Alimagnet Lake Alum Treatment Feasibility Study

Prepared for
Vermillion River Watershed Joint Powers Organization
City of Apple Valley
City of Burnsville

August 2023

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Abbreviations

AL-P	aluminum bond
Alum	Aluminum sulfate
BMPs	best management practices
CLP	Curly-leaf pondweed
Fe-P	iron bound phosphorus
EWM	Eurasian watermilfoil
LA	load allocation
Org-P	organically bound phosphorus
P	Phosphorus
PAC	Polyaluminum chloride
TMDL	Total Maximum Daily Load
VRWJPO	Vermillion River Watershed Joint Powers Organization

1 Project Background and Purpose

1.1 Background

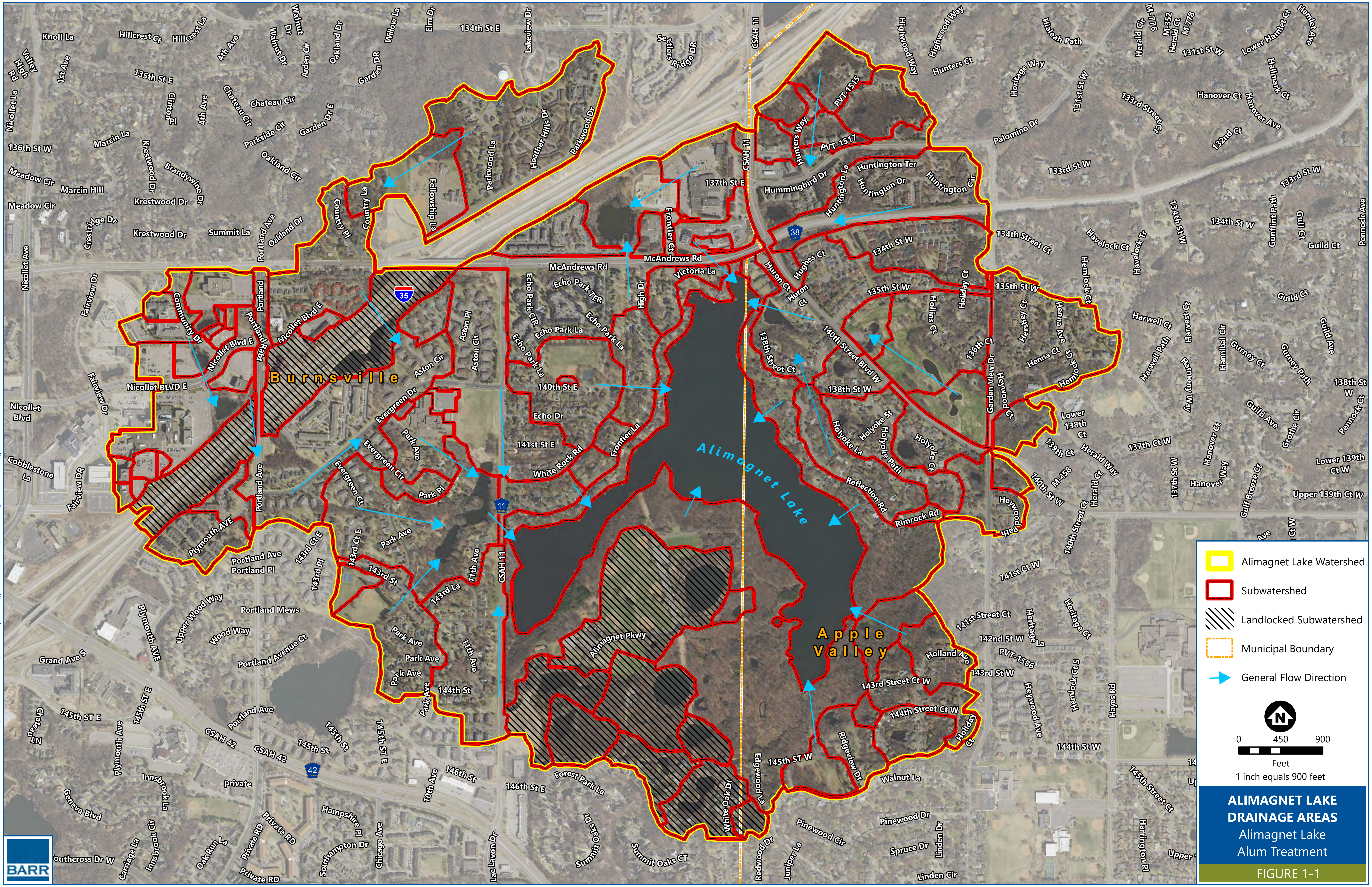
Barr Engineering Company (Barr) completed a study to evaluate the feasibility of conducting an aluminum sulfate (alum) treatment of Alimagnet Lake to improve the lake water quality for Vermillion River Watershed Joint Powers Organization (VRWJPO). The feasibility study included sediment core collection and analysis, creating an alum dosage plan and compiling information to help support an application for a Board of Water and Soil Resources (BWSR) Clean Water Fund grant that would aid the in-lake management practices. The VRWJPO and partner cities believe that watershed loads were addressed through the implementation of watershed best management practices (BMPs) and that internal phosphorus (P) loading is the most significant remaining nutrient source to the lake preventing it from meeting state water quality standards. While some projects to address internal loading were completed in Alimagnet Lake, the scale of the projects was not sufficient to wholly address the issue. Since the lake is well positioned for an internal P load reduction project, this feasibility study investigates the process, improvement potential, alternatives, and cost associated with an internal load control project.

Alimagnet Lake is a small (109 acres), shallow lake (average depth of 6 feet) that sits on the border between Apple Valley and Burnsville (Table 1-1, Figure 1-1). For a shallow lake, the residence time of the lake is relatively long (>1.7 years) due to the relatively small watershed (9:1 watershed to lake area ratio). Further, some of the watershed area near the lake is noncontributing with no outlet draining to the lake. The long residence time and small watershed suggest that Alimagnet Lake will be highly responsive to internal phosphorus loading.

Table 1-1 Lake Morphology and Watershed Characteristics

Parameter	Alimagnet Lake
Surface Area (acres)[1]	105
Average Depth (feet) [1]	6
Maximum Depth (feet) [1]	11
Residence Time (years)	1.7
Direct Drainage (acres)	985
Lake Volume (acre-ft) [1]	648
Depth Class	Shallow

[1] Calculated from new contour map generated from point depths collected by Blue Water Science (2022)



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Recent depth data were collected for Alimagnet Lake allowing for an update of the bathymetry of the lake. A new bathymetric map for Alimagnet Lake was developed using sounding data collected by Blue Water Science on June 6, 2022 (Figure 1-2). The shoreline was delineated using the extent of the National Wetland Inventory polygons that made up the lake. The shoreline represented the extent of the lake and the zero-depth contour. Contours representing 6- and 10-feet depths were also digitized based on visual interpolation of the soundings. To develop the bathymetric surface of the lake, the digitized contours and soundings were input to the Topo to Raster geoprocessing tool in Esri ArcGIS Pro. This resulted in a 4-foot pixel raster that represents the lake depth in feet of Alimagnet Lake which was then converted to depth contours (Figure 1-2).

Figure 1-2 Measured depths and calculated contours in Alimagnet Lake

1.2 Summary of Water Quality Monitoring

Water quality on Alimagnet Lake is routinely monitored through the Metropolitan Council's Citizen-Assisted Monitoring Program (CAMP). Since 2008, water quality has been relatively poor in Alimagnet Lake. Alimagnet Lake has not met water quality standards in 14 of 15 years (Figure 1-3). Summer growing season average phosphorus concentrations typically exceed 75 µg/L, well above the state water quality standard for shallow lakes (<60 µg/L as a summer average). Nuisance algae levels follow the high phosphorus concentrations with summer average chlorophyll-a concentrations typically exceeding 50 µg/L (Figure 1-4). Finally, water clarity follows a similar pattern with summer average Secchi depths well below the 1-meter shallow lake standard in most years (Figure 1-5).

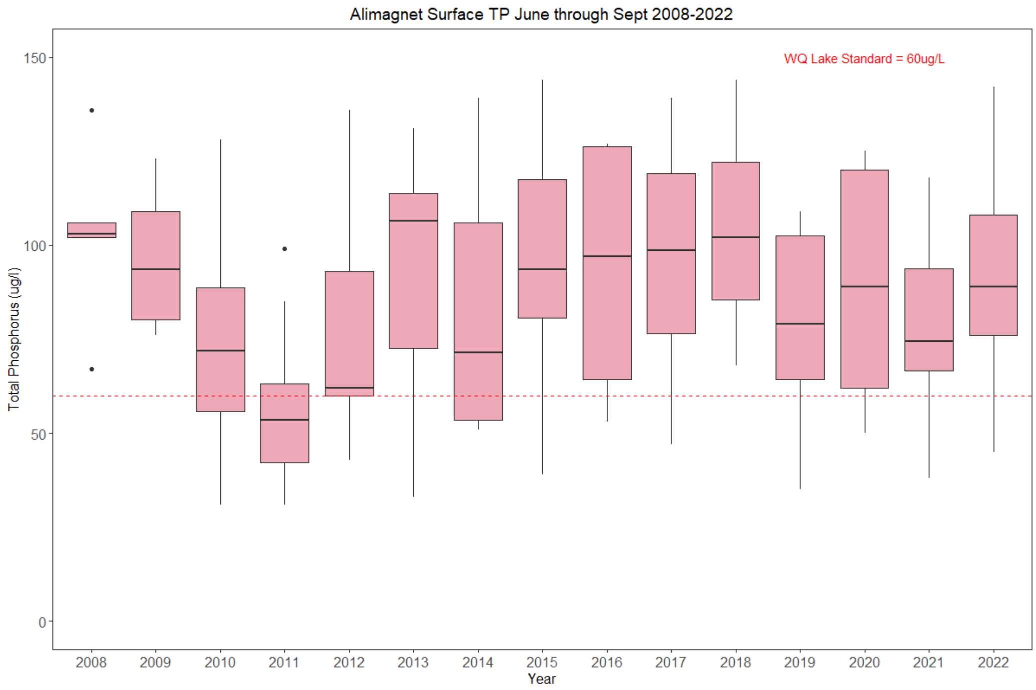


Figure 1-3 Summer Average (June-Sept) Total Phosphorus Concentrations (µg/L)

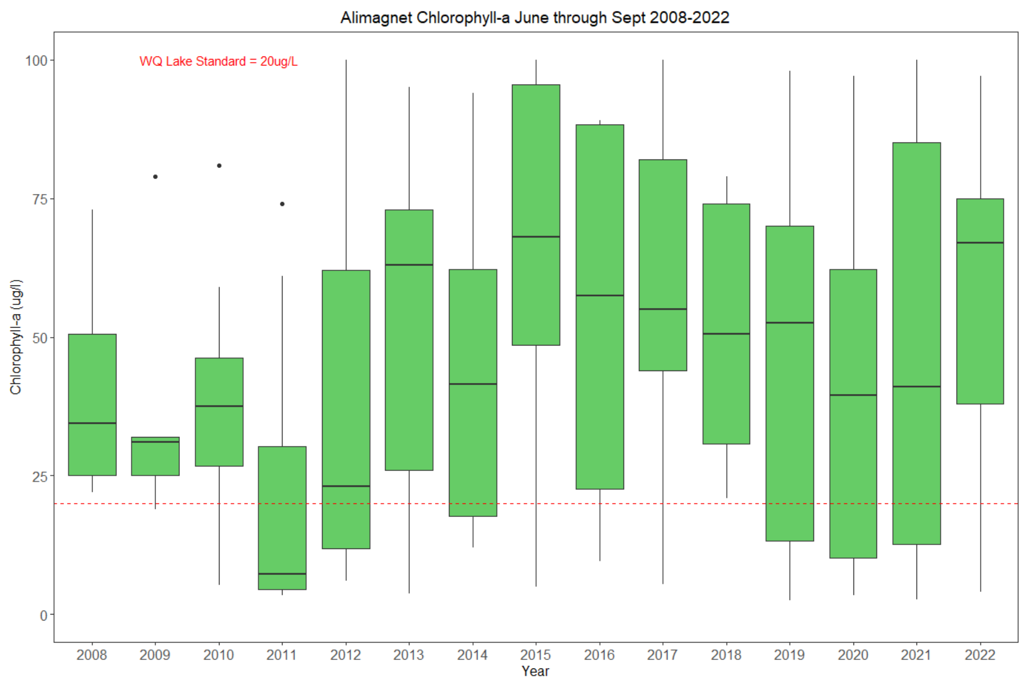


Figure 1-4 Summer Average (June-Sept) Chlorophyll-a Concentrations (µg/L)

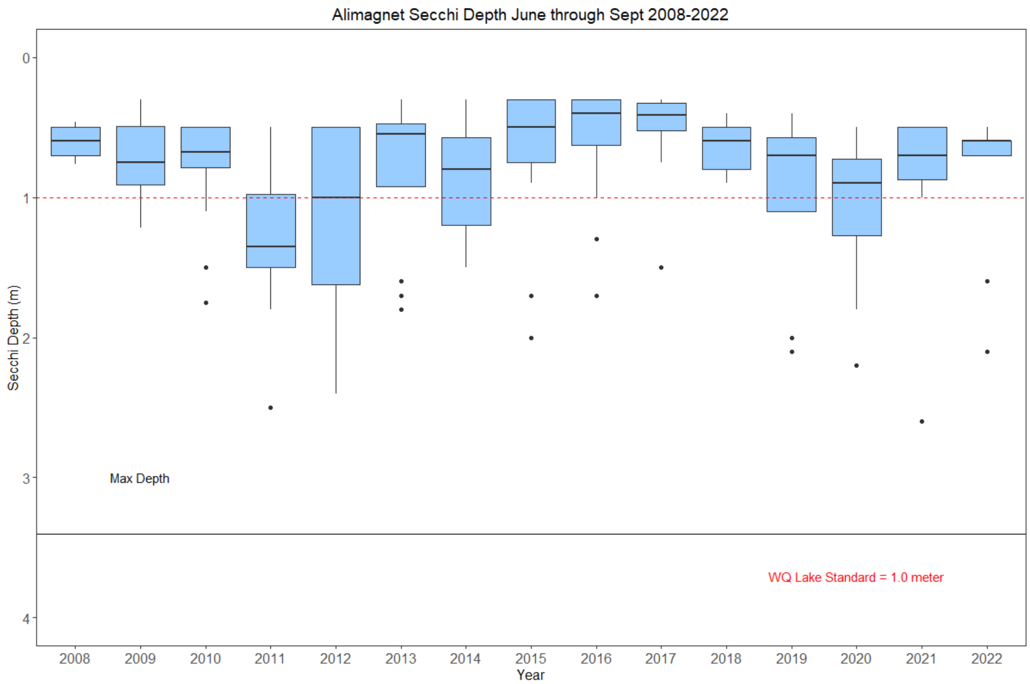


Figure 1-5 Summer Average (June-Sept) Secchi Disc Transparency (meters)

1.3 Submerged Aquatic Vegetation

Submerged aquatic vegetation are monitored annually in Alimagnet Lake (Appendix A). In 2022, submerged aquatic vegetation in Alimagnet Lake was dominated by Coontail covering up to 58% of the lake (Table 1-2). Alimagnet Lake also contains two invasive plant species, Curly-leaf pondweed (CLP) and Eurasian watermilfoil (EWM). In 2022, a total of 4 native species were measured in Alimagnet Lake.

Table 1-2 Percent Occurrence of Submerged Vegetation for June and August 2022

Species	June 6, 2022 Survey	August 10, 2022 Survey
	Percent Occurrence	
Coontail (*Ceratophyllum demersum*)	54	58
Chara *(Chara Sp.)*	---	1
Eurasian watermilfoil *(Myriophyllum spicatum)*	36	10
Curryleaf pondweed *(Potamogeton crispus)*	2	---
Stringy pondweed *(P. sp)*	3	---
Filamentous algae Floating	---	22

Historically, the submerged aquatic plant community demonstrates varied dominance by Coontail, EWM, and CLP and species richness ranged between 4 and 6 native species in the Spring surveys (Table 1-3). In 2013, the plant community was dominated by Elodea as well as Coontail, but Elodea has only been minimally found since the 2013 survey. A Naiad and Nitella were historically found in Fall surveys but have not been present in the lake in recent years (Table 1-4).

Table 1-3 Percent Occurrence of Submerged Vegetation for Spring surveys 2013-2022

Species	June 10, 2013	June 27, 2014	June 12, 2015	May 26, 2016	June 5, 2018	June 12, 2019	June 4, 2020	June 28, 2021	June 2, 2022
Duckweed *(Lemna sp)*					3	1			
Coontail (*Ceratophyllum demersum*)	62	23	22	20	8	18	14	37	52
Chara *(Chara Sp.)*	2			2				1	
Elodea *(Elodea canadensis)*	46		5	3				1	
Eurasian watermilfoil *(Myriophyllum spicatum)*			1	13	3	49	70		36
Curlyleaf pondweed *(Potamogeton crispus)*	1		1	47	23	15	53	54	2
Stringy pondweed *(Potamogeton sp.)*	4		4	1		1	1	13	3
Number of Species	**5**	**4**	**6**	**6**	**5**	**5**	**4**	**5**	**4**

Table 1-4 Percent Occurrence of Submerged Vegetation for Fall surveys 2013-2022

Species	Aug. 18, 2014	July 31, 2015	July 27, 2016	Aug. 1 5, 2017	July 11, 2018	Aug. 2, 2019	Aug. 13, 2020	Aug. 13, 2021	Aug. 10, 2022
Duckweed *(Lemna sp)*	3		2	3	1		3		
Watermeal *(Wolffia columbiana)*							3	13	
Coontail (*Ceratophyllum demersum*)	23	22	10	4	7	14	23	47	59
Chara *(Chara Sp.)*		4	2						1
Elodea *(Elodea canadensis)*	4	8							
Eurasian watermilfoil *(Myriophyllum spicatum)*	1	10	15	25	23	43	40	58	10
Naiads *(Najas flexillis)*			1						
Nitella *(Nitella sp)*		4							
Curlyleaf pondweed *(Potamogeton crispus)*									
Stringy pondweed *(P. sp)*		1					2	9	
Number of Species	**4**	**6**	**5**	**3**	**3**	**2**	**5**	**4**	**3**

1.4 Fisheries

The fish community in Alimagnet Lake is highly managed with both removals and stocking occurring over the past two decades. Fish surveys are routinely conducted on Alimagnet Lake to better describe the fish community and any potential effects on water quality in the lake. Although Black bullheads and bluegills were removed from the lake from 2006 through 2012, the lake remains dominated by bluegills whereas the black bullhead population is significantly reduced. Alimagnet Lake appears to lack a robust top predator community. More information on the fisheries can be found in Appendix B.

2 Phosphorus Loading and BMP Assessment

2.1 TMDL Summary

Alimagnet Lake was included on the MPCA's impaired waterbody list in 2002 for excess nutrients. Sources of phosphorus include urban land use and sediment release. A Total Maximum Daily Load (TMDL) for P was developed for Alimagnet Lake in September 2015 (Table 2-1). The TMDL (Wenck 2015) estimated that internal load accounted for 184 pounds/yr of TP with an allowable load of 77.2 pounds/yr and called for:

- A nutrient Wasteload allocation reduction (WLA) of 35% (60.8 pounds)
- A nutrient load allocation (LA) reduction of 51% (106.7 pounds)

To support TMDL development, sediment cores were collected from a centrally located point in Alimagnet Lake and analyzed for sediment chemistry (top 10-centimeter composite) and sediment P release (aerobic and anaerobic). Using the measured release rates (0.2 mg/m2/day aerobic release and 4.7 mg/m^2/day anaerobic release) and an estimate of anoxia over the sediments, the internal load was estimated at 183.9 pounds/year (55.7 from aerobic release and 18.3 from anaerobic release).

As a part of the TMDL, total external and internal TP loads to Alimagnet Lake were calculated using a Canfield-Bachmann lake response model. In a previous Alimagnet Lake management plan, it was estimated that internal loading or lake sediment P release contributed to up to 50% (300 pounds) of the total yearly load (Blue Water Science 2005). While the result of the previous Alimagnet Lake management plan may not perfectly represent current internal loading estimates based on updated data and current scientific information, it did clearly recognize that internal loading is a significant contribution to overall loading to Alimagnet Lake when it was developed.

