Ham Lake
Comprehensive Lake Management Plan
2018-2022

Prepared by the Coon Creek Watershed District
November 2017

Table of Contents

List of Tables

List of Figures

1.0 Introduction

Despite multiple users and agencies playing a role in the health of Ham Lake, an overarching lake management plan had not yet been established. To protect and enhance the health of Ham Lake, the Coon Creek Watershed District (CCWD) advocated for long-range comprehensive planning with the cooperation of the most vital stewards of the lake, the lakeshore residents. Development of this Ham Lake Comprehensive Lake Management Plan started in the winter of 2014 following the discovery of invasive Eurasian Watermilfoil earlier that year. In response to the invasive milfoil infestation, the Ham Lake Lake Association (HLLA) was formed with the purpose of preserving the natural and recreational uses of the lake for residents and visitors. The CCWD has been actively involved with the HLLA since its inception and encouraged the group to consider lake issues comprehensively and based on scientific information. The HLLA supported the development of a comprehensive lake management plan and served as the Steering Committee for plan development. Technical and Advisory Committees comprised of natural resource specialists and representatives of state and local units of government were also involved in plan development.

1.1 Scope and Purpose of the Plan

The purpose of the Plan is to provide a comprehensive "picture" of Ham Lake based on scientific and historical information and to outline management strategies to protect and enhance the long-term health of the lake. This Plan summarizes the lake's characteristics, condition, and previous management efforts and develops management goals and actions to address the current issues facing Ham Lake.

Successful lake management requires a strong commitment to adaptive management. A flexible, adaptive management approach is critical because it allows managers to respond to changing conditions, unforeseen problems, and to continuously incorporate new findings into management decisions. To best facilitate adaptive management, a thorough assessment of lake health trends, implications, and management needs and outcomes is periodically conducted. This Plan will outline proposed management strategies for the next 5 years (2018-2022). In 2022, the Plan will be revisited and revised as necessary.

The primary goals of this Plan and planning process are to:

1. Encourage partnerships between lakeshore owners, watershed residents, local units of government, and resource management agencies
2. Develop an understanding of the physical, biological, & social attributes of Ham Lake along with realistic expectations for a healthy shallow lake
3. Identify the concerns facing Ham Lake that stakeholders believe are important
4. Develop management goals and strategies for the protection and enhancement of Ham Lake's water quality and related beneficial uses

1.2 Location & Setting

Ham Lake is located within the City of Ham Lake, MN in central Anoka County. Ham Lake is designated as Public Water 02-0053-00 by the Minnesota Department of Natural Resources (MN DNR) and is also wholly contained within the Coon Creek Watershed District (Figure 1). Ham Lake is a relatively small natural lake with a surface area of 203 acres. The lake is oriented in a southwest to northeast direction, a pattern typical of many lakes scattered across the previously glaciated Anoka Sand Plain. Ham Lake is relatively shallow with an average depth of 6 feet, an expansive littoral zone (<15ft) comprising 93% of the total lake surface area, and a maximum depth of 22 feet. It contains one small island (8 acres) in the southwest bay.

Ham Lake is sustained by a combination of ground water inputs and surface water runoff from a 633-acre lakeshed (total area that drains to the lake). The lake receives stormwater inputs from the City of Ham Lake's storm sewer system and small local drainage ditches. The lake has no natural surface water inlets or tributaries and contains one outlet located at the southern end of the lake. Ham Lake is situated in a rural residential area where land use is primarily single-family residential, recreational, or vacant. Public lands surround approximately one third of the lake, including a public access located on the southern shoreline with a concrete ramp operated and maintained by the City of Ham Lake. There is also a popular, privately-owned campground along the northeast shoreline where visitors can swim and rent non-motorized watercrafts.

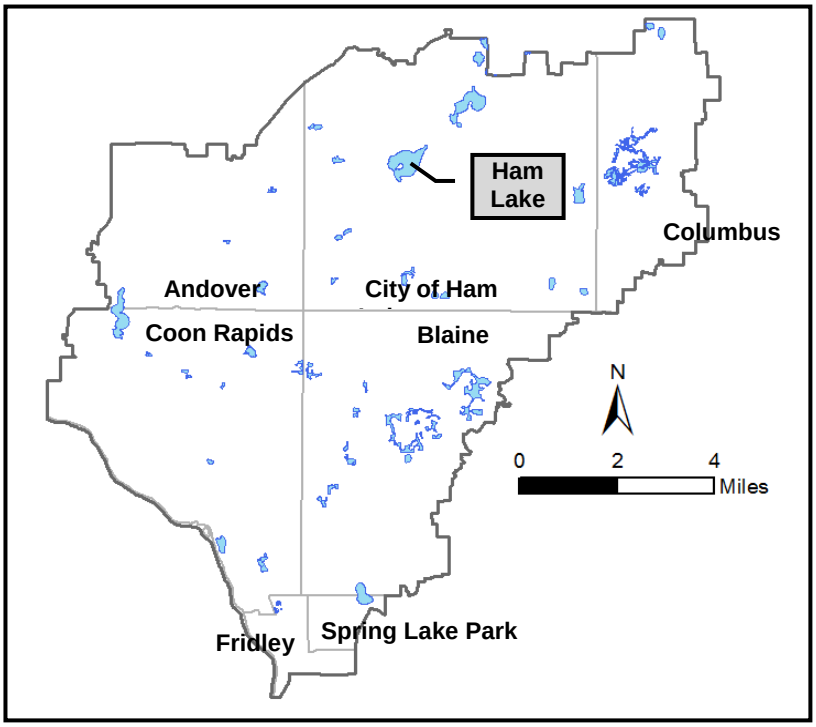

Figure 1. Location of Ham Lake within the Coon Creek Watershed District in Anoka County, MN, USA.

2.0 Lake and Watershed Characteristics

2.1 Geologic Setting

Ham Lake is located in the portion of the Anoka Sand Plain known as the Glacial Lake Hugo Plain. This landform is an undulating sand plain comprised of rolling dunes and small flats in the uplands as well as low-lying depressions. The elevation generally ranges from 890 to 920 feet above sea level with an average slope of roughly 0.95%. Soils in the lakeshed range from excessively drained to very poorly drained and are dominated by Zimmerman, Isanti, and Lino fine sands and organic glacial deposits such as mucky peat (Figure 2).

