DRAFT

Arrowhead and Indianhead Lakes Water Quality Improvement Project

Feasibility Study / Preliminary Engineering

Prepared for
Nine Mile Creek Watershed District

October 2023

Barr Engineering Co.
4300 MarketPointe Drive, Suite 200
Minneapolis, MN 55435

Arrowhead and Indianhead Lakes Water Quality Improvement Project

Feasibility Study and Preliminary Engineering

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Certification

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the state of Minnesota.

Janna Kieffer
PE #: 43571

Date

Abbreviations

AACE	Association for the Advancement of Cost Engineering
ac	acre
AIS	aquatic invasive species
Al	aluminum
BMPs	Best Management Practices
Cl	chloride
cm	centimeter
dBa	decibles A
hp	horsepower
kg	kilogram
m	meter
MIDS	minimal impact design standards
NMCWD	Nine Mile Creek Watershed District
RWMWD	Ramsey-Washington Metro Watershed District
SRP	soluble reactive phosphorus
Tal	total aluminum
Tfe	total iron
TDP	total dissolved phosphorus
TP	total phosphorus
w/w	weight for weight

1 Introduction and Project Background

In August 2022, the Nine Mile Creek Watershed District (NMCWD) completed the *Arrowhead and Indianhead Lakes Water Quality Study* to assess and prescribe management activities to improve water quality in these lakes in the City of Edina (Barr Engineering Co., 2022). Following the water quality study, NMCWD completed this feasibility and preliminary engineering study to further evaluate the feasibility of the recommended management activities.

1.1 Project Background

Arrowhead and Indianhead Lakes are landlocked lakes located in the southwestern portion of Edina. The total drainage area to Arrowhead Lake is 178 acres and to Indianhead Lake it is 107 acres. The Arrowhead and Indianhead Lake watersheds are nearly fully developed. The major land use classification is single-family residential, which constitutes over 82% of the tributary watershed for Indianhead Lake and 45% of the tributary watershed for Arrowhead Lake. The Arrowhead Lake watershed also includes highways (21%), open water (12%), open space (4%), and parks (3%).

Recent monitoring data indicates that Arrowhead and Indianhead Lakes are not consistently meeting Minnesota's water quality standards for shallow lakes due to excess nutrients (e.g., phosphorus and nitrogen). The 2022 water quality study found that approximately 54% of the phosphorus in Arrowhead Lake originated from internal sources such as nutrient-rich sediments, while for Indianhead Lake, internal sources were 84% of the phosphorus load to the lake (Barr Engineering Co., 2022). The other phosporus sources for both lakes include stormwater runoff from the watersheds and groundwater inflows.

The water quality study identified recommendations to improve water quality. These recommendations were focused on the control of internal phosphorus loading, as this is the predominant source of phosphorus to these lakes. Enhanced street sweeping was also recommended as a means to reduce phosphorus loads from stormwater.

2 Arrowhead Lake and Indianhead Lake Overview

The following sections describe the characteristics of Arrowhead and Indianhead Lakes. Additional background information can be reviewed in the *Arrowhead and Indianhead Lakes Water Quality Study* (Barr Engineering Co., 2022).

2.1 Arrowhead Lake

Arrowhead Lake has a water surface area of approximately 22 acres, a maximum depth of approximately 8 feet, and a mean depth of 3.2 feet at a 10-year average water surface elevation of 874.8 (NGVD29). At this elevation, the lake volume is approximately 83 acre-feet (see Figure 2-1 for a map of Arrowhead Lake bathymetry). Arrowhead Lake is land-locked with no surface outlets. Thus, the water level in the lake depends on weather conditions (snowmelt, rainfall, evaporation) and groundwater flows. Arrowhead Lake's direct watershed is approximately 178 acres, including the surface area of the lake (22 acres). The watershed area, compared to the lake surface area, is relatively small (approximately 8:1 ratio). Runoff from the watershed enters Arrowhead Lake through overland flow and from several storm sewer outfalls at various points along the lakeshore.

Recent monitoring data indicate that Arrowhead Lake is not meeting Minnesota's water quality standards for shallow lakes (Figure 2-2). The summer-average (June-September) total phosphorus concentrations between 2004 and 2020 in Arrowhead Lake were above the shallow lake standard of 60 µg/L for 4 of the 5 years monitored. Average summer chlorophyll-*a* concentrations between 2004 and 2020 were also above the shallow lake standard of 20 µg/L for 3 of the 5 years monitored. The summer-average Secchi disk depths between 2004 and 2020 ranged from 0.5 to 1.2 meters and were less than the minimum 1.0 meter Secchi depth standard for 2 of the 5 years monitored.

Two non-native aquatic invasive species (AIS) are currently present in Arrowhead Lake: Purple loosestrife and curly-leaf pondweed. The City of Edina has been managing curly-leaf pondweed in Arrowhead Lake since spring 2017. Eurasian watermilfoil has been observed in the past but was not present in the most recent survey completed in 2020. Eurasian watermilfoil was found in Arrowhead Lake in the first recorded survey in 2004 in the eastern, western, and southern portions of the lake. By 2011, Eurasian watermilfoil was more widespread, with observations not only in the eastern, western, and southern portions but also in the north. Similar extents of Eurasian watermilfoil were also observed in 2014. The extent of Eurasian watermilfoil decreased in 2019, with observations noted in northern portions of the lake. No observations of Eurasian watermilfoil were noted in the June and August 2020 surveys.

City of Edina Bathymetry (2017)

Elevation, NGVD29

- 867
- 868
- 869
- 870
- 871
- 872
- 873
- 874
- 875

0 250
Feet

ARROWHEAD LAKE BATHYMETRY
Nine Mile Creek Watershed District

FIGURE 2-1

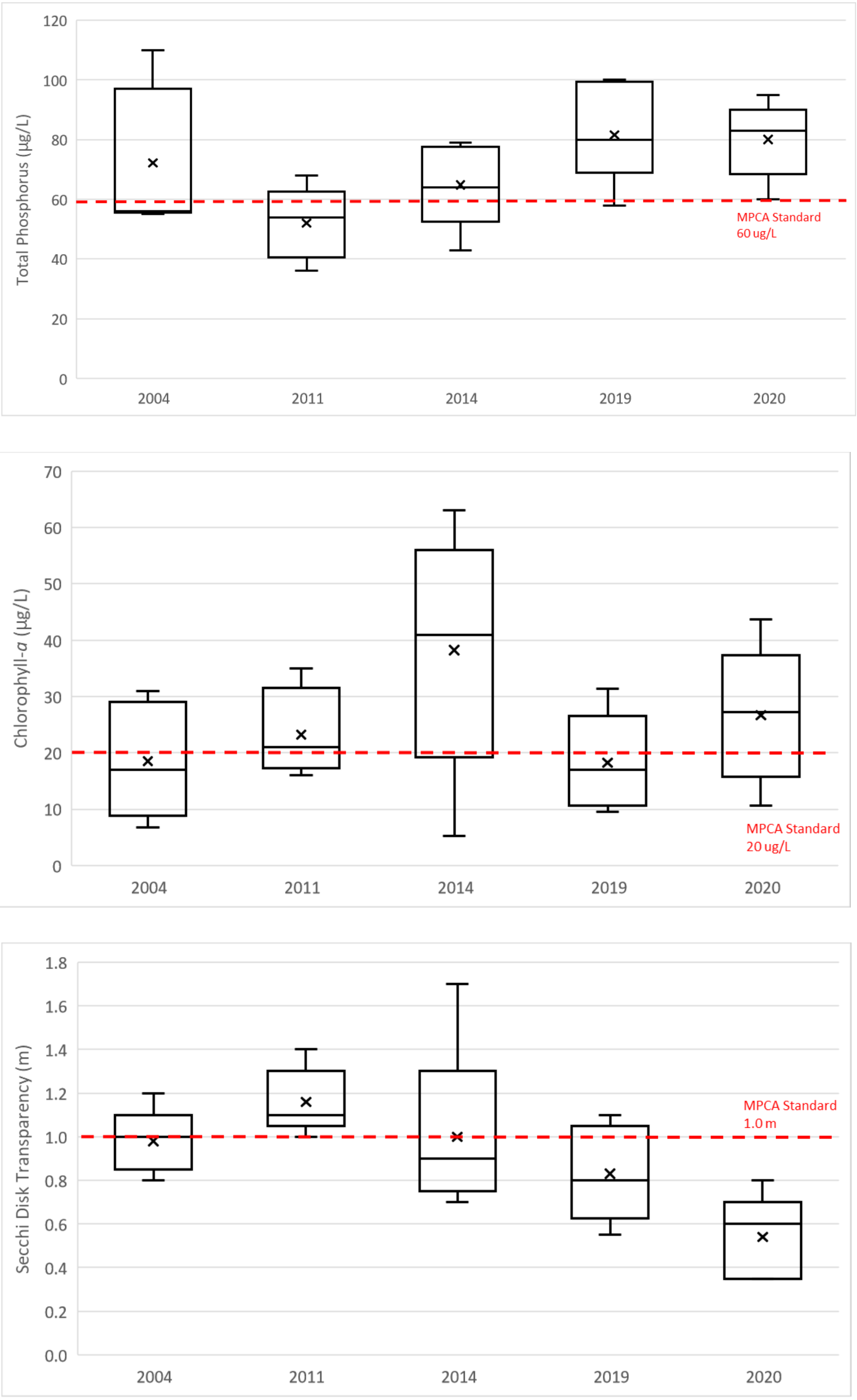


Figure 2-2 Total phosphorus and chlorophyll-*a* concentrations and Secchi disk transparency from 2004 through 2020 in Arrowhead Lake

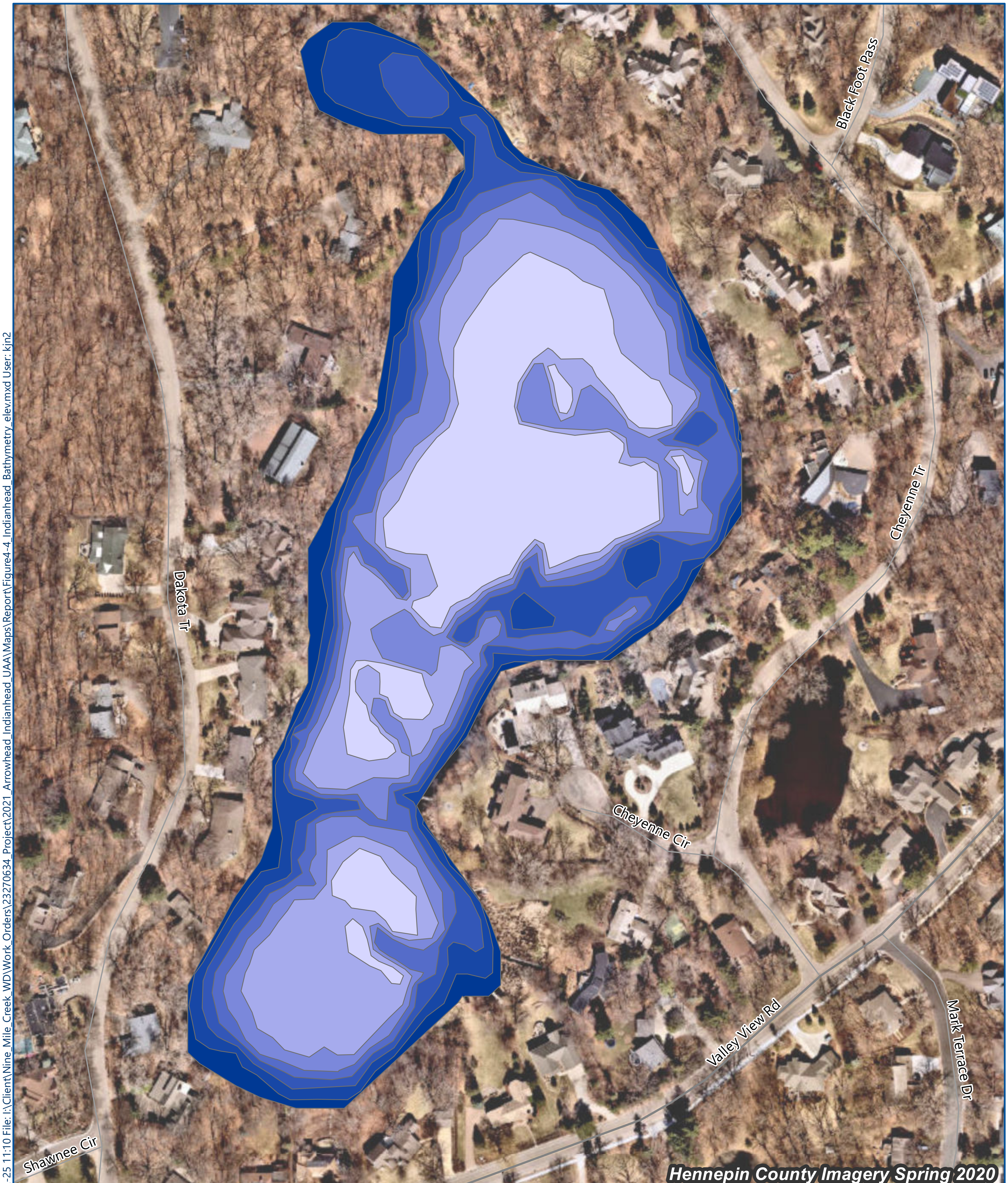
The black "x" indicates the summer average (June through September).

2.2 Indianhead Lake

Indianhead Lake has a water surface area of approximately 14.3 acres, a maximum depth of approximately 5.1 feet, and a mean depth of 3.1 feet at a 10-year average water surface elevation of 863.1 (NGVD29). At this elevation, the lake volume is approximately 49.4 acre-feet (Figure 2-3). Indianhead Lake is land-locked with no surface outlets. Thus, the water level in the lake primarily depends on weather conditions (snowmelt, rainfall, evaporation) and groundwater flow; during times of high-water conditions there has also been periodic occurrences of pumping to control water levels.

Recent monitoring data indicates that Indianhead Lake is not meeting Minnesota's water quality standards for shallow lakes (Figure 2-4). The summer-average (June – September) total phosphorus concentrations between 2004 and 2020 in Indianhead Lake were above the shallow lake standard of 60 µg/L for three out of the five monitoring years, with the highest concentrations observed in the most recent two years monitored. Indianhead Lake summer-average chlorophyll-*a* concentrations measured between 2004 and 2020 were also above the shallow lake standard of 20 µg/L for three out of the five monitoring years. Similarly, the summer average Secchi disk depths between 2004 and 2020 ranged between 0.5 – 1.3 meters, with three of the five sampling events reporting less than the minimum 1.0 meter Secchi depth standard.

Three non-native AIS are currently present in Indianhead Lake: purple loosestrife, curly-leaf pondweed, and yellow iris. Purple loosestrife has been observed in Indianhead Lake since a macrophyte survey was completed in 2019. A macrophyte survey in 2014 identified a widespread curly-leaf pondweed population in Indianhead Lake. In June 2019 and 2020, less curly-leaf pondweed was observed during the June macrophyte surveys due to management efforts completed by the City of Edina. Yellow iris has been recorded along sections of the Indianhead Lake shoreline since 2004. Surveys completed in 2019 and 2020 noted the plant along portions of the northern, eastern, western, and southern shorelines.



City of Edina Bathymetry (2017)

Elevation, NGVD29

- 858
- 859
- 860
- 861
- 862
- 863
- 864

N

0 200

Feet

INDIANHEAD LAKE
BATHYMETRY
Nine Mile Creek
Watershed District

FIGURE 2-3

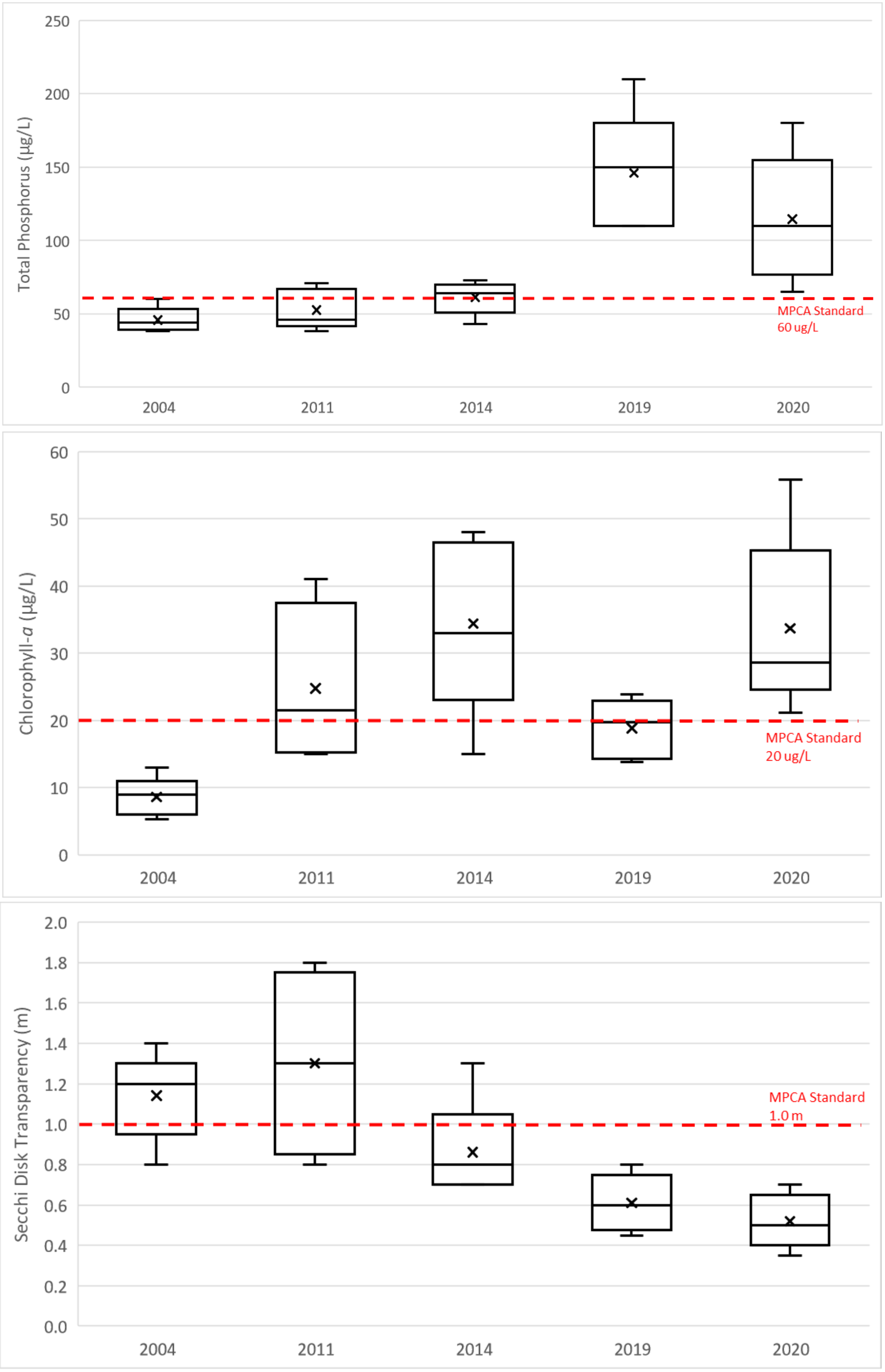


Figure 2-4 Total phosphorus and chlorophyll-*a* concentrations and Secchi disk transparency from 2004 through 2020 in Indianhead Lake

The black "x" indicates the summer average (June through September).

3 Summary of Evaluated Management Practices

The goals of this study are to evaluate the feasibility and cost-effectiveness of the management strategies recommended in the *Arrowhead and Indianhead Lakes Water Quality Study* (Barr Engineering Co., 2022).

