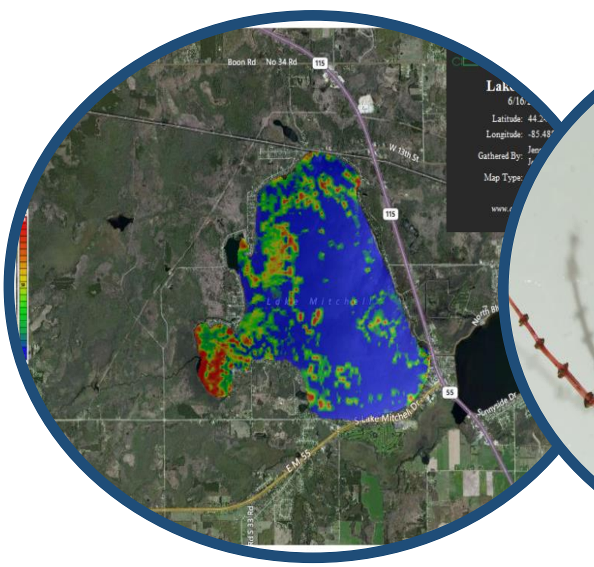
## Lake Mitchell 2014 Annual Progress Report

# An Annual Assessment Of
# Aquatic Vegetation and Water Quality in
# Lake Mitchell
# Wexford County, Michigan

**January, 2015**

**(Revised March, 2015)**





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# An Annual Progress Report of Aquatic Vegetation and Water Quality in Lake Mitchell Wexford County, Michigan

## January, 2015 (Revised, March, 2015)

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## 1.0 EXECUTIVE SUMMARY

Over the past few decades, Lake Mitchell has been managed for nuisance invasive aquatic plants such as the exotic, Eurasian Watermilfoil (*Myriophyllum spicatum;* EWM) and Hybrid Watermilfoil (*Myriophyllum spicatum var. M. sibiricum;* HWM). The native aquatic plant biodiversity in Lake Mitchell is very high with 18 submersed, 4 floating-leaved, and 5 emergent aquatic plant species for a grand total of 27 species. The dense stands of milfoil have threatened the native aquatic plant biodiversity and have impaired navigation and recreational activities, and may affect waterfront property values.

**An initial whole lake GPS grid survey of 1,888 sampling points and whole lake scan of Lake Mitchell was conducted on June 16, 2014 which was later than usual due to the harsh winter during 2013 and late ice-off in 2014. The survey found approximately 134 total acres of hybrid milfoil in the main lake and coves, which represented about 5.2% of the lake surface area.** On June 26, 2014, the systemic aquatic herbicides Sculpin G® (2,-D amine salt) was used at doses of between 180-200 pounds per acre with great success in reduction of the hybrid milfoil. Due to concerns about shallow wells at the northeast region of the lake, granular triclopyr (Renovate OTF LZR®) was used at a dose of 120-200 pounds per acre with great success. The coves were treated on June 16, 2014 with the use of various strong contact herbicides such as Aquathol-K (3 gallons per acre) for pondweed growth and Clipper (flumioxazin; 200-300 ppb) for control of Watershield and other nuisance native weed growth.

The Torenta Canal required an algae treatment using chelated copper (SeClear® at a dose of 10 gallons per acre) for dense *Cladophora* blooms. The canal was also treated with SeClear® again on July 8, 2014.

A second lake treatment of approximately 20 additional new acres of milfoil was completed on August 13, 2014. In the main lake, Renovate OTF LZR® was used on 8 acres of milfoil in the northern region of the lake at a dose of 160 pounds per acre. On that same day, 11 acres of milfoil were treated with Sculpin G® at a dose of 200 pounds per acre. An additional 2.5 acres of algae were treated in Little Cove and 3 acres in the Torenta Canal using SeClear® at a dose of 10 gallons per acre.

**A post-treatment survey on September 29, 2014** determined that all milfoil in the lake appeared to be dying due to the treatment and the nuisance native aquatic vegetation in the coves was reduced. The algae in the Torenta Canal was also reduced but stagnation is creating water quality issues in the Canal. Treatment recommendations for 2015 include using the same products but alternating with areas treated in 2014 if the milfoil returns to reduce tolerance.

**On July 8, 2014, approximately 27 pots of cultured *Galerucella* sp. beetles** were transplanted into Big Cove and Franke North Cove. Beetles were cultured at the Kalamazoo Nature Center in Kalamazoo, Michigan. More stocking is recommended in 2015.

**Water quality sampling of the deep basins and tributaries of Lake Mitchell was conducted on June 16, 2014.** Nutrient levels continue to be in the eutrophic (nutrient-rich) range for the entire lake, with elevated levels entering the lake from all of the tributaries. The water clarity has increased over the past few years, likely the result of lower chlorophyll-*a* values and lower dissolved solids. The majority of the water quality parameters such as pH, total alkalinity, and dissolved oxygen have been consistent over the past few years. A summary of all lake management events is shown in the timeline below:

**Timeline of 2014 Lake Mitchell Lake Management Events:**

May 17-Initial cove survey by RLS with R. Moelker

May 26-Second cove survey by RLS (note: plants behind with growth but temp over 70°F)

May 27-RLS interviewed by Cadillac Daily News for article on lake status

June 16- Initial whole lake survey and Bio Base® lake scan and initial treatment of coves and canal. RLS was present to oversee treatments during survey

June 20-LMIB special meeting

June 22-RLS creates specific treatment maps for PLM

June 26-Treatment of lake milfoil (135 acres) by PLM with oversight by RLS

June 28-LMIB meeting

July 8-Purple Loosestrife beetle stocking by RLS and PLM

July 8-Second Torenta Canal treatment

August 9-LMIB meeting

August 13-Re-treatment of 20 acres by PLM with oversight by RLS

September 4-Purple Loosestrife beetle assessment by RLS

September 29-Post-treatment survey and second whole lake survey by RLS

October 21-LMIB meeting; RLS recommends harvest in Franke Cove South and Torenta Canal

December 11-LMIB special meeting

**Acreage of Milfoil treated in Lake Mitchell 2009-2014**

| Treatment Year | Acres of Milfoil Treated |
|---|---|
| 2009 | 310 |
| 2010 | 379 |
| 2011 | 186 |
| 2012 | 339 |
| 2013 | 235 |
| 2014 | 155 |

Note the reduction in acreage of milfoil since 2009. As of fall, 2014, all milfoil treated in the lake appeared to be dying. A spring 2015 survey is planned.

## 2.0 AQUATIC PLANT SURVEY METHODS

The aquatic plant sampling methods used for lake surveys of aquatic plant communities commonly consist of shoreline surveys, visual abundance surveys, transect surveys, AVAS surveys, and Point-Intercept Grid surveys. The Michigan Department of Environmental Quality (MDEQ) prefers that an Aquatic Vegetation Assessment Site (AVAS) Survey, or a GPS Point-Intercept survey (or both) be conducted on most inland lakes following large-scale aquatic herbicide treatments to assess the changes in aquatic vegetation structure and to record the relative abundance and locations of native aquatic plant species. Due to the large size and shallow mean depth of Lake Mitchell, a bi-seasonal GPS Point-Intercept grid matrix survey is conducted to assess all aquatic species, including emergent and floating-leaved species. In 2014, the use of a side-scan sonar GPS device to scan the aquatic plant biovolume of the lake was conducted using a Lowrance® HDS 8 GPS side and bottom scanning sonar unit with Bio Base software.

### 2.1 The GPS Point-Intercept Survey Method

While the MDEQ AVAS protocol considers sampling vegetation using visual observations in areas around the littoral zone, the Point-Intercept Grid Survey method is meant to assess vegetation throughout the entire surface area of a lake (Madsen et *al*. 1994; 1996). This method involves conducting measurements at Global Positioning Systems (GPS)-defined locations that have been pre-selected on the computer to avoid sampling bias. Furthermore, the GPS points are equally spaced on a map. The points should be placed together as closely and feasibly as possible to obtain adequate information of the aquatic vegetation communities throughout the entire lake. At each GPS Point location, two rake tosses are conducted and the aquatic vegetation species presence and abundance are estimated. In between the GPS points, any additional species and their relative abundance are also recorded using visual techniques.

This is especially important to add to the Point-Intercept method, since EWM and other invasive plants may be present between GPS points but not necessarily at the pre-selected GPS points. Once the aquatic vegetation communities throughout the lake have been recorded using the GPS points, the data can be placed into a Geographic Information System (GIS) software package to create maps showing the distribution and relative abundance of particular species. The GPS Point- Intercept method is particularly useful for monitoring aquatic vegetation communities through time and for identification of nuisance species that could potentially spread to other previously uninhabited areas of the lake.

**The GPS Point-Intercept method surveys on June 16, 2014 and on September 29, 2014 consisted of 1,888 equidistantly-spaced grid points on Lake Mitchell, using a Lowrance® HDS 8 50-satellite GPS WAAS-enabled unit (accuracy within 2 feet; Figure 1). The objective of the surveys is to compare the changes in both milfoil and native aquatic vegetation prior to treatment and after treatment.** A combination of rake tosses and visual data accounted for each point and the distance between points for the survey. In addition, a biovolume scan of al submersed aquatic vegetation in the lake was conducted (Figure 2).

## 3.0 AQUATIC PLANT SURVEY RESULTS FOR 2014

The 2014 aquatic vegetation surveys of Lake Mitchell were necessary to record the relative abundance and locations of native aquatic plant species present and to record the current distribution of EWM and HWM within the lake. Currently, the majority of the milfoil in the lake is HWM since previous infestations by EWM were successfully controlled.