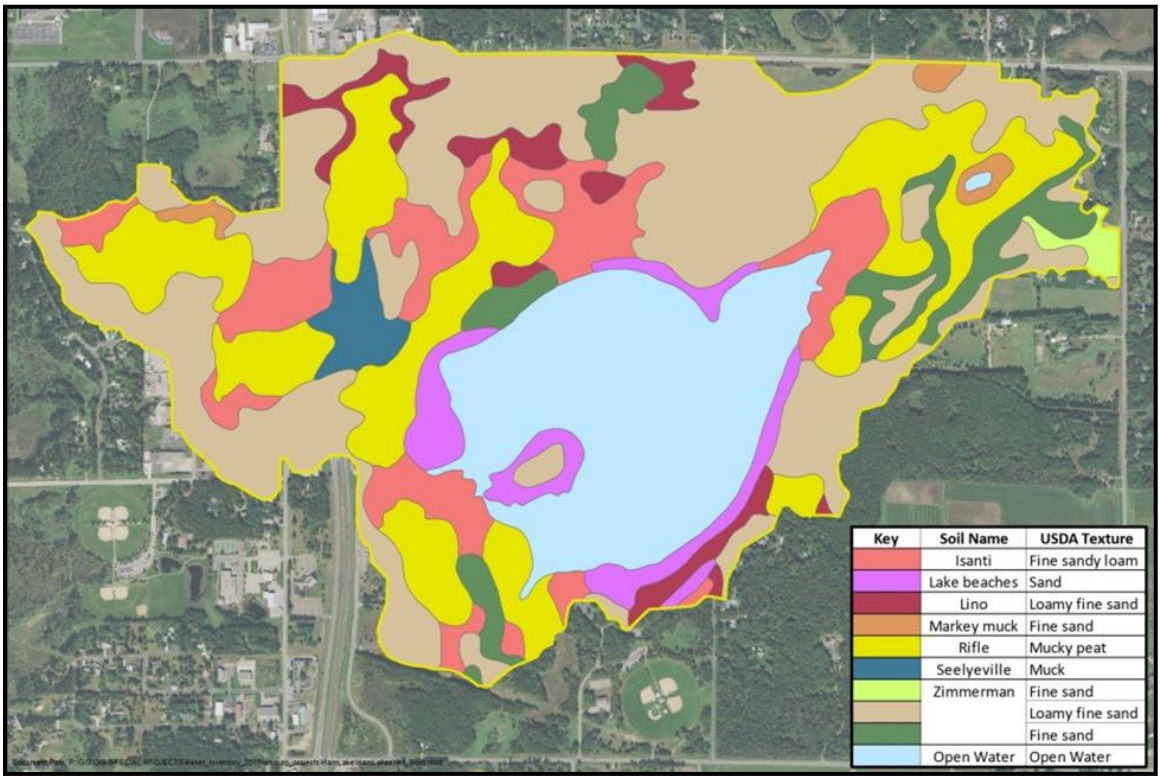

Figure 2. Ham Lake lakeshed Surficial Geology

The bedrock of the Ham Lake lakeshed consists mainly of St. Lawrence and Tunnel City Group (formerly called Franconia) formations. Bedrock elevations range from 700-800 feet above sea level resulting in a depth to bedrock of roughly 100-200 feet. Depth to bedrock is shallowest west and north of the lake and deepest in the southeast portion of the lakeshed (Geologic Atlas of Anoka County, Minnesota [Part A]; Setterholm, 2013)

2.2 Hydrology

2.2.1 Hydrogeology

Groundwater elevations in the Ham Lake lakeshed range from approximately 875 to 900 feet above sea level, resulting in a depth to ground water of approximately 5 to 30 feet. Groundwater generally flows from the northeast to the southwest towards the Mississippi River. The susceptibility of ground water to pollution is ranked very high in this area, with water-borne contaminants at the land's surface taking only hours to months to reach the uppermost aquifer (Anoka Sandplain Regional Hydrogeologic Assessment; MN Department of Natural Resources, 1993).

2.2.2 Surface Hydrology

Ham Lake is sustained by a combination of groundwater inputs and surface water runoff. The area that drains to Ham Lake, the lakeshed, is approximately 633 acres in size, resulting in a small drainage area to lake area ratio of approximately 3:1. Ham Lake has a relatively long water residence time of roughly 5 years (time it takes for the entire volume of Ham Lake to be renewed). The lakeshed is comprised of 18 minor catchments that can be combined to form 9 subwatersheds that discharge to the lake via stormwater pipes or small drainage ditches. (Figure 3; Table 1).

