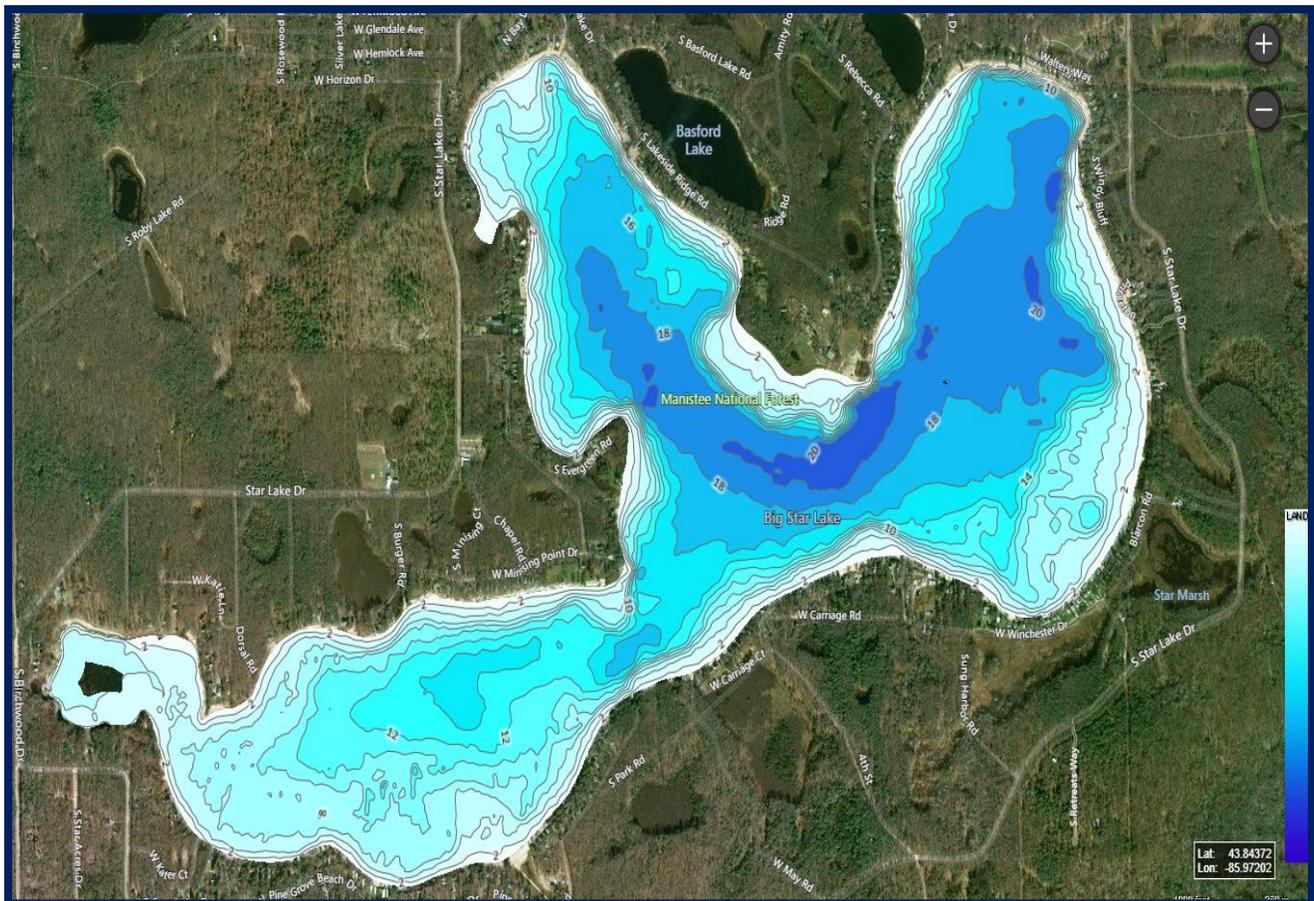# Big Star Lake 2021 Aquatic Vegetation, Water Quality, and 2022 Management Recommendations Report

November, 2021

Big Star Lake 2021 Aquatic Vegetation, Water Quality, and 2022 Management Recommendations Report

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18406 Big Star Spring Lake Road
Spring Lake, Michigan 49456
Website: http://www.restorativelakesciences.com

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Big Star Lake 2021 Aquatic Vegetation, Water Quality, and 2022 Management Recommendations Report

The following Big Star Lake report is a summary of key lake findings collected in 2021.

