# Lake Mitchell 2013 Annual Progress Report

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

**January, 2014**


Prepared for: Lake Mitchell Improvement Board
C/o Mike Solomon, Chair
400 Lake Street, Suite 600
Cadillac, MI 49601

Prepared by: Restorative Lake Sciences
Jennifer Jermalowicz-Jones, PhD Candidate
Water Resources Director
18406 West Spring Lake Road
Spring Lake, MI 49456
www.restorativelakesciences.com

## TABLE OF CONTENTS

**SECTION** **PAGE**

## FIGURES

## TABLES

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

## January, 2014

---

## 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.

In previous years, milfoil was treated with doses of systemic (root-killing) aquatic herbicides such as 2,4-D and triclopyr. The standard doses of 2,4-D ranged from 80-150 pounds per acre and doses of triclopyr were at 150 pounds per acre for granular and 3.0 gallons per acre for liquid. A tolerance to these doses preceded the genetic determination of hybrid watermilfoil in the lake in 2011, which required higher doses of systemic herbicides along with varied product usage over time to reduce the probability of further tolerance.

**An initial whole lake GPS grid survey of 1,888 sampling points and lake scan was conducted on June 10-11, 2013 and found approximately 420 total acres of hybrid milfoil in the main lake and coves, which represented about 16% of the lake surface area.** The distribution was patchy but large beds of milfoil were noted throughout all coves and at the northwest region of the lake. **This distribution differed greatly from previous years, since the dense biomass was noted at the east and south regions of the lake during 2009-2011.** On June 20, 2013, the systemic aquatic herbicide 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®) was used at a dose of 150 pounds per acre with some success. Treatment of this region is a challenge due to product use limitations.

The systemic herbicide liquid triclopyr (Navitrol®) was used with chelated copper algaecide to treat a bloom of dense milfoil in Big Cove. Due to the mixture of nuisance pondweeds and milfoil in Little Cove, three contact herbicides including diquat, hydrothol, and chelated copper algaecide were used together. In the Franke Coves, application of flumioxazin (Clipper®) at 200 ppb reduced the growth of all nuisance aquatic plants but a later treatment in those areas with the contacts used in Little Cove was required to suppress new growth. The Torenta Canal required an algae treatment using chelated copper (Cutrine®) for dense *Cladophora* blooms.

**A post-treatment survey on August 1, 2013** was conducted and included two members of the Lake Mitchell Improvement Board, a representative from the herbicide manufacturer, SePRO, an applicator from PLM, an aquatic biologist from RLS, and an MDEQ permitting unit representative. The survey was conducted to assess the efficacy of the treatment throughout the lake and agree on any areas needed for re-treatment. It was mutually determined by those stakeholders that a re-treatment of approximately 7 acres of HWM throughout the lake was needed and an additional 70 acres of some new milfoil growth was noted at the north region outside of the original treatment area.

**On July 12, 2013, approximately 40 pots of cultured *Galerucella* sp. beetles** were transplanted into areas that contained actively growing Purple Loosestrife. In many cases, individual beetles were hand-delivered to individual florescences of Purple Loosestrife plants. Transplant areas included Little Cove, the Franke Coves, Big Cove, and the Torenta Canal. Beetles were cultured at the Kalamazoo Nature Center in Kalamazoo, Michigan. **On August 24$^{th}$, 2013, approximately 3-5 florescences on different plants were evaluated at each of the stocking sites. The mean damage index was 3.1±1.0 and the mean number of beetles observed on a given florescence**

**was 2.5±1.3. Final surveys conducted on September 17th and October 11th, 2013 determined that many of the HWM areas that were treated showed significant damage and many beds had completely retreated to the lake bottom.** A few areas at the northwest side of the lake showed some resistance but a spring 2014 survey is needed to fully determine the extent of systemic herbicide damage. **The weevil activity in Big Cove has declined to almost non-detectable levels and future stocking of milfoil weevils in Big Cove is not advised.**

**Water quality sampling of the deep basins and tributaries of Lake Mitchell was conducted on June 16, 2013.** 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 newly revised depth contour map of the lake was created by RLS during the summer of 2013.

An inaugural Lake Mitchell and Lake Cadillac "expo" was held at the Cherry Grove Township Hall on August 10 and RLS staff educated many riparians on overall lake health, lake management activities, problems present in individual areas of the lake, and unique biota (such as macroinvertebtrates and rare aquatic plant species) found in the lake.

Finally, a post-treatment end of the season survey was conducted on September 17 by RLS staff and determined that the majority of the milfoil beds were dead or in the process of herbicide-damage decay.

**Recommendations for 2014** include the continued use of systemic aquatic herbicides in the open water and preliminary testing for MDEQ Sonar permitting requirements given 2013 results by SePRO that determined the susceptibility of Lake Mitchell milfoil plants to fluridone (Sonar®) at a 6 ppb bump 6 ppb dose. Systemic herbicides to be used in 2014 may consist of Sculpin® and Navigate® in the open waters and high dose triclopyr in the coves for milfoil control. Nuisance native aquatic plants in the coves can be treated with strong contact herbicides such as flumioxazin (Clipper® at 400 ppb) and then a mechanical harvest could follow if removal of dead biomass is desired. Over the past five years, the EWM/HWM has fluctuated between 400 acres in 2009 to a low of 273 acres in 2012. The aggressive HWM infestation in Big Cove and the northwest region of the lake in 2013 accounted for an increase in acreage. Given the post-treatment results, we anticipate much less acreage in 2014; however, it is difficult to predict distribution growth patterns of hybrid milfoil. **A key point to note is that the overall cover and distribution of the HWM has shifted dramatically over the past five years and intense surveys are needed to ascertain reduced cover throughout the lake in future years.**

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

June 10-11- Initial Survey and Bio Base® lake scan
June 16-Completion of lake scan and water quality/tributary sampling by RLS staff
June 20-Initial treatment by PLM with oversight by RLS staff
June 26-Treatment of Franke Coves w/Clipper @ 200 ppb
July 12-Purple Loosestrife beetle stocking by RLS staff
July 18-PLM treatment of coves and canal
July 20-Lake Mitchell Improvement Board Meeting
July 20-Post treatment survey by RLS staff
August 10-Lake Mitchell Expo with 3 RLS staff present
August 1-Post-treatment survey with MDEQ, Mike Solomon and Shari Spoelman, PLM, and Jake Britton (SePRO), RLS staff
August 14-Second herbicide treatment and re-treatment by PLM oversight by RLS staff Note: 7 acres of re-treat with 2 acres of algae plus 70 acres of new treatment at west region of lake
August 24-Stems of Purple Loosestrife and milfoil collected and analyzed for beetle/weevil damage
September 17-Post-treatment survey of Aug 14 treatment by RLS staff
September 26-Meeting of LMIB Special Treatment Committee, RLS, and PLM to discuss cove early treatment in 2014 and overall treatment program.
October 11-Recon survey of lake by RLS staff

## 2.0 AQUATIC PLANT SURVEY METHODS

The aquatic plant sampling methods used for lake surveys of macrophyte 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 2013, 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 10-11, 2013 and on October 10-11, 2013 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 2013

The 2013 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 10-11, 2013 survey detected four invasive species, including EWM and Hybrid watermilfoil (Figure 3). The distribution of HWM in June of 2013 (before treatment) is shown in Figure 4. Distribution "post-treatment" will need to be conducted in spring of 2014 due to observations of standing crop (dead but present) in the late summer/fall of 2013. The other submersed exotic Curly-Leaf Pondweed (Figure 5), and emergent Purple Loosestrife (Figure 6) are also shown below. Exotic species found in Lake Mitchell during 2013 are listed below in Table 1.

