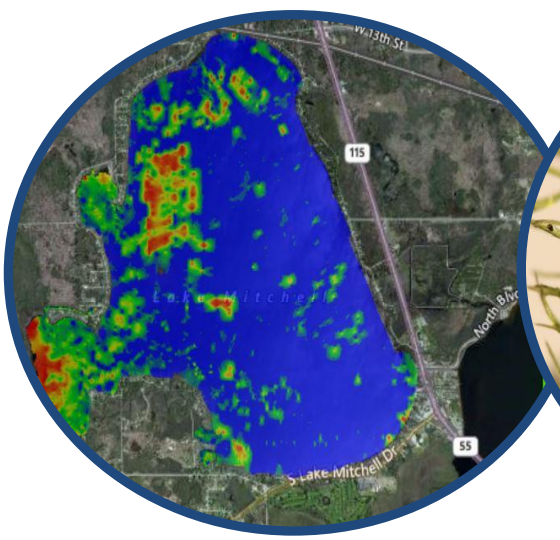
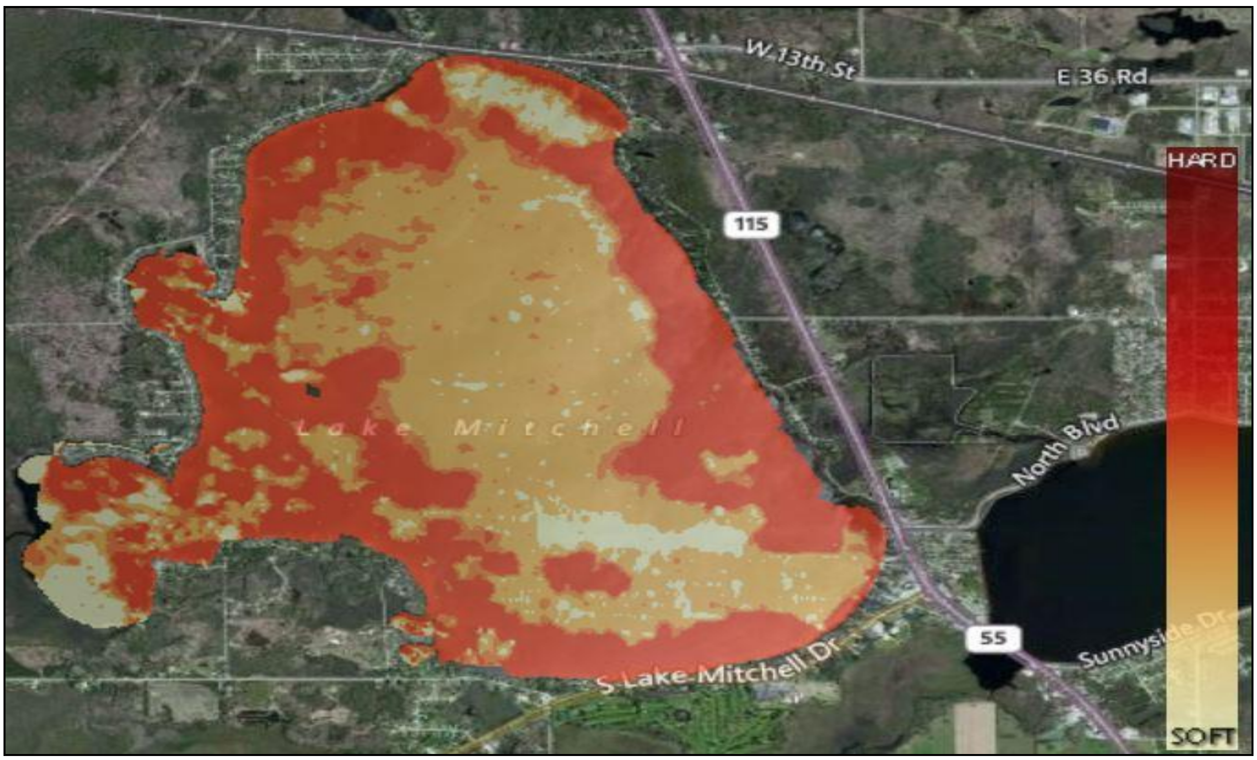
Lake Mitchell 2016 Aquatic Vegetation & Water Quality Report & 2017 Management Recommendations



October, 2016

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

(2009-2016)



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1

Lake Mitchell 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 Lake Mitchell is ranked in the top 15% of developed lakes of similar size in the state of Michigan. The water clarity in 2016 averaged around 8.5 feet which is favorable. Additionally, the lake has enough nutrients (phosphorus and nitrogen) to support some algae and submersed aquatic plant growth in the shallow littoral zone, but the nutrient levels are considered moderate.

Protection of the 26 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 or nuisance pondweeds in the coves).

Invasive species such as Eurasian Watermilfoil (EWM) are able to grow in moderate nutrient waters and thus are a challenge to the Lake Mitchell ecosystem. In 2016, a total of 33.5 acres of EWM were treated in the coves and none was found in the Torenta Canal. Approximately 71 acres of EWM was treated in the main lake. Combined these totals equal approximately 4.0% of the lake surface area. EWM may have increased in 2016 due to the significantly higher water temperatures and amount of sunlight relative to 2015. A total of $69,950.33 was spent on aquatic herbicide treatments in 2016.

The Purple Loosestrife stocking occurred in 2016 and is still showing promise but higher stocking levels are recommended for Big Cove in 2017.

