



# REPORT SUMMARY

## Arrowhead and Indianhead Lakes Water Quality Study

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*August 2022*

Prepared for  
Nine Mile Creek  
Watershed District



# IMPROVING LAKE WATER QUALITY

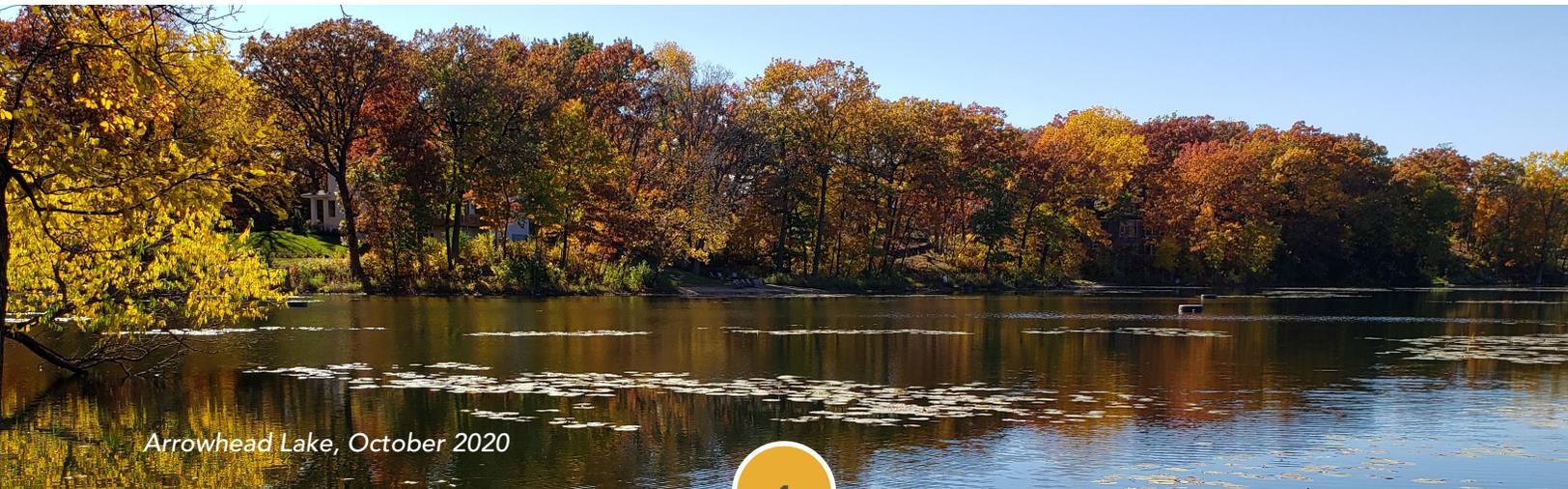
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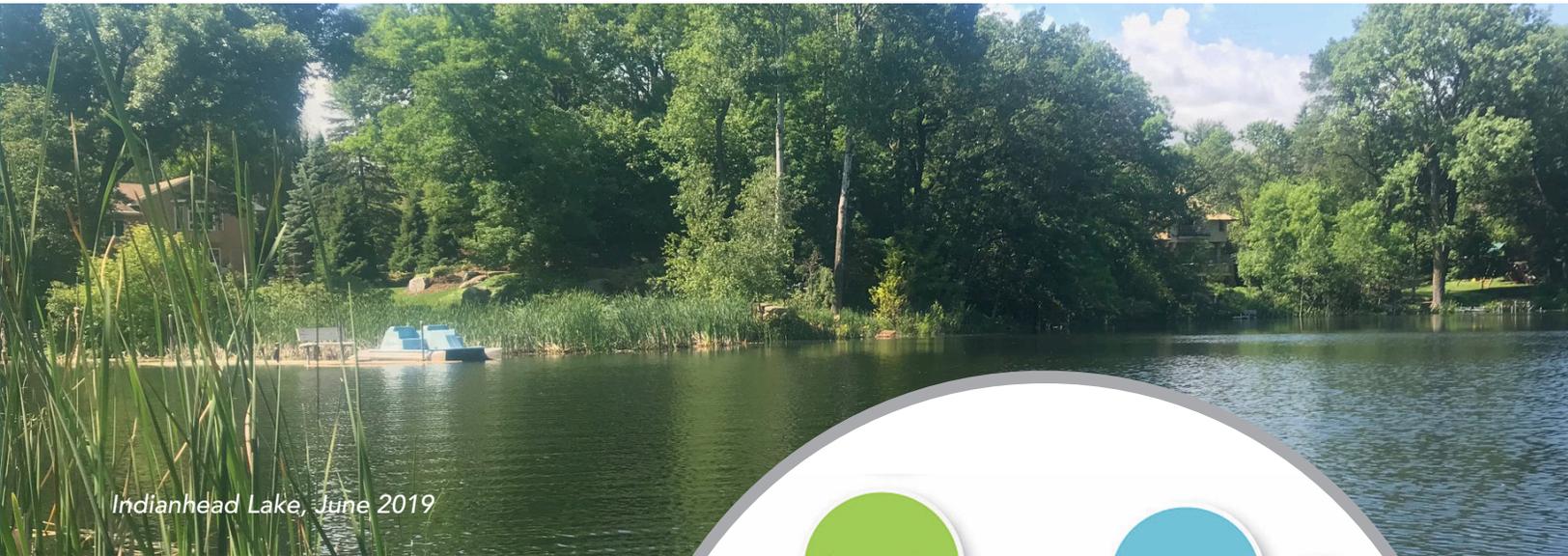
## Protecting and Enhancing Water Quality

