Item 5A.
BCWMC 7-20-23

Lost Lake 2022 water quality monitoring

Photo by Laura Jester

About Lost Lake

BCWMC classification	Priority-2 shallow lake
Watershed area	61 acres
Lake size	22 acres
Average depth	3.5 feet
Maximum depth	6.5 feet
Ordinary high water level	-----
Normal water level	939 feet
Downstream receiving water body	None (landlocked)
Location (city)	Plymouth
MPCA impairments	None
Aquatic invasive species	Curly-leaf pondweed, purple loosestrife, reed canary grass, yellow iris, narrow-leaved cattail
Public access	None

Monitoring water quality in Lost Lake

The Bassett Creek Watershed Management Commission (BCWMC) has monitored water quality conditions in the watershed's 10 priority lakes since 1972. The BCWMC performs this monitoring to detect changes or trends in water quality and evaluate the effectiveness of efforts to preserve or improve water quality. A summary of 2022 monitoring efforts on Lost Lake is provided below; more comprehensive information can be found on pages 2–10.

At a glance: 2022 monitoring results

In 2022, the BCWMC monitored Lost Lake for the following:

- Water chemistry (nutrients, chlorophyll *a*, chloride)
- Water clarity and dissolved oxygen
- Phytoplankton and zooplankton (microscopic plants and animals)
- Macrophytes (aquatic plants).

Results of 2022 monitoring show that Lost Lake met the maximum and chronic Minnesota Pollution Control Agency (MPCA) chloride standards but failed to meet the applicable MPCA and BCWMC water quality standards for Secchi disc (a measure of clarity), total phosphorus, and chlorophyll *a*. Trend analyses show a significant increase in chlorophyll *a* and total phosphorus and a significant decline in Secchi disc depth over the past 10 years. More detailed results and recommendations are discussed on page 2.

At a glance: 2022 monitoring results (cont.)

- In 2022, the number of plant species in the lake and Floristic Quality Index (FQI) values were better than the Minnesota Department of Natural Resources (MNDNR) Plant Index of Biotic Integrity (IBI) threshold. These were the highest values measured during the period of record (1993–2022).
- Hooded arrowhead (*Sagittaria calycina*), a rare species in Minnesota listed by the MNDNR as threatened, was observed in the lake in August. This species is drought-tolerant, thrives on large, exposed mud flats, and prefers soft mud (silt) to firm substrates. The dry conditions in 2022 provided favorable conditions for hooded arrowhead.
- Five aquatic invasive species were present in Lost Lake in 2022: curly-leaf pondweed, purple loosestrife, reed canary grass, yellow iris, and narrow-leaved cattail.
- 2022 phytoplankton (algae) numbers from the routine mid-lake monitoring location were within the range observed during the period of record (1993–2022) but were more than an order of magnitude lower than 2017 numbers. The 2022 decrease in phytoplankton numbers was primarily due to a decrease in blue-green algae, a favorable change for the lake.
- Blue-green numbers from the mid-lake monitoring location in 2022 were below the threshold for moderate probability of adverse health effects to recreational users, as outlined by the World Health Organization (WHO). However, a significant blue-green algal bloom occurred along the north shore of the lake in September of 2022. The number of blue-green algae at this location was more than an order of magnitude above the WHO threshold for a moderate probability of adverse health effects to recreational users.
- The highest and second-highest numbers of zooplankton during the period of record (1993–2022) were found in April and September of 2022, respectively.
- In 2022, the numbers of cladocerans (small crustaceans) were higher than in previous years. These increased numbers are likely due in part to an improved plant community that provided greater refuge from fish predation.
- The results of an aquatic invasive species (AIS) suitability analysis indicate that Lost Lake's water quality only partially meets the suitability requirements for rusty crayfish, starry stonewort, spiny waterflea, zebra mussel, faucet snail, and Chinese mystery snail. Hence, these species would likely survive but may not thrive in Lost Lake.
- Although lower oxygen levels were observed near the lake bottom in July, the lake was generally well oxygenated and had sufficient oxygen to support a fish community throughout the monitoring period. The amount of oxygen dissolved in water depends on water temperature, the amount of wind mixing that brings water into contact with the atmosphere, the biological activity that consumes or produces oxygen within a lake, and the composition of groundwater and surface water entering the lake.