Section

2

Lake Mitchell Water Quality Data (2009-2016)

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 chlorophyll-*a* (in µg/L), and algal species composition. In 2016, water quality was measured in the deepest basin of Lake Mitchell in spring and late summer (Figure 1). Trend data was calculated using mean values for each parameter for each season. **Lake Mitchell would be considered eutrophic (relatively productive) since it does contain ample phosphorus, nitrogen, and aquatic vegetation growth but also has good water clarity and moderate algal growth. General water quality classification criteria are defined in Table 1. 2016 water quality data for Lake Mitchell and its tributaries are shown below in Tables 2-4.**

Figure 1. Water quality sampling locations for Lake Mitchell and its tributaries

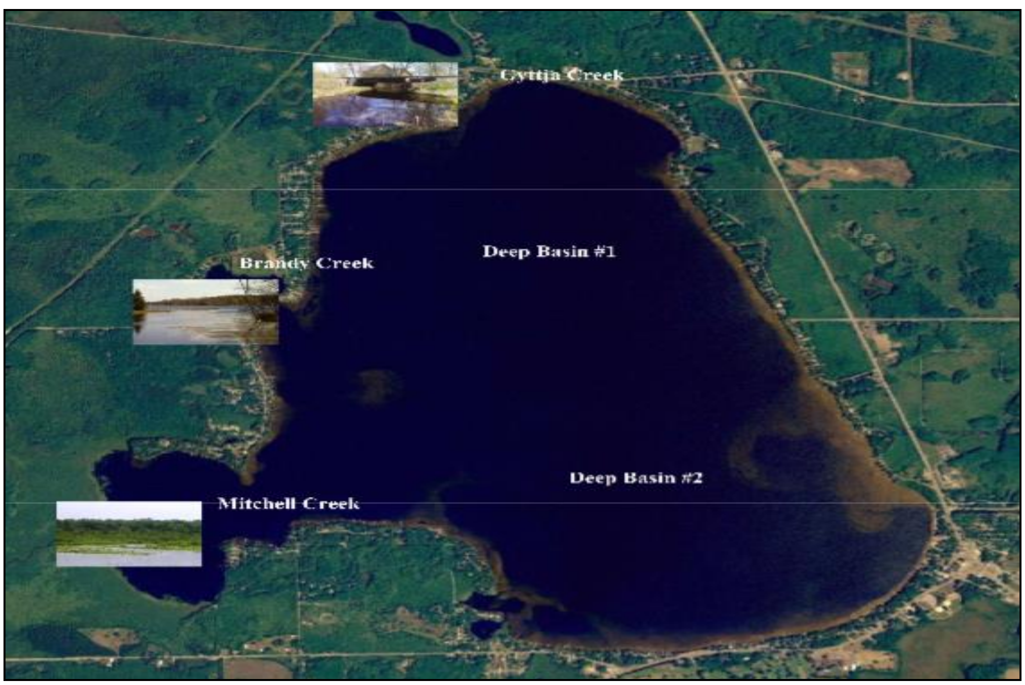


Table 1. Lake trophic classification (MDNR).

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. Lake Mitchell water quality parameter data collected over the deep basin on May 26, 2016.

Depth ft.	*Water Temp ºF*	*DO mg L^{-1}*	*pH S.U.*	*Cond. $\mu S\ cm^{-1}$*	*Turb. NTU*	*ORP mV*	*Total Dissolved Solids mg L^{-1}*	*Total Alk. mg L^{-1} $CaCO_3$*	*Total Phos. mg L^{-1}*
0	56.9	10.0	7.8	166	0.7	144.6	50	48	0.020
10	52.7	8.8	8.0	170	0.7	129.1	47	50	0.020
20	48.6	7.9	7.9	164	0.8	110.5	42	46	0.040

Table 3. Lake Mitchell water quality parameter data collected over the deep basin on August, 21, 2016.

Depth ft.	*Water Temp ºF*	*DO mg L^{-1}*	*pH S.U.*	*Cond. $\mu S\ cm^{-1}$*	*Turb. NTU*	*ORP mV*	*Total Dissolved Solids mg L^{-1}*	*Total Alk. mg L^{-1} $CaCO_3$*	*Total Phos. mg L^{-1}*
0	76.3	8.9	8.0	168	0.5	139.0	50	49	0.020
10	71.6	8.0	7.9	170	0.7	142.7	47	50	0.028
20	66.0	6.4	7.8	162	0.6	88.1	44	48	0.036

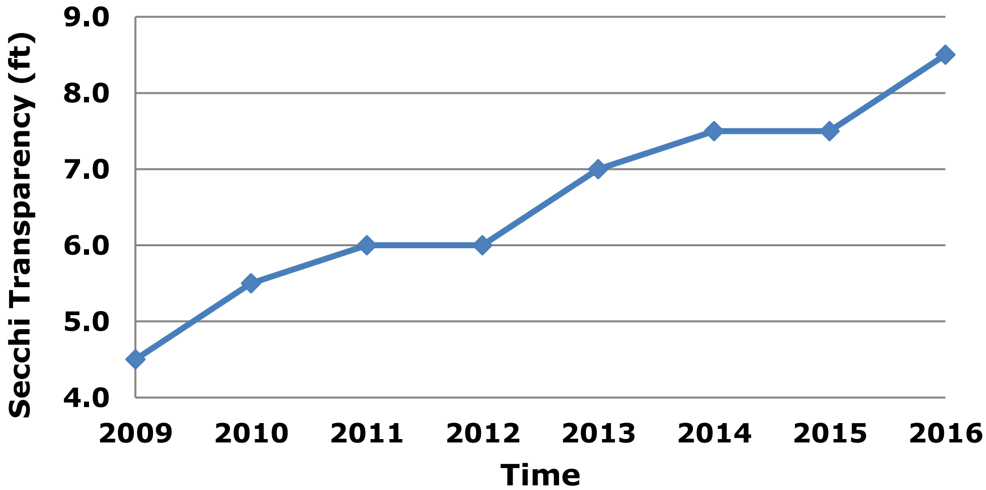
Table 4. Lake Mitchell Tributary water quality parameter data collected on May 26, 2016.

Tributary	*Water Temp ºF*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*TDS mg L^{-1}*	*ORP mV*	*Total Phos. mg L^{-1}*
Mitchell	53.9	7.9	7.5	232	97	123.5	0.020
Brandy	54.3	8.0	7.4	145	88	110.9	0.030
Gyttja	56.8	7.5	7.4	208	65	115.8	0.042