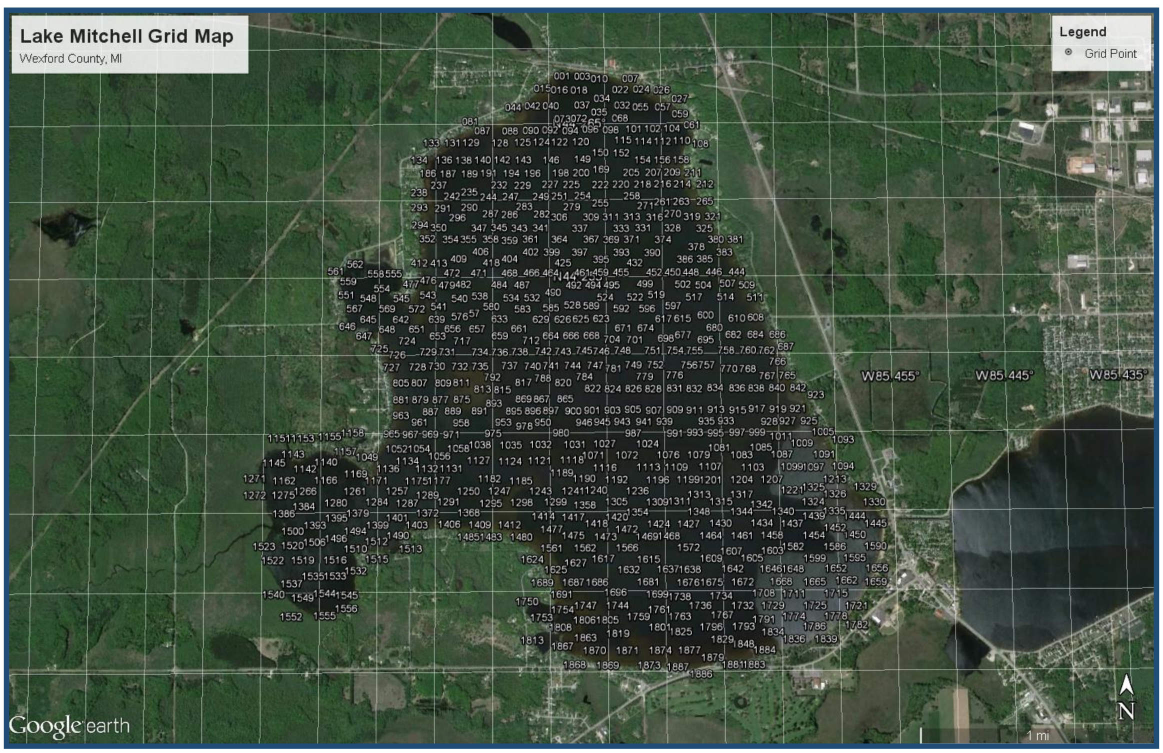



Figure 1. A map showing GPS sampling location points on Lake Mitchell, Wexford County, Michigan.

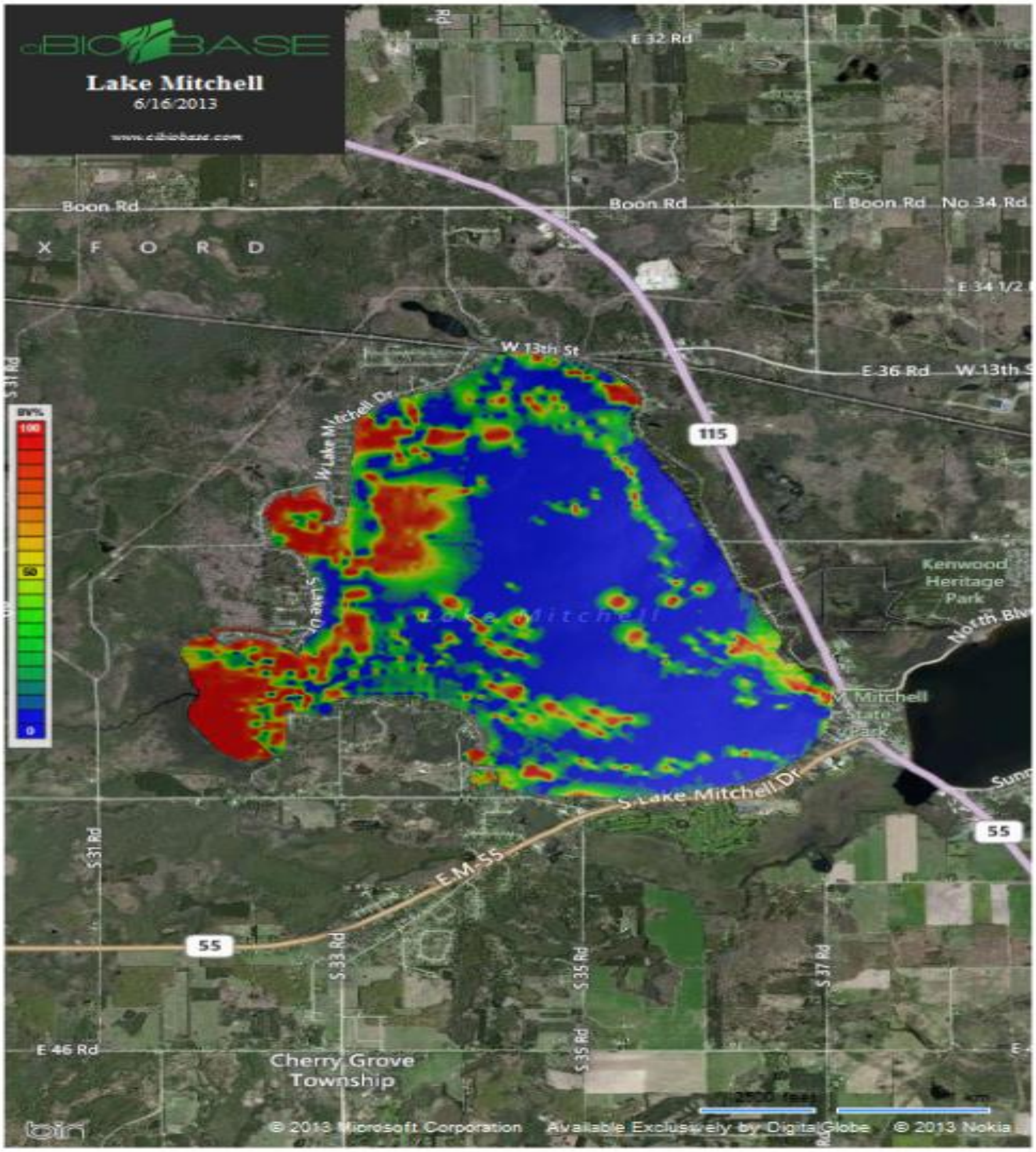



Figure 2. Whole-lake BioBase aquatic vegetation biovolume scan of all aquatic vegetation in Lake Mitchell (June, 2013). Note: Red and orange colors denote thick vegetation while yellow and green denote less dense vegetation. Blue color denotes areas void of vegetation.

| ***Macrophyte Species and Code*** | ***Common Name*** | ***Plant Growth Form*** | ***% of Lake Covered (2013)*** |
|---|---|---|---|
| *M. spicatum var. sibiricum* | Hybrid Watermilfoil | Submersed; Rooted | 16 |
| *Potamogeton crispus* | Curly-Leaf Pondweed | Submersed; Rooted | 2 |
| *Lythrum salicaria* | Purple Loosestrife | Emergent | 2 |
| | | | |

Table 1. Exotic aquatic plant species present within or around Lake Mitchell (2013). Note: Genetic testing has confirmed that most milfoil in Lake Mitchell has converted to the hybrid biotype and distinctive phenotype (appearance) characteristics are present.