The following sections of the report summarize the findings of the feasibility evaluation and recommendations for lake and watershed management practices:

- Section 4 – Arrowhead Lake In-Lake Management
    - Arrowhead Lake sediment treatment to reduce internal phosphorus loading from sediments
    - Arrowhead Lake aeration to reduce internal phosphorus loading from sediments
- Section 5 – Indianhead Lake In-Lake Management
    - Indianhead Lake sediment treatment to reduce internal phosphorus loading from sediments
    - Indianhead Lake aeration to reduce internal phosphorus loading from sediments
- Section 6 – Enhanced Street Sweeping in Arrowhead Lake and Indianhead Lake subwatersheds to reduce external nutrient loads
- Section 7 – Conclusions and Recommendations

4 Arrowhead Lake In-lake Management

Phosphorus release from lake bottom sediments within Arrowhead Lake is coming from organically-bound phosphorus contained in the bottom sediments. Results of analysis from lake sediment coring completed as part of the 2022 water quality study indicate that there is approximately eight times more organically-bound phosphorus compared to iron-bound phosphorus within the lake. This presents a challenge in that aluminum (e.g., alum treatments) cannot directly bind phosphorus that is incorporated into the organic matter. Over time, organically-bound phosphorus decays and is converted into a form that aluminum can bind. However, aluminum ages and loses its binding capacity over time. Hence, the recommended treatment of lake bottom sediments for Arrowhead Lake includes both aluminum and iron. Iron will serve to capture phosphorus (e.g., bind phosphorus) once it is released from decaying organic matter. If oxygen remains sufficiently high in the lake, then iron should be persistently available to bind and immobilize phosphorus. Hence, aeration, which acts to maintain higher oxygen by enhancing oxygen exchange at the water surface, is an important component of this treatment approach.

Iron dosing is based upon the concentration of organically-bound phosphorus in the top four centimeters of lake bottom sediment. Interpretation of previous data Barr has collected regarding sediment phosphorus and iron suggests that a 40 to 1 ratio of iron to organically-bound phosphorus on a mass basis will be able to capture phosphorus released from organic matter. Iron will be added as liquid ferric chloride, which is an acid. In order to buffer the addition of the ferric chloride, aluminum, in the form of sodium aluminate (a base), will be added to maintain pH within the range of 6.5 to 8. Aluminum will also bind with available phosphorus in the water column and lake sediments immediately after treatment and for a few years after treatment completion.

4.1 Aluminum and Iron Laboratory Analysis

A series of jar tests were conducted using a range of sodium aluminate doses and a fixed ferric chloride dose, to determine how much sodium aluminate should be added with the ferric chloride to maintain a pH between 6.5 and 8 and minimize the residual aluminum and iron in the water column after treatment. Table 4-1 shows jar testing results with Arrowhead Lake water with respect to pH, and Table 4-2 shows residual iron, aluminum, and turbidity. These data were used to identify optimal iron and aluminum doses. Figure 4-1 shows an image of iron and aluminum floc in the jar tests. This type of floc is expected to settle to the bottom of Arrowhead Lake. It should be noted that once the floc settles to the lake bottom, it is expected to mix very rapidly into the sediment and is not expected to be visible a few months after treatment.

At a mass ratio of 0.36 aluminum to iron, residual iron and aluminum will be low (approximately 0.26 mg/L for iron and 0.08 mg/L for aluminum) in the lake water column treatment, and lake pH is expected to be within the target range of 6.5 to 8. Dosing for aluminum was based on achieving an aluminum-to-iron ratio of 0.36 while applying iron at 58 grams per square meter of lake surface area.

Table 4-1 Effect of aluminum (as sodium aluminate) and iron (as ferric chloride) dosing ratios on pH for jar tests conducted with Arrowhead Lake water

Lake	Al/Fe Mass Based Dosing Ratio									
	0.18		0.36		0.72		1.44		2.87	
	-----pH-----									
	Initial	**24Hrs**	**Initial**	**24 Hrs**	**Initial**	**24 Hrs**	**Initial**	**24 Hrs**	**Initial**	**24 Hrs**
Arrowhead	6.8	7.5	6.5	7.2	7.0	7.5	9.2	9.2	nd	9.6

Table 4-2 Effect of aluminum (as sodium aluminate) and iron (as ferric chloride) dosing ratios on residual iron, aluminum, and turbidity in jar tests conducted with Arrowhead Lake water

Lake	Al/Fe Mass Based Dosing Ratio														
	0.18			0.36			0.72			1.44			2.87		
	----------------Residual Iron, Aluminum, and Turbidity in Jars-----------------														
	Fe	Al	Turb.	Fe	Al	Turb.	Fe	Al	Turb.	Fe	Al	Turb.	Fe	Al	Turb.
Arrowhead	0.19	0.67	0.81	0.26	0.08	0.34	0.16	0.3	0.29	0.3	15.2	0.75	0.24	49.6	0.91

*Units are mg/L for Fe and Al and NTU for turbidity

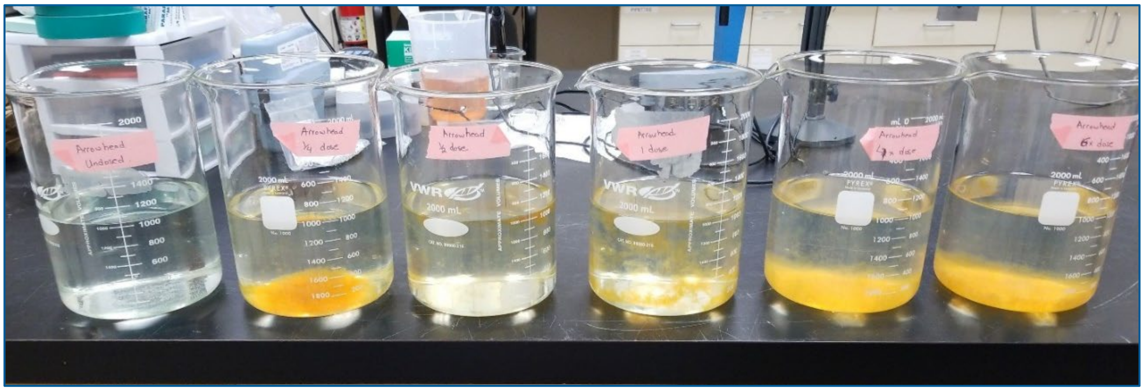


Figure 4-1 Photograph of aluminum and iron floc in jar tests with Arrowhead Lake water treated with ferric chloride and sodium aluminate
The recommended dosing is the third jar from the left. The far-left jar is untreated Arrowhead Lake water.

4.2 Arrowhead Lake Treatment Plan

The iron and aluminum application specifications provided in Table 4-3 are based upon an aluminum-to-iron ratio of 0.36 while applying iron at 58 grams per square meter of lake surface area. At this ratio, residual aluminum will be at its minimum (0.08 mg/L), and pH will be maintained within the target range. The total gallons of liquid ferric chloride and liquid sodium aluminate identified in Table 4-3 assume that liquid ferric chloride is 40 percent by weight (e.g., w/w), liquid sodium aluminate is approximately 32 percent $Na_2Al_2O_4$ by weight (e.g., w/w), and that application is conducted across the surface of the lake up to the 2-foot depth contour (at an elevation of 870.8, the treatment area is 20.6 acres). Splitting the application into two treatments is recommended to minimize the expected increase in in-lake chloride concentrations from the ferric chloride application and to prevent concentrations from exceeding the state standard. It is recommended that treatments be conducted in Year 1 and Year 3, with in-lake chloride monitoring in Year 2 to confirm chloride concentrations are low enough that a planned second treatment can proceed in Year 3. If Year 2 chloride concentrations are such that a Year 3 treatment would not be recommended, an updated treatment timeline should be reassess at that time.

The application is recommended to be conducted in the spring before lilypad growth can prevent the even settling and distribution of iron and aluminum floc onto the sediment bottom. There is city-owned property on the southeast end of the lake, which could be a potential access point for the treatment. However, Arrowhead Lake is shallow at this location and the water level at the time of treatment will dictate if this location is feasible. If water levels are too low, accessing through a residential property would be the alternative. A small treatment barge (see Figure 4-2) will need to be carried down to the water, at which point a shoreline dock or mooring could be used to house the treatment barge overnight if needed. To refill the barge, a hose can be extended across the city-owned or residential property from a refilling tank sited on a low-traffic road, driveway, parking lot, or flat turf grassed area. It should be noted that the treatment barge at right in Figure 4-2 can be disassembled, which makes access more feasible via the city-owned property for Arrowhead Lake.

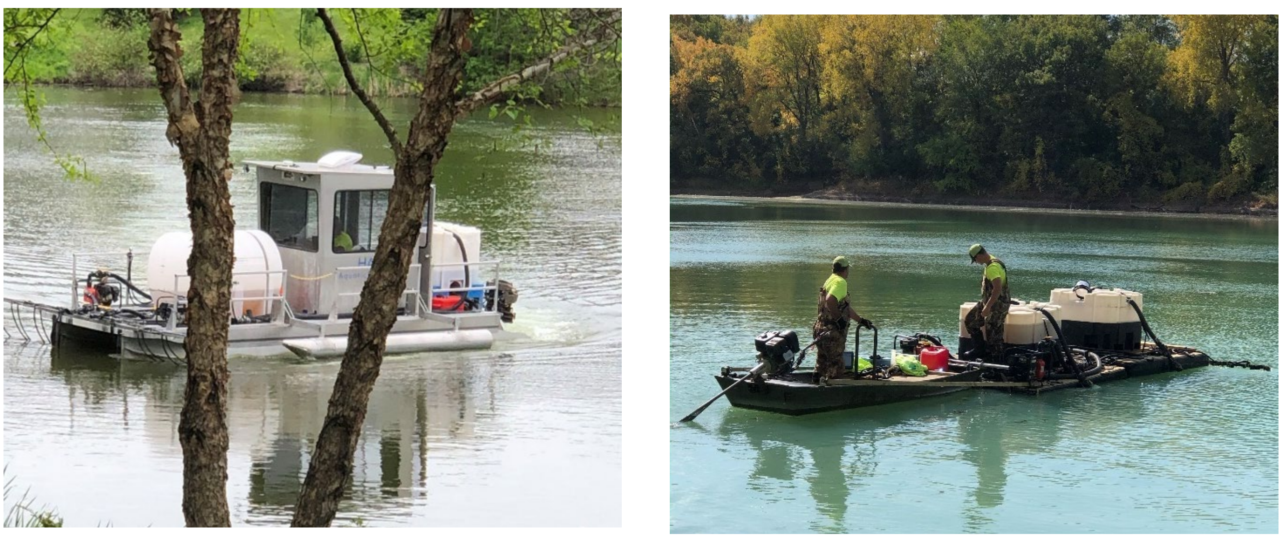


Figure 4-2 Examples of treatment barges that may be used to apply ferric chloride and sodium aluminate to Arrowhead Lake

Since the application of iron in conjunction with aluminum is a new technique for the NMCWD, more comprehensive monitoring and assessment are recommended. The recommended monitoring program following the aluminum and iron application is summarized in Table 4-4. Follow-up sediment coring is recommended at two years, four years, and ten years after treatment to assess the formation of iron-phosphate (Fe-P) and aluminum phosphate (Al-P). The results of follow-up water quality monitoring and sediment coring will be used to determine if another iron-aluminum treatment is needed to bind remaining or accumulated phosphorus post-treatment. It is recommended that the District review monitoring results and consider the potential need for retreatment in years 5 and 10.

Table 4-3 Ferric chloride and sodium aluminate dosing plan for Arrowhead Lake

Dosing and Application Plan		
Phosphorus Fraction within Lake Sediments (g m^{-2} cm^{-1})	Full Dose	Half Dose
Organic Phosphorus: Average Top 6 cm	0.36	0.36
Iron-Bound Phosphorus: Average Top 6 cm	0.05	0.05
Iron and Aluminum Dosing		
Targeted pH	6.5 – 8.0	6.5 – 8.0
Iron Mass to Immobilize Organic Phosphorus (g Fe m^{-2} 1 cm sediment depth)	15	7.5
Estimated Active Layer (cm) for Iron	4	4
Total Iron Dose (g Fe m^{-2})	58	28
Aluminum ($NaAl(OH)_4$) Mass for Buffering (g Al m^{-2} 1 cm sediment depth) and P Binding	5.3	2.65
Estimated Active Layer (cm) for Aluminum	4	4
Total Aluminum Dose (g Al m^{-2})	21	10.5
Ferric Chloride and Sodium Aluminate Treatment Volumes		
Lake Area (ac)	22.3	22.3
Treatment Area (ac)	20.6	20.6
Total Mass Iron Applied (kg)	4866	2433
Total Mass Aluminum Applied (kg)	1752	876
Iron Composition (kg Fe/gallon)	0.70	0.70
Sodium Aluminate Composition (kg Al/gallon)	0.59	0.59
Total Ferric Chloride (gallons)	6935	3468
Final Sodium Aluminate Dose (gallons)	2955	1478

Table 4-4 Sediment treatment monitoring plan for Arrowhead Lake

Activity By Year	Activity Details
Year 1: Apply ferric chloride and sodium aluminate	Application of ½ of the prescribed full dose in the spring. Collect chloride sample immediately after treatment.
Year 2: Sediment coring	Collect 5 sediment cores and analyze for phosphorus fractions, iron, and aluminum.
Year 2: Lake water monitoring	Parameters (1-meter composite): Total Phosphorus (TP), Total Dissolved Phosphorus (TDP), Soluble Reactive Phosphorus (SRP), Total Aluminum (Tal), Total Iron (Tfe), Secchi Disk, Chlorophyll-*a*, Chloride (Cl).
Year 3 (tentative): Apply ferric chloride and sodium aluminate	Application of ½ of the prescribed full dose in the spring. Collect chloride sample immediately after treatment.
Year 4: Sediment coring	Collect 3 sediment cores and analyze for phosphorus fractions, iron, and aluminum.
Year 4: Lake water monitoring	Parameters (1-meter composite): TP, TDP, SRP, Tal, Tfe, Secchi Disk, Chl *a*, Cl.
Year 5: Assess the need for additional treatment	
Year 10: Sediment coring	Collect 3 sediment cores and analyze for phosphorus fractions, iron, and aluminum.
Years 5-10: Lake water monitoring	Determine monitoring schedule based on Year 5 data assessment
Year 10: Assess the need for additional treatment	

4.3 Aeration System Design

The existing aeration system for Arrowhead Lake consists of one ¾ horsepower (hp) compressor, a small shelter, and three aerator heads installed on the lake bottom (see Figure 4-3 and Figure 4-4). The compressor and shelter are situated on a privately-owned residential property on the eastern shore of Arrowhead Lake. The aerator heads are located in a small area in the eastern 1/3 of the lake. Dissolved oxygen, continuously measured within the northwest portion of the lake from May to early October 2022, often fell to low levels during the summer months (see Figure 4-5). Dissolved oxygen needs to be maintained at approximately 5 mg/L to consistently and effectively prevent phosphorus release from lake bottom sediments. Based on the data collected, this system is undersized to meet the needs of the proposed iron and aluminum treatment; hence, an upgrade to the existing system is recommended.

The proposed aeration system consists of two 1-hp compressors (15 cubic feet per minute), weighted aeration lines, and eight aerator heads (specifications for the recommended aeration equipment are provided in Appendix B). The proposed placement of the aerator heads is shown in Figure 4-6. It is recommended that air from compressor 1 be directed to the west and the east sides of the lake. Similarly, air from compressor 2 will also be directed to the west and the east sides of the lake. A splitter box placed downstream of each compressor, and valves in the box, can be used to turn off or direct air to individual aeration heads (Figure 4-7). This design feature allows airflow from both compressors to be directed to one area of the lake in the winter, to prevent ice formation at the lake surface at a localized area. Aeration to support the lake sediment treatments is expected to be most critical during the nonwinter months. However, continuing the practice of winter aeration will benefit lake water quality by: (1) enabling the sediment treatment to be more effective during the winter months resulting in lower phosphorus concentrations in the spring, and (2) helping to maintain a diverse fish population in Arrowhead Lake (see Section 4.7) by preventing winter fish kills that result in establishment of a rough fish population consisting primarily of goldfish and bullheads.

Flexibility of operation is provided with the proposed design. Air from compressor 1 could be directed to aerator heads 2 and 4, and air from compressor 2 could be directed to aerator heads 6 and 8. This is the recommended configuration. However, there is flexibility in the system in that the two compressors can be independently turned off and on. Operation can also be limited to one compressor, if needed. For example, one rather than two compressors could be operated during the winter season to reduce the size of the open water area to accomodate winter uses at the lake. Similarly, during the open water season, operation of one compressor will be capable of delivering air to all corners of the lake. Additional operational flexibility includes the valves in the splitter box (see Figure 4-7) that can be used to selectively direct air to the aerator heads.

Additional direction on the anticipated operational plan for the Arrowhead Lake aeration system will be considered during final design.

Figure 4-3 Existing aeration system at Arrowhead Lake

Existing Compressor Location

Existing Aerators

Existing Compressor Aeration Line

0 200 400

Feet

EXISTING AERATOR PLACEMENT
Arrowhead Lake
Nine Mile Creek Watershed District

FIGURE 4-4

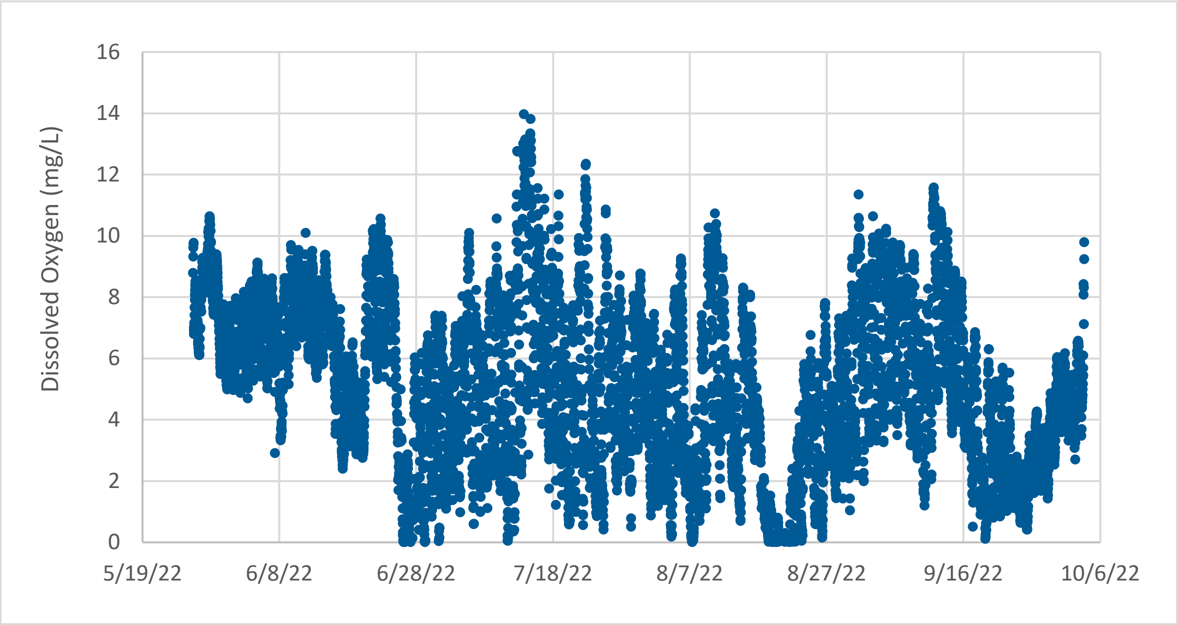
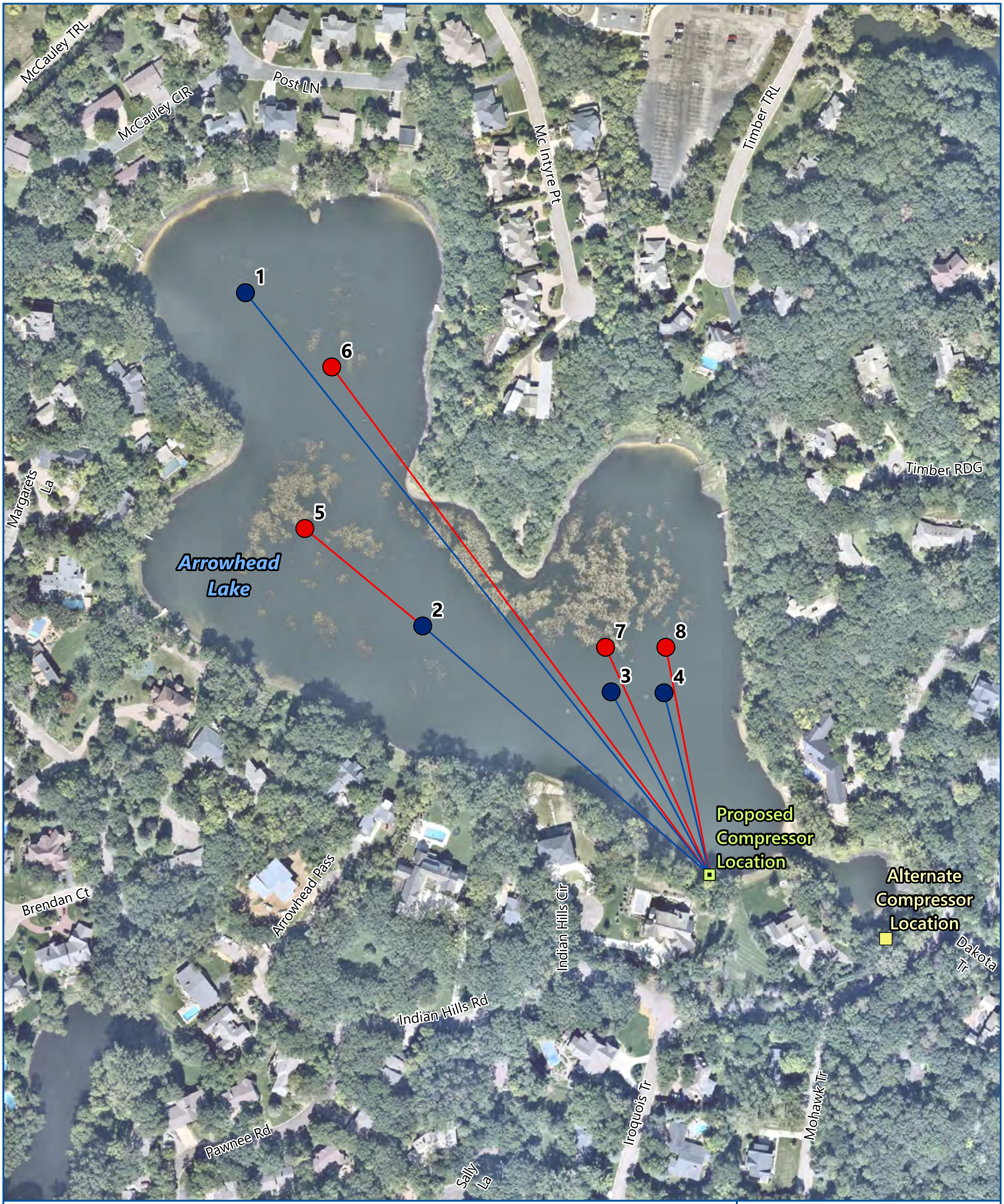