Table 2-1 Alimagnet Lake Total Phosphorus Loading and Reductions from 2015 TMDL Report

Alimagnet Lake Loading Sources	Existing TP Load (lbs/yr)	Allowable TP Load (lbs/yr)	Estimated Load Reduction (lbs/yr)
Construction/Industrial	3.5	3.5	0
Apple Valley	69.9	39.1	30.8
Burnsville	88	62.4	25.6
Dakota County	6	4.2	2.6
MnDOT	8.6	6	1.8
Atmospheric Deposition	26.1	26.1	0
Internal Load	183.9	77.2	106.7
Total	**386**	**218.5**	**167.5**

2.2 Water Quality Studies

Several water quality studies were developed for Alimagnet Lake including:

- 2005 Lake Management Plan for Alimagnet Lake, Dakota County, MN
- 2015 Vermillion River Watershed TMDL Report – includes Alimagnet Lake
- 2016 Alimagnet Lake Subwatershed Assessment Report

Since the development of the TMDL report, the Cities of Apple Valley. Burnsville, and the VRWJPO have been partnering to design and install watershed practices to reduce nutrient loading to the lake. Further, the Cities actively manage in-lake conditions including aquatic vegetation and fisheries.

2.3 Watershed Best Management Practices

Since the development of the TMDL, the City of Apple Valley, the City of Burnsville, and the VRWJPO have cooperatively implemented a number of watershed BMPs to reduce nutrient loading the Alimagnet Lake. Figure 2-1 shows the locations in the watershed where BMPs were implemented for stormwater treatment. Table 2-2 summarizes estimated annual total phosphorus reductions to the lake because of these projects. The estimated total watershed phosphorus load reduction to the lake is approximately 64.4 pounds accounting for the stormwater pond alum treatment reductions. Only 50% of the total P reduction from the alum treatments was assumed to account for declining performance over time. Further, we did not include reductions from raingardens to be conservative. These projects alone represent approximately 83% of the required watershed load reductions and suggest that the lake is ready for an internal load reduction project.

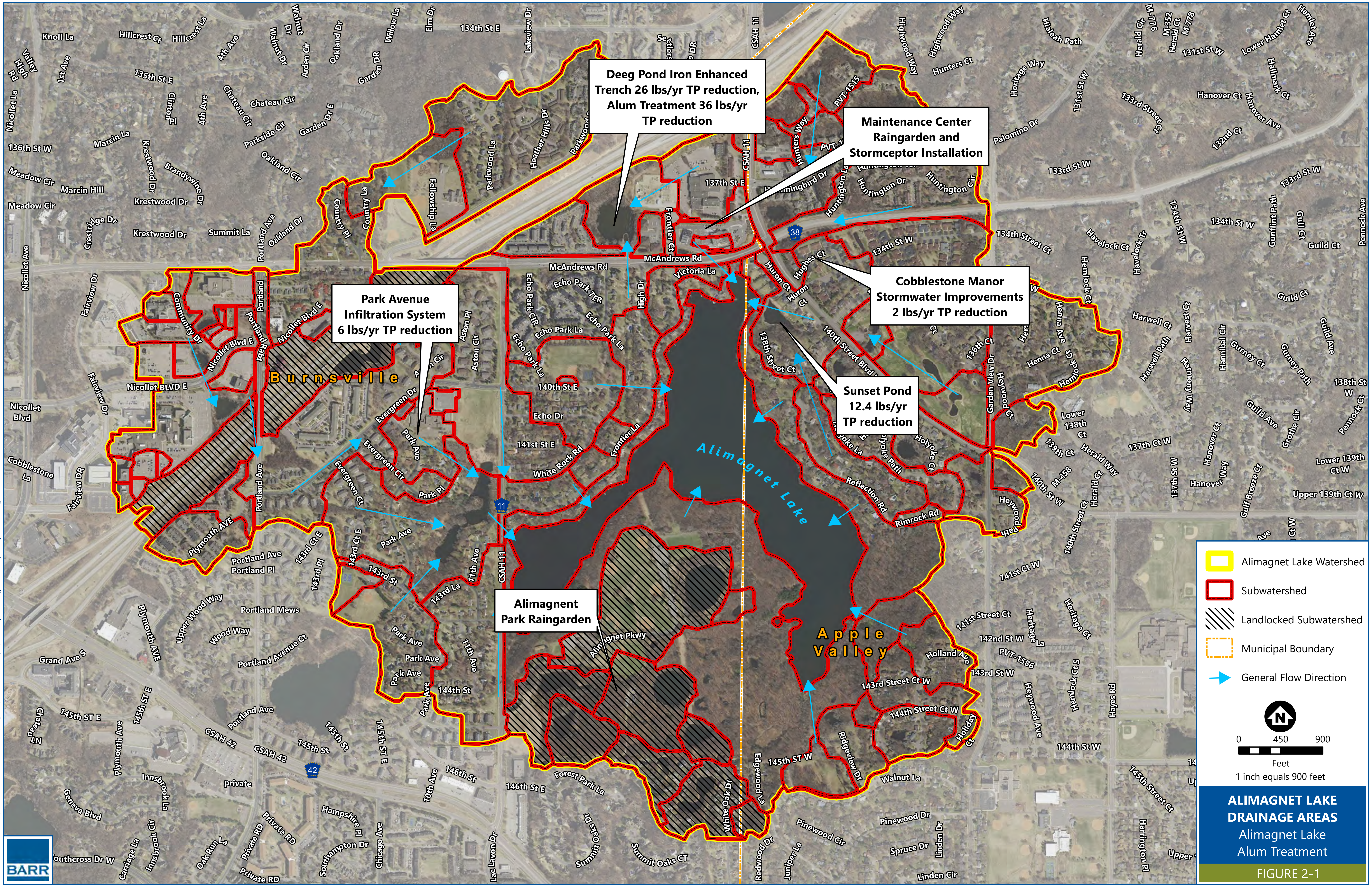
It should be noted that other management practices implemented in the Alimagnet Lake watershed are not included in the table. From 2005 through 2016, barley straw was routinely added to stormwater ponds to reduce phosphorus loading from the ponds. Fish surveys were also conducted on stormwater ponds to evaluate the potential impacts from fish foraging on nutrient resuspension and export from the ponds. While no fish management projects were implemented in the ponds, the Cities continue to evaluate potential impacts to ensure the ponds are operating at peak performance.

Table 2-2 Expected Performance of Implemented BMP's

BMP	Location	Estimated Annual TP Reduction to Lake (lbs/yr)
Maintenance Center Raingarden	Burnsville	--
Alimagnet Park Raingarden	Burnsville	--
Park Avenue Infiltration System	Burnsville	6
Iron Enhanced Infiltration Trench and alum treatment (Deeg Pond; (LA2-A)	Burnsville	26 (36 pounds from alum treatment)[1]
Maintenance Center Stormceptor Installed	Burnsville	--
Sunset Pond (AL-P8) Iron Enhanced Sand Filter	Apple Valley	12.4
Eagle Point Development	Apple Valley	--
Cobblestone Manor (AL-P3)	Apple Valley	2
Total TP Reduction to Lake (Since TMDL Completion)		64.4

[1]-- Reductions were not accounted for in existing conditions model.

[1]used half of the load reduction estimate



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2.4 Lake Response to Phosphorus Reductions

To estimate Alimagnet Lake's response to changes in watershed nutrient loading, the Canfield-Bachmann model used to develop the TMDL for Alimagnet Lake was updated with the estimated load reductions from the completed watershed projects. Assuming watershed loads were reduced by 64.4 pounds, the Canfield-Bachmann model predicts in-lake total phosphorus concentrations around 75 µg/L, consistent with current water quality results (Table 2-3). If an alum treatment were implemented and assuming it only addressed anaerobic phosphorus release of 114.9 pounds, Alimagnet Lake would achieve State water quality standards for phosphorus (Table 2-3). It should be noted that the alum treatment will reduce both anaerobic and aerobic P release, and only anaerobic release was reduced for this model scenario (61% reduction in overall internal loading) to be conservative. It is likely the lake will achieve better water quality than what is predicted in this model scenario.

Table 2-3 Summary of achieved and projected TP load reductions.

Alimagnet Lake Loading Sources	TMDL TP Load(lbs/yr)	Current TP Load (lbs/yr)	TP load with Alum Treatment (lbs/yr)
Construction/Industrial	3.5	3.5	3.5
Apple Valley	69.9	***55.5***	***55.5***
Burnsville	88	***38***	***38***
Dakota County	6	6	6
MnDot	8.6	8.6	8.6
Atmospheric Deposition	26.1	26.1	26.1
Internal Load	183.9	183.9	***69***
Total	**386**	**322**	**207**
Predicted Summer Average TP	**83.5**	**74.6**	**56.2**

2.5 In-lake Management

A number of in-lake management activities were implemented for Alimagnet Lake over the past decade including fisheries management and invasive aquatic plant control.

2.5.1 Aquatic Vegetation Management and Invasive Species Control

Aquatic invasive aquatic plants management occurred as far back as 1997. From 1997 through 2014, residents cut and removed Curly-leaf pondweed to control the plant population. Herbicide applications occurred in 2014, 2017, 2021 and 2022 to target Curly-leaf pondweed (see Appendix A). Curly-leaf pondweed continues to be a management focus for Alimagnet Lake.

Eurasian watermilfoil is also present in Alimagnet Lake, reaching as high as 70% frequency of occurrence in Spring point intercept surveys. In 2022, 3.4 acres were treated with an herbicide to reduce the nuisance population. This treatment reduced the frequency of occurrence for Eurasian water milfoil from 36% to approximately 10% occurrence. Eurasian watermilfoil continues to be a management focus for Alimagnet Lake.

2.5.2 Other In-lake Management Activities

Algae control has also been a focus point for Alimagnet Lake. In 2019, the lake association conducted a near entire lake copper sulfate treatment to target algae.

2.5.3 Past Invasive Fish Monitoring and Management Activities

Active fish management has occurred on Alimagnet Lake since 2005 targeting the removal of black bullheads, control of the bluegill population size, and the addition of top predators in an effort to improve water quality (Table 2-4). While the black bullhead population appears to be successfully controlled with removal since 2005, bluegills continue to dominate the fish community even with the addition of top predators (Table 2-4). Water quality remained poor during these fish management efforts suggesting other aspects of nutrient loading are the primary drivers of poor water quality in Alimagnet Lake.

Table 2-4 Summary of Rough Fish Removal and Native Fish Additions

Management Tactic	Year	Removed (lbs) / # of Fish Added
Removal of bullheads and stunted bluegill	2005	231
	2006	1,786
	2007	2,436
	2008	2,849
	2009	2,401
Channel catfish stocked	2007	9,000
Largemouth bass stocked	2008	1,000
	2016	2,000
	2020	1,000
Removal of crappies and stunted bluegill	2010	3,400
	2011	3,278
	2012	1,475

3 Alternatives Analysis

Since Alimagnet Lake is ready for an internal phosphorus load reduction project, several in-lake management options were considered to control sediment P release from the sediments (Table 3-1). All of the options were assumed to result in similar total phosphorus release reductions (80% reduction or a total of 115 pounds) making the total cost comparisons the same as a pounds/dollar estimate.

For a sediment phosphorus inactivation project, several chemicals were reviewed for their effectiveness, feasibility and cost including alum/sodium aluminate, iron filings, lanthanum modified bentonite clay, and polyaluminum bentonite clay. Iron filings and lanthanum bentonite clay are still considered experimental and while they show promise, they were ruled out since they have a minimal track record and require further research. Polyaluminum chloride (PAC) is used to deliver aluminum hydroxide in Europe, but is difficult to find in the United States and is significantly more expensive than alum. Based on this review, alum or a buffered application of alum and sodium aluminate are the most proven and cost-effective chemicals for sediment phosphorus inactivation.

Engineering approaches including artificial circulation and mirofloc injection were reviewed. However, these approaches are very expensive and require significant infrastructure as well as annual operations and maintenance. While artificial circulation could potentially inhibit sediment phosphorus release without the addition of chemicals, these systems are difficult to operate and if mechanical issues arise, poor water quality will appear quickly in the lake. Further, the complex morphometry of the lake would make aeration difficult, requiring multiple aeration zones and diffusers and potentially multiple compressor locations. Aeration in complex, shallow lakes such as Alimagnet Lake can be problematic with the length of tubing required and issues with floating air lines.

Aquatic plant management and fisheries management, especially carp, are critical components of any internal load control project. While common carp have not been documented in the lake, bullheads were historically a dominant species. However, the Cities of Burnsville and Apple Valley manage the fisheries and have reduced the bullhead population to very low levels. The Cities also actively manage the aquatic plant community and will continue to manage the aquatic plant community as needed for the benefit of the lake.

Table 3-1 A comparison of alternatives for reducing sediment phosphorus loading by 80% in Alimagnet Lake

BMP Type	Product	Advantages	Disadvantages	Application/Timing Options	Risk/Uncertainty	Feasibility	Relative Capital Cost (20 years)	Implementation Timeline
In-Lake – Sediment Phosphorus Inactivation[1]	Aluminum Sulfate/Sodium Aluminate	• Reduction of phosphorus release from sediments • Anoxic conditions do not negatively impact phosphorus binding • Water column stripping provides 2-4 years water quality benefit • Minimal maintenance costs	• pH control necessary during application (sodium aluminate used to control pH during application) • Sodium aluminate may reduce binding efficiency of aluminum hydroxide • Long term control may require maintenance applications	• Spring/Fall application • Split dose over 2 to 4 years	• Long term control (>30 years) requires new P balance in lake which may take future applications	High	$320,000	Implementation Start: <1 year Implementation Duration: 3 to 6 years
	Polyaluminum Chloride	• Reduction of phosphorus release from sediments • Anoxic conditions do not negatively impact phosphorus binding • Water column stripping provides 2-4 years water quality benefit • No pH control required • No maintenance costs	• Increase in chloride concentrations which may impact biota in the short term	• Spring/Fall application • Split dose over 2 to 4 years	• Long term control (>30 years) requires new P balance in lake which may take future applications • Chloride may remain in lake long-term because of long residence time	Medium	>$500,000	Implementation Start: <1 year Implementation Duration: 4 to 6 years
	Iron Filings	• Reduction of phosphorus release from sediments with oxic conditions • Potential reduction of phosphorus release from sediments with anoxic conditions • No maintenance costs	• Anoxic conditions impact phosphorus binding efficacy • Requires aeration/oxygenation to ensure P control • Control under anoxic conditions still unproven for large lake systems • Application may be challenging for large lakes • May result in high iron concentrations that leads to iron toxicity • Iron is a micronutrient that supports cyanobacteria	• Application has never been conducted on a large lake • Application of dry material may be challenging	• Long term control in lakes that present significant anoxia has not been demonstrated without aeration. • While iron addition and aeration are proven to work, iron filings have not been used in such a large-scale application • May require future applications	Medium	<300,000	Implementation Start: <1 year Implementation Duration: 1 year
	Ferric Chloride	• Reduction of phosphorus release from sediments with oxic conditions • No maintenance costs	• Increase in chloride concentrations • Anoxic conditions impact phosphorus binding efficacy • Potential iron toxicity with increased iron release	• Spring/Fall application	• Chloride may remain in lake long-term because of long residence time	Medium	<$300,000	Implementation Start: <1 year Implementation Duration: 1 year
	Lanthanum (Phoslock)	• Reduction of phosphorus release from sediments • May provide longer term binding capacity than aluminum • No maintenance costs	• Limited long-term case studies to demonstrate long-term effectiveness • Limited research on dosing and binding efficiency • Application of dry material requires slurry • Does not provide water column stripping, so it is often applied along with alum (Floc and Lock) • Short- and long-term lanthanum toxicity not well defined	• Application of dry material requires slurry production and application	• Limited long-term case studies to demonstrate long-term effectiveness • Proprietary product subject to owner pricing • May require dosing study to verify dose	Medium	>$500,000	Implementation Start: <1 year Implementation Duration: 1 year
In-Lake – Biomanipulation[2]	Roughfish Management	• Increased clarity through turbidity reduction • Possible decrease in internal sediment loading • Decrease in aquatic plant uprooting; improved plant health • Increased habitat area for native fish species	• Targeted fish species are difficult to eradicate/control • Control likely needs to be on-going, rather than a one-time effort to maximize control efforts • Carp are not currently at high population levels • Previous biomanipulations have not resulted in long-lasting water quality improvements	• Under ice seining • Open water seining, electrofishing, box netting, gill netting, barriers • Recruitment season predator control (e.g., blue gills)	• Applying multiple approaches to manage carp populations (e.g., box nets, electrofishing, barriers, predator species introduction) can be difficult, if carp recruitment and migration extends beyond LGU boundaries (multiple stakeholder coordination required) • Water levels shown to significantly impact carp movement patterns and removal success	Medium	$15,000	Implementation Start: 1 -2 year Implementation Duration: 5+ years

BMP Type	Product	Advantages	Disadvantages	Application/Timing Options	Risk/Uncertainty	Feasibility	Relative Capital Cost (20 years)	Implementation Timeline
	Whole or Partial Lake Drawdown	• Invigorate the submerged aquatic seed bank to increase native diversity and extent • Consolidates sediments creating a better rooting zone for submerged plants • Increases denitrification and total nitrogen loss from the sediments • May provide an opportunity for a fish renovation to improve top-down effects	• Typically occurs during the fall and may impact recreational use of the lake • Drawdown will likely impact turtles and amphibians in the short term, but habitat will improve in the long term. • Drawdown is not a proven sediment phosphorus release control technique and may result in increased loading for 1 to 3 years • May need to be repeated periodically to maintain sediment conditions • May result in a fish kill limiting the recreational fishery	• Fall for native plants • Winter for CLP control	• Water quality may deteriorate with increased sediment phosphorus loading following the drawdown • Partial drawdown may not invigorate the seed bed limiting the desired results	Low	>$500,000	2-3 years
	Aquatic Plant Management	• Sediment stabilization to prevent resuspension • Habitat improvement – fisheries benefit, zooplankton benefit • Nutrient and light competition with algae • Management of invasive species	• The switch from algal-dominated to plant-dominated conditions may cause unexpected or undesirable changes to lake recreation (e.g., boating)	• Annual management • Assumes the use of both herbicides and mechanical based on needs	• Uncertainty in aquatic plant response to various management actions • Unclear if harvesting can occur in Alimagnet Lake due to its shallowness	High	<$20,000/year	Implementation Start: <1 year Implementation Duration: Annually
In-Lake – Structural BMPs[3]	Artificial Circulation/ Destratification	• Full column oxygenation – fisheries benefit • Sediment internal load control (phosphorus) • Odor reduction • Non-chemical alternative • Reduction in dissolved metals (Fe, Mn) • When water column mixing rate exceeds cyanobacteria buoyancy regulation rate, cells are destabilized and sink to depths with low light conditions → growth rate suppression	• Warming of entire water column – negative fishery impact, potential promotion of cyanobacteria • High operation and maintenance needs (labor, capital costs) • On-going electrical power consumption • Without an alum sediment treatment, a mid-season breakdown could lead to rapid water quality changes due to reduced dissolved oxygen in the hypolimnion and internal sediment loading (phosphorus) • If full circulation isn't achieved, hypolimnetic phosphorus may be entrained into the epilimnion • Destabilization and sinking of cyanobacteria may result in high sedimentation and decomposition creating an oxygen deficit layer despite aeration • If system is operated in winter to control early season blooms, less ice thickness can be expected '	• Limitations for winter operation to maintain ice thickness for recreation • MNDNR permit required	• Impacts to nitrogen cycle is unclear. A shift from denitrification dominance to nitrification dominance would result in higher nitrate/nitrite concentrations • May increase aerobic organic phosphorus decay and release • Visual indication of a bloom is removed due to mixing. High toxin concentrations could be present without visual warning • Oxygenation results in higher sedimentation and decomposition of organic matter. If the sediment oxygen demand exceeds the maximum aeration supply, the sediment surface will remain anoxic despite having an oxygenated hypolimnion	Low	>$400,000	Implementation Start: <2 years Implementation Duration: 1 year
	Micro-floc Systems (Alum Injection Systems)	• Hypolimnetic oxygenation – fisheries benefit • Sediment internal load control (phosphorus) through aeration and alum treatment • Odor reduction • Can be implemented prior to carp management • Reduction in dissolved metals (Fe, Mn) • More efficient binding of water column phosphate than typical sediment application (binding active layer)	• High operation and maintenance needs (labor, capital costs) • On-going electrical power consumption • Without an alum sediment treatment, a mid-season breakdown could lead to rapid water quality changes due to reduced dissolved oxygen, no micro-floc development, and internal sediment loading (phosphorus) •	• Cannot be used in winter due to limitations with alum	• This type of system has never been permitted in Minnesota • Impacts to nitrogen cycle is unclear. A shift from denitrification dominance to nitrification dominance would result in higher nitrate/nitrite concentrations • May increase aerobic organic phosphorus decay and release	Low	>$500,000	Never been permitted in MN