Water Clarity (Transparency) Data

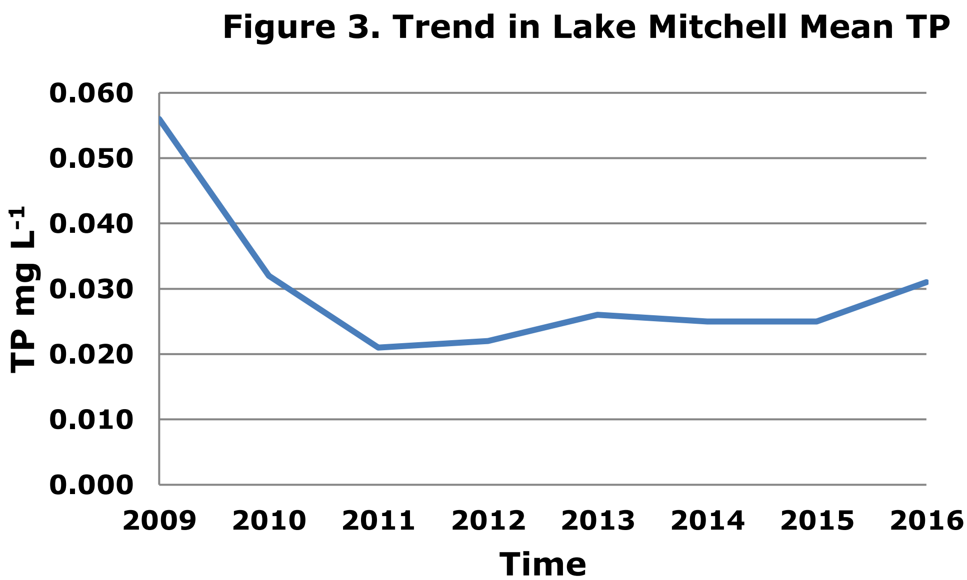
Elevated Secchi transparency readings allow for more aquatic plant and algae growth. **The transparency in Lake Mitchell during the 2016 sampling events averaged around 8.5 feet which is adequate to allow abundant growth of algae and aquatic plants in the majority of the littoral zone of the lake.** 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 Lake Mitchell were quite low in 2016 at ≤0.8 NTU's and ≤50 mg/L, respectively. Figure 2 below shows an increase in Secchi transparency in recent years. This cannot be attributed to solely Zebra Mussel filtration since their population is not very strong in the lake due to the low alkalinity. It may be due to less intense runoff which was observed on many lakes during the summer of 2016.**

Figure 2. Trend in Lake Mitchell Mean Secchi Transparency



Total Phosphorus

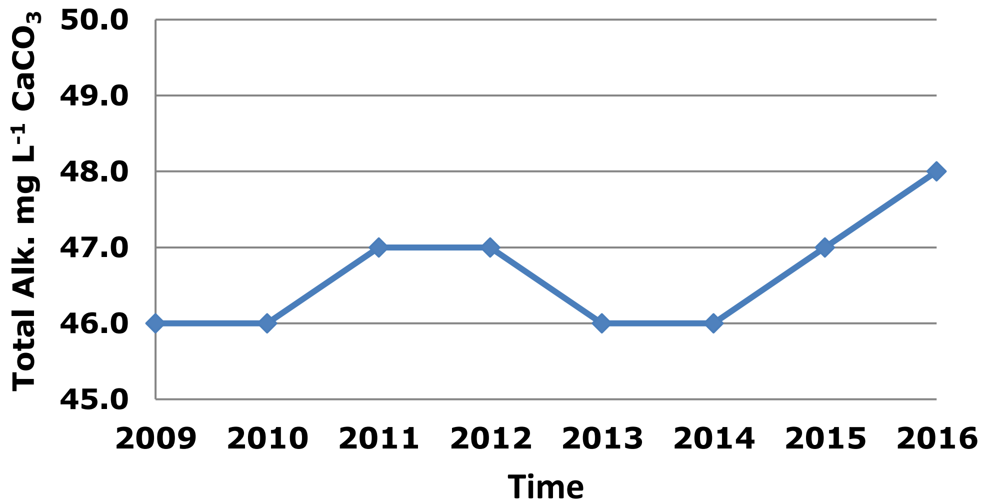
Total phosphorus (TP) is a measure of the amount of phosphorus (P) present in the water column. Phosphorus is the primary nutrient necessary for abundant algae and aquatic plant growth. TP concentrations are usually higher at increased depths due to higher release rates of P from lake sediments under low oxygen (anoxic) conditions. Phosphorus may also be released from sediments as pH increases. **Fortunately, even though the TP levels in Lake Mitchell are moderate, the dissolved oxygen levels are good enough at the bottom to not cause release of phosphorus from the bottom. TP concentrations during the 2016 sampling events ranged from 0.020-0.036 mg L^{-1}, which is amongst some of the lowest concentrations (Figure 3). Again, this may be attributed to decreased runoff.**



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 Lake Mitchell is quite low and is indicative of a "soft water" aquatic ecosystem. The total alkalinity during the sampling events ranged from 46-50 mg L^{-1} of $CaCO_3$ (Figure 4)**.

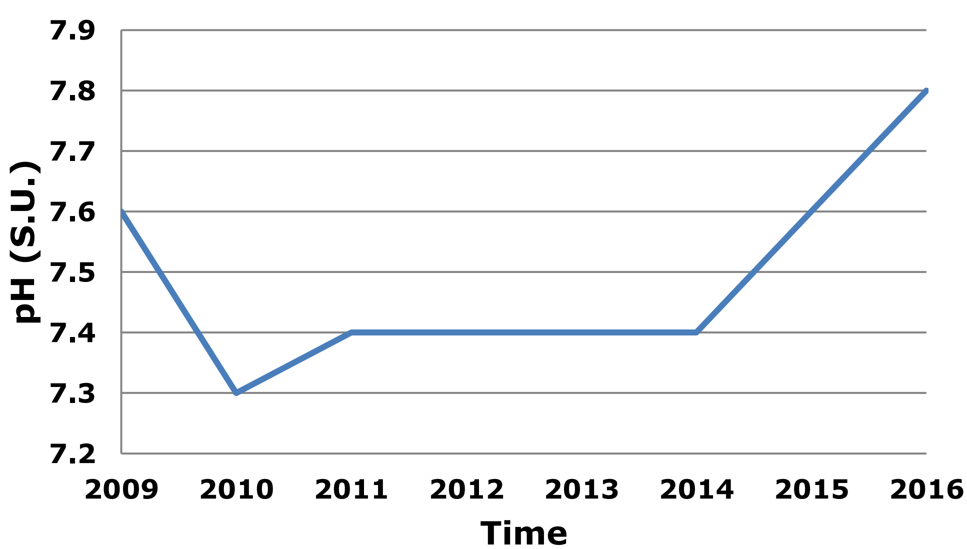
Figure 4. Trend in Lake Mitchell Mean Total Alkalinity



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**). Lake Mitchell is considered "neutral" on the pH scale. The pH of Lake Mitchell in 2016 was similar to previous years and ranged from 7.8-8.0 S.U. which is ideal for an inland lake (Figure 5).**