Figure 3. Photo showing the aggressive growth habit of hybrid watermilfoil. ©RLS, 2012.

***Information on Hybrid Watermilfoil***

Hybrid Watermilfoil was genetically determined during June of 2013 to be related to the above-mentioned red-stemmed phenotype. Hybrid watermilfoil is a serious problem in Michigan inland lakes. A similar milfoil species that is considered to be exotic by some scientists (*Myriophyllum heterophyllum*) in New Hampshire was found to have significant impacts on waterfront property values (Halstead et *al*., 2003). Moody and Les (2007) were among the first to determine a means of genotypic and phenotypic identification of the hybrid watermilfoil variant and further warned of the potential difficulties in the management of hybrids relative to the parental genotypes. It is commonly known that hybrid vigor is likely due to increased ecological tolerances relative to parental genotypes (Anderson 1948), which would give hybrid watermilfoil a distinct advantage to earlier growth, faster growth rates, and increased robustness in harsh environmental conditions. In regards to impacts on native vegetation, hybrid watermilfoil possesses a faster growth rate than Eurasian milfoil or other plants and thus may effectively displace other vegetation (Les and Philbrick 1993; Vilá et *al*. 2000).
Furthermore, the required dose of 2,4-D for successful control of the hybrid watermilfoil is likely to be higher since there is much more water volume at greater depths it can occupy and also due to the fact that hybrid watermilfoil has shown increased tolerance to traditionally used doses of systemic aquatic herbicides. There has been significant scientific debate in the aquatic plant management scientific community regarding the required doses for effective control of hybrid watermilfoil. Glomski and Netherland (2010) found that the greatest percentage of hybrid watermilfoil (93-100%) was successfully killed with 2,4-D concentrations greater than or equal to 70 µg $L^{-1}$. Their results may vary dramatically from open-water systems; however, as they were tested in laboratory aquaria and the results in field trials would be subjected to a multitude of external environmental factors. However, the concentration of 70 µg $L^{-1}$ yielded a desired 2,4-D residue concentration to be maintained for up to 21 days as in the study by

Glomski and Netherland (2010). Thus, residue sampling intervals could be recommended at the treatment areas for 2 hours after treatment, 1 week after treatment, and 20 days post-treatment. Concentration-Exposure Time (CET) studies such as those by Glomski and Netherland (2010) and Poovey et *al.*, (2007) are important in the determination of dose requirements for hybrid watermilfoil; however, they were conducted in laboratory aquaria and field CET studies are therefore needed.

Stems of hybrid watermilfoil were collected by the aquatic herbicide manufacturer SePRO and submitted to the SePRO® laboratory in North Carolina 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.

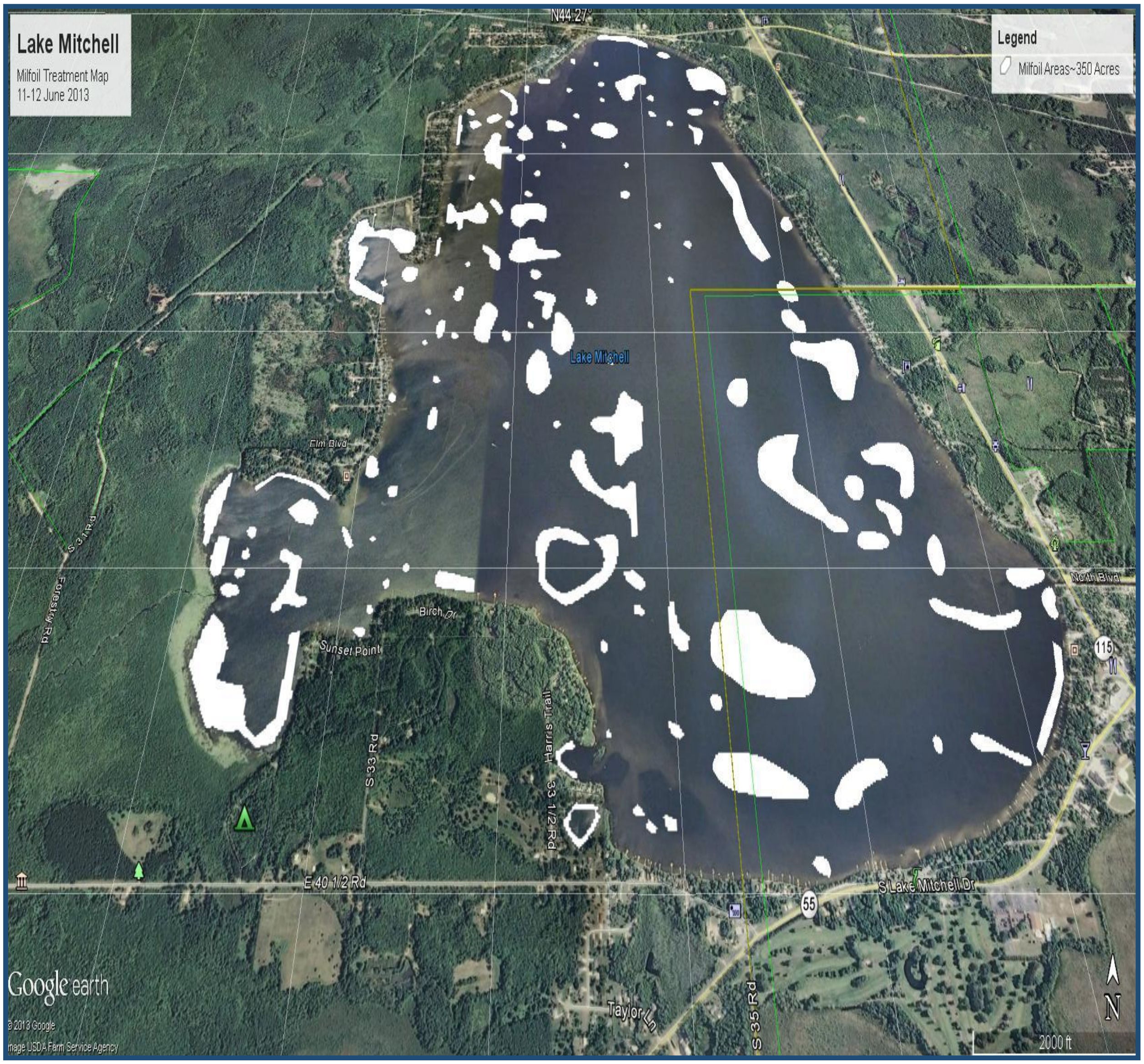



Figure 4. HWM distribution in Lake Mitchell (June, 2013).