BMP Type	Product	Advantages	Disadvantages	Application/Timing Options	Risk/Uncertainty	Feasibility	Relative Capital Cost (20 years)	Implementation Timeline
	Iron Magnetic Microparticles; Nano-Iron Particles	• Can reduce dissolved inorganic phosphorus concentrations • Permanent removal of phosphorus from the waterbody • Large number of sites for phosphorus binding	• Achievement of significant chlorophyll-a reductions may involve higher iron microparticle or nanoparticle doses • Removal of phosphorus from one location to another location • Knowledge gaps on optimization and scalability of equipment for larger waterbodies	• Install after ice-out and remove in the fall	• Relatively new technology – knowledge gaps in treatment optimization for large waterbodies and cost prohibitive to expand to large, deep lakes • Unclear impacts to aquatic wildlife (ingestion of iron microparticles/nanoparticles)	Low	N/A, new technology	N/A, new technology
In-Lake – Structural BMPs[3]	Dredging	• Can reduce sediment release rates of C, P, and N • Increases water depth • Can reduce sediment oxygen demand if enough organic carbon sources are removed; increase in hypolimnetic dissolved oxygen concentrations • Can remove portion of cyanobacteria akinetes	• Can increase organic P release rates depending on sediment chemistry • Impacts to aquatic organisms: physical removal or damage, burial from sedimentation, loss of habitat, and effects of increased turbidity and/or toxic substances in the water column (e.g., benthic invertebrates, fish, aquatic plants) • Will cause turbid water conditions during dredging operations, especially if wet excavation methods are used, which can affect plant health • Recreation impacts during dredging efforts • Shoreline containment area usually needed to dry sediments prior to hauling • Requires disposal site • May result in only short-term water quality improvements; lakes shown to return to initial pre-dredging water quality conditions after a few years • Higher costs for deep lakes; logistical challenges such as water draining, pumping, treating overlying water, and transportation of dredged sediment material to disposal site • For larger, deep lakes, sectional dredging may be the best option, but this may only remove small portions of the sediment yielding insignificant or very short-term water quality benefits	• Open water dredging	• Uncertainties related to short- and long-term impacts to aquatic ecosystem • While some dredging case studies have reported water quality improvements, a good portion of case studies have also reported unsuccessful improvements to water quality • Without targeted external nutrient load reductions, dredging may only have short term benefits • Natural lake mixing dynamics may hinder long-term sediment removal benefits, especially when only sections of a lake are dredged • Extensive effort may be needed to address permitting concerns	Low	>$1.5M	Implementation Start: <2 years Implementation Duration: 1-3 years

4 Sediment Chemistry and Alum Dosing

Internal phosphorus loading, or sediment P release, is the result of mobile sediment P fractions (loosely bound P, iron-bound P, labile organic P) moving from the sediments to overlying water. In Upper Midwest lakes, mobile P is primarily comprised of redox sensitive species including loosely bound and iron bound P. These fractions readily move into porewater and migrate to overlying water under anoxic conditions and are typically the primary drivers of sediment P release. P bound up in labile organic material can also be a source of sediment P when the organic material is mineralized. This process occurs under both aerobic and anaerobic conditions and released P can either migrate to surface waters or report to metal hydroxides in the sediment becoming available for release under anoxic conditions.

4.1 Existing Sediment Data

A TMDL for P was developed for Alimagnet Lake in September 2015. To support TMDL development, sediment cores were collected from a centrally located point in Alimagnet Lake and analyzed for sediment chemistry (top 10-centimeter composite) and sediment P release (aerobic and anaerobic). However, these fractions can get "washed out" by deeper sediments (5-10 centimeters) when composited, and more detailed sediment profiles were needed to develop an appropriate alum dose for the lake. Using the measured release rates (0.2 $mg/m^2/day$ aerobic release and 4.7 $mg/m^2/day$ anaerobic release) and an estimate of anoxia over the sediments, the internal load was estimated at 183.9 pounds/year (55.7 from aerobic release and 128 from anaerobic release).

P fractions susceptible to anaerobic P release (loosely bound and iron-bound P) were only moderately high, suggesting that mineralization of the labile organic P is an important source of sediment P release. Further, the role of labile organic P mineralization is likely important in Alimagnet Lake, requiring alternative strategies for alum applications in shallow lakes.

The purpose of collecting sediment samples is to quantify the amount of iron bound P (Fe-P) and labile organic P (Org-P) to determine an alum dose. The amount of Fe-P and Org-P within the sediment will determine the amount of alum applied to the waterbody. The aluminum treatment will result in the phosphorus moving away from the Fe-P bond to the aluminum bond or Al-P. This bond is inert and will result in the immobilization of phosphorus. The alum treatments are designed to deliver an excess of aluminum to the sediment so that phosphorus can continue to form bonds for years following the treatment.

4.2 Sediment Chemistry and Release Rates

Three sediment cores were collected on May 11, 2023 in Alimagnet Lake using a gravity coring device (Aquatic Research Instruments, Hope ID), minimizing disturbance to the sediment/water interface (Figure 1-1). The sediment core collected at the deepest location was sliced into 2-cm sections from a depth of 0-10 cm, 5-cm intervals were collected from 10-cm and deeper. The other two sediment cores were sliced at 5-cm intervals. All sediment sections were extracted and assessed for mobile phosphorus fractions (loosely bound P, iron-bound P, labile organic P), inactive aluminum-bound P fraction, percent solids, and Loss on Ignition (LOI; Psenner and Puckso 1988, Nürnberg 1988). Bulk density was estimated according to Håkanson and Jansson 2002.

Sediment phosphorus release rates were estimated using an established regression relationship between sediment Redox-P and measured release rates (James and Bischoff unpublished data; (Figure 4-1). Sediment data collected in 2013 suggested anaerobic phosphorus release in Alimagnet Lake was consistent with this relationship.

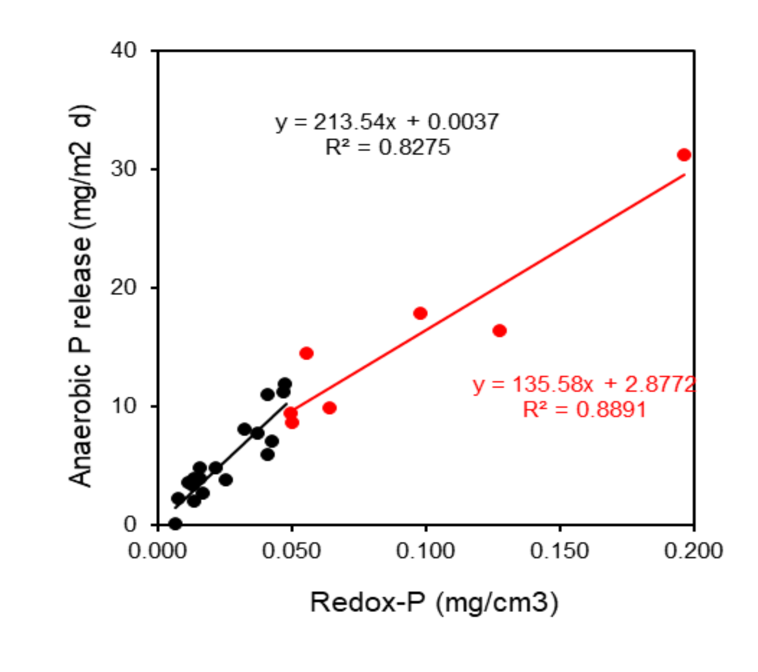


Figure 4-1 Relationship between Redox-P and sediment phosphorus release rates for lakes in Minnesota and Wisconsin. (James and Bischoff unpublished data)

4.2.1 Sediment Chemistry

Vertical profiles of sediment chemistry in Alimagnet Lake demonstrated moderately high mobile phosphorus fraction (loosely bound P plus iron bound P) especially in the deep portion of the lake (Figure 4-2). The mobile P fractions are likely contributing to sediment P release in Alimagnet Lake. Labile organic P was also moderately high at all three stations suggesting that sediment mineralization is contributing to internal loading. This is common in lakes where sediment is formed by years of high algal production producing easily digestible carbon sources for bacteria, which can result in higher P contributions to surface waters. Both of these fractions should be addressed in a sediment phosphorus inactivation approach.

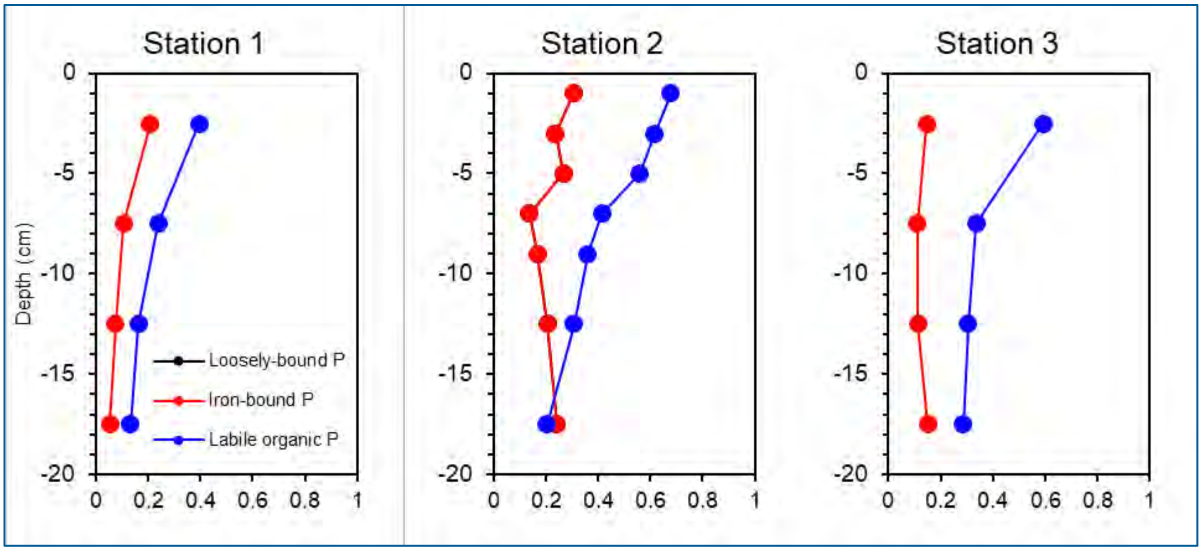


Figure 4-2 Sediment chemistry profiles for the three sediment sampling locations in Alimagnet Lake

4.2.2 Sediment Phosphorus Release Rates

Estimated sediment phosphorus release from the 2023 sediment sampling event ranged between 2.4 and 3.9 mg/m²/day, slightly lower but still consistent with previously measured P release in 2015 (Table 4-1). Since 2023 data were estimated using the previously described regression, and 2015 data were a direct measurement, the TMDL continues to be the best estimate of internal loading in Alimagnet Lake. These results confirm the importance of internal loading in Alignment Lake and the need to reduce internal loading to meet water quality goals.

Table 4-1 Anaerobic sediment phosphorus release rates in Alimagnet Lake

Sample Location	Sediment Phosphorus Release (mg/m²/day)	
	2015	2023
Station 1	--	3.7
Station 2	4.7	3.9
Station 3	--	2.4

4.2.3 Alum Dose and Cost Estimate

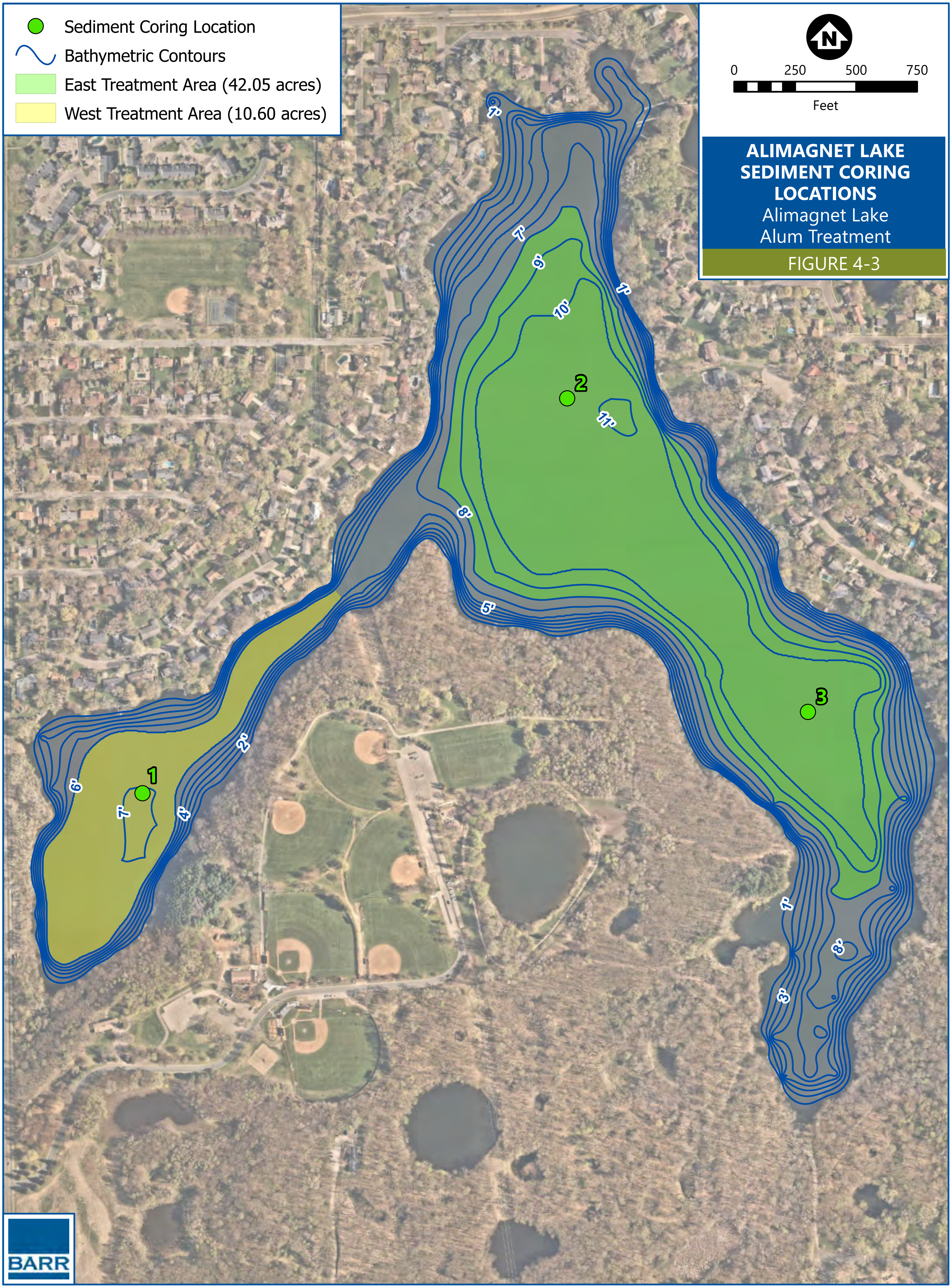
Using the sediment chemistry results, an alum dose and strategy was developed for Alimagnet Lake. Three different dosing methods were used to estimate the amount of aluminum needed to inactivate mobile phosphorus in the lake sediments. The first method targets the pools of phosphorus that are mobile under anoxic conditions (James and Bischoff 2015). This approach has been successfully applied throughout Minnesota and Wisconsin resulting in over 30 successful alum treatments. The second method targets the mobile pool and the labile pool using an 11:1 Al:P ratio but has not been tested and typically underestimates the required dose for redox sensitive P. The third approach targets the mass of phosphorus released in each growing season recognizing that the binding capacity of the alum will diminish over time. This approach targets released P regardless of if it is from sediment mineralization or sediment reduction.

Using the traditional redox-P approach, an aluminum application of 71 to 81 g Al/m^2 is required to reduce internal loading by 80% (Table 4-2). The published approach (Method 2) of using 11:1, but including the labile organic pool, was significantly lower than the amount of aluminum required to address the redox P in the sediments. Since this method did not consider the variable ratios required based on redox-P concentrations, this method was considered too low. Method 3 was similar to Method 1, suggesting an aluminum dose of 71 g Al/m^2 is required to address the mass of phosphorus released every two growing seasons (Table 4-2).

Table 4-2 Areal aluminum concentrations required to reduce internal loading by 80% using three different dosing methods

Method	Zone 1-Main Basin (g Al/m^2)	Zone 2-West Basin (g Al/m^2)
1-Redox-P	81	71
2-Redox-P plus Labile P	29	64
3-P Release	71	--

Since method 1 has been successfully applied in Minnesota lakes and agrees with method 3, the selected alum dose for Alimagnet Lake is 81 g Al/m^2 in the main basin, and 71 g-Al/m^2 in the shallow west basin. This approach targets the upper 5-6 centimeters of sediment. An application area of greater than 8 feet in depth in the main basin (42 acres) and greater than 6 feet in depth in the west basin (10.6 acres; Figure 4-3).


Sediment Coring Location
Bathymetric Contours
East Treatment Area (42.05 acres)
West Treatment Area (10.60 acres)
N
0
250
500
750
Feet
ALIMAGNET LAKE SEDIMENT CORING LOCATIONS
Alimagnet Lake
Alum Treatment
FIGURE 4-3
1
2
3
BARR

A cost estimate was developed for the proposed alum application assuming a buffered application is required (Table 4-3). A total applied cost of $300,149 was estimated to complete a buffered alum treatment on Alimagnet Lake. We recommend splitting the alum dose into two applications with sediment monitoring between applications. Splitting the dose provides an opportunity to adjust the approach following the first application. Further, split dose applications are proving to be more effective at converting sediment phosphorus to aluminum bound phosphorus, the primary goal of the alum treatment.

Table 4-3 Cost estimate for treating Zone 1 and Zone 2 in Alimagnet Lake. Zone 1 targets the top 6 cm of sediment with 81 g Al/m2 for phosphorus inactivation. Zone 2 targets the top 5 cm of sediment with 71 g Al/m2 for phosphorus inactivation

Zone	Acres	Item	Unit	Quantity	Unit Cost	Total Cost
1-Main Basin	42	Aluminum sulfate	Gal $Al_2(SO_4)_3$	26,893	$2.94	$79,065
		Sodium aluminate	Gal $NaAlO_2$	13,446	$7.55	$101,517
2-West Basin	11	Aluminum sulfate	Gal $Al_2(SO_4)_3$	6,201	$2.94	$18,231
		Sodium aluminate	Gal $NaAlO_2$	3,101	$7.55	$23,413
		Mobilization	Lump sum	2	$7,000	$14,000
		Monitoring (2 events)	Lump sum	2	$15,000	$30,000
		Plans and Specifications	Lump sum	1	$15,000	$15,000
		Application Oversight	Lump sum	2	$5,000	$10,000
		Contingency		10%	--	$25,923
Total Application Cost Estimate						$317,149

A split dose application typically occurs in a 2-to-3-year window. A typical application may look as follows:

Year 1: Specifications and Project Bidding; Half dose alum application
Year 2: Water quality and sediment monitoring
Year 2/3: Second half dose application
Year 3: Final sediment monitoring

In the case of Alimagnet Lake, if funding is secured the first application could occur in the Fall of 2024 followed by sediment monitoring in Fall of 2025. The final half dose could be applied in Spring or Fall of 2026 with sediment monitoring occurring in 2027.

There are not specific permitting requirements for lake alum treatments at this time although the Minnesota pollution Control Agency requests information regarding the calculated dose, application timing, prior phosphorus reductions, and expected outcomes of the treatments. These are typically included in a letter to the Agency where they will respond with an approval or requests for more information prior to the treatment.

Access to the lake can be obtained primarily through the park trails (Figure 4-4), however filling the application barge and chemical handling is preferred to occur at the canoe launch (Figure 4-5). Tanker trucks can offload chemicals off of the main road preventing any major traffic concerns. Tanks can be placed in the canoe launch area for alum storage (Figure 4-5).

Figure 4-4 Possible access route for launching alum application equipment.

Figure 4-5 Possible access route for storing and loading alum onto application equipment

It remains unclear if the tanker trucks can make this turn without running up on the curb, but the curb could be armored to protect any damage at the site (Figure 4-6).