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 2021 was between 15-18 feet which is excellent. The other measured water quality parameters indicated a well-balanced aquatic ecosystem with ideal pH and conductivity.

Although the nutrients in the lake are moderate, 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 9.0 acres requiring herbicide treatment in 2021. There was some evidence of tolerance of the EWM to the usual systemic herbicides and thus a newer herbicide called ProcellaCOR® was used to effectively reduce the EWM without resistance.

Protection of the twenty-one 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).

Big Star Lake Water Quality Data (2021)

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 deep basin of Big Star Lake in late spring and summer of 2021. 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. 2021 water quality data for Big Star Lake is 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 deep basin on May 26, 2021.

| Depth ft.	Water Temp °C	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 CaCO₃	Total Phos. mg L⁻¹
0	16.8	9.2	8.3	152	0.3	126.9	56	58	0.010
11	15.1	8.7	8.3	152	1.5	121.3	56	58	0.020
22	14.7	8.2	8.2	166	1.9	115.4	69	59	0.020

Table 3. Big Star Lake water quality parameter data collected over the deep basin on September 03, 2021.

| Depth ft.	Water Temp °C	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 CaCO₃	Total Phos. mg L⁻¹
0	22.9	8.9	8.4	150	0.7	108.9	58	59	0.010
11	20.1	8.1	8.4	150	1.8	102.0	58	59	0.020
22	18.7	7.7	8.4	159	2.2	99.6	66	59	0.030

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 2021 (15-18.0 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 2021 at ≤2.2 NTU's (below graph) and ≤69 mg/L, respectively during the recent period which is highly favorable.

## Trend in Mean Secchi Transparency in Big Star Lake
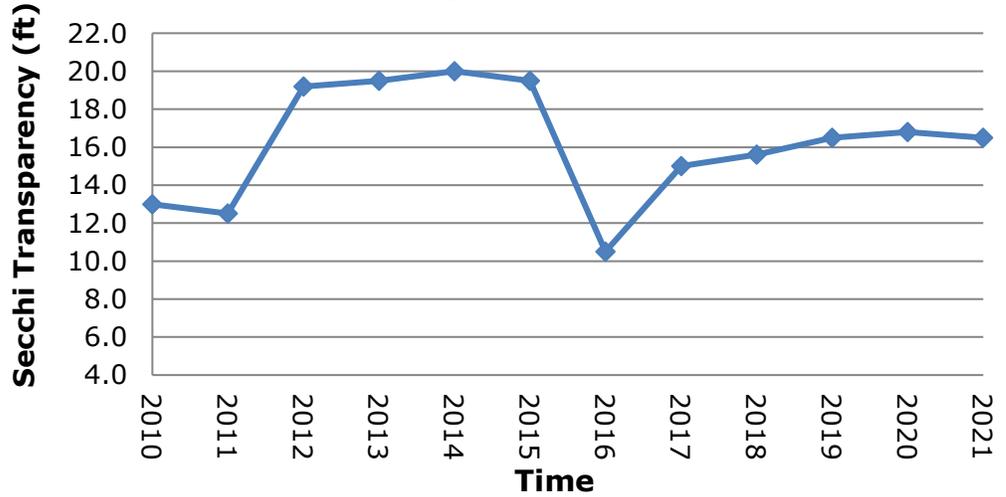
Trend in Mean Turbidity in Big Star Lake
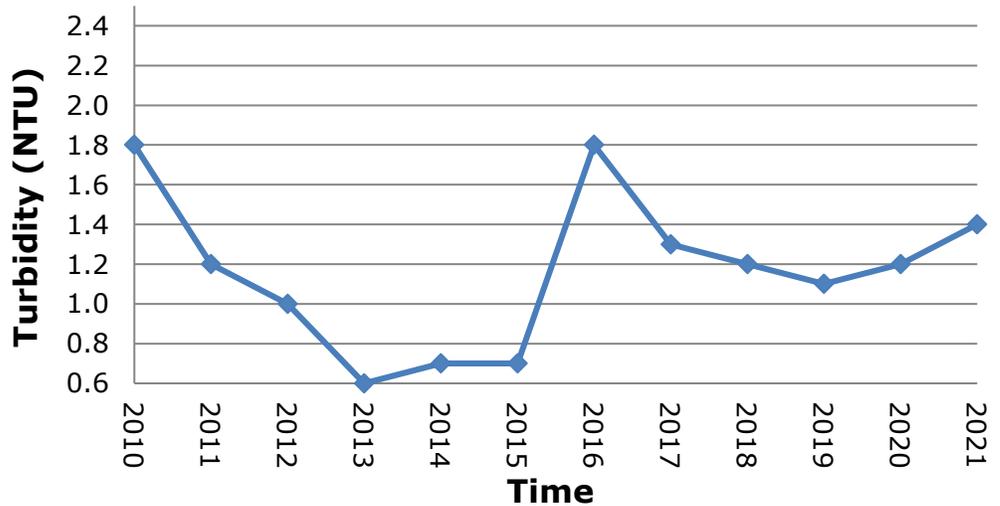
Total Phosphorus