Recommendations

- Determine causes for the lake's significant decline in water quality over the past 10 years and identify feasible management measures to improve water quality
- Continue to provide education and information to lake users to reduce AIS introduction
- Continue water quality and biological monitoring at a 5-year frequency

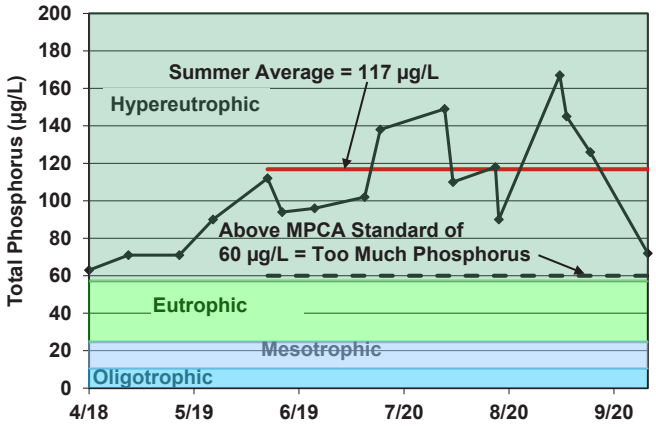
Dry conditions in 2022 provided favorable conditions for hooded arrowhead—a rare, threatened species.

Water chemistry monitoring: 2022

Total phosphorus levels

While phosphorus is necessary for plant and algae growth, too much phosphorus leads to excessive algae, decreased water clarity, and water quality impairment.

- **BCWMC/MPCA standard:** 60 micrograms per liter (µg/L) or less
- **Range:** Low of 63 µg/L in April to a high of 167 µg/L in early September
- **Summer average:** 117 µg/L (failed to meet BCWMC/MPCA standard)



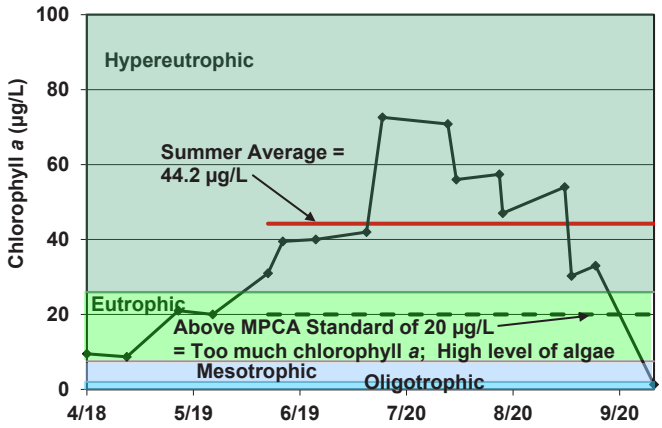
Definitions

- ***Hypereutrophic:*** Nutrient-rich lake conditions characterized by frequent and severe algal blooms and low water clarity; excessive algae can significantly reduce lake oxygen levels
- ***Eutrophic:*** Lake condition characterized by abundant accumulation of nutrients supporting dense growth of algae and other organisms; decay of algae can reduce lake oxygen levels
- ***Mesotrophic:*** Lake condition characterized by medium levels of nutrients and clear water
- ***Oligotrophic:*** Lake condition characterized by a low accumulation of dissolved nutrients, high oxygen content, sparse algae growth, and very clear water

Chlorophyll *a* levels

Chlorophyll *a* is a pigment in algae and generally reflects the amount of algae growth in a lake. Lakes that appear clear generally have chlorophyll *a* levels less than 15 micrograms per liter (µg/L).

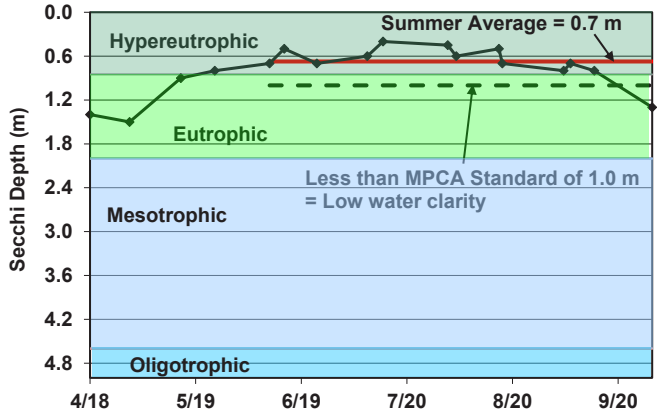
- **BCWMC/MPCA standard:** 20 µg/L or less
- **Range:** Low of 1 µg/L in late September to a high of 72 µg/L in mid-July
- **Summer average:** 44 µg/L (failed to meet BCWMC/MPCA standard)



Water clarity

The number of algae or other photosynthetic organisms in a lake often affects water clarity. It is usually measured by lowering an 8-inch "Secchi" disc into the lake; the depth at which the disc is no longer visible is considered a measure of the water's transparency.