### 3.1 Lake Mitchell Exotic Aquatic Plant Species

The June 16, 2014 survey detected four invasive species, including EWM and Hybrid watermilfoil (Figure 3). The distribution of HWM in June of 2014 (before treatment) is shown in Figure 4. Distribution "post-treatment" will need to be conducted in spring of 2015 due to observations of standing crop (dead but present) in the late September of 2014. Exotic species found in Lake Mitchell during 2014 are listed below in Table 1. Figures 3 and 4 show the differences in overall aquatic plant biovolume in June of 2013 and 2014, respectively. There was less overall native aquatic plant growth and milfoil growth during the 2014 season. Figure 5 shows the distribution of milfoil in June of 2014 and Figure 6 shows the distribution of milfoil in August of 2014. The other submersed exotic Curly-Leaf Pondweed (Figure 7), and emergent Purple Loosestrife (Figure 8) are also shown below.

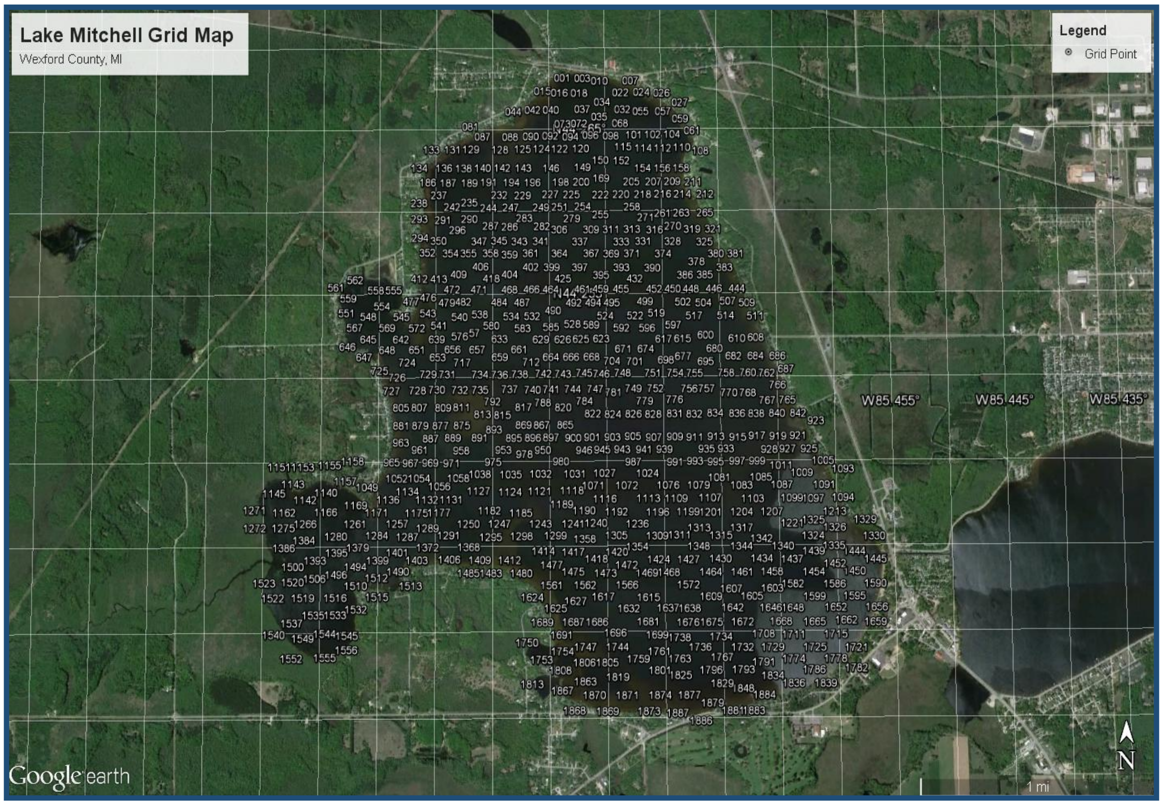



Figure 1. A map showing GPS sampling location points on Lake Mitchell, Wexford County, Michigan.

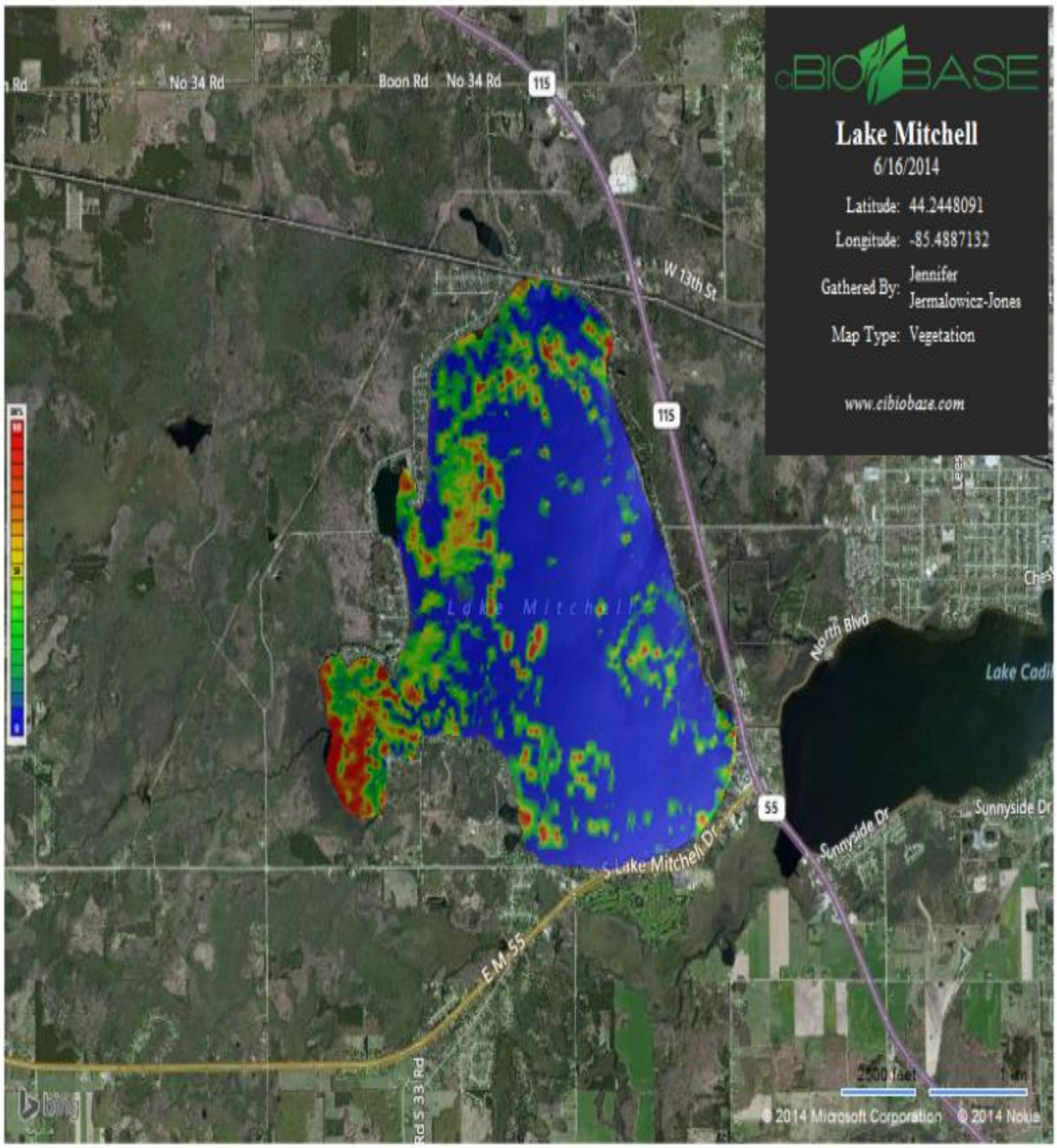



Figure 2. Whole-lake BioBase aquatic vegetation biovolume scan of all aquatic vegetation in Lake Mitchell (June, 2014). Note: Red and orange colors denote thick vegetation while yellow and green denote less dense vegetation. Blue color denotes areas void of vegetation.

| ***Aquatic plant Species and Code*** | ***Common Name*** | ***Plant Growth Form*** | ***% of Lake Covered (2014)*** |
|---|---|---|---|
| *M. spicatum var. sibiricum* | Hybrid Watermilfoil | Submersed; Rooted | 5.2 |
| *Potamogeton crispus* | Curly-Leaf Pondweed | Submersed; Rooted | 0.5 |
| *Lythrum salicaria* | Purple Loosestrife | Emergent | 2 |
| | | | |

Table 1. Exotic aquatic plant species present within or around Lake Mitchell (2014). Note: The % cover was calculated before treatment and is higher than values discussed below post-treatment.

