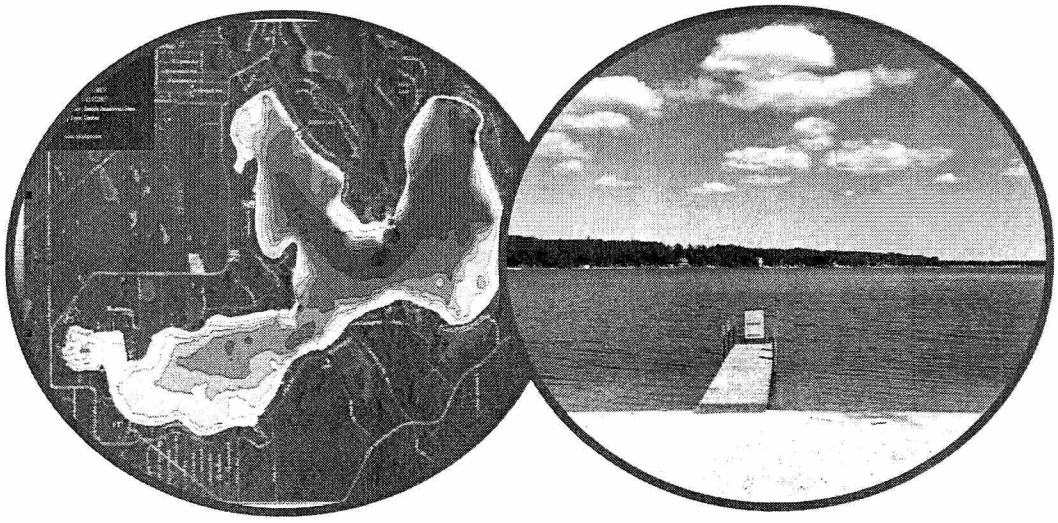
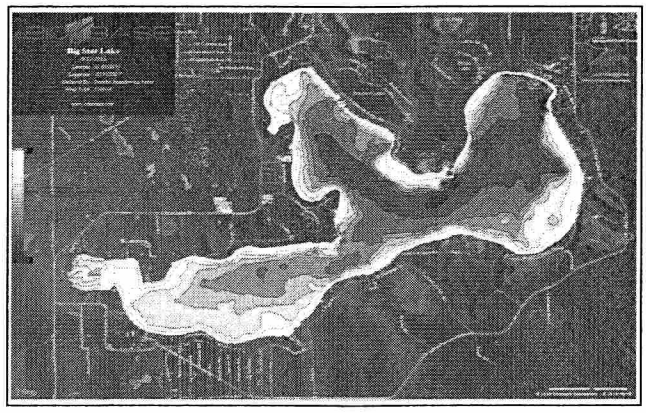
Restorative Lake Sciences™

Big Star Lake "State of the Lake" (2015) Report & 2016 Management Recommendations



November, 2015

Big Star Lake "State of the Lake" Report



(2015)

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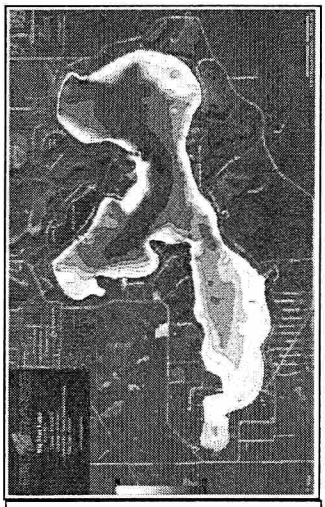
Big Star Lake "State of the Lake" Summary

The following Big Star Lake report is a summary of key lake findings collected during the spring and summer of 2015.

The overall condition of Big Star Lake is ranked in the top 15% of developed lakes of similar size in the state of Michigan. The water clarity is between 12 feet at the lowest and 20 feet at the highest. Some of this clarity is due to filtration of the water by Zebra Mussels; however, the majority of the clarity is due to coarse bottom sediment that does not create silty, turbid conditions when high wave or boat activity agitates the lake water. Additionally, the lake has enough nutrients (phosphorus and nitrogen) to support some algae and submersed aquatic plant growth, but the nutrient levels are considered moderate. Invasive species such as Eurasian Watermilfoil are able to grow in moderate nutrient waters and thus are a challenge to the Big Star Lake ecosystem. However, management of the plant has been a large success. Protection of the 21 native aquatic plant species is paramount for the health of the lake fishery and these plants should not be managed unless they are a nuisance to lakefront property owners and possess navigational and recreational hazards (i.e. lily pads).

The lake did not experience a high depletion of dissolved oxygen with depth during mid-summer which is rare for a large inland lake that stratifies. In the spring dissolved oxygen was high between 7.9-10.9 mg/L and the water temperature varied by 3°F. During mid to late summer, the dissolved oxygen was 8.9 mg/L at the surface and 6.0 mg/L at 25 feet. Water temperatures varied by 12°F. Conductivity continues to be low which is favorable. Total phosphorus remained similar to previous years as well and was moderate. The total nitrogen in considered moderate as well. In late August of 2015, Bernie Woltjer collected 28 E. coli bacteria samples and one came back positive. These results indicate that E. coli bacteria is not a problem on Big Star Lake at present.

Big Star Lake Water Quality Data (2015)



Did You Know? Big Star Lake has a maximum depth of 25 feet

Water Quality Parameters Measured

There are hundreds of water quality parameters one can measure on an inland lake but several are the most critical indicators of lake health. These parameters include water temperature (measured in °F), dissolved oxygen (measured in mg/L), pH (measured in standard units-SU), conductivity (measured in micro-Siemens per centimeter-μS/cm), total alkalinity or hardness (measured in mg of calcium carbonate per liter-mg $CaCO_3$/L), total dissolved solids (mg/L), secchi transparency (feet), total phosphorus and total nitrate nitrogen (both in μg/L), chlorophyll-*a* (in μg/L), and algal species composition. Graphs that show trends for each parameter in spring and late summer of each year are displayed below. Water quality is measured in the deep basin of Big Star Lake in spring and/or late summer of each year. Trend data was calculated using mean values for each parameter for each season over the sampling location. Table 1 below demonstrates how lakes are classified based on key parameters. Big Star Lake would be considered mesotrophic (relatively productive) since it does contain ample phosphorus, nitrogen, and aquatic vegetation growth but has excellent water clarity and moderate algal growth. General water quality classification criteria are defined in Table 1. 2015 water quality data for Big Star Lake is shown below in Tables 2-3.