Figure 4-6 The Alimagnet Lake canoe launch that could be used for storing and loading alum onto application equipment

4.2.4 Alum Longevity

The final step in evaluating the feasibility of an alum treatment on Alimagnet Lake is to estimate how long the alum treatment is expected to last. To develop an estimate for how long the alum treatment is expected to last, we calculated the amount of time to replace the mass of phosphorus inactivated from watershed loading. Using the P sedimentation term in the Canfield-Bachmann model and the total mass of phosphorus in the top 6 centimeters of sediment (the targeted sediment depth), an estimate of the years required to replace the inactivated sediment phosphorus was developed. Using this approach, an alum treatment on Alimagnet Lake is expected to last between 10 and 14 years. It should be noted that this approach does not account for changes in the plant community and sediment characteristics following a switch to the plant dominated state. Sediments created by aquatic plants are thought to reduce the amount of releasable P by binding it in more stable organic forms. This process would extend the effectiveness of the alum as sediment formation changes from algae driven to aquatic plant driven.

5 Summary and Recommendations

5.1 Water Quality Improvement Options

Significant effort was expended in the Alimagnet watershed through the installation of watershed Best Management Practices to reduce phosphorus loading to Alimagnet Lake by as much as 64.4 pounds. The most feasible remaining phosphorus source to address is sediment phosphorus release. A project is needed to reduce sediment phosphorus loading to Alimagnet Lake.

5.2 Recommendations

After reviewing the potential options for reducing sediment phosphorus loading the Alimagnet Lake, an alum treatment for Alimagnet Lake was identified as the most cost-effective and feasible treatment to target the internal phosphorus loading. An alum treatment will reduce sediment phosphorus loading to Alimagnet Lake by more than 80% and models suggest the lake would meet State water quality standards. The overall cost of the alum treatment is approximately $300,000. The project should be completed over a 2 to 3-year span applying half the calculated alum dose in each application. An alum treatment on Alimagnet Lake is expected to last at least 10-14 years.

5.3 Post Alum Monitoring Plan

Monitoring for the effectiveness of an alum treatment in a shallow lake can be challenging as it is difficult to determine the cause of changes in water quality. As a result, we recommend a two-step approach to post alum monitoring starting with monitoring phosphorus concentrations in the lake followed by sediment sampling if water quality shows signs of degradation. Once the alum treatment is completed, a new average total phosphorus concentration will be established in the lake, which can be used as a baseline. If the concentrations begin to trend upward, sediment sampling should occur to measure sediment P release and sediment chemistry. A post alum treatment sediment sampling event should occur within 1-2 years following the alum treatment to establish post-alum baseline conditions. Future sediment sampling will evaluate changes in sediment phosphorus release rates and sediment chemistry to determine if the alum treatment is losing effectiveness and if additional follow up treatments are required.

5.4 Post Alum Lake Management

The Cities of Burnsville and Apple Valley recognize that ongoing management will be required following an alum treatment on the lake and are prepared to implement needed projects. The Cities actively manage both the aquatic plants and fisheries in the lake and are prepared for an expansion of the aquatic plant community. The Cities also monitor lake water quality through the Citizens Assisted Monitoring Program and continue to monitor the aquatic plant community through point intercept surveys.

6 References

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Appendices

Appendix A

Aqautic Plant Surveys for Alimagnet Lake, Dakota County

Kayaker on Alimagnet Lake on June 6, 2022

Aquatic Plant Surveys for Alimagnet Lake, Dakota County, 2022

Curlyleaf pondweed delineation conducted on May 9, 2022
Curlyleaf pondweed treatment on May 25, 2022 (3.06 acres)
Eurasian watermilfoil treatment on May 25, 2022 (3.4 acres)
Early season point intercept survey conducted on June 6, 2022
Late season point intercept survey conducted on August 10, 2022

Prepared for:
Cities of Apple Valley and Burnsville
Dakota County, MN

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January 12, 2023

Aquatic Plant Surveys for Alimagnet Lake, Dakota County, 2022

Summary

Management Activity Summary

Curlyleaf Pondweed Delineation Survey (May 9, 2022)
Results of the curlyleaf pondweed delineation (May 9, 2022) using a meandering survey format found curlyleaf was well distributed throughout the Apple Valley lobe and the northern basin of the main lake with a number of sites with stem densities (5 or greater per rake sample). Two areas were delineated for treatment in May 2022.

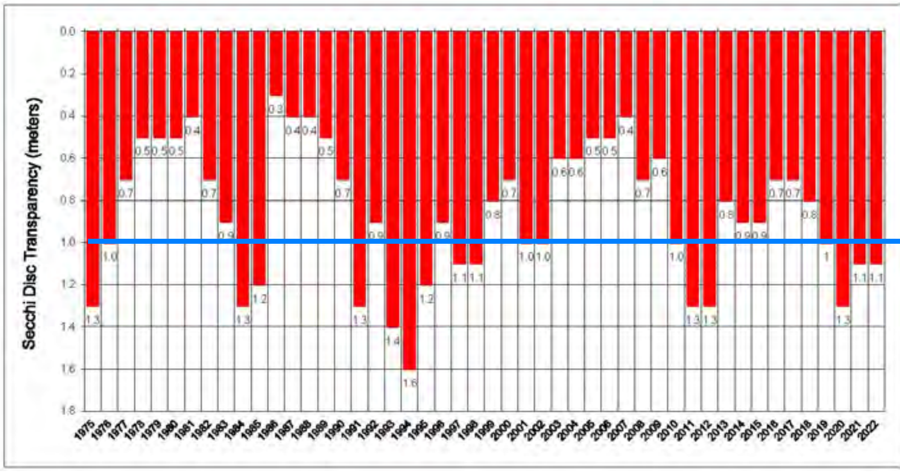
Curlyleaf Pondweed Herbicide Application in 2022
A total of 3.06 acres of curlyleaf were treated with diquat on May 25, 2022.

Eurasian Watermilfoil Herbicide Application in 2022
A total of 3.4 acres of nuisance plants and Eurasian watermilfoil were treated with diquat on May 25, 2022.

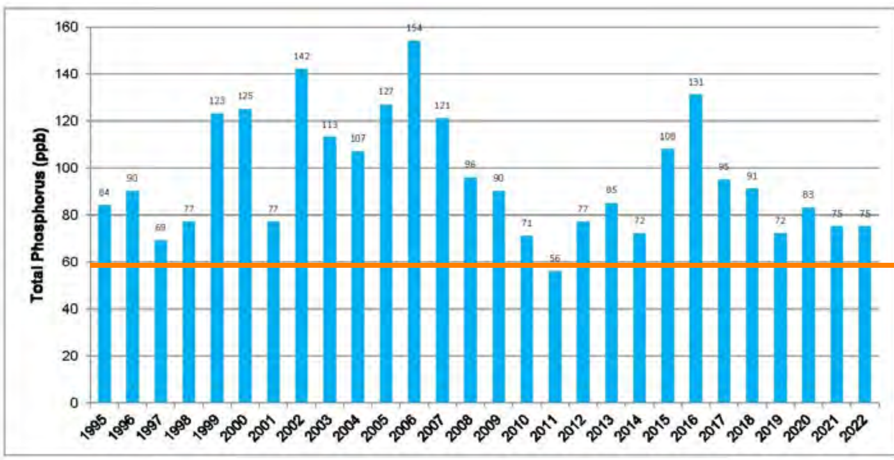
Early Summer Plant Survey (June 6, 2022)
An aquatic plant survey was conducted on June 6, 2022 in Alimagnet Lake (89 acres). Aquatic plant growth in Alimagnet Lake was light to heavy and 4 submerged plant species were found. Coontail (*Ceratophyllum demersum*) was the dominant native submerged plant with 48 acres of plant growth. Plant coverage of Alimagnet Lake was about 63% in the early summer of 2022.

Late Summer Plant Survey (August 10, 2022)
An aquatic plant survey was conducted on August 10, 2022 in Alimagnet Lake (89 acres). Aquatic plant growth in Alimagnet Lake was light to heavy and 3 submerged plant species were sampled. Coontail (*Ceratophyllum demersum*) was the dominant native plant. Plant coverage of Alimagnet Lake was about 56% in the lake summer of 2022.

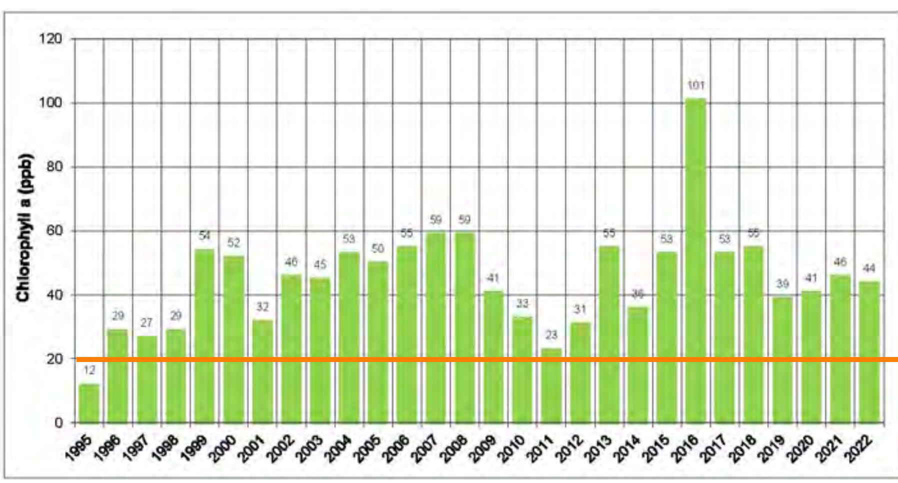
Water Quality Summary



Lake Goal
>1.0 m
(*Impaired Lake 1.0 m*)



Lake Goal
<60 ppb
(*Impaired Lake 60 ppb*)



Lake Goal
<20 ppb
(*Impaired Lake 20 ppb*)

Figure 1. Seasonal water quality data averages for May-September for Alimagnet Lake. Data are from the Met Council CAMP program.

Aquatic Plant Summaries

Table 1. Alimagnet Lake aquatic plant occurrences for early season plant surveys conducted in 2003, 2008 through 2022.

	May 16, 2003 % Occur (n=100)	May 28, 2008 % Occur (n=100)	June 1, 2009 % Occur (n=100)	May 28, 2010 % Occur (n-92)	June 7, 2011 % Occur (n=92)	May 14, 2012 % Occur (n=92)	June 10, 2013 % Occur (n=92)	June 27, 2014 % Occur (n=92)	June 12, 2015 % Occur (n=92)	May 26, 2016 % Occur (n=92)	April 7, 2017 % Occur (n=92)	June 5, 2018 % Occur (n=92)	June 12, 2019 % Occur (n=92)	June 4, 2020 % Occur (n=92)	May 28, 2021 % Occur (n=92)	June 6, 2022 % Occur (n=92)
Duckweed (*Lemna sp*)				2%								3%	1%			
Coontail (*Ceratophyllum canadensis*)				3%	4%	24%	62%	23%	22%	20%		8%	18%	14%	37%	54%
Chara (*Chara sp*)			3%	2%	4%	2%	2%		2%	2%					1%	
Elodea (*Elodea canadensis*)	30%			2%	35%	63%	46%	5%	9%	3%					1%	
Eurasian watermilfoil (*Myriophyllum spicatum*)									1%	13%	3%	23%	49%	70% (1.5)		36 (1.2)
Curlyleaf pondweed (*Potamogeton crispus*)	69% (1.9)	52% (2.7)	65% (2.6)	72% (2.6)	57% (2.4)	92% (2.1)	62% (2.3)	1%	35% (1.5)	47% (1.7)	23%	10% (1.0)	15% (1.1)	53% (1.7)	54% (1.5)	2% (1.0)
Stringy pondweed (*P. sp*)				7%	26%	23%	5%	4%	2%	1%		1%	1%	1%	13%	3%
Sago pondweed (*Stuckenia pectinata*)																
Number of species	2	1	2	6	5	5	5	4	6	6	2	5	5	4	5	4

Table 2. Alimagnet Lake aquatic plant occurrences for late season plant surveys conducted in 2003, 2007 through 2022.

	Aug 6, 2003 % Occur (n=100)	July 26, 2007 % Occur (n=100)	Oct 10, 2008 % Occur (n=100)	Aug 24, 2009 % Occur (n=100)	Aug 24, 2010 % Occur (n-92)	July 26, 2011 % Occur (n=92)	July 11, 2012 % Occur (n=92)	July 17, 2013 % Occur (n=92)	Aug 18, 2014 % Occur (n=92)	July 31, 2015 % Occur (n=92)	July 27, 2016 % Occur (n=92)	Aug 15, 2017 % Occur (n=92)	July 11, 2018 % Occur (n=92)	Aug 2, 2019 % Occur (n=92)	Aug 13, 2020 % Occur (n=92)	Aug 13, 2021 % Occur (n=92)	Aug 10, 2022 % Occur (n=92)
Duckweed (*Lemna sp*)						1%	8%	5%	3%		2%	3%	1%		3%		
Watermeal (*Wolffia columbiana*)							21%								3%	13%	
Coontail (*Ceratophyllum canadensis*)			2%	1%	14%	21%	70%	47%	23%	22%	10%	4%	7%	14%	25%	47%	58%
Chara (*Chara sp*)				1%						4%	2%						1%
Elodea (*Elodea canadensis*)	51%	1%		1%	34%	64%	89%	22%	4%	8%							
Quillwort (*Isoetes sp*)				3%													
Eurasian watermilfoil (*Myriophyllum spicatum*)									1%	10%	15%	25%	23%	43%	40%	58%	10%
Naiads (*Najas flexilis*)											1%						
Nitella (*Nitella sp*)	1%			1%						4%							
Curlyleaf pondweed (*Potamogeton crispus*)		3%		17%		11%											
Stringy pondweed (*P. sp*)				5%	40%	97%	78%	5%		1%					2%	9%	
Sago pondweed (*Stuckenia pectinata*)	2%																
Number of species	3	2	1	7	3	5	5	4	4	6	5	3	3	2	5	4	3
Water Quality Average(May-September)																	
Secchi Disc Transparency (m)	0.6	0.4	0.7	0.6	1.0	1.3	1.3	0.8	0.9	0.7	0.7	0.7	0.8	1.0	1.3	1.1	1.1
Total Phosphorus (ppb)	113	121	96	90	71	56	77	85	72	108	131	95	91	72	83	75	75
Chlorophyll a (ppb)	45	59	59	41	33	23	31	55	36	53	101*	53	55	39	41	46	44

*Aug 28, 2016 data point value of 260 not used

Native Plant Summary for 2022

Three different native aquatic plant species were sampled in 2022. No native submerged aquatic plants were sampled on the meandering survey on May 9, 2022. Curlyleaf pondweed and Eurasian watermilfoil (non-native plants) were found growing out to a depth of 11 feet on May 9, 2022. Coontail and stringy pondweed were the only native submerged aquatic plant species present in the lake on the June 6, 2022 point intercept survey. Results from the June 6, 2022 found that plants grew to a water depth of 10 feet and coontail was found at 54% of the sample sites. Results of the late summer survey (August 10, 2022) found that plants grew to a water depth of 9 feet and chara and coontail were the only native submerged aquatic plant species present in the lake. Results from the August 10 point intercept survey found that plants covered about 56% of the lake and coontail was found at 58% of the sample sites.

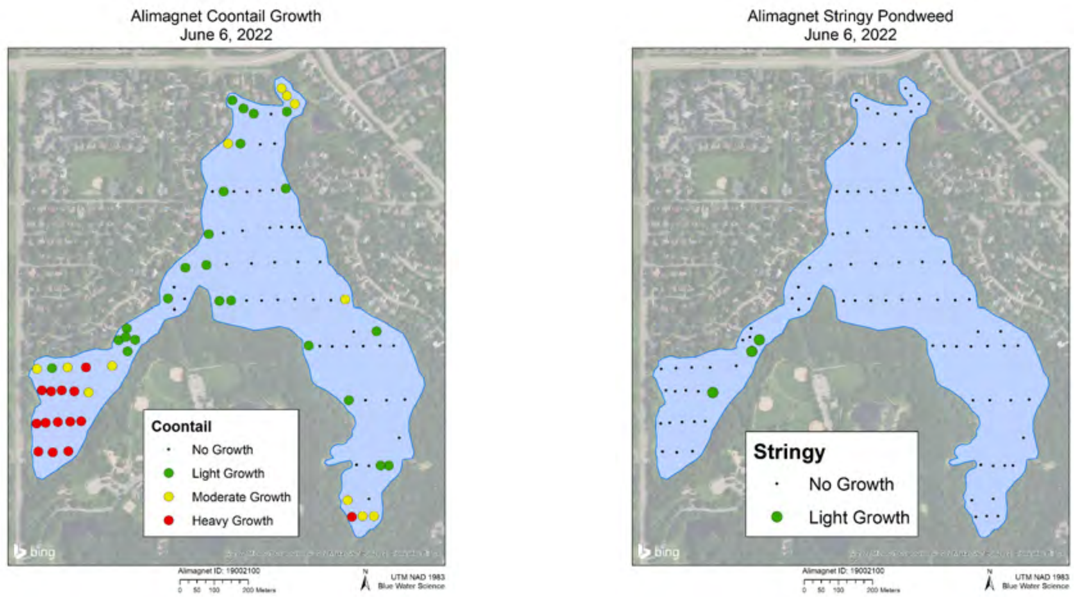


Figure 2. Native plant coverage and abundance maps for the June 6, 2022 survey.
Key: Green dot = light growth, yellow dot = moderate growth, red dot = heavy growth, and black dot = no growth.

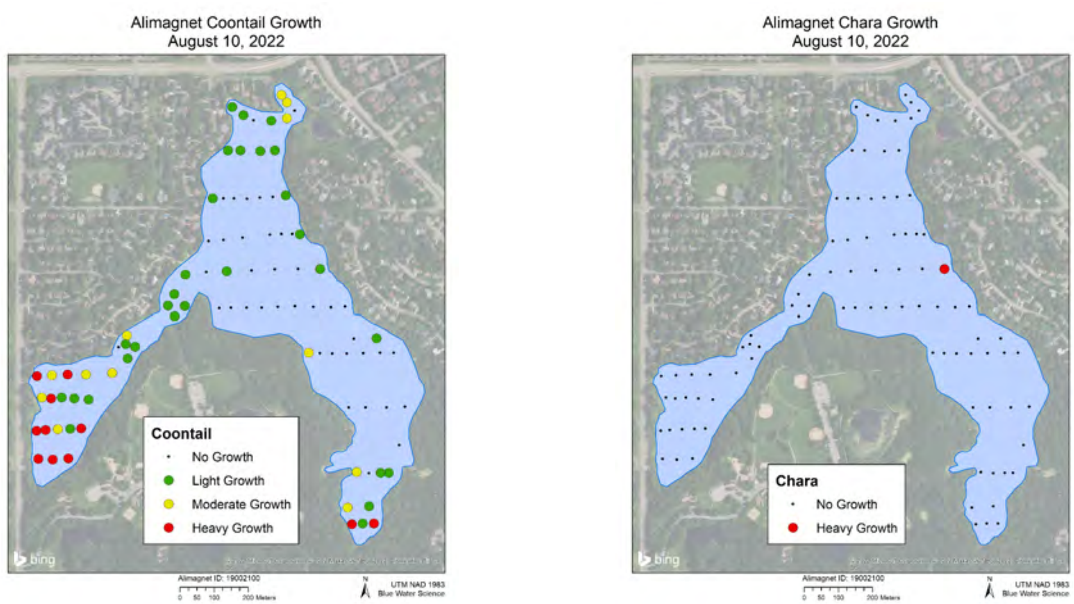


Figure 3. Native plant coverage and abundance maps for the August 10, 2022 survey.
Key: Green dot = light growth, yellow dot = moderate growth, red dot = heavy growth, and black dot = no growth.

General Aquatic Plant Management

Lake Association Control of Curlyleaf Pondweed From 1997-2013: From 1997 through 2013, the Alimagnet Lake Association controlled nuisance curlyleaf pondweed by conducting spring curlyleaf cutting and pulling operations. In 2013, the last year of volunteer curlyleaf control activities, cutting started on May 25 and continued off and on until about June 17. A dumpster was filled with curlyleaf pondweed cuttings over the weekend of June 22/23. Dave Scheerer, Alimagnet Lake Association president, estimated up to 5 acres of curlyleaf was cut by June 17, with cutting conducted close to the shoreline.

Herbicide Control of Curlyleaf Pondweed in 2014-2022: In 2014, an herbicide application was used for curlyleaf control for the first time. In 2015 and 2016, herbicides were used again on about 2 acres each year. In 2017, herbicides were used on 7.3 acres. In 2018 through 2020, there was no herbicide treatment. In 2021, herbicides were used on 1.29 acres. In 2022, herbicides were used on 3.06 acres.

