Big Star Lake 2024 Aquatic Vegetation, Water Quality, and 2025 Management Recommendations Report

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Section 1

Big Star Lake 2024 Aquatic Vegetation, Water Quality, and 2025 Management Recommendations Report

The following Big Star Lake report is a summary of key lake findings collected in 2024.

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 in the summer of 2024 was between 8 – 9.2 feet, which is good. The other measured water quality parameters indicated a well-balanced aquatic ecosystem with ideal pH and conductivity. Although the nutrients in the lake are quite low, the lake has enough nutrients (phosphorus and nitrogen) to support some algae and submersed aquatic plant growth. Invasive species such as Eurasian Watermilfoil (EWM) 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 over the past several years with a total of 4.0 acres requiring herbicide treatment in 2024. There was some evidence of tolerance of the EWM to the usual systemic herbicides previously used and thus a newer herbicide called ProcellaCOR® was used in combination with diquat to effectively reduce the EWM without resistance.

Protection of the twenty-seven 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 in swim areas only).

Section

2

Big Star Lake Water Quality Data (2024)

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 °C), 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 of each year are displayed below. Water quality was measured in the East and West deep basins of Big Star Lake in late summer of 2023. 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 good water clarity and moderate algal growth.** General water quality classification criteria are defined in Table 1. 2024 water quality data for Big Star Lake are shown below in Tables 2-3.

Table 1. Lake trophic classification (MDNR).

Lake Trophic Status	*Total Phosphorus (µg L^{-1})*	*Chlorophyll-a (µg L^{-1})*	*Secchi Transparency (feet)*
Oligotrophic	**< 10.0**	**< 2.2**	**> 15.0**
Mesotrophic	**10.0 – 20.0**	**2.2 – 6.0**	**7.5 – 15.0**
Eutrophic	**> 20.0**	**> 6.0**	**< 7.5**

Table 2. Big Star Lake water quality parameter data collected over the East deep basin on August 15, 2024.

Depth ft.	*Water Temp ºC*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Turb. NTU*	*Total Dissolved Solids mg L^{-1}*	*Total Alk. mg L^{-1} $CaCO_3$*	*Total Phos. mg L^{-1}*	*TKN mg L^{-1}*
0	24.82	8.99	8.44	152.9	0.4	97.8	59	<0.010	0.76
11	24.79	9.08	8.40	152.9	1.5	97.8	59	<0.010	0.58
22	24.04	9.23	8.42	152.6	1.9	97.6	60	<0.010	0.6

Table 3. Big Star Lake water quality parameter data collected over the West deep basin on August 15, 2024.

Depth ft.	*Water Temp ºC*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Turb. NTU*	*Total Dissolved Solids mg L^{-1}*	*Total Alk. mg L^{-1} $CaCO_3$*	*Total Phos. mg L^{-1}*	*TKN mg L^{-1}*
0	24.8	9.2	8.6	152.8	0.3	97.8	59	<0.010	0.76
6	24.8	9.6	8.5	152.8	1.6	97.8	59	<0.010	0.60
12	24.4	9.7	8.5	152.3	2.1	97.4	61	<0.010	0.78

Dissolved Oxygen (D.O)

Dissolved oxygen is a measure of the amount of oxygen that exists in the water column. In general, dissolved oxygen levels should be greater than 5 mg L^{-1} to sustain a healthy warm-water fishery. Dissolved oxygen concentrations 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 was measured in milligrams per liter (mg L^{-1}) with the use of a calibrated Eureka Manta II® dissolved oxygen meter and multi-probe. During the summer months, dissolved oxygen at the surface is generally higher due to the exchange of oxygen from the atmosphere with the lake surface, whereas dissolved oxygen is lower at the lake bottom due to decreased contact with the atmosphere and increased biochemical oxygen demand (BOD) from microbial activity. **Dissolved oxygen concentrations during the August 15, 2024 sampling event ranged from a high of 9.7 mg L^{-1} to a low of 7.6 mg L^{-1}. When dissolved oxygen levels fall below 3.0 mg L^{-1} phosphorus can be released from the sediments.**

Water Clarity (Transparency) Data

Elevated Secchi transparency readings allow for more aquatic plant and algae growth. The transparency throughout Big Star Lake was adequate in August of 2024 (8.1 - 9.2) feet; below graph) 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 number 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 were quite low in 2024 at ≤ 2.1 NTU's (below graph) and ~100 mg/L, respectively during the recent period, which is highly favorable.**