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 1. Lake trophic classification (MDNR).

Depth ft.	*Water Temp °F*	*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	61.5	10.9	8.3	122	0.5	117.5	58	55	0.015
12.5	58.3	10.0	8.4	125	0.8	123.5	58	57	0.010
25	58.1	7.9	8.4	125	1.4	110.6	62	58	0.025

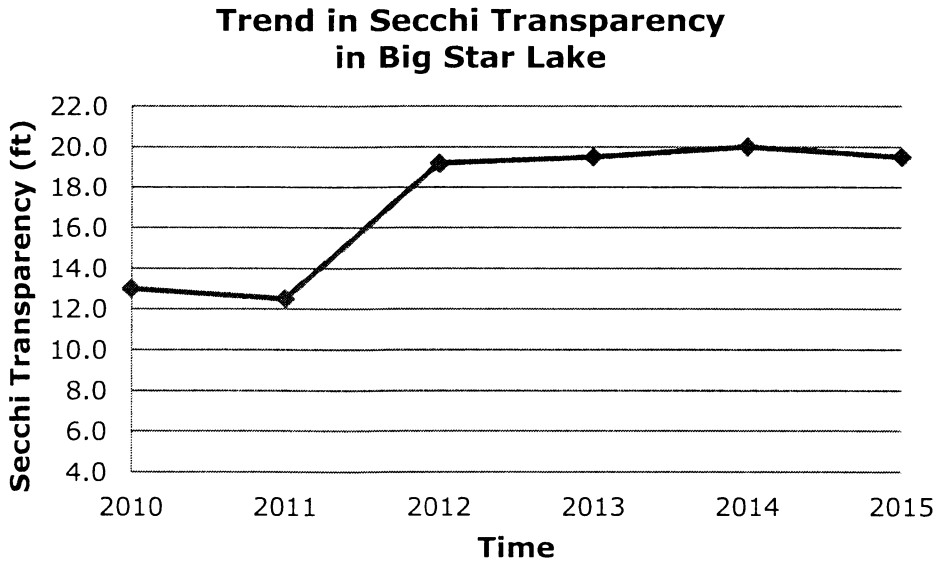
Table 2. Big Star Lake water quality parameter data collected over the deep basin on May 27, 2015.

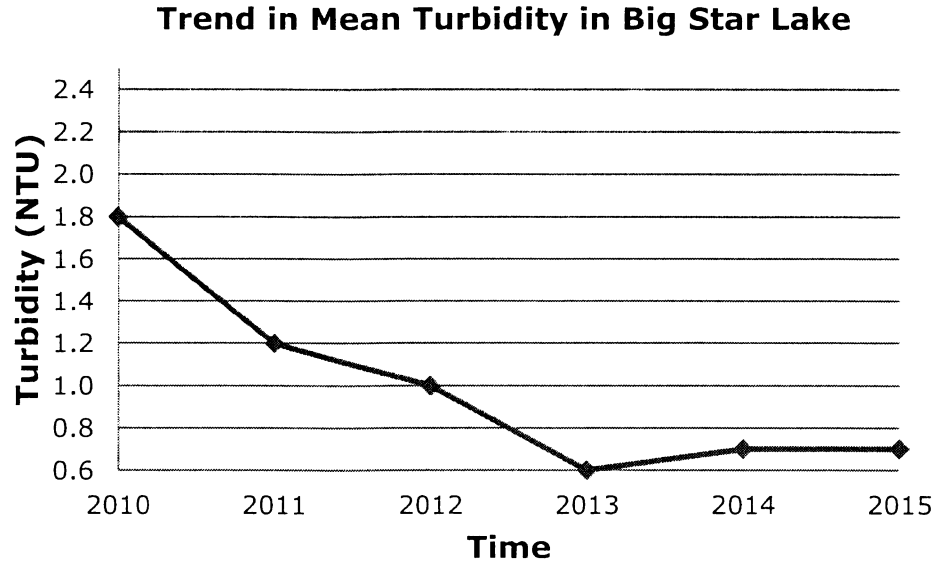
Depth ft.	*Water Temp °F*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Turb. NTU*	*ORP mV*	*Total Dissolved Solids mg L^{-1}*	*Total Alk. mg L^{-1} $CaCO_3$*	*Total Phos. mg L^{-1}*
0	74.1	8.9	8.3	126	0.6	129.5	56	55	0.020
12.5	69.6	8.0	8.4	131	0.6	115.7	52	55	0.020
25	62.5	6.0	8.4	128	1.4	79.4	54	58	0.022

Table 3. Big Star Lake water quality parameter data collected over the deep basin on August 17, 2015.