- **BCWMC/MPCA standard:** 1.0 meter or more
- **Range:** Low of 0.4 meters in mid-July to a high of 1.5 meters in late April
- **Summer average:** 0.7 meters (failed to meet BCWMC/MPCA standard)



Water chemistry monitoring: 1977–2022

Summer water quality in Lost Lake has been monitored since 1977. Summer averages (June through September) of total phosphorus, chlorophyll *a*, and Secchi disc depth from 1977 to 2022 are shown in the figures at right. During the period of record, 86 percent of total phosphorus and Secchi disc averages and 79 percent of chlorophyll *a* averages failed to meet the Minnesota State Water Quality Standards for shallow lakes in the North Central Hardwood Forest Ecoregion published in the Minnesota Rules (Minn. R. Ch. 7050.0222 Subp. 4). Summer averages of total phosphorus, chlorophyll *a*, and Secchi depth failed to meet the BCWMC/MPCA standards in 2022.

Trend analyses for the last 10 years show:

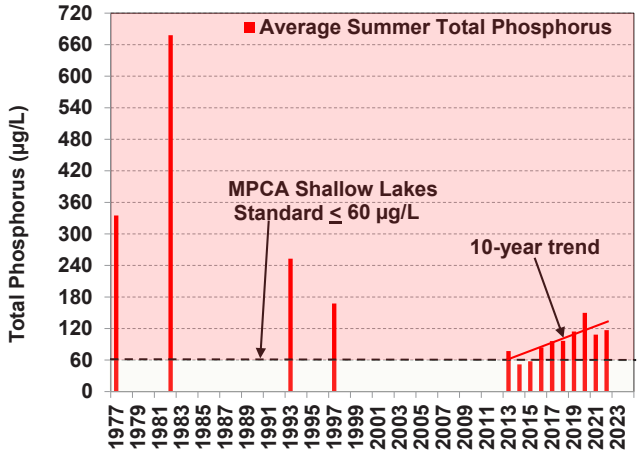
- Increasing summer-average total phosphorus concentrations.
- Increasing summer-average chlorophyll *a* concentrations.
- Declining summer-average Secchi disc depths.

All changes are statistically significant (95-percent confidence level).

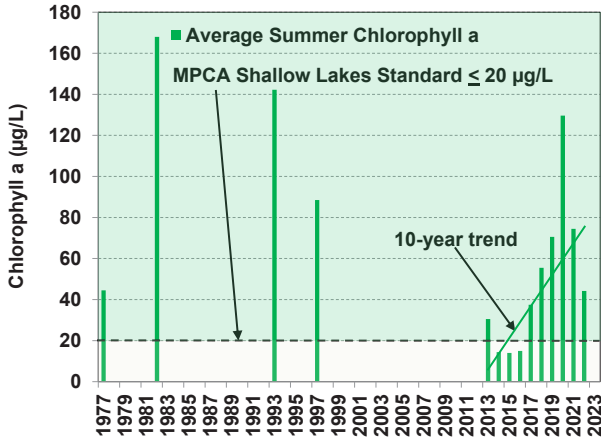
Trend analyses show declining water quality in Lost Lake.

Historical water quality trends

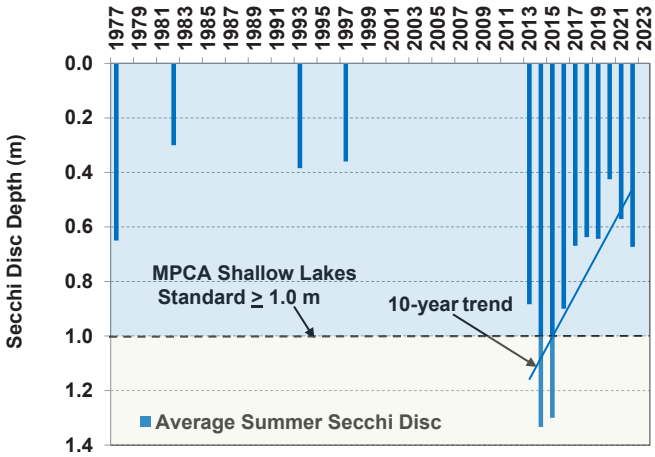
1977—2022 phosophorus levels (significant increase)



1977—2022 chlorophyll *a* levels (significant increase)



1977—2022 secchi disc depths (significant decrease)

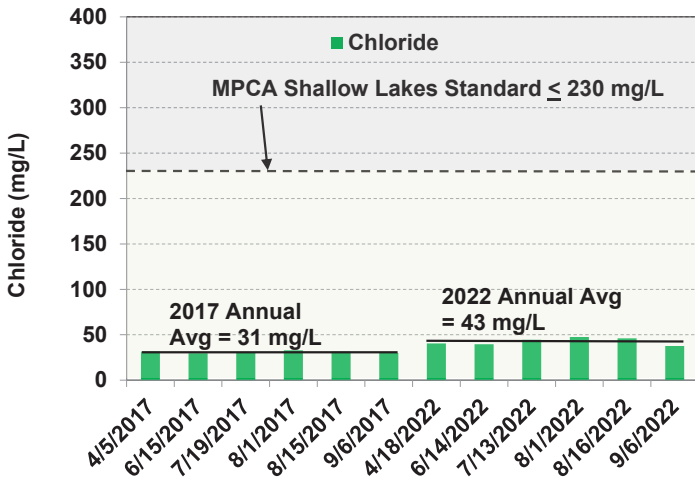


Chloride levels in 2017 and 2022

Chloride concentrations in area lakes have increased since the early 1990s when many government agencies switched from sand or sand/salt mixtures to salt for winter road maintenance. When snow and ice melt, the salt goes with it, washing into lakes, streams, wetlands, and groundwater. It only takes 1 teaspoon of road salt to permanently pollute 5 gallons of water. Once in the water, chloride is very difficult and expensive to remove.