Figure 4-5 Dissolved oxygen in Arrowhead Lake measured on the northwest side of the lake



Alternative Compressor Location
Proposed Compressor Location
Aeration Head (Compressor 1)
Aeration Head (Compressor 2)
Compressor 1 Aeration Line
Compressor 2 Aeration Line

0 200 400
Feet

PROPOSED LAKE AERATOR CONFIGURATION
Arrowhead Lake
Nine Mile Creek Watershed District

FIGURE 4-6

Figure 4-7 Splitter box and valves that control airflow to the aeration heads

The current aeration system is located on a privately-owned residential property. Based on recent discussions with the City of Edina and the property owner, it is anticipated that the proposed aeration system would continue to be located at the same property. If the proposed project moves forward to implementation, the District will pursue necessary easements and/or agreements with the City and property owners, as needed. Since the system is planned to be located on private property, the option of enclosing the system with a roofed structure constructed from high-quality cedar or other high-quality wood material was considered. This structure would be more aesthetically pleasing than a standard cabinet and also provide additional soundproofing in order to minimize noise disturbance associated with the upgraded aerator (see discussion below regarding noise expected from the new compressor). An image of the schematic design for the enclosure is shown in Figure 4-8.

Barr staff with expertise in noise studies performed on-site noise testing[1] to better understand the noise level of the existing system. As part of the sound evaluation, a range of measurements were conducted near the existing compressor at a distance of 6 feet (average of 55 to 59 decibles-dBA) while the system was in operation. Other measurements taken included background conditions (40 dBA on 8/2/23 when the compressor was out of operation) and a residential air conditioner (57 dBA at 6 feet). Measurements at the residence patio with the existing compressor system in operation on 8/10/23 were around 41 to 42 dBA, with audible sounds of both distant traffic as well as a slight hum from the existing compressor. Sound measurements on the lower lawn below the patio, approximately 35 feet from the compressor, were 44 dBA, with the hum of the compressor audible. The manufacturer of the proposed compressor replacement (*AirLift 10 HF*) indicates the system operates at 55 dBA at a distance of 6 feet. This is in the range of sound emitting from the existing system. Based on the on-site noise testing, the similarity in sound levels emitted from the existing and the proposed systems suggest that additional shielding is not

[1] Casella sound measurement equipment was used for this evaluation. https://www.casellasolutions.com/categories/noisemonitoring1.html

necessary with the upgraded system. However, it is recommended that additional shielding be considered to reduce the noise level of the proposed system.

Figure 4-8 Schematic design for aerator enclosure at Arrowhead Lake

4.4 Cost-Benefit Analysis

Planning-level opinions of probable cost were developed for an iron (ferric chloride) and aluminum (sodium aluminate) application to lake bottom sediments and an aeration system for Arrowhead Lake. Table 4-5 summarizes the estimated construction, engineering/design, and operations and maintenance costs for the sediment treatments and installation of the aeration system based on 2023 values. Costs for sediment treatment include the total cost to conduct one-half of the total prescribed dose in Year 1 and one-half of the prescribed dose in Year 3. The opinion of cost is intended to aid in evaluating and comparing alternatives and should not be assumed as an absolute value. The Association for the Advancement of Cost Engineering (AACE) Class 4 opinion of cost was used based on the partial project definition, use of parametric models to calculate estimated costs (i.e., making use of order-of-magnitude costs from similar projects), and uncertainty, with an acceptable range of between -20% and +30% of the estimated project cost. Detailed opinions of probable cost for the Arrowhead Lake sediment treatment and aeration system are included in Appendix A.

The aeration costs (Table 4-5) are provided for the replacement of the aeration system at its current location. During project discussions with the city, a question arose about potentially relocating the aeration system to a city-owned parcel on the southeast side of the lake, if needed. The city-owned parcel has limited space for siting the compressors and a new electrical line would need to be provided in order to relocate the system. Although the existing site is expected to be available for the upgraded compressor, costs for relocating the compressors were estimated and are provided in Appendix A for the alternative site near the intersection of Dakota Trail and Indian Hills Trail.

Table 4-5 Planning-level cost estimates for ferric chloride and sodium aluminate treatment and aeration system installation in Arrowhead Lake

Project	Construction Cost Estimate	Engineering/ Design Cost Estimate	Total Capital Cost Estimate (-20% - +30%)	Annual Operations & Maintenance Cost Estimate[1]	Annual Monitoring Cost
Lake Treatment-Internal Loading	$140,000	$42,000	$182,000 ($146,000–$237,000)	$0	$1,500
Aeration System	$68,000	$20,400	$89,000 ($72,000–$116,000)	$5,400	---

[1] Operational costs do not include estimates for posting and maintaining signage related to the potential for thin ice hazards.

The annualized cost-benefit for the Arrowhead Lake sediment treatment and aeration system is $1,500 per pound of phosphorus removed, assuming the costs presented in Table 4-5, a 15-year project lifespan, and 18 pounds of annual total phosphorus removal.

4.5 Permitting/Regulatory Considerations

There is no formal permitting program for the iron and aluminum treatments (Minnesota Pollution Control Agency, n.d.) being recommended, but a request must be submitted to the MPCA. Barr has historically made this request in a letter that includes a narrative describing the basis of the treatment (e.g., the need for the treatment to reduce internal loading of phosphorus into a waterbody), proposed treatment doses, monitoring and oversight during treatment, and when the application is planned.

A permit from the MN DNR is required to operate an aeration system in public waters in Minnesota. Completion of an online application through the MN DNR Permits and Reporting System (MPARs) is required. It is assumed that the existing aeration system is already permitted, but as part of the renewal process, system upgrades can be described. It is expected that signs posting potential thin ice hazards will continue to be required as part of a new permit for any winter aeration. Additional information on the lake aeration permit program is available on the MNDNR Lake Aeration Program webpage.

4.6 Aeration System Maintenance

The proposed aeration system in Arrowhead Lake will require regular maintenance. While maintenance requirements will vary depending on the system design, an owner's manual and maintenance manual provided by the vendor for the proposed aeration system is included as an example in Attachment A. Recommended frequency of maintenance is provided in these documents. Maintenance requirements include the following:

- Inspect and clean the air intake port and tube of the air filter canister.
- Inspect and replace the air intake filter.
- Inspect and confirm the operation of the cooling fan.
- Clean aerator head membranes by using the "flexing the membrane" procedure identified in the owner's manual.
- General inspection of the aerator heads and potential sediment accumulation.

The manufacturer also suggests that the air compressor cylinders should be rebuilt every two years. The vendor has kits to perform the rebuild.

4.7 Fisheries

There is an abundant and diverse fish population in Arrowhead Lake, and it is likely because of winter aeration that reduces the frequency of winter fish kills (see MN DNR, 2012 regarding the use of aeration to support gamefish populations in shallow lakes). Winter kills tend to promote the establishment of rough fish such as bullheads, common carp, and goldfish. According to the results of trap surveys conducted in September 2021 and June 2022 (WSB, 2022), the fishery in Arrowhead Lake consists of bluegill sunfish, bullhead, hybrid sunfish, and largemouth bass. Bluegill sunfish were the most abundant (total of 385). Only one black bullhead was caught in the September trapping, while three were caught in June. An electrofishing survey concuted in August 2022 captured black bullhead, goldfish, bluegill sunfish, hybrid sunfish, and largemouth bass. In contrast to Indianhead Lake, there appears to be a small population of bullheads and goldfish. It is possible that the presence of bullheads and goldfish are an indication that the aeration system is undersized. The upgrades being recommended to the aeration system as a result of this study will help to promote the distribution of oxygen across the lake (see Section 4.3), and to increase winter and summer concentrations. Maintaining a fisheries population with few or no rough fish will assist efforts to improve water quality and is also likely to increase the longevity of the recommended sediment treatments.

5 Indianhead Lake In-lake Management

Similar to Arrowhead Lake, the internal phosphorus release from lake bottom sediments within Indianhead Lake comes primarily from organically bound phosphorus. This presents a similar challenge to what was described for Arrowhead Lake in Section 4, in that aluminum (e.g., alum treatments) cannot directly bind phosphorus that is incorporated into organic matter. The recommended treatment of lake bottom sediments within Indianhead Lake includes both aluminum and iron. Over time, organically bound phosphorus decays and is converted into a form that aluminum can bind. However, aluminum ages and loses its binding capacity over time. Hence, treatment of lake bottom sediments is recommended to include both aluminum and iron. Iron will serve to capture phosphorus (e.g., bind it) once it is released from decaying organic matter. If oxygen remains sufficiently high in the lake, then iron should be persistently available to bind and immobilize phosphorus. Hence, aeration, which acts to maintain higher oxygen by enhancing oxygen exchange at the lake water surface, is an important component of this treatment approach.

Iron dosing is based on the concentration of organically-bound phosphorus in the top four centimeters of lake bottom sediment. Previous studies of sediment phosphorus and iron suggest that a 40 to 1 ratio of iron to organic phosphorus on a mass basis will be able to capture phosphorus released from organic matter. Iron will be added as liquid ferric chloride, which is an acid, and hence aluminum, in the form of sodium aluminate, which is a base, will be added to maintain pH within the range of 6.5 to 8. Aluminum will also serve to bind available phosphorus in the water column and in the lake sediments immediately after treatment and for a few years after treatment.

5.1 Aluminum and Iron Laboratory Analysis

Similar to the Arrowhead Lake laboratory investigation, a series of jar tests were conducted with a range of aluminum doses and a fixed ferric chloride dose to determine how much sodium aluminate should be added with ferric chloride to maintain pH between 6.5 and 8 as well as minimize residual aluminum and iron in the water column. Table 5-1 shows jar testing results with water from Indianhead Lake for pH, and Table 5-2 shows results for residual iron, aluminum, and turbidity. These data were used to identify optimal iron and aluminum doses. Figure 5-1 shows an image of iron and aluminum floc in the jar tests. This type of floc is expected to form in the water column of Indianhead Lake and then settle to the lake bottom. It should be noted that the floc will mix in with the sediment and is not expected to be visible a few months after treatment.

Table 5-1 **Effect of aluminum (as sodium aluminate) and iron (as ferric chloride) dosing ratios on pH for jar tests conducted with Indianhead Lake water**

Lake	Al/Fe Mass Based Dosing Ratio									
	0.13		0.25		0.51		1.02		2.03	
	-----pH-----									
	Initial	**24 Hrs**	**Initial**	**24 Hrs**	**Initial**	**24 Hrs**	**Initial**	**24 Hrs**	**Initial**	**24 Hrs**
Indianhead	6.9	7.7	7.3	8.4	8.5	9.3	9.5	9.7	9.7	8.4

Table 5-2 **Residual iron, aluminum, and turbidity after 24 hours of settling in jar tests with water from Indianhead Lake**

Lake	Al/Fe Mass Based Dosing Ratio														
	0.13			0.25			0.51			1.02			2.03		
	----------------Residual Iron, Aluminum, and Turbidity in Jars-----------------														
	Fe	Al	Turb	Fe	Al	Turb	Fe	Al	Turb	Fe	Al	Turb	Fe	Al	Turb
Indianhead	0.25	0.31	0.4	0.13	0.24	0.28	7.07	2.4	1.5	0.05	19.4	0.9	0.79	32	3.7

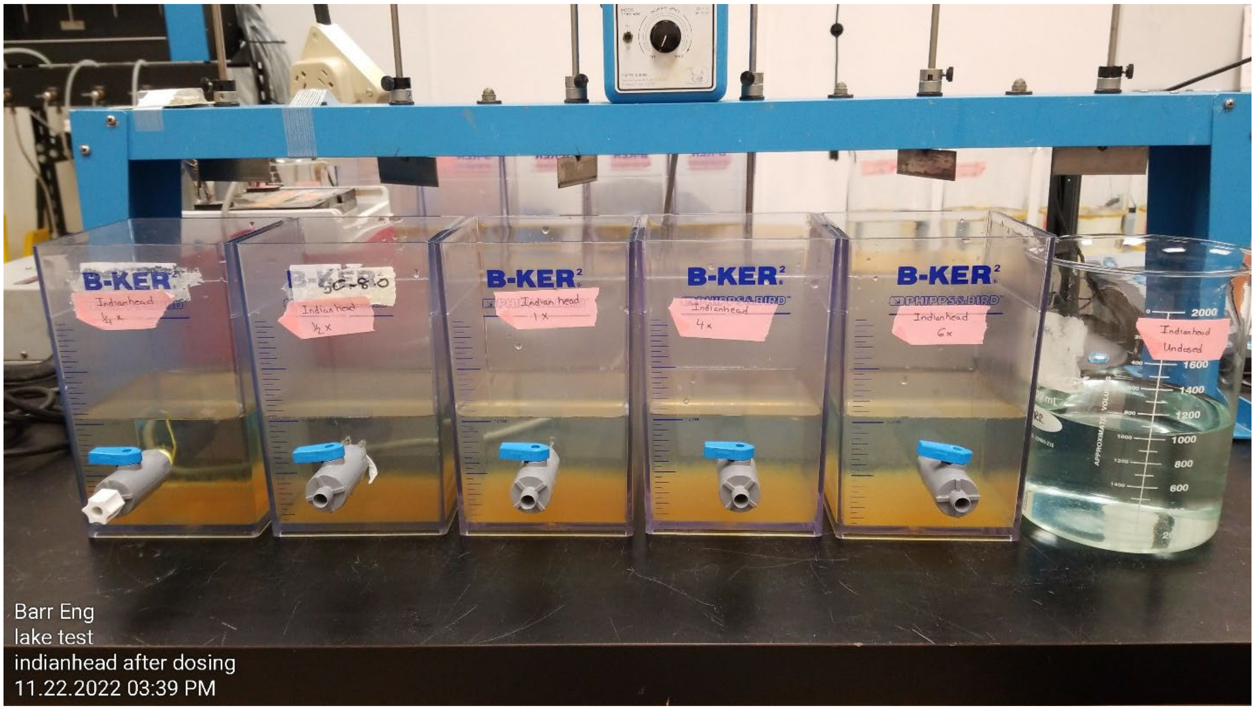


Figure 5-1 **Picture of aluminum and iron floc in jar tests with Indianhead Lake water treated with ferric chloride and sodium aluminate**

The recommended dosing is the third jar from the left. The far-right jar is untreated Indianhead Lake water.

5.2 Indianhead Lake Treatment Plan

The specifications for iron and aluminum application provided below in Table 5-3 are based upon an aluminum-to-iron ratio of 0.36 while applying iron at a dose of 64 grams iron per square meter of lake surface area. At this ratio, residual aluminum will be near its minimum (approximately 0.24 mg/L), and pH will be maintained near the target range. The total gallons of liquid ferric chloride and liquid sodium aluminate identified in Table 5-3 assumes that liquid ferric chloride is 40 percent by weight (e.g., w/w) and liquid sodium aluminate is approximately 32 percent $Na_2Al_2O_4$ by weight (e.g., w/w), and application is conducted across the surface of the lake up to the 2-foot depth contour (at an elevation of 859.1 ft, the total treatment area is 10.7 acres).

A single application of aluminum and iron is recommended. The application is recommended to be conducted in the spring before lilypad growth can prevent even settling and distribution of iron and aluminum floc on the lake bottom sediments. There is city-owned property that extends from Indian Hills Road at the north end of the lake that could be a potential access point for the treatment (Figure 5-2). It may be necessary for a small treatment barge (see Figure 4-2 in Section 4) to be carried down to the water by a bobcat with forks, which may require additional site restoration. To refill the barge, a hose can be extended from refilling tanks positioned near the roadway to the lake where the barge is moored.