Water Clarity (Transparency) Data

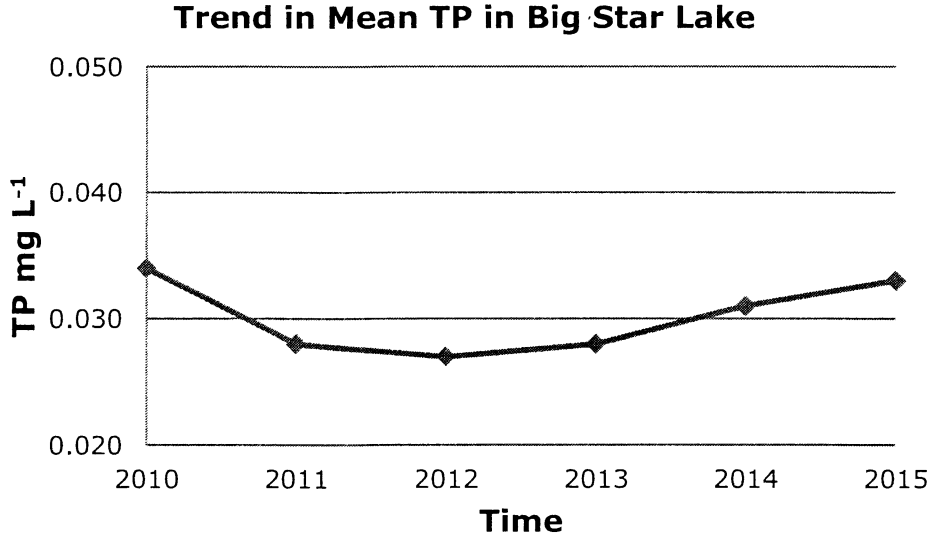
Elevated Secchi transparency readings allow for more aquatic plant and algae growth. The transparency throughout Big Star Lake is adequate (12-20 feet) to allow abundant growth of algae and aquatic plants in the majority of the littoral zone of the lake. Secchi transparency is variable and depends on the amount of suspended particles in the water (often due to windy conditions of lake water mixing) and the amount of sunlight present at the time of measurement. Other parameters such as turbidity (measured in NTU's) and Total Dissolved Solids (measured in mg/L) are correlated with water clarity and show an increase as clarity decreases. The turbidity and total dissolved solids in Big Star Lake have been quite low at less than 1.4 NTU's and 62 mg/L, respectively during recent and historic periods.


Trend in Secchi Transparency in Big Star Lake
Secchi Transparency (ft)
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2010
2011
2012
2013
2014
2015
Time


Trend in Mean Turbidity in Big Star Lake
Turbidity (NTU)
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
2010
2011
2012
2013
2014
2015
Time

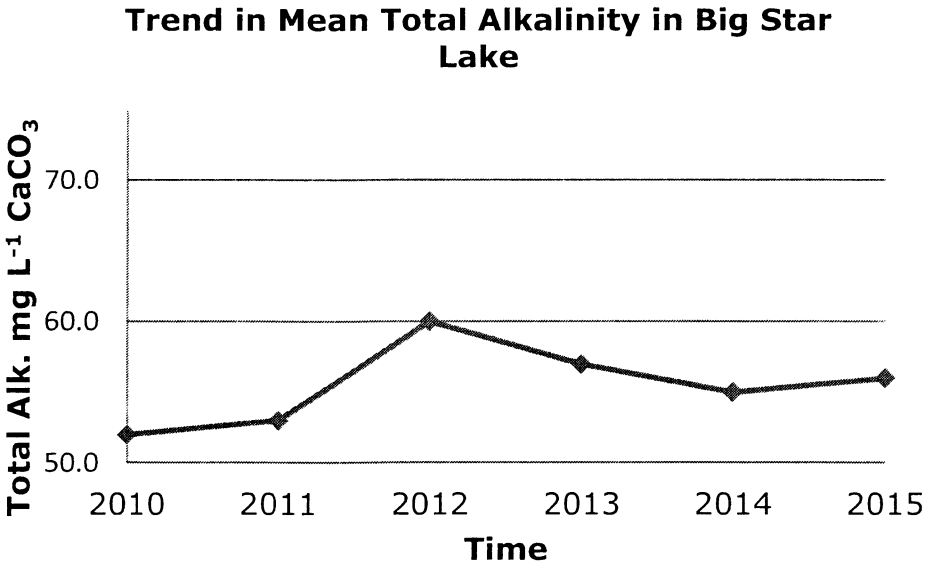
Total Phosphorus

Total phosphorus (TP) is a measure of the amount of phosphorus (P) present in the water column. Phosphorus is the primary nutrient necessary for abundant algae and aquatic plant growth. TP concentrations are usually higher at increased depths due to higher release rates of P from lake sediments under low oxygen (anoxic) conditions. Phosphorus may also be released from sediments as pH increases. Fortunately, even though the TP levels in Big Star Lake are moderate, the dissolved oxygen levels are good enough at the bottom to not cause release of phosphorus from the bottom. TP concentrations have typically been below 0.035 mg L^{-1} over the past five years and usually increase later in the season.



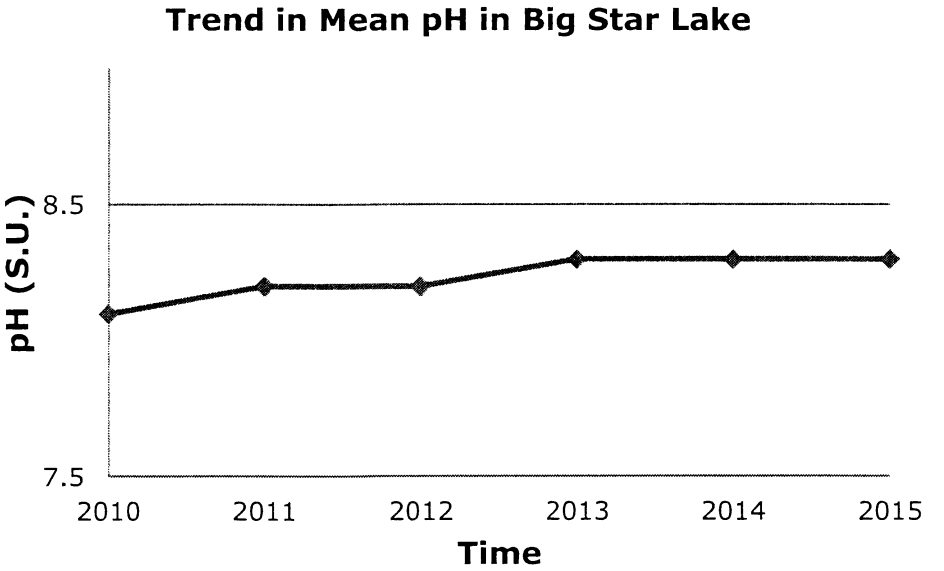
Total Alkalinity

Lakes with high alkalinity (> 150 mg L^{-1} of $CaCO_3$) are able to tolerate larger acid inputs with less change in water column pH. Many Michigan lakes contain high concentrations of $CaCO_3$ and are categorized as having "hard" water. Total alkalinity may change on a daily basis due to the re-suspension of sedimentary deposits in the water and respond to seasonal changes due to the cyclic turnover of the lake water. The alkalinity of Big Star Lake is moderately low and indicates a more soft water lake.