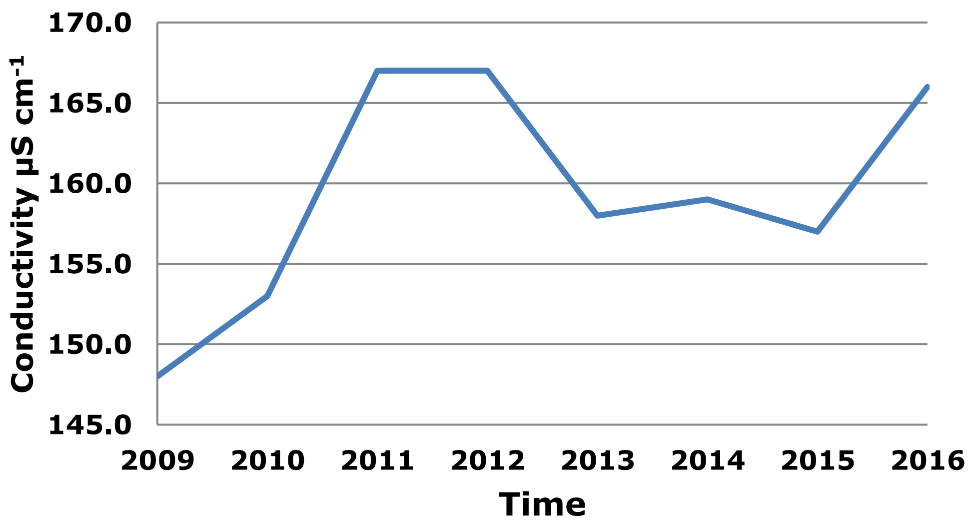
Figure 5. Trend in Lake Mitchell Mean pH



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 Lake Mitchell are moderately low for a large, shallow inland lake and ranged from 162-170 µS/cm during the 2016 sampling events (Figure 6).** Severe water quality impairments do not occur until values exceed 800 µS/cm and are toxic to aquatic life around 1,000 µS/cm. Conductivity may be increasing due to more road salt applications during recent harsh winters.

Figure 6. Trend in Lake Mitchell Mean Conductivity

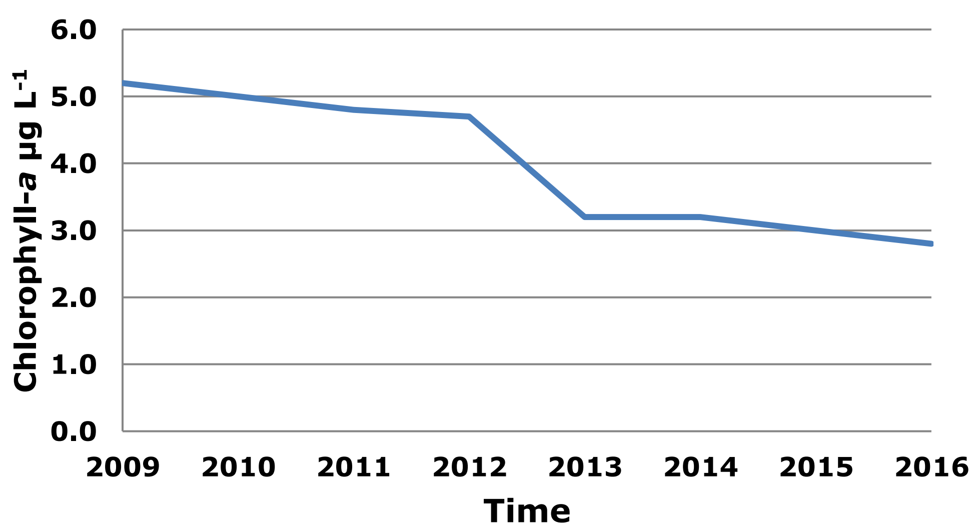


Chlorophyll-*a* and Algal Species Composition

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 mean chlorophyll-*a* concentrations in spring and late summer in Lake Mitchell did not exceed 2.9 µg/L which is quite low for an inland Michigan lake, especially given the extremely high water temperatures observed in 2016 (Figure 7).**

The algal genera were determined from composite water samples collected over the deep basin of Lake Mitchell in 2016 were analyzed with a compound bright field microscope. The genera present included the Chlorophyta (green algae; Figure 8): *Scenedesmus* sp., *Haematococcus* sp., *Euglena* sp., *Chlorella* sp., *Cladophora* sp., *Pediastrum* sp., *Pandorina* sp., *Radiococcus* sp., *Mougeotia* sp., and *Chloromonas* sp. The Cyanophyta (blue-green algae; Figure 9): G*leocapsa* sp., the Bascillariophyta (diatoms; Figure 10)*: Navicula* sp., *Fragilaria* sp., *Synedra* sp., *Cymbella* sp., and *Nitzschia* 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 7. Trend in Lake Mitchell Mean Chlorophyll-*a*



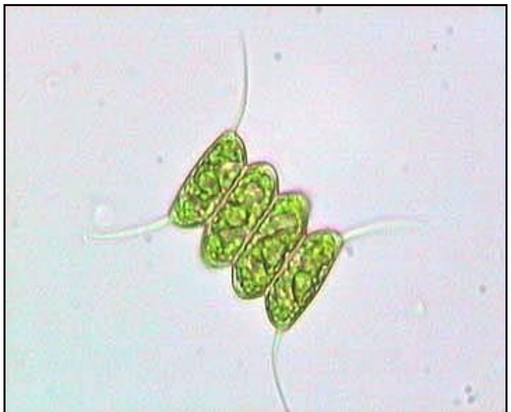


Figure 8. A Green Alga

Figure 9. A Blue-Green Algae

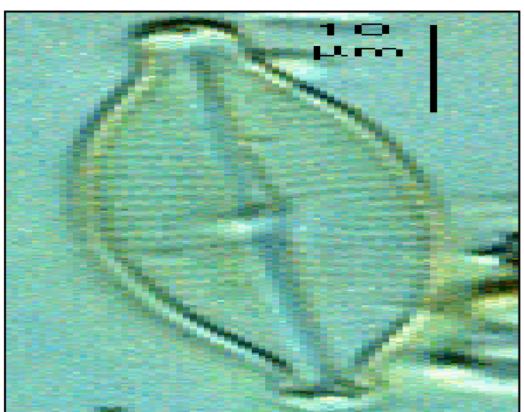


Figure 10. A Diatom

Section 3

Aquatic Vegetation Data (2016)