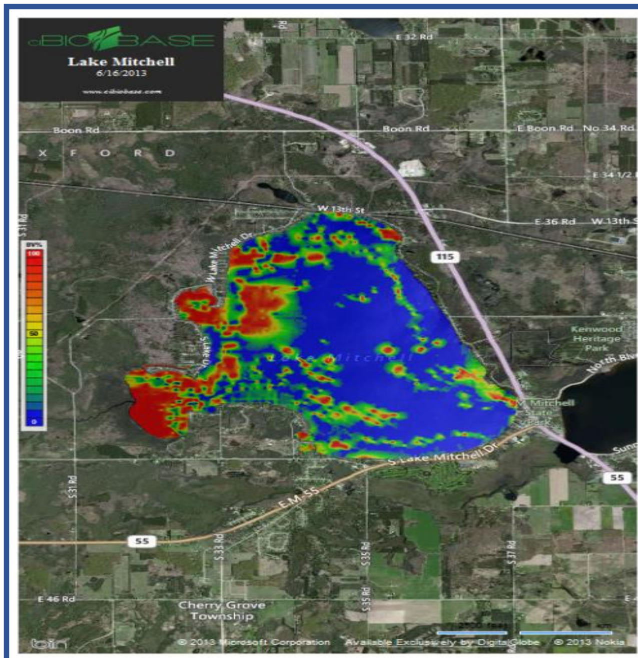



Figure 3. BioBase map June 2013

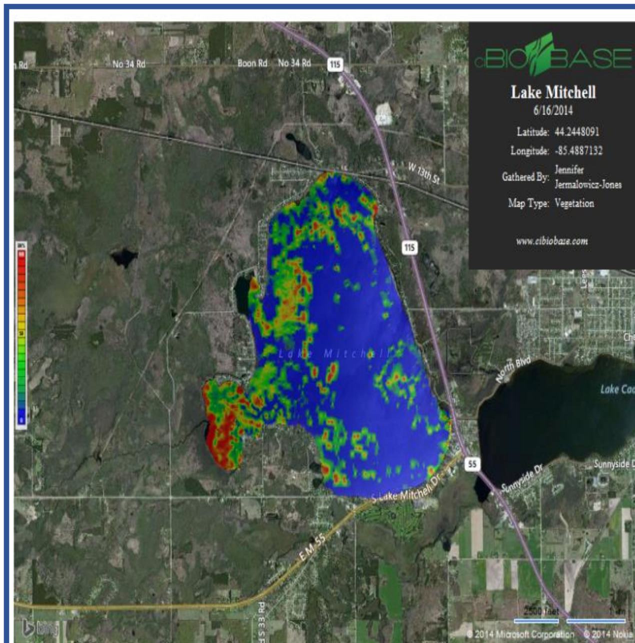



Figure 4. BioBase map June 2014

During the 2013 season, stems of hybrid watermilfoil were collected by the aquatic herbicide manufacturer SePRO® and submitted to the SePRO® laboratory to determine which types and doses of aquatic herbicides would best kill the milfoil. Additionally, the stems were subjected to the aquatic herbicide fluridone (Sonar®) in order to determine if that herbicide could possibly hold promise in future treatments. There are limitations to this method in that laboratory testing conditions are not the same as exist *in situ* in Lake Mitchell (i.e. the lake water chemistry is likely different from laboratory water chemistry and sediment chelation behavior was not an experimental component measured). Recent results indicate the hybrid milfoil within Lake Mitchell is susceptible to Sonar® at a 6 ppb bump 6 ppb dose and may possibly be an effective tool for future milfoil treatment. **On June 16, 2014, the use of Sculpin G® which is an amine salt of 2,4-D at a dose of 180-200 pounds per acre in the majority of the open waters and Renovate OTF LZR® at a dose of 120-200 pounds per acre allowed for excellent control of all of the milfoil (approximately 135 acres) in Lake Mitchell. A later second treatment on August 13, 2014 with 20 new acres of milfoil was used with Sculpin G® at a dose of 200 pounds per acre and Renovate OTF LZR® at a dose of 160 pounds per acre.**

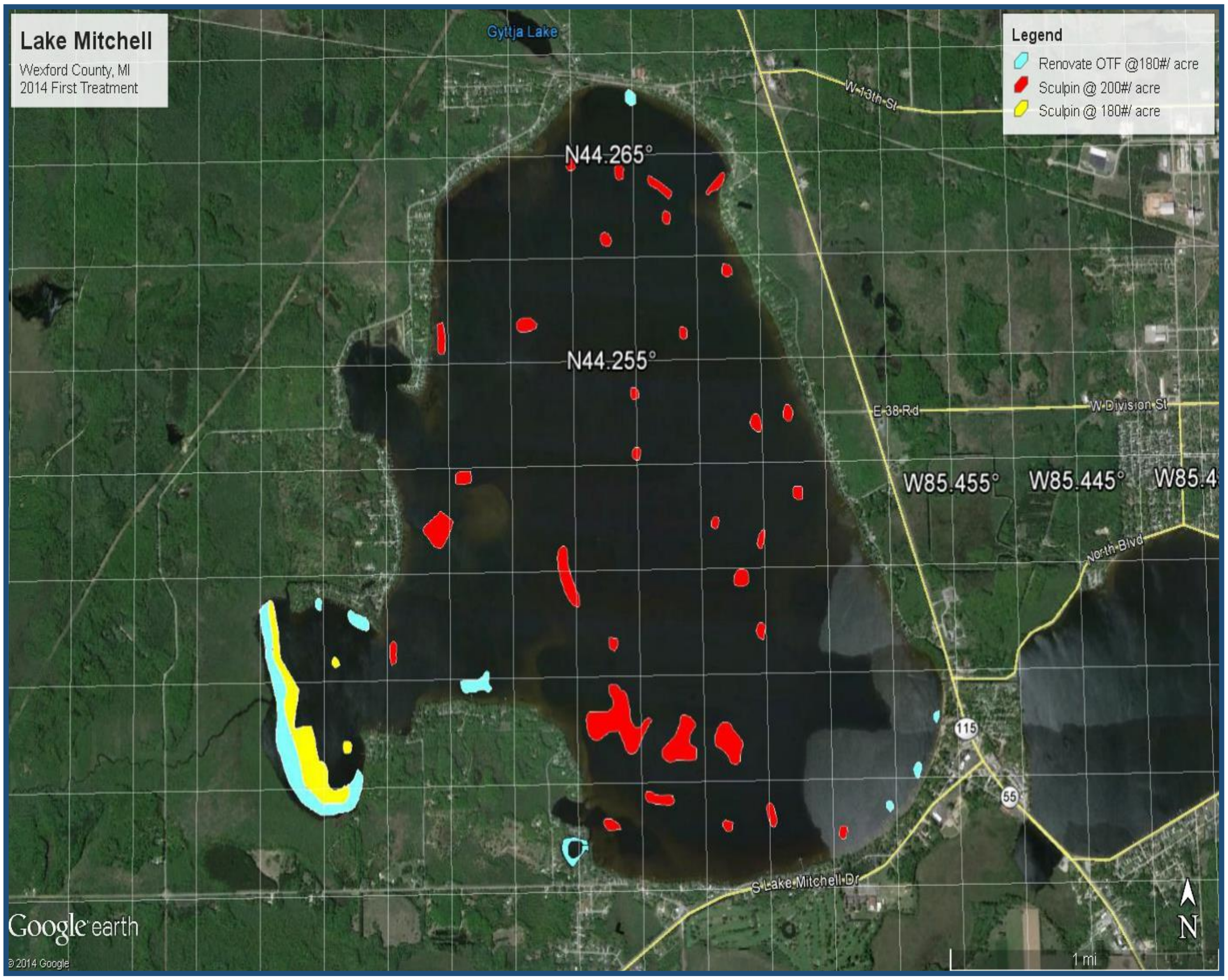



Figure 5. HWM distribution in Lake Mitchell-First Treatment Map (June, 2014).

Note: The milfoil beds were observed to be dead in late September of 2014. A spring 2014 survey will reveal how much HWM remains since it takes winter decay to remove dead biomass months after treatment with systemic herbicides.

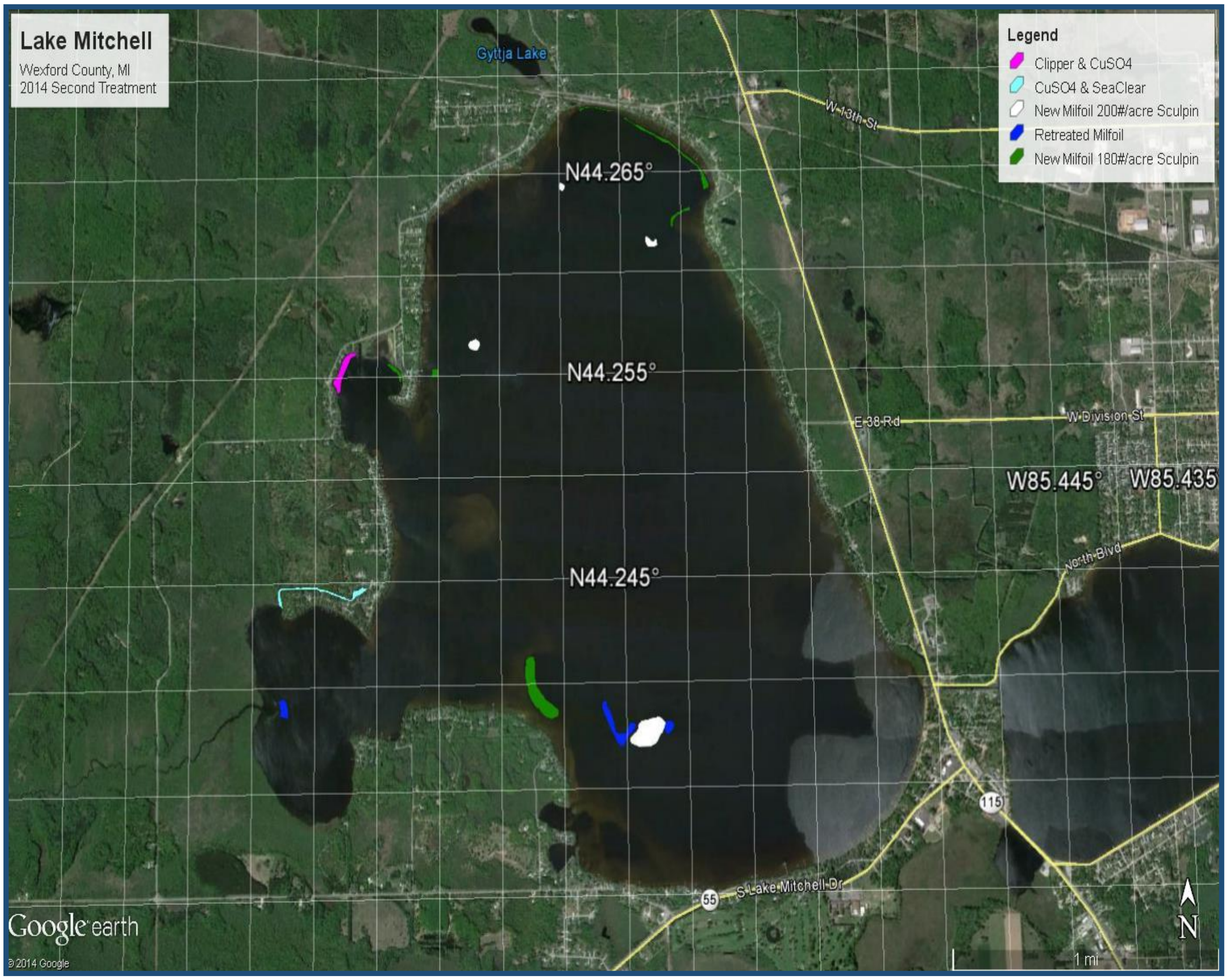



Figure 6. HWM distribution in Lake Mitchell-Second Treatment Map (August, 2014).