Arrowhead Lake and Indianhead Lake are shallow lakes located in the southwestern portion of the city of Edina, south of Highway 62 and east of Highway 169. The shallow, urban lakes suffer from moderate to poor water quality. The Nine Mile Creek Watershed District (NMCWD), a local unit of government that works to address water-related problems, conducted a study of Arrowhead and Indianhead lakes in 2021 to evaluate current water quality and identify protection and improvement strategies. Additional information on the current lake conditions, water quality challenges, and recommended management strategies are summarized in this project overview, including proposed implementation timelines.

Protecting and enhancing the water quality of the lakes within the Nine Mile Creek watershed is one of the primary goals of the Nine Mile Creek Watershed District. The NMCWD's lake management program includes data collection (monitoring), assessment (e.g., studies), and implementation of projects and programs to protect and improve water quality and aquatic habitat. Using monitoring data collected by NMCWD in recent years (2019 and 2020), the objectives of this study were to assess or "diagnose" the lakes' water quality problems, understand the cause or sources of the problems, and recommend management strategies to improve the water quality and overall health of the lakes.



*Arrowhead Lake, October 2020*



Indianhead Lake, June 2019

### Lake Management Goals

When assessing the ecological health of a lake, it is important to take a holistic approach, considering factors such as in-lake water quality (e.g., phosphorus and nitrogen concentrations), the health and quality of the aquatic communities, and water quantity (see Figure 1). How recreation and wildlife habitat affect and are affected by overall lake health are also considered. Numerical goals exist for some of these factors, such as state water quality standards. However, other factors are assessed relative to narrative criteria that describe the desired condition and do not have strict numerical goals. For this study, the primary goals are to achieve the water quality standards for shallow lakes; attain a diverse, native macrophyte (aquatic plant) population; and support a healthy, balanced aquatic ecosystem.

