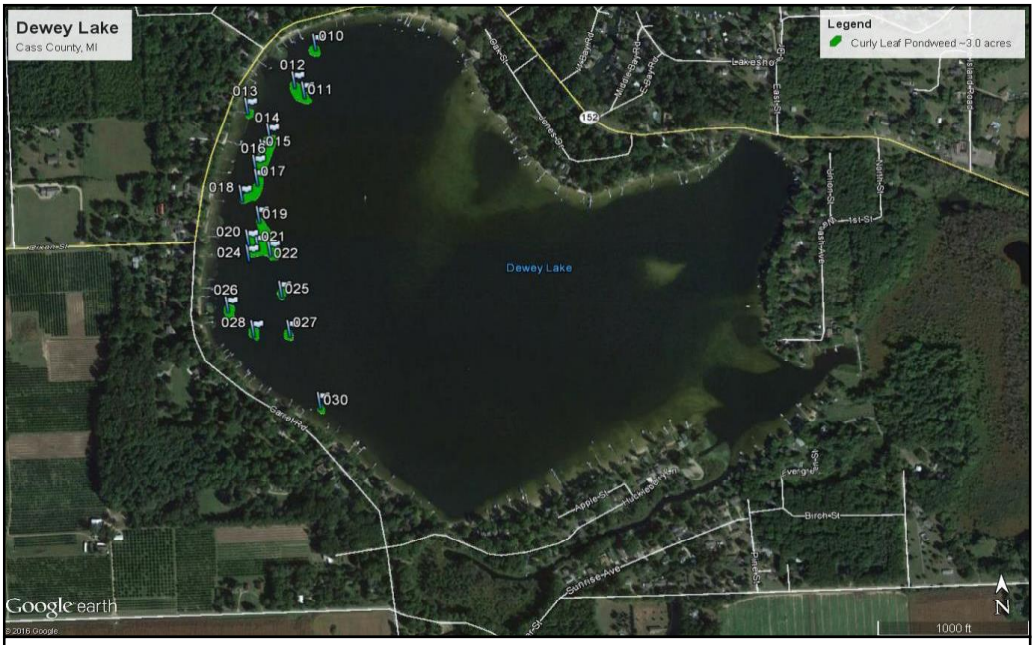

Figure 10. CLP distribution in Dewey Lake (May, 2016).

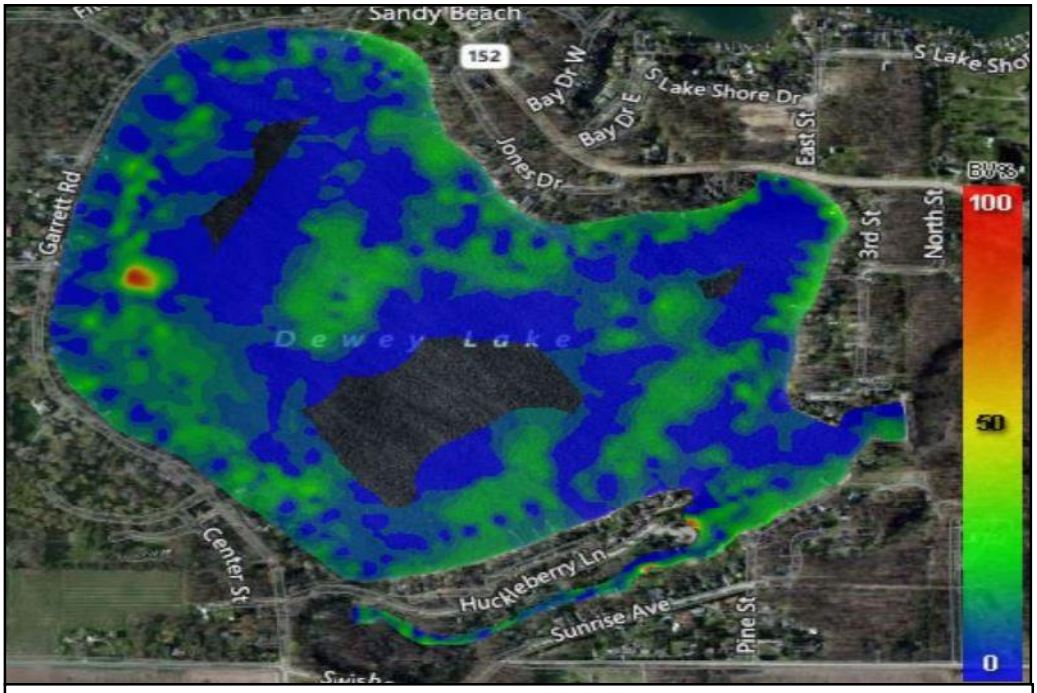

Figure 11. Aquatic vegetation biovolume map of Dewey Lake (May, 2016). Note: The blue color represents no vegetation. The green color represents low-growing vegetation. The red color represents high-growing vegetation such as water lilies.

Section 4

Management Recommendations for 2017

Continuous aquatic vegetation surveys are needed to determine the precise locations of EWM, CLP, or other problematic invasives in Dewey Lake. These surveys should occur in late-May to early-June and again post-treatment in 2017. Scientists from Restorative Lake Sciences will also be present to oversee the lake treatments.

Due to the relative scarcity of native aquatic vegetation in Dewey Lake, the treatment of these species with aquatic herbicides is only recommended for dense pondweeds and lily pads in a few select areas of the lake. The plan for 2017 includes the use of high dose systemic aquatic herbicides for spot-treatments of any new milfoil. Sculpin G® at a dose of 150 lbs. per acre would be recommended offshore and a dose of 120-150 lbs. per acre for Renovate OTF® nearshore for effective control of the milfoil. The lily pads should not require such extensive treatment as in 2016 but would respond well to Clipper® at 400 ppb. Curly-leaf Pondweed will respond well to Aquathol-K® at 1-2 gallons per acre.

Water quality parameters in the main lake will also be monitored in 2017 and enough data will then be available to begin graphing long-term data trends which can serve as measures of change in the Dewey Lake aquatic ecosystem.

In conclusion, Dewey Lake is a healthy lake with good aquatic plant biodiversity and water clarity, moderate nutrients, and a healthy lake fishery. Management of the EWM, CLP, 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.

6) Sedimentary Deposits- refers to the type of lake bottom sediments that are present. In some lakes, gravel and sand are prevalent. In others, organic muck, peat, and silt are more common.