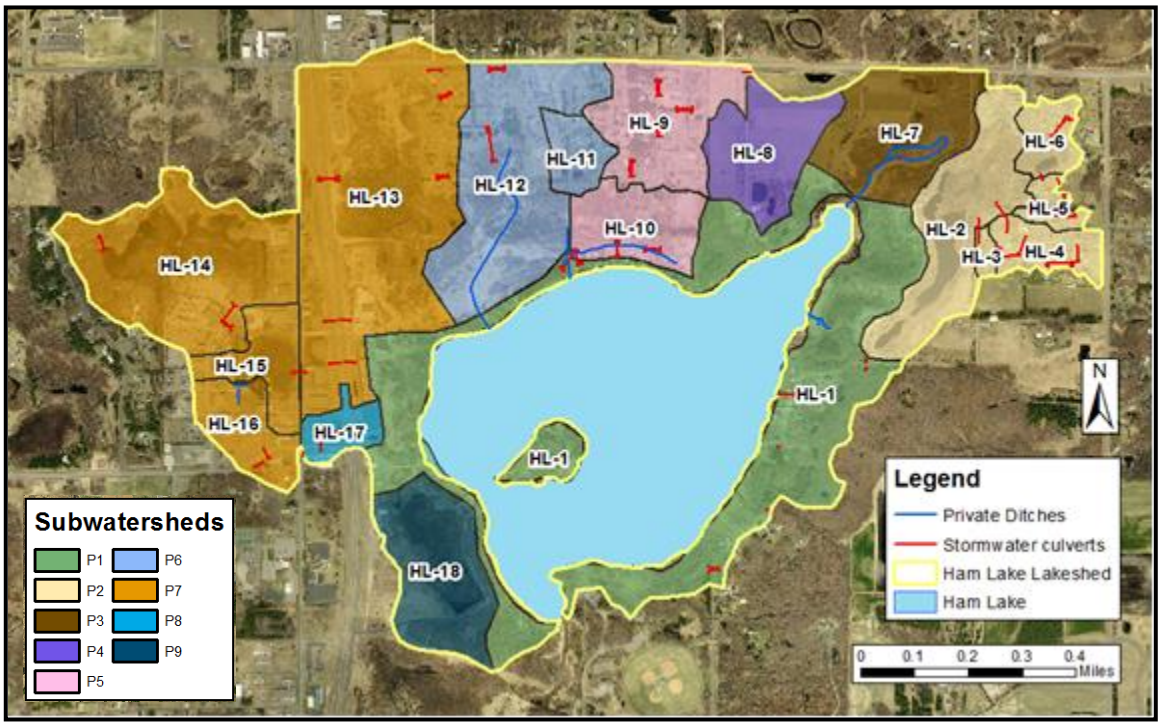

Figure 3. Map of the minor catchments (HL-1 through HL-18), subwatersheds (P1-P9; color-coded), and stormwater conveyance system within the Ham Lake lakeshed.

Table 1. Subwatersheds and minor catchements of the Ham Lake lakeshed

Subwatershed	Minor Catchment(s)	Area (Ac)
Ham Lake-P1	HL-1 (direct)	132
Ham Lake-P2	HL-2, 3, 4, 5, & 6	68
Ham Lake-P3	HL-7	37
Ham Lake-P4	HL-8	27
Ham Lake-P5	HL-9 & 10	54
Ham Lake-P6	HL-11 & 12	70
Ham Lake-P7	HL-13, 14, 15, & 16	201
Ham Lake-P8	HL-17	9
Ham Lake-P9	HL-18	35
Total		**633**

Ham Lake has one outlet located at the southern tip of the lake (Figure 4). Water flows through an expansive wetland area, over a concrete weir set at an elevation of 896.7 ft, through a box culvert, and eventually discharges to Coon Creek. The outlet structure was constructed in 1953 by the MN DNR and is inspected annually by the Coon Creek Watershed District.

Figure 4. Location of the Ham Lake outlet and photographs of the box culvert during wet conditions (upper right) and the channel looking upstream of the outlet structure during dry conditions (lower right).

2.3 Watershed Land Use & Development

2.3.1 Land Use

Ham Lake is situated in a rural residential area where land use is primarily single-family residential, parks/recreation, or vacant (Figure 5). There are some light industrial and commercial uses along the Highway 65 corridor and approximately 30 acres of agriculture in the northeastern portion of the lakeshed.

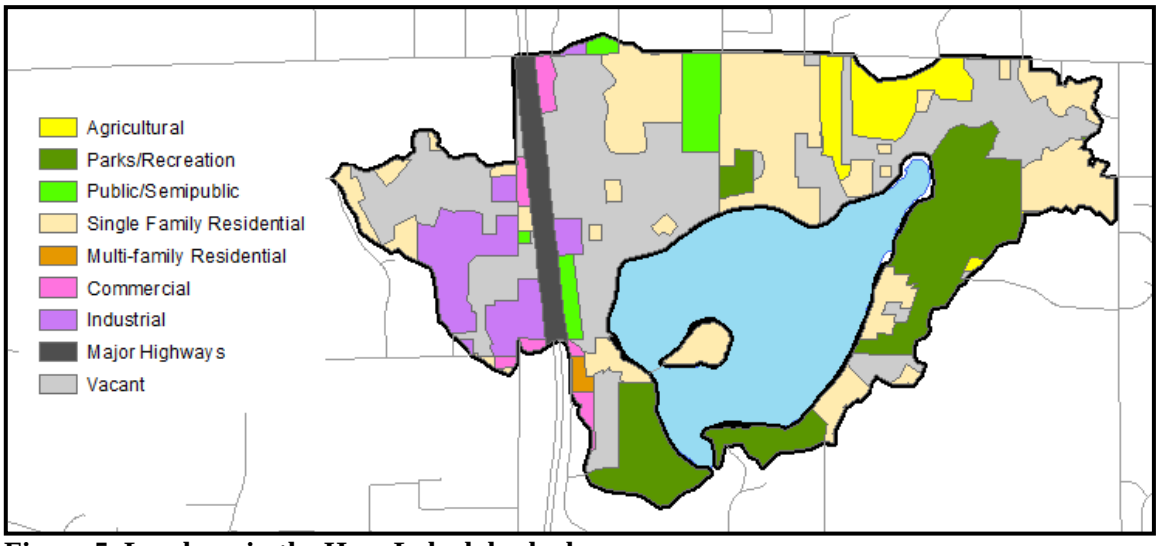

Figure 5. Land use in the Ham Lake lakeshed

2.3.2 Land Cover

The land cover surrounding Ham Lake is mostly natural, with both forested areas and expansive wetlands (Figure 6). In the developed areas, land cover is generally less than 25% impervious, except for along the Highway 65 corridor.