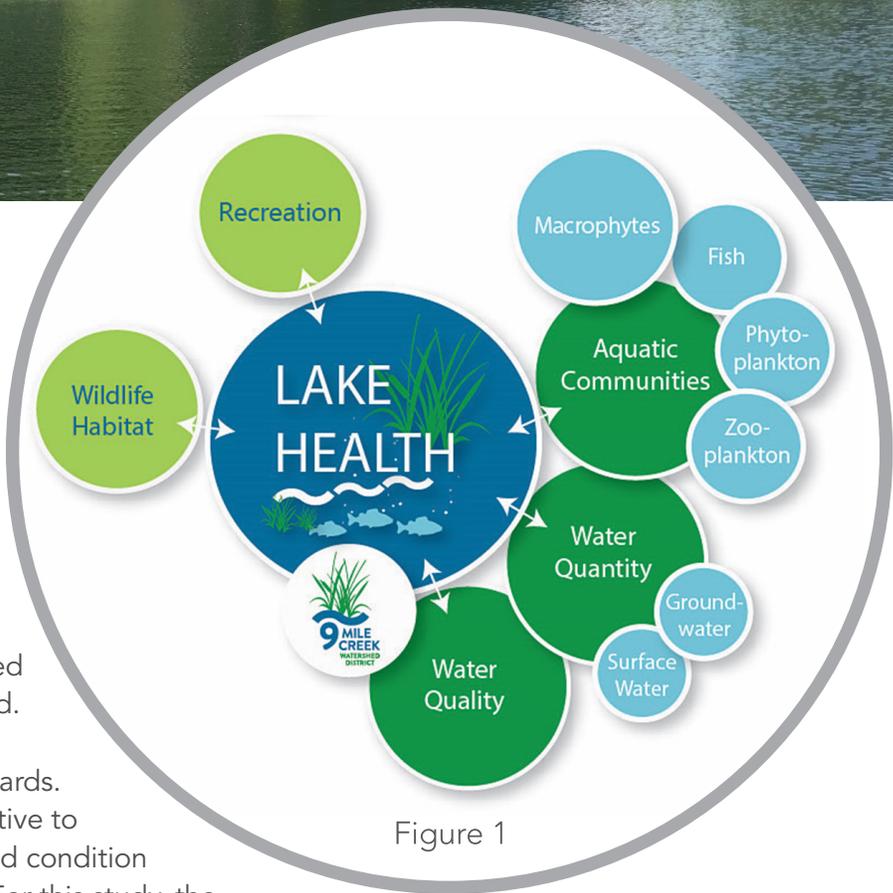


Figure 1

*For this study, the primary goals are to achieve the water quality standards for shallow lakes, attain a diverse, native macrophyte (aquatic plant) population, and support a healthy, balanced fishery.*