Status of Native Aquatic Vegetation in Lake Mitchell

The native aquatic vegetation present in Lake Mitchell is essential for the overall health of the lake and the support of the lake fishery. **The most recent survey in September of 2016 determined that there were a total of 26 native aquatic plant species in Lake Mitchell. These include 17 submersed species, 4 floating-leaved species, and 5 emergent species**. This indicates a very high biodiversity of aquatic vegetation in Lake Mitchell and is likely a significant reason for the great fishery in the 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 and not treated unless they become a nuisance in shallow coves or the Torenta Canal. **A list of all native aquatic plants and their relative abundance can be found in Table 5 below.**

The most common aquatic plants found during the 2016 surveys included: 1) Leafless Watermilfoil (Figure 11), which lies close to the bottom and resembles an underwater lawn. This plant has no true leaves and is in the milfoil family but bears no resemblance to Eurasian Watermilfoil; 2) Fern-leaf Pondweed (Figure 12) which also lies close to the bottom and resembles small fern-like leaves. The plant thrives in stained waters; 3) White-stem Pondweed which grows tall into the water column and has bright, elongated green leaves (Figure 13).

During the whole-lake scan, an aquatic vegetation biovolume map (Figure 14) was developed which shows the areas where aquatic vegetation is absent (blue color), sparse (green color), or high-growing (red color). The red colors usually represent milfoil growth in Lake Mitchell which has declined over the past few years.

Figure 11. Leafless Watermilfoil

Figure 12. Fern leaf Pondweed

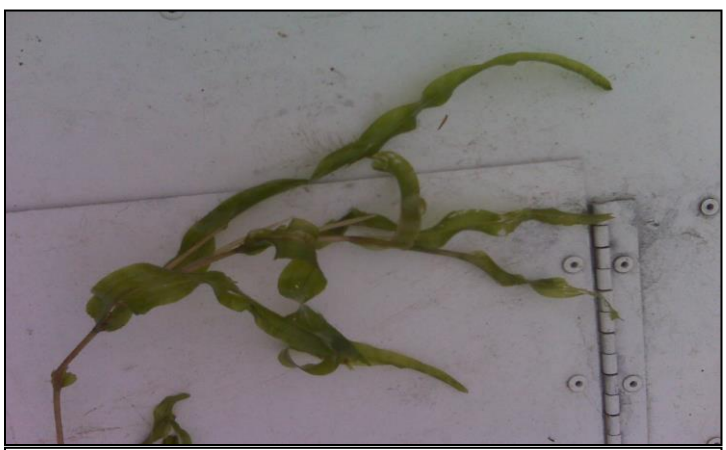


Figure 13. White-stem Pondweed

Table 5. Native aquatic plants found in Lake Mitchell in 2016.

Aquatic Plant Species Name	*Aquatic Plant Common Name*	*Aquatic Plant Growth Form*	*% Coverage of Lake (2016)*
Chara vulgaris (macroalga)	Muskgrass	Submersed; Rooted	16
Potamogeton pectinatus	Sago Pondweed	Submersed; Rooted	17
Potamogeton robbinsii	Fern-leaf Pondweed	Submersed; Rooted	62
Potamogeton gramineus	Variable-leaf Pondweed	Submersed; Rooted	16
Potamogeton praelongus	White-stem Pondweed	Submersed; Rooted	55
Potamogeton richardsonii	Clasping-leaf Pondweed	Submersed; Rooted	16
Potamogeton illinoensis	Illinois Pondweed	Submersed; Rooted	29
Potamogeton amplifolius	Large-leaf Pondweed	Submersed; Rooted	32
Myriophyllum sibiricum	Northern Watermilfoil	Submersed; Rooted	4
Ceratophyllum demersum	Coontail	Submersed; Non-rooted	9
Elodea canadensis	Common Waterweed	Submersed: Rooted	17
Utricularia vulgaris	Common Bladderwort	Submersed; Non-rooted	30
Utricularia minor	Mini Bladderwort	Submersed; Non-rooted	8
Najas guadalupensis	Southern Naiad	Submersed; Rooted	12
Najas flexilis	Slender Naiad	Submersed; Rooted	20
Myriophyllum tenellum	Leafless Watermilfoil	Submersed; Rooted	69
Potamogeton pusillus	Small-leaf Pondweed	Submersed; Rooted	15
Megalodonta beckii	Water Marigold	Submersed; Rooted	14
Nymphaea odorata	White Waterlily	Floating-leaved	7
Nuphar variegata	Yellow Waterlily	Floating-leaved	10
Brasenia schreberi	Watershield	Floating-leaved	6
Lemna trisulca	Star Duckweed	Floating-Leaved; Non-rooted	1
Pontedaria cordata	Pickerelweed	Emergent	9
Typha latifolia	Cattails	Emergent	10
Scirpus acutus	Bulrushes	Emergent	37
Decodon verticillatus	Swamp Loosestrife	Emergent	11
Eleocharis acicularis	Spikerush	Emergent	21