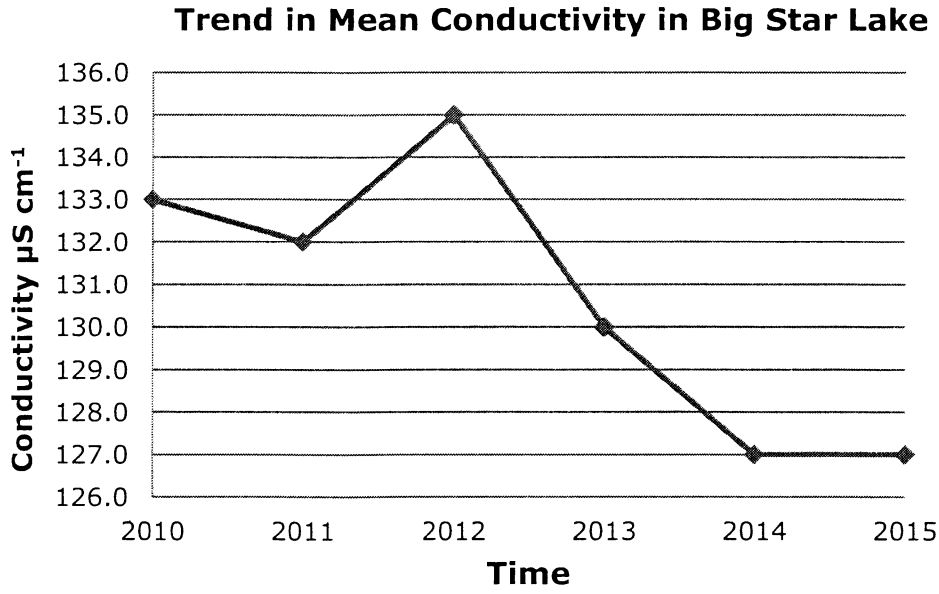
pH

Most Michigan lakes have pH values that range from 6.5 to 9.5. Acidic lakes (pH < 7) are rare in Michigan and are most sensitive to inputs of acidic substances due to a low acid neutralizing capacity (ANC). Big Star Lake is considered "slightly basic" on the pH scale. The pH of Big Star Lake has stabilized over the past several years to 8.4 S.U. which is ideal for an inland lake.



Conductivity

Conductivity is a measure of the amount of mineral ions present in the water, especially those of salts and other dissolved inorganic substances. Conductivity generally increases as the amount of dissolved minerals and salts in a lake increases, and also increases as water temperature increases. The conductivity values for Big Star Lake are low and range from 127-133 µS/cm. Severe water quality impairments do not occur until values exceed 800 µS/cm and are toxic to aquatic life around 1,000 µS/cm. Fortunately, the concentrations have declined over the past few years.

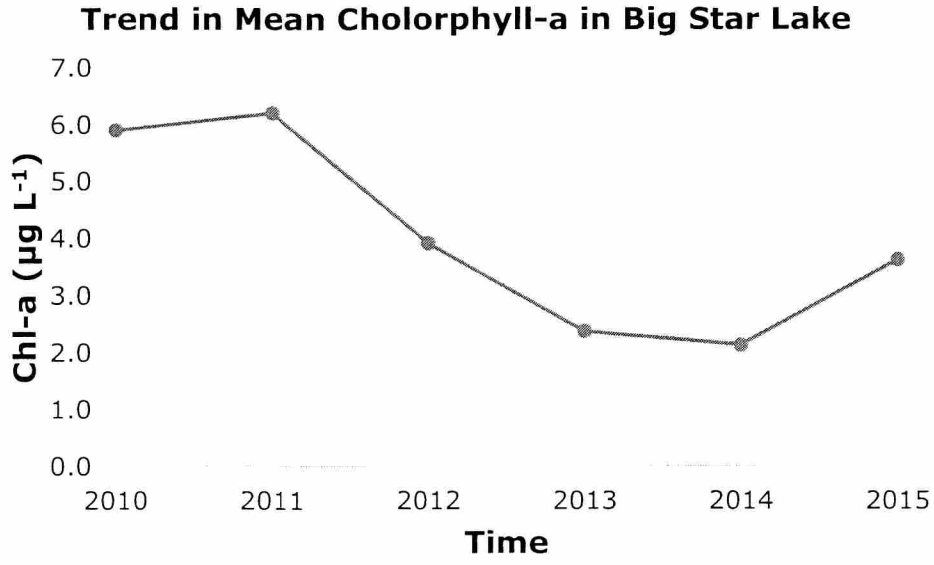


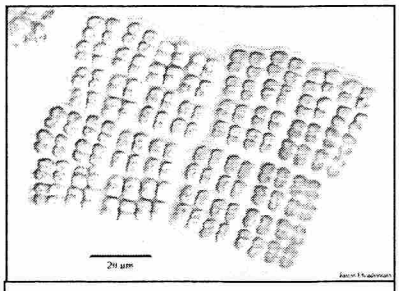
Chlorophyll-*a* and Algal Species Composition

Chlorophyll-*a* is a measure of the amount of green plant pigment present in the water, often in the form of planktonic algae. High chlorophyll-*a* concentrations are indicative of nutrient-enriched lakes. Chlorophyll-*a* concentrations greater than 6 µg L^{-1} are found in eutrophic or nutrient-enriched aquatic systems, whereas chlorophyll-*a* concentrations less than 2.2 µg/L are found in nutrient-poor or oligotrophic lakes. Chlorophyll-a concentrations vary among years but have repeatedly been below 4.0 µg/L.