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 2021 was 0.020 mg L^{-1} (below graph), which is much lower than in recent years.

Trend in Mean TP in Big Star Lake
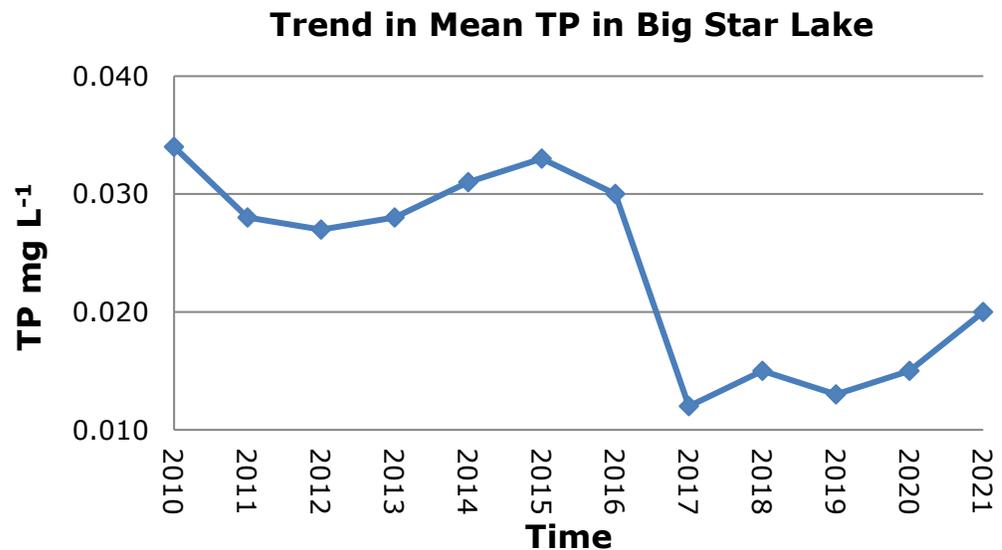
Total Nitrogen

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 2021 averaged 0.8 mg L^{-1}, which is moderately low for an inland lake. The graph below demonstrates the changes in total nitrogen with time in Big Star Lake.