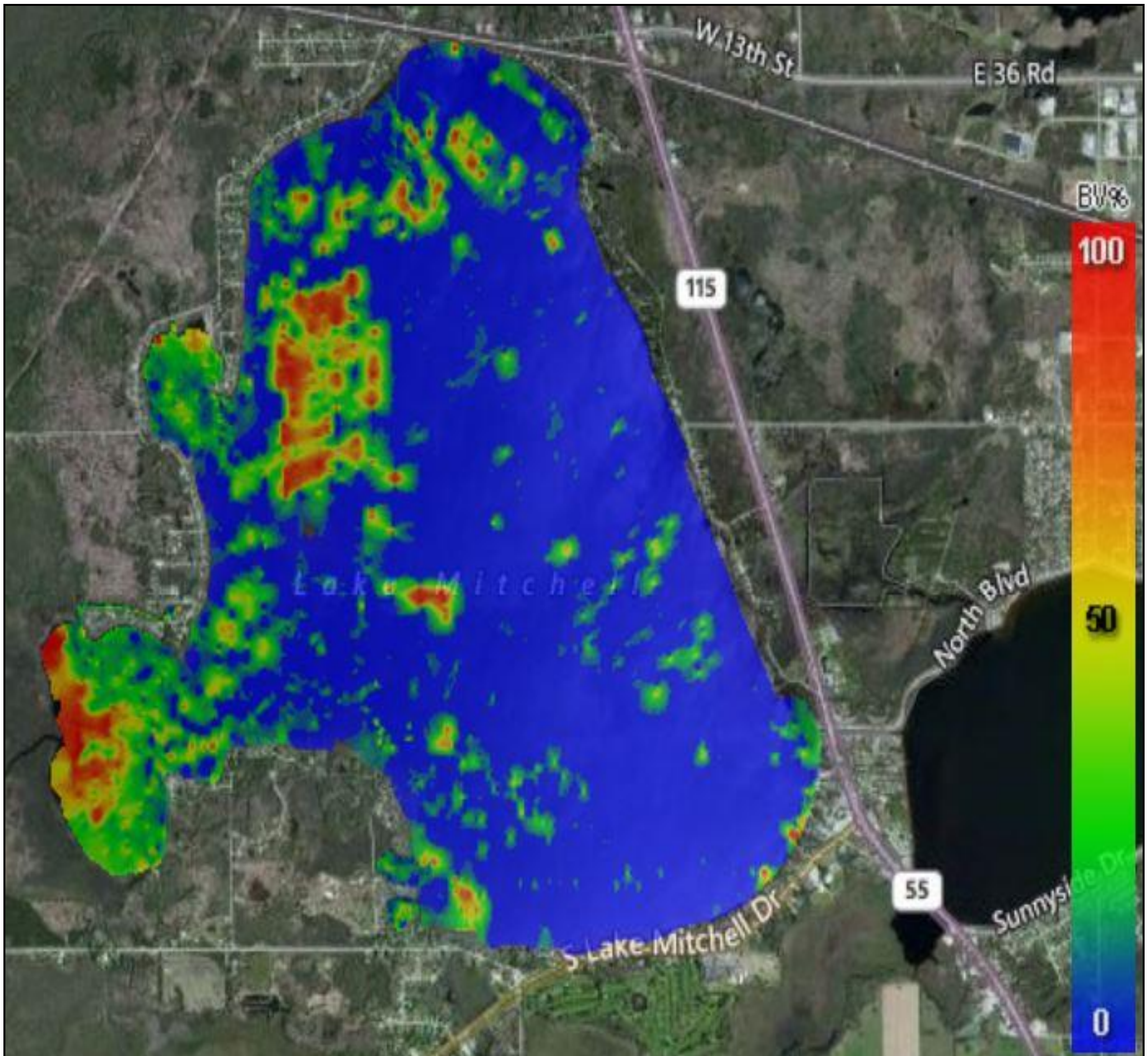


Figure 14. Aquatic Vegetation Biovolume in Lake Mitchell (May, 2016).

Status of Invasive (Exotic) Aquatic Plant Species in Lake Mitchell

The amount of Eurasian Watermilfoil (Figure 15) present in Lake Mitchell varies each year and is dependent upon climatic conditions, especially runoff-associated nutrients. 2016 was amongst the hottest years on record and many lakes experienced nuisance milfoil and algal outbreaks even given the two consecutive harsh winters. **A whole-lake survey of the main lake was conducted on May 25-26, 2016 and revealed that approximately 71 acres of milfoil were found throughout the entire lake (Note: some additional new growth of milfoil was noted after the survey and this was added to the total for treatment to equal 83.8 total acres). Earlier on May 11, 2016, the coves and Torenta Canal were surveyed. The coves had approximately 33.5 acres of milfoil combined. Table 6 below shows the total acres of milfoil and Curly-leaf Pondweed (Figure 16) found in each region of the lake that was treated on various dates. Also noted are the effective products and doses used.**

The treatments were very successful with no viable milfoil remaining at the end of 2016. A spring, 2017 survey is needed, however, to determine if all of the dying milfoil will not return. Treatment maps for each of these invasive species are shown in the maps below (Figures 17-21). **Also noted are the effective products and doses used. As in previous years, Loosestrife Beetles were also placed in Little Cove and Big Cove in July of 2016. Figure 22 shows the changes with time since the beetles have been placed in the coves.**

Figure 15. Eurasian Watermilfoil

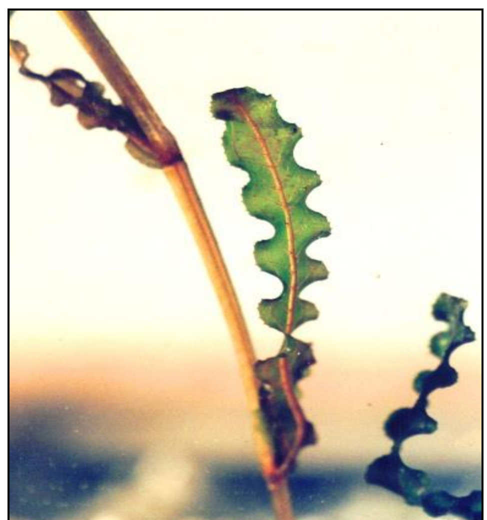


Figure 16. Curly-leaf Pondweed

Table 6. Number of acres of milfoil present in various regions of Lake Mitchell (May, 2016).

Area of Lake Treated	Date Treated	# Acres of EWM	# Acres of CLP or Nuisance Pondweeds	Products Used and Associated Doses
Main Lake	6-1;6-2; 8-30	9.2+10.5+54+10.1	0	Renovate OTF @240lbs/acre + Sculpin G @240lbs/acre; Renovate OTF @240lbs/acre; Sculpin G @240lbs/acre; Renovate OTF @200lbs/acre; Sculpin G at 200 lbs./acre
Big Cove	5-17;7-13	26.7+2.0	0	Sculpin G @250lbs/acre; Sculpin G @200lbs/acre
Little Cove	5-17;6-2	2.5	1.3+3.0+1.5+2.0+2.0 (algae)	Renovate OTF @200lbs/acre; Aquathol-K @2gal/acre for CLP; Aquathol-K @3gal/acre for Pondweeds; Diquat @ 2gal/acre; Clipper 100 ppb + 1 gal/acre Diquat; SeClear 30lbs/acre
Franke South Cove	5-17;6-1;	2.0	3.0+2.0	Renovate OTF @200lbs/acre; Aquathol-K@ 3gal/acre for Pondweeds; Diquat @ 2gal/acre
Franke North Cove	5-17; 6-1;7-13	0.3	1.0+0.5	Renovate OTF @200lbs/acre; Aquathol-K@ 3gal/acre for Pondweeds; Diquat @2gal/acre
Torenta Canal	7-13	0	3.0 (algae)	SeClear 30lbs/acre