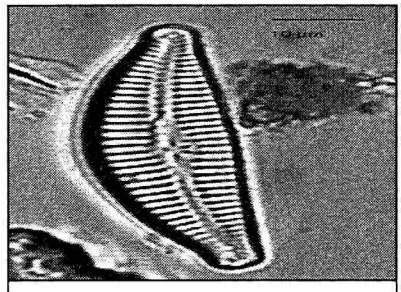
The algal genera were determined from composite water samples collected over the deep basin of Big Star Lake in 2015 were analyzed with a compound bright field microscope. The genera present included the Chlorophyta (green algae): *Scenedesmus* sp., *Haematococcus* sp., *Chlorella* sp., *Cladophora* sp., *Pediastrum* sp., *Radiococcus* sp., *Gleocystis* sp., *Pandorina* sp., and *Chloromonas* sp. The Cyanophyta (blue-green algae): *Oscillatoria* sp.,; the Bascillariophyta (diatoms*): Fragilaria* sp., *Synedra* sp., *Navicula* sp., *Cymbella* sp., and *Tabellaria* sp. The aforementioned

species indicate a diverse algal flora and represent a good diversity of alga with an abundance of diatoms that are indicative of great water quality.

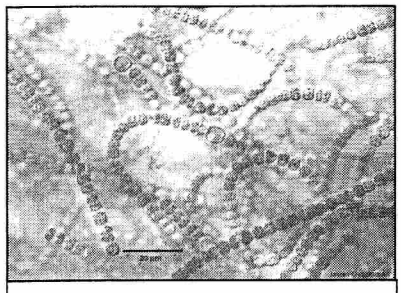




A Green Alga (Good)



A Diatom (Good)



A Blue-Green Alga (Bad)

Aquatic Vegetation Data (2015)

Status of Native Aquatic Vegetation in Big Star Lake

The native aquatic vegetation present in Big Star Lake is essential for the overall health of the lake and the support of the lake fishery. The June, 2015 determined that there were a total of 21 native aquatic plant species in Big Star Lake. These include 12 submersed species, 3 floating-leaved species, and 6 emergent species. This indicates a very high biodiversity of aquatic vegetation in Big Star Lake. The overall % cover of the lake by native aquatic plants is low relative to the lake size due to the great mean depth and thus these plants should be protected unless growing near swim areas at nuisance levels. A list of all current native aquatic plant species is shown below in Table 4.

The most dominant aquatic plant species included the marco-alga Chara which has a skunky odor and lies on the lake bottom. Other dominant species included Leafless Watermilfoil, which creates a dense sod-like carpet on the lake bottom and Bladderwort, which is a rootless, bright green plant that has clear bladders and lies on the lake bottom. This plant traps zooplankton in its bladders for a food source. Lastly, Illinois Pondweed was also abundant and grows tall in the water column. It serves as excellent fish forage habitat.

Aquatic Plant Species and Code	***Aquatic Plant Common Name***	***% Cover in Littoral (Shallow) Zone of Big Star Lake (2015)***
Chara vulgaris (macroalga), 3	Muskgrass	23.8%
Potamogeton pectinatus, 4	Thinleaf Pondweed	2.4%
Potamogeton gramineus, 7	Variable-leaved Pondweed	7.2%
Potamogeton praelongus, 8	White-Stemmed Pondweed	7.3%
Potamogeton illinoensis, 10	Illinois Pondweed	8.6%
Potamogeton amplifolius, 11	Large-leaf Pondweed	7.1%
Potamogeton natans, 13	Floating-leaf Pondweed	2.4%
Zosterella dubia, 14	Water Stargrass	2.9%
Vallisneria americana, 15	Wild Celery	1.1%
Utricularia vulgaris, 22	Common Bladderwort	9.5%
Najas guadalupensis, 25	Southern Naiad	4.5%
*Myriophyllum tenellum,*29	Leafless Watermilfoil	10.4%
Nymphaea odorata, 30	White Waterlily	4.2%
Nuphar advena, 31	Yellow Waterlily	5.8%
Brasenia schreberi, 32	Watershield	2.8%
Typha latifolia, 39	Cattails	3.1%
Scirpus acutus, 40	Bulrushes	0.2%
Iris versicolor, 41	Blueflag Iris	1.5%
Decodon verticillatus, 42	Swamp Loosestrife	2.8%
Polygonum amphibium, 44	Water Smartweed	1.0%
Eriocaulon sp., 46	Pipewort	2.4%