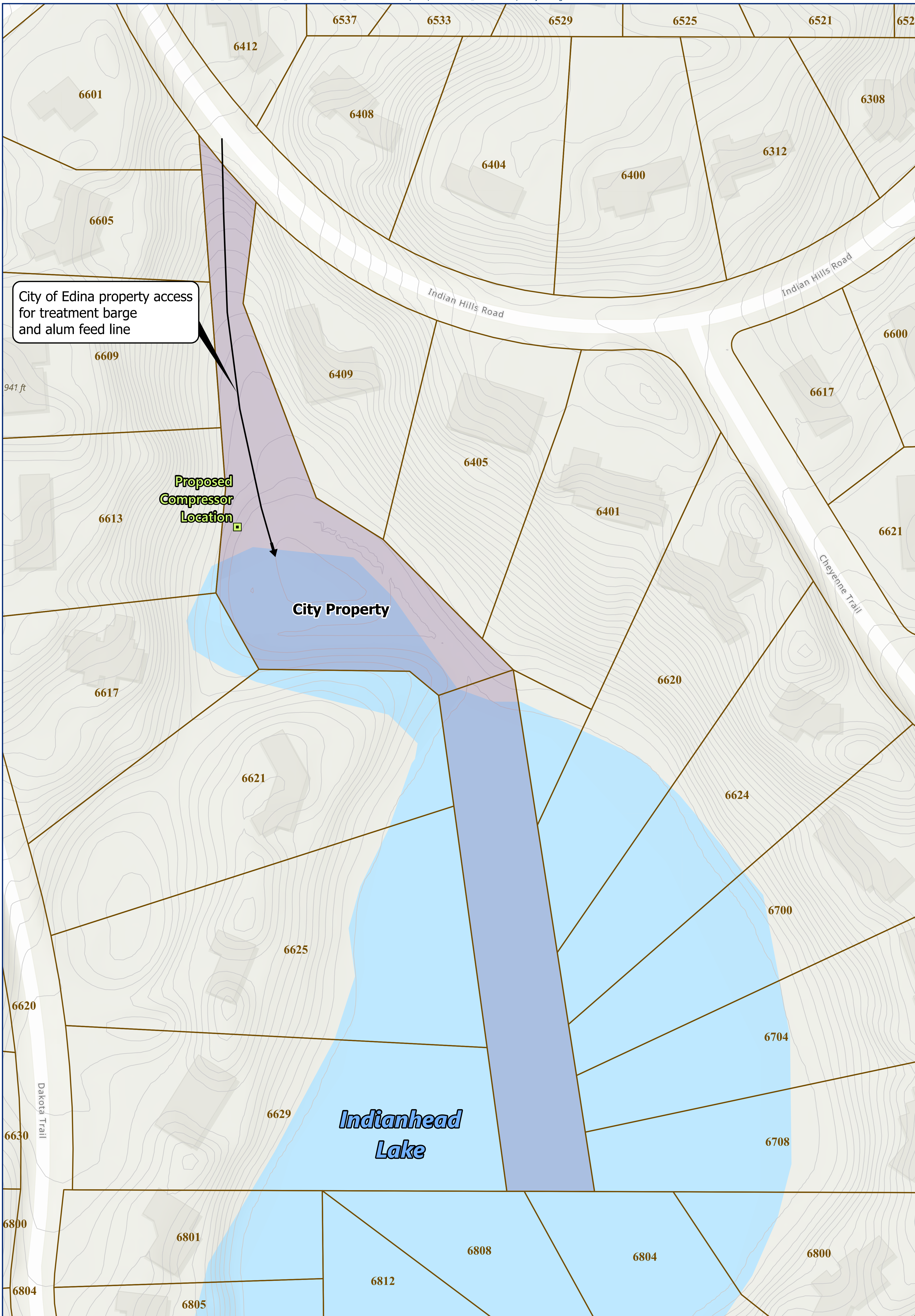
Since the application of iron in conjunction with aluminum is a new technique for the NMCWD, more comprehensive monitoring and assessment are recommended. The recommended monitoring program following the aluminum and iron application is summarized in Table 5-4. Follow-up sediment coring is recommended at two years, four years, and ten years after treatment to assess the formation of iron-phosphate (Fe-P) and aluminum phosphate (Al-P). The results of follow-up water quality monitoring and sediment coring will be used to determine if another iron-aluminum treatment is needed to bind remaining or accumulated phosphorus post-treatment. It is recommended that the District review monitoring results and consider the potential need for retreatment in years 5 and 10.

Table 5-3 Ferric chloride and sodium aluminate dosing plan for Indianhead Lake

Dosing and Application Plan	
Phosphorus Fraction within Lake Sediments (g m^{-2} cm^{-1})	
Organic Phosphorus: Average Top 6 cm	0.40
Iron-Bound Phosphorus: Average Top 6 cm	0.06
Iron and Aluminum Dosing	
Targeted pH	6.5–8
Iron Mass to Immobilize Organic P (g Fe m-2 1 cm depth)	16
Estimated Active Layer (cm) for Iron	4
Total Iron Dose (g Fe m-2)	64
Aluminum (NaAl(OH)4) Mass for Buffering (g Al m-2 1 cm depth) and P Binding	5.8
Estimated Active Layer (cm) for Aluminum	4
Total Al Dose (g Al m-2)	23
Ferric Chloride and Sodium Aluminate Treatment Volumes	
Lake Area (ac)	14.3
Treatment Area (ac)	10.7
Total Mass Iron Applied (kg)	2,786
Total Mass Aluminum Applied (kg)	1,003
Iron Composition (kg Fe/gallon)	0.70
Sodium Aluminate Composition (kg Al/gallon)	0.59
Total Ferric Chloride (gallons)	3,972
Final Sodium Aluminate Dose (gallons)	1,692

Table 5-4 Sediment treatment monitoring plan for Indianhead Lake

Activity By Year	Activity Details
Year 1: Apply ferric chloride and sodium aluminate	Application in the spring. Collect chloride sample immediately after treatment.
Year 2: Sediment coring	Collect 5 sediment cores and analyze for phosphorus fractions, iron, and aluminum.
Year 2: Lake water monitoring	Parameters (1-meter composite): Total Phosphorus (TP), Total Dissolved Phosphorus (TDP), Soluble Reactive Phosphorus (SRP), Total Aluminum (TAl), Total Iron (TFe), Secchi Disk, Chlorophyll-*a,* Chloride (Cl).
Year 4: Sediment coring	Collect 3 sediment cores and analyze for phosphorus fractions, iron, and aluminum.
Year 4: Lake water monitoring	Parameters (1-meter composite): TP, TDP, SRP, TAl, TFe, Secchi Disk, Chl *a,* Cl.
Year 5: Assess the need for additional treatment	
Year 10: Sediment coring	Collect 3 sediment cores and analyze for phosphorus fractions, iron, and aluminum.
Year 5-10: Lake water monitoring	Determine monitoring schedule based on Year 5 data assessment
Year 10: Assess the need for additional treatment.	



Proposed Compressor Location

Potential Access

City of Edina Property

Hennepin County Parcel

0 50 100 200

Feet

POTENTIAL ACCESS FOR CONTRACTOR TREATMENT BARGE
INDIANHEAD LAKE
Nine Mile Creek
Watershed District

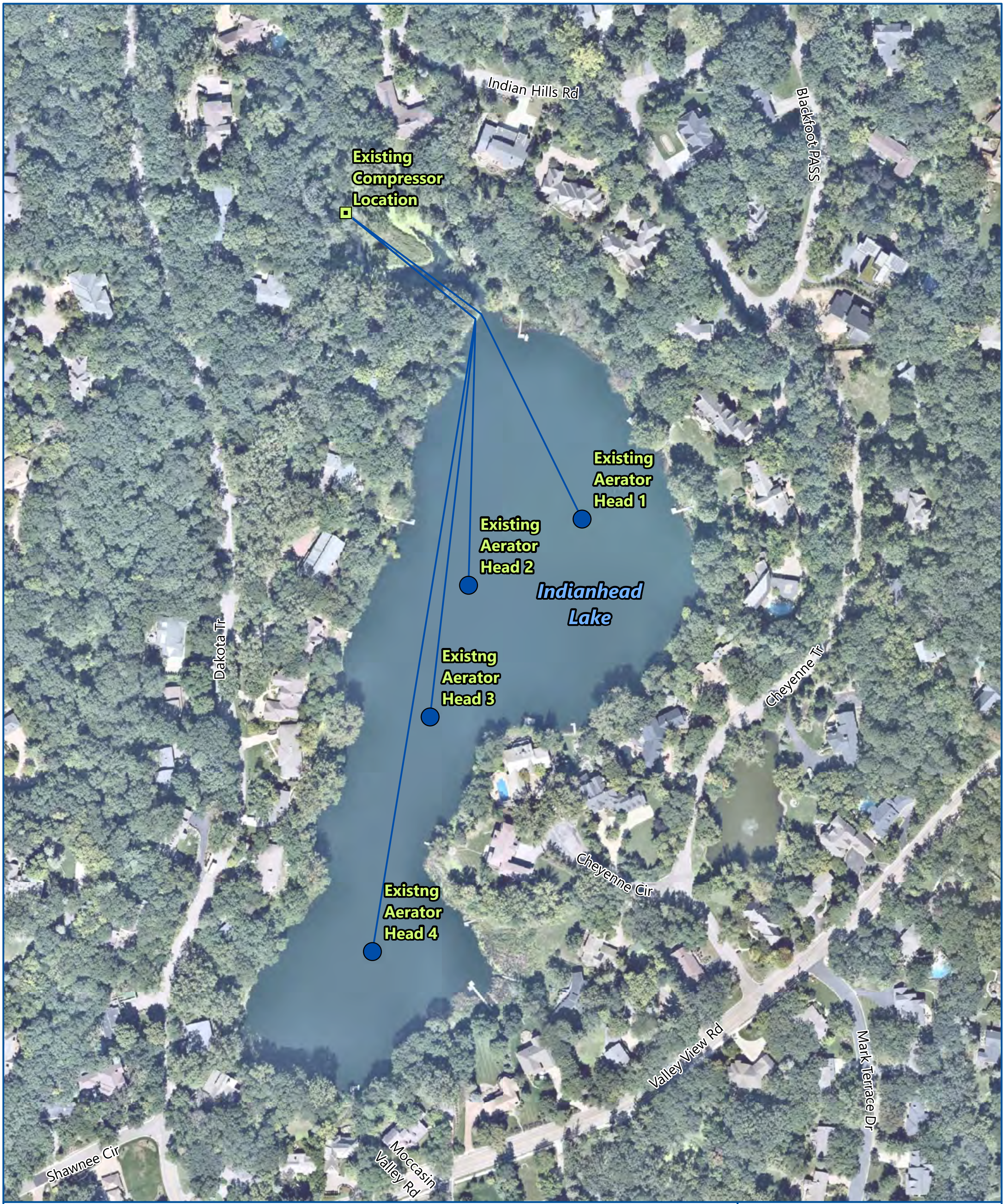
FIGURE 5-2

5.3 Indianhead Lake Aeration System

The existing Indianhead Lake aeration system consists of three operational ¾ hp compressors (Figure 5-3) that are located in the north end (lagoon) of Indianhead Lake on city-owned property. The compressors feed air to four aerator heads that are evenly spaced across the lake (see Figure 5-4). Dissolved oxygen measurements collected in 2022 showed oxygen levels were generally above 4 mg/L with operation of the existing aeration system, except for a few occurrences where the levels dropped to zero in response to copper sulfate treatments (Figure 5-5). The 2022 monitoring was performed with a dissolved oxygen probe that was located approximately 150 feet from one of the aerators. Due to variability in lake mixing, it is expected that there are areas of the lake with lower dissolved oxygen levels. Also, the probe was placed mid-depth in the water column, and it can also be presumed that dissolved oxygen is lower at the lake bottom.

An upgraded aeration system is recommended for Indianhead Lake to attain consistent and improved dissolved oxygen distribution. The recommended system would include a new metal enclosure for the compressor, weighted aeration lines, and better aeration heads. The recommended aeration equipment is the same as that for Arrowhead Lake (see Section 4.3 and Appendix B) with the exception of the additional cedar structure that will not be constructed for Indianhead Lake. The existing wooden enclosure is expected to be sufficient for housing the new compressor system, but it is recommended that a concrete base be included as part of the installation.

Figure 5-3 Existing compressors and housing system for the Indianhead Lake aeration system



Existing Compressor Location

Existing Aerators

Existing Compressor Aeration Line

0 200 400

Feet

EXISTING AERATOR PLACEMENT
Indianhead Lake
Nine Mile Creek Watershed District

FIGURE 5-4

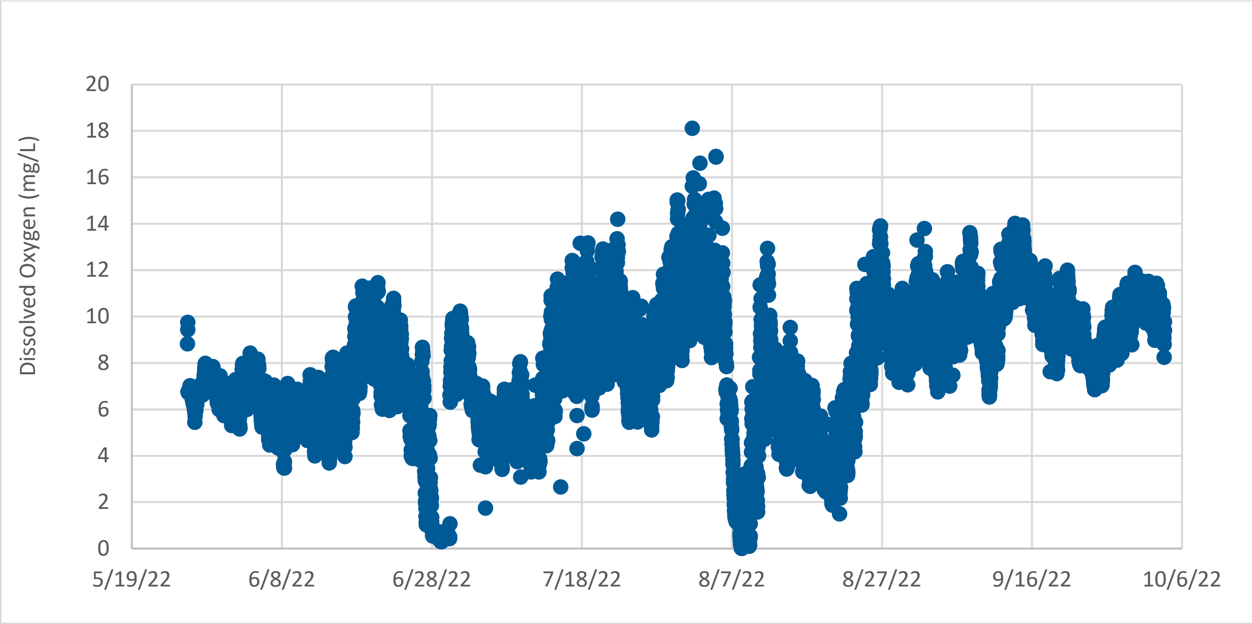
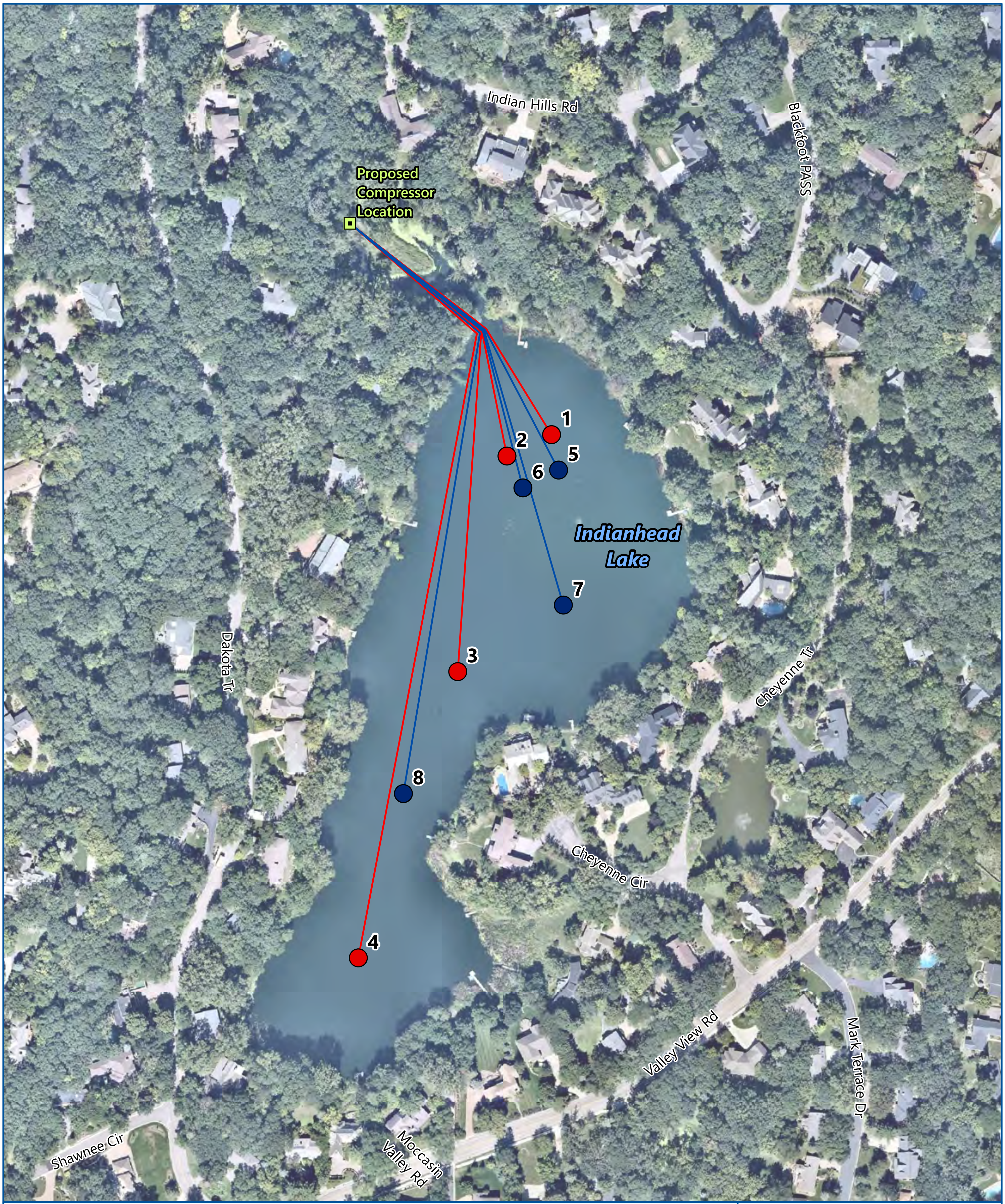


Figure 5-5 Dissolved oxygen in Indianhead Lake measured on the northwest side of the lake approximately 150 feet from an aerator head

The proposed aeration compressor system would be installed on land at the location of the existing system. Figure 5-6 shows the proposed configuration, with aeration lines extending from the compressor to eight aeration heads. The proposed system is designed such that during winter, air from two compressors can be directed using the splitter box and valves (see Figure 4.7 as an example) to four of the aerator heads (identified as number 1, 2, 5, and 6 in Figure 5-6) to push more air into one focused location in the lake to prevent ice formation, if desired. This would prevent ice formation on the lake in this localized area and minimize the likelihood of fish kills. An operational plan for the Indianhead Lake aeration system will be considered during final project design.



- Proposed Compressor Location
- Aeration Head (Compressor 1)
- Aeration Head (Compressor 2)
- Compressor 1 Aeration Line
- Compressor 2 Aeration Line

N

0 200 400
Feet

PROPOSED LAKE AERATOR CONFIGURATION
Indianhead Lake
Nine Mile Creek Watershed District

FIGURE 5-6

5.4 Cost-Benefit Analysis

A planning-level opinion of probable cost was developed for an iron (ferric chloride) and aluminum (sodium aluminate) application to lake bottom sediments of Indianhead Lake and the installation of an upgraded aeration system that would replace all the components of the existing aeration system. Table 5-5 summarizes the estimated construction, engineering/design, and operations and maintenance costs for the project based on 2023 values. The opinion of cost is intended to aid in evaluating and comparing alternatives and should not be assumed as an absolute value. The AACE Class 4 opinion of cost was used based on the partial project definition, use of parametric models to calculate estimated costs (i.e., making use of order-of-magnitude costs from similar projects), and uncertainty, with an acceptable range of between -20% and +30% of the estimated project cost. Detailed opinions of probable cost for the Indianhead Lake treatment and aeration system upgrade are included in Appendix A.

Table 5-5 Planning-level cost estimates for ferric chloride and sodium aluminate treatment and aeration system installation in Indianhead Lake

Project	Construction Cost Estimate	Engineering/ Design Cost Estimate	Total Capital Cost Estimate (-20% - +30%)	Annual Operations & Maintenance Cost Estimate[1]	Annual Monitoring Cost
Lake Treatment-Internal Loading	$94,000	$28,000	$122,000 ($98,000–$159,000)	$0	$1,500
Aeration System	$73,000	$22,000	$95,000 ($76,000–$124,000)	$5,400	---

[1] Operational costs do not include estimates for posting and maintaining signage related to the potential for thin ice hazards during the winter season.

The annualized cost-benefit for the project is $1000 per pound of phosphorus removed, assuming the costs presented in Table 5-5, a 15-year project lifespan, an annual total phosphorus removal of 31 pounds, and follow-up sediment monitoring.