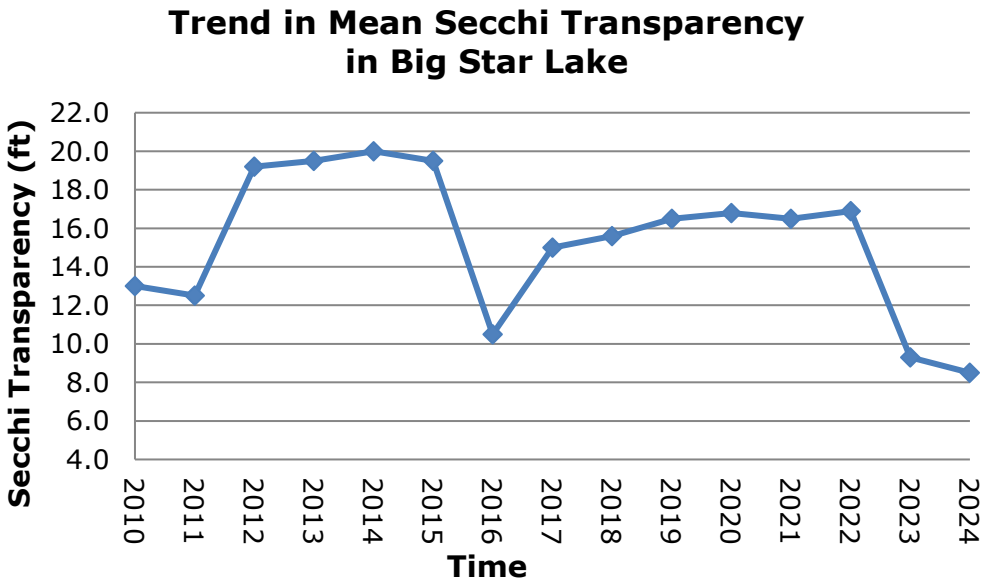

Figure 1: Trend in water clarity within Big Star Lake from 2010-2024.

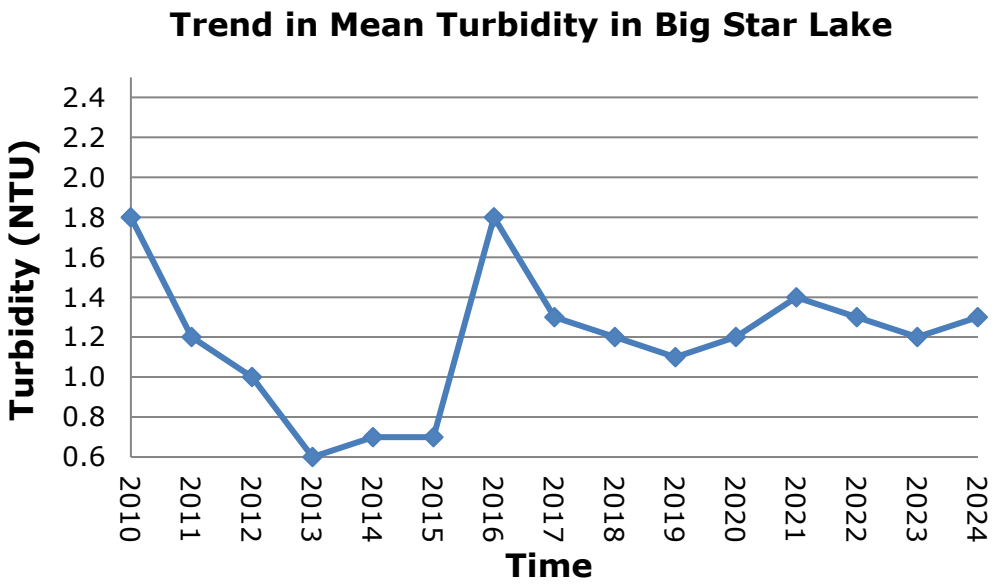

Figure 2: Trend of mean Turbidity within Big Star Lake from 2010-2024.

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. **The mean TP concentration in summer of 2024 was <0.010 mg L^{-1} (below graph), which is much lower than in recent years and very favorable.**

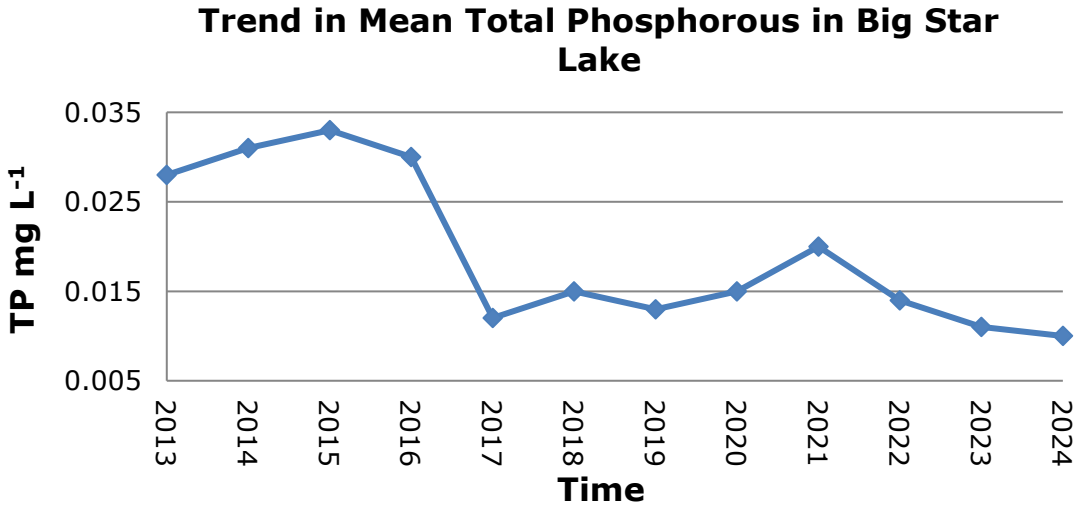

Figure 3: Trend in average Total Phosphorous within Big Star Lake from 2013-2024.