Because high chloride concentrations can harm fish and plant life, the MPCA has established maximum and chronic chloride standards. The maximum standard is the highest concentration of chloride that aquatic organisms can be exposed to for a brief time with zero-to-slight mortality. The chronic standard is the highest chloride concentration that aquatic life can be exposed to indefinitely without causing chronic toxicity. Chronic toxicity is defined as a stimulus that lingers or continues for a long period, often one-tenth the life span or more. A chronic effect can be mortality, reduced growth, reproduction impairment, harmful changes in behavior, and other nonlethal effects. A lake is considered impaired if two or more measurements exceed the chronic criterion (230 mg/L) within a 3-year period or if one measurement exceeds the maximum criterion (860 mg/L).

All 2017 and 2022 measurements were well below the maximum and chronic chloride standards; however, chloride concentrations increased in 2022. The 2022 average annual chloride concentration was 43 mg/L compared with the 2017 average of 31 mg/L.



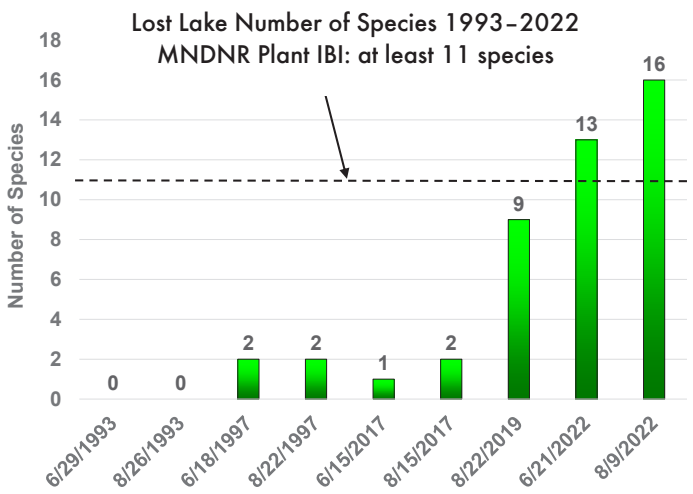
Macrophytes (aquatic plants)

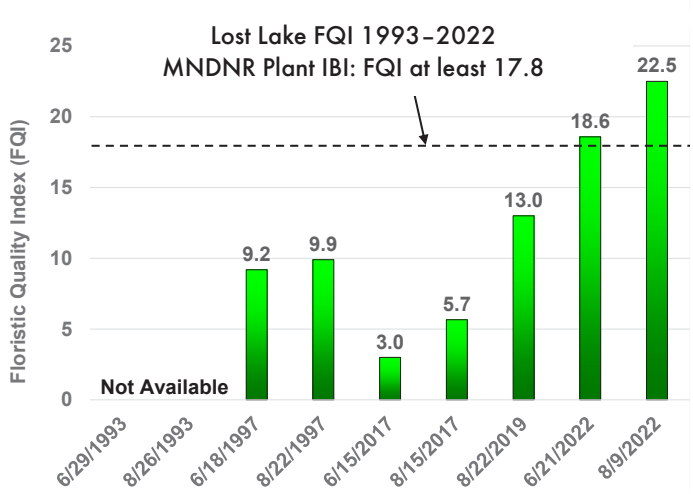
Lake Plant Eutrophication Index of Biological Integrity (IBI)

Eutrophication (excessive nutrients) may harm a lake, including reducing the quantity and diversity of plants. The MNDNR developed a Lake Plant Eutrophication Index of Biological Integrity (IBI) to measure the response of a lake plant community to eutrophication. The Lake Plant Eutrophication IBI includes two metrics: (1) the number of species in a lake and (2) the "quality" of the species, as measured by the Floristic Quality Index (FQI). The MNDNR has determined a threshold for each metric. Lakes that score below the thresholds contain degraded plant communities and are likely stressed from anthropogenic (human-caused) eutrophication.

Plant survey data from 1993 to 2022 were assessed to determine Plant IBI trends. The figures on page 6 show Lost Lake FQI scores and number of species for that period compared to the MNDNR Plant IBI thresholds.