Note: The milfoil beds were observed to be dead in late September of 2014. A spring 2014 survey will reveal how much HWM remains since it takes winter decay to remove dead biomass months after treatment with systemic herbicides.

Figure 7. A photograph of the Curly-Leaf Pondweed (*Potamogeton crispus*) ©RLS

Figure 8. A photograph of Purple Loosestrife (*Lythrum salicaria*) ©RLS

### 3.2 Lake Mitchell Native Aquatic Plant Species

The native aquatic vegetation present in Lake Mitchell has shown a significant re-bound since the EWM has been reduced from the 2009 densities. In 2009 with the dense EWM beds observed, there were only 15 submersed, 4 floating-leaved, and 5 emergent species. **In 2012-2014, a total of 18 submersed, 4 floating-leaved, and 5 emergent aquatic plant species were found for a grand total of 27 species** (Table 2). This indicates a **very high biodiversity of aquatic vegetation in Lake Mitchell** and also emphasizes that 3 more native species have germinated in the lake since reduction of light limitation from EWM and HWM canopies that once occupied the east and south regions of the lake. **The numbers in Table 2 on page 19 were calculated based on aquatic vegetation found among the 1,888 GPS grid points sampled.** A few photographs of common aquatic plant species found in Lake Mitchell can be found on page 19 (Figures 9-12) and rare species are displayed on page 20 (Figures 13-16).

| ***TABLE 2. Aquatic Plant Species*** | ***Common Name*** | ***Plant Growth Form*** | ***% Coverage of Sampled Lake Area (2014)*** |
|---|---|---|---|
| *Chara vulgaris* (macroalga) | Muskgrass | Submersed; Rooted | 22 |
| *Potamogeton pectinatus* | Sago Pondweed | Submersed; Rooted | 24 |
| *Potamogeton robbinsii* | Fern-leaf Pondweed | Submersed; Rooted | 67 |
| *Potamogeton gramineus* | Variable-leaf Pondweed | Submersed; Rooted | 25 |
| *Potamogeton praelongus* | White-stem Pondweed | Submersed; Rooted | 51 |
| *Potamogeton richardsonii* | Clasping-leaf Pondweed | Submersed; Rooted | 27 |
| *Potamogeton illinoensis* | Illinois Pondweed | Submersed; Rooted | 25 |
| *Potamogeton amplifolius* | Large-leaf Pondweed | Submersed; Rooted | 22 |
| *Myriophyllum sibiricum* | Northern Watermilfoil | Submersed; Rooted | 7 |
| *Ceratophyllum demersum* | Coontail | Submersed; Non-rooted | 12 |
| *Elodea canadensis* | Common Waterweed | Submersed: Rooted | 24 |
| *Utricularia vulgaris* | Common Bladderwort | Submersed; Non-rooted | 27 |
| *Utricularia minor* | Mini Bladderwort | Submersed; Non-rooted | 11 |
| *Najas guadalupensis* | Southern Naiad | Submersed; Rooted | 9 |
| *Najas flexilis* | Slender Naiad | Submersed; Rooted | 29 |
| *Potamogeton pusillus* | Small-leaf Pondweed | Submersed; Rooted | 27 |
| *Nymphaea odorata* | White Waterlily | Floating-leaved | 5 |
| *Nuphar variegata* | Yellow Waterlily | Floating-leaved | 7 |
| *Brasenia schreberi* | Watershield | Floating-leaved | 8 |
| *Lemna trisulca* | Star Duckweed | Floating-Leaved; Non-rooted | 2 |
| *Pontedaria cordata* | Pickerelweed | Emergent | 6 |
| *Typha latifolia* | Cattails | Emergent | 12 |
| *Scirpus acutus* | Bulrushes | Emergent | 42 |
| *Decodon verticillatus* | Swamp Loosestrife | Emergent | 9 |
| *Myriophyllum tenellum* | Leafless Watermilfoil | Submersed; Rooted | 71 |
| *Eleocharis acicularis* | Spikerush | Emergent | 27 |
| *Bidens beckii* | Water Marigold | Submersed; Rooted | 17 |

## Most Common Aquatic Plant Species Present in Lake Mitchell (2012-2014)

Figure 9. A photograph of Fern-Leaf Pondweed (*Potmageton robbinsii*) ©RLS

Figure 10. A photograph of Leafless Watermilfoil (*Myriophyllum tenellum*) ©RLS

Figure 11. A photograph of White-stem Pondweed (*Potmageton praelongus*) ©RLS

Figure 12. A photograph of Bulrushes (*Scirpus acutus*) ©RLS

## Most Rare Aquatic Plant Species Present in Lake Mitchell (2012-2014)

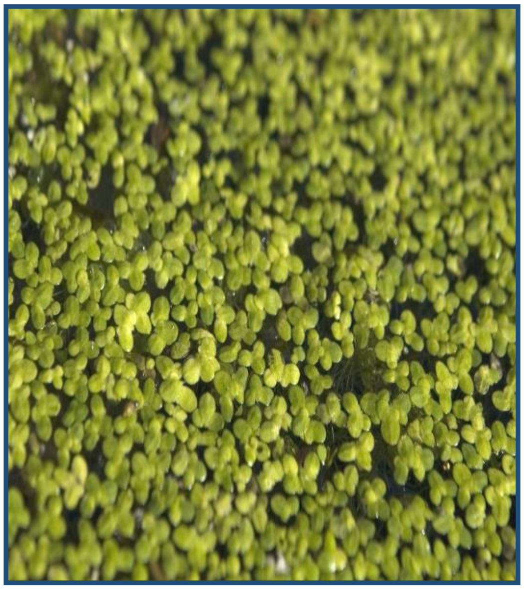


Figure 13. A photograph of Duckweed (*Lemna minor*) ©RLS

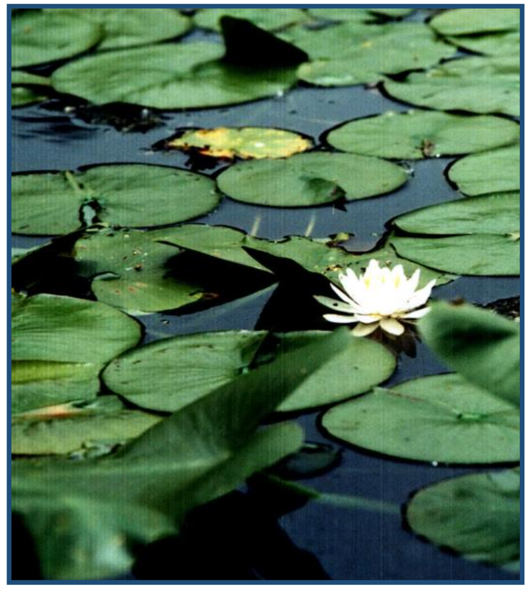


Figure 14. A photograph of White Waterlily (*Nymphaea odorata*)©RLS

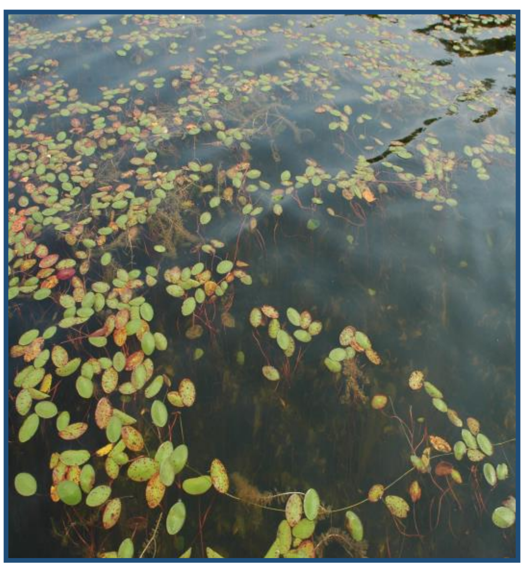


Figure 15. A photograph of Watershield (*Brasenia schreberi*) ©RLS

Figure 16. A photograph of Mini Bladderwort (*Utricularia minor*) ©RLS

## 3.3 Lake Mitchell Purple Loosestrife Beetle Assessment

Purple loosestrife is an invasive (i.e. exotic) emergent aquatic plant that inhabits wetlands and shoreline areas. It has showy magenta-colored flowers that bloom in mid-July and terminate in late September. The seeds are highly resistant to tough environmental conditions and may reside in the ground for extended periods of time. It exhibits rigorous growth and may out-compete other favorable native emergents such as cattails (*Typha latifolia*) or native swamp loosestrife (*Decodon verticillatus*) and thus reduce the biological diversity of localized ecosystems. The plant is spreading rapidly across the United States and is converting diverse wetland habitats to monocultures with substantially lower biological diversity. Biological control vectors such as the beetles *Galerucella calmariensis* (Figure 17) and *G. pusilla* have been effective on the treatment of shoreline purple loosestrife in many locations throughout the Midwest. However, these beetles usually prefer a large stand of Purple Loosestrife to promote their population. As a result, beetles that were cultured at the Kalamazoo Nature Center were released into areas around Lake Mitchell that had adequate stands of the plant. **A total of 27 cultured pots were released on July 8, 2014 into areas that contained significant stands of Purple Loosestrife plants and that were previously stocked (specifically, Big Cove and Franke North Cove).** A damage index similar to the weevil index was used to determine the degree of damage observed on individual florescences (flowers) on individual Purple Loosestrife plants. **On September 4$^{th}$, 2014, approximately 3-5 florescences on different plants were evaluated at each of the stocking sites. The mean damage index was 3.7±0.8 and the mean number of beetles observed on a given florescence was 1.7 ±1.4.** This data indicates that the beetles have resulted in significant damage of many loosestrife plants but due to a decline in number beetles actually observed (relative to 2013), more stocking is recommended in future years. A map showing the distribution of the beetles is shown below in Figure 18.