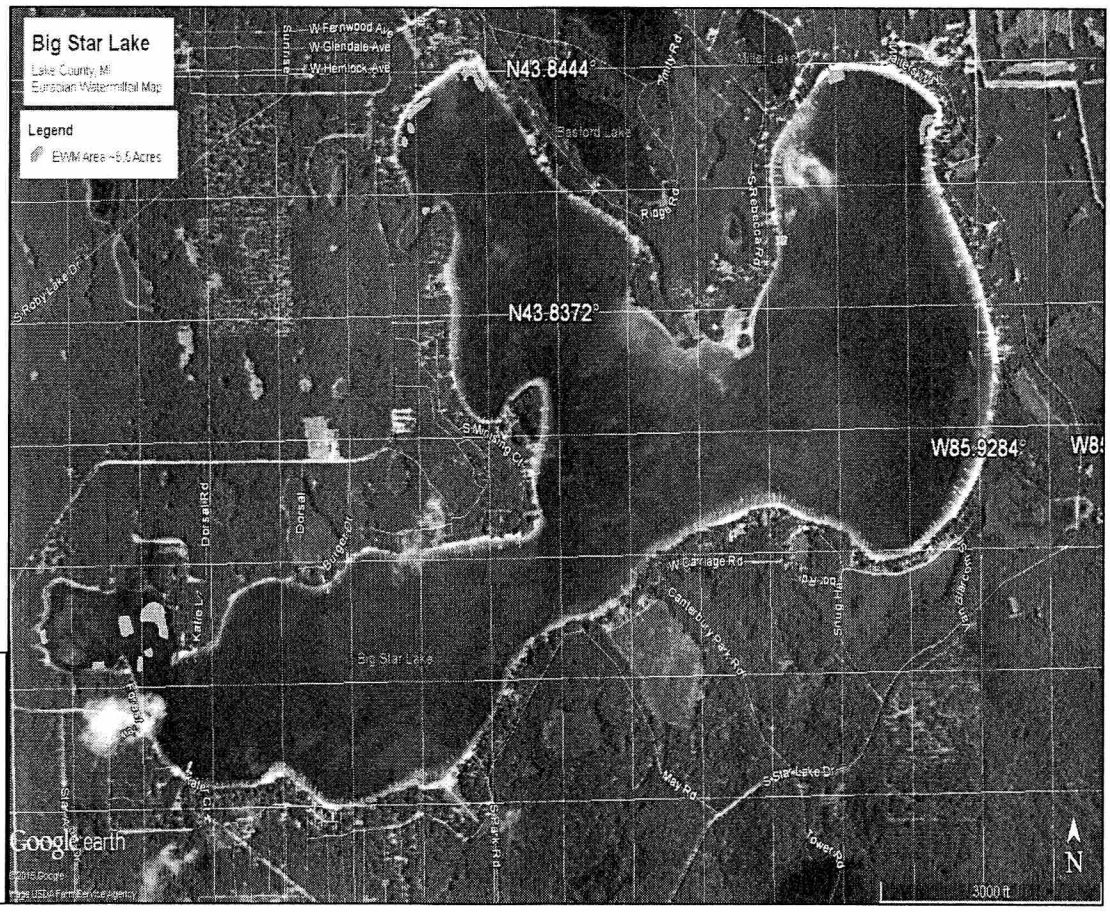
Table 4. Big Star Lake Native Aquatic Plant Species (August, 2015).

Invasive (Exotic) Aquatic Plant Species

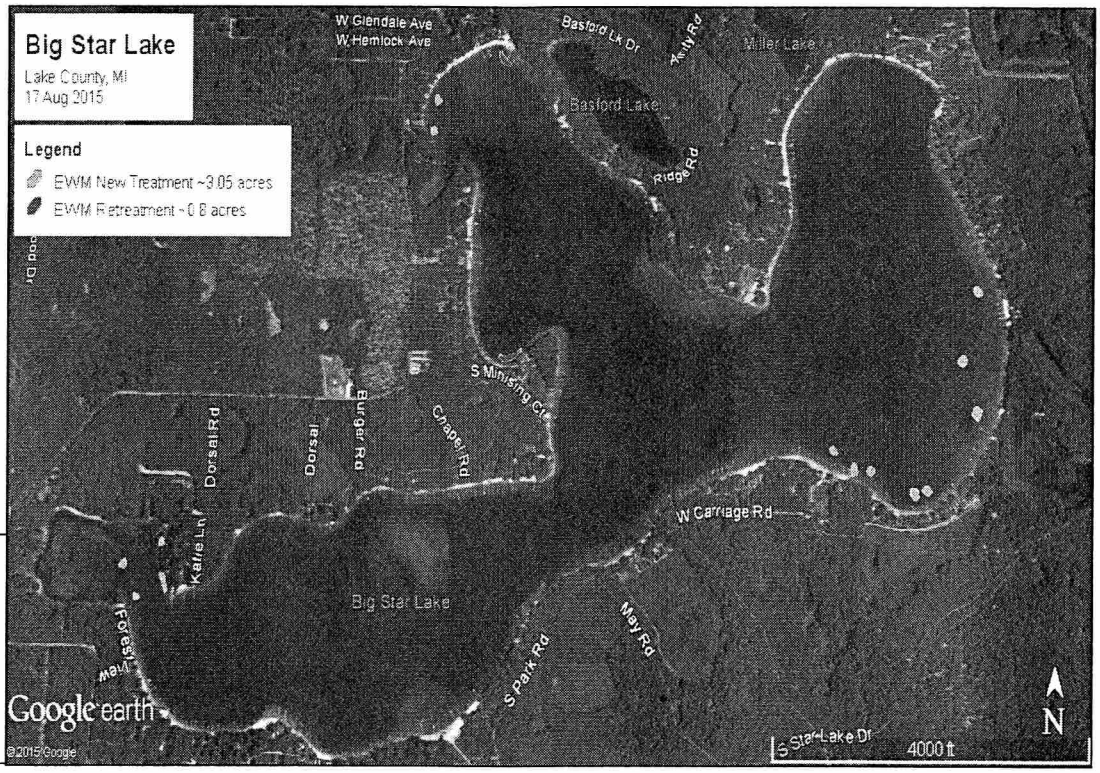
Eurasian Watermilfoil

The amount of Eurasian Watermilfoil present in Big Star Lake varies each year and is dependent upon climatic conditions, especially runoff-associated nutrients. 2015 was the wettest year on record and many lakes experienced nuisance milfoil and algal outbreaks even given the two consecutive harsh winters. The June 2015 survey revealed that approximately 6.5 acres of milfoil was found throughout the entire lake. I late June, the milfoil was treated with high dose granular triclopyr (Renovate OTF®). The treatment was successful overall but late in the season another 3.1 acres of milfoil grew and also required a treatment with the triclopyr. A new area of milfoil growth at the north end of the lake was noted in the fall and will be treated immediately in the spring of 2016.