Note: The milfoil beds were observed to be dead in August/October of 2013. 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 5. A photograph of the Curly-Leaf Pondweed (*Potamogeton crispus*) ©RLS

Figure 6. 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 2012-2013, 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 20 (Figures 7-10) and rare species are displayed on page 21 (Figures 11-14).

| ***Aquatic Plant Species*** | ***Common Name*** | ***Plant Growth Form*** | ***% Coverage of Sampled Lake Area (2013)*** |
|---|---|---|---|
| *Chara vulgaris* (macroalga) | Muskgrass | Submersed; Rooted | 26 |
| *Potamogeton pectinatus* | Sago Pondweed | Submersed; Rooted | 21 |
| *Potamogeton robbinsii* | Fern-leaf Pondweed | Submersed; Rooted | 69 |
| *Potamogeton gramineus* | Variable-leaf Pondweed | Submersed; Rooted | 22 |
| *Potamogeton praelongus* | White-stem Pondweed | Submersed; Rooted | 56 |
| *Potamogeton richardsonii* | Clasping-leaf Pondweed | Submersed; Rooted | 32 |
| *Potamogeton illinoensis* | Illinois Pondweed | Submersed; Rooted | 22 |
| *Potamogeton amplifolius* | Large-leaf Pondweed | Submersed; Rooted | 19 |
| *Myriophyllum sibiricum* | Northern Watermilfoil | Submersed; Rooted | 17 |
| *Ceratophyllum demersum* | Coontail | Submersed; Non-rooted | 15 |
| *Elodea canadensis* | Common Waterweed | Submersed: Rooted | 21 |
| *Utricularia vulgaris* | Common Bladderwort | Submersed; Non-rooted | 13 |
| *Utricularia minor* | Mini Bladderwort | Submersed; Non-rooted | 7 |
| *Najas guadalupensis* | Southern Naiad | Submersed; Rooted | 28 |
| *Najas flexilis* | Slender Naiad | Submersed; Rooted | 22 |
| *Potamogeton pusillus* | Small-leaf Pondweed | Submersed; Rooted | 21 |
| *Nymphaea odorata* | White Waterlily | Floating-leaved | 4 |
| *Nuphar variegata* | Yellow Waterlily | Floating-leaved | 5 |
| *Brasenia schreberi* | Watershield | Floating-leaved | 5 |
| *Lemna trisulca* | Star Duckweed | Floating-Leaved; Non-rooted | 4 |
| *Pontedaria cordata* | Pickerelweed | Emergent | 5 |
| *Typha latifolia* | Cattails | Emergent | 11 |
| *Scirpus acutus* | Bulrushes | Emergent | 45 |
| *Decodon verticillatus* | Swamp Loosestrife | Emergent | 8 |
| *Myriophyllum tenellum* | Leafless Watermilfoil | Submersed; Rooted | 66 |
| *Eleocharis acicularis* | Spikerush | Emergent | 32 |
| *Bidens beckii* | Water Marigold | Submersed; Rooted | 12 |

## Most Common Aquatic Plant Species Present in Lake Mitchell (2012-2013)

Figure 7. A photograph of Fern-Leaf Pondweed (*Potmageton robbinsii*) ©RLS

Figure 8. A photograph of Leafless Watermilfoil (*Myriophyllum tenellum*) ©RLS

Figure 9. A photograph of White-stem Pondweed (*Potmageton praelongus*) ©RLS

Figure 10. A photograph of Bulrushes (*Scirpus acutus*) ©RLS

## Most Rare Aquatic Plant Species Present in Lake Mitchell (2012-2013)

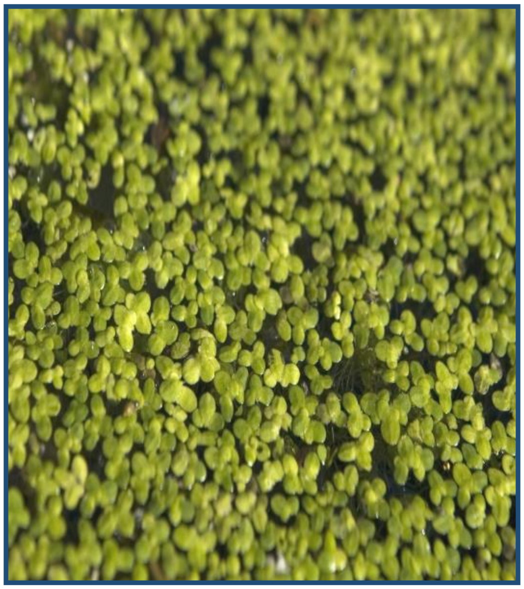


Figure 11. A photograph of Duckweed (*Lemna minor*) ©RLS

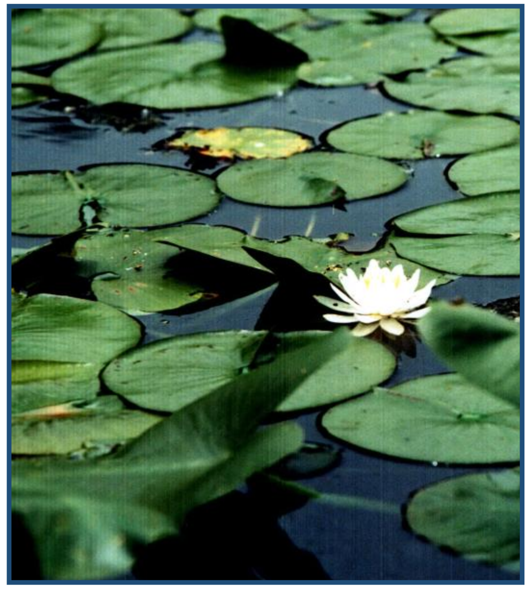


Figure 12. A photograph of White Waterlily (*Nymphaea odorata*)©RLS

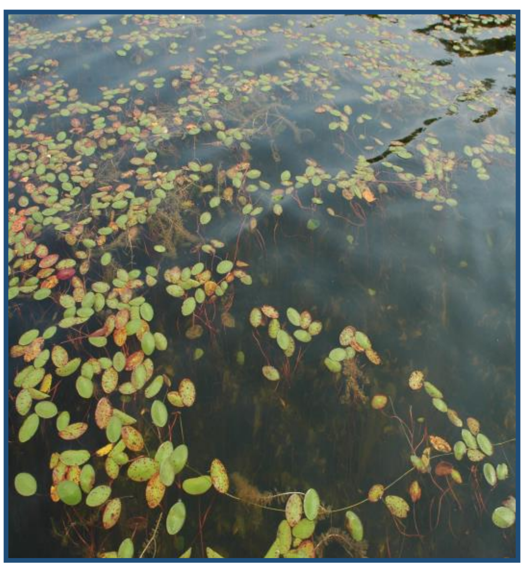


Figure 13. A photograph of Watershield (*Brasenia schreberi*) ©RLS

Figure 14. A photograph of Mini Bladderwort (*Utricularia minor*) ©RLS

## 3.3 Lake Mitchell Big Cove Weevil Assessment

The use of the aquatic weevil, *Euhrychiopsis lecontei* to control EWM has been used in inland lakes for milfoil control. The weevil naturally exists in many of our lakes; however, the lack of adequate populations in many lakes requires that they be stocked for successful control of EWM. The weevil feeds almost entirely on EWM and will leave native aquatic species unharmed. The weevil burrows into the stems of EWM and removes the vascular tissue, thereby reducing the plant's ability to store carbohydrates (Newman et *al.* 1996; Figure 15). Eventually, the EWM stems lose buoyancy and the plant decomposes on the lake bottom.