- **Number of species:** A shallow lake such as Lost Lake fails to meet the MNDNR Plant IBI threshold when fewer than 11 species are present. In 1993, the only plants observed were cattails and purple loosestrife around the lake's perimeter; neither is included in the computation of the MNDNR Plant IBI. From 1997 through 2022, the number of species in Lost Lake ranged from one to 16, exceeding the MNDNR Plant IBI threshold in June and August 2022. The number of species consistently increased from 2017 to 2022: from one in June 2017 to 16 in August 2022. In 2022, the number of species ranged from 13 to 16.
- **FQI values (quality of species):** The MNDNR Plant IBI threshold for shallow lakes, as measured by FQI, is a minimum value of 17.8. From 1997 through 2022, FQI values in Lost Lake ranged from 3.0 to 22.5, exceeding the MNDNR Plant IBI threshold in June and August 2022. In 2022, the FQI ranged from 18.6 to 22.5.
- **2022 results summary:** In 2022, the number of species in the lake and FQI values were better than the MNDNR Plant IBI threshold and the highest values measured during the period examined. The frequency of plants in Lost Lake increased from 48 percent in August 2019 to 58 percent in August 2022.





Hooded Arrowhead

Because 2022 was a very dry year, the lake's water level decreased, resulting in exposed mud flats along the shore. Thousands of hooded arrowheads (*Sagittaria calycina*) grew on the exposed mud flats. This species had not previously been observed in Lost Lake.

Hooded arrowhead is a rare species in Minnesota listed by the MNDNR as threatened. A species is considered threatened if it is likely to become endangered within the foreseeable future throughout all or a significant portion of its range in Minnesota. Hooded arrowhead is drought-tolerant, thrives on large exposed mud flats, and prefers soft mud (silt) to firm substrates. The dry conditions in 2022 provided favorable conditions for this species, which was collected on the rake at three locations (frequency of 2 percent) and visually observed at an additional three locations in August. The rake density of hooded arrowhead ranged from 1 to 3 and averaged 1.7 on a scale of 1 to 3, with increasing numbers indicating increased density. The MNDNR was notified of the presence of hooded arrowhead in Lost Lake

Aquatic invasive species

In 2022, there were five aquatic invasive species in Lost Lake.

- Curly-leaf pondweed (*Potamogeton crispus*, CLP): CLP was first observed at two Lost Lake locations in August 2019. In June 2022, CLP was collected on the rake at 31 locations (frequency of 25 percent) and observed at an additional 14 locations. In August 2022, CLP was collected on the rake at one location (frequency of 1 percent) and visually observed at three additional locations.
- Purple loosestrife (*Lythrum salicaria*): This emergent species has been scattered along the lake's perimeter during the entire period examined.
- Reed canary grass (*Phalaris arundinacea*): This emergent species was first observed at one location in August 2019. In 2022, reed canary grass was scattered along the lake's perimeter.
- Yellow iris (*Iris pseudacorus*): This emergent species was first observed in August 2019 in the eastern inlet. In 2022, yellow iris was observed at the lake's northwest corner in June and near the eastern inlet in August.
- Narrow-leaved cattail (*Typha angustifolia*): This emergent species was first observed in August 2019 at one location. In 2022, narrow-leaved cattail was scattered along the perimeter of the lake.

Yellow iris along the shore of Lost Lake

Phytoplankton (algae)

Phytoplankton, or algae, are small aquatic plants naturally present in lakes. Phytoplankton derive energy from the sun through photosynthesis and provide food for several types of aquatic organisms, including zooplankton (microscopic animals), which are, in turn, eaten by fish. An inadequate phytoplankton population limits a lake's zooplankton population and indirectly limits fish production in a lake. Excess phytoplankton can reduce water clarity.

Phytoplankton samples were collected from Lost Lake to evaluate water quality and the quality of food available to zooplankton. The phytoplankton monitoring also included blue-green algae, a type of bacteria called cyanobacteria. This type of bacteria thrives in warm, nutrient-rich water and can proliferate under certain conditions, causing "blooms." Blue-green algae can produce algal toxins, which can harm humans or animals. Blue-green algae are also a poor-quality food for zooplankton; they can be toxic to zooplankton and may not be assimilated if ingested.

The figure below summarizes the number and major groups of phytoplankton observed in Lost Lake in 2022. Green algae, diatoms, and cryptomonads—good food sources for zooplankton—were well represented.