5.5 Permitting/Regulatory Considerations

See Section 4.5 for a description of permitting considerations.

5.6 Aeration System Maintenance

See Section 4.6 for a description of aeration maintenance needs.

5.7 Fisheries

There is an abundant and diverse fish population in Indianhead Lake, and it is likely because of winter aeration that prevents regular winter fish kills. Winter kills tend to promote the establishment of rough fish such as bullheads, common carp, and goldfish. According to the results of trap surveys conducted in September 2021 and June 2022, the fishery in Indianhead Lake consists of black crappie, bluegill sunfish, golden shiner, hybrid sunfish, and largemouth bass. Sunfish were the most abundant. An electrofishing survey conducted in August 2022 captured black crappie, bluegill sunfish, hybrid sunfish, and largemouth bass. It does not appear that bullheads, common carp or goldfish reside in Indianhead Lake. Maintaining a fisheries population that is free of rough fish will assist efforts to improve water quality and also likely increase the longevity of the recommended sediment treatments.

6 Enhanced Street Sweeping

Enhanced or "targeted" street sweeping was identified as a management action to consider in the *Arrowhead and Indianhead Lakes Water Quality Study* (Barr, 2022) to help reduce external nutrient loading to these waterbodies. Because the Arrowhead and Indianhead Lake watersheds are nearly fully developed, land availability for installing structural stormwater treatment Best Management Practices (BMPs) is limited. Enhanced street sweeping was identified as an alternate "source control" approach to reducing sediment and nutrients in these waterbodies. During the 2022 study, planning-level cost estimates were developed for the implementation of an enhanced street-sweeping program, but the pollutant removal from an enhanced street-sweeping program was not evaluated.

The following subsections describe the modeling analysis conducted as part of this feasibility study to estimate the water quality impact of existing and enhanced street sweeping operations in the Arrowhead and Indianhead Lake watersheds.

6.1 Existing Street Sweeping Evaluation

As noted in the 2022 water quality study, street sweeping can be an effective, non-structural BMP for reducing sediment and nutrient pollutant loading from impervious surfaces. The City of Edina currently performs two city-wide street sweeping operations per year as their baseline condition: one in the spring, immediately following snowmelt, and one in the fall. The City has also recently started performing additional street sweepings in areas that drain to select waterbodies, with the goal of reducing stormwater pollutant loading from watershed runoff. The areas surrounding Arrowhead and Indianhead Lakes received additional sweepings during the summers of 2022 and 2023.

The Barr-developed GIS-Based Water Quality Model (GISWQM; Barr, 2018) was used to calculate pollutant loading and estimate street sweeping pollutant recovery. The objectives of this analysis were to (a) evaluate the effectiveness of the City's current baseline street sweeping operations, (b) estimate the potential impact of "enhanced" street sweeping operations, and (c) provide additional information to help inform the optimization of street sweeping operations within these watersheds. Development of the GISWQM for the Arrowhead and Indianhead Lake watersheds and evaluation of existing conditions are discussed in the following subsections.

6.1.1 Model Development

As the name suggests, the GISWQM is a "GIS-based" water quality model that exists as a series of calculation modules in ESRI GIS mapping software programs, including ArcGIS and ArcGIS Pro. The model utilizes a P8-based methodology for annualized pollutant loading and uses methodology from the Minimal Impact Design Standards (MIDS) calculator to evaluate the performance of water quality BMPs.

Within the GISWQM, a street-sweeping module is used to estimate street-sweeping recovery from seasonal street-sweeping operations prior to routing pollutants downstream. The calculator utilizes a series of regression equations (Kalinosky, Baker, & Hobbie, 2014) (Sutherland & Jelen, 1997) for calculating street sweeping pollutant recovery as a function of:

- Seasonal street sweeping frequency (i.e., the number of sweeping operations in the spring, summer, and fall).
- Curb-length swept (i.e., the total curb length of all road areas included in street sweeping operations).
- Canopy cover (i.e., the percentage of tree canopy overhanging street areas).

Road area and curb length were digitized for each study area subwatershed utilizing the best available imagery and road centerline data. Canopy cover was estimated utilizing 2022 NearMap imagery (September 1, 2022; 12-inch resolution) and GIS processing techniques to calculate the percentage of tree canopy overhang over road surfaces within each subwatershed. Subwatershed and major watershed divides were developed using the subwatershed delineation from the 2022 water quality study. These were further subdivided by a 250- by 250-foot grid to provide a higher degree of model resolution. Figure 6-1 shows the average percent canopy cover overhang calculated within subwatersheds tributary to Arrowhead and Indianhead Lakes.

In addition to estimating pollutant loading and street sweeping pollutant recovery, the GISWQM also estimates the impact of downstream treatment to differentiate between raw pollutant “recovery” and effective pollutant “reduction,” as described below:

- Raw pollutant “recovery” is the pollutant recovered from the street surface via street sweeping operations.
- Effective pollutant “reduction” is the pollution that is prevented from reaching a downstream waterbody (i.e., Arrowhead and Indianhead Lakes), considering other treatment that occurs in downstream waterbodies that are accounted for within the model.

The following provides an example of the calculation of pollutant “recovery” versus pollutant “reduction” for a hypothetical subwatershed in the Arrowhead Lake drainage area:

- Runoff from Subwatershed A passes through two ponds prior to discharging to Arrowhead Lake: Pond A and Pond B. Pond A removes 60% of influent TP, and Pond B removes 40% of influent TP.
- The GISWQM estimates the annual street sweeping recovery within Subwatershed A to be 4 pounds of TP per year. i.e., pollutant “recovery” = 4 lbs TP/year.
- To account for downstream treatment, the effective pollutant “reduction” from Subwatershed A is calculated as follows:
    - “Recovery” = 4 lbs TP/year
    - “Reduction” = (4 lbs TP/year recovery) x (1 – 0.6) x (1 – 0.4) = 0.96 lbs TP/year.

As illustrated by this example, street sweeping pollutant “reduction” is always less than or equal to raw pollutant “recovery” and accounts for the effectiveness of other pollutant removal that occurs as runoff flows through downstream waterbodies prior to reaching the receiving waterbody. To calculate the cumulative impact of all BMPs within the Arrowhead and Indianhead Lake watersheds, the cumulative pollutant reduction from each subwatershed was evaluated using the P8 water quality models for each area. Figure 6-2 shows the estimated cumulative TP reduction for each subwatershed in the Arrowhead and Indianhead Lake watersheds due to existing BMPs, wetlands, or ponds. In "untreated" areas, street sweeping pollutant "recovery" is assumed to be equivalent to "reduction," as there is limited or no downstream treatment prior to discharge to the lake in these areas.

The data sources described above were used to develop a GISWQM spanning the Arrowhead and Indianhead Lake watersheds. Annual pollutant loading, street sweeping recovery, and street sweeping reduction were evaluated for existing sweeping operations. The results of this analysis are summarized in the following section.

6.1.2 Existing Street Sweeping Performance

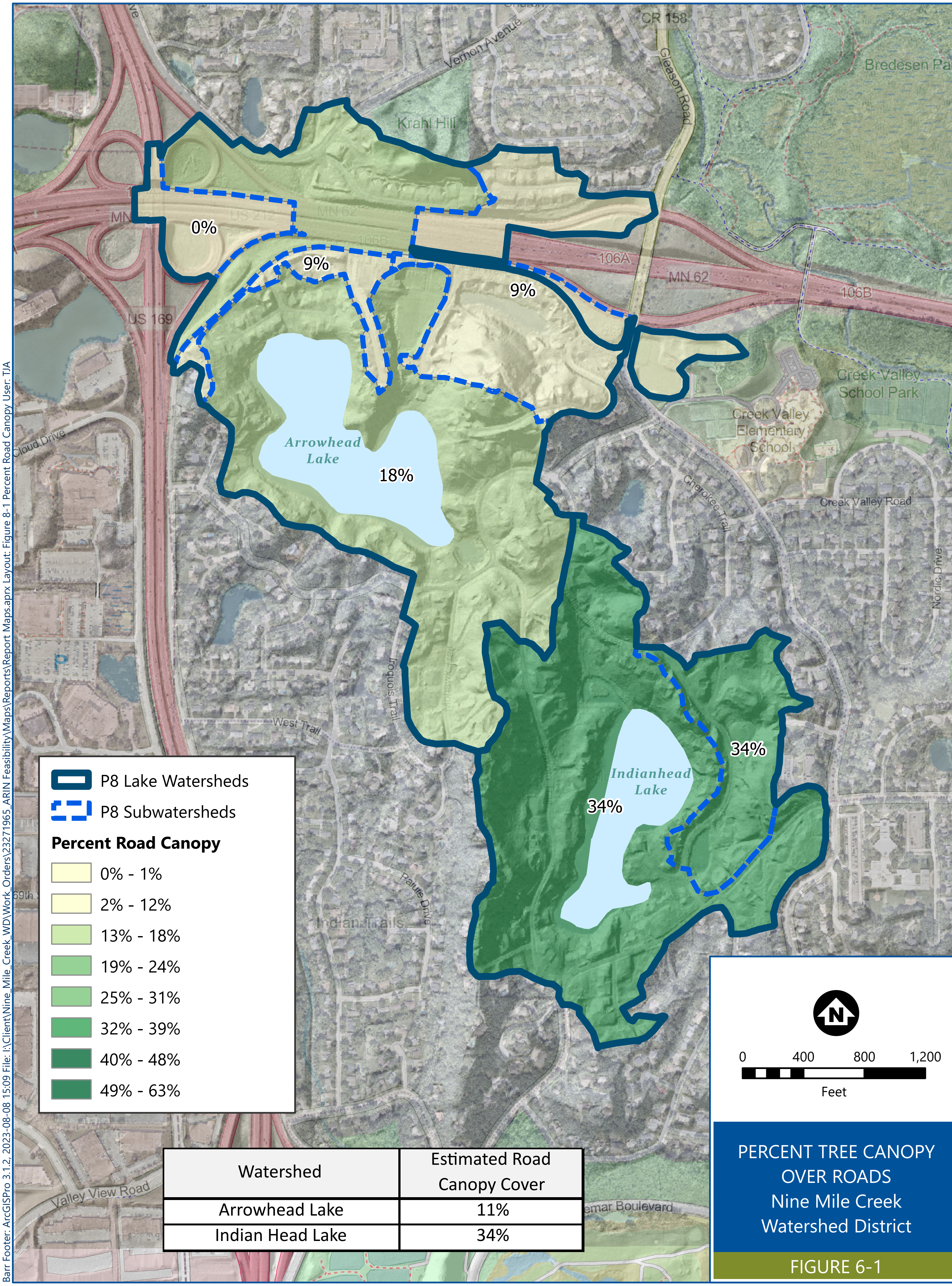
As discussed in Section 6.1, the City of Edina currently performs two city-wide street sweeping operations per year as their baseline condition: one in the spring, following snowmelt, and one in the fall. Existing street sweeping operations were evaluated using the GISWQM. Table 6-1 provides estimated street sweeping "recovery" and "reduction" for this sweeping, as calculated by the GISWQM.

Table 6-1 Estimated annual phosphorus removal from street sweeping under existing conditions

		GISWQM: Street Sweeping Performance Summary			
Watershed	**Annual Phosphorus Loading (lbs/yr)**	**Annual Phosphorus Recovery [1] (lbs/yr)**	**% Annual Phosphorus Recovery (%)**	**Effective Phosphorus Reduction [1] (lbs/yr)**	**% Effective Phosphorus Reduction (%)**
Arrowhead	90	6.4	7%	4.9	5%
Indianhead	30	4.1	14%	3.5	12%
TOTAL:	120	10	9%	8	7%

[1] Total phosphorus street sweeping "recovery" and "reduction" as defined in Section 6.1.1.

As shown in Table 6-1, under current operations, street sweeping results in approximately 7 to 14% raw TP recovery in each watershed, which equates to 5 to 12% effective TP reduction in each area. As noted in Section 6.1.1, reduction and recovery estimates shown above are estimated as a function of curb length swept, street sweeping frequency, and canopy cover (Kalinosky, Baker, & Hobbie, 2014), as well as total phosphorus removals predicted by P8 models for downstream waterbodies. It is recommended that the phosphorus recovery estimates shown in Table 6-1 be verified using other methods of estimating street sweeping performance, including weight-based estimates as described in Section 6.2.3.

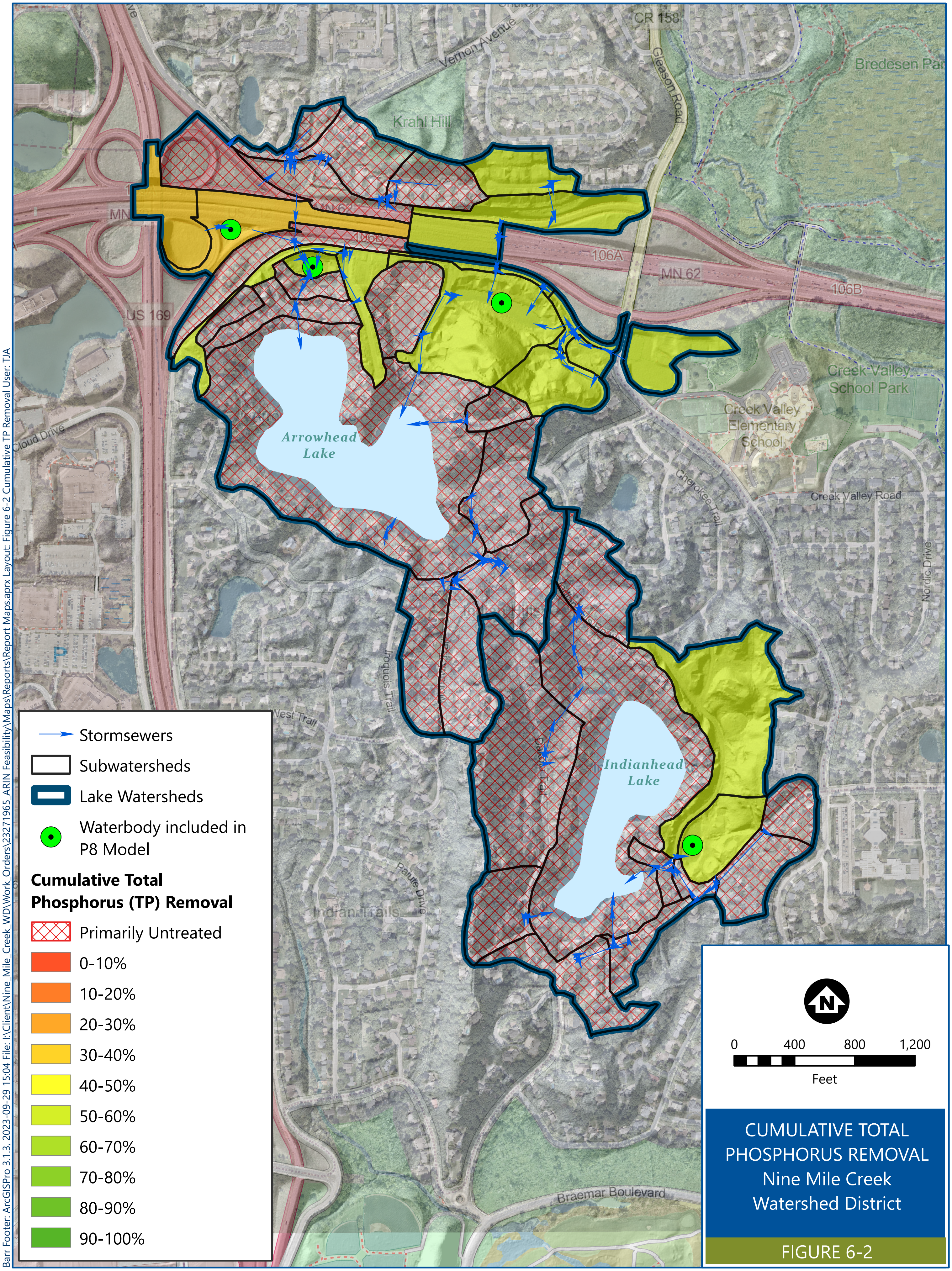


Watershed	Estimated Road Canopy Cover
Arrowhead Lake	11%
Indian Head Lake	34%

PERCENT TREE CANOPY OVER ROADS
Nine Mile Creek Watershed District

FIGURE 6-1

Barr Footer: ArcGISPro 3.1.2, 2023-08-08 15:09 File: I:\Client\Nine_Mile_Creek_WD\Work_Orders\23271965_ARIN Feasibility\Maps\Reports\Report Maps.aprx Layout: Figure 8-1 Percent Road Canopy User: TJA



CUMULATIVE TOTAL PHOSPHORUS REMOVAL
Nine Mile Creek Watershed District

FIGURE 6-2

6.2 Enhanced Street Sweeping Evaluation

"Enhanced" street sweeping alternatives beyond the current baseline practice of two annual city-wide sweeping operations were evaluated. The following subsections outline (a) the seasonal effectiveness of street sweeping operations, (b) a high-level cost-benefit analysis for additional street sweeping operations, and (c) considerations related to implementation and tracking of enhanced street sweeping efforts.

6.2.1 Seasonal Street Sweeping Evaluation

Table 6-2 through Table 6-4 provide a summary of seasonal street-sweeping effectiveness as evaluated using street-sweeping regression equations (Kalinosky, Baker, & Hobbie, 2014) within the GISWQM. The results for one spring sweeping plus one fall sweeping estimate the performance of the City's existing street sweeping operation, while the results of subsequent sweepings per season show the potential pollutant recovery and reduction of enhanced street sweeping operations. While results reported in Table 6-2 through Table 6-4 are cumulative for a given season, results between seasons (e.g., spring, summer, and fall) are not cumulative. For this reason, results for a given annual street sweeping scenario (e.g., two spring sweepings, one summer sweeping, three fall sweepings) can be calculated by summing the recovery/reduction values from the tables below (e.g., for Arrowhead Lake, the estimated recovery for the scenario described would be 3.6 lbs/spring + 1.6 lbs/summer + 7.6 lbs/fall) = 12.8 lbs TP recovery/year). Results of this analysis show that estimated phosphorus removals from street sweeping are highest in the fall, followed by the spring and then summer months. The amount of overall phosphorus removed increases with the number of sweepings; however, the marginal benefit achieved decreases with each additional sweeping (Figure 6-3).

Table 6-2 Estimated annual phosphorus removal from seasonal street sweeping: Arrowhead Lake

Season	Sweepings per Season (#)	Annual Phosphorus Loading, Recovery, and Reduction				
		Annual Loading (lbs/yr)	Cumulative Recovery (lbs/yr) [1]	Cumulative Recovery (%)	Effective Reduction (lbs/yr) [1]	Effective Reduction (%)
Spring	1	90	2.3	3%	1.8	2%
	2		3.6	4%	2.8	3%
	3		4.3	5%	3.3	4%
	4		4.5	5%	3.4	4%
Summer	1		1.6	2%	1.2	1%
	2		2.6	3%	2.0	2%
	3		3.0	3%	2.3	3%
	4		3.2	4%	2.4	3%
Fall	1		4.1	5%	3.1	4%
	2		6.5	7%	4.9	6%
	3		7.6	9%	5.8	7%
	4		8.0	9%	6.1	7%

[1] Total phosphorus street sweeping "recovery" and "reduction" as defined in Section 6.1.1.

Table 6-3 Estimated annual phosphorus removal from seasonal street sweeping: Indianhead Lake

Season	Sweepings per Season (#)	Annual Phosphorus Loading, Recovery, and Reduction				
		Annual Loading (lbs/yr)	Cumulative Recovery (lbs/yr) [1]	Cumulative Recovery (%)	Effective Reduction (lbs/yr) [1]	Effective Reduction (%)
Spring	1	30	1.5	5%	1.3	4%
	2		2.3	8%	2.0	7%
	3		2.7	9%	2.3	8%
	4		2.9	10%	2.5	8%
Summer	1		1.0	4%	0.9	3%
	2		1.6	6%	1.4	5%
	3		1.9	7%	1.7	6%
	4		2.0	7%	1.7	6%
Fall	1		2.6	9%	2.2	8%
	2		4.1	14%	3.5	12%
	3		4.9	16%	4.2	14%
	4		5.1	17%	4.4	15%

[1] Total phosphorus street sweeping "recovery" and "reduction" as defined in Section 6.1.1.