Figure 15. Weevil stem damage by a pupa of the milfoil weevil

Recent research has shown that the weevils require a substantial amount of aquatic plant biomass for successful control of *M. spicatum*. Additionally, there is increasing evidence that the weevil is much less effective on HWM, which is now dominant in Lake Mitchell. In addition, the weevils require adequate over-wintering habitat since they overwinter within shoreline vegetation. Lakes with sparse milfoil distribution and abundant metal and concrete seawalls are not ideal candidates for the milfoil weevil. During July of 2009, approximately 10,000 weevil units were transplanted into a 1-acre area near Mitchell Creek in Big Cove. Over the past few years, staff from RLS have assessed the populations of the weevil and have determined that the population has not been adequately sustained. **Data from 2013 indicated that the average stem damage index was 0.1±0.3 (based on 60 stems), which is lower than previously recorded means and indicates that the milfoil is healthy and is not being impacted by the weevils.** Each milfoil stem was carefully investigated under a dissecting microscope and analyzed for stem diameter, number of lateral branches, an index of weevil damage, and stem length. The index of weevil damage was developed to assess the degree of stem damage associated with the weevil activity. The index ranged from 0 - 5 with a value of “0” denoting no weevil damage visible, a “2” denoting the presence of larvae or eggs on or in the stem, a “3” indicated the presence of larvae in the stem tissues and vascular tissue damage, “4” indicated the presence of larvae or pupae and severe necrosis of the stem tissue, and a “5” denoted both severe tissue necrosis, weevil pupae or larvae, and the loss of foliar leaves.

Additional stocking is not recommended at this time.

### 3.4 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 16) 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 40 cultured pots were released on July 12, 2013 into areas that contained significant stands of Purple Loosestrife plants and that were previously stocked.** 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 August 24th, 2013, approximately 3-5 florescences on different plants were evaluated at each of the stocking sites. The mean damage index was 3.4±1.0 and the mean number of beetles observed on a given florescence was 2.2 ±1.2.** This data indicates that the beetles have moderately damaged some of the flowers and more stocking is recommended. A map showing the distribution of the beetles is shown below in Figure 17.

Figure 16. *Galerucella*, the Purple Loosestrife-eating beetle.

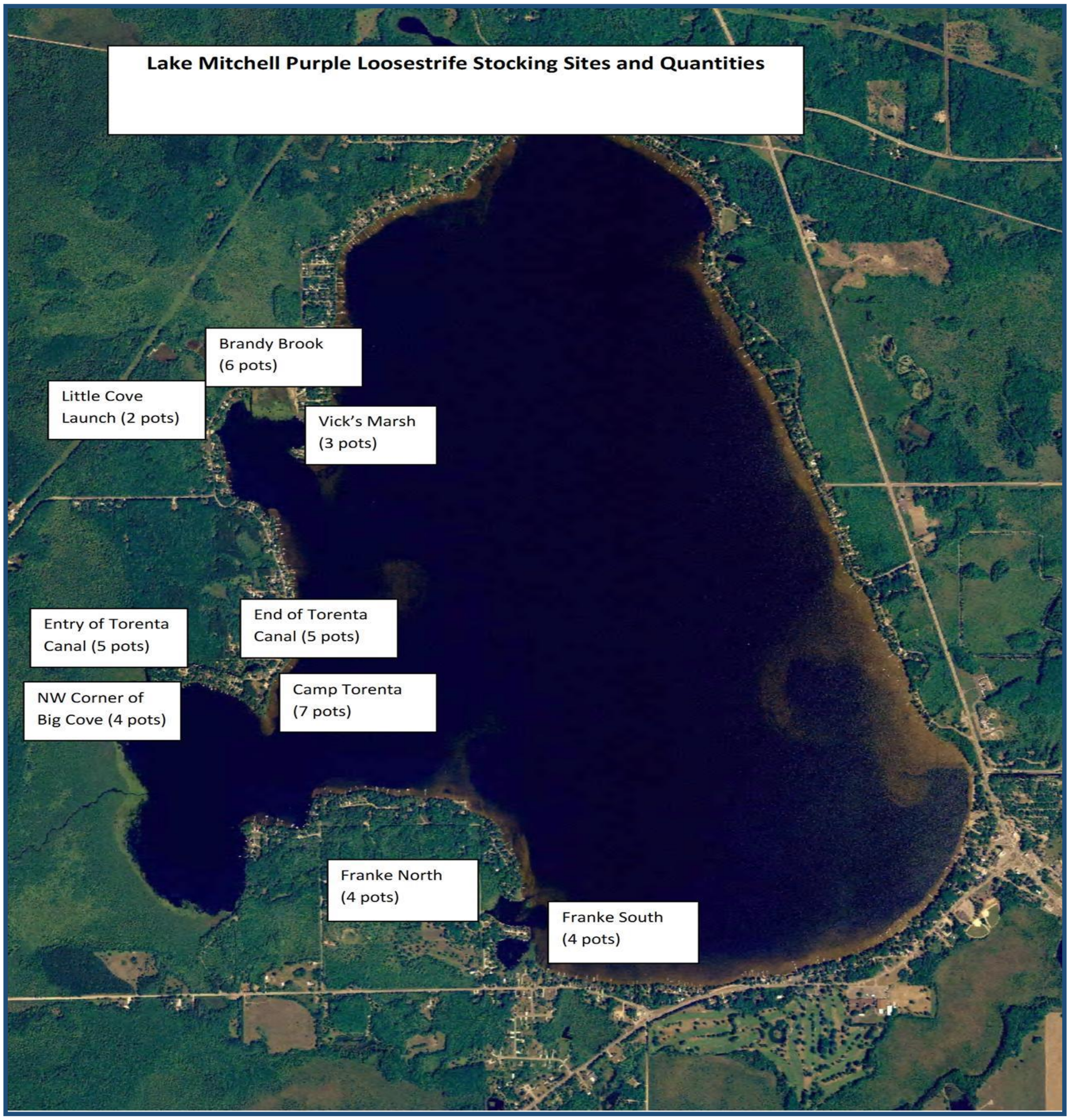



Figure 17. Purple Loosestrife beetle stocking sites around Lake Mitchell in July, 2013

## 4.0 LAKE MITCHELL 2013 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 18) 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, 2013.