Figure 17. *Galerucella*, the Purple Loosestrife-eating beetle.

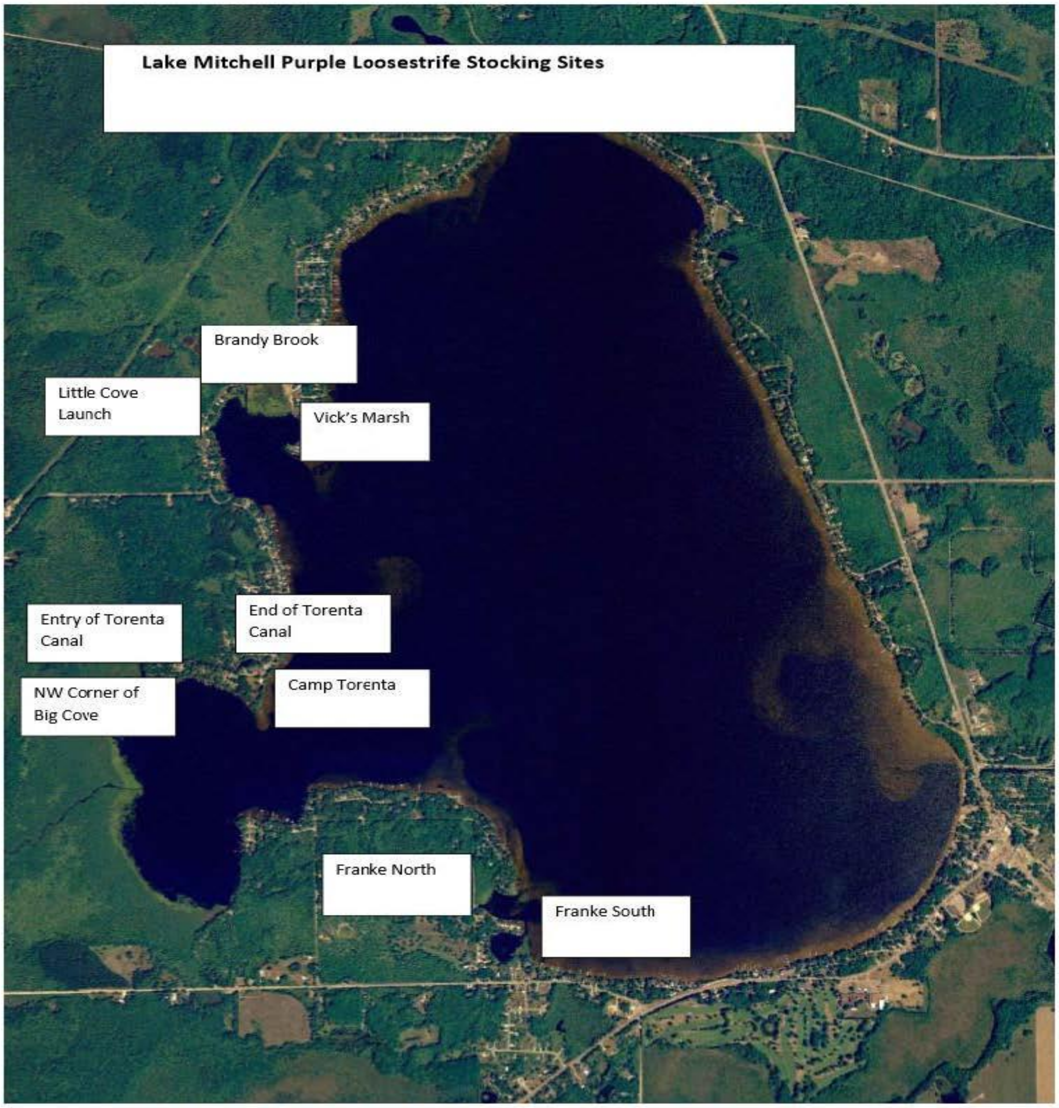



Figure 18. Purple Loosestrife beetle stocking sites around Lake Mitchell. Note: On July 8, 2014, sixteen pots of beetles were stocked in Big Cove and 11 pots were stocked in Franke North Cove.

## 4.0 LAKE MITCHELL 2014 WATER QUALITY RESULTS

The quality of water is highly variable among Michigan inland lakes, although some characteristics are common among particular lake classification types. The water quality of Lake Mitchell is affected by both land use practices and climatic events. Climatic factors (i.e., spring runoff, heavy rainfall) may alter water quality in the short term; whereas, anthropogenic (man-induced) factors (i.e. shoreline development, lawn fertilizer use) alter water quality over longer time periods. Furthermore, lake water quality helps to determine the classification of particular lakes (Table 3). Lakes that are high in nutrients (such as phosphorus and nitrogen) and chlorophyll-*a*, and low in transparency are classified as **eutrophic**; whereas those that are low in nutrients and chlorophyll-*a*, and high in transparency are classified as **oligotrophic**. Lakes that fall in between these two categories are classified as **mesotrophic**. **Lake Mitchell is classified as eutrophic based on its moderately low transparency and high nutrient and moderate chlorophyll-*a* concentrations.**

| *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 3. Lake Trophic Status Classification Table (MDEQ)

### 4.1 Lake Mitchell and Tributary Water Quality Parameters

Water quality parameters such as dissolved oxygen, water temperature, conductivity, turbidity, total dissolved solids, pH, total alkalinity, total phosphorus, Secchi transparency, chlorophyll-*a*, among others, all respond to changes in water quality and consequently serve as indicators of water quality change. These parameters were collected at the deep basins and tributaries (Figure 19) and are discussed below along with water quality data specific to Lake Mitchell. (Tables 4-6 and assorted graphs). Water quality samples for the lake and tributaries were collected on June 16, 2014.

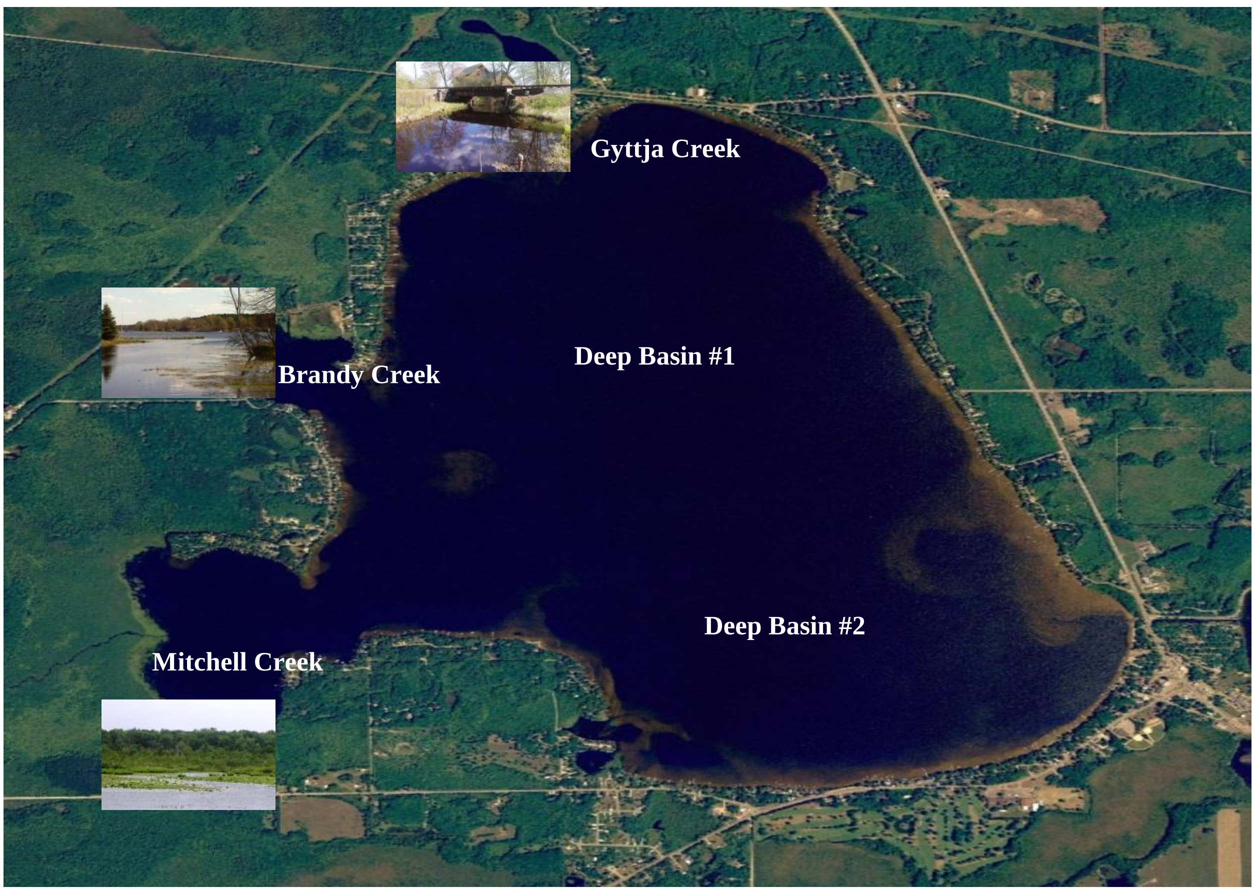



Figure 19. A location map of water quality lake and tributary sampling stations on Lake Mitchell (June, 2014).