Total Kjeldahl Nitrogen

Total Kjeldahl Nitrogen (TKN) is the sum of nitrate (NO_3^-), nitrite (NO_2^-), ammonia (NH_4^+), and organic nitrogen forms in freshwater systems. Much nitrogen (amino acids and proteins) also comprises the bulk of living organisms in an aquatic ecosystem. Nitrogen originates from atmospheric inputs (i.e., burning of fossil fuels), wastewater sources from developed areas (i.e., runoff from fertilized lawns), agricultural lands, septic systems, and from waterfowl droppings. It also enters lakes through ground or surface drainage, drainage from marshes and wetlands, or from precipitation (Wetzel, 2001). In lakes with an abundance of nitrogen (N: P > 15), phosphorus may be the limiting nutrient for phytoplankton and aquatic macrophyte growth. Alternatively, in lakes with low nitrogen concentrations (and relatively high phosphorus), the blue-green algae populations may increase due to the ability to fix nitrogen gas from atmospheric inputs. Lakes with a mean TKN value of 0.66 mg L^{-1} may be classified as oligotrophic, those with a mean TKN value of 0.75 mg L^{-1} may be classified as mesotrophic, and those with a mean TKN value greater than 1.88 mg L^{-1} may be classified as eutrophic. **The mean TKN concentration in Big Star Lake in summer of 2024 averaged 0.66 mg L^{-1}, which is moderately low and favorable for an inland lake.** The graph below demonstrates the changes in total nitrogen with time in Big Star Lake.

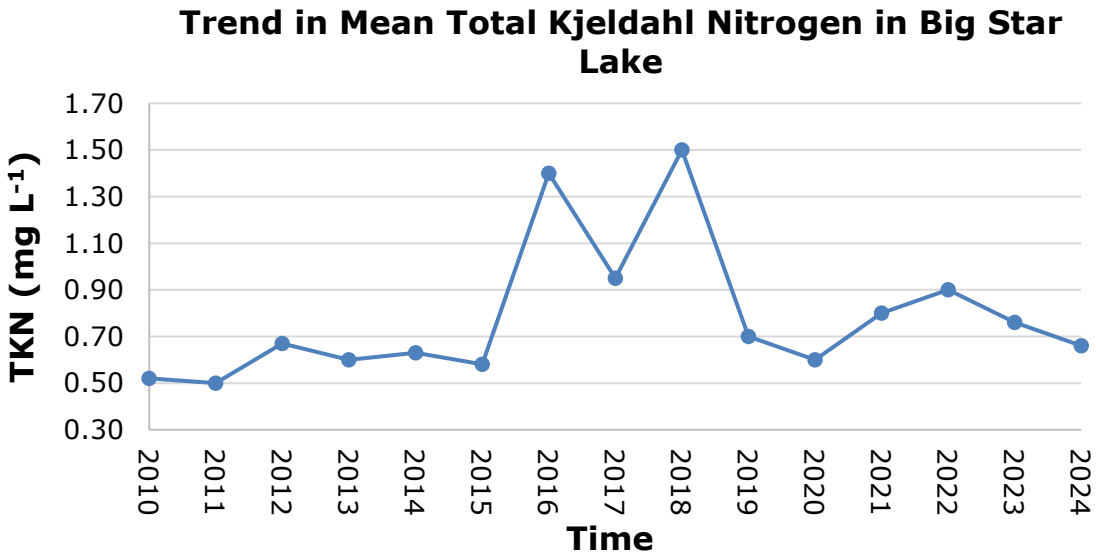

Figure 4: Trend in average Total Kjeldahl Nitrogen within Big Star Lake from 2010-2024.

Total Alkalinity

Lakes with high alkalinity (<60 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 soft water lake with a mean of 60.0 mg L^{-1} CaCO3 in 2024.** The graph below demonstrates the changes in total alkalinity over time.

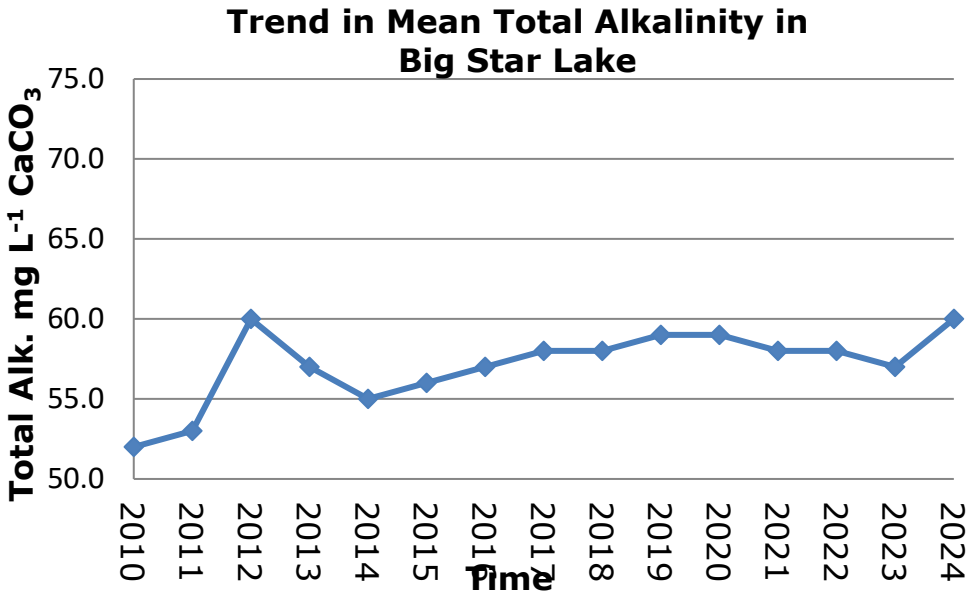

Figure 5: Trend of average Total Alkalinity within Big Star Lake from 2010-2024.