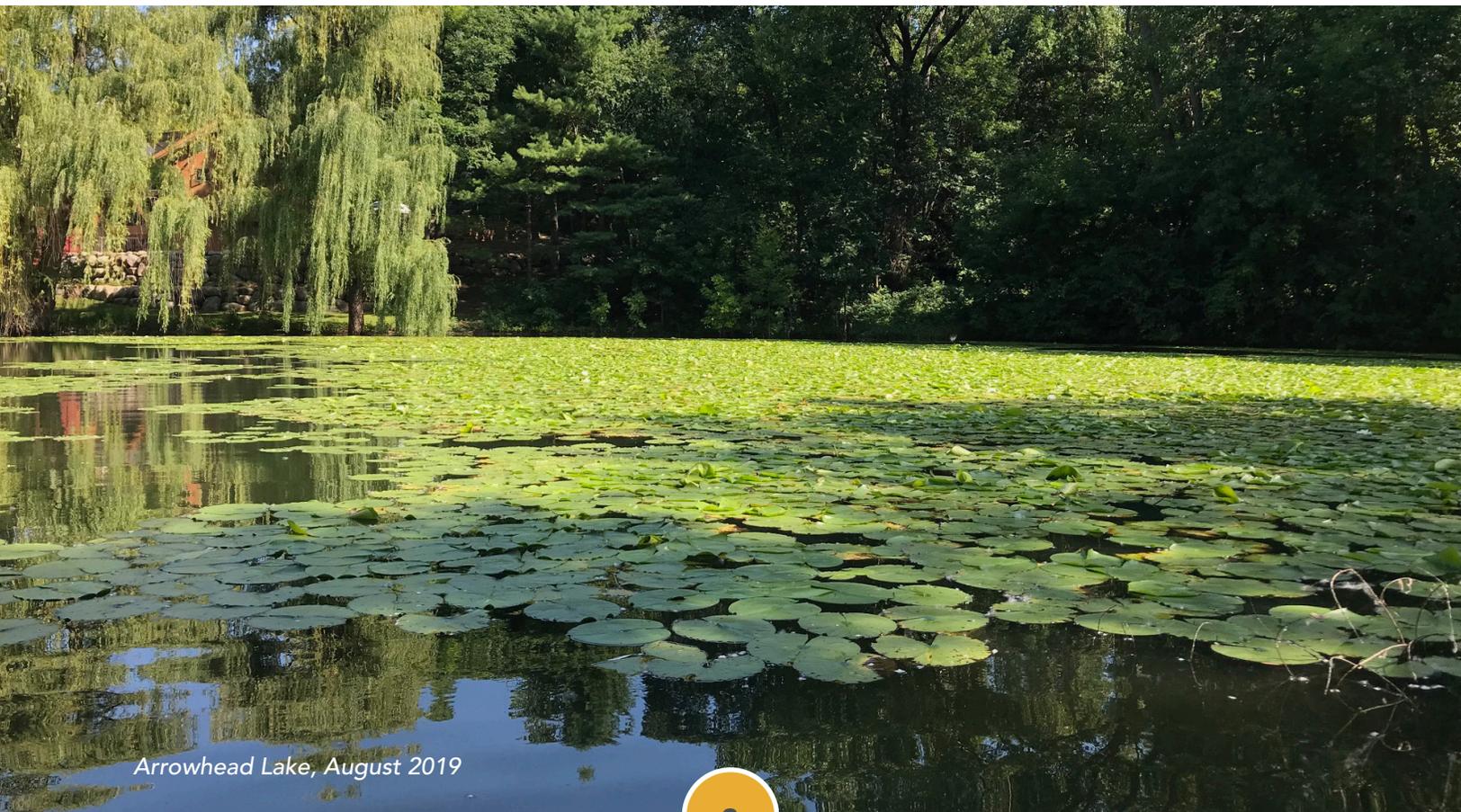


# Looking at Current Lake Conditions

## Healthy Shallow Lakes

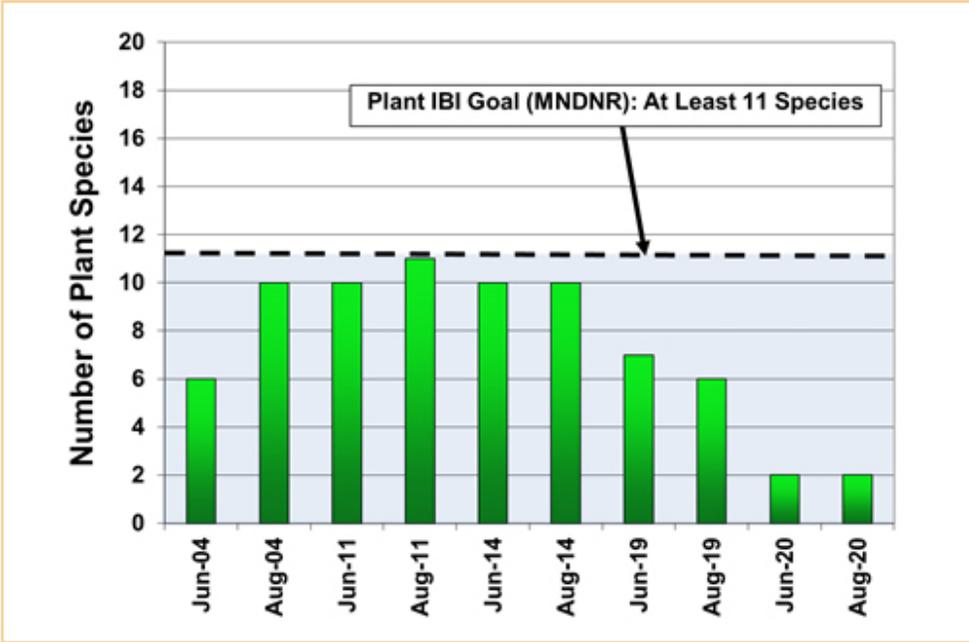
Shallow lakes are unique ecosystems that differ from deeper lakes. Shallow lakes have depths that allow for light to reach the lake bottom throughout most or all of the lake (often less than 10 feet deep). These lakes also tend to be more nutrient-rich than other deeper lakes, especially in an urban setting where they receive nutrients (e.g., phosphorus and nitrogen) from stormwater. A healthy shallow lake will have abundant aquatic plant growth due to the shallowness and nutrients. However, excess nutrients can lead to algal growth that creates turbid (murky-looking, low clarity) water and limits or prevents aquatic plant growth. Aquatic plants are good for shallow lake ecosystems. Healthy shallow lakes have plants growing throughout the entire lake, with a variety of species such as coontail, native pondweed, and water lily. The plants can take phosphorus and nitrogen from the lake water, reducing the amount of nutrients available for algae. Aquatic plants also provide excellent habitat for insects, zooplankton, fish, waterfowl and other wildlife.