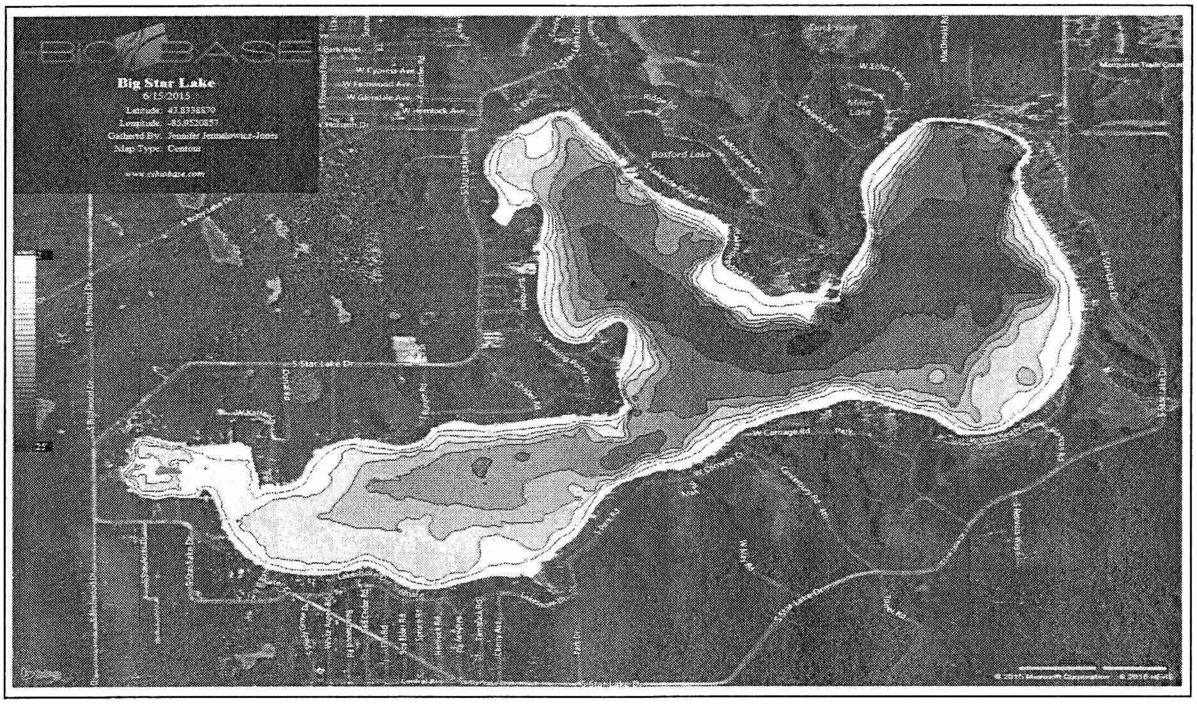
Native aquatic plants did not necessitate treatment in 2015 and this is likely due to the two consecutive harsh winters that reduced overall growth. Treatment maps for each of these invasive species are shown in the maps below.



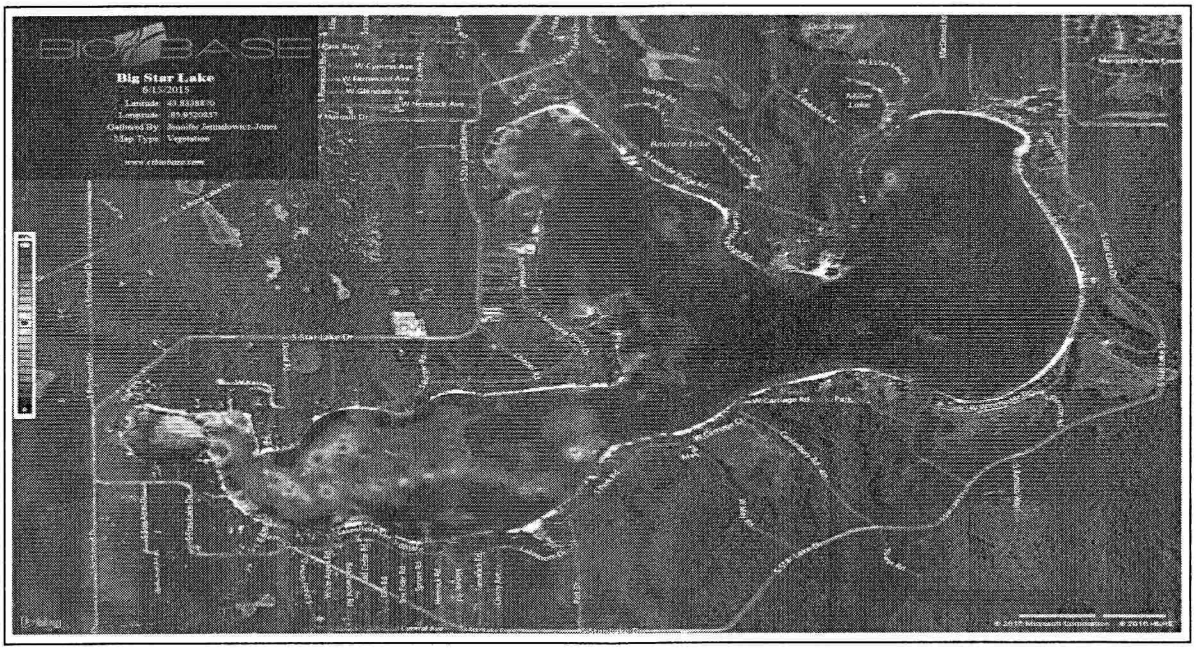
Big Star Lake June 15, 2015 Milfoil Distribution Map



Big Star Lake August 17, 2015 EWM Distribution Map



Big Star Lake Depth Contour Map (RLS, 2015).



Big Star Lake Aquatic Plant Biovolume Map (RLS, 2015).

Section

Management Recommendations for 2016

Continuous aquatic vegetation surveys are needed to determine the precise locations of EWM or other problematic invasives in Big Star Lake. These surveys should occur in late-May to early-June and again post-treatment in 2016.