Trend in Mean TKN in Big Star Lake
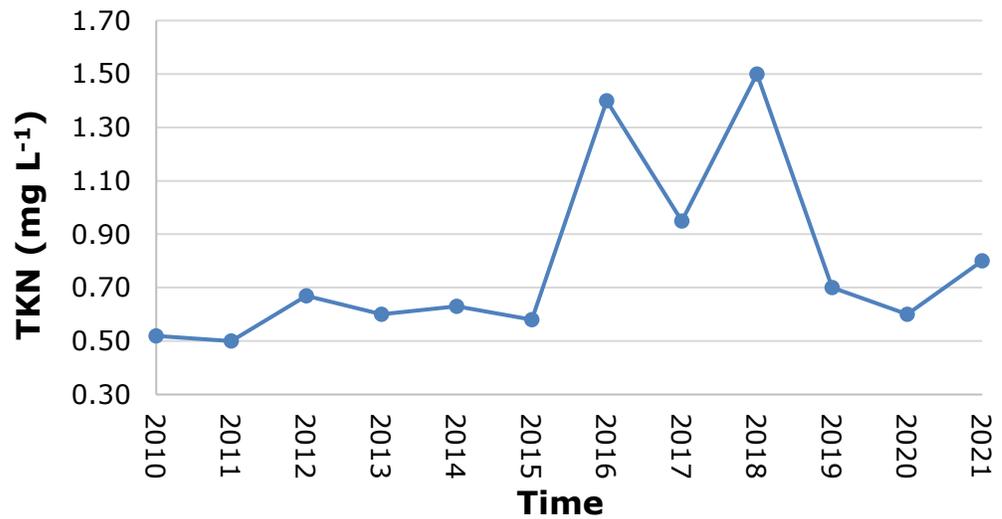
Total Alkalinity

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 somewhat soft water lake. The graph below demonstrates the changes in total alkalinity over time.

Trend in Mean Total Alkalinity in Big Star Lake
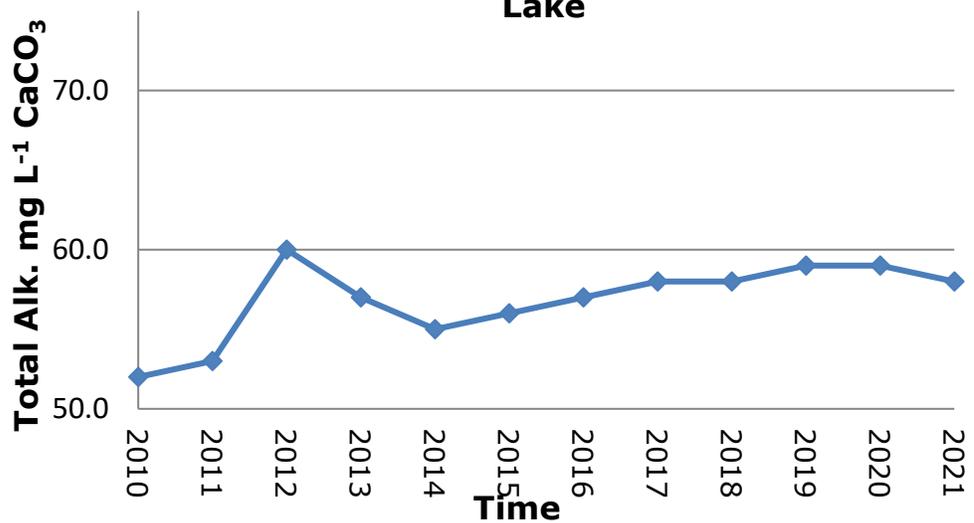
pH