One measure of a lake's health is the community of plants, fish and aquatic life it sustains. For aquatic plants, the Minnesota Department of Natural Resources (MNDNR) has developed an index of biological integrity (IBI), which is a score that compares the types and numbers of plants observed in a lake to what is expected for a healthy lake. As shown on page 4, the number of plant species in Arrowhead and Indianhead lakes in recent years are well below the DNR's threshold of at least 11 species for a healthy lake. In 2020, only 2–3 species were found in the lakes.

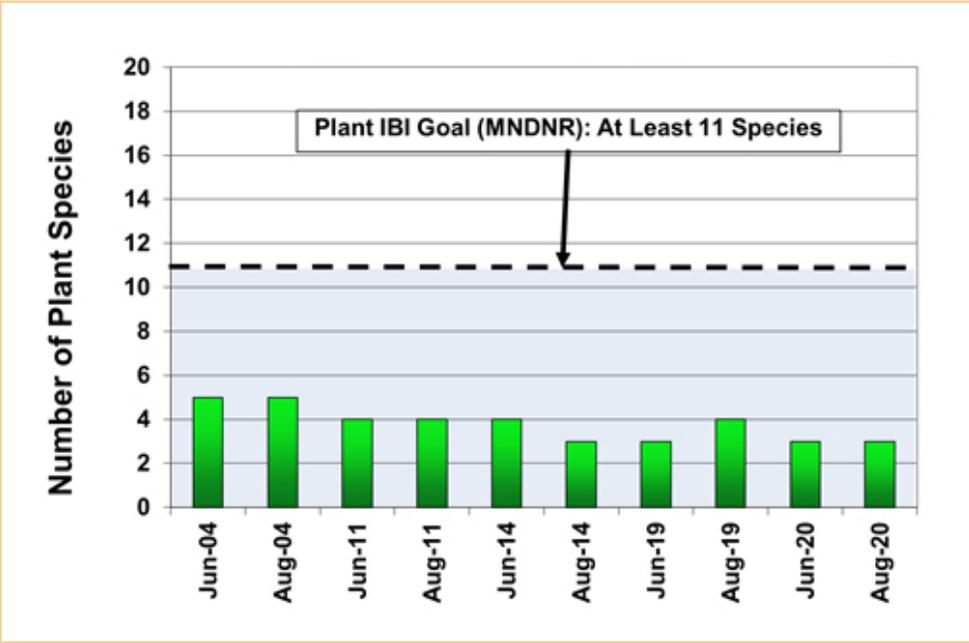


Arrowhead Lake, August 2019

Arrowhead and Indianhead Lakes are below the MNDNR threshold for healthy number of plant species in the lakes, indicating a degraded plant community.



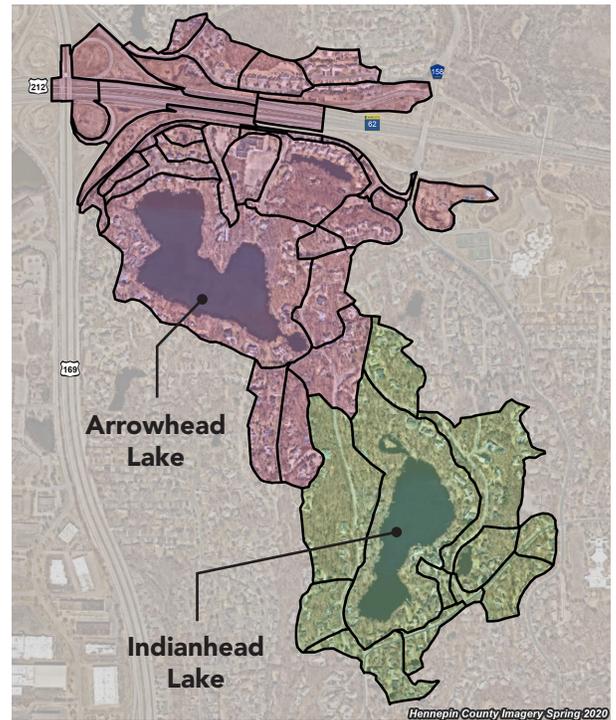
Arrowhead Lake Macrophyte Species Richness Compared with Plant IBI Threshold for Species Richness