Table 6-4 Estimated annual phosphorus removal from seasonal street sweeping: Arrowhead Lake and Indianhead Lake combined

Season	Sweepings per Season (#)	Annual Phosphorus Loading, Recovery, and Reduction				
		Annual Loading (lbs/yr)	Cumulative Recovery (lbs/yr) [1]	Cumulative Recovery (%)	Effective Reduction (lbs/yr) [1]	Effective Reduction (%)
Spring	1	120	3.8	3%	3.0	3%
	2		6.0	5%	4.8	4%
	3		7.0	6%	5.6	5%
	4		7.4	6%	5.9	5%
Summer	1		2.7	2%	2.1	2%
	2		4.2	4%	3.4	3%
	3		5.0	4%	4.0	3%
	4		5.2	4%	4.2	4%
Fall	1		6.7	6%	5.4	5%
	2		10.6	9%	8.5	7%
	3		12.5	10%	10.0	8%
	4		13.1	11%	10.5	9%

[1] Total phosphorus street sweeping "recovery" and "reduction" as defined in Section 6.1.1.

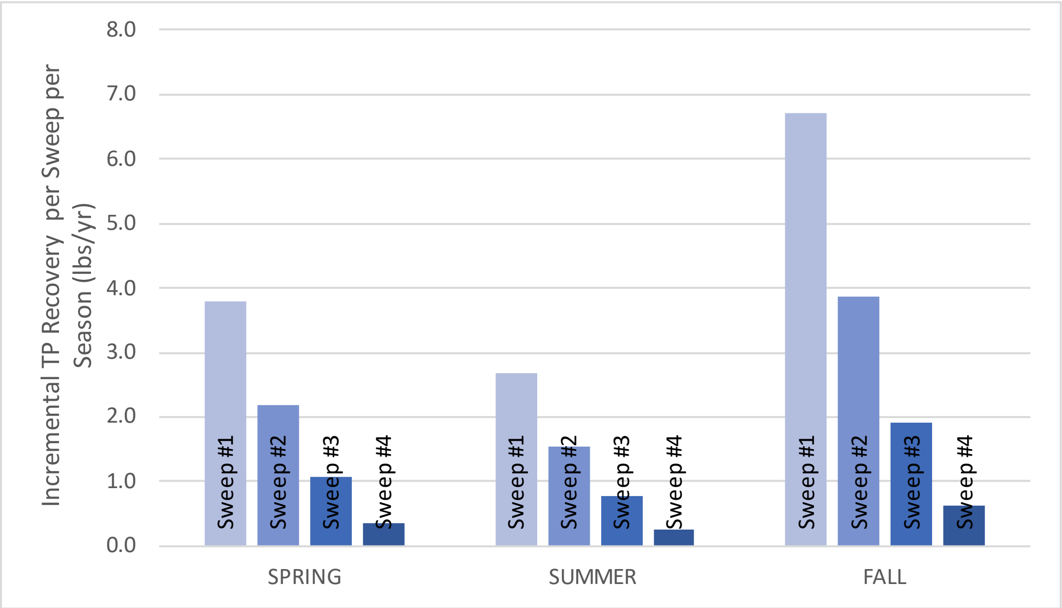


Figure 6-3 Incremental seasonal street sweeping recovery per season

6.2.2 Cost-Benefit Analysis

For the purposes of generating a cost-benefit analysis for "enhanced" street sweeping operations within the Arrowhead and Indianhead Lake watersheds, it is assumed that additional sweeping efforts will be completed utilizing City of Edina street sweeping equipment and operators. Cost estimates originally developed for the 2015 Edina Street Sweeping Management Plan (EOR, 2015) were reviewed and adapted (i.e., adjusted for inflation) for use in this study. Cost estimates presented in the 2015 study were for sweeping operations conducted by the City, and ranged from $56.50 ($74 2023 dollars) per curb mile for "baseline" (existing condition sweeping) to $34 ($44 2023 dollars) per curb-mile for monthly sweeping.

In addition to cost estimates generated for the City of Edina to complete street sweeping with their equipment and operators, a cost estimate for contracted street sweeping was also calculated. A recently completed survey of cities within the Ramsey-Washington Metro Watershed District (Barr, 2023) found the average cost for contracted sweeping to be approximately $150 per curb mile. Table 6-5 provides a summary of curb miles assumed to be swept and the estimated total cost to perform up to four sweeping operations within the Arrowhead and Indianhead Lake watersheds.

Table 6-5 Seasonal street sweeping cost estimate for contracted sweeping

Number of Seasonal Sweeps (#)	Curb-Miles Swept (miles)	Total Annual Cost for City Crews ($)[1]	Cost-Efficiency for City Crews ($/lane-mile) [1]	Contracted Total Cost ($/lane-mile) [2]	Contracted Cost-Efficiency ($/lane-mile) [2]
1	14.9	$1,092	$73	$2,234	$150
2	29.8	$1,750	$59	$4,469	
3	44.7	$2,407	$54	$6,703	
4	59.6	$3,064	$51	$8,937	

1 Determined from assumptions outlined in the 2015 Street Sweeping Management Plan (EOR, 2015).

2 Average contracted sweeping cost from cities in RWMWD (Barr, 2023).

Table 6-6 provides a cost estimate and cost-benefit summary for seasonal street sweeping operations conducted in the Arrowhead and Indianhead Lake watersheds corresponding to the alternatives discussed in Section 6.2.1. Costs estimated in Table 6-7 assume the City of Edina would complete additional sweeping operations using their existing equipment and staff.

Table 6-6 Cost-benefit of total phosphorus (TP) removal for seasonal street sweeping alternatives

Season	Sweepings per Season (#)	TP Recovery (lbs/yr)	TP Reduction (lbs/yr)	Cost-Benefit: Edina Street Sweeping [1]	
				TP Recovery Efficiency ($/lb/yr)	TP Reduction Efficiency ($/lb/yr)
Spring	1	3.8	3.0	$289	$361
	2	6.0	4.8	$294	$367
	3	7.0	5.6	$342	$428
	4	7.4	5.9	$415	$519
Summer	1	2.7	2.1	$408	$510
	2	4.2	3.4	$415	$519
	3	5.0	4.0	$483	$604
	4	5.2	4.2	$586	$732
Fall	1	6.7	5.4	$163	$203
	2	10.6	8.5	$165	$207
	3	12.5	10.0	$193	$241
	4	13.1	10.5	$234	$292

1 Costs in the table are based on the 2015 Edina Street Sweeping Management Plan and assume City of Edina equipment and operators will be used to conduct sweeping operations.

Based on the results highlighted in Table 6-6, street sweeping conducted in the fall is the most cost-effective for the removal of TP, followed by spring and summer sweepings. Cost-benefit values for TP recovery range from approximately $160 to $590 per pound of TP, while cost-benefit values for TP reduction (i.e., TP prevented from reaching Arrowhead and Indianhead Lakes) vary from $200 to $730 per pound of TP.

6.2.3 Implementation Considerations

Results of the enhanced street sweeping analyses indicate that the phosphorus removal from street sweeping varies by season and by the number of sweepings. The greatest phosphorus removal occurs from fall sweepings, followed by spring and then summer. The number of sweepings per season increases the overall phosphorus removal achieved; however, the marginal benefit decreases with each additional sweeping. The conclusions of the analysis suggest that an enhanced street sweeping program should prioritize additional fall sweepings, followed by additional spring sweepings. One or two sweeping events in the summer could also be considered. Summer season sweepings could be timed following the release of summer flowering material and seeds (e.g., maple seeds) to maximize effectiveness, and fall sweeping should be timed with leaf drop to the extent practicable.

The analysis presented in this study demonstrates that street sweeping, and in particular fall street sweeping, is cost-efficient in terms of dollars spent per pound of phosphorus removed compared to common, structural BMPs. While cost-effectiveness for stormwater management practices can vary widely depending on a variety of factors, the estimated annualized costs per pound of phosphorus removal from seasonal street sweeping alternatives shown in Table 6-7 are below the costs for many common structural stormwater management practices, which can range up to $14,000 or more per pound of total phosphorus per year (RWMWD, 2018). However, it is important to note that structural BMPs generally provide more consistent pollutant removal throughout spring through fall, so it is difficult to directly compare the cost-effectiveness with street sweeping.

As discussed, the effectiveness of street sweeping in reducing phosphorus loading to downstream lakes will vary depending on other treatment (sedimentation) that occurs in downstream ponds or wetlands prior to reaching the lake. Enhanced sweeping should prioritize additional sweeping efforts in the "untreated" portions of the watershed first (i.e., areas that are not treated by water quality BMPs or other waterbodies prior to discharge to the lakes) if the capacity for enhanced sweeping is limited.

The following list provides additional recommendations regarding estimating and tracking the effectiveness of an enhanced street-sweeping program:

- Consider the collection of swept material weight during sweeping operations. This can be used to track the effectiveness of operations and can be utilized to produce estimates of pollutant reduction. If it is not feasible to collect weights for every hopper load, consider developing an estimate of material weight for a typical load and using that to perform estimates (e.g., determine the average weight of a full hopper and use this value to estimate collected material weights per load).
- If weights are collected, consider evaluating associated pollutant reduction as estimated using the MPCA's Street Sweeping Phosphorus Calculator. This calculator estimates the total phosphorus recovery associated with the wet or dry weight of swept material collected.
- Consider performing a validation effort between the MPCA's weight-based calculator, the GISWQM calculator, and observed results from the 2020 enhanced street sweeping study to determine if a relationship/correlation could be developed to improve calculator estimates.

7 Conclusion and Recommendations

In 2022, the NMCWD completed a water quality study of Arrowhead and Indianhead Lakes in Edina to assess and prescribe management activities to improve water quality within these lakes. The study recommended further consideration of potential watershed and in-lake management activities. This report summarizes a feasibility analysis and evaluation of the following management activities, which were included within those recommendations:

- A combined aluminum (sodium aluminate) and iron (ferric chloride) treatment in Arrowhead Lake.
- Evaluation of the existing lake aeration system within Arrowhead Lake to support the sediment treatment.
- A combined aluminum (sodium aluminate) and iron (ferric chloride) treatment in Indianhead Lake.
- Evaluation of the existing lake aeration system within Indianhead Lake to support the sediment treatment.
- Enhanced street sweeping within the watersheds draining to Arrowhead and Indianhead Lakes.

As a result of this study, the following recommendations were developed:

- A combined aluminum (sodium aluminate) and iron (ferric chloride) treatment is recommended for Arrowhead Lake in conjunction with an upgrade to the existing lake aeration system. The estimated treatment area within the lake is 20.6 acres.
  - It is recommended that the Arrowhead Lake ferric chloride and sodium aluminate treatment be split into two doses, with the first dose to be performed in the spring of 2024 and the second in spring of 2026. Water quality monitoring of chloride concentrations within the lake are recommended for 2025 to confirm concentrations are low enough for the second treatment to proceed in 2026.
  - Replacement of the existing forced-air aeration system is recommended as part of the Arrowhead Lake treatment plan. It is recommended that the cabinet and compressor pumps for this system be placed at the same location as the existing system, on the south side of Arrowhead Lake.
  - The planning-level estimated costs of the ferric chloride and sodium aluminate treatment and aeration system in Arrowhead Lake are shown in Table 7-1. The estimated cost-benefit of the combined activities is approximately $1,500 per pound of TP reduction.
  - Since the application of iron and aluminum is a new sediment treatment technique for the NMCWD, more comprehensive monitoring and assessment of the Arrowhead Lake in-lake treatment is recommended. The recommended monitoring program includes follow-up sediment coring at 2 years, 4 years, and 10 years after treatment; lake water monitoring at years 2, 4, and 5-10 (the frequency of lake water monitoring within years 5-10 would be determined as part of a year 5 comprehensive review of results); and a

comprehensive review of monitoring results at years 5 and 10 to evaluate the potential need for retreatment.

- A combined aluminum (sodium aluminate) and iron (ferric chloride) treatment is also recommended for Indianhead Lake. The estimated treatment area within the lake is 10.7 acres. The City of Edina and NMCWD have indicated a desire to upgrade the existing Indianhead Lake aeration system in combination with the sediment treatment.
    - It is recommended that the Indianhead Lake ferric chloride and sodium aluminate treatment be performed in the spring of 2024.
    - Replacement of the existing forced-air aeration system is included as part of the Indianhead Lake treatment plan. It is recommended that the cabinet and compressor pumps for this system be placed at the same location as the existing system, on the north side of Indianhead Lake.
    - The planning-level estimated costs of the ferric chloride and sodium aluminate treatment and aeration system in Indianhead Lake are shown in Table 7-1. The estimated cost-benefit of the combined activities is approximately $1000 per pound of TP reduction.
    - Since the application of iron and aluminum is a new sediment treatment technique for the NMCWD, more comprehensive monitoring and assessment of the Indianhead Lake in-lake treatment is recommended. The recommended monitoring program includes follow-up sediment coring at 2 years, 5 years, and 10 years after treatment; lake water monitoring at years 2, 4, and 5-10 (the frequency of lake water monitoring within years 5-10 would be determined as part of a year 5 comprehensive review of results); and a comprehensive review of monitoring results at years 5 and 10 to evaluate the potential need for retreatment.
- Results of the enhanced street sweeping analyses indicate that the phosphorus removal achieved from street sweeping varies by season and by the number of sweepings. Conclusions from the analysis suggest that an enhanced street sweeping program within the Arrowhead and Indianhead Lake subwatersheds should prioritize additional fall and then spring sweepings first. One or two sweeping events in the summer could also be considered. Summer season sweepings could be timed following the release of summer flowering material and seeds (e.g., maple seeds) to maximize effectiveness, and fall sweeping should be timed with leaf drop to the extent practicable.
    - It is recommended that the City of Edina and NMCWD continue discussions on the additional amount and prioritization of areas for enhanced street sweeping within the Arrowhead and Indianhead Lake subwatersheds that may be best, taking into account water quality improvement goals for each of these waterbodies in addition to considerations for operational constraints.

Table 7-1 Summary of planning-level costs for recommended capital improvement projects

Management Activity	Planning-level Cost Estimate[1]	Notes
Arrowhead Lake Aluminum + Iron Treatment	$182,000 ($146,000-$237,000)	Cost for 2 treatments to be conducted in Years 1 and 3.
Arrowhead Lake Aeration	$89,000 ($72,000-$116,000)	Assuming the aeration compressor location is unchanged from existing.
Indianhead Lake Aluminum + Iron Treatment	$122,000 ($98,000-$159,000)	Single treatment.
Indianhead Lake Aeration	$95,000 ($76,000-$124,000)	Assuming the aeration compressor location is unchanged from existing.

[1] Cost reflects an accuracy range between -20% and +30% of the estimated project cost.

References

Minnesota Pollution Control Agency. (n.d.). *Lake Protection and Management*. Retrieved from Minnesota Pollution Control Agency: https://www.pca.state.mn.us/business-with-us/lake-protection-and-management#:~:text=MPCA%20guidelines%20for%20alum%20application,documented%20in%20soft%20water%20lakes

MN DNR, 2012. Shallow Lake Management Report to the 2012 Minnesota Legislature. Submitted January 9, 2012 by the Minnesota Department of Natural Resources

WSB, 2022a. Arrowhead Fisheries Survey, Edina, MN. September, 2022. Memorandum from Jordan Wein to Jessica Vanderwerff Wilson.

WSB, 2022b. Indianhead Fishery Survey and Dissolved Oxygen Profiles Edina, MN. August, 2022. Memorandum from Jordan Wein to Jessica Vanderwerff Wilson.

Appendix A

Engineer's Opinion of Estimated Costs

Arrowhead and Indianhead Lake Water Quality Improvement Project

ENGINEERS OPINION OF COST

ARROWHEAD LAKE SEDIMENT TREATMENT				
ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	COST
Sodium Aluminate Sediment Treatment	gallons	2,955	$ 11.0	$ 33,000
Iron Sediment Treatment	gallons	6,935	$ 12.0	$ 83,000
			Construction Subtotal	$ 116,000
			Total With Contingency (20%)	$ 140,000
			Engineerng/Design (30%)	$ 42,000
			Total	$ 182,000
			-20%	$ 146,000
			+30%	$ 237,000

Assumptions

- 2,955 gallons sodium aluminate
- 6,935 gallons of ferric chloride
- Engineering assistance with bid administration and contract documents
- Two engineering staff members to observe application and perform pH monitoring
- Estimated total cost is reported to the nearest thousand dollars

Arrowhead and Indianhead Lake Water Quality Improvement Project
ENGINEERS OPINION OF COST

ARROWHEAD LAKE FORCED AIR AERATION (EXISTING LOCATION)				
ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	COST
Aerator Equipment	LS	1	$ 16,000	$ 16,000
Aerator Installation (Electrical/Gravel Base/Materials/Placement in Lake)	LS	1	$ 35,000	$ 35,000
Shelter	LS	1	$ 6,000	$ 6,000
			Construction Subtotal	$ 57,000
			Total With Contingency (20%)	$ 68,000
			Engineerng/Design (30%)	$ 20,400
			Total	***$ 89,000***
			-20%	$ 72,000
			30%	$ 116,000

Assumptions
- Engineering assistance with bid administration and contract documents

- Aerator installation includes:
*Mobilization of equipment to and from the site
*Construct cedar shelter on 6” of class 5 aggregate base
*Electrical install from existing facility
*Install ~350 LF (two runs) of 1” SDR 11 HDPE pipe from shelter to manifold
*Placement of aerator line and heads in lake.

- Aerator equipment includes:
*Hydro Logic Products AirLift 10 HighFlow aeration system (220V/single phase).
*Lockable powder coated steel enclosure
*2, 1 HP dual piston air compressors with 15 CFM capacity
*2 high volume cooling fans
*10 AirPod air diffusers
*Hydro Logic Products DownUnder weighted air supply tubing-5/8 inch, 4,000 ft total length.

- Assuming Class 4 opinion of cost with accuracy range of -20% to +30% standards established by the Association for the Advancement of Cost Engineering (AACE).
- Estimated total cost is reported to the nearest thousand dollars.

Arrowhead and Indianhead Lake Water Quality Improvement Project
ENGINEERS OPINION OF COST

ARROWHEAD LAKE FORCED AIR AERATION (ALTERNATIVE LOCATION)				
ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	COST
Aerator Equipment	LS	1	$ 16,000	$ 16,000
Aerator Installation (Electrical/Concrete Pad/Materials/Placement in Lake)	LS	1	$ 45,000	$ 45,000
Road Repair	LS	1	$ 7,500	$ 7,500
			Construction Subtotal	$ 69,000
			Total With Contingency (20%)	$ 76,000
			Engineerng/Design (30%)	$ 23,000
			Total	***$ 99,000***
			-20%	$ 80,000
			30%	$ 129,000

Assumptions

- Engineering assistance with bid administration and contract documents

- Aerator installation includes:

*Mobilization of equipment to and from the site
*Install 6” of class 5 aggregate base for concrete pad
*Prep area and install new 4’ wide by 4’ long by 6” deep concrete pad
*Electrical install from existing facility on other side of Indian Hills Road
*Asphalt road repair (5' by 25').
*Install ~350 LF (two runs) of 1” SDR 11 HDPE pipe from new concrete pad to manifold
*Placement of aerator line and heads in lake.

- Aerator equipment includes:

*Hydro Logic Products AirLift 10 HighFlow aeration system (220V/single phase).
*Lockable powder coated steel enclosure
*2, 1 HP dual piston air compressors with 15 CFM capacity
*2 high volume cooling fans
*10 AirPod air diffusers
*Hydro Logic Products DownUnder weighted air supply tubing-5/8 inch, 4,000 ft total length.