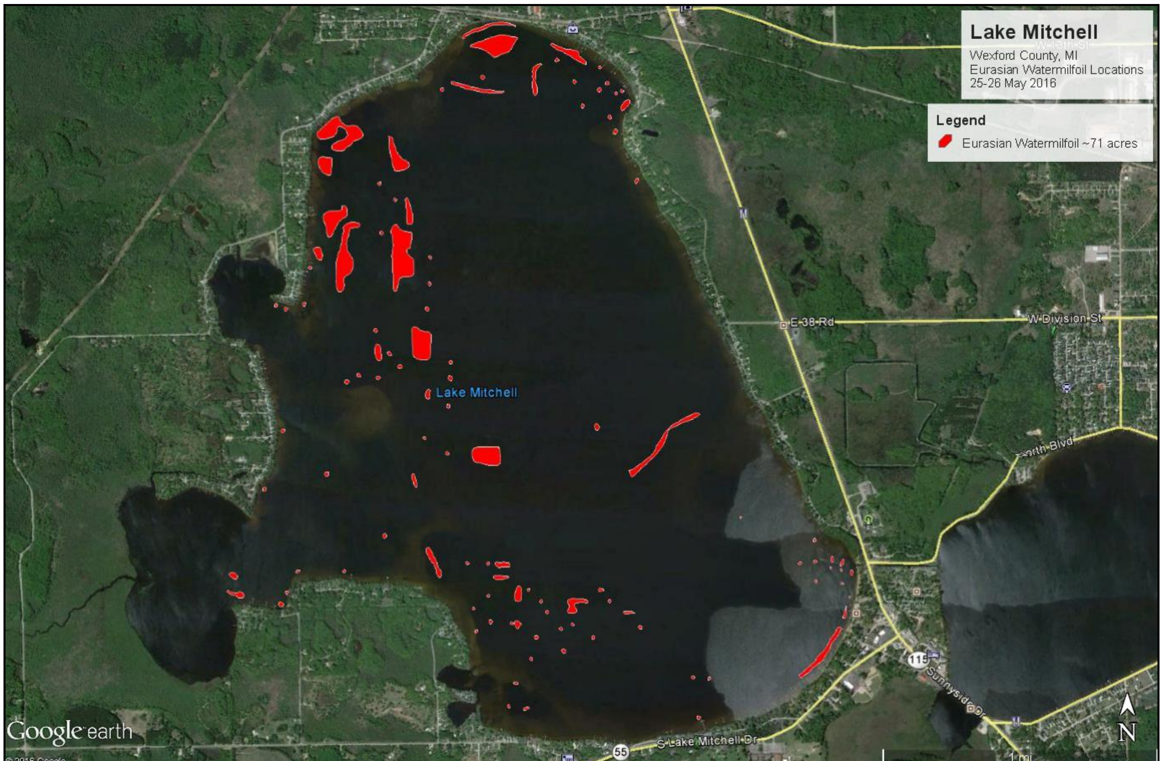


Figure 17. Distribution of EWM in Lake Mitchell (May, 2016). Note: Milfoil was mapped separately in the coves.

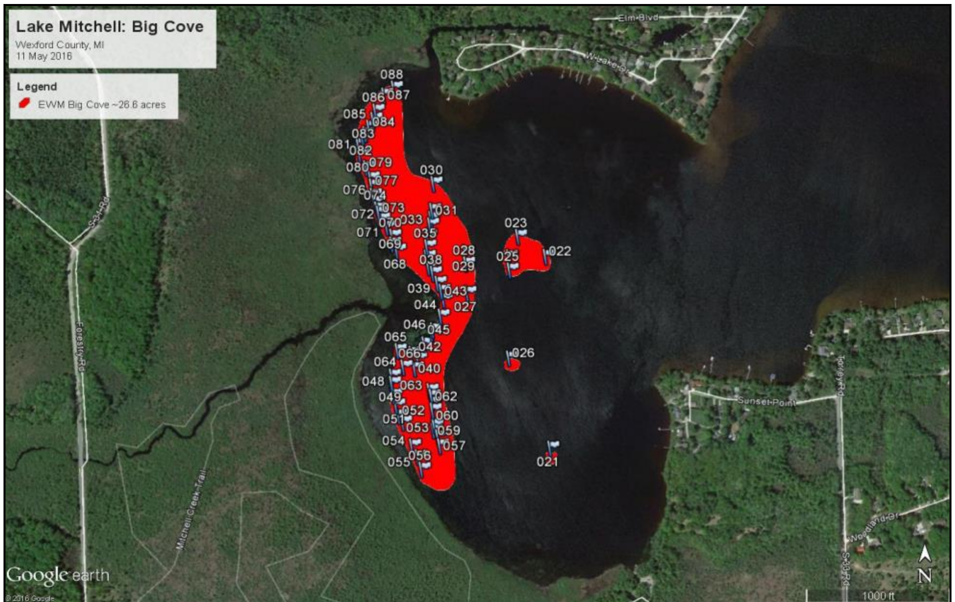


Figure 18. Distribution of EWM in Big Cove (May, 2016).