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 averaged 8.4 S.U. (below graph) in the summer of 2021 which is ideal for an inland lake that has a healthy aquatic vegetation community which is actively photosynthesizing.
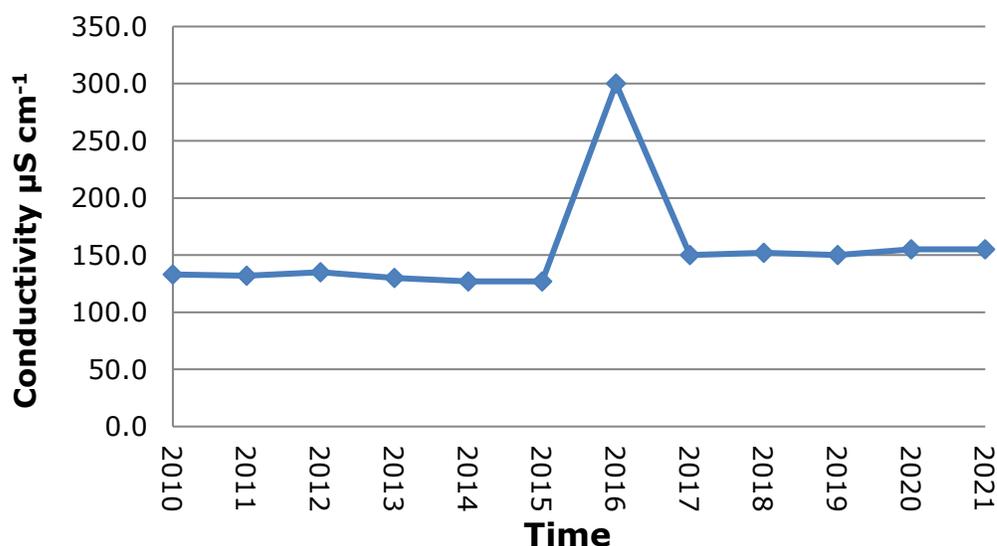
Trend in Mean pH in Big Star Lake
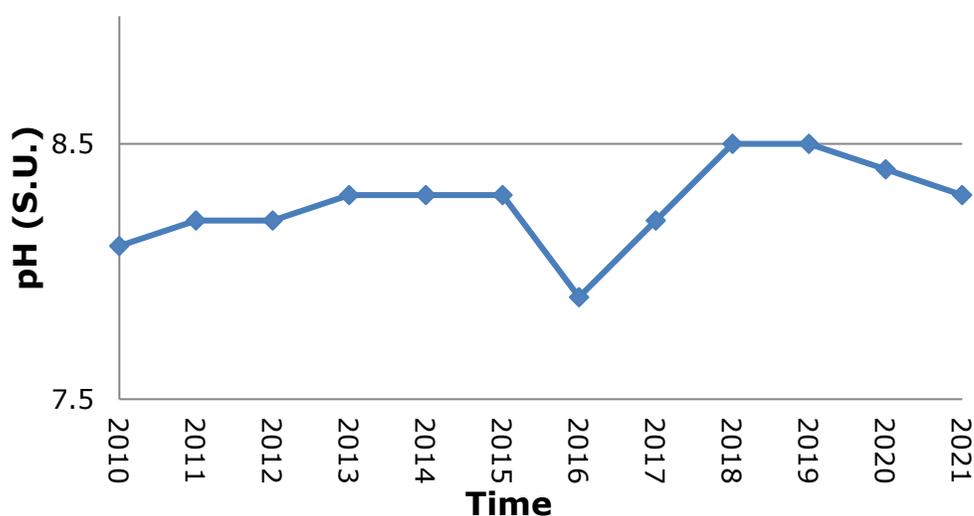
Conductivity

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 2021 averaged 155 µS/cm (below graph), which is very favorable. Severe water quality impairments do not occur until values exceed 800 µS/cm and are toxic to aquatic life around 1,000 µS/cm.

Trend in Mean Conductivity in Big Star Lake

Conductivity $\mu S\ cm^{-1}$ (y-axis: 0.0, 50.0, 100.0, 150.0, 200.0, 250.0, 300.0, 350.0)

Time (x-axis: 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021)

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 $\mu g\ L^{-1}$ are found in eutrophic or nutrient-enriched aquatic systems, whereas chlorophyll-*a* concentrations less than 2.2 $\mu g/L$ are found in nutrient-poor or oligotrophic lakes. Chlorophyll-*a* concentrations vary among years but were slightly lower in 2021 (below graph).