Table 3. Summary of Alimagnet Lake aquatic plant control options.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
CLP Harvesting (acres)	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CLP Herbicides (acres)														

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
CLP Harvesting (acres)	X	X	about 5 ac									
CLP Herbicides (acres)				8 ac	2 ac	2 ac	7.3 ac				1.29 ac	3.06 ac
EWM Herbicides (acres)												3.4 ac

Curlyleaf Pondweed Summary for 2022

Curlyleaf Pondweed Delineation Survey (May 9, 2022): Results of the curlyleaf pondweed delineation (May 9, 2022) using a meandering survey format found curlyleaf was well distributed throughout the east basin and the northern end of the main lake, with a number of sites with stem densities (5 or greater per rake sample). Two areas totaling 3.06 acres was delineated for treatment.

Curlyleaf Pondweed Herbicide Application in 2022: A total of 3.06 acres of curlyleaf were treated with diquat on May 25, 2022.

Early Summer Plant Survey (June 6, 2022): An aquatic plant point intercept survey was conducted on June 6, 2022 in Alimagnet Lake (89 acres) found curlyleaf pondweed at 2 sample sites and at light growth conditions. Curlyleaf pondweed coverage of Alimagnet Lake was about 2% in the early summer of 2022.

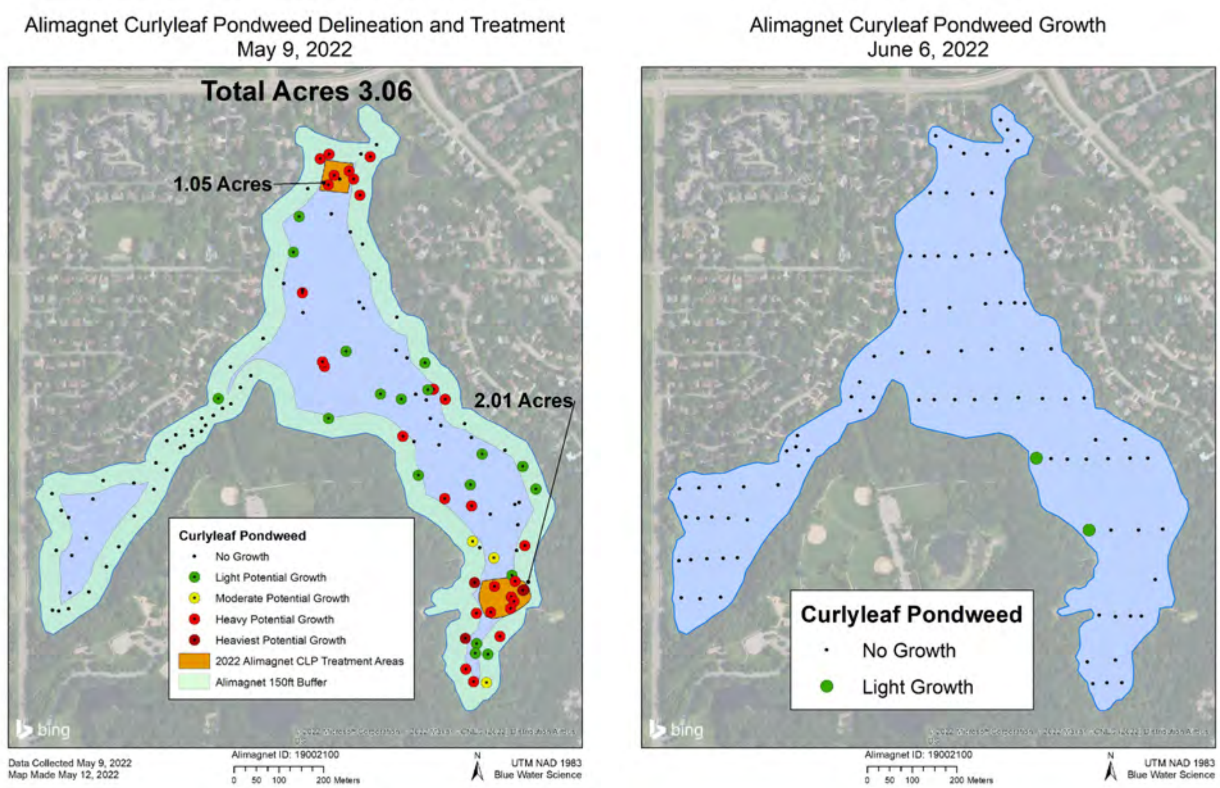


Figure 4. Curlyleaf pondweed coverage and abundance maps for the May 9 and June 6, 2022 surveys.

Eurasian Watermilfoil Summary for 2022

Eurasian Watermilfoil Delineation Survey (May 9, 2022): Results of the Eurasian watermilfoil delineation (May 9, 2022) using a meandering survey format found milfoil at 55 sites.

Eurasian Watermilfoil Herbicide Application in 2022: A total of 3.4 acres of nuisance plants and Eurasian watermilfoil were treated with diquat on May 25, 2022 on the western side of Alimagnet Lake.

Results of the June 6, 2022 Plant Survey: Results of the early season aquatic plant point intercept survey conducted on June 6, 2022 found that EWM was sampled at 33 sites in Alimagnet Lake. EWM coverage was about 36% of the area of Alimagnet Lake. The maximum depth of EWM growth was 10 feet (Figure 5).

Results of the August 10, 2022 Plant Survey: Results of the late season aquatic plant point intercept survey conducted on August 10, 2022 found that EWM was sampled at 9 sites in Alimagnet Lake. EWM coverage was about 10% of the area of Alimagnet Lake. The maximum depth of EWM growth was 8 feet (Figure 5).

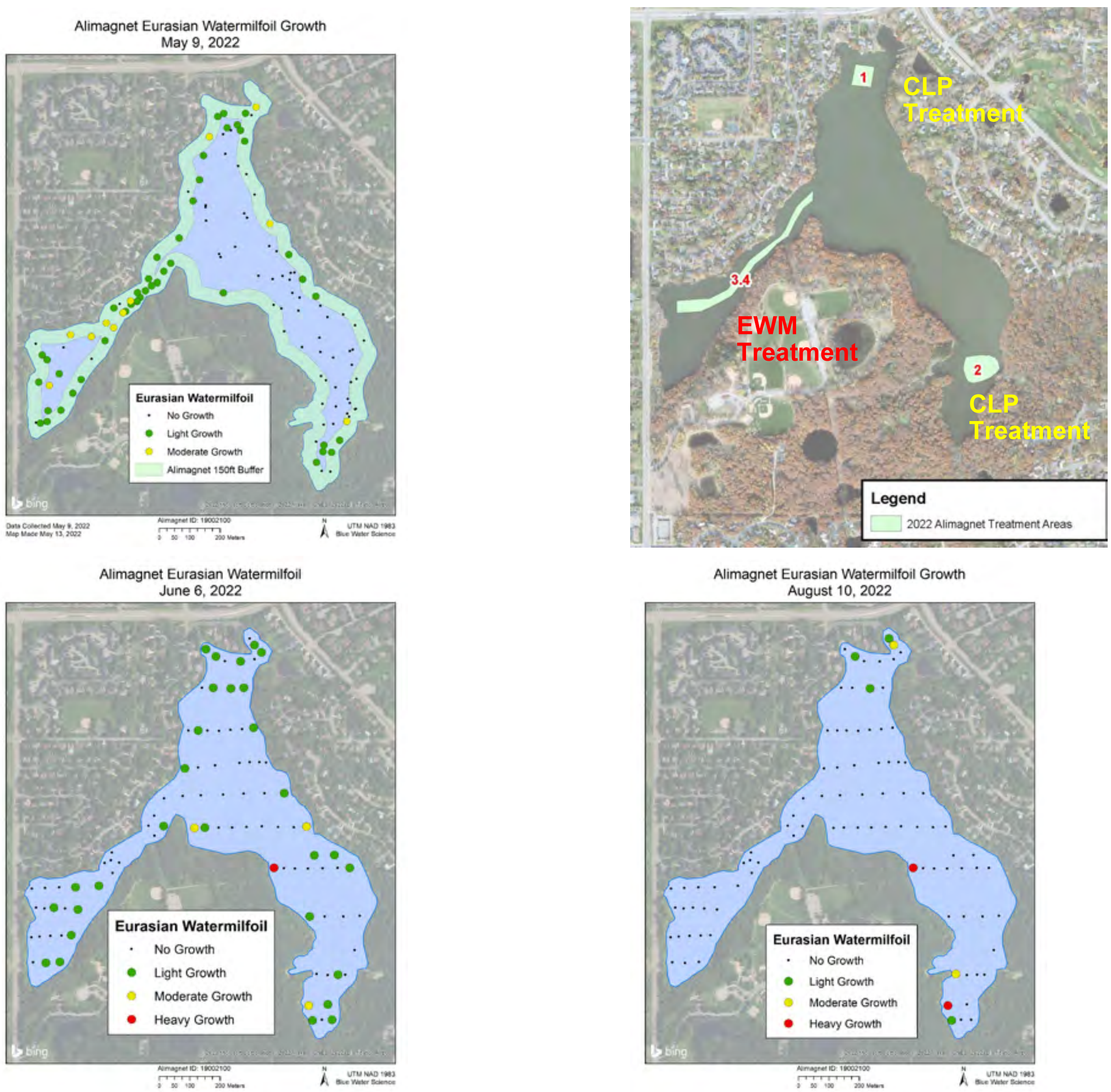


Figure 5. Eurasian watermilfoil coverage and abundance maps for the May 9, June 6, and August 10, 2022 surveys. EWM treatment occurred on 3.4 acres on May 25, 2022 and is shown in the upper right map.

APPENDIX

Methods

An early season meandered curlyleaf pondweed delineation was conducted on May 9, 2022 and aquatic plant point intercept surveys were conducted on June 6 and August 10, 2022. The point intercept survey consisted of 92 points that were distributed throughout the 89 acre lake (Figure 6). Sample sites averaged a distance of 64 m between points.

Based on these plant survey results, plant distribution maps were constructed and results from 2022 were compared to past surveys.

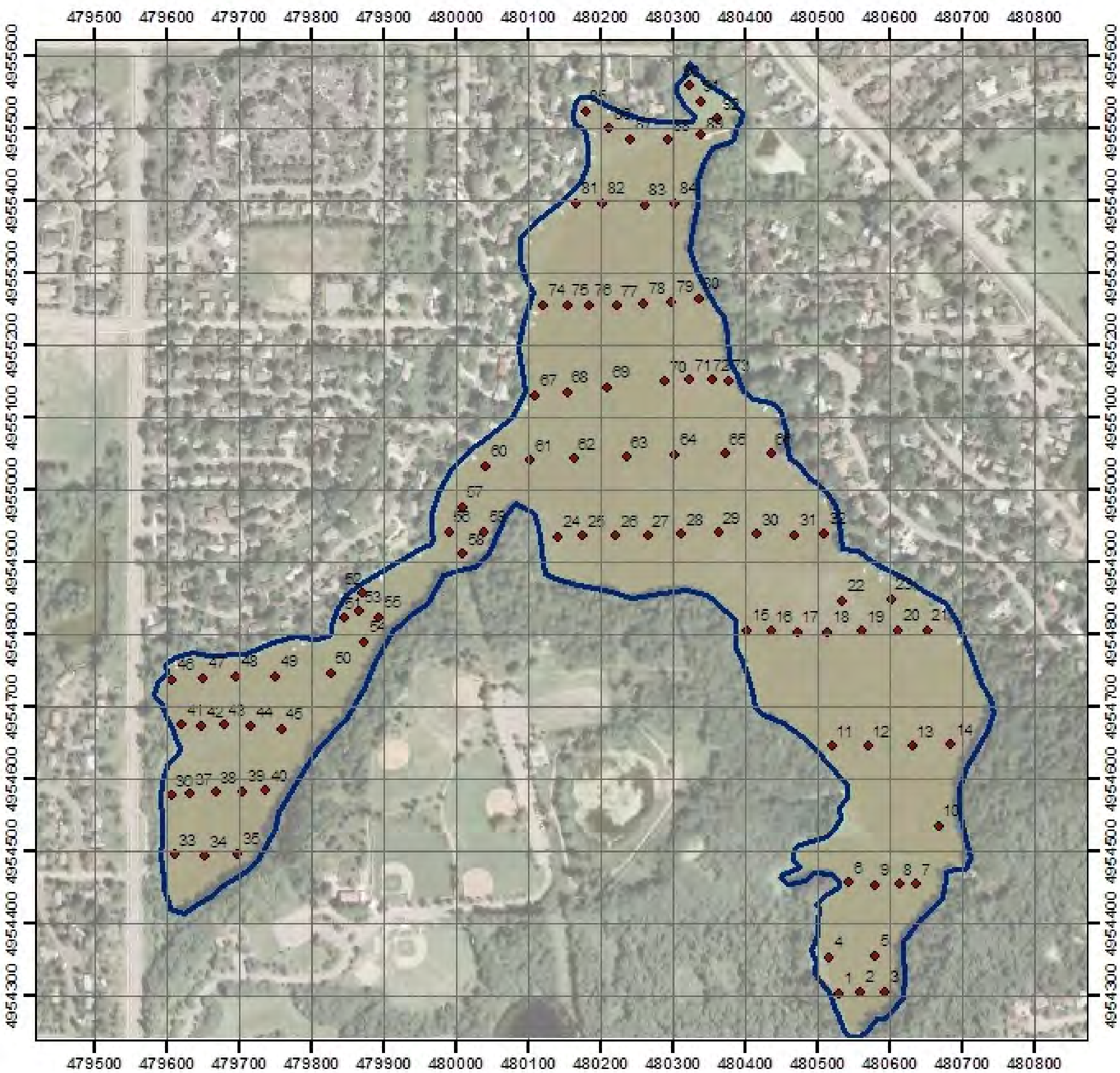


Figure 6. Point locations for 2022 surveys.

Results of the May 9, 2022 Plant Survey

Table 4. Individual meandering survey data for Alimagnet Lake for May 9, 2022. For CLP the number associated with the plants is a stem count on the rake.

Site	Depth (ft)	CLP	EWM
1	4		1
2	7		1
3	7		1
4	7		1
5	6		1
6	6		1
7	7		1
8	6		1
9	7		1
10	7		2
11	6		2
12	6		1
13	6		
14	7		1
15	6		1
16	6		1
17	6		1
18	6		1
19	5		
20	7		1
21	6		1
22	7		2
23	6		1
24	5		1
25	6		1
26	5		
27	7		
28	7		2
29	7		2
30	6		2
31	6		1
32	6		
33	6		2
34	5		1
35	6	1	1
36	6		1
37	8		1
38	10		
39	10	6	
40			
41	7		1
42	9		
43	7	1	1
44	9	2	1
45	5		2
46	8	5	
47	8	7	1
48	6	4	1
49	6	5	1
50	7	6	1
51	6		1
52	3		2
53	5	8	
54	8		
55	8	5	1
56	8	5	1
57	10		
58	9		
59			
60	10		
61			
62	11		
63	7		2
64			
65			
66	8	2	1
67	10	6	
68	10	2	
69			
70	11		
71	9	7	1
72	11		
73			
74	6		1
75			
76	10	1	
77			
78	10	1	
79	9	1	
80			
81	10		
82			
83	10	4	
84	10		
85	9	3	
86	10	2	
87	8	23	
88	8	30	
89	9	7	
90	9	7	
91	8	4	
92	9	16	
93	8	5	2
94	8	7	
95	8	12	1
96	8	2	1
97	8	1	1
98	8	2	1
99	7	3	
100	7	6	
101	7	5	1
102	9	18	
103	9	15	
104	8	24	
105			
106	9	3	
107			
108	11	5	
109	10	8	
110	9	2	
111			
112			
113	10	5	
114	11	2	
115	8	1	1
116	11	6	
117	11	4	
118	11	1	
119	10	2	
120	11	2	
Average		6.0	1.2
Occurrence (120 sites)		52	55

Results of the June 6, 2022 Plant Survey

Table 5. Individual point intercept data for Alimagnet Lake for June 6, 2022. The number associated with the plants is a density rating on a scale from 1 to 3 with 3 the most dense.

Site	Depth (ft)	Coontail	Curlyleaf	EWM	Stringy	No plants
1	7	3		1		
2	7	2				
3	6	2		1		
4	7	2		2		
5	8			1		
6	7					1
7	8	1				
8	9	1		1		
9	8					1
10	9					1
11	9	1	1	1		
12	10					1
13	10					1
14	9					1
15	5	1	1	3		
16	9					1
17	11					1
18	11					1
19	11					1
20	11					1
21	10			1		
22	9			1		
23	8	1		1		
24	8	1		2		
25	9	1		1		
26	10					1
27	10					1
28	10					1
29	11					1
30	11					1
31	10					1
32	7	2		2		
33	6	3				
34	6	3		1		
35	6	3		1		
36	6	3				
37	6	3				
38	6	3				
39	7	3				
40	7	3		1		
41	5	3				
42	6	3				
43	7	3		1		
44	7	3				
45	7	2		1	1	
46	4	2				
47	5	1				
48	6	2				
49	6	3		1		
50	7	2		1		
51	6	1				
52	6	1				
53	6	1				
54	6	1			1	
55	6	1			1	
56	6	1				
57	6					1

Table 5. Individual point intercept data for Alimagnet Lake for June 6, 2022. The number associated with the plants is a density rating on a scale from 1 to 3 with 3 the most dense.

Site	Depth (ft)	Coontail	Curlyleaf	EWM	Stringy	No plants
58	5					1
59	6			1		
60	6	1				
61	8	1				
62	10					1
63	11					1
64	10					1
65	11					1
66	8			1		
67	7	1		1		
68	10					1
69	11					1
70	11					1
71	11					1
72	11					1
73	6					1
74	6					1
75	7	1		1		
76	9					1
77	10					1
78	10					1
79	11					1
80	8	1		1		
81	3	2				
82	4	1		1		
83	8			1		
84	8			1		
85	4	1		1		
86	5	1		1		
87	6	1				
88	7			1		
89	4	1				
90	3	2				
91	3	2		1		
92	3	2		1		
Average		1.8	1.0	1.2	1.0	
Occurrence (92 sites)		50	2	33	3	34
% occurrence		54	2	36	3	

Results of the August 10, 2022 Plant Survey

Table 6. Individual point intercept data for Alimagnet Lake for August 10, 2022. The number associated with the plants is a density rating on a scale from 1 to 3 with 3 the most dense.

Site	Depth (ft)	Chara	Coontail	EWM	FA-benthic	FA-floating	No plants
1	6		3	1		3	
2	7		1			1	
3	7		3				
4	6		2	3			
5	7		1			2	
6	5		2	2			
7	7		1				
8	8		1				
9	8						1
10	8						1
11	9						1
12	10						1
13	10						1
14	9						1
15	4		2	3			
16	9						1
17	10						1
18	10						1
19	10						1
20	10						1
21	9						1
22	10						1
23	8		1				
24	8						1
25	9						1
26	9						1
27	10						1
28	10						1
29	10						1
30	10						1
31	11						1
32	7						1
33	4		3			1	
34	6		3			1	
35	4		3			1	
36	3		3			2	
37	6		3				
38	7		2				
39	7		1				
40	6		3			1	
41	5		2				
42	6		3				
43	6		1				
44	7		1				
45	7		1				
46	3		3			1	
47	5		2				
48	5		3				
49	6		2				
50	6		2				
51	5						1
52	5		2				
53	6		1				
54	6		1				
55	6		1				
56	6		1				1
57	6		1				
58	6		1				
59	5		1				
60	6		1				
61	8						1
62	9		1				
63	10						1

Table 6. Individual point intercept data for Alimagnet Lake for August 10, 2022. The number associated with the plants is a density rating on a scale from 1 to 3 with 3 the most dense.

Site	Depth (ft)	Chara	Coontail	EWM	FA-benthic	FA-floating	No plants
64	11						1
65	10						1
66	7	3	1				
67	7						1
68	10						1
69	10						1
70	11						1
71	10						1
72	10						1
73	7		1				
74	5		1				
75	9						1
76	10						1
77	10						1
78	10						1
79	10						1
80	7		1		1		
81	4		1				
82	7		1		1	1	
83	8		1	1			
84	7		1				
85	3		1		2		
86	5		1	1	2		
87	6						1
88	6		1		2		
89	4		2		2		
90	2		2	1		2	
91	2		2	2		2	
92	3		2	1	1	1	
Average		3.0	1.7	1.7	1.6	1.5	
Occurrence (92 sites)		1	53	9	7	13	40
% occurrence		1	58	10	8	14	

Table 7. Alimagnet Lake aquatic plant occurrences and densities for the point intercept surv eys in 2022. Density ratings are 1-3 with 1 being low and 3 being most dense.