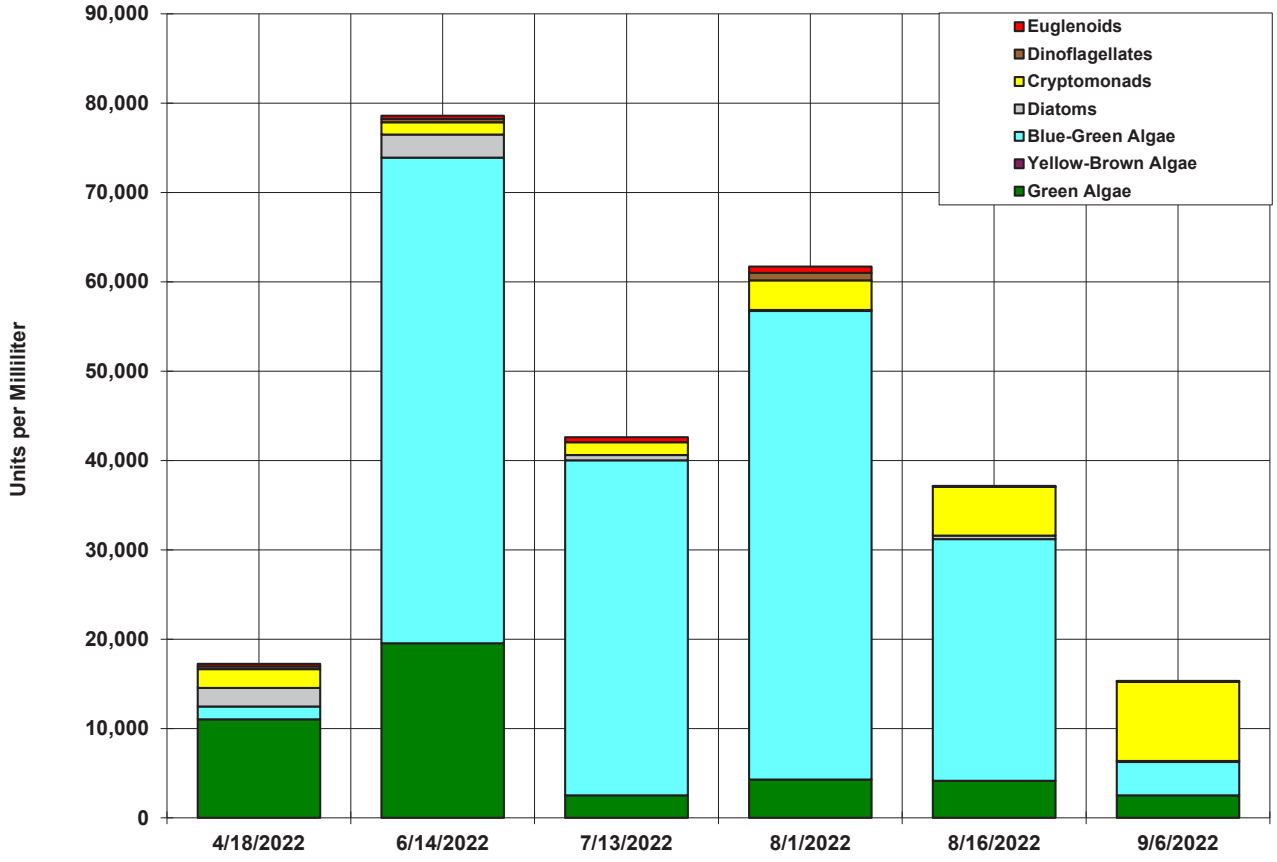
The figure at the top of page 8 summarizes the number and major groups of phytoplankton in Lost Lake for monitored years. The numbers of phytoplankton collected from the routine mid-lake monitoring location in 2022 were within the range observed during the period of record but were more than an order of magnitude lower than the 2017 numbers. An overall decrease in blue-green algae numbers, compared to 2017, was a favorable change for the lake.