Indianhead Lake Macrophyte Species Richness Compared with Plant IBI Threshold for Species Richness

## Urban Watersheds

A lake watershed is all the land area that drains to the lake through overland flow, channels, and storm pipes. Land use practices within a lake's watershed impact the lake and its water quality by altering the amount of stormwater runoff, sediment, and nutrients (namely phosphorus and nitrogen) that reaches the lake. Each type of land use contributes a different amount of runoff and pollutants to the lake, thereby impacting the lake's water quality differently. Land use within the highly developed Arrowhead and Indianhead watersheds is primarily single family residential, highway, open water, and public open space, with smaller areas of multi-family residential and churches. Arrowhead and Indianhead lakes can be particularly sensitive to land use impacts on stormwater quantity and quality because both are land-locked with no surface outlets.



Map showing watersheds for Arrowhead Lake (shaded purple) and Indianhead Lake (shaded green).



Arrowhead Lake, June 2019

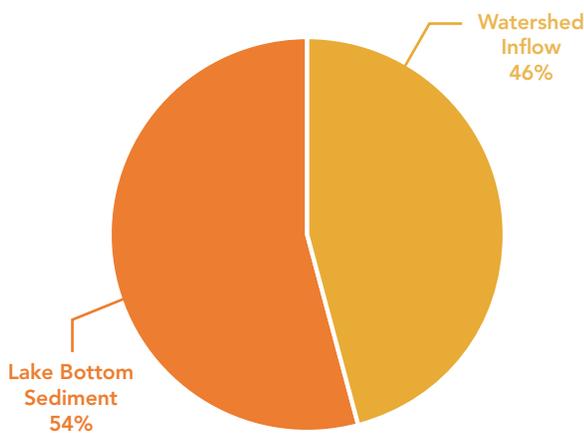
## Sources of Nutrients

Nutrients (phosphorus and nitrogen) are a food source for algae. An overabundance of these nutrients in a lake can result in nuisance algal blooms and threaten the health of the aquatic plant community. In Minnesota, phosphorus is most commonly the “limiting nutrient,” although nitrogen can also be limiting for portions of the growing season. Whether phosphorus or nitrogen is the “limiting nutrient” this means the available quantity of this nutrient tends to control the amount of algae and aquatic plants produced. The two primary sources are summarized below:

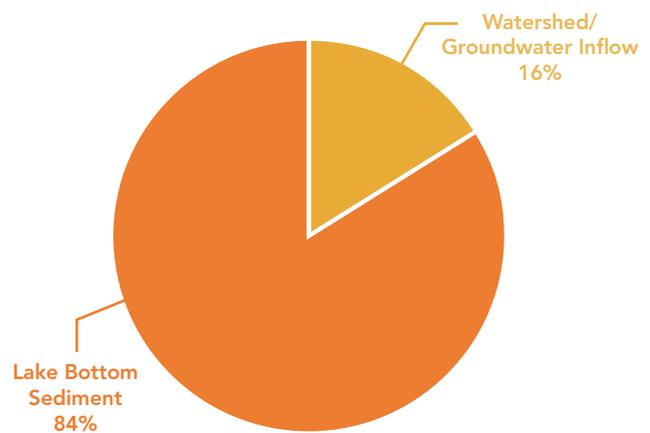
- **Phosphorus and nitrogen in stormwater runoff from the direct watershed—** Stormwater runoff conveys phosphorus and nitrogen from streets, lawns, and parking lots within the direct watersheds to Arrowhead and Indianhead lakes via a series of drainage channels and storm drain pipes. This study confirmed that stormwater runoff is a major contributor of phosphorus and nitrogen to Arrowhead and Indianhead lakes.
- **Nutrient-rich sediment—** Phosphorus builds up over time in lake bottom sediments as a result of sedimentation and die-off of vegetation and algae. In general, two forms of sediment phosphorus can release back into the water column when certain environmental conditions are met. When oxygen levels are low at the lake bottom (typically periodically throughout the summer), the form of phosphorus called “mobile-P” is released from the sediment into the water column. “Organic-P” can also release from bottom sediments, where the release rate is controlled by lake water temperature. This study confirmed that phosphorus release from lake bottom sediments, typically termed “internal loading,” is a major contributor of phosphorus to Arrowhead and Indianhead Lakes.