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 averaged 8.4 S.U. (below graph) in the summer of 2024 which is ideal for an inland lake that has a healthy aquatic vegetation community with active photosynthesis.**

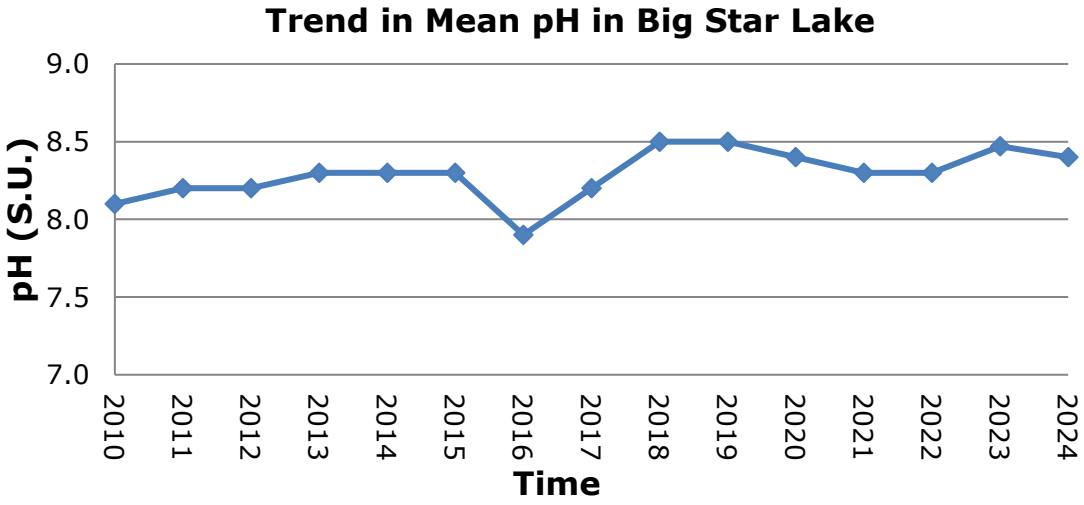

Figure 6: Trend in average pH in Big Star Lake from 2010-2024.

Conductivity

Conductivity is a measure of the number 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 in 2024 averaged 156 mS/cm (below graph), which is very favorable.** Severe water quality impairments do not occur until values exceed 800 mS/cm and are toxic to aquatic life around 1,000 mS/cm.

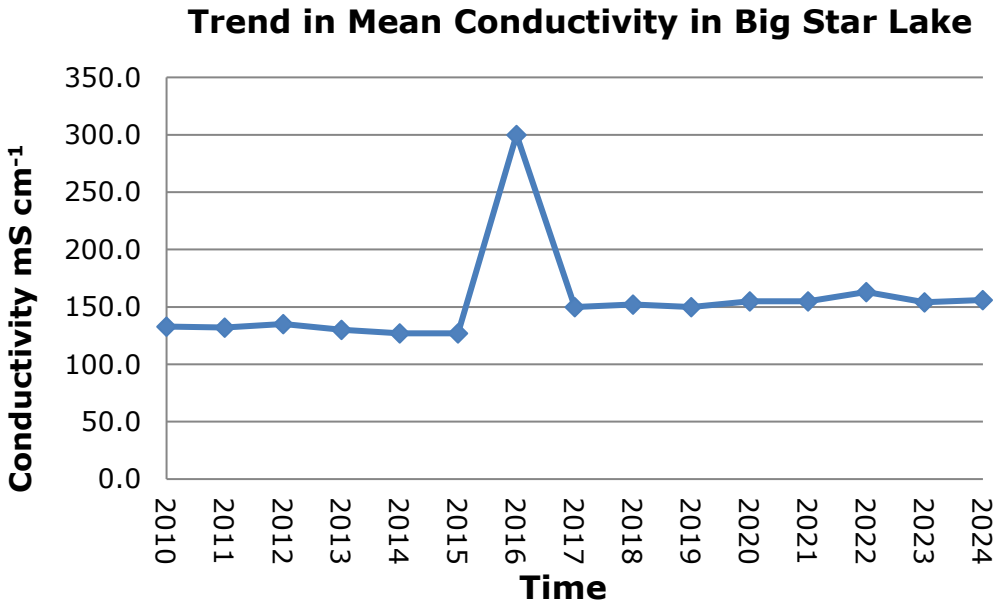

Figure 7: Trend in average Conductivity within Big Star Lake from 2010-2024.

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 and were lower in 2024 compared to previous years (below graph). The lower concentrations were likely attributed to less rainfall and runoff.**

The algal genera were determined from composite water samples collected over the deep basin of Big Star Lake in 2024 and were analyzed with a compound bright field microscope. The genera present included the Chlorophyta (green algae; Figure 9): *Chlorella* sp., *Scenedesmus* sp., *Ulothrix* sp., sp., *Haematococcus* sp., and *Pediastrum* sp.; The Cyanophyta (blue-green algae; Figure 10): *Gleocapsa* sp.; The Bascillariophyta (diatoms; Figure 11)*: Synedra* sp., *Navicula* sp., *Cymbella* sp., *Eunotia* sp., and *Stephanodiscus* sp.. The aforementioned species indicate a diverse algal flora and represent a good diversity of alga with an abundance of diatoms that are indicative of great water quality.