The algal genera were determined from composite water samples collected over the deep basin of Big Star Lake in 2021 were analyzed with a compound bright field microscope. The genera present included the Chlorophyta (green algae; Figure 1): *Chlorella* sp., *Spirogyra* sp., *Scenedesmus* sp., *Cladophora* sp., *Mougeotia* sp., *Pandorina* sp., and *Chloromonas* sp.; The Cyanophyta (blue-green algae; Figure 2): *Oscillatoria* sp.; The Bascillariophyta (diatoms; Figure 3)*: Synedra* sp., *Navicula* sp., *Fragillaria* sp., and *Cymbella* 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.
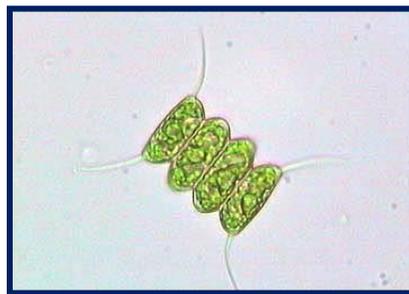
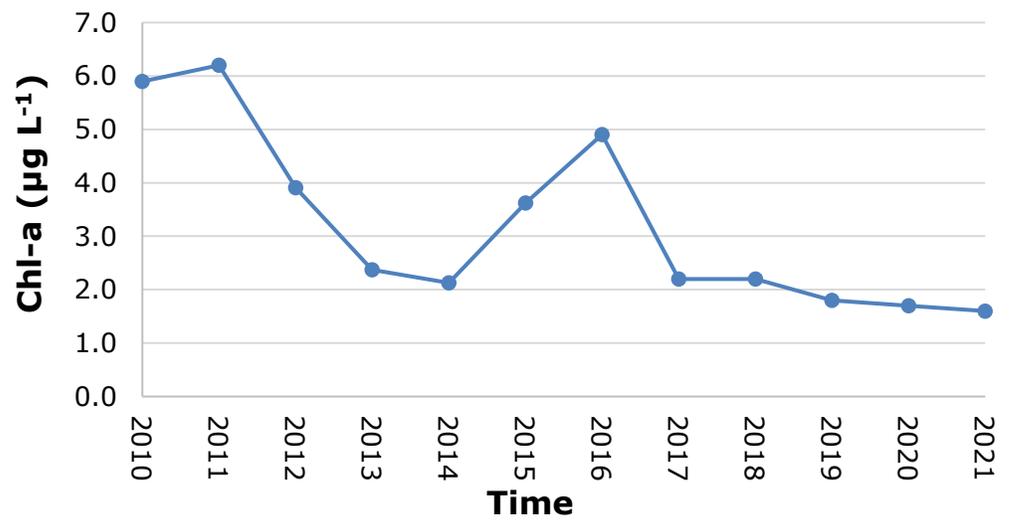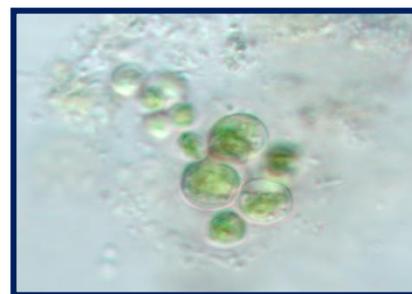## Trend in Mean Chlorophyll-a in Big Star Lake

Figure 1. A Green Alga

Figure 2. A Blue-Green Alga

Figure 3. A Diatom

Section

3

Aquatic Vegetation Data (2021)

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 May 26, 2021 whole-lake survey determined that there were a total of twenty-one native aquatic plant species in Big Star Lake. These include twelve submersed species, three 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 in late May of 2021 included: 1) Leafless watermilfoil which appears as a small spike-like plant with fragile roots and has the appearance of sod on the lake bottom (Figure 4); 2) Illinois Pondweed (Figure 5), which has long, slightly curled brown leaves with a prominent seed head that can break the surface of the lake. 3) Chara, (Figure 6) 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;

Table 4. Big Star Lake Native Aquatic Plant Species (May 26, 2021).