***Dissolved Oxygen***

Dissolved oxygen (DO) is a measure of the amount of oxygen that exists in the water column. In general, DO levels should be greater than 5 mg $L^{-1}$ to sustain a healthy warm-water fishery. Dissolved oxygen concentrations in Lake Mitchell may decline if there is a high biochemical oxygen demand (BOD) where organismal consumption of oxygen is high due to respiration. Dissolved oxygen is generally higher in colder waters. Dissolved oxygen is measured in milligrams per liter (mg $L^{-1}$) with the use of a DO meter and/or through the use of Winkler titration methods. The June DO concentrations in Lake Mitchell were high at the surface and slightly lower at the lake bottom. **DO ranged from 5.0 mg $L^{-1}$ at the bottom to 10.4 mg $L^{-1}$ at the surface, with average values around 8.4 mg $L^{-1}$ for the tributaries.** A decline in DO may cause increased release rates of phosphorus (P) from Lake Mitchell bottom sediments if DO levels drop to near zero milligrams per liter.

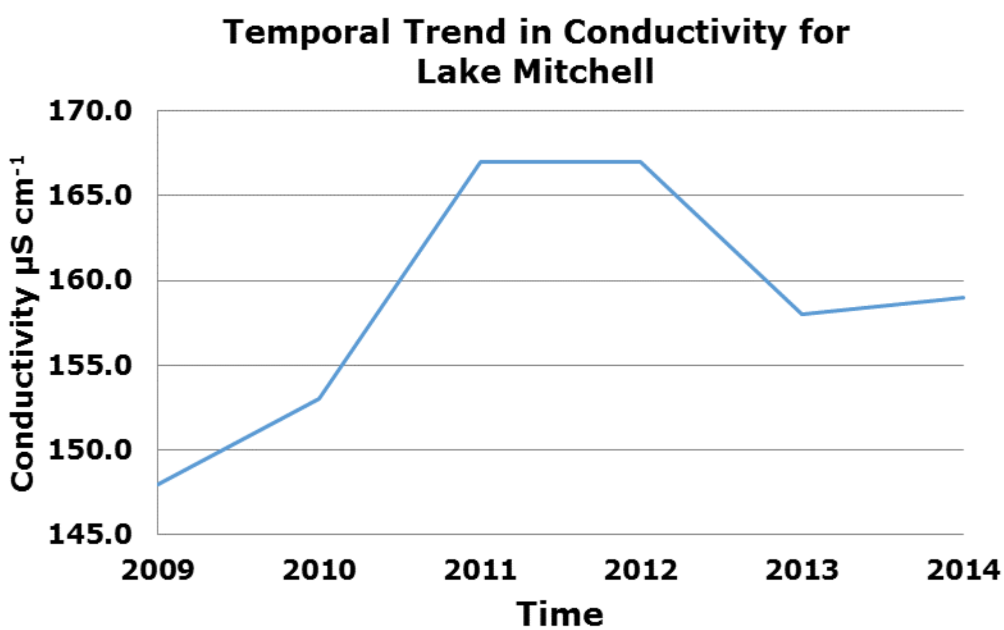
***Water Temperature***

The water temperature of lakes varies within and among seasons and is nearly uniform with depth under winter ice cover because lake mixing is reduced when waters are not exposed to wind. When the upper layers of water begin to warm in the spring after ice-off, the colder, dense layers remain at the bottom. This process results in a “thermocline” that acts as a transition layer between warmer and colder water layers. During the fall season, the upper layers begin to cool and become denser than the warmer layers, causing an inversion known as “fall turnover”. In general, lakes with deep basins will stratify and experience turnover cycles. Water temperature is measured in degrees Celsius (ºC) or degrees Fahrenheit (ºF) with the use of a submersible thermometer. The June, 2014 water temperatures of Lake Mitchell demonstrated a notable thermocline between the surface and a “middle depth” and bottom since the lake was sampled during a stratified period. **Water temperatures ranged from 62.8 ºF at the surface to 51.2 ºF at the lake bottom. The water temperatures for all of the**

**tributaries were higher and averaged 68 ºF, with the lowest temperature observed in Mitchell Creek.**

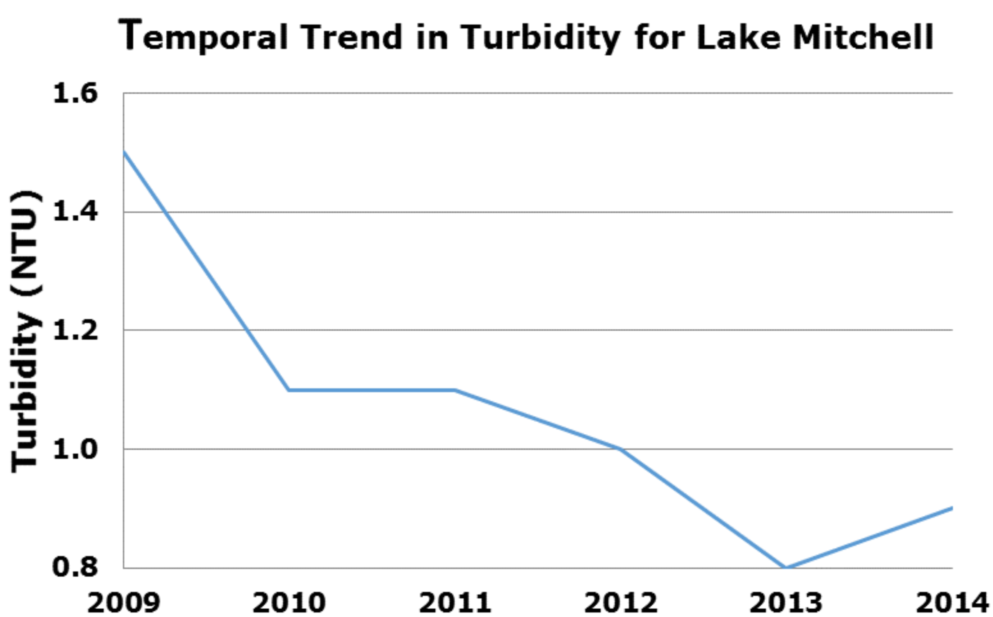
*Conductivity*

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. Conductivity is measured in microsiemens per centimeter (µS $cm^{-1}$) with the use of a conductivity probe and meter. **Conductivity values for Lake Mitchell were low and ranged from 157-161 µS $cm^{-1}$, which was lower than in previous years. These values are also significantly lower than many inland lakes. The conductivity of Mitchell and Gyttja Creeks was 229 µS $cm^{-1}$ and 212 µS $cm^{-1}$, respectively, and the conductivity of Brandy Brook was 115 µS $cm^{-1}$, which was slightly lower than the other two tributaries.** A graph showing the temporal trend in mean conductivity for Lake Mitchell is shown below.



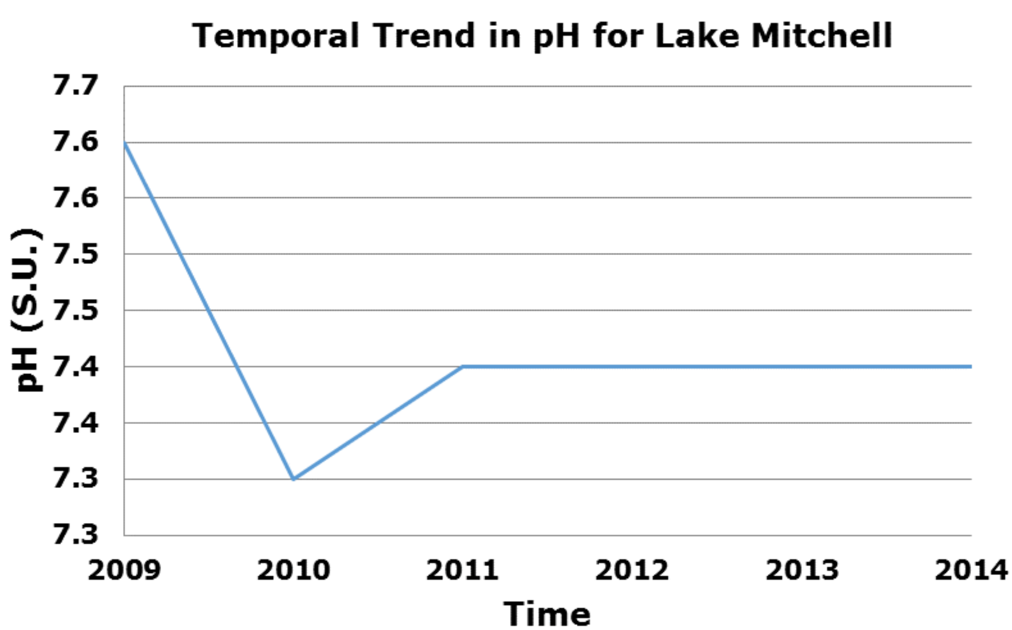
***Turbidity***

Turbidity is a measure of the loss of water transparency due to the presence of suspended particles. The turbidity of water increases as the number of total suspended particles increases. Turbidity may be caused from erosion inputs, phytoplankton blooms, stormwater discharge, urban runoff, re-suspension of bottom sediments, and by large bottom-feeding fish such as carp. Particles suspended in the water column absorb heat from the sun and raise the water temperature. Since higher water temperatures generally hold less oxygen, shallow turbid waters are usually lower in dissolved oxygen. Turbidity is measured in Nephelometric Turbidity Units (NTU's) with the use of a turbimeter. The World Health Organization (WHO) requires that drinking water be less than 5 NTU's; however, recreational waters may be significantly higher than that. **The turbidity of Lake Mitchell was low and ranged from 0.6-1.4 NTU's during the June sampling event which was lower than in previous years.** A graph showing the temporal trends in mean turbidity for Lake Mitchell is shown below.