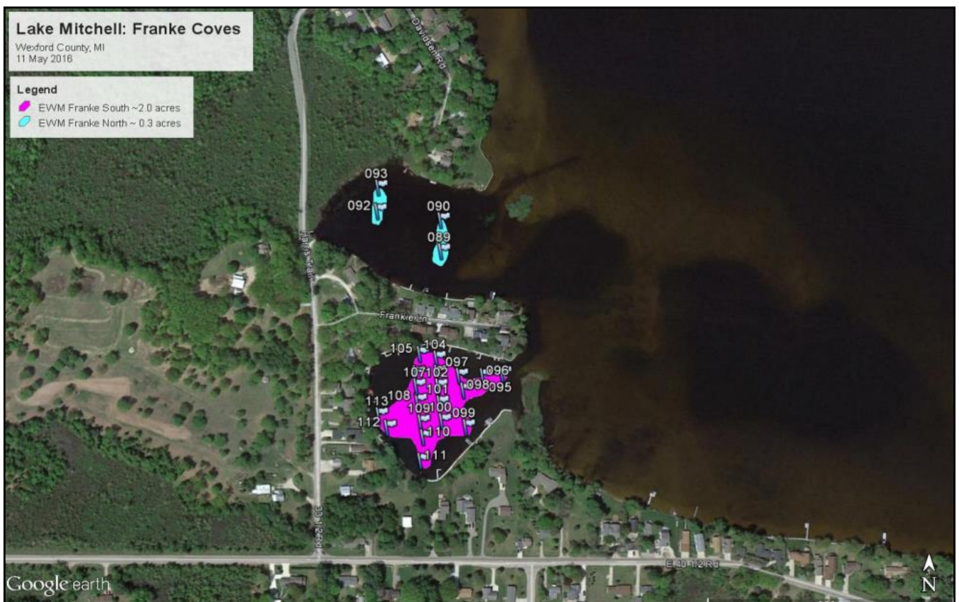


Figure 19. Distribution of EWM in Franke North and Franke South Coves (May, 2016).

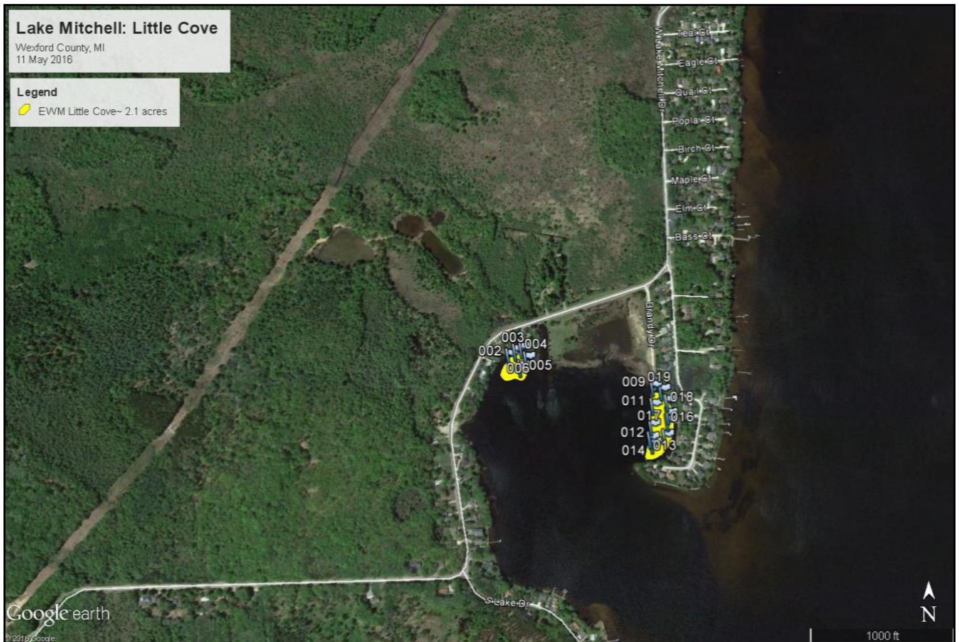
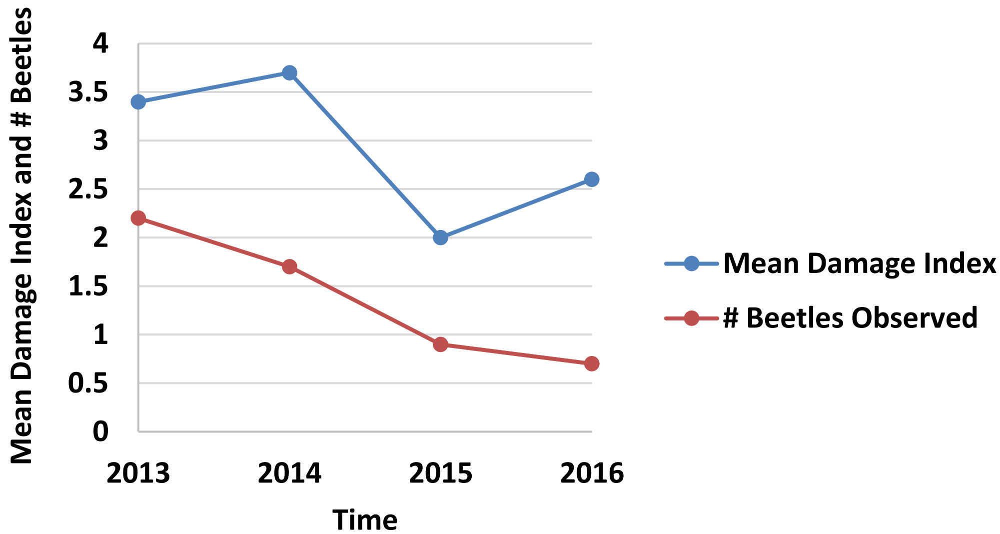


Figure 20. Distribution of EWM in Little Cove (May, 2016)

Figure 21. Distribution of EWM in Lake Mitchell (August, 2016)

Figure 22. Mean Purple Loosestrife Stem Damage and # of Beetles Observed with Time



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 and around Lake Mitchell. **These surveys should occur in late-May to early-June and again post-treatment in 2017. RLS scientists will again be present to oversee all treatments in 2017.**

Due to the relative scarcity of native aquatic vegetation in Lake Mitchell, the treatment of these species with aquatic herbicides is not recommended (one exception is the overgrowth of pondweeds and lily pads in a few select areas of the lake such as the coves). The plan for 2017 includes the continued use of high-dose systemic aquatic herbicides due to the genetically determined strains of hybrid milfoil that require such doses for effective treatment. **Higher doses such as Sculpin G® at a dose of 250 lbs. /acre would be recommended offshore and a dose of 250 lbs. /acre for Renovate OTF® nearshore for effective control of the hybrid milfoil. Nuisance lily pads and pondweeds will respond well to Clipper® at 400 ppb or to Clipper® at 100-200 ppb with Diquat at 1-2 gal/acre. Curly-leaf Pondweed will respond well to Aquathol-K® at 2 gallons per acre. The algae in Torenta Canal and Little Cove will respond well to SeClear® and chelated copper algaecide. Purple Loosestrife stocking should also continue with higher doses in Big Cove near the Canal.**

Water quality parameters in the main lake and the tributaries will again be monitored and graphed with historical data to observe long-term trends.

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