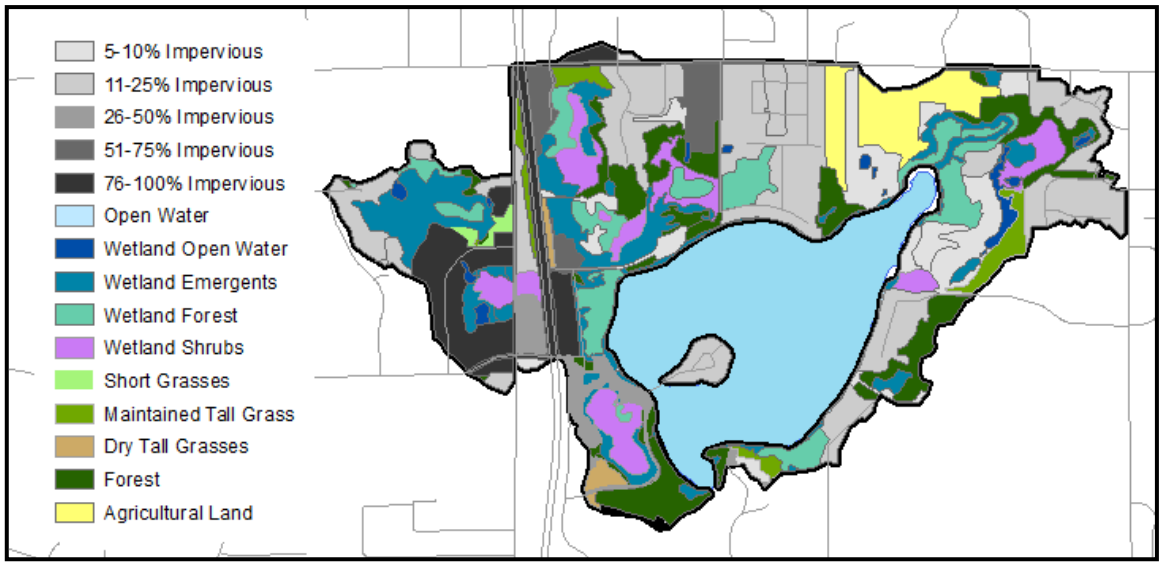

Figure 6. Land cover in the Ham Lake lakeshed

2.3.3 Land ownership

Land ownership in the lakeshed is split between private individuals and public entities with the City of Ham Lake being the single largest owner of shoreline (27%; Figure 7). City-owned land includes a large park on the southern end of the lake which contains a public access with a concrete ramp operated and maintained by the City through an agreement with the MN DNR executed in 1993. The MN DNR owns the parcel surrounding the lake's outlet which accounts for approximately 2% of the shoreline. The rest of the shoreline (71%) is in private ownership, including a large campground located along the northeast shoreline of the lake and the Ham Lake Baptist Camp and Retreat Center on the eastern shore. The island, Temperance Island, is entirely in private ownership with roughly a dozen single-family homes and a few parcels classified as seasonal recreational.

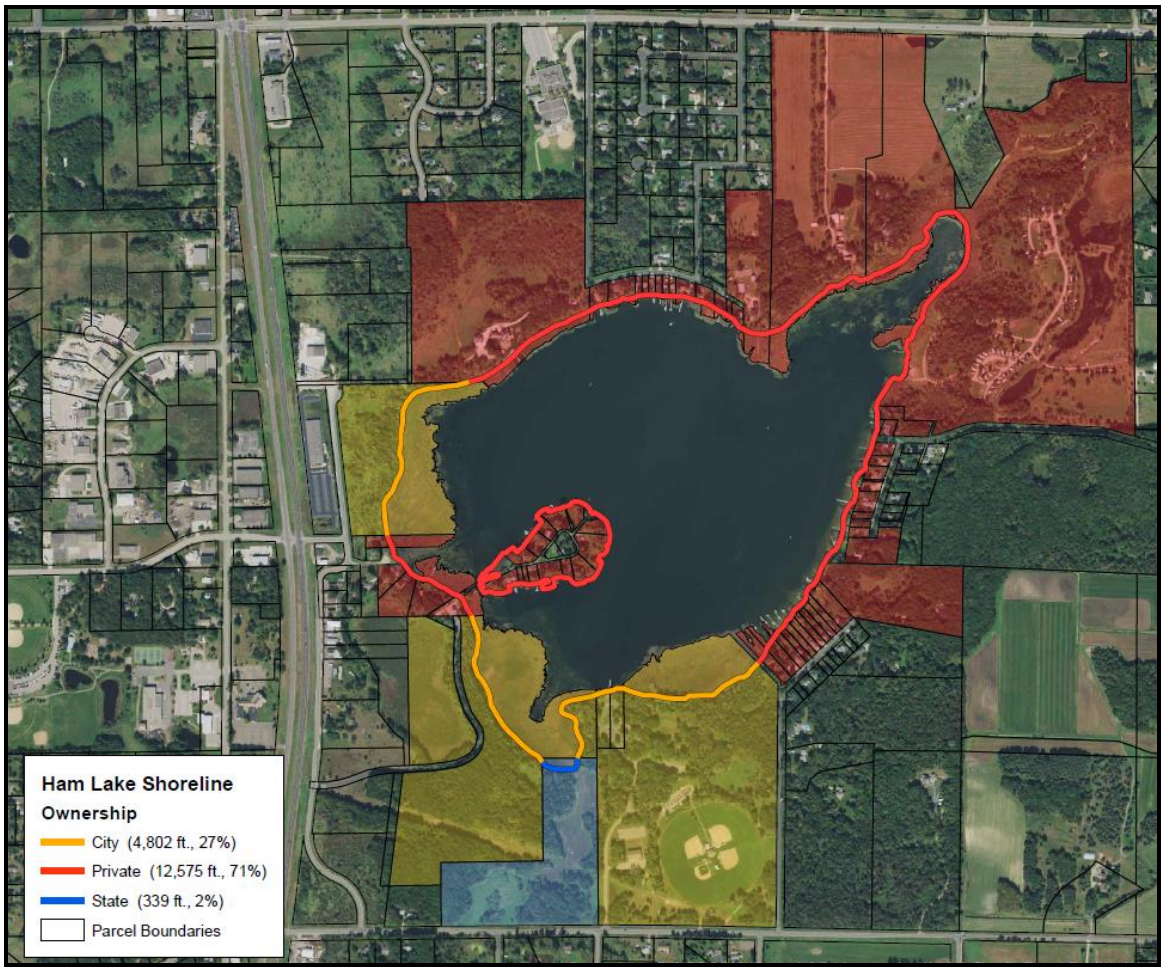

Figure 7. Land ownership adjacent to Ham Lake

2.3.4 Lakeshed Development Characteristics

Currently, there are 293 parcels located within or partially within the Ham Lake lakeshed, with 71 parcels characterized as lakefront property. The majority of parcels are classified as single-family residential. The first home in the lakeshed dates back to 1920, but residential development adjacent to the lake largely began in the 1950s, with most of the northern shoreline being developed later in the 1970s and the outer portions of the lakeshed post-1990 (Figure 8). The average single-family home in the lakeshed is roughly 1,500 sq feet in total size, sits on a 1.6-acre lot, and is valued at approximately $260,000 (Table 2).