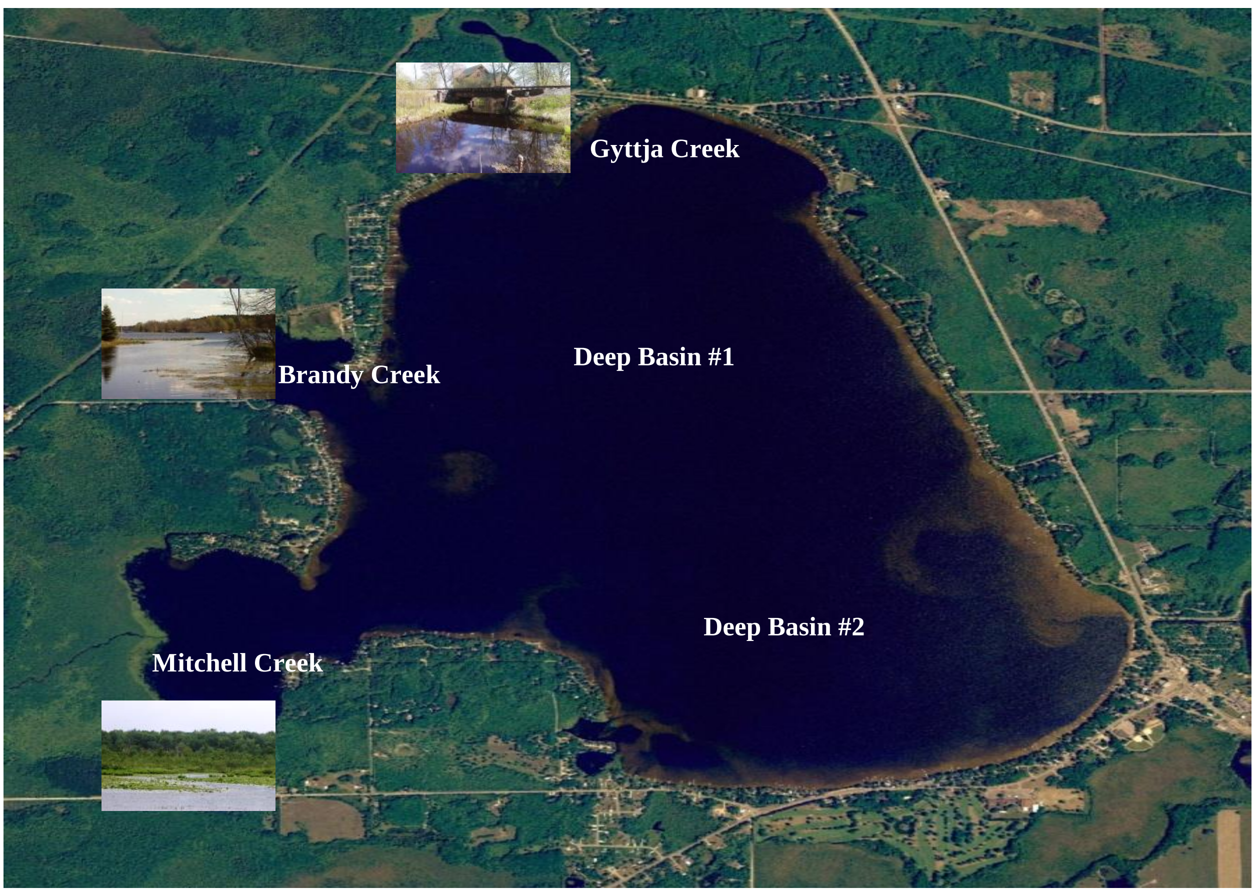



Figure 18. A location map of water quality lake and tributary sampling stations on Lake Mitchell (June, 2013).

***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 4.9 mg $L^{-1}$ at the bottom to 10.1 mg $L^{-1}$ at the surface, with average values around 8.2 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.

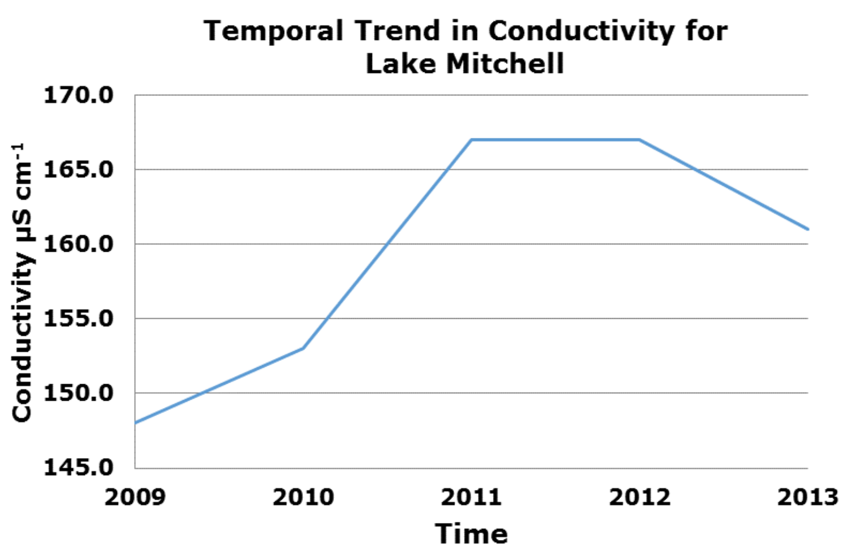
***Water Temperature***

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, 2013 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 67.5 ºF at the surface to 53.0 ºF at the lake bottom. The water temperatures for all of the**

**tributaries were higher and averaged 73 ºF, with the lowest temperature observed in Brandy Creek.**

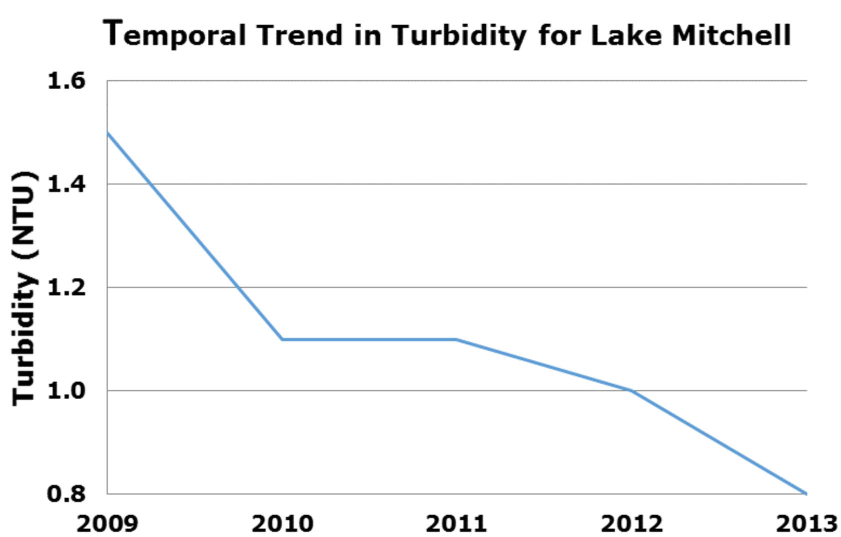
***Conductivity***

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 ($\mu S\ cm^{-1}$) with the use of a conductivity probe and meter. **Conductivity values for Lake Mitchell were low and ranged from 159-164 $\mu S\ cm^{-1}$, 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 220 $\mu S\ cm^{-1}$ and 209 $\mu S\ cm^{-1}$, respectively, and the conductivity of Brandy Brook was 110 $\mu S\ cm^{-1}$, which was slightly lower than the other two tributaries.** A graph showing the temporal trend in mean conductivity for Lake Mitchell is shown below.



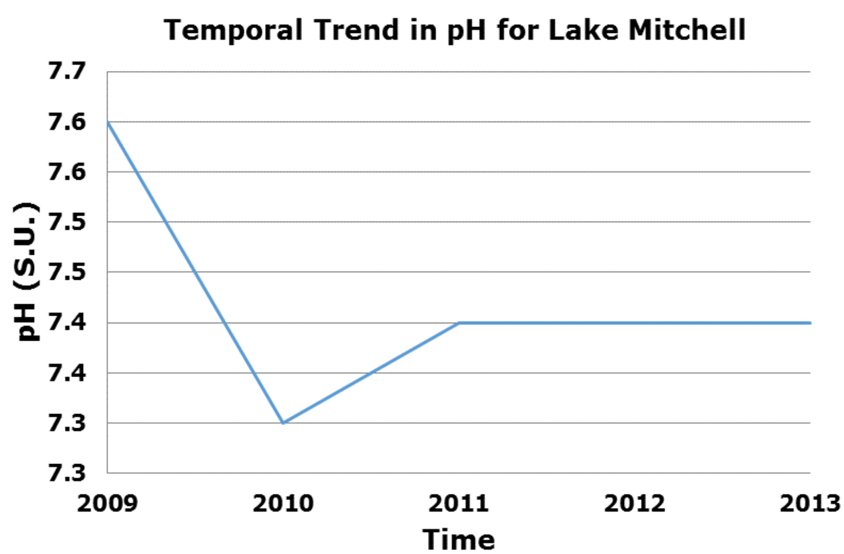
***Turbidity***

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 0.7-1.0 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.