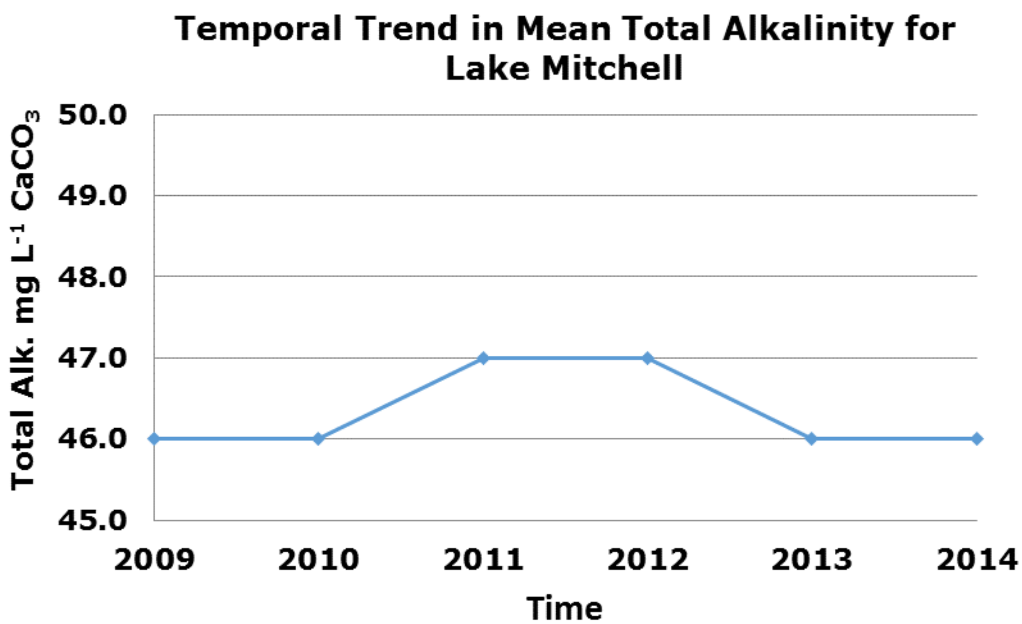
***pH***

pH is the measure of acidity or basicity of water. The standard pH scale ranges from 0 (acidic) to 14 (alkaline), with neutral values around 7. 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). pH is measured with a pH electrode and pH-meter in Standard Units (S.U). **The pH of Lake Mitchell water ranged from 7.3–7.4 during the June sampling. The mean pH of the tributaries was 7.4, which was similar to those measured in the lake during June.** The graph below shows the trends in mean pH in Lake Mitchell over a six year period.



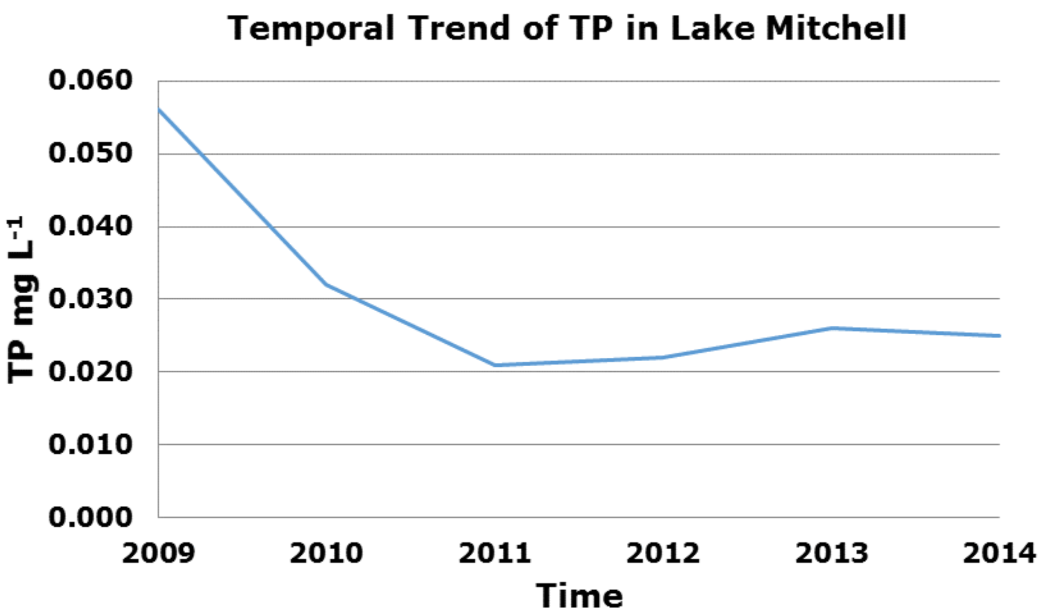

***Total Alkalinity***

Total alkalinity is the measure of the pH-buffering capacity of lake water. 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 is measured in milligrams per liter of $CaCO_3$ through an acid titration method. The total alkalinity of Lake Mitchell is considered "low" (< 50 mg $L^{-1}$ of $CaCO_3$), and indicates that the water is soft. **Total alkalinity ranged from 45-46 mg $L^{-1}$ of $CaCO_3$ during the June, 2014 sampling.** 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 graph below shows the trends in mean total alkalinity in Lake Mitchell over the past six years.



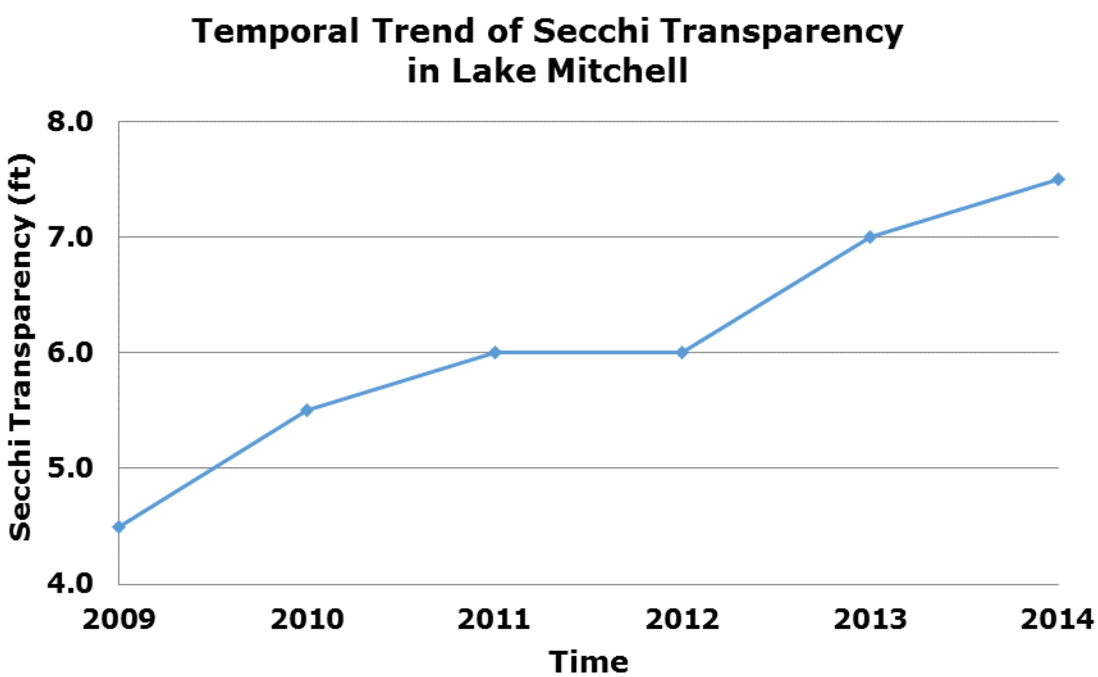

***Total Phosphorus***

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. Lakes which contain greater than 0.025 mg $L^{-1}$ of TP are defined as eutrophic or nutrient-enriched. 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. Since the water temperatures were still fairly low at the time of sampling, the TP concentrations did not vary substantially among depths and ranged from **0.020 mg $L^{-1}$ at the surface to 0.033 mg $L^{-1}$ near the bottom. The mean TP concentration for the tributaries was 0.034 mg $L^{-1}$, with Gyttja Creek possessing the highest TP value.** The graph below shows the trends in mean TP in Lake Mitchell over the past six years.




***Secchi Transparency***

Secchi transparency is a measure of the clarity or transparency of lake water, and is measured with the use of an 8-inch diameter standardized Secchi disk. Secchi disk transparency is measured in feet (ft.) or meters (m) by lowering the disk over the shaded side of a boat around noon and taking the mean of the measurements of disappearance and reappearance of the disk. Elevated Secchi transparency readings allow for more aquatic plant and algae growth. Eutrophic systems generally have Secchi disk transparency measurements less than 7.5 feet due to turbidity caused by excessive planktonic algae growth. **The Secchi transparency of Lake Mitchell averaged 7.5 feet over the deep basins during the 2014 sampling period (based on n=5 measurements by RLS staff).** This transparency is adequate though 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. The graph below shows the trends in Secchi transparency for Lake Mitchell over that past six years.