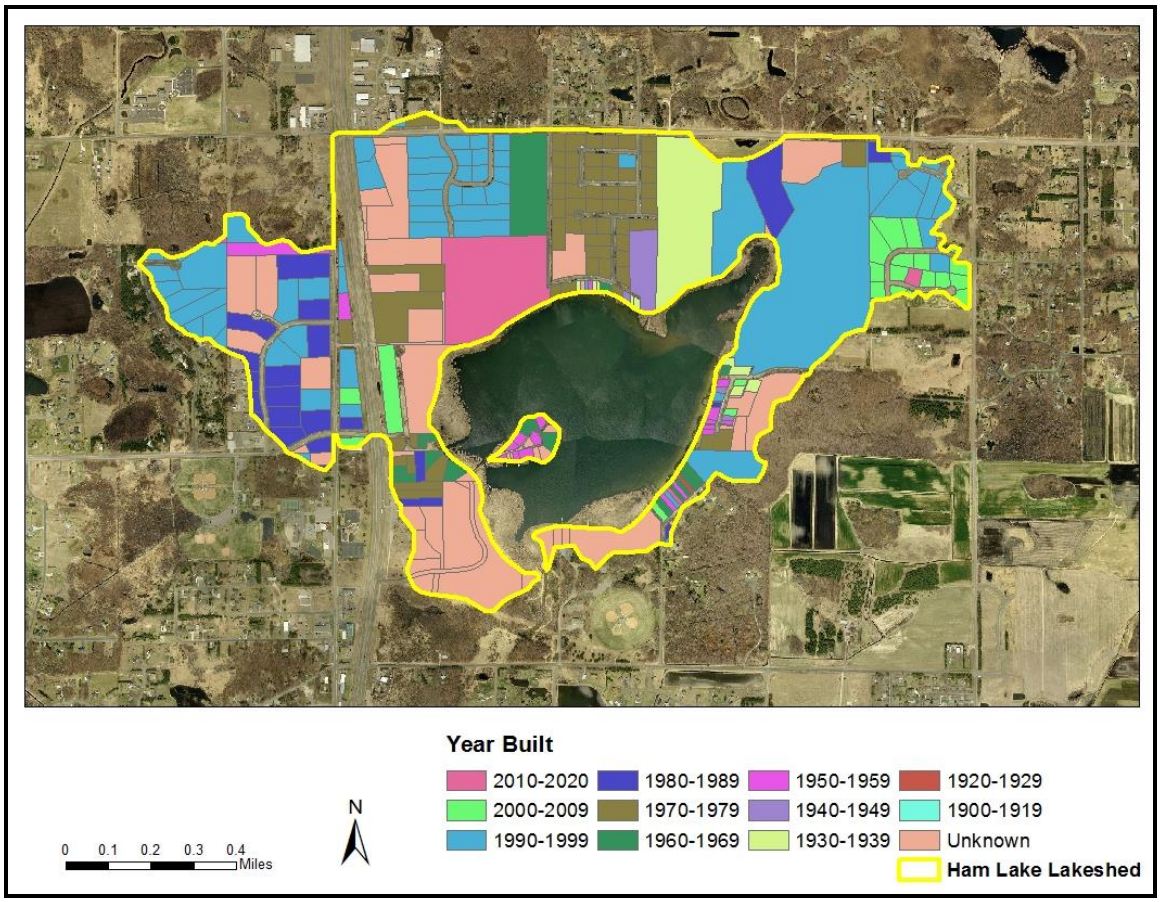

Figure 8. Timeline of development in the Ham Lake lakeshed

Table 2. Summary statistics for single-family residential parcels in the Ham Lake Lakeshed

Average lot size	1.59 acres
Average house size	1,466 sq ft; 3 bedrooms, 2 baths
Average house Age	37 years (built in 1980)
Oldest house	97 years (built in 1920)
Newest house	2 years (built in 2015)
Average home value	$263,583

2.4 Physical attributes of Ham Lake

2.4.1 Lake Morphology & Bathymetry

Ham Lake, named after its ham-like shape, is a natural lake that was formed as the Superior lobe of the Wisconsin glacier retreated. Ham Lake has a surface area of approximately 203 acres with a mean depth of 6.6 feet and a volume of approximately 1,350 acre-ft. Ham Lake is a shallow lake with 94 percent of the lake classified as littoral zone (<15 feet). The deepest portion of the lake is just east of the center, with a maximum depth of 22 feet (Figure 9). Ham Lake has a meandered shoreline length of 3.36 miles, including an 8-acre island that is separated from the southwest shoreline by a narrow channel, but accessible by footbridge. The fetch (maximum windswept distance) of Ham Lake is 0.9 miles oriented in a southwest-northeast direction.

Table 3. Physical attributes of Ham Lake

Parameter	
Surface Area (acres)	203
Average Depth (ft)	6.6
Maximum Depth (ft)	22
Littoral Area (acres)	191
Littoral Area (%)	94%
Volume (acre-ft)	1,353
Residence Time (yrs)	5.1

Table 4. Lake bathymetry at 5-foot increments

Depth (ft)	Area (acres)	% Lake Area	Volume (acre-ft)
> 0	203	100	1,353
> 5	95	47	734
> 10	64	32	394
> 15	16	8	185
> 20	2	3	40