Due to the relative scarcity of native aquatic vegetation in Big Star Lake, the treatment of these species with aquatic herbicides is not recommended (one exception is the overgrowth of nuisance pondweeds and in a few select areas of the lake and shallow area to the west of the main public access site). The plan for 2016 includes the use of higher doses of systemic aquatic herbicides (such as tricopyr nearshore and 2,4-D offshore) for the milfoil that may be present and the previously found milfoil from the fall of 2015 (if it survives the winter). Nuisance pondweeds will respond well to Aquathol-K® at 2 gallons per acre if present.

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

In conclusion, Big Star Lake is a healthy lake with excellent aquatic plant biodiversity, excellent water clarity, moderate nutrients, and a healthy lake fishery. Management of the EWM and protection of the water quality are paramount for the long-term health of the lake.

Glossary of Scientific Terms used in this Report

1) Biodiversity- The relative abundance or amount of unique and different biological life forms found in a given aquatic ecosystem. A more diverse ecosystem will have many different life forms such as species.

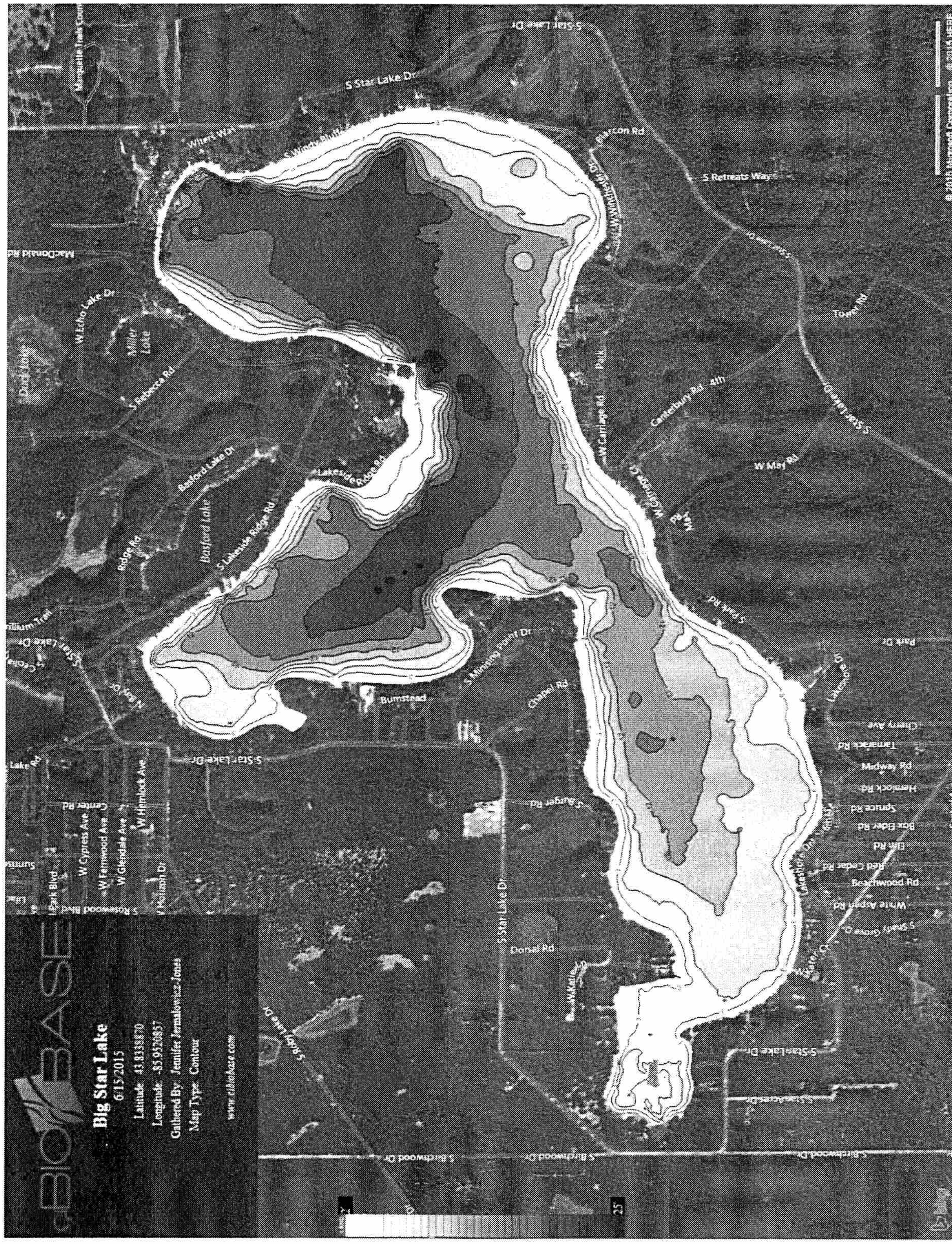
2) CaCO3- The molecular acronym for calcium carbonate; also referred to as "marl" or mineral sediment content.

3) Eutrophic- Meaning "nutrient-rich" refers to a lake condition that consists of high nutrients in the water column, low water clarity, and an over-abundance of algae and aquatic plants.

4) Mesotrophic- Meaning "moderate nutrients" refers to a lake with a moderate quantity of nutrients that allows the lake to have some eutrophic qualities while still having some nutrient-poor characteristics

5) Oligotrophic- Meaning "low in nutrients or nutrient-poor" refers to a lake with minimal nutrients to allow for only scarce growth of aquatic plant and algae life. Also associated with very clear waters.

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



BIOBASE
Big Star Lake
6/15/2015
Latitude: 43.8338870
Longitude: -85.9520857
Gathered By: Jennifer Jermalowicz-Jones
Map Type: Contour
www.cibiobase.com
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S Retreats Way
Tower Rd
W May Rd
Bumstead
Chapel Rd
Dorsal Rd
S Birchwood Dr
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BIOBASE
Big Star Lake
6/15/2015
Latitude 43.8338870
Longitude -85.9520857
Gathered By Jennifer Jermalowicz-Jones
Map Type Vegetation
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Midway Rd
Beachwood Rd
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Ridge Rd
W Echo Lake Dr
Miller Lake
S Rebecca Rd
MacDonald Rd
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