Arrowhead Lake 2020  
Total Phosphorus Sources



Indianhead Lake 2020  
Total Phosphorus Sources

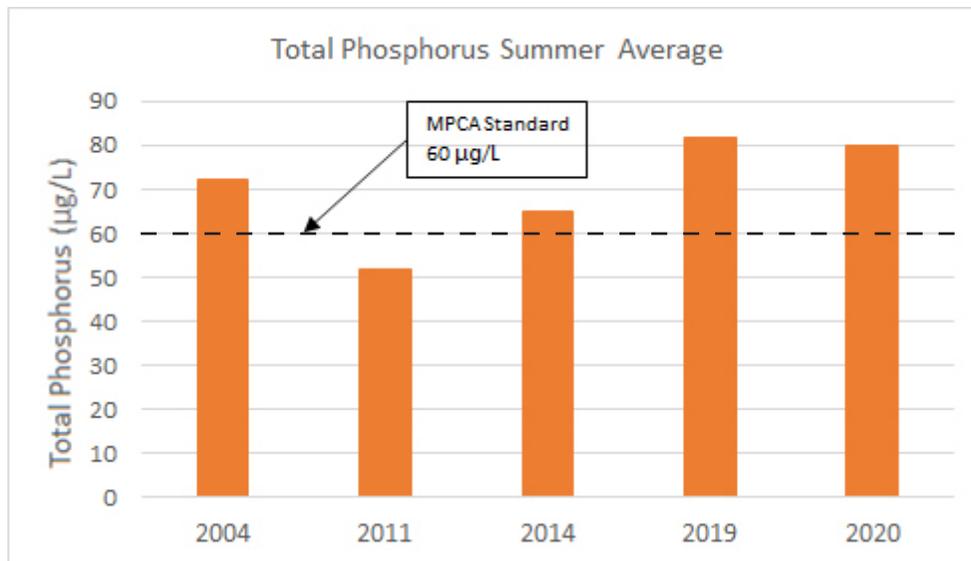




Arrowhead Lake, September 2020

## Arrowhead Lake Water Quality Challenges

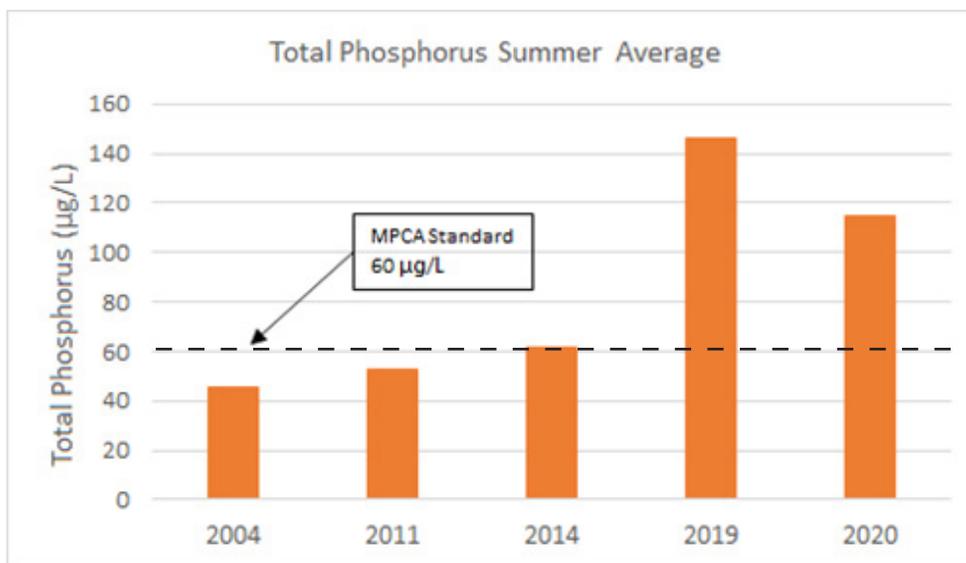
Review of historic data indicates that water quality in Arrowhead Lake is poor, with summer average total phosphorus and chlorophyll-a concentrations generally above the state standard for shallow lakes. The poor water quality is primarily due to excess nutrients in the lake, which fuels algal growth and decreases water clarity. The phosphorus in Arrowhead Lake comes from several sources, including stormwater runoff from the watershed and internal sources such as nutrient-rich sediments. Additionally, the decrease in the number of plant species as well as the quantity of plants in the lake since 2014 is likely contributing to the decrease in water quality.