- Assuming Class 4 opinion of cost with accuracy range of -20% to +30% standards established by the Association for the Advancement of Cost Engineering (AACE).
- Estimated total cost is reported to the nearest thousand dollars.

Arrowhead and Indianhead Lake Water Quality Improvement Project

ENGINEERS OPINION OF COST

INDIANHEAD LAKE SEDIMENT TREATMENT				
ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	COST
Sodium Aluminate Sediment Treatment	gallons	1692	$ 13.0	$ 22,000
Ferric Chloride Sediment Treatment	gallons	3972	$ 14.0	$ 56,000
			Subtotal	$ 78,000
			Total With Contingency (20%)	$ 94,000
			Engineerng/Design (30%)	$ 28,000
			Construction Total	$ 122,000
			Construction Total -20%	$ 98,000
			Construction Total +30%	$ 159,000

Assumptions

- 1,692 gallons of sodium aluminate
- 3,972 gallons of ferric chloride
- Engineering assistance with bid administration and contract documents
- Two engineering staff members to observe alum application and perform pH monitoring.
- Estimated total cost is reported to the nearest thousand dollars

Arrowhead and Indianhead Lake Water Quality Improvement Project

ENGINEERS OPINION OF COST

INDIANHEAD LAKE FORCED AIR AERATION				
ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT COST	COST
Aerator Equipment	LS	1	$ 16,000	$ 16,000.00
Aerator Installation (Electrical/Concrete Base/Materials/Placement in Lake)	LS	1	$ 45,000	$ 45,000.00
			Construction Subtotal	$ 61,000.00
			Total With Contingency (20%)	$ 73,000.00
			Enginering / Design (30%)	$ 22,000.00
			Total	***$ 95,000.00***
			-20%	$ 76,000.00
			30%	$ 124,000.00

Assumptions

- Engineering assistance with bid administration and contract documents

- Aerator installation includes:

*Mobilization of equipment to and from the site

*Install 6” of class 5 aggregate base for concrete pad

*Prep area and install new 4’ wide by 4’ long by 6” deep concrete pad

*Electrical install from existing facility

*Install ~350 LF (two runs) of 1” SDR 11 HDPE pipe from new concrete pad to manifold

*Placement of aerator line and heads in lake.

- Aerator equipment includes:

*Hydro Logic Products AirLift 10 HighFlow aeration system (220V/single phase).

*Lockable powder coated steel enclosure

*2, 1 HP dual piston air compressors wit 15 CFM capacity

*2 high volume cooling fans

*10 AirPod air diffusers

*Hydro Logic Products DownUnder weighted air supply tubing-5/8 inch, 4,000 ft total length.

- Assuming Class 4 opinion of cost with accuracy range of -20% to +30% standards established by the Association for the Advancement of Cost Engineering (AACE).

- Estimated total cost is reported to the nearest thousand dollars.

Appendix B

Aeration System Specifications

Hydro Logic Products

Pond & Lake Aeration plus Aquatic Products

AirLift 10 HF Aeration System
by **Hydro Logic Products**

X 10 = 10 AirPod Diffusers

HighFlow™ Large Lake Series

AirLift 10 HighFlow™

SPECIFICATIONS

Large Lake AirLift™ Aeration Benefits:

- **Increase Dissolved Oxygen Concentrations**
- **Eliminate Stress to Fish & Aquatic Organisms**
- **Increase Water Clarity (Transparency)**
- **Reduce Algal Blooms (Algae)**
- **Reduce High Metal Concentrations**
- **Reduce Nutrient Releases by Anoxic Sediments**
- **Reduce Buildup of Poisonous Gases**
- **Reduce Release of Noxious Odors**
- **Reduce the Accumulation of Sediments**
- **May Reduce Nuisance Levels of Aquatic Plants**
- **No Electricity in the Water**
- **Warranties on all System Components**

Hydro Logic Products® AirLift 10 HighFlow™ large lake aeration systems are designed and built to cost effectively mix and aerate lakes. Our systems use billions of micron sized bubbles to improve pond and lake water quality. Our **AirLift 10 HighFlow™** aeration system can aerate ponds and lakes up to 22^+ acres in size depending on air diffuser placement, nutrient concentrations, biological oxygen demand (BOD), water depth and other physical characteristics of the waterbody.

Our **AirLift 10 HighFlow™** aeration system is powered by two (2) 1 H.P. energy efficient, dual piston air compressors equipped with our proprietary **SureStart™** technology. Our dual piston air compressors, which can deliver air under high pressures (water depths over 50 feet), operate very quietly (55 decibels at 2 meters or 6 feet). In comparison, the noise levels of our air compressors are about 15 decibels less than equivalent rotary vane air compressors.

Our **AirLift 10 HighFlow™** aeration system contains ten **(10)** **AirPod™** air diffusers. Each AirPod™ contains a self-cleaning 20-inch tube, EPDM flexible membrane air diffuser equipped with a **triple check valve** system. Our air diffusers are constructed to withstand total airflow from the compressor without damaging the EPDM membranes (unlike EPDM disc air diffusers). The base of the AirPod™ provides a large surface area between the EPDM membrane and the sediments, thereby preventing sediment disturbance during system operation. The AirPods are extremely easy to install. Simply fill the two ballast tubes with pea gravel or sand prior to their placement in the pond or lake.

Compressed air from our dual piston compressors are delivered to the AirPods using our **DownUnder™** self-weighted tubing. DownUnder™ air supply tubing is constructed of a flexible PVC composite and is kink proof and puncture resistant. Our easy to install tubing comes in several different lengths and diameters to meet your installation needs.

P.O. Box 605 Doylestown, PA 18901- 0605
Phone: 215.230.9325 • • • Fax: 215.230.9326 • • • www.HydroLogicProducts.com

COMPRESSORS **(Drawing on Page 4)**

- **Two (2) one (1) HP dual piston air compressors with integral thermal motor overload protection**
- **Produce high airflow volumes (15 cfm combined) & operate under high pressures (45 psi max.)**
- **Oil-less air compressors that are virtually maintenance free**
- **SureStart™ technology allows air compressors to restart under pressure after power outages**
- **High air pressure allows diffusers to be cleaned in ponds or lakes (unlike rotary vane compressors)**
- **U.L. listed 240 volt (8.2 amps combined) under full load**
- **5-micron air filters maximize air compressor life expectancy**
- **Easy field repairs - plumbing connections with push-on style fittings & flexible 100 psi tubing**
- **Noise reduction - mounted on cylindrical vibration pads & connected to flexible tubing**
- **Extremely quiet operation (55 decibels @ 2 meters or 6 feet @ 20 psi)**
- **Two-year warranty (best in the industry)**

All of our dual piston air compressors are outfitted with our proprietary **SureStart™** technology. This allows automatic restart of our air compressors under full pressure during any power outage (blackouts or brownouts) without damaging the air compressor motors. Each air compressor is oil-less, thermally protected and requires no lubrication. All air compressors include rotors/stators manufactured with the most advanced magnetic materials, sealed heavy-duty precision bearings and starting capacitors. The only required routine maintenance of our air compressors is periodically changing the 5-micron air filters. Our air compressors typically can operate approximately 3 years or more before any decline in performance is observed. This is 2 to 3 times better performance over standard piston, diaphragm and rotary vane compressors. Thereafter, our air compressors can be easily serviced by replacing the piston seals. Airflow versus pressure performance curves for our dual piston compressor varies less than for diaphragm and rotary vane compressors. This simply means that our dual piston compressors provide more air while using less energy. Lastly, our dual piston air compressors can operate under high pressures, thereby allowing the air diffuser membranes to be easily cleaned without pulling the AirPods from the pond or lake.

CABINET **(Drawing on Page 4)**

- **Commercial grade, 14-gauge steel cabinet that is rustproof & vandal resistant**
- **Powder coated, forest green finish to blend into its surroundings**
- **Easy access design with lock & key for added security**
- **6½ foot 3 prong plug for easy connection to standard 2-pole 3 wire 15A/20A electrical outlet**
- **Electrical circuits are Class "A" GFCI protected with a trip 4-6mA trip rating**
- **Ball bearing fan-cooled to maximize life of air compressors**
- **SuperCool™ dual cooling fans (470 cfm) included to further improve air compressor longevity**
- **Manifold equipped with sealed valves to precisely control the airflow to AirPod diffusers**
- **Heavy duty (24"L x 24"W x 2"H) HDPE mounting pad included**
- **Overall dimensions (24"L x 24"W x 24.6"H)**
- **Five-year warranty (best in industry)**

The commercial-grade cabinet is constructed of 14-gauge steel with forest green electro-statically bonded powder coating. The cabinet is manufactured with a stamped ventilation intake grill and low resistance exhaust plenum (duct work). The cabinet comes equipped with sealed ball bearing cooling fan to maximize air compressor life and Class “A” GFCI Protection on all circuits. All cabinet components are easily disassembled using standard household tools. The cabinet includes a 5-year warranty against rust and corrosion and a 2-year warranty on all components mounted inside of the cabinet.

AirPod™ Air DIFFUSERS **(Drawing on Page 4)**

- **Ten (10) AirPods each equipped with single flexible, fine pore EPDM rubber membrane tube diffuser**
- **More durable than air stone, porous media & EPDM disc diffusers**
- **Produces extremely fine air bubbles (500 – 1,000 micron or 0.020 - 0.040 inch)**
- **Triple check valves prevent water & sediment from entering the air supply lines**
- **One EPDM tube diffuser is 20% larger than two 9-inch EPDM disc diffusers**
- **Self-cleaning & very low maintenance**
- **Large HDPE base (20”L x 15”W) to prevent sediment disturbance**
- **All AirPod components are corrosion resistant using PVC, fiberglass & HDPE materials**
- **Five-year warranty (best in the industry)**

Each **AirPod™** air diffuser contains a self-cleaning 20-inch, EPDM flexible membrane tube diffuser equipped with a **triple check valve system**. The triple check valves prevent water and sediment from flowing back into the air supply lines during system shut down. The EPDM tube air diffuser is mounted to heavy-duty PVC strut with ratcheting tie downs to provide easy assembly/disassembly. The above components are secured to a large HDPE base. Two hollow ballast tubes are anchored beneath the base. The ballasts tubes are designed so that pea gravel or sand can be easily added to these tubes during installation.

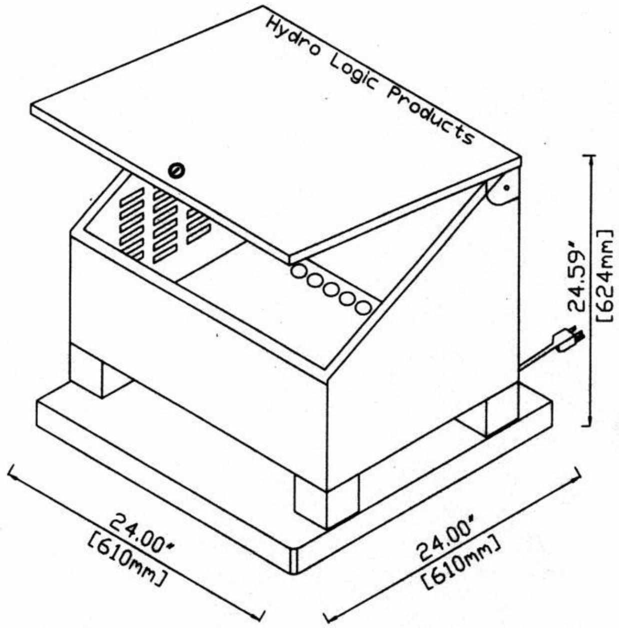
DownUnder™ SELF-WEIGHTED AIR SUPPLY TUBING **(Drawing on Page 4)**

- **Over-sized 0.58 inch I.D. for low-pressure drop applications***
- **Heavy-duty wall thickness for durability**
- **Self-weighted for easy installation**
- **Kink proof & puncture resistant**
- **Available in 100 ft. (boxed) & both 200 & 500 ft. (rolls) lengths**
- **10-year warranty (best in the industry)**

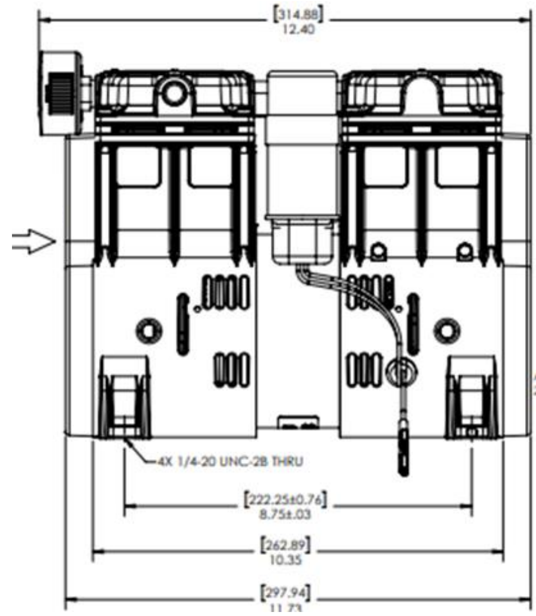
***** DownUnder™ air supply tubing is also available in 0.375 in. I.D. for smaller pond and lake applications

DownUnder™ air supply tubing is constructed of a flexible PVC composite and is self-weighted in order to firmly remain along the pond or lake bottom after the installation. Sections of DownUnder™ tubing are connected together using standard PVC solvent weld cement and ½ inch insert fittings. DownUnder™ air supply tubing has low friction walls for maximizing airflow rates and minimizing air pressure drops. Our DownUnder™ tubing is designed to reduce the overall system pressure requirements and to extend the life of the air compressors. The wall thickness provides long-term durability and protection against kinking and punctures. The air supply tubing remains flexible in cold temperatures allowing for easy year round installations.

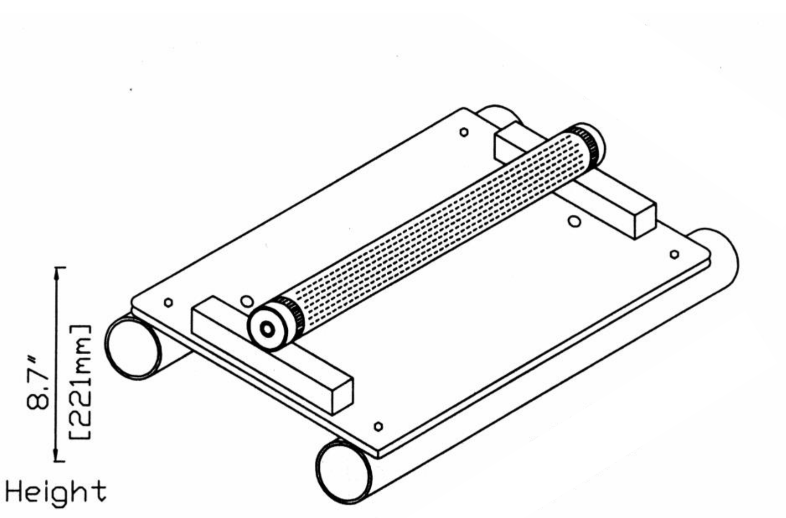
Drawings



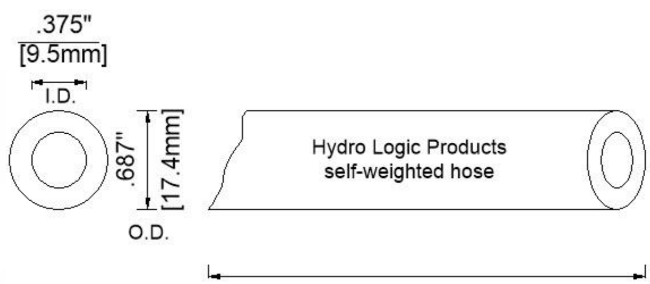
Air Compressor
Cabinet



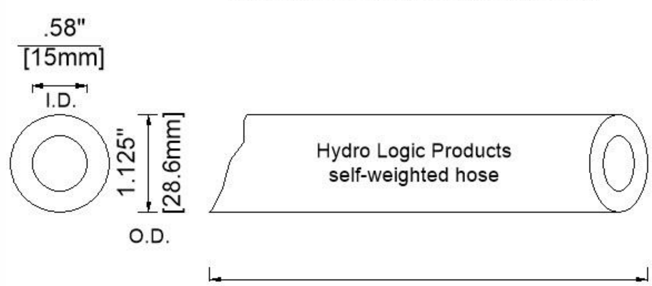
Dual Piston Air Compressor
Side View



AirPod
Air Diffuser



Available in 100ft boxes and 500ft reels.



Available in 100ft boxes, 200ft and 500ft reels.

DownUnder Self-Weighted
Air Supply Tubing

Important Notice: Install all electrical equipment in accordance with Article 680 of the National Electrical Code and all local codes. Hydro Logic Products reserves the right to improve and change our aeration system designs and/or specifications without notice or obligation.

Attachment A

Owner's and Maintenance Manual

P.O. Box 605
Doylestown, PA 18901

Phone: 215.230.9325

www.hydrologicproducts.com

HLP AirLift Owners Manual 2023 rev 12.21.22

Hydro Logic Products

Pond & Lake Aeration plus Aquatic Products

Owner's Manual
AirLift & AirLift XL Aeration Systems

AirLift 6 Aeration System
by **Hydro Logic Products**

X 6 = 6 AirPod Diffusers

AirLift 4XL Aeration System
by **Hydro Logic Products**

X 4 = 4 AirPod XL Diffusers

Table of Contents

Congratulations on purchasing an **AirLift™** pond and lake aeration system manufactured by **Hydro Logic Products®**! Our mission at Hydro Logic Products is to provide our customers with the highest quality, most reliable aeration systems on the market today.

Hydro Logic Products AirLift™ aeration systems are designed and built to completely mix and aerate ponds and lakes. Our systems use billions of micron sized bubbles to cost effectively improve water quality. In addition to reliability, Hydro Logic Products AirLift™ and AirLift XL™ aeration systems were designed to be extremely energy efficient, thereby allowing you to enjoy low operating and maintenance costs for years to come.

Benefits of Aeration

Hydro Logic Products AirLift aeration systems are scientifically-proven management tools used by professional pond and lake managers. Diffused-air aeration systems like the Hydro Logic Products AirLift™ and AirLift XL™ can significantly improve water quality and the ecological health of ponds and lakes. Increased dissolved oxygen concentrations will lower the amount of nutrients throughout the water column.

This translates into lesser amounts of algae resulting in improved water clarity. Aeration also allows for less noxious, poisonous gases (methane and hydrogen sulfide) to be generated. The end result is clearer, healthier ponds and lakes for their owners and all forms of aquatic life.

not completely circulate ponds and lakes if their water depths exceed five feet. In addition, water fountains are prone to clog if substantial amounts of filamentous algae are present.

Some pond and lake owners find water fountains very attractive. For those individuals, Hydro Logic Products recommends installing a water fountain in conjunction with a diffused-air aeration system. This is especially true when eutrophic conditions prevail. Overall, water fountains will primarily serve as aesthetically-pleasing water features, while the diffused-air aeration systems will be responsible for providing the bulk of the water mixing and aeration.

Diffused-air aeration systems like the Hydro Logic Products AirLift and AirLift XL series can significantly improve water quality and the ecological health of ponds and lakes. Increased dissolved oxygen concentrations will lower the amount of nutrients throughout the water column. This translates into lesser amounts of algae resulting in improved water clarity. Aeration also allows for less noxious, poisonous gases (methane and hydrogen sulfide) to be generated. The end result is clearer, healthier ponds and lakes for their owners and all forms of aquatic life.

Hydro Logic Aeration Resources...

For more information about our Hydro Logic AirLift pond and lake aeration systems including useful tips for installation and maintenance, please visit the following links:

- Hydro Logic Products Website
- Hydro Logic Aeration YouTube Channel
- Hydro Logic Instagram Page
- Hydro Logic Facebook Page

Hydro Logic Products
Aeration & Aquatic Products
Ponds & Lakes

will be given to you stating the nature and extent of the damage. If any part of the shipment is “lost in transit”, you should have the shortage noted on the freight bill by the agent.