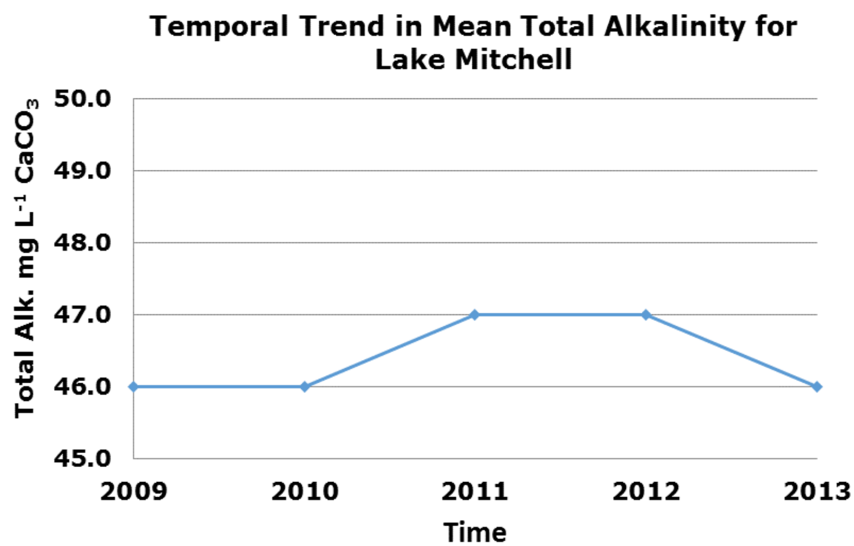
***pH***

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 7.3, 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 five year period.



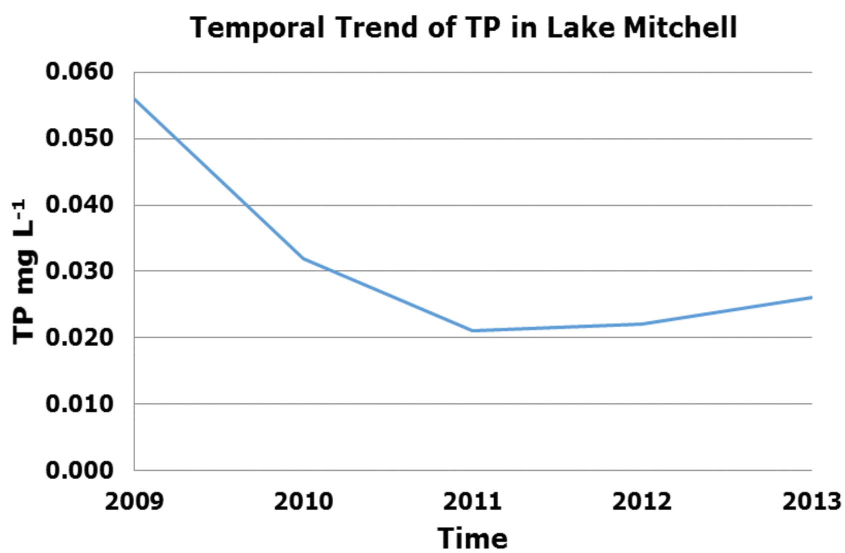

***Total Alkalinity***

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 44-48 mg $L^{-1}$ of $CaCO_3$ during the June, 2013 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 five years.



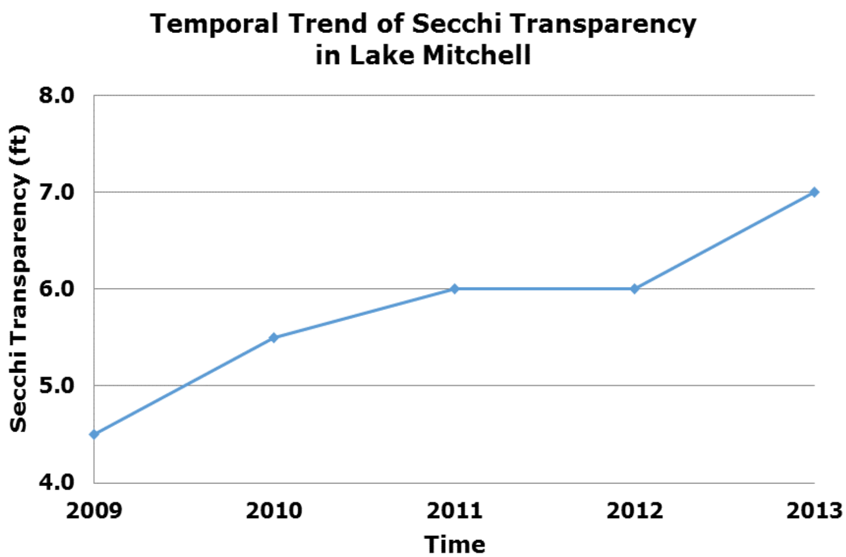

***Total Phosphorus***

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 0.031 mg $L^{-1}$ near the bottom. The mean TP concentration for the tributaries was 0.035 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 five 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 7.0 feet over the deep basins during the 2013 sampling period (based on n=3 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 five 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 53 mg $L^{-1}$ to 72 mg $L^{-1}$, which was slightly lower than in 2011-2012. The TDS of**

**tributary waters ranged from 82 mg $L^{-1}$ to 114 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 166.3 mV and 46.7 mV from the surface to the bottom within the lake, and indicated oxidized rather than reduced conditions. The ORP of tributary waters ranged from 135.9 mV to 171.1 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 and correlate with higher water clarity observed in 2013.**

**A composite sample of the Lake Mitchell water column was collected over both deep basins during the June, 2013 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 | 67.5 | 10.1 | 7.4 | 162 | 0.8 | 166.3 | 61 | 47 | 0.020 |
| 10 | 62.6 | 7.8 | 7.4 | 159 | 0.7 | 131.7 | 64 | 48 | 0.030 |
| 19.5 | 53.8 | 4.9 | 7.3 | 164 | 1.0 | 87.2 | 72 | 44 | 0.028 |

Table 4. Lake Mitchell water quality parameter data collected over Deep Basin 1 on June 16, 2013.

| *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 | 67.1 | 9.8 | 7.4 | 162 | 0.7 | 146.3 | 53 | 48 | 0.020 |
| 9 | 63.9 | 8.3 | 7.3 | 163 | 0.8 | 128.0 | 59 | 47 | 0.027 |
| 20 | 53.0 | 5.1 | 7.3 | 162 | 1.0 | 46.7 | 60 | 45 | 0.031 |

Table 5. Lake Mitchell water quality parameter data collected over Deep Basin 2 on June 16, 2013.

| *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** | 73.6 | 8.8 | 7.3 | 220 | 98 | 156.3 | 0.035 |
| **Brandy** | 72.5 | 8.3 | 7.2 | 110 | 114 | 171.1 | 0.030 |
| **Gyttja** | 74.8 | 7.5 | 7.3 | 209 | 82 | 135.9 | 0.040 |

Table 6. Lake Mitchell Tributary water quality parameter data collected on June 16, 2013.