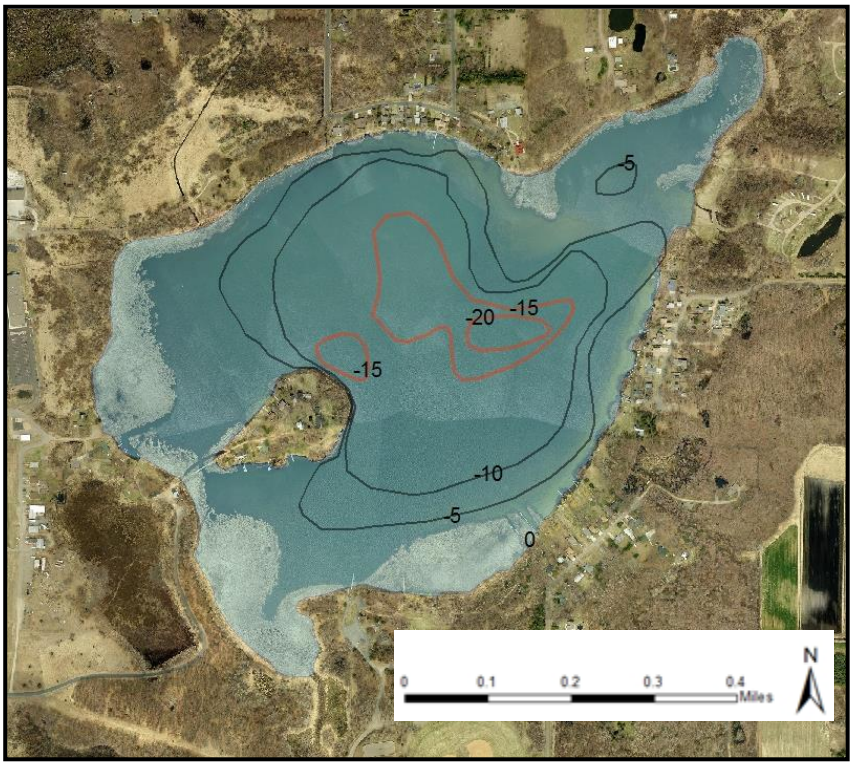

Figure 9. Ham Lake bathymetric map

2.4.2 Lake Levels

The water level of Ham Lake is ultimately controlled by a cement weir located in the outlet channel approximately 1,000 feet south of the lake's edge at a surveyed elevation of 896.7 feet above sea level (CCWD, 2011). During many years, water levels do not reach this elevation and the lake does not discharge. Historical water level data collected weekly or monthly during the open water season by local volunteers is available for Ham Lake dating back to 1985 (Lake Water Level Report for Ham Lake, MN DNR). Ham Lake's water level has been generally stable, with no apparent long-term increasing or decreasing trend (Figure 10). Despite a range of 4.8 feet of total bounce (difference between the lowest and highest water levels on record), annual fluctuations in water level are typically closer to a foot (Table 5). The Ordinary High Water Level for Ham Lake designated by the MN DNR is 897.2 ft. Flooding concerns for Ham Lake are minimal given its small drainage area and the expansive low-lying wetlands that surround the lake and provide a buffer against rising waters. Ham Lake is however vulnerable to drought conditions given its reliance on surficial groundwater as a significant source of water.

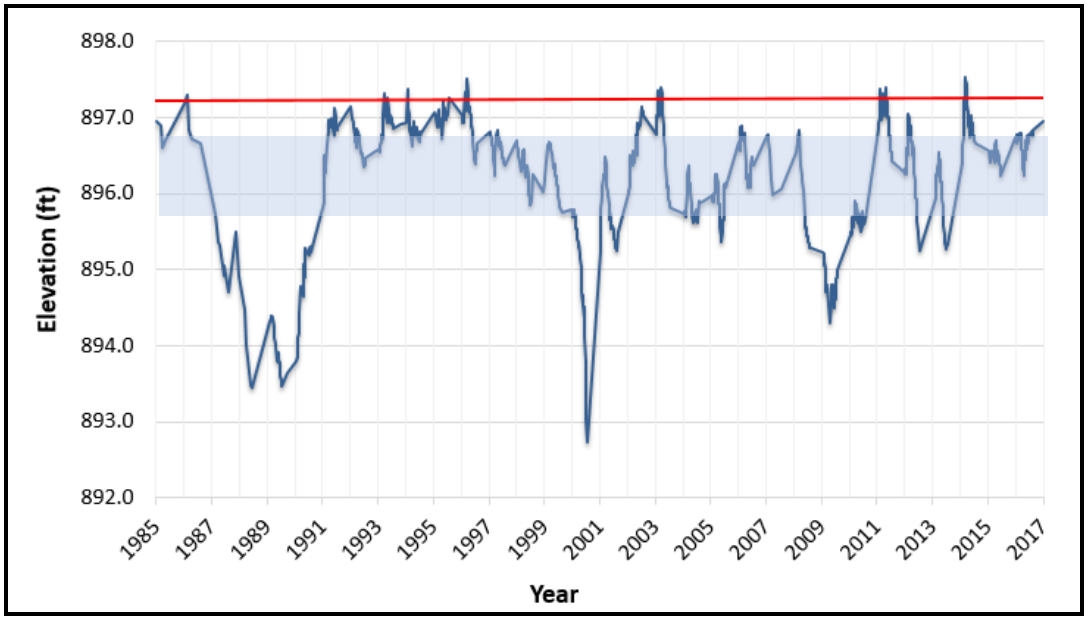

Figure 10. Ham Lake water levels from June 1985 through April 2017. The red line indicates the Ordinary High Water Level elevation and the blue shaded box illustrates the range between the 25th and 75th percentiles of all reported lake level data.

Table 5. Ham Lake lake level summary statistics for all data records

Parameter	ft
Lowest level on record	892.73 (10/26/2000)
Highest level on record	897.53 (6/20/2014)
Total recorded range	4.80
Average (median) water level	896.47
Average annual range	1.05
Ordinary High Water Level	897.20

2.4.3 Lake Stratification & Mixing

Thermal stratification and lake mixing play important roles in lake ecology including nutrient cycling and the spatial distribution of aquatic organisms. Water stratifies based on the temperature and pressure differences that arise from uneven heating and cooling at different depths. Wind and wave action may prevent lake stratification if the lake mixes to the bottom. If a lake is stratified, the bottom unmixed layer known as the hypolimnion is slowly depleted of oxygen and may become anoxic. Most lakes in Minnesota are dimictic, meaning they mix twice a year in spring and fall (i.e. lake turnover) and are stratified throughout the summer and winter months. Shallow lakes often behave differently and may mix more often (polymictic) due to more even heating/cooling of the water and less resistance to mixing by wind.