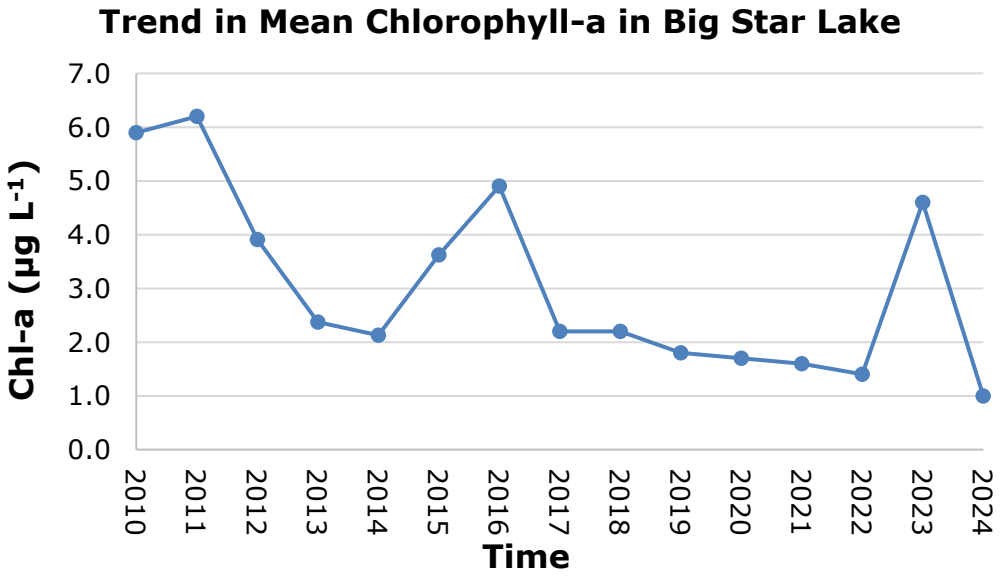

Figure 8: Trend in average Chlorophyll-a in Big Star Lake from 2010-2024

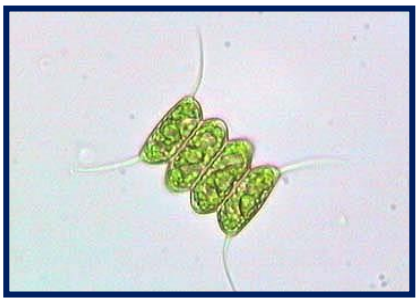

Figure 9. A Green Alga

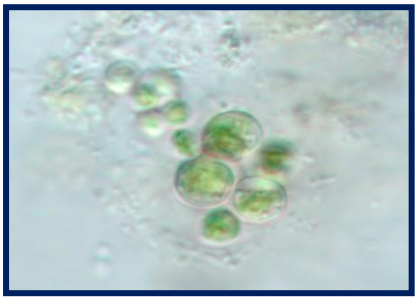

Figure 10. A Blue-Green Alga

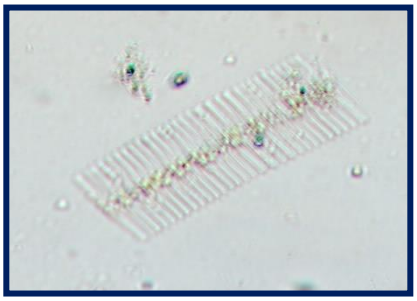

Figure 11. A Diatom

Section

3

Aquatic Vegetation Data (2024)

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 August 15, 2024 whole-lake survey determined that there was a total of twenty-seven native aquatic plant species in Big Star Lake. These include 20 submersed species, 4 floating-leaved species, and 3 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 during the August 15, 2024 survey included: 1) Chara (Figure 12) which has a skunky odor and lies on the lake bottom. This macroalga is beneficial since it prevents EWM from rooting in the lake bottom and thus its growth is encouraged; 2) Southern Naiad (Figure 13); This plant has very slender green / purplish leaves that are 1/16 inch wide. It is a great bottom cover providing habitat for micro and macro invertebrates along as providing food for waterfowl with its seeds, and 3) Wild Celery (Figure 14) which also has a tall grassy appearance. When it reaches maturity the seed heads will reach the surface in a spiral pattern with a small seed head on top.

During the August 15, 2024 full lake survey, a Biobase benthic scan was done as well. This scan produced the contour lines of Big Star Lake. The lighter colors represent shallow water where the darker blues represent deep water. Along with this, the scan provided aquatic vegetation biovolume and sediment relative hardness maps of the lake vegetation growth and sediments respectively. These images can be found below in Figures 15 - 17. On the biovolume map, greens to red represent sparse to dense vegetation growth and dark blue represents no growth. On the sediment relative hardness map, the lighter shades represent soft sediments as where the darker shades represent firmer or more consolidated sediments.

Table 4. Big Star Lake Native Aquatic Plant Species (August 15, 2024).