Summer average total phosphorus concentrations measured in Arrowhead Lake between 2004 and 2020

## Indianhead Lake Water Quality Challenges

Review of historic data indicates that water quality in Indianhead Lake has been declining since 2004, with summer average total phosphorus above the state standards for shallow lakes in 2019 and 2020 and chlorophyll-a concentrations generally above the state standard for shallow lakes since 2011. The degradation in water quality is primarily due to excess nutrients in the lake, which fuels algal growth and decreases water clarity. The phosphorus in Indianhead Lake comes from several sources, including stormwater runoff from the watershed and internal sources such as nutrient-rich sediments. Additionally, vegetation management reducing the number of plant species as well as the quantity of plants in the lake is likely contributing to the decrease in water quality.



Summer average total phosphorus concentrations measured in Indianhead Lake between 2004 and 2020

## Too Much Salt

Observed chloride concentrations in Arrowhead Lake in April 2019 were moderately high (185 mg/L). The MPCA chloride standard is 230 mg/L. While chloride occurs naturally in lakes and streams, too much chloride can be harmful to fish and other aquatic life. The primary source of chlorides in our lakes and streams is road salt, which is commonly used in the winter to minimize the amount of ice on our roadways, parking lots, and sidewalks. With Arrowhead Lake receiving stormwater runoff from several highways, local roadways, private parking lots, and an area of developed residential properties, the lake is especially vulnerable to chloride pollution. NMCWD works to provide training and other resources to reduce the harmful impacts of chloride on our local waterbodies. For more information about chloride, visit: [www.pca.state.mn.us/water/chloride-salts](http://www.pca.state.mn.us/water/chloride-salts)





*Indianhead Lake, August 2019*

## Managing to Protect and Improve Our Lakes

Water quality in Arrowhead and Indianhead Lakes has declined in the past decade. The lakes currently do not meet water quality and ecological health goals and given this, future management efforts should focus on improving lake water quality and ecosystem health, monitoring for changes, and continuing water quality and ecosystem health protection measures as improvements are obtained. The recommended management and protection strategies for Arrowhead and Indianhead Lakes are summarized on the next page.

Planning-level opinions of probable cost were developed for several new management alternatives evaluated as part of this study. These opinions of cost are intended to provide assistance in evaluating and comparing alternatives and should not be considered as absolute values. All estimated costs are presented in 2021 dollars and include costs for engineering and project administration.

- Arrowhead Lake Bottom Sediment Treatment: \$125,000
- Indianhead Lake Bottom Sediment Treatment: \$120,000
- Arrowhead and Indianhead Lakes Street Sweeping Program: \$250,000
- Arrowhead and Indianhead Lakes Fertilization Optimization Program: \$20,000

Management/Protection Action	Basis	Estimated Timeline	
<b>Address Internal Bottom Sediment Loading</b>	Continuous dissolved oxygen monitoring	Determine aeration capacity of existing system	2022 - 2024
	Alum and iron treatment	Reduce bottom sediment phosphorus load	2023/2024
	Modify aeration system, as needed		2024
	Sediment release monitoring	Assess management effectiveness	2024 - 2025+
<b>Address External Nutrient Loading</b>	Enhanced street sweeping program	Reduce pollutant loading from stormwater	2022 - 2023 (Planning begins)
	Fertilizer management program	Reduce nitrogen sources from excess fertilizer use	2022 - 2023 (Planning begins)
	Chloride monitoring	Continue to identify/track chloride levels from winter salt use	As part of continued lake monitoring program
	Promote NMCWD cost-share grants to watershed residents	In a fully developed watershed, opportunities for largescale BMPs are limited	2022+
<b>Aquatic Invasive Species</b>	Curly-leaf pondweed management	Continue to monitor and treat curly-leaf pondweed growth	2022+
<b>Promote Sustainable Management</b>	Discontinue copper sulfate treatments	Evaluate timeline to discontinue copper sulfate treatments after internal loading management	2025
	Promote native aquatic plant growth	Encourage native plants to promote clear water conditions and competition with algae	2022
	Discontinue blue dye applications	Unnecessary addition of chemicals	2022



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