The presence and extent of lake stratification is observed by taking measurements of temperature and/or dissolved oxygen at various depths throughout the year. There is very limited data available to assess stratification in Ham Lake. No temperature profiles have been reported, but monthly oxygen profiles were measured in Ham Lake throughout the open water season of 1984. Despite being a shallow lake, Ham Lake does have a 22-foot deep hole which likely leads to stratification in most years. In 1984, there was evidence of stratification from early July through August (Figure 11). The water column dissolved oxygen levels were homogenous in May and into Mid-June (yellow and orange profiles), but the waters deeper than roughly 4 meters were depleted of oxygen in July and August (red profiles), and there was evidence of lake mixing by early September (violet profile).

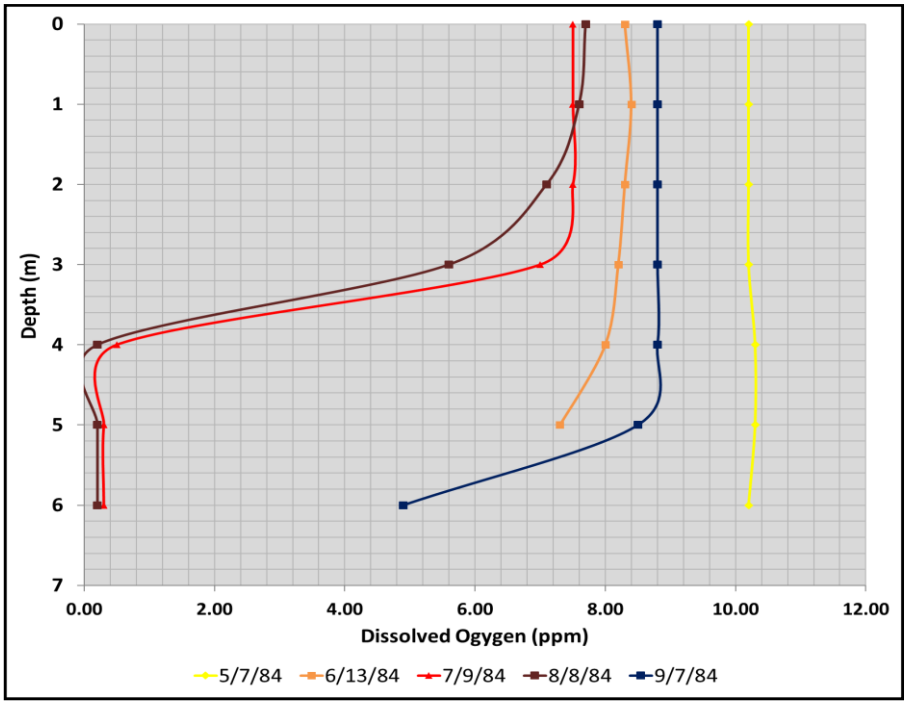

Figure 11. Monthly dissolved oxygen profiles measured at the deepest point in Ham Lake from May through September of 1984 (MPCA).

2.5 Ham Lake's Water Quality

2.5.1 Pollution Standards & Impairments

Ham Lake is classified as a Class 2B shallow lake. Class 2B waters have designated beneficial uses defined in MN Rule 7050.0222, *"The quality of Class 2B surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life, and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing…"*. For Class 2B shallow lakes within the North Central Hardwood Forests ecoregion, the following standards apply:

Parameter	Standard
Total Phosphorus	<60 µg/L
Chlorophyll-a	<20 µg/L
Secchi depth (transparency)	>1.0 meters

To determine whether Ham lake supported recreational uses and met fish consumption standards, formal condition assessments were conducted by the Minnesota Pollution Control Agency in 2009 and 2007, respectively. To be considered impaired, a lake must exceed the standard for total phosphorus and also fail to meet standards for either chlorophyll-a or Secchi depth. Ham Lake was determined to be fully supporting of aquatic recreation, but was listed as impaired for aquatic consumption in 2008 based on elevated levels of mercury in fish tissue samples. Fish consumption guidelines for Ham Lake were established by the Minnesota Department of Health (Figure 12). Addressing mercury levels in Ham Lake is part of a state, national, and international effort to reduce mercury pollution in surface waters due to atmospheric deposition.

Pregnant Women, Women who may become pregnant and Children under age 15

LAKE NAME County, DOWID	Species	Meal Advice				Contaminants
		Unrestricted	1 meal/week	1 meal/month	Do not eat	
HAM Anoka Co., 02005300	Bluegill Sunfish		All sizes			Mercury
	Northern Pike			All sizes		Mercury
	White Sucker		All sizes			Mercury

General Population

LAKE NAME County, DOWID	Species	Meal Advice				Contaminants
		Unrestricted	1 meal/week	1 meal/month	Do not eat	
HAM Anoka Co., 02005300	Bluegill Sunfish	All sizes				
	Northern Pike		All sizes			Mercury
	White Sucker	All sizes				

Figure 12. Fish consumption guidelines for Ham Lake established by the Minnesota Department of Health and reported by the Minnesota Department of Natural Resources (MN DNR, Fish Consumption Guidelines for 02005300)

2.5.2 Water Clarity

Lake transparency is driven by nutrient concentrations, algal and plant growth, and sediment loading and resuspension. The average growing-season clarity of Ham Lake over the past 10 years (2007-2016) as measured by Secchi depth is 2.6 m (8.5 ft). Water clarity in the spring is typically closer to 4 m (13 ft) and commonly drops to approximately 1.5 m (5 ft) by late summer. The average growing-season transparency of Ham Lake has been stable over the past 25 years (Figure 13). The transparency is well above the established State standard of 1 m for shallow lakes.