Aquatic Plant Species and Code	*Aquatic Plant Common Name*	*% Frequency in Littoral (Shallow) Zone of Big Star Lake (2024)*
Chara vulgaris **(macro alga)**	**Muskgrass**	**31.39**
Potamogeton **spp.**	**Thin leaf Pondweed**	**3.06**
Potamogeton gramineus	**Variable-leaved Pondweed**	**19.72**
Potamogeton praelongus	**White-Stemmed Pondweed**	**11.39**
Potamogeton illinoensis	**Illinois Pondweed**	**3.06**
Potamogeton amplifolius	**Large-leaf Pondweed**	**13.61**
Potamogeton robbinsii	**Robbins Pondweed**	**6.39**
Potamogeton nodosus	**American Pondweed**	**1.94**
Myriophyllum sibiricum	**Northern Watermilfoil**	**0.56**
Sagittaria **spp.**	**Submersed Sagittaria**	**0.28**
Megalodonta beckii	**Water Marigold**	**0.56**
Myriophyllum tenellum	**Leafless Watermilfoil**	**0.56**
Scirpus subterminalis	**Submersed Bulrush**	**1.67**
Potamogeton zosteriformis	**Flat-stem Pondweed**	**12.5**
Elodea canadensis	**Common Waterweed**	**3.06**
Potamogeton pusillus	**Small-leaf Pondweed**	**2.5**
Vallisneria americana	**Wild Celery**	**19.44**
Stuckenia pectinata	**Sago Pondweed**	**3.61**
Utricularia vulgaris	**Common Bladderwort**	**1.11**
Najas guadalupensis	**Southern Naiad**	**14.2**
Potamogeton richardsonii	**Richardson's Pondweed**	**0.28**
Nymphaea odorata	**White Waterlily**	**5.0**
Nuphar advena	**Yellow Waterlily**	**0.56**
Brasenia schreberi	**Watershield**	**2.22**
Typha latifolia	**Cattails**	**1.11**
Schoenoplectus acutus	**Bulrushes**	**3.61**
Iris **sp.**	**Wild Iris**	

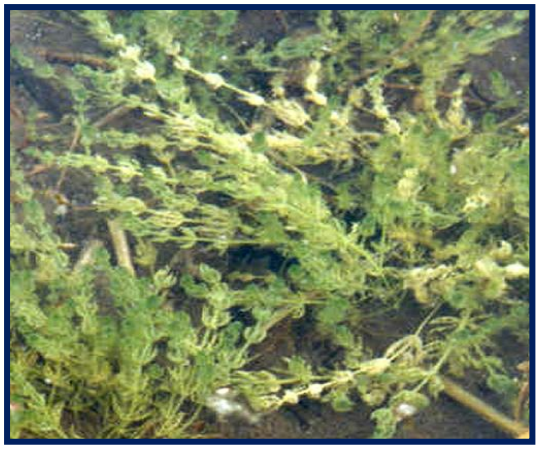

Figure 12. Chara

Figure 13. Southern Naiad

Figure 14. Wild Celery

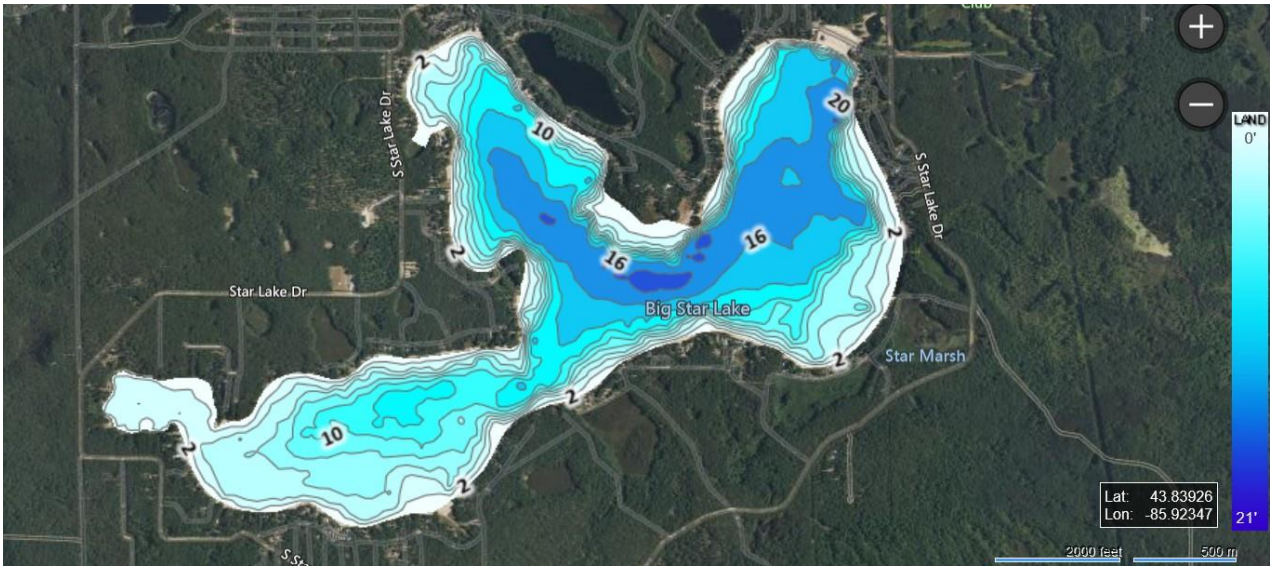

Figure 15: Depth contour map of Big Star Lake from the August 15th, 2024 scan.