Concealed Damage – if damage is discovered that was not apparent upon delivery, notify the transportation company immediately to inspect the damaged aeration system. The inspector will be required to provide a “concealed bad order” report. All inspections must be requested within 7 days of delivery. Do not move the damaged goods from the original point of delivery. Retain all original packing and boxes for inspection. File a “full value replacement claim” against the transportation company.

Product Warranty

Hydro Logic Products will repair or replace any defective parts for a period of 1 year from the date of purchase. The AirPod and AirPod XL air diffusers and the air supply tubing has a 5-year warranty.

Customers are responsible for shipping the equipment back to Hydro Logic Products for inspection. After inspection, if the product shows manufacturing defect, Hydro Logic Products will replace or repair it at no cost to the customer. Should the inspection indicate non-warranty failure (incorrect voltage, faulty installation, vandalism, customer negligence, etc.), the warranty will be void.

The warranty period for all warranty work begins on the date that the aeration system was originally purchased. All warranty claims are based upon when you first notify Hydro Logic Products of a known problem.

More About Aeration...

Professional pond and lake managers have a number of scientifically proven tools to properly manage eutrophic water bodies. One of the most common tools in their toolboxes is aeration. Aeration is the process of adding more air or more specifically, more dissolved oxygen into the water. Aeration is frequently implemented with other lake management restoration practices such as the use of algaecides and aquatic herbicides to control nuisance quantities of algae and aquatic plants, respectively.

The two most common methods for aerating ponds and lakes are installing water fountains and diffused-air aeration systems. Of these two techniques, diffused-air aeration systems are much more cost-effective and require far less maintenance. In many instances, water fountains will

Safety First…

Hydro Logic Products ***strongly recommends that you read this entire manual before installing and operating your new AirLift aeration system***. Failure to do so may result in personal injury or rescinding of the warranty agreement between you and Hydro Logic Products.

Drowning Danger - Operating your aeration system during the winter (freezing conditions) may result in open water and/or thin ice conditions above and/or near the air diffusers (AirPod™ and AirPod XL™). Injury or fatality may result from falling through the ice. The owner must make all others aware of this danger by clearly posting these areas at frequent intervals. The owner assumes all responsibility for operating the aeration system during the winter months.

GFCI Testing – All of our 110 volt cabinets contain a GFCI receptacle with “TEST” and “RESET” buttons. At a minimum, the GFCI receptacle should be tested monthly. To test the receptacle, press the “TEST” button in order to trip the device. This should stop the flow of electricity making the air compressor(s) and cooling fan turn off.

If the air compressor(s) and cooling fan do not shut off – remove all plugs from all receptacles (outlets) inside of the cabinet. This includes removing all plugs from the GFCI receptacle. Next, turn off the electric power at the service breaker panel and immediately call a licensed electrician for service or replacement. If the power goes off, press the “RESET” button to turn on the air compressor(s) and cooling fan. The cooling fan should turn on immediately. If your cabinet is equipped with a delay timer, it will take anywhere from 1 to 10 minutes for the air compressor(s) to restart.

It should be noted that all of our 220 volt cabinets are hardwired and therefore do not contain a GFCI receptacles. For our 220 volt units, please contact a licensed electrician for hardwiring our 220 volt units.

It should be noted that a GFCI receptacle does not protect against circuit overloads, short circuits or shocks. To prevent severe shock or electrocution, always turn the *power OFF at* the service breaker panel before working with electricity. In addition, unplug the external plug of the cabinet from the outlet that was installed by the licensed electrician.

Warnings to Remember

- Always have a licensed electrician bring electricity to your pond and lake.
- Have a licensed electrician connect your aeration system to the electric power supply. The licensed electrician should turn on the air compressor(s) and cooling fan and certify that all electrical components in the cabinet are working properly.
- Always connect the power cord (110 volt systems only) of the cabinet to a properly grounded outlet. A licensed electrician should be retained to ensure that the outlet is properly grounded.
- Do not allow anything to rest on the power cord of the cabinet.
- Always locate the cabinet on level, solid ground.
- Always located the cabinet at a higher elevation than the surface water elevation of the pond or lake.
- Securely anchor the plastics pad of the cabinet to the underlying ground. This may be accomplished by first pouring a concrete pad. Next, place the cabinet along with its plastic pad on top of the concrete pad. The concrete and plastic pads can then be anchored together using bolts.
- Locate the cabinet a safe distance from all standing and flooding waters.
- Locate the cabinet away from irrigation sprinklers.
- Never push any sharp objects into the slots in the cabinet. This may result in a fire, an electric shock or electrocution.

2. Clean the AirPod or AirPod XL air diffusers by simply “flexing” the rubber membranes of the tubular air diffusers. To do so, adjust the valves to allow all of the air from the compressor(s) to flow to a single AirPod or AirPod XL for 30 seconds. Repeat two to three times per AirPod or AirPod XL. In general, it is recommended that you “flex” your air diffusers at least twice per year.

   Note: this step can not be performed for AirLift 1™ and AirLift 1 XL™ aeration systems. This is because both of these systems only have a single AirPod or AirPod XL air diffuser.

3. Under normal conditions, clean the air filter at least twice a year. Replace worn or damaged air filters with original Hydro Logic Products parts.
4. Typically, our aeration systems are continuously operated for 6 to 8 months from Spring to Fall (March/April through October). Therefore, after two years of operation, it is recommended that your air compressor(s) be serviced. You can do this task yourself by purchasing a Hydro Logic Products air compressor maintenance kit or simply sending your air compressor(s) back to us for service.

Turning Off Your Aeration System

Most pond and lake owners turn off their AirLift aeration systems during the winter months. To do so, simply unplug the air compressor(s) and cooling fan from the outlet(s) inside of the cabinet, which includes the GFCI receptacle. In addition, turn off the power at the service breaker panel (turn off the circuit breaker).

Product Damage in Delivery

The AirLift aeration system was properly packed and accepted by the freight carrier for shipment. Therefore, it is the freight carrier’s responsibility to deliver the aeration system to you in perfect condition.

Apparent Damage or Loss – if upon delivery, the aeration system is damaged or boxes containing the aeration system are marked “damage in transit”, you should not accept any goods until the transportation company’s agent has noted such on the freight bill. A copy of such a bill

Aeration System Startup

Hydro Logic Products recommends that you start up your aeration system in the Spring and let it run 24 hours a day, 7 days a week until the Fall. The greatest benefits of aeration occur when your pond or lake is properly aerated throughout the entire day and especially at night.

Your AirLift aeration system is designed to completely mix the entire water column of your pond or lake. If your pond or lake is partially or fully stratified, the deeper waters may be devoid of dissolved oxygen and may contain potentially harmful gases. Under such conditions, turning on your aeration system and letting it run continuously may adversely affect aquatic life and can result in a **fish kill**. The best way to start aerating your pond or lake is to use the ***Double Time Rule***. The Double Time Rule is as follows:

- Day 1 - turn on your aeration system for 15 minutes and then turn it off for the remainder of the first day.
- Day 2 - restart your aeration on Day 2 and let it run for 30 minutes. Next turn it off for the remainder of the second day.
- On each of the following days (Days 3 – 8), operate your aeration system twice as long as you did on the previous day. By doing so, your aeration system will be operating 24 hours a day on the 8^{th} day.

Maintenance & Troubleshooting

Hydro Logic Products AirLift aeration systems were design to be durable, energy efficient and low maintenance. The following maintenance should be performed as indicated below or when the water boil above the AirPod or AirPod XL air diffusers has significantly decreased.

Caution: When performing any maintenance or troubleshooting work, always unplug the air compressor(s) and cooling fan from the outlet(s) inside of the cabinet in our 110 volt units. This includes the GFCI receptacle (outlet). In addition, turn off the power at the service breaker panel (turn off the circuit breaker) for both 110 and 220 volt units.

1. The cabinet air vents and the exhaust vent for the cooling fan should be clear of debris, which includes high grasses or weeds.

- Never attempt any maintenance service that is not specified in this manual.
- Never operate the aeration system if unusual noises or smells are detected. If unusual noises or smells are detected, immediately turn off all power to the aeration system and immediately call a licensed electrician or Hydro Logic Products for service.
- Always disconnect the electricity to the aeration system prior to doing any troubleshooting or maintenance work.
- When or around water, always wear a Coast Guard approved life jacket and follow all water safety guidelines.

Maintenance Safety

- Always use parts that are supplied or approved by Hydro Logic Products. Use of other parts may result in poor performance and could result in a dangerous situation.
- Do not use acids or other corrosive cleaners on any components of the cabinets or the AirPod air diffusers.
- Before performing any maintenance work, always unplug the air compressor(s) and cooling fan from the outlets (receptacles) inside of the cabinet (110 volt units only). This includes GFCI receptacle. Next, turn off the electricity (power supply) to the entire aeration system at the service breaker panel (both 110 and 220 volt units).
- Any maintenance or repair work that is not described in this manual should be performed by a licensed electrician or Hydro Logic Products.

Aeration System Components

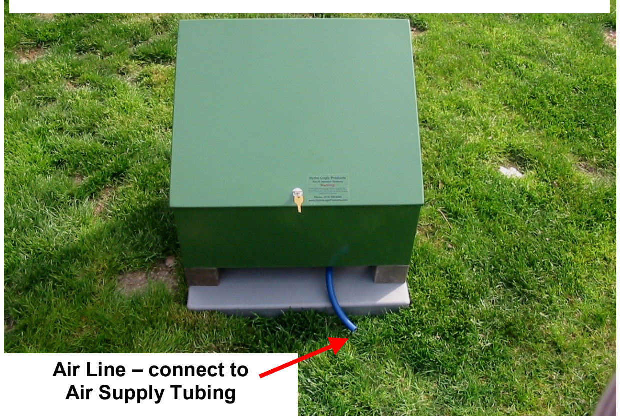
Hydro Logic Products manufacturers two lines of pond and lake aeration equipment: the AirLift™ and AirLift XL™ Series. All models for both series have these common components:

- Air Compressor(s)
- Air Compressor Cabinets with HDPE Pad
- Air diffusers (AirPods and AirPods XL)
- Weighted Air Supply Tubing

Air Compressor Cabinet *– Our cabinets are powder-coated steel and have limited lifetime rustproof protection. All cabinets are equipped with heavy duty cooling fans, a lock, a GFCI receptacle (110V units only) and air compressor(s).*

Air Diffusers *– All AirPod and AirPod XL air diffusers contain large HDPE bases to eliminate sediment disturbance. Our AirPods have single, tubular air diffusers, while our AirPod XLs have dual, tubular air diffusers. In addition, two ballast tubes are filled with rock, gravel or sand in order to easily sink the AirPod and AirPod XL air diffusers to the bottom of your pond or lake.*

Cabinet Containing Air Compressor(s)



7. Return back to shore and attach the other end of the air supply tubing to the air line of the cabinet. You may have to cut any excess air supply line using your utility razor knife. Thereafter, connect the air supply tubing to the fitting of the air line at the cabinet using PVC primer and PVC cement per the manufacturer's instructions. For the best results, be sure to swab a generous amount of PVC cement inside of the air supply tubing and around the fitting. Immediately after applying the PVC cement, firmly push the fitting into the air supply tubing. Let the PVC cement dry for several minutes and then proceed to Step 8.

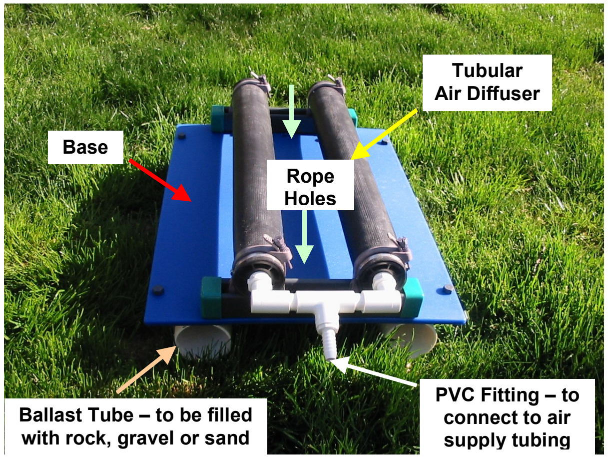
8. Repeat Steps 3 through 7 to install all air supply lines and their corresponding AirPod and AirPod XL air diffusers.

9. Once all AirPod or AirPod XL diffusers are installed, back fill the open trench with excavated soils in Step 2.

Note: Air supply tubing is shipped in 100-foot coils or on plastic reels (200 to 500 foot lengths). Air supply tubing is connected or spliced together using PVC fittings and PVC cement. For very long lengths, Step 3 can be performed on a boat. It is recommended that one person uncoils and connects the air supply tubing together while the other person operates the motor boat in reverse. Uncoiling aeration tubing on reels can be done from shore or on a boat.

5. At the buoy, carefully cut any excess air supply tubing using a utility razor knife. Next, connect the air supply tubing to the fitting on the AirPod or AirPod XL air diffuser using PVC primer and PVC cement per the manufacturer's instructions. For the best results, be sure to swab a generous amount of PVC cement inside of the air supply tubing and around the fitting. Immediately after applying the PVC cement, firmly push the fitting into the air supply tubing. Let the PVC dry for several minutes and continue with Step 6.

6. Thread a thin rope through the two holes in base of the AirPod or AirPod XL. Pull the rope through so that the AirPod or AirPod XL is at the mid point of the rope. Next, while holding both ends of the rope, begin to ***slowly*** lower the AirPod or AirPod XL into the pond or lake. Once on the bottom, release one end of the rope and pull the other end until all of the rope is retrieved.



Tools and Materials Needed

Hydro Logic Products recommends the following tools and materials to properly install your AirLift aeration system:

- ***Rope*** – thin polypropylene or nylon rope (less than 5/8 inch in diameter) at lease twice the water depth. The rope is used to lower the AirPods to the pond or lake bottom.
- ***Utility Razor Knife*** – to cut air supply tubing
- ***Level*** – to make sure the cabinet is level
- ***Boat with Motor*** – to install air supply tubing and AirPods
- ***Landscaping rock, pea gravel or sand*** - to weight ballast tubes of AirPod air diffusers
- ***PVC Primer & PVC Cement*** – to connect all PVC fittings to air line(s), air supply tubing and AirPods. To secure PVC caps to ballast tubes once filled with rock, gravel or sand.
- ***Shovel*** – to clear and level the area for the cabinet plus to dig a trench for the air supply tubing

Cabinet Installation

1. Clear and level the ground for the cabinet. Next, place cabinet and its attached plastic pad on the cleared, leveled ground. The cabinet should be placed so that the blue air line(s) from beneath the cabinet are facing towards the pond or lake.

For added security, first pour a concrete pad on the cleared, leveled ground. Next, attach the plastic pad of the cabinet directly to the concrete pad using masonry bolts.

2. Retain a licensed electrician to bring electricity to cabinet. The licensed electrician should plug in your aeration system to the electric power supply. The licensed electrician should turn on the air compressor(s) and cooling fan and certify that all electrical components in the cabinet are working properly. Note: 220 volt units will be hardwired by your licensed electrician.

AirPod Assembly & Placement

Your AirPod or AirPod XL air diffusers have been completely assembled by Hydro Logic Products. All you have to do is add some small landscaping rock, pea gravel or sand to the two ballast tubes of the AirPod or AirPod XL air diffuser(s). These materials are readily available at landscaping supply stores or home improvement stores such as Lowe's or Home Depot. Once filled with rock, gravel or sand, simply glue the end caps of the two ballast tubes using PVC primer and PVC cement per the manufacturer's instructions. The air diffuser can be installed shortly after the PVC cement has dried.

Warning: Do not place any AirPod or AirPod XL air diffusers in water depths greater than 50 feet. At greater depths, aeration can result in elevated nitrogen concentrations, which may be dangerous to fish.

Air Supply Tubing & AirPod Installation

1. Hydro Logic Products recommends that you first mark the locations of where you want to install your AirPod or AirPod XL air diffusers. Theses locations can simply be marked using buoys.

2. Dig a trench from the cabinet down to the water's edge of the pond or lake. The trench should be about 12 to 18 inches in depth.

   Note: If you plan to operate your aeration system during the winter, you must dig the trench below the frost line and insulate the air line(s) coming out of the cabinet.

3. Uncoil the weighted air supply tubing along the shoreline as shown below. It is extremely important to make sure the tubing is not twisted for proper installation. Next, secure one end of the air supply tubing plus an additional 3 feet near the cabinet. Place the uncoiled tubing in the trench.

4. At the water's edge, grab the other end of the air supply tubing. Put your motor boat in reverse and begin navigating towards one of the buoys as described in Step 1. Boating in reverse will eliminate the possibility of cutting the air supply tubing with the propeller of your outboard motor.

AirLift & AirLift HighFlow Aeration Systems

Recommended Maintenance

Hydro Logic Products recommends the following maintenance program to keep your AirLift and AirLift HighFlow aeration systems working optimally thereby ensuring that your pond and lake is being aerated properly. Routine maintenance involves inspecting the inside and outside of your air compressor cabinet, air compressor(s), airlines and AirPod air diffuser(s).

For additional information, please refer to the Hydro Logic AirLift Owner's Manual which also provides additional information on aeration system maintenance.

Air Compressor Cabinet & Air Compressors

1. The outside of the air compressor should be devoid of any tall objects such as tall grasses, shrubs and trees. Any tall objects near the air compressor cabinet will inevitably impact the exchange of clean air into the cabinet and hot air forced from the cabinet from the cooling fan(s). Good air exchange is essential for your AirLift aeration system to operate properly and to avoid damaging your air compressor(s) and cooling fan(s).

2. The inside of the cabinet should be cleaned regularly to remove any accumulated debris such as grass clippings and insects.

3. The air filter inside of the air filter canister should be inspected monthly and replaced when dirty. The frequency of replacement will highly depend upon local site conditions. At a minimum, the air filter element should be replaced annually in clean environments.

4. When inspecting an air filter, the air filter canister containing the air filter should also be inspected. Be sure to carefully inspect both the air intake port and tube of the air filter canister. The easiest way to quickly clean the air intake port and tube is by using a small tool such as a screw driver, Q tip or nail. To clean, simply push the small tool completely through the air intake tube 5 to 10 times. Debris will often accumulate inside of the air intake port tube and this, in turn, can significantly reduce the air flow to an air compressor.

5. All cooling fans inside of the air compressor cabinet should be inspected monthly. If a cooling fan is not operating properly, it is strongly recommended to turn off the aeration system and replace the cooling fan immediately.

6. For optimal performance, the cylinders of an air compressor should be rebuilt every 2 years. Air compressor cylinder rebuild kits can be purchased directly from Hydro Logic Products. Unless otherwise specified, your air compressor(s) is/are oil-less and therefore do not require any other internal maintenance besides what is noted above.

DownUnder Airlines & AirPod Air Diffusers

1. All submerged airlines leaving the air compressor cabinet and all DownUnder self-weighted airlines should be routinely inspected for leaks or other damage. If an airline has been cut or damaged in some manner, this airline should be repaired immediately.

2. All AirPod air diffusers should be inspected monthly to ensure that the airflow is evenly distributed to all of the air diffusers. If this is not the case, one or several air diffusers have become partially clogged with algae, other organic matter, or deposited sediment and should be cleaned as noted below.

3. If an AirPod air diffuser has become partially clogged, the air diffuser can be un-clogged by using the "flexing the membrane" procedure as discussed in the Owner's manual.

4. AirPod air diffusers can also be cleaned manually by raising any partially clogged AirPod air diffuser to the surface of the pond or lake. While suspended in the water, the air diffuser can easily be cleaned using a soft bristle brush to clear away any accumulated organic or sediment buildup. The AirPod air diffusers can be snagged using a grappling hook or another similar tool without any sharp edges – be careful not to damage the rubber membrane air diffuser itself. The grappling hook will be used to snag the tubular air diffuser itself or a rope handle attached to the base of the AirPod air diffuser (if installed).

5. It is recommended to occasionally lift and lower all AirPod air diffusers annually or at least every several years. This will allow you to replace your air diffusers on top of any sediments that may have accumulated since the initial installation or the last time your air diffusers were raised or lowered. This step may not be needed in ponds or lakes with very low amounts of annual sediment buildup.