Aquatic Plant Species and Code	Aquatic Plant Common Name	% Cover in Littoral (Shallow) Zone of Big Star Lake (2021)
Chara vulgaris (macro alga)	Muskgrass	22.0
Potamogeton pectinatus	Thin leaf Pondweed	4.0
Potamogeton gramineus	Variable-leaved Pondweed	10.5
Potamogeton praelongus	White-Stemmed Pondweed	12.0
Potamogeton illinoensis	Illinois Pondweed	25.5
Potamogeton amplifolius	Large-leaf Pondweed	9.0
Potamogeton natans	Floating-leaf Pondweed	2.1
Zosterella dubia	Water Stargrass	0.7
Vallisneria americana	Wild Celery	9.0
Utricularia vulgaris	Common Bladderwort	15.0
Najas guadalupensis	Southern Naiad	5.1
Myriophyllum tenellum	Leafless Watermilfoil	28.4
Nymphaea odorata	White Waterlily	4.0
Nuphar advena	Yellow Waterlily	4.0
Brasenia schreberi	Watershield	3.1
Typha latifolia	Cattails	3.6
Schoenoplectus acutus	Bulrushes	0.4
Iris versicolor	Blue flag Iris	0.4
Decodon verticillatus	Swamp Loosestrife	3.2
Polygonum amphibium	Water Smartweed	1.6
Eriocaulon sp.	Pipewort	2.7

Figure 4. Leafless Watermilfoil

Figure 5. Illinois Pondweed

Figure 6. Chara

Status of Invasive (Exotic) Aquatic Plant Species

The amount of Eurasian Watermilfoil (Figure 7) present in Big Star Lake varies each year and is dependent upon climatic conditions, especially runoff-associated nutrients. The May 26, 2021 survey revealed that approximately 5.0 acres of milfoil was found throughout the entire lake. On June 7, 2021, the milfoil was treated with a combination of ProcellaCOR® and diquat. The treatment was very successful with one additional treatment of 4.0 acres needed on September 13, 2021. That milfoil was also treated with a combination of ProcellaCOR® and diquat.

Treatment maps for the EWM are shown in the maps below (Figures 8-10).
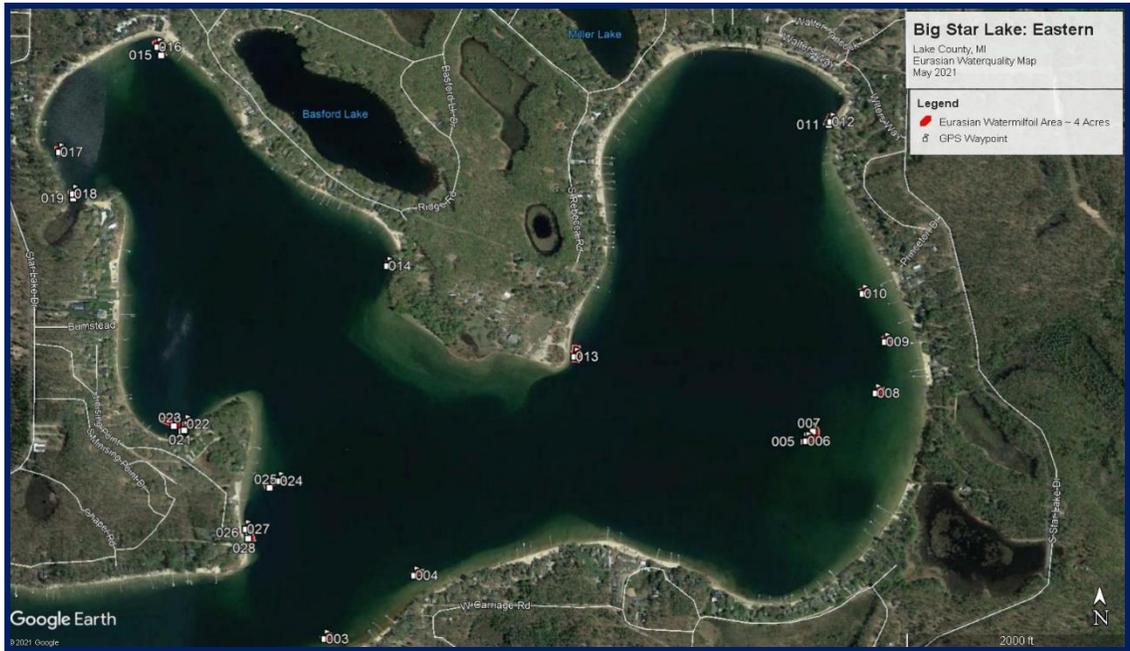

Figure 7. Eurasian Watermilfoil (Leaf and leaflets).