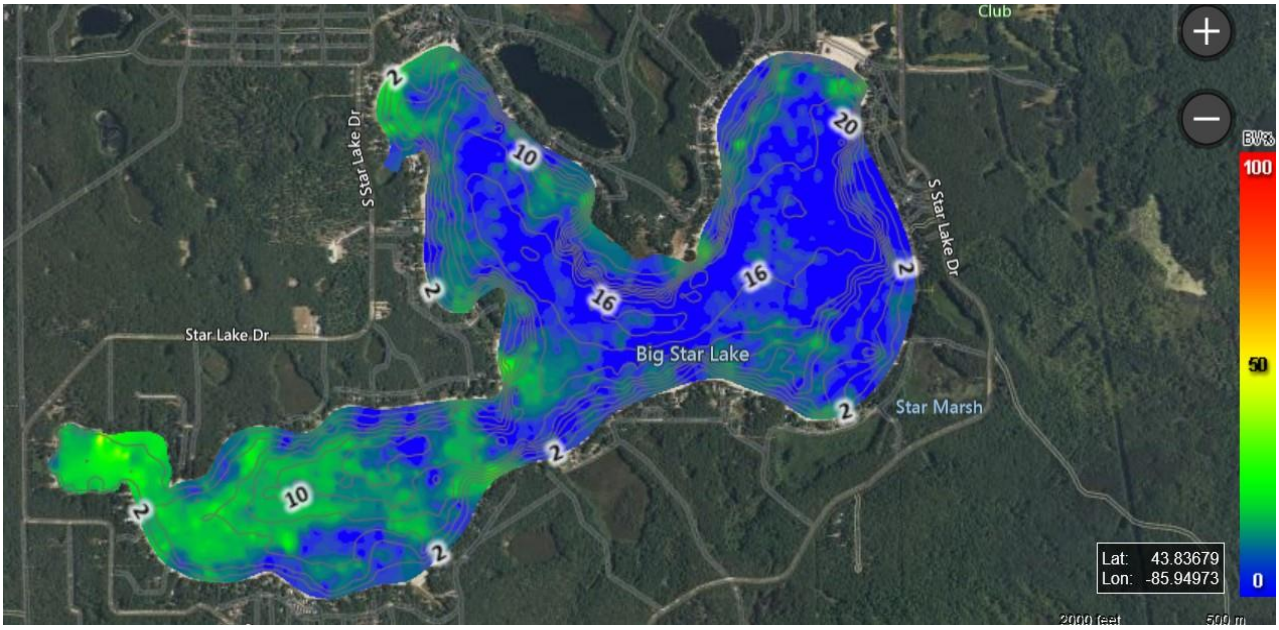

Figure 16: Biovolume map of Big Star Lake from the August 15th, 2024 scan.

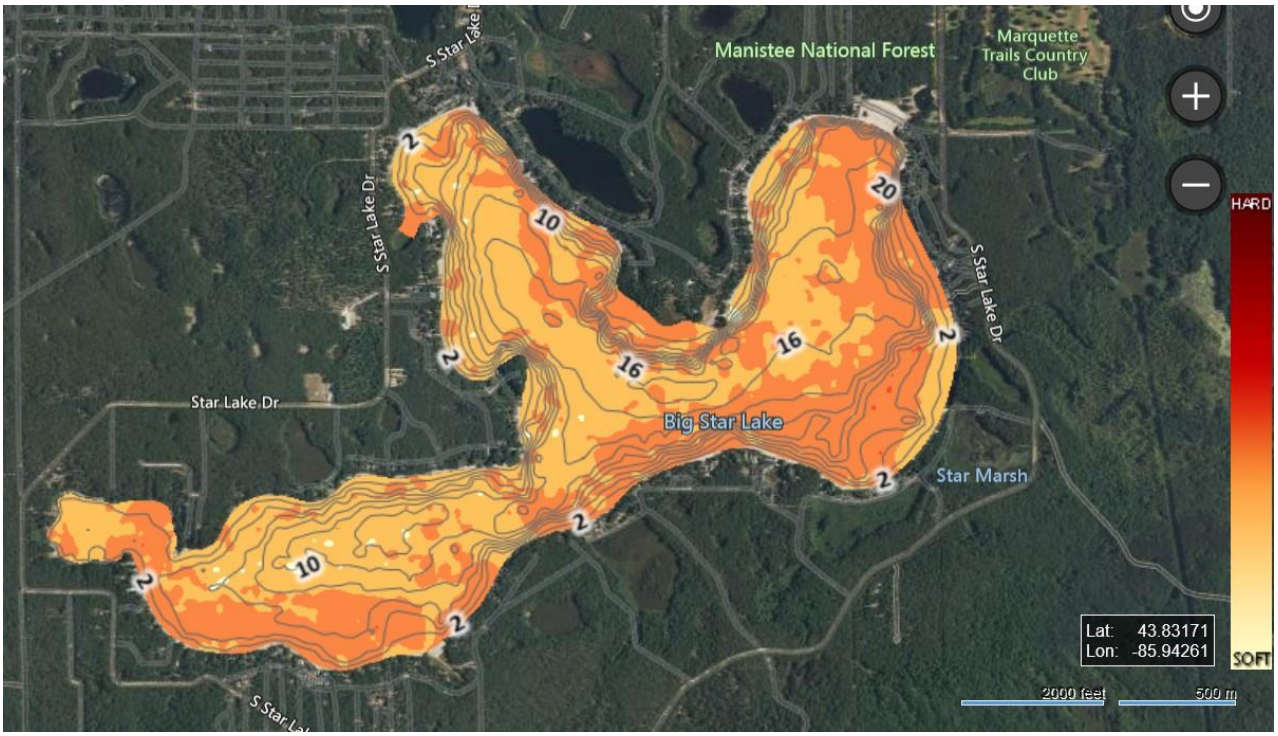

Figure 17: Sediment relative hardness map of Big Star Lake from the August 15th, 2024 scan.