	Alimagnet Lake Early Season Point Intercept Survey (n=92) June 6, 2022			Alimagnet Lake Late Season Point Intercept Survey (n=92) August 10, 2022		
	Occur	% Occur	Density	Occur	% Occur	Density
Coontail (*Ceratophyllum demersum*)	50	54	1.8	53	58	1.7
Chara (*Chara sp*)				1	1	3.0
Eurasian watermilfoil (*Myriophyllum spicatum*)	33	36	1.2	9	10	1.7
Curlyleaf pondweed (*Potamogeton crispus*)	2	2	1.0			
Stringy pondweed (*P. sp*)	3	3	1.0			
Filamentous algae Floating				20	22	1.6
Number of submerged plant species	4			4		
Herbicide treatment	3.06 ac					
Water Quality (CAMP data)(May-Sept)						
Secchi disc (m)	1.1					
Total phosphorus (ppb)	75					
Chlorophyll a (ppb)	44					

Appendix B

Summary of Fish Surveys in Alimagnet Lake

Black Bullhead Caught in Alimagnet Lake in October 2020

Summary of Fish Surveys in Alimagnet Lake (ID #19-0021-00), Burnsville and Apple Valley, Minnesota for 2005 - 2020

Fish Survey: October 13-15, 2020
MnDNR Permit Number: 29777

Submitted to:
Cities of Apple Valley and Burnsville and MnDNR

Prepared by:
Steve McComas
Blue Water Science
St. Paul, MN 55116

February 1, 2021

Summary of Fish Surveys in Alimagnet Lake (ID #19-0021-00), Burnsville and Apple Valley, Minnesota, 2005 - 2020

Summary

Review of Fish Trapnet Surveys from 2000 Through 2020: The fish community of Alimagnet Lake has been manipulated and monitored over the years with a fish removal program in place from 2005-2012 plus 9,000 channel catfish were stocked in 2007, then 1,000 largemouth bass were stocked in 2008, and 2,000 largemouth bass fingerlings were stocked in 2016. Results of fish surveys conducted since 2000 are shown in Table S1.

Bullheads were removed from Alimagnet from 2005 through 2009, black crappies from 2008 through 2012, and bluegills from 2006 through 2012. The average bullhead catch per trapnet was less in 2020 compared to 2005 which was a lake management objective. Bluegill numbers peaked in 2015 and have declined since then. Yellow perch increased in 2011 and 2012 compared to previous years but then were lower in 2013-2020. For gamefish, northern pike numbers have gone down since 2005 whereas largemouth bass numbers have stayed about the same over the duration of the program. Channel catfish were not sampled in 2017, 2018, and 2020 and they may be scarce in Alimagnet Lake.

Sunfish sampled from one net in Alimagnet Lake in 2020.

Fish Trapnet Survey Results for 2000-2020

Table S1. Trapnet data represents fish caught per net. Data are for standard trapnet siz es. Black bullheads have been removed from 2005-2009 and bluegills from 2006-2012. Years of fish remov al are highlighted with yellow shading.

	2000 (fish/lift) (MnDNR)	2005 (fish/lift) (BWS) (n=24)	2006 (fish/lift) (BWS) (n=80)	2007 (fish/lift) (BWS) (n=112)	2008 (fish/lift) (BWS) (n=80)	2009 (fish/lift) (BWS) (n=80)	2010 (fish/lift) (BWS) (n=18)	2011 (fish/lift) (BWS) (n=12)	2012 (fish/lift) (BWS) (n=12)
Bluegill sunfish	4	193	96	132	103	108	54	128	59
Black bullhead	84	50	35	14	19	4.5	4.0	1.1	0.3
Black crappie	5	16	13	24	52	33	16	15	7.3
Channel catfish	0	0	0	0	0.5	0.3	0	0.1	0.1
Golden shiner	0	0	0	0	0	0	0	0	0.1
Green sunfish	0	0	0	0	0	0	0	0	0.1
Hybrid sunfish	0	0	0	0	0	0	0	0	0
Largemouth bass	0.5	0.5	0.6	0.4	0.3	0.1	0.2	0.7	0
Madtom	0	0	0	0	0	0	0	0	0
Northern pike	3.9	0.7	0.5	0.3	0.3	0.2	0.3	0.1	0
Pumpkinseed	0	0	0	0	0	0	2.7	16	7.3
Walleye	0.3	0.04	0	0	0	0	0	0	0
White sucker	0	0.4	0.1	0.1	0.01	0.1	0	0.3	0
Yellow bullhead	0	0	0	0	0	0	0	0	0
Yellow perch	0	0.5	1.1	1	0.4	1.1	0.3	13	7.9
Number of Fish Species	6	8	7	7	8	8	7	9	8

	2013 (fish/lift) (BWS) (n=12)	2014 (fish/lift) (BWS) (n=12)	2015 (fish/lift) (BWS) (n=12)	2016 (fish/left) (BWS) (n=12)	2017 (fish/lift) (BWS) (n=12)	2018 (fish/lift) (BWS) (n=12)	2020 (fish/lift) (BWS) (n=12)
Bluegill sunfish	202	202	306	139	88	106	171
Black bullhead	0.7	0.3	1.1	0.7	0.3	0.2	0.2
Black crappie	49	60	37	45	56	7.8	27
Channel catfish	0.1	0.4	0.2	0.1	0	0	0
Golden shiner	0	0	0.2	0.1	0.1	0	0
Green sunfish	0.1	0.1	0	0	0	0.8	0
Hybrid sunfish	0.8	0.6	0	0	0	0.8	1.0
Largemouth bass	0.3	0.2	0.5	0.3	0	0.4	0.4
Madtom	0	0	0	0	0	0.1	0
Northern pike	0.4	0.2	0.4	0	0.3	0	0.1
Pumpkinseed	15	11	3.1	2.6	4.7	4.8	12
Walleye	0	0	0	0	0	0	0
White sucker	0.1	0	0.2	0	0.1	0	0
Yellow bullhead	0	0.1	0	0	0	0	0
Yellow perch	0.7	0.3	0.2	0.1	0.1	0.1	0.3
Number of Fish Species	11	11	10	8	8	9	8

Fish Removal Summary: In efforts to improve water quality in Alimagnet Lake, the Cities of Apple Valley and Burnsville sponsored bullhead and sunfish removal projects from 2005 through 2012. Approximately 179 pounds of fish per lake acre were removed over the 8-year period from 2005 through 2012, for a total of 17,866 pounds of fish (Table S2). Nearly ten times as many bluegills were removed compared to bullheads, but the bluegill biomass is only about four times that of the bullhead biomass (Table S2). In addition, over two thousand pounds of crappies were removed from 2008 - 2012 and restocked into area lakes and ponds. No fish were removed in 2013 through 2020.

Table S2. Summary of fish removed from Alimagnet Lake from 2005-2012.

	Black Bullheads		Bluegills		Crappies		Totals		Fish Removal per Lake Acre (100 ac lake)
	number	pounds	number	pounds	number	pounds	number	pounds	
2005	739	231	0	0	0	0	739	231	2
2006	2,777	868	7,711	918	0	0	10,488	1,786	18
2007	1,464	488	14,610	1,948	0	0	16,074	2,436	24
2008	2,972	1,010	14,303	1,607	1,694	242	18,969	2,859	29
2009	649	259	13,804	1,980	907	162	15,360	2,401	24
2010	--	--	16,083	2,681	3,894	719	19,977	3,400	34
2011	--	--	10,219	2,237	3,738	1,041	13,357	3,278	33
2012*	--	--	6,220	1,349	540	126	6,760	1,475	15
Totals	**8,601**	**2,856**	**82,950**	**12,720**	**10,773**	**2,290**	**102,324**	**17,866**	**179**

* Yellow perch removal: 185 fish at 34 pounds in 2012

Fish Community Responses to Fish Removal and Fish Stocking: Fish removal efforts from 2005 through 2012 appear to have temporarily reduced numbers of bluegill sunfish over that time period based on the number of fish caught per trapnet set. Crappies increased in 2007 and 2008, then leveled off for a few years, although there were less crappies in 2018 (Figure S1). Bluegill sunfish increased from 2013 through 2015 and dropped off in 2016 and again in 2017 but were slightly higher in 2018 and 2020. Black bullhead numbers have remained low from 2009 - 2020 (Figure S1).

Fish Abundance and Total Lengths

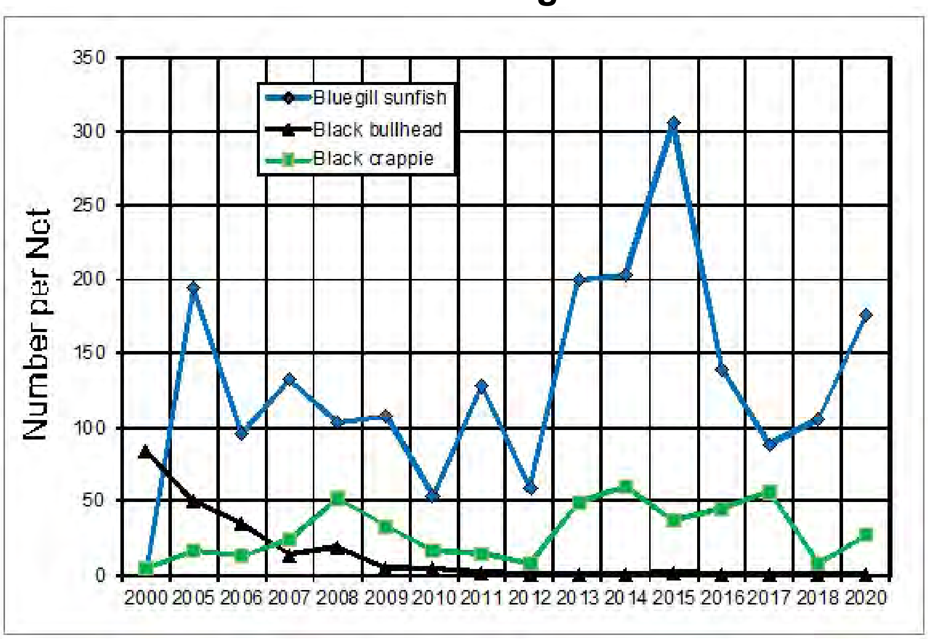


Figure S1. Fish abundance as measured with fish per trapnet from 2000 through 2018 and 2020.

Lake Water Quality: A winter aerator was installed in Alimagnet Lake over the winter of 1999-2000. Prior to the aerator installation, winter fish kills occasionally occurred resulting in temporary water quality improvements. With winter aeration, a winterkill has not been detected since 2000. Winter aeration initially sustained a fishery dominated by bullheads and sunfish. Since fish removal started in 2005 and catfish stocking in 2007 and water clarity peaked in 2011 and 2012 and declined for a few years with gradual increases in clarity since 2018 (Figure S2).

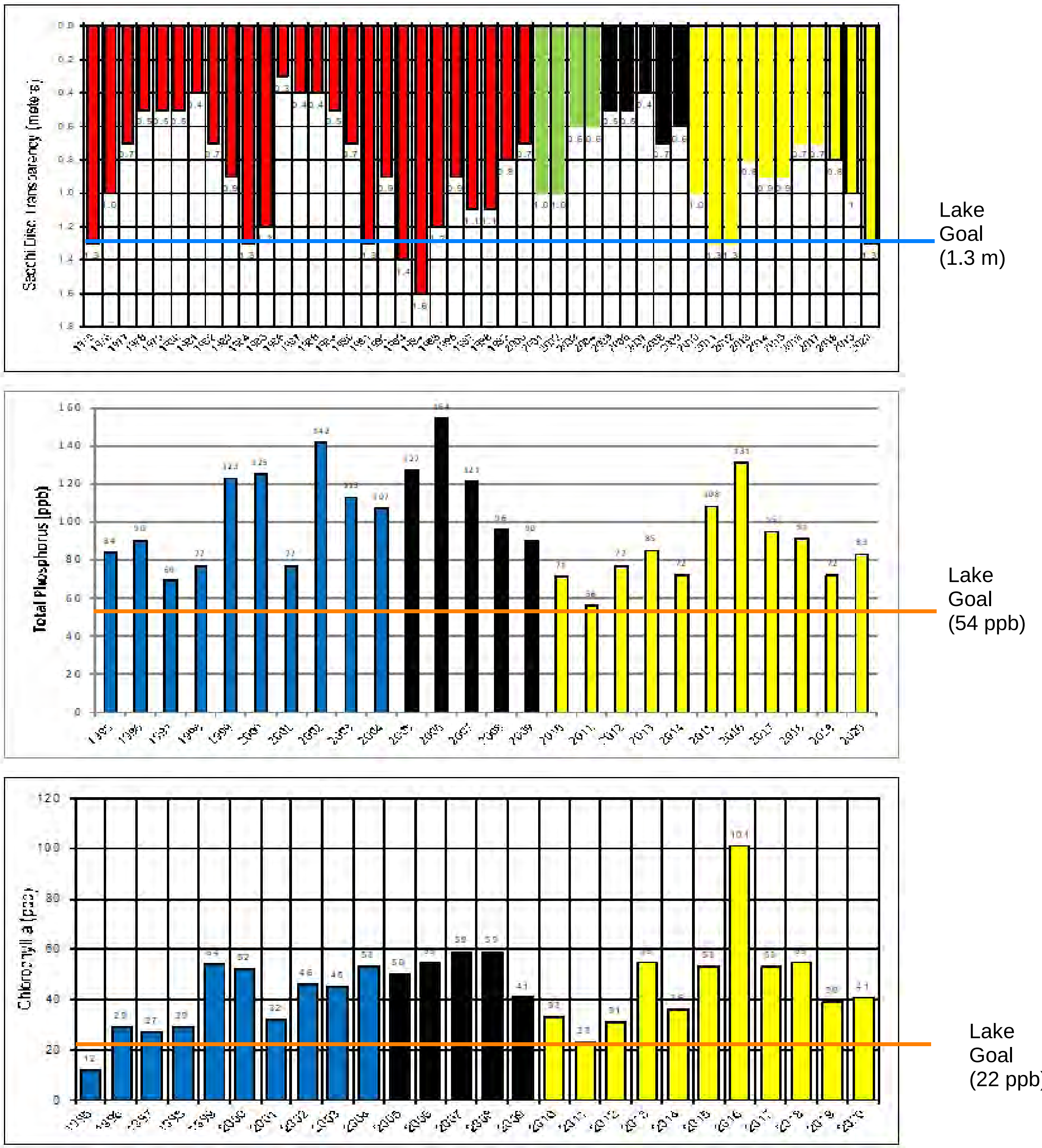


Figure S2. Seasonal water quality data for Alimagnet Lake. Seasonal average is from May - September. Data are from the Met Council CAMP program. Black bars indicate five years of improvement project implementation and the yellow bar represents maintenance projects occurring.

Observations and Conclusions

1. In 2007, 9,000 channel catfish were stocked. They gradually increased in size up to 2016. However, their abundance is relatively unknown at this time.
2. In 2008, 1,000 largemouth bass were stocked and in 2016, 2,000 largemouth bass were stocked. In 2020, another 1,000 largemouth bass were stocked. However, largemouth bass abundance has been sparse over the years with minor spawning evidence.
3. As of 2012, 179 pounds of fish/acre have been removed. This is over the removal goal of 100 pounds of fish per lake acre for a total of 10,000 pounds (based on a 100 acre lake). Water quality had fluctuated since 2011.
4. In 2012, bluegill sunfish and black crappie numbers were less than 2011 catch rates, but there was an increase in smaller lengths in 2012 compared to 2011. The increase in smaller lengths with higher numbers of fish continued in 2013, 2014, and 2015. It may be that the abundant vegetation was serving as a refuge for smaller fish.
5. The Alimagnet fish community, from a sport fishery perspective, is in good shape. Bluegill abundance is above average. If largemouth bass are to become established, stocking at 1 pound per acre (100 lbs) or 4,000 fish may be needed to establish a significant bass population.
6. From a water quality perspective, fish do not appear to be adversely impacting water quality. Other factors may be contributing to phosphorus loading including unmonitored runoff or phosphorus translocation by rising benthic algae off lake sediments.

Channel catfish caught in 2017. The catfish stocked in 2007 would now be about 11 years old in 2018. Channel catfish live for about 15 years.

Summary of Fish Surveys in Alimagnet Lake (ID #19-0021-00), Burnsville and Apple Valley, Minnesota for 2005 - 2020

Lake size: 89 ac (MnDNR)
Littoral area: 89 ac (MnDNR)
Maximum depth: 11.5 ft (MnDNR)

Introduction

Alimagnet Lake (ID # 19-0021) is an 89-acre lake located in Apple Valley and Burnsville, Minnesota. Alimagnet Lake has had fluctuating water quality conditions over the last 30 years. Alimagnet Lake has a moderately-sized watershed of 1,094 acres which is 11 times bigger than the lake surface area. Because of this relatively small watershed size there is the potential for good water quality. However, Alimagnet Lake has experienced poor water quality conditions over the years. An organic carbon amendment, using crushed corn, was applied over the summers of 2005 and 2006 with the objective to reduce lake phosphorus concentrations and improve water clarity. However, little water quality improvement was noted. It was speculated in 2005 that a previous winterkill in the 1990s, with a resulting rebound in an unbalanced fish community, could adversely be impacting lake water quality. A fish survey in 2005 documented high densities of bluegill sunfish and black bullheads.

From 2005 through 2012 there has been a fish removal program that included black bullheads, bluegill sunfish, and black crappies over various years. Channel catfish and largemouth bass have also been stocked. The objective was to use a fish removal program combined with stocking to help improve lake water quality. In 2020, a fish survey was conducted to evaluate the current fishery after 9 years of fish removal and after the stocking of largemouth bass and channel catfish.

Fish Survey Methods

In 2020, a fish survey used a total of 6 trapnets set for 2 nights from October 14-15, 2020. The standard-sized trapnet was a MnDNR-style with a 4 x 6 foot square frame with five hoops, two throats and a 50-foot lead. The net mesh size was ½ inch (bar length). Locations of the trapnets in Alimagnet Lake are shown in Figure 1. All fish that were captured were recorded and released back into Alimagnet Lake.

Trapnets have been used to remove fish in Alimagnet Lake from 2005-2012. Both the MnDNR (2006-2012) and Blue Water Science (2005-2009) have removed fish (Figure 2). No fish removal has been conducted from 2013 through 2020.

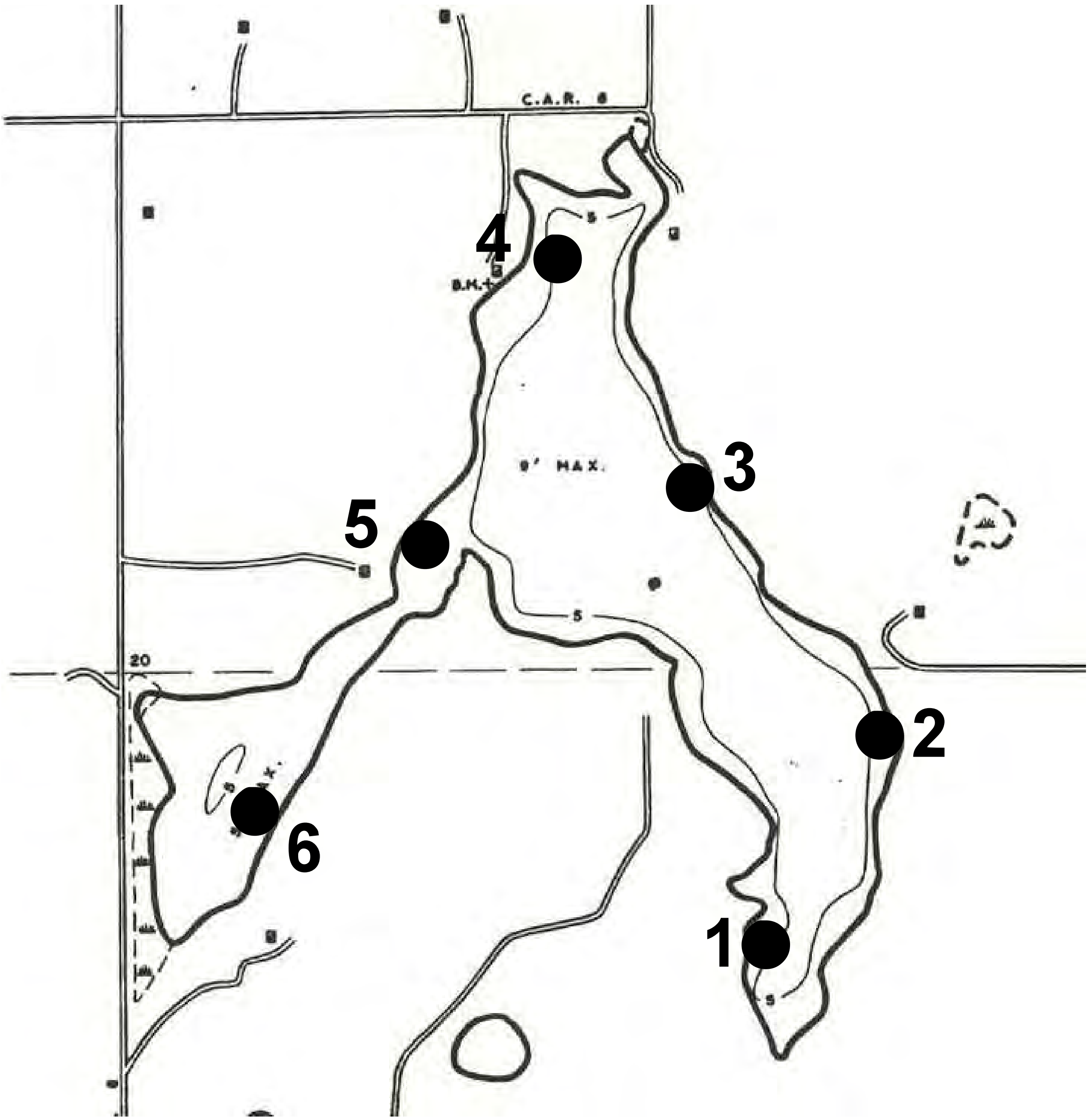


Figure 1. Trapnet locations for the fish survey in Alimagnet Lake in 2020. These are the same locations that have been used for the last few years.