***Total Dissolved Solids***

Total Dissolved Solids (TDS) is the measure of the amount of dissolved organic and inorganic particles in the water column. Particles dissolved in the water column absorb heat from the sun and raise the water temperature and increase conductivity. Total dissolved solids are often measured with the use of a calibrated meter in mg $L^{-1}$. Spring values would likely be higher due to increased watershed inputs from spring runoff and/or increased planktonic algal communities. **The concentration of TDS in Lake Mitchell during the June sampling event**

**ranged from 55 mg $L^{-1}$ to 69 mg $L^{-1}$, which was slightly lower than in 2011-2013. The TDS of tributary waters ranged from 87 mg $L^{-1}$ to 99 mg $L^{-1}$, which was lower than in previous years but is still higher than values measured in the lake.**

***Oxidative Reduction Potential***

The oxidation-reduction potential ($E_h$) of lake water describes the effectiveness of certain atoms to serve as potential oxidizers and indicates the degree of reductants present within the water. In general, the Eh level (measured in millivolts) decreases in anoxic (low oxygen) waters. Low $E_h$ values are therefore indicative of reducing environments where sulfates (if present in the lake water) may be reduced to hydrogen sulfide ($H_2S$). Decomposition by microorganisms in the hypolimnion may also cause the $E_h$ value to decline with depth during periods of thermal stratification. **The $E_h$ (ORP) values for Lake Mitchell ranged from 156.1 mV and 98.2 mV from the surface to the bottom within the lake, and indicated oxidized rather than reduced conditions. The ORP of tributary waters ranged from 141.4 mV to 169.3 mV.**

***Chlorophyll-a and Phytoplankton Communities***

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 $L^{-1}$ are found in nutrient-poor or oligotrophic lakes. Chlorophyll-*a* is measured in micrograms per liter (µg $L^{-1}$) with the use of an acetone extraction method and a spectrometer. The chlorophyll-*a* concentrations in Lake Mitchell were determined by collecting a composite sample of the algae throughout the water column at the deep basins from just above the lake bottom to the lake surface. **The chlorophyll-*a* concentration of Deep Basin #1 was 3.2 µg $L^{-1}$ and the concentration for Deep Basin #2 was 3.3 µg $L^{-1}$, which indicated an abundance of green algae**

**in the water column. These numbers were lower than those observed in 2012-2013 and correlate with higher water clarity observed in 2014.**

**A composite sample of the Lake Mitchell water column was collected over both deep basins during the June, 2014 sampling date and also analyzed for algal species composition.** Sub-samples from the collected deep basin samples were analyzed under a bright field compound microscope and identified to the genus level. The dominant genera present included *Haematococcus* sp., *Chloromonas* sp., *Chlorella* sp., *Gleocystis* sp., *Staurastrum* sp.,*Euglena* sp., *Scenedesmus* sp., *Melosira* sp., *Fragillaria* sp., and *Synedra* sp. The genera present included the Chlorophyta (green algae): *Haematococcus* sp., *Euglena* sp., *Scenedesmus* sp., *Cladophora* sp., *Ulothrix* sp., *Micrasterias* sp., *Hydrodictyon* sp., and *Quadrigula* sp.; the Cyanophyta (blue-green algae): *Oscillatoria* sp., *Microcystis* sp., and *Gleocapsa* sp.; the Bascillariophyta (diatoms): *Synedra* sp., *Navicula* sp., *Fragilaria* sp., *Asterionella* sp., *Cymbella* sp., *Pinnularia* sp., *Rhoicosphenia* sp., *Diatomella* sp., and *Opehora* sp.

These genera indicate a favorable balance of green algae, diatoms and blue-green algae to serve as the autotrophic base of the Lake Mitchell aquatic ecosystem food chain.

| Depth ft. | Water Temp ºF | DO mg $L^{-1}$ | pH S.U. | Cond. µS $cm^{-1}$ | Turb. NTU | ORP mV | Total Dissolved Solids mg $L^{-1}$ | Total Alk. mg $L^{-1}$ $CaCO_3$ | Total Phos. mg $L^{-1}$ |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 62.8 | 10.4 | 7.3 | 159 | 0.6 | 144.0 | 58 | 45 | 0.020 |
| 10 | 59.2 | 7.9 | 7.4 | 157 | 0.9 | 122.3 | 62 | 46 | 0.028 |
| 19.5 | 51.3 | 5.0 | 7.4 | 161 | 1.4 | 98.2 | 69 | 45 | 0.031 |

Table 4. Lake Mitchell water quality parameter data collected over Deep Basin 1 on June 16, 2014.

| Depth ft. | Water Temp ºF | DO mg $L^{-1}$ | pH S.U. | Cond. µS $cm^{-1}$ | Turb. NTU | ORP mV | Total Dissolved Solids mg $L^{-1}$ | Total Alk. mg $L^{-1}$ $CaCO_3$ | Total Phos. mg $L^{-1}$ |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 63.0 | 9.9 | 7.3 | 160 | 0.6 | 156.1 | 55 | 45 | 0.020 |
| 9 | 60.1 | 8.2 | 7.4 | 160 | 0.9 | 142.7 | 55 | 46 | 0.020 |
| 20 | 51.2 | 5.2 | 7.3 | 159 | 1.1 | 101.2 | 57 | 46 | 0.033 |

Table 5. Lake Mitchell water quality parameter data collected over Deep Basin 2 on June 16, 2014.

| *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** | 66.3 | 8.9 | 7.4 | 229 | 93 | 146.2 | 0.030 |
| **Brandy** | 67.2 | 8.5 | 7.3 | 115 | 99 | 169.3 | 0.032 |
| **Gyttja** | 69.4 | 7.7 | 7.3 | 212 | 87 | 141.4 | 0.039 |

Table 6. Lake Mitchell Tributary water quality parameter data collected on June 16, 2014.

## 5.0 LAKE MITCHELL AND TORENTA CANAL 2015 MANAGEMENT RECOMMENDATIONS

The use of aquatic chemical herbicides are regulated by the MDEQ under Part 33 (Aquatic Nuisance) of the Natural Resources and Environmental Protection Act, P.A. 451 of 1994, and require a permit. The permit contains a list of approved herbicides for a particular body of water, as well as dosage rates, treatment areas, and water use restrictions. Wherever possible, it is preferred to use a systemic aquatic herbicide for longer-lasting plant control. The continued use of Sculpin G® and Renovate OTF LZR® is recommended for spot-treatment of invasive milfoil throughout the lake. Doses of both should not be less than 120 pounds per acre for optimal efficacy.

**The coves** should be managed for both navigability and aesthetics and thus strong contact herbicides that offer season-long control are recommended. Clipper® contains the active ingredient, flumioxazin, which works best for actively growing submersed vegetation of all types including EWM, HWM, Elodea, pondweeds, floating-leaved plants, and even some types of algae. RLS recommends treating all of the infested areas with Clipper® at 200-400 ppb. Dense pondweed growth may require heavy treatment with Aquathol-K, especially in Franke Cove South where thick

Large-leaf pondweeds dominate. Additional mechanical harvesting may be pursued in late summer if removal of dead biomass and/or new infestations occur. **The Torenta Canal** should be treated with chelated copper to control *Cladophora* and contact herbicides such as Reward® and Aquathol-K® to decrease growth of nuisance native plants. The canal is prone to severe stagnation which could be alleviated by aeration. **Care must be taken wherever possible to protect the diversity of native aquatic vegetation in Lake Mitchell which is so pivotal to the fishery and overall lake health.**

**RLS limnologists will continue to monitor the Purple Loosestrife beetle efficacy in all of the previously stocked areas. Additional stocking will occur during the summer of 2015 and beetles will be applied to all previously stocked areas.**

**Water quality parameters** as noted above will be monitored in the lake and tributaries during 2015.

RLS also has created some proposed management methods and estimated associated costs for the Torenta Canal below:

| Improvement Method | Advantages | Disadvantages | Approx. Cost for Canal | Rating for Potential Success |
|---|---|---|---|---|
| **Dredging** | **Immediate, remove mass** | **Costly, fill-in imminent, will not reduce stagnation** | **~ $50K-$80K** | **3** |
| **Aeration** | **Reduces stagnation, reduces algae, reduces muck** | **Costly, requires electricity via compressor location(s)** | **~ $19,200 for YR 1 ~$13,650 for YR 2+** | **4** |
| **Small-Mesh Harvesting** | **Immediate, remove algal biomass, cost-effective** | **Temporary, does not reduce stagnation,** | **~$3,000 per harvest** | **3** |
| **Chemical Treatment of Algae** | **Works within a week, kills algae that is present, cost-effective** | **Does not reduce stagnation, does not kill algae that is new growth post-treatment** | **$450 for 3 treatments** | **3** |
| **Biological Enzymes (*)** | **Breaks down organic muck, cost-effective, may last an entire season** | **Usually more costly than algaecides, will not reduce stagnation alone** | **~ $2,500 for 1 treatment** | **3** |

**Note: Rating for Potential of Success was created with a 1-5 scale with a 5 denoting very high probability of improvement of conditions in the Torenta Canal and 1 with a lower probability of improvement of problematic conditions.**

**∗ Biological Enzymes are usually added along with aeration to augment the effects of aeration on breakdown of muck and algae. Adding Aeration with Enzymes may result in a success probability score of 4-5.**

## 6.0 LITERATURE CITED

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