Blue-green algae

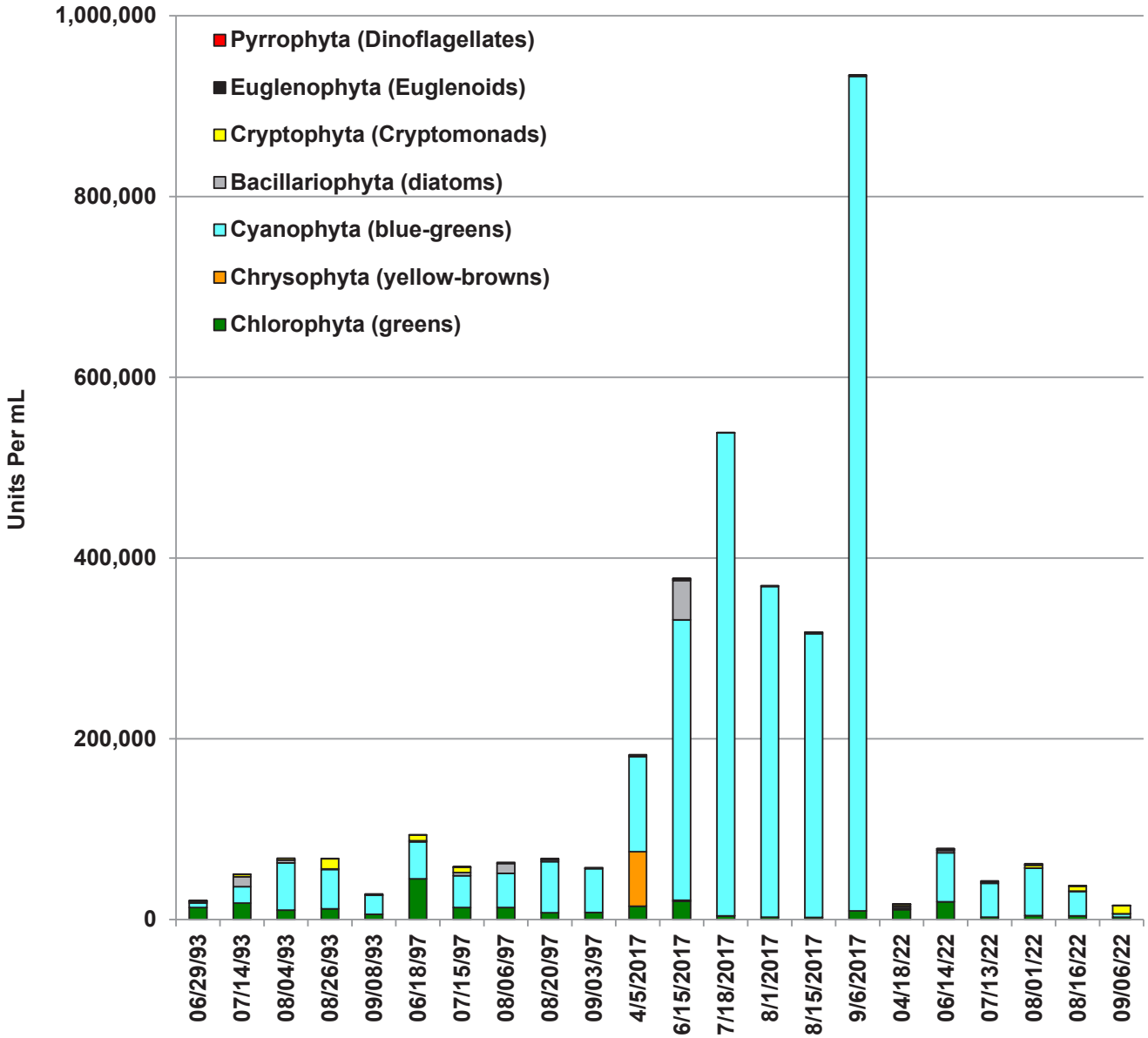
In 2017, the number of blue-green algae collected from the mid-lake monitoring location was above the threshold (100,000 units per milliliter) for a moderate probability of adverse health effects to recreational users, as outlined by the World Health Organization (WHO). Blue-green numbers at this location were below this threshold on all other monitoring dates (see figure on page 9).

In 2022 blue-green algae dominated the phytoplankton community from June through August. In September, blue-green numbers declined at the mid-lake monitoring station, but a blue-green algal bloom was observed along the north shore of the lake. The number of blue-green algae in the sample collected from the north