Figure 2. [top] A trapnet is a live fish trap. Fish run into the 50-foot lead net and follow it to the back of the net through a series of hoops with funnel mouths. Fish end up in the back hoop. This net is on the shoreline. The back hoop is tied to a tree and the lead is being stretched out so the full net can be seen.
[bottom] Fish are removed from the back hoop and transferred to tubs. Then the fish are counted and measured and returned to the lake.

Results

Fish Survey Catch Rates in 2020

In October, Blue Water Science conducted a fish survey using 6 trapnets set over 2 nights for a total of 12 sets. Results for each net on each day are shown in Table 1.

Table 1. Alimagnet Lake trapnet results for the fish survey conducted in October 14-15, 2020. All fish were included in these counts.

	Fish Captured (October 14-15, 2020)												Total Catch	2020 Fish per Net (n=12)	Normal Range (MnDNR)
	Net 1		Net 2		Net 3		Net 4		Net 5		Net 6				
	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2			
Black bullhead (*Ameiurus melas*)		1							1				2	0.2	2.2 - 60.5
Black crappies (*Pomoxis nigromaculatus*)	10	8	41	219	4	12	3		18	9	3		327	27	2.4 - 15.1
Bluegill sunfish (*Lepomis macrochirus*)	305	56	141	145	50	79	129	49	755	332	58	13	2,112	176	1.9 - 29.5
Hybrid sunfish (*Lepomis sp*)		2	8	2								1	13	1.1	NA
Largemouth bass (*Micropterus salmoides*)			1	1					3				5	0.4	0.3 - 1.2
Northern pike (*Esox lucius*)					1								1	0.1	NA
Pumpkinseed sunfish (*Lepomis gibbosus*)	26	5	12	13	1	6	17	4	30	24	6		144	12	0.8 - 8.4
Yellow perch (*Perca flavescens*)				2					1				3	0.3	0.8 - 6.2
TOTAL FISH	341	72	203	382	56	97	149	53	808	365	67	14	2,607	217	

Length Frequencies in 2020

Fish lengths for all fish species are shown in Table 2. Black bullheads were scarce. Black crappies were common but relatively small with most fish less than 7.5 inches. Bluegills were abundant with a majority of fish were in the 6.5-7 inch category. Northern pike were the longest fish in Alimagnet.

Table 2. Length frequency of fish species (as total length) for the Alimagnet Lake fish survey on October 14-15, 2020. Fish in the yellow shading were considered to be young of the year and were not included in the statistics.

	Black bullhead	Black crappie	Bluegill	Hybrid sunfish	Largemouth Bass	Northern pike	Pumpkinseed	Yellow perch
<3			58	1			3	
3		1						
3.5		1	7				1	
4		2	24				2	
4.5			10				13	
5		2	32	1	1		6	
5.5		7	42	2	1		15	
6		7	70	1			34	
6.5		4	172	1			44	
7		33	128	4			25	
7.5		47	6	2	1		1	
8		24			1			1
8.5		1		1				2
9		2						
9.5								
10	2	1						
11								
12								
13								
14								
15								
16								
17								
18								
19					1			
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								
32								
33								
34								
35						1		
Measured	**2**	**132**	**491**	**12**	**5**	**1**	**141**	**3**
Counted		195	1,563					
TOTAL	**2**	**327**	**2,054**	**12**	**5**	**1**	**141**	**3**
fish/ net (12 nets)	0.2	27	171	1.0	0.4	0.1	12	0.3

Fish Trap Data Summary for 2000-2020

Results of the trapnet data from 2000 to 2020 may reflect influences of fish removal, stocking and the aquatic plant status. After bluegill removal was concluded at the end of 2012, bluegill numbers have been increasing since 2013 but in 2016 and 2017 bluegill numbers decreased (Table 3). In 2020 bluegill numbers were higher than in 2016-2018 but not as high as 2015.

Gamefish abundance has been relatively low based on trapnet results. A northern pike was found in the 2020. Largemouth bass were sampled at 0.4 fish per net and has been relatively unchanged for a number of years. It may be that there are not enough predators to keep bluegill numbers in check.

Table 3. Trapnet data represents fish caught per net. Data are for standard trapnet siz es. Black bullheads have been removed from 2005-2009 and bluegills from 2006-2012. Years of fish remov al are highlighted with yellow shading.

	2000 (fish/lift) (MnDNR)	2005 (fish/lift) (BWS) (n=24)	2006 (fish/lift) (BWS) (n=80)	2007 (fish/lift) (BWS) (n=112)	2008 (fish/lift) (BWS) (n=80)	2009 (fish/lift) (BWS) (n=80)	2010 (fish/lift) (BWS) (n=18)	2011 (fish/lift) (BWS) (n=12)	2012 (fish/lift) (BWS) (n=12)
Bluegill sunfish	4	193	96	132	103	108	54	128	59
Black bullhead	84	50	35	14	19	4.5	4.0	1.1	0.3
Black crappie	5	16	13	24	52	33	16	15	7.3
Channel catfish	0	0	0	0	0.5	0.3	0	0.1	0.1
Golden shiner	0	0	0	0	0	0	0	0	0.1
Green sunfish	0	0	0	0	0	0	0	0	0.1
Hybrid sunfish	0	0	0	0	0	0	0	0	0
Largemouth bass	0.5	0.5	0.6	0.4	0.3	0.1	0.2	0.7	0
Madtom	0	0	0	0	0	0	0	0	0
Northern pike	3.9	0.7	0.5	0.3	0.3	0.2	0.3	0.1	0
Pumpkinseed	0	0	0	0	0	0	2.7	16	7.3
Walleye	0.3	0.04	0	0	0	0	0	0	0
White sucker	0	0.4	0.1	0.1	0.01	0.1	0	0.3	0
Yellow bullhead	0	0	0	0	0	0	0	0	0
Yellow perch	0	0.5	1.1	1	0.4	1.1	0.3	13	7.9
Number of Fish Species	6	8	7	7	8	8	7	9	8

	2013 (fish/lift) (BWS) (n=12)	2014 (fish/lift) (BWS) (n=12)	2015 (fish/lift) (BWS) (n=12)	2016 (fish/left) (BWS) (n=12)	2017 (fish/lift) (BWS) (n=12)	2018 (fish/lift) (BWS) (n=12)	2020 (fish/lift) (BWS) (n=12)
Bluegill sunfish	202	202	306	139	88	106	171
Black bullhead	0.7	0.3	1.1	0.7	0.3	0.2	0.2
Black crappie	49	60	37	45	56	7.8	27
Channel catfish	0.1	0.4	0.2	0.1	0	0	0
Golden shiner	0	0	0.2	0.1	0.1	0	0
Green sunfish	0.1	0.1	0	0	0	0.8	0
Hybrid sunfish	0.8	0.6	0	0	0	0.8	1.0
Largemouth bass	0.3	0.2	0.5	0.3	0	0.4	0.4
Madtom	0	0	0	0	0	0.1	0
Northern pike	0.4	0.2	0.4	0	0.3	0	0.1
Pumpkinseed	15	11	3.1	2.6	4.7	4.8	12
Walleye	0	0	0	0	0	0	0
White sucker	0.1	0	0.2	0	0.1	0	0
Yellow bullhead	0	0.1	0	0	0	0	0
Yellow perch	0.7	0.3	0.2	0.1	0.1	0.1	0.3
Number of Fish Species	11	11	10	8	8	9	8

Length Frequency Analysis from 2005 to 2018 and 2020

Overall, the bluegill population was small-sized in 2005 and only 6% of the bluegills were 6-inches or greater. In 2016, 51% were 6 inches or greater (Table 4). Bluegills may be slightly increasing in length in 2015 compared to 2014. Black crappies have increased in number since 2005 but their average length has decreased slightly.

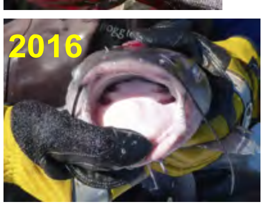
Table 4. Length frequency of bluegill, black bullhead, and black crappies (total length). Blue shading represents dominant length.

Size Range (inches)	Bluegill							Black Bullhead								Black Crappie							
	2005 (10% measure) (n=486)	2012 (100% measure) (n=713)	2015 (4% measure) (n=147)	2016 (12% measure) (n=206)	2017 (50% measure) (n=523)	2018 (54% measure) (n=1267)	2020 (26% measure) (n=491)	2005 (14% measure) (n=171)	2012 (100% measure) (n=4)	2015 (100% measure) (n=13)	2016 (100% measure) (n=8)	2017 (100% measure) (n=4)	2017 (100% measure) (n=2)	2018 (100% measure) (n=2)	2020 (100% measure) (n=2)	2005 (64% measure) (n=248)	2012 (100% measure) (n=87)	2015 (58% measure) (n=257)	2016 (41% measure) (n=223)	2017 (93% measure) (n=623)	2017 (93% measure) (n=94)	2018 (100% measure) (n=94)	2020 (40% measure) (n=132)
<3.0	(8)					(31)	(58)													(2)			5
3.0	2% (11)	1% (5)		4% (9)		1% (1)													1% (1)				1% (1)
3.5	1% (1)	19% (139)	1% (1)	3% (7)	1% (1)	1% (2)	1% (7)										1% (1)	1% (2)	1% (3)	1% (2)			1% (1)
4.0	9% (43)	25% (181)		1% (3)	2% (9)	1% (6)	5% (24)										33% (29)		19% (42)				2% (2)
4.5	15% (73)	4% (32)	1% (1)	3% (6)	11% (57)	2% (15)	2% (10)										9% (8)						
5.0	41% (197)	6% (43)	12% (17)	4% (8)	15% (80)	13% (90)	7% (32)									2% (5)	1% (1)	1% (1)	2% (4)	6% (37)	1% (1)	1% (1)	2% (2)
5.5	26% (126)	7% (51)	39% (58)	33% (69)	22% (116)	21% (140)	9% (42)											1% (3)	12% (26)	18% (112)	2% (2)	2% (2)	5% (7)
6.0	4% (21)	5% (36)	40% (59)	36% (75)	33% (172)	34% (230)	14% (70)									2% (5)	11% (10)	12% (32)	7% (16)	11% (66)	29% (27)	29% (27)	5% (7)
6.5	1% (2)	5% (36)	7% (10)	14% (28)	16% (83)	21% (145)	35% (172)									4% (11)	7% (6)	43% (111)	20% (45)	29% (182)	41% (39)	41% (39)	3% (4)
7.0	1% (4)	12% (85)		1% (1)	1% (5)	3% (20)	26 (128)	1% (1)								21% (51)	1% (1)	37% (96)	29% (65)	29% (178)	24% (23)	24% (23)	25% (33)
7.5		13% (92)	1% (1)			1% (2)	1% (6)	3% (5)								18% (44)	1% (1)	3% (8)	6% (13)	5% (34)	2% (2)	2% (2)	36% (47)
8.0		2% (13)						88% (150)								38% (94)	6% (5)	1% (3)	2% (5)	1% (5)			18% (24)
8.5								7% (12)								10% (25)	15% (13)	1% (1)	1% (1)	1% (1)			1% (1)
9.0								2% (3)	25% (1)							4% (10)	6% (5)		1% (2)	1% (1)			2% (2)
9.5																1% (2)	7% (6)			1% (2)			
10.0									25% (1)			25% (1)			100% (2)		1% (1)						1% (1)
10.5										1% (8)													
11.0									25% (1)											1% (1)			
11.5									25% (1)	1% (8)	13% (1)		50% (1)	50% (1)		0.4% (1)							
12										38% (5)	38% (3)												
12.5										31% (4)	25% (2)												
13.0										15% (2)	13% (1)	50% (2)	50% (1)	50% (1)									
13.5											13% (1)												
14												25% (1)	25% (1)										

Channel Catfish Statistics - Alimagnet Lake

Total Length (inches)	2007 (stocking Nov 16)	2008	2009	2010 (MnDNR)	2011	2012	2013	2014	2015	2016	2017	2018	2020
1													
2													
3													
4													
5													
6													
7	11% (2)												
8	39% (7)												
9	28% (5)												
10	17% (3)												
11	6% (1)	10% (4)											
12		5 % (2)											
13		23% (9)	5% (1)										
14		26% (10)	14% (3)	4% (2)									
15		5% (2)	26((6)	24% (13)									
16		3% (1)	33% (7)	26% (14)									
17			14% (3)	35% (19)	41 total fish 17-23 inches								
18			5% (1)	11% (6)									
19													
20													
21													
22						100% (1)							
23								40% (2)					
24							100% (1)			100% (1)			
25									50% (1)				
26								20% (1)					
27								20% (1)	50% (1)				
28													
29													
30								20% (1)					
Total Fish Measured	18 (subsample of the 9,000 catfish stocked)	39 (total catch from 80 trapnet lifts) (Oct 7-16) (0.5 fish/lift)	21 (total catch from 80 trapnet lifts) (July 14-23) (0.3 fish/lift)	54 (MnDNR trapnetting)	41 (MnDNR trapnetting)	1	1	5	2	1	0	0	0
Age of Channel Catfish	2 years*	3 years	4 years	5 years	6 years	7 years	8 years	9 years	10 years	11 years	12 years	13 years	15 years

*2 years (personal comm. Osage Fisheries, MO, supplier of the fish)



2017 and 2020 no channel catfish

Figure 3. The gape of channel catfish, Alimagnet Lake, October 2008 (top-left), October 2011 (top-second-left), September 2012 (top-center left), October 2013 (top-center-right), September 2014 (top-second right), October 2015 (top-right), and October 2016 (bottom-left).

Fish Removal from 2005 - 2012

From 2005 through 2012, the Cities of Apple Valley and Burnsville oversaw a bullhead and sunfish removal project which also has served as fish surveys as well. The objectives of the fish removal program were to improve lake water quality and improve the fishery.

A summary of annual fish removal is shown in Table 5. Fish removal occurred over an eight year period from 2005 - 2012.

The removal goal has been a total of 100 pounds of fish per lake acre over a 5 to 6 year period. This amount of removal has resulted in water clarity improvements in Lee Lake, another lake in the metro area (McComas 2007, unpublished). At the end of 2012, an estimated 170 pounds of fish per acre have been removed with a total of 17,046 pounds removed (Table 5).

Table 5. Summary of fish removed from Alimagnet Lake from 2005-2012.

	Black Bullheads		Bluegills		Crappies		Totals		Fish Removal per Lake Acre (100 ac lake)
	number	pounds	number	pounds	number	pounds	number	pounds	
2005	739	231	0	0	0	0	739	231	2
2006	2,777	868	7,711	918	0	0	10,488	1,786	18
2007	1,464	488	14,610	1,948	0	0	16,074	2,436	24
2008	2,972	1,010	14,303	1,607	1,694	242	18,969	2,859	29
2009	649	259	13,804	1,980	907	162	15,360	2,401	24
2010	--	--	16,083	2,681	3,894	719	19,977	3,400	34
2011	--	--	10,219	2,237	3,738	1,041	13,357	3,278	33
2012*	--	--	6,220	1,349	540	126	6,760	1,455	15
Totals	**8,601**	**2,856**	**82,950**	**12,720**	**10,773**	**2,290**	**102,324**	**17,866**	**179**

* Yellow perch removal: 185 fish in 2012

Details of Alimagnet Fish Removal

Table 6. Summary of Alimagnet Lake fish removal efforts from 2005-2012. Alimagnet Lake is approximately 100 acres in size.

2005 (Sept 20-23)	Black Bullheads		Bluegills				Totals	
	number	pounds	numbers	pounds			numbers	pounds
4-day total (n=24)	739	231	0	0			739	231
Average per net	30	9.6	0	0			30	9.6
Fish removed per lake acre	7	2	0	0			7	2

2006 (Sept 11-21)	Black Bullheads		Bluegills				Totals	
	number	pounds	numbers	pounds			numbers	pounds
10-day total (n=80)	2,777	868	7,711	918			10,488	1,786
Average per net	35	10.8	96	11.5			131	22.3
Fish removed per lake acre	28	8.7	77	9.2			105	18

2007 (Aug 7 - 11 and Sept 11-19)	Black Bullheads		Bluegills				Totals	
	number	pounds	numbers	pounds			numbers	pounds
14-day total (n=112)	1,464	488	14,610	1,948			16,074	2,436
Average per net	14	4.4	132	17.4			146	21.8
Fish removed per lake acre	15	5	146	19			161	24

2008	Black Bullheads		Bluegills		Crappies		Totals	
	number	pounds	numbers	pounds	numbers	pounds	numbers	pounds
October 7-16, 2008								
10-day total (n=80)	1,496	576	8,232	968			9,728	1,544
Average per net	19	7.2	103	12.1			122	19.3
Fish removed per lake acre	15	6	82	10			97	16
June 24-27, 2008 (MnDNR)								
4-day total (n=76)	1,476	434	6,071	639	1,694	242	9,241	1,305
Average per net	19	5.7	80	8.3	22	3.2	121	17.2
Fish removed per lake acre	15	4	61	6	17	2	92	13

2009	Black Bullheads		Bluegills		Crappies		Totals	
	number	pounds	numbers	pounds	numbers	pounds	numbers	pounds
April 30 - May 4, 2009 (MnDNR)								
5-day total (n=54)	168	56	1,709	259	907	162	2,784	477
Average per net	3.1	1.0	32	4.8	17	3.0	52	8.8
Fish removed per lake acre	1.7	0.6	171	2.6	91	1.6	264	4.8
June 22-26, 2009 (MnDNR)								
5-day total (n=72)	120	40	3,452	523			3,572	563
Average per net	1.7	0.6	48	7.3			50	7.9
Fish removed per lake acre	1.2	0.4	35	5.2			36.2	5.6
July 14-23, 2009								
10-day total (n=80)	361	163	8,643	1,198			9,004	1,361
Average per net	4.5	2	108	15			113	17
Fish removed per lake acre	3.6	1.6	86	12			89.6	13.6

2010 (April 4-21, May 5, 10, 11, June 8) (MnDNR)	Black Bullheads		Bluegills		Crappies		Totals	
	number	pounds	numbers	pounds	number	pounds	numbers	pounds
14-day total	--	--	16,083	2,681	3,894	719	19,977	3,400
Fish removed per lake acre	--	--	161	26.8	39	7.2	200	34.0

2011* (April 18- June 3, June 16) (MnDNR)	Black Bullheads		Bluegills		Crappies		Totals	
	number	pounds	numbers	pounds	number	pounds	numbers	pounds
42-day total (28 nests/day)	--	--	10,219	2,237	3,738	1,041	13,957	3,278
Fish removed per lake acre	--	--	102	22	37	10	140	33

*81 yellow perch removed at 9 pounds

2012* (March 29 - May 17) (MnDNR)	Black Bullheads		Bluegills		Crappies		Totals	
	number	pounds	numbers	pounds	number	pounds	numbers	pounds
Fish removal total	--	--	6,220	1,349	540	126	6,760	1,475
Fish removed per lake acre	--	--	62	5.9	5.4	0.6	68	14.8

* 185 yellow perch removed at 34 pounds

Fish Stocking in 2007, 2008, 2016, and 2020

Fish stocking from 2007 through 2020 is summarized in Table 7.