Status of Invasive (Exotic) Aquatic Plant Species

The amount of Eurasian Watermilfoil (Figure 18) present in Big Star Lake varies each year and is dependent upon climatic conditions, especially runoff-associated nutrients. The May 17th, 2024 survey revealed that approximately 4.0 acres of milfoil were found throughout the entire lake. An additional 1.0 acre was found during the treatment day of May 28th, 2024 and these 5.0 acres were treated with the combination of ProcellaCOR® (6 PDU dose) and diquat (1 gal/acre dose). The second whole-lake inventory survey on August 15th, 2024, showed the first treatment was very successful and less than 1.0 acre of EWM was found in a couple different areas in sparse density so this was not treated. EWM growth in the lake will need to be re-evaluated in spring of 2025 and treated if it survives the winter. The 2024 treatment map for the EWM is shown in the map below (Figure 19)

Figure 18. Eurasian Watermilfoil (Seed head, lateral branch and main stem).

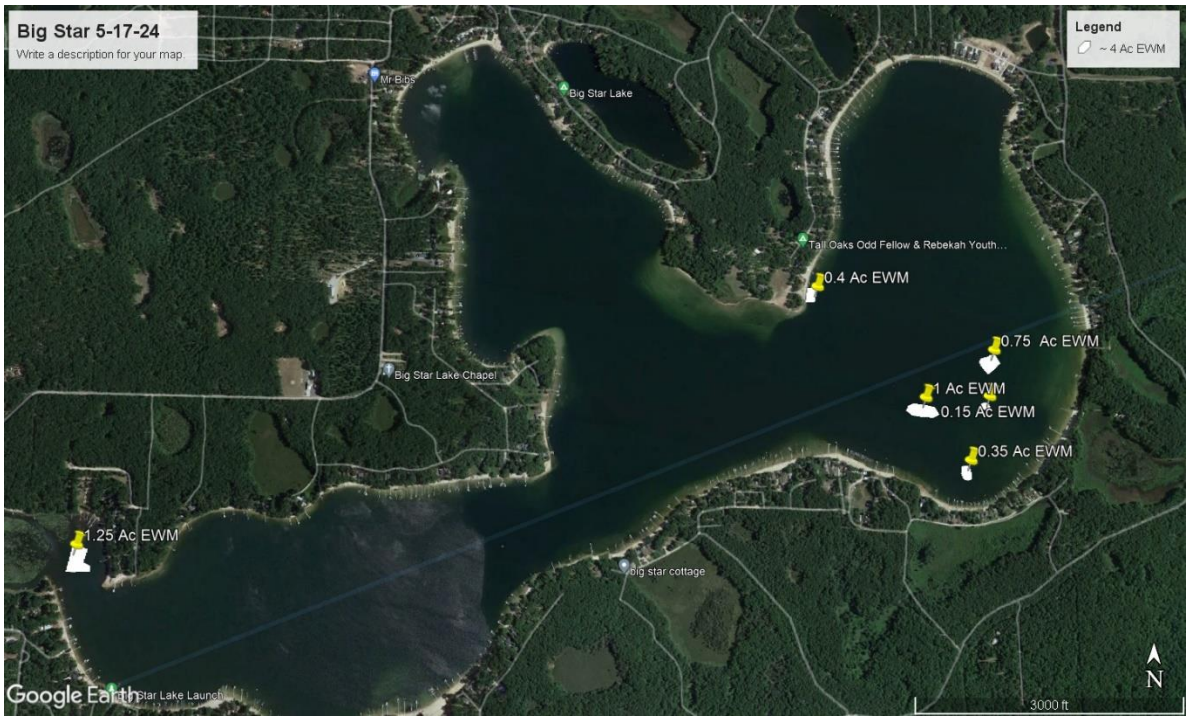

Figure 19. EWM Distribution in Big Star Lake (May 17, 2024).

Section

4

Management Recommendations for 2025

Aquatic vegetation surveys will be conducted in late May or early June of 2025 with treatments to follow within a week or two of the surveys. These surveys will prescribe treatments for EWM, CLP, or any other invasive aquatic plant species. **Care should be taken to reduce the need for treatment on native aquatic plants as they are scarce given the lake surface area and should thus be preserved.** An additional survey after the treatments will determine the efficacy of the treatment and any follow-up treatments that may be needed. To reduce tolerance of EWM to triclopyr which has been frequently applied, EWM will again be treated with a combination of the new systemic herbicide ProcellaCOR® and diquat in 2025. Nuisance CLP may be treated with Aquathol K®, diquat, and/or flumioxazin. Additional treatment of emergent invasives such as *Phragmites* may also be necessary in 2025. To ensure quality control and due diligence, RLS will be present to oversee treatments as in previous years. This level of oversight is important to certify that the treatments were conducted according to the EGLE-issued permit.

Water quality will be monitored in the lake in 2025 and graphed with historical data to determine any trends over time. **In conclusion, the overall water quality in Big Star Lake remains very high. Water clarity is high allowing light penetration to deeper water that helps support abundant aquatic plant growth throughout many areas of the lake**. Levels of nutrients such as phosphorus and nitrogen are low, but sufficient to support aquatic plant growth. There is a robust fishery in the lake. Management of EWM and nuisance natives will continue to be emphasized in 2025 and beyond.

Big Star Lake has improved substantially since the lake management program began with a massive reduction in EWM due to rigorous whole lake scans and surveys.