2022 Lost Lake phytoplankton summary by division



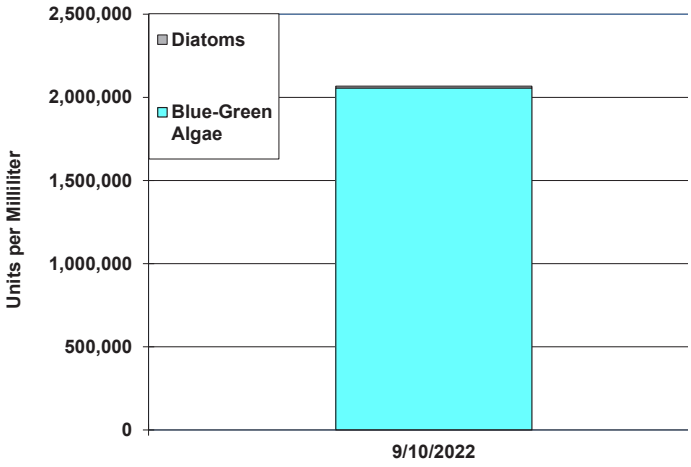
Historical Lost Lake phytoplankton



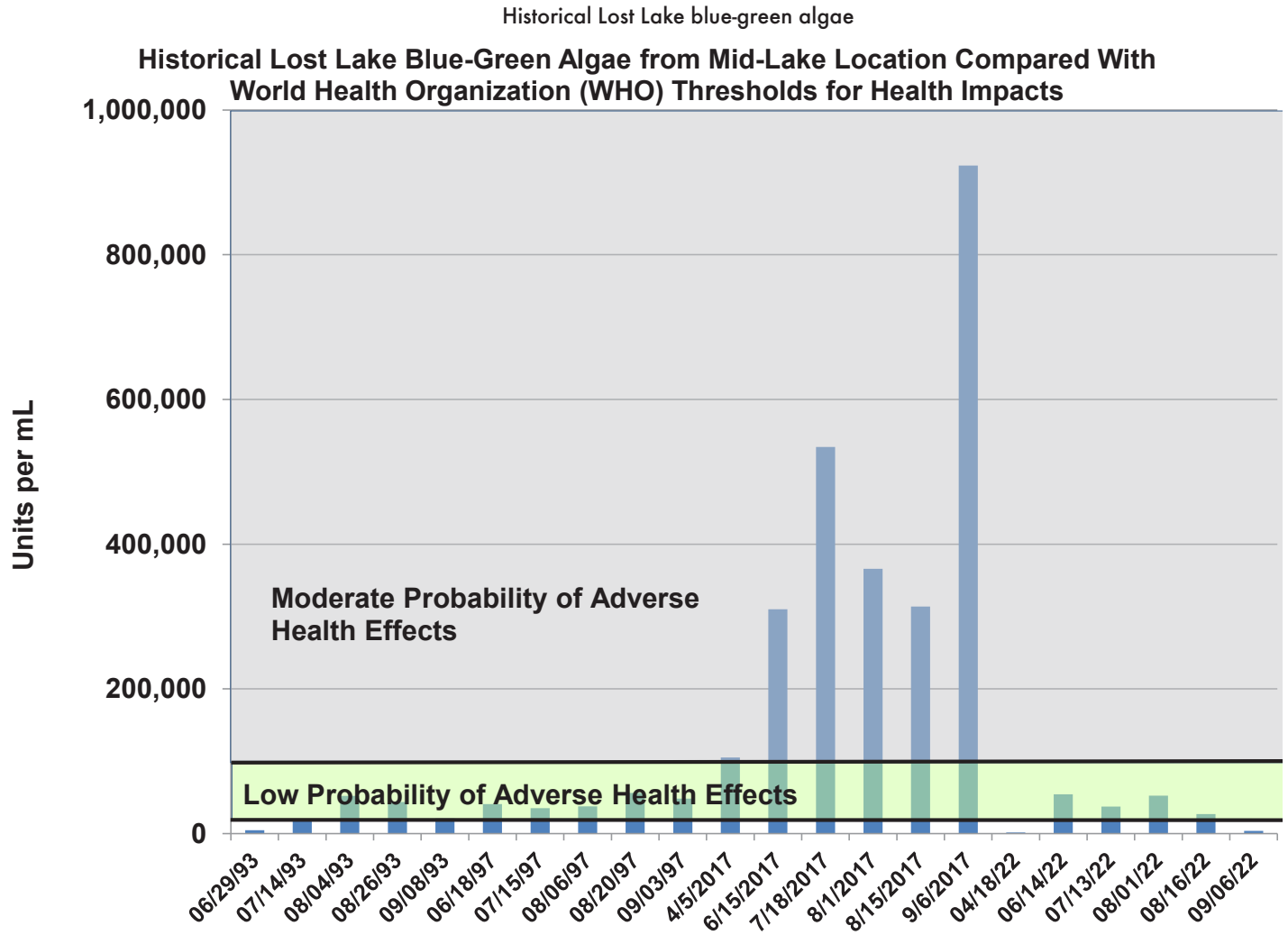
shore was greater than two million units per milliliter (see figure at right) compared with blue-green numbers of approximately 4,000 per milliliter from the mid-lake location (see figure on page 9). This was more than an order of magnitude above the WHO threshold for a moderate probability of adverse health effects to recreational users.

Blue-green algae are generally found at the lake's surface, where they are easily moved by wind. Wind movement can result in the accumulation of this algae along the shore and lower numbers in the middle of the lake. The lower numbers of blue-green algae at the mid-lake station and higher numbers along the north shore in September may be due to wind movement.

2022 north shore algal bloom



Blue-green algal bloom along the Lost Lake north shore in 2022



Zooplankton

Unlike phytoplankton, zooplankton do not produce their own food. As "filter feeders," they eat millions of small algae; given the right quantity and species, they can filter the volume of an entire lake in a matter of days. They are also valuable food for planktivorous fish and other organisms. Fish generally select the largest zooplankters they see and prefer cladocerans to copepods. Cladocerans swim slowly and lack the copepods' ability to escape predation by jerking or jumping out of the way.

As shown in the figure below, the highest number of zooplankton was in April of 2022, when rotifers comprised 99.6 percent of the zooplankton community. The second-highest number of zooplankton was in September 2022. The composition of the zooplankton community was balanced between cladocerans, copepods, and rotifers from July through September 2022, indicating a healthy community.

In 2022, the number of cladocerans was higher than in previous years, with a maximum of approximately one million compared with approximately 64,000 in previous years. The increased numbers of cladocerans in 2022 are likely due, in part, to an improved plant community that provided refuge from fish predation.

Historical Lost Lake zooplankton