Table 7. Cities of Burnsville and Apple Valley sponsored stocking from 2007 through 2020.

Date	Species	Number Stocked	Size (inches)	Source
2007 (November 16)	Channel catfish	9,000	8-10	Osage Catfisheries Osage Beach, Missouri
2008 (November 5)	Largemouth bass	1,000	4-6	Rademacher Ponds Waconia, MN
2016 (October 12)	Largemouth bass	2,000 (90 fish/lb) (22 lbs)	3-5	Rademacher Ponds Waconia, MN
2020 (Autumn)	Largemouth bass	1,000	4-6	Rademacher Ponds Waconia, MN

2007 - Catfish - 9,000

2008 - Largemouth bass - 1,000

2016 - Largemouth bass - 2,000

2020 - Largemouth bass - 1,000

Water Quality in Alimagnet Lake

Water clarity in Alimagnet Lake from 1995 through 2010 and 2013 through 2019 was not meeting water quality goals. However, in 2011, 2012, and 2020 water clarity reached the lake goal (Figure 4). Prior to installation of winter aeration in 2000, years of good clarity were loosely correlated with previous winterkill episodes (winterkill was based primarily on lake resident observations). A winter aeration system was first operated over the winter of 1999-2000, and since that time, there have been no winterkill conditions (based on dissolved oxygen measurements taken by the City of Apple Valley). The fish community has continued to thrive without the setback of a winterkill. The disadvantage of this condition was that bluegills and maybe bullhead populations increased. The objectives of the fish removal project and predator fish stocking have been to “re-balance” the fish community has been reduced also. In addition watershed nutrient loading was decreased through watershed projects. It is anticipated that the cumulative effect of these projects should improve and sustain good water quality in Alimagnet Lake.

Secchi disc transparency, as characterized by summer averages, has fluctuated over the years of record, from 1975-2020 (Figure 4). The fluctuating seasonal averages going back to 1975 could represent the effect of occasional winterkills on water quality.

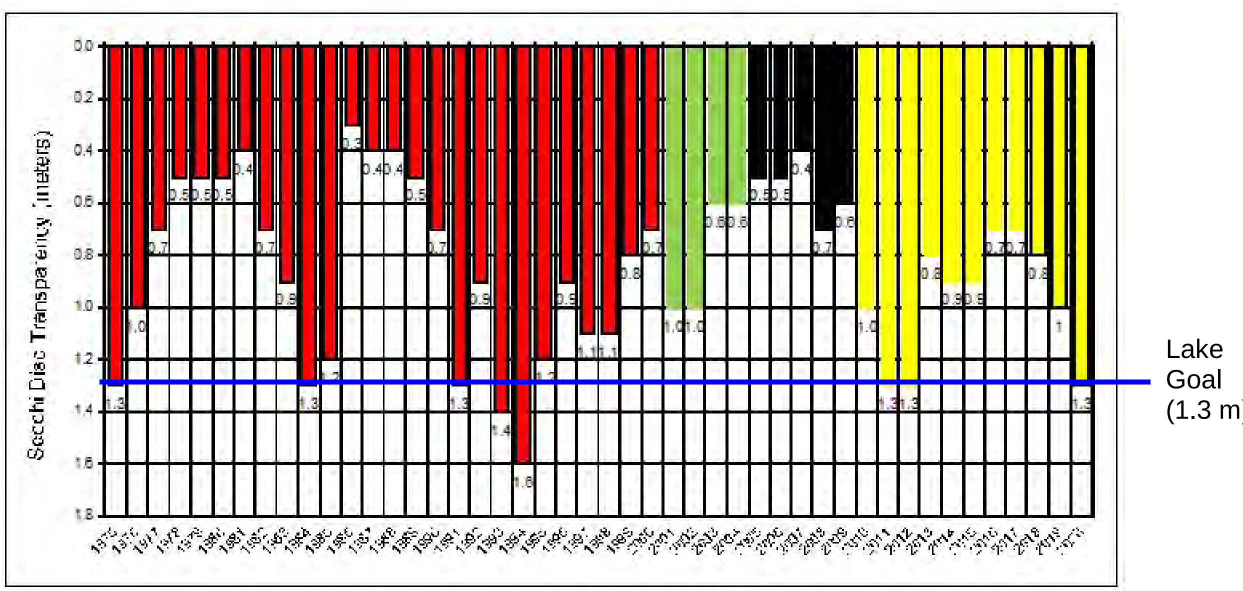


Figure 4. Summer average (May-September) for Secchi disc readings from 1975-2020. Data from 1975 - 1994 are from the MPCA. Data from 1995 - 2020 are from the Met Council CAMP program. Green bars indicate 4 years of winter aeration with no projects. Winter aeration has continued through 2015. Black bars indicate five years of improvement project implementation. Yellow bars represent maintenance projects but no fish removal.

Observations and Conclusions

1. In 2007, 9,000 channel catfish were stocked. They gradually increased in size up to 2016. However, their abundance is relatively unknown at this time.
2. In 2008, 1,000 largemouth bass were stocked and in 2016, 2,000 largemouth bass were stocked. Largemouth bass abundance has been sparse over the years with minor spawning evidence.
3. As of 2012, 179 pounds of fish/acre have been removed. This is over the removal goal of 100 pounds of fish per lake acre for a total of 10,000 pounds (based on a 100 acre lake). Water quality had fluctuated since 2011.
4. In 2012, bluegill sunfish and black crappie numbers were less than 2011 catch rates, but there was an increase in smaller lengths in 2012 compared to 2011. The increase in smaller lengths with higher numbers of fish continued in 2013, 2014, and 2015. It may be that the abundant vegetation was serving as a refuge for smaller fish.
5. The Alimagnet fish community, from a sport fishery perspective, is in good shape. Bluegill abundance is above average. If largemouth bass are to become established, stocing at 1 pound of fish per acre (100 lbs) or 4,000 fish may be needed to establish a significant bass population.
6. From a water quality perspective, fish do not appear to be adversely impacting water quality. Other factors may be contributing to phosphorus loading including unmonitored runoff or phosphorus translocation by rising benthic algae off lake sediments.

APPENDIX

Fish Permit and Notification E-Mail for 2020
2012 through 2018 Length Frequencies

Fish Permit and Notification Email

From: Steve McComas [mailto:mccomas@pclink.com]
Sent: Tuesday, October 13, 2020 8:26 AM
To: DeBates, TJ (DNR); Capt. Jason Peterson
Cc: Samantha Berger (Samantha.Berger@applevalleymn.gov); Caleb Ashling; Linnea Wier (Linnea.Wier@burnsvillemn.gov)
Subject: Fish survey on Alimagnet Lake, Dakota County

Hello all,

Blue Water Science will be conducting a fish survey in Alimagnet Lake (MN ID 19-002100), Dakota County starting on Tuesday, October 13, 2020. We will set 6 standard fyke nets in Alimagnet Lake. In Alimagnet Lake, the nets will be monitored daily on Wednesday and Thursday and all fish will be weighed and measured and returned to the water body. The nets will be removed on Thursday, October 15, 2020. The fish survey is sponsored by the Cities of Apple Valley and Burnsville with the objectives of characterizing the existing fish community structure and assessing potential impacts of fish on water quality.

This survey is being conducted under the permit number: 29777.

Thank you,

Steve McComas
BLUE WATER SCIENCE
550 South Snelling Avenue
St. Paul, MN 55116
651 690 9602
mccomas@pclink.com

Length Frequencies, September 25-26, 2012

Bluegills

Total Length (in)	September 25, 2012							September 26, 2012							Totals	%
	Net 1	Net 2	Net 3	Net 4	Net 5	Net 6	tot	Net 1	Net 2	Net 3	Net 4	Net 5	Net 6	tot		
<3.0																
3.0						3	**3**			2				**2**	**5**	**1**
3.5			15	2	3	11	**62**	2		23		52		**77**	**139**	**19**
4.0	4	3	20	5	58	25	**115**	1	1	35		28	1	**66**	**181**	**25**
4.5	4			2	15	6	**27**		1	3		1		**5**	**32**	**4**
5.0	1	3	2		6	2	**14**		11	9	1	8		**29**	**43**	**6**
5.5	4	3			11	5	**23**		12	5	1	10		**28**	**51**	**7**
6.0	2	4	1	2	2	9	**20**		2	3	1	10		**16**	**36**	**5**
6.5		7		1	3	2	**13**	1	4	5	3	10		**23**	**36**	**5**
7.0	2	9	1	5	6	3	**26**	5	6	14	12	22		**59**	**85**	**12**
7.5	7	12	5	5	10	2	**41**	5	9	7	8	22		**51**	**92**	**13**
8.0	2	4			1		**7**		2	2		2		**6**	**13**	**2**
8.5																
9.0																
	26	45	44	22	146	68	**351**	14	48	108	26	164	1	**362**	**713**	

Black Bullheads

Total Length (in)	September 25, 2012							September 26, 2012							Totals
	Net 1	Net 2	Net 3	Net 4	Net 5	Net 6	tot	Net 1	Net 2	Net 3	Net 4	Net 5	Net 6	tot	
<3.0															
3.0															
3.5															
4.0															
4.5															
5.0															
5.5															
6.0															
6.5															
7.0															
7.5															
8.0															
8.5															
9.0												1		**1**	**1**
9.5															
10.0				1			**1**								**1**
10.5															
11.0												1		**1**	**1**
11.5								1						**1**	**1**
12.0															
12.5															
13.0															
13.5															
14.0															
	0	0	0	1	0	0	**1**	1	0	0	0	2	0	**3**	**4**

Crappies

Total Length (in)	September 25, 2012							September 26, 2012							Totals
	Net 1	Net 2	Net 3	Net 4	Net 5	Net 6	tot	Net 1	Net 2	Net 3	Net 4	Net 5	Net 6	tot	
<3.0															
3.0															
3.5						1	**1**								**1**
4.0	3				4	12	**19**	1	2			4	3	**10**	**29**
4.5	2	1			1	2	**6**		1	1				**2**	**8**
5.0								1						**1**	**1**
5.5															
6.0		1			3	1	**5**			3		2		**5**	**10**
6.5	1					1	**2**		3	1				**4**	**6**
7.0	1						**1**								**1**
7.5					1		**1**								**1**
8.0		1			1		**2**			1	1	1		**3**	**5**
8.5		1		1			**3**		2		6	2		**10**	**13**
9.0				1	1		**3**			1	1			**2**	**5**
9.5				1		1	**1**		1		2	2		**5**	**6**
10.0						1	**1**								**1**
	7	4	0	4	11	19	**45**	2	9	7	10	11	3	**42**	**87**

Pumpkinseed Sunfish

Total Length (in)	September 25, 2012							September 26, 2012							Totals
	Net 1	Net 2	Net 3	Net 4	Net 5	Net 6	tot	Net 1	Net 2	Net 3	Net 4	Net 5	Net 6	tot	
<3.0															
3.0															
3.5															
4.0					1		**1**	1		1		1		**3**	**4**
4.5	1	1	1		3		**6**			1		3		**4**	**10**
5.0	2		1				**3**								**3**
5.5	1		1		1		**3**		3			1		**4**	**7**
6.0		4	1	1	1	1	**8**	2	4	4	1	2		**13**	**21**
6.5		3	2	1	4	2	**12**		1		2	4		**7**	**19**
7.0				2	1	1	**4**	3	1		1	4	1	**10**	**14**
7.5	1		1		2	1	**5**					3		**3**	**8**
8.0					1		**1**								**1**
8.5									1					**1**	**1**
9.0															
	5	8	7	4	14	5	**43**	6	10	6	4	18	1	**45**	**88**

Yellow Perch

Total Length (in)	September 25, 2012							September 26, 2012							Totals
	Net 1	Net 2	Net 3	Net 4	Net 5	Net 6	tot	Net 1	Net 2	Net 3	Net 4	Net 5	Net 6	tot	
<3.0															
3.0															
3.5															
4.0															
4.5												1		**1**	**1**
5.0															
5.5															
6.0															
6.5															
7.0		2	1		3		**6**			3		2		**5**	**11**
7.5			3		2		**5**			4		1		**5**	**10**
8.0	1	1			2		**4**		4	4		1		**9**	**13**
8.5		1		1	4		**6**		2	1	1	4		**8**	**14**
9.0	1	3			4		**8**	2	6	4	4	2		**18**	**26**
9.5	3		1				**4**		5	1	1	1		**8**	**12**
10.0					1		**1**		5		1			**6**	**7**
10.5		1					**1**								**1**
11.0															
	5	8	5	1	16	0	**35**	2	22	17	7	12	0	**60**	**95**

Channel Catfish

Total Length (in)	Totals
<3.0	
3.0	
3.5	
4.0	
4.5	
5.0	
5.5	
6.0	
6.5	
7.0	
7.5	
8.0	
8.5	
9.0	
9.5	
10.0	
11.0	
12.0	
13.0	
14.0	
15.0	
16.0	
17.0	
18.0	
19.0	
20.0	
21.0	
22	**1**
	1

Golden Shiner

Total Length (in)	Totals
<3.0	
3.0	
3.5	
4.0	
4.5	
5.0	
5.5	
6.0	
6.5	**1**
7.0	
7.5	
8.0	
8.5	
9.0	
	1

Green Sunfish

Total Length (in)	Totals
<3.0	
3.0	
3.5	
4.0	
4.5	
5.0	**1**
5.5	
6.0	
6.5	
7.0	
7.5	
8.0	
8.5	
9.0	
	1

2013: Length frequency of fish species (as total length) for the Alimagnet Lake fish survey.

Length (inches)	Black bullhead	Black crappie	Bluegill sunfish	Channel catfish	Green sunfish	Hybrid sunfish	Largemouth bass	Northern pike	Pumpkin-seed	White sucker	Yellow perch
<3			1								
3			45								
3.5		1	52								
4			128						2		
4.5		2	265		1				7		
5		49	214						8		1
5.5		149	78			1			25		2
6		130	99			6			31		1
6.5		72	67			2			16		
7		15	71			1			26		3
7.5		5	40				1		5		1
8		21	17								
8.5		43	1								
9		17									
9.5	2	4									
10											
10.5	2										
11											
11.5	1										
12	2										
12.5	1										
13											
13.5											
14											
14.5											
15							1				
15.5											
16							1				
16.5											
17											
17.5											
18							1				
18.5											
19											
19.5											
20								1			
20.5											
21										1	
21.5											
22											
22.5											
23				1							
23.5											
24								2			
24.5											
25											
26								1			
27											
28											
29											
30											
31											
32											
33											
34								1			
Number of fish caught	**8**	**508**	**1077**	**1**	**1**	**10**	**4**	**5**	**120**	**1**	**8**

2014: Length frequency of fish species (as total length) for the Alimagnet Lake fish survey on September 11-12, 2014.

Length (inches)	Black bullhead	Black crappie	Bluegill sunfish	Channel catfish	Green sunfish	Hybrid sunfish	Largemouth bass	Northern pike	Pumpkin-seed	Yellow bullhead	Yellow perch
<3		2	37								
3											
3.5			1				1				
4			1						4		
4.5			8						9		
5			87		1	1			26		
5.5		8	161						26		1
6		115	76						22		1
6.5		173	20			4			19		
7		36	7			2			16		
7.5		2	5						7		
8		7							1		
8.5		5									1
9		2									
9.5		1									
10	1	1									
10.5	3										
11											
11.5											
12											
12.5											
13											
13.5										1	
14											
14.5											
15											
15.5											
16											
16.5											
17											
17.5											
18											
18.5											
19							1				
19.5											
20											
20.5											
21											
21.5											
22											
22.5				1							
23				1				1			
23.5											
24											
24.5											
25											
25.5											
26				1							
26.5				1							
27.5											
28											
28.5											
29								1			
29.5											
30				1							
Number of fish measured	**4**	**350**	**366**	**5**	**1**	**7**	**2**	**2**	**130**	**1**	**3**
Number of fish caught	**4**	**741**	**2,420**	**5**	**1**	**7**	**2**	**2**	**130**	**1**	**3**
Percent of fish measured	**100%**	**47%**	**15%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

2015: Length frequency of fish species (as total length) for the Alimagnet Lake fish survey on October 14-15, 2015.

Length (inches)	Black bullhead	Black crappie	Bluegill sunfish	Channel catfish	Golden shiner	Largemouth bass	Northern pike	Pumpkin-seed	White sucker	Yellow perch
<3										
3										
3.5		2	1							
4										
4.5			1							
5		1	17					2		
5.5		3	58					1		
6		32	59		1			14		
6.5		111	10					8		1
7		96						10		
7.5		8	1			1		2		1
8		3			1					
8.5		1								
9										
9.5										
10										
10.5	1									
11										
11.5	1									
12	5									
12.5	4									
13	2									
13.5										
14										
14.5										
15						1				
15.5										
16						3				
16.5						1				
17										
17.5										
18										
18.5										
19										
19.5										
20									1	
20.5										
21									1	
21.5										
22										
22.5										
23										
23.5										
24										
24.5										
25				1			1			
26							1			
27				1						
28							2			
29										
30										
31										
32							1			
Number of fish measured	**13**	**257**	**147**	**2**	**2**	**6**	**5**	**37**	**2**	**2**
Number of fish caught	**13**	**442**	**3671**	**2**	**2**	**6**	**5**	**37**	**2**	**2**
Percent of fish measured	**100%**	**58%**	**4%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

2016: Length frequency of fish species (as total length) for the Alimagnet Lake fish survey on October 12-13, 2016.

Alimagnet	Black bullhead	Black crappie	Bluegill	Channel catfish	Golden shiner	Largemouth bass	Northern pike	Pumpkinseed	Yellow perch
<3.5		1	9					1	
3.5		3	7					1	
4		42	3			1		6	
4.5			6					6	
5		4	8					8	
5.5		26	69					2	
6		16	75					2	
6.5		45	28					4	
7		65	1					1	1
7.5		13							
8		5							
8.5		1							
9		2							
9.5					1				
10									
10.5									
11									
11.5	1								
12	3								
12.5	2								
13	1								
13.5	1								
14									
14.5									
15									
15.5									
16						1			
16.5						1			
17									
17.5									
18									
18.5									
19									
19.5						1			
20									
20.5									
21									
21.5									
22									
22.5									
23									
23.5									
24				1					
24.5									
25									
25.5									
26									
26.5									
27									
27.5							1		
28									
28.5									
29							1		
29.5									
30									
30.5									
31							1		

2017: Length frequency of fish species (as total length) for the Alimagnet Lake fish survey on October 12-13, 2017.

Alimagnet	Black bullhead	Black crappie	Bluegill	Golden shiner	Northern pike	Pumpkinseed	White sucker	Yellow perch
<3.5		2						
3.5		2	1					
4			9			2		
4.5			57			2		
5		37	80			17		
5.5		112	116			9		
6		66	172			13		
6.5		182	83			9		
7		178	5			4		
7.5		34						1
8		5		1				
8.5		1						
9		1						
9.5		2						
10	1							
10.5								
11		1						
11.5								
12								
12.5								
13	2							
13.5								
14	1							
14.5								
15								
15.5								
16								
16.5								
17								
17.5								
18								
18.5								
19								
19.5								
20								
20.5								
21							1	
21.5								
22								
22.5								
23								
23.5								
24								
24.5								
25								
25.5								
26								
26.5								
27					1			
27.5								
28					1			
28.5								
29								
29.5								
30								
30.5								
31								
31.5								
32					1			
Total	4	623	523	1	3	56	1	1

2018: Length frequency of fish species (as total length) for the Alimagnet Lake fish survey on October 23-24, 2018.

	Black bullhead	Black crappie	Bluegill	Green sunfish	Hybrid sunfish	LM Bass	Madtom	Pumpkin-seed	Yellow perch
<3.5			31						
3.5			1						
4			2	1			1	1	
4.5			6	4		1		1	
5			15	2					
5.5		1	90	3	1			6	
6		2	140		5			27	
6.5		27	230		1			16	
7		39	145		2			5	
7.5		23	20		1			1	
8		2	2						1
8.5									
9									
9.5						1			
10									
10.5									
11						0			
11.5						1			
12	1								
12.5									
13									
13.5	1								
14						1			
14.5									
15									
15.5									
16						1			
Counted not measured			585						
Total	2	94	682	10	10	5	1	57	1