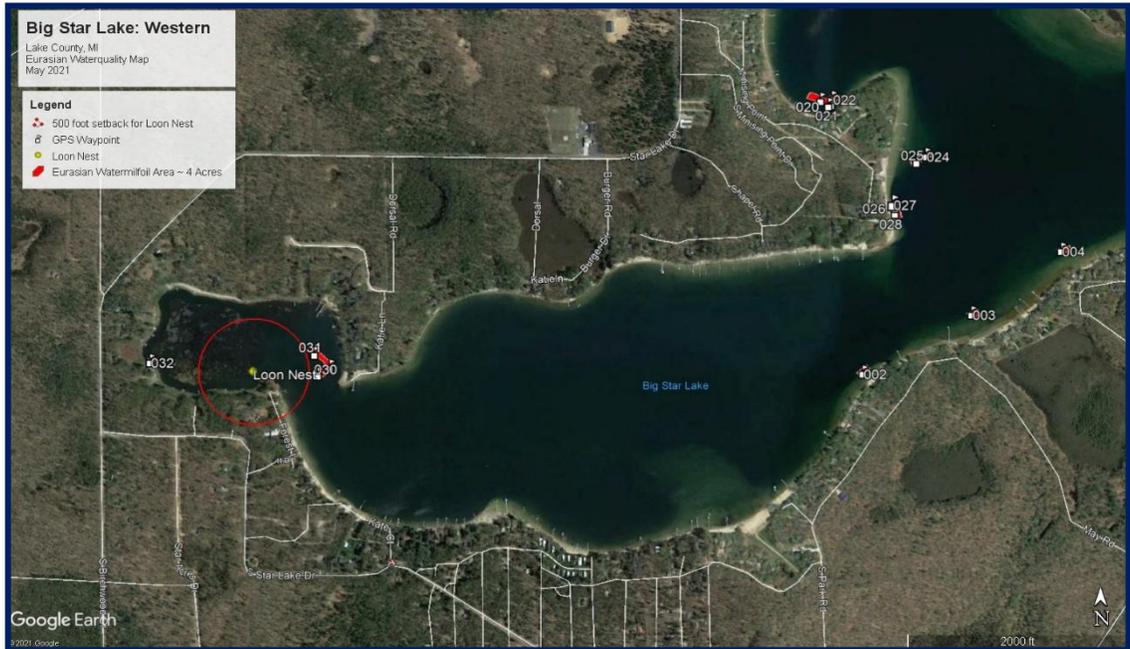**Figure 8. EWM Distribution in East Big Star Lake (May 26, 2021).**

Figure 8. EWM Distribution in West Big Star Lake (May 26, 2021).

Figure 8. EWM Distribution in Big Star Lake (August 23, 2021).

Management Recommendations for 2022

Aquatic vegetation surveys will be conducted in late May or early June of 2022 with treatments to follow within a week or two of the surveys. These surveys will prescribe treatments for EWM, CLP, and nuisance native aquatic vegetation. Care should be taken to reduce the need for treatment on native aquatic plants as they are scarce given the lake surface area. 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, EWM will be treated with a combination of the new systemic herbicide ProcellaCOR® and diquat in 2022. Nuisance CLP may be treated with Aquathol K®, diquat, and/or flumioxazin. To assure quality control and due diligence, RLS will be present to oversee all treatments as in previous years.

Water quality will be monitored in the lake in 2022 and graphed with historic data to determine any trends over time. In conclusion, water quality in Big Star Lake remains high. Water clarity is moderately high allowing light penetration to deeper water that helps support an abundant aquatic plant growth throughout many areas of the lake. Levels of nutrients such as phosphorus and nitrogen are moderate, 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 2022 and beyond.

RLS supports the placement of Aquatic Invasive Species (AIS) signs near boat launches around the lake to educate lake users about the importance of trailer and boat inspection to avoid transport of invasive species into and out of Big Star Lake.