## 5.0 LAKE MITCHELL 2014 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. **Due to the hybrid watermilfoil observed throughout the lake during the June 2013 survey, use of a strong 2,4-D product (Navigate® or Renovate Max G® at ≥ 180+ lbs per acre) is recommended. Whenever possible, a systemic herbicide is preferred for long-term control. Analysis of the milfoil stems by** the SePRO® laboratory determined that the milfoil stems are susceptible to fluridone (Sonar®) and thus the required sampling for future permits is recommended in 2014. In addition, testing of hybrid milfoil locations in individual treatment polygons is also recommended to evaluate response with biotype.

**The coves** should be managed for both navigability and aesthetics and thus a strong contact herbicide that offers season-long control is 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 400 ppb (the maximum permitted dose). 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. **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 2014 and beetles will be applied to all previously stocked areas. No additional stocking of the milfoil weevil, *Euhrychiopsis lecontei* is recommended for 2014 due to the observed low efficacy over the past few years.**

**Water quality parameters** as noted above will be monitored in the lake and tributaries during 2013.

**A proposed lake improvement budget and treatment plan for 2014** is shown in Figure 19 below and includes specific activities for the Franke Coves, Torenta Canal, and main lake, as well as associated costs for all management activities.

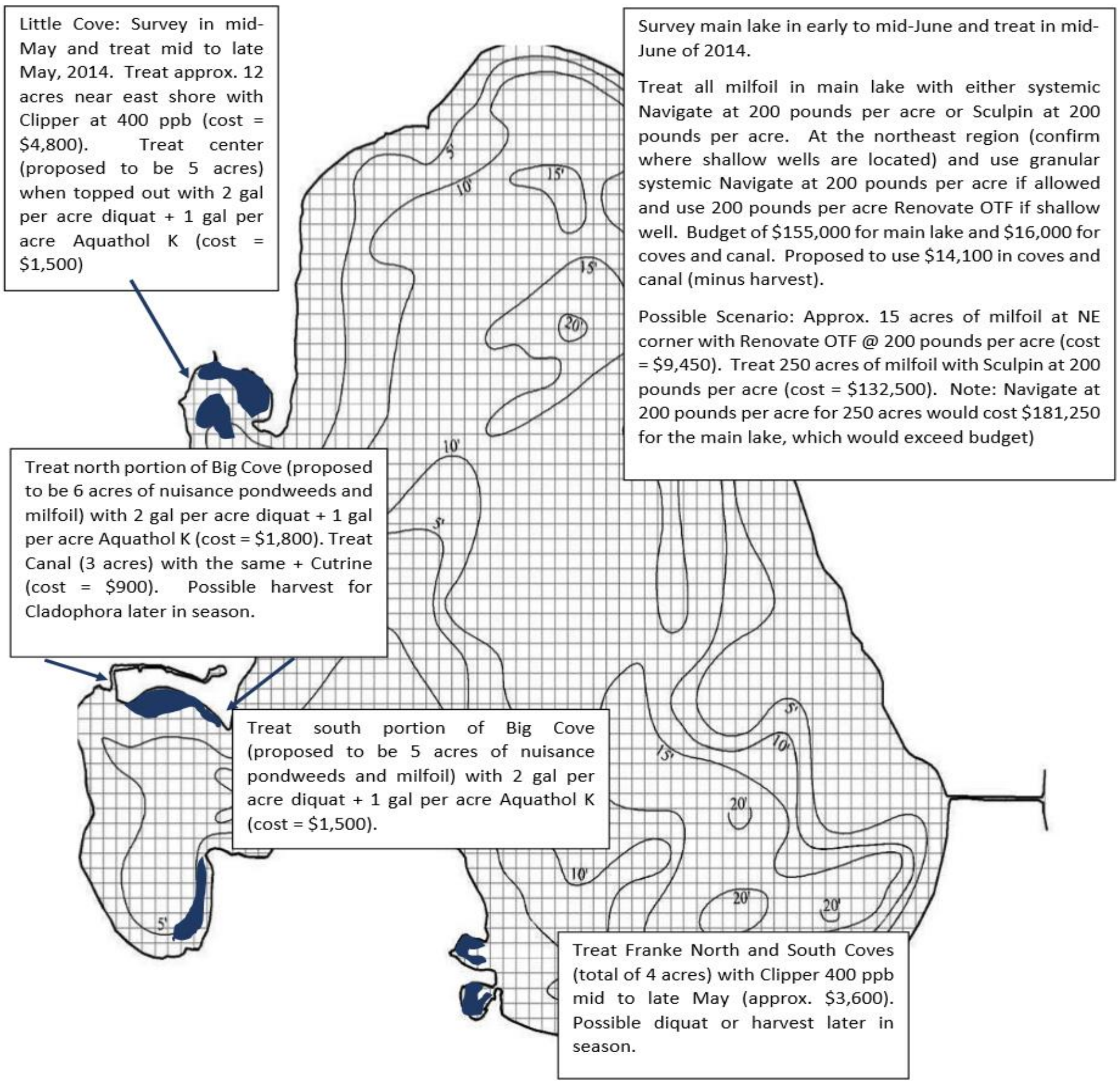



Figure 19. Proposed budget and treatment strategy for Lake Mitchell in 2014.

## 6.0 LITERATURE CITED

Anderson, E. 1948. Hybridization of the habitat. *Evolution* 2:1-9.

Glomski, L.M., and M.D. Netherland. 2010. Response of Eurasian and hybrid watermilfoil to low use rates and extended exposures of 2,4-D and Triclopyr. *Journal of Aquatic Plant Management* 48:12-14.

Les, D.H., and C.T. Philbrick. 1993. Studies of hybridization and chromosome number variation in aquatic angiosperms: Evolutionary implications. *Aquatic Botany* 44: 181-228.

Madsen, J.D., J.A. Bloomfield, J.W. Sutherland, L.W. Eichler, and C.W. Boylen. 1996. The aquatic macrophyte community of Onondaga Lake: Field survey and plant growth bioassays of lake sediments, *Lake and Reservoir Management* 12:73-79.

Madsen, J.D. G.O. Dick, D. Honnell, J. Schearer, and R.M. Smart. 1994. Ecological assessment of Kirk Pond, Miscellaneous Paper A-94-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Moody, M.L., and D.H. Les. 2007. Geographic distribution and genotypic composition of invasive hybrid watermilfoil (*Myriophyllum spicatum* x *M. sibiricum*) populations in North America. *Biological Invasions* 9: 559-570.

Poovey, A. G., J.G. Slade, and M.D. Netherland. 2007. Susceptibility of Eurasian watermilfoil (*Myriophyllum spicatum*) and a milfoil hybrid (*Myriophyllum spicatum* x *M. sibiricum*) to Triclopyr and 2,4-D amine. *Journal of Aquatic Plant Management* 45:111-115.

Vilá, M., E. Weber, and C.M. D'Antonio. 2000. Conservation implications of invasion by plant hybridization. *Biological Invasions* 2:207-217.