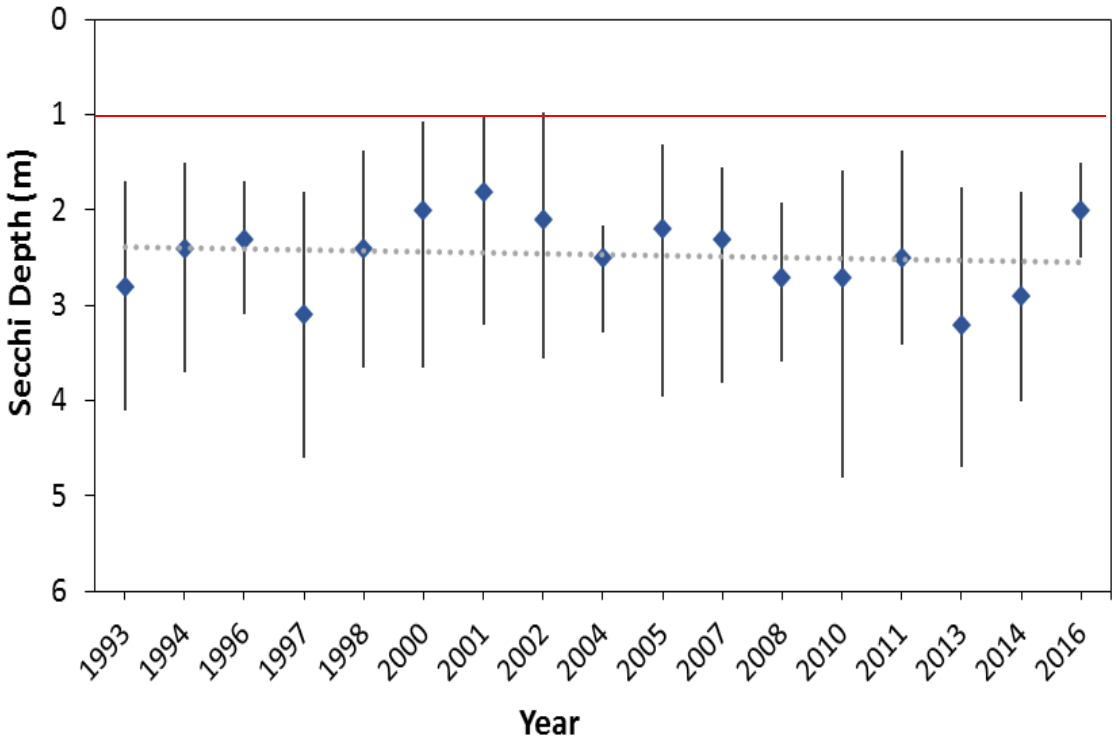

Figure 13. Average (mean) growing-season Secchi depth measured at the deepest point in Ham Lake from 1993 through 2016. The vertical lines represent the range between the minimum and maximum measurements each year. The solid red line indicates the State standard (>1 m) and the dashed grey line depicts the long-term trend (linear regression).

2.5.3 Chlorophyll-a

Chlorophyll-a is a pigment used in photosynthesis by plants and alge. Quantifying chlorophyll-a concentrations provides a measure of the amount of algae in the lake. Algal growth is driven by nutrient availability, lake clarity (sunlight penetration), temperature, and predation by zooplankton. The average growing-season concentration of chlorophyll-a in Ham Lake over the past 10 years (2007-2016) is 6.0 µg/L, which is well below the State pollutant standard of 20 µg/L. Over the past 25 years, there is a declining (i.e. improving) long-term trend in chlorophyll-a concentrations (Figure 14). Intra-annual variation in chlorophyll-a concentrations has also decreased compared to the early 2000s when the maximum concentrations regularly exceeded the State pollutant standard.

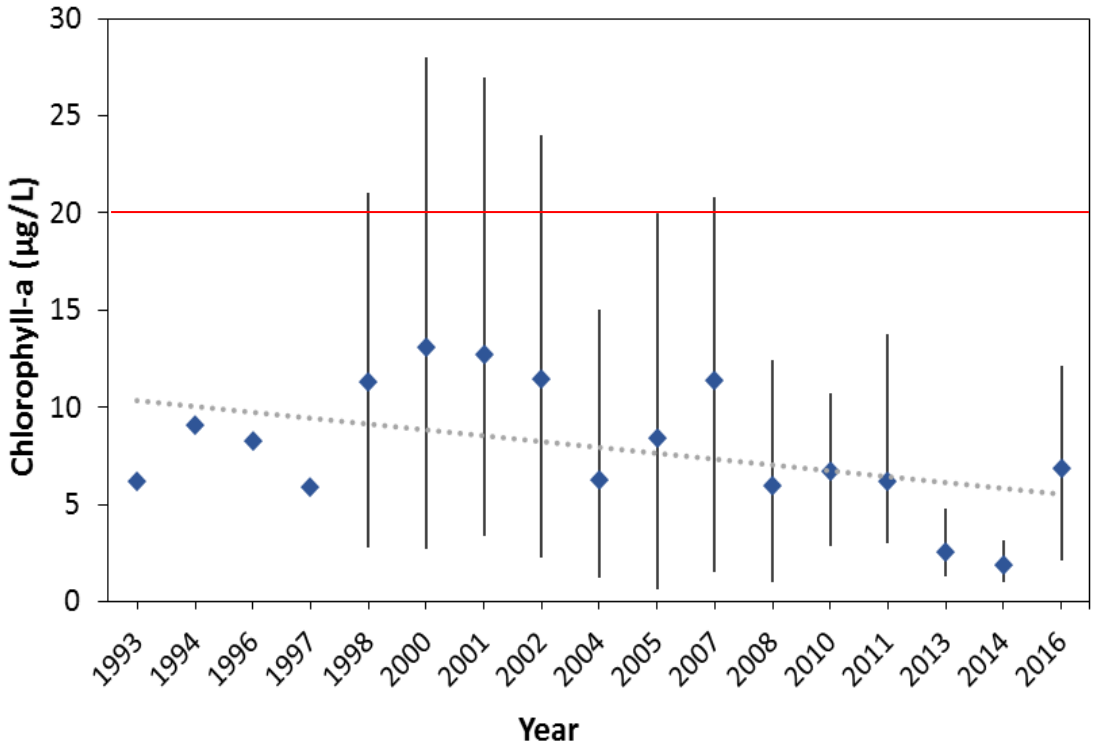

Figure 14. Average (mean) growing-season chlorophyll-a concentrations (µg/L) measured at the deepest point in Ham Lake from 1993 through 2016. The vertical lines represent the range between the minimum and maximum measurements each year. The solid red line indicates the State pollutant standard (20 µg/L) and the dashed grey line depicts the long-term trend (linear regression).

2.5.4 Total Phosphorus

Total phosphorus (TP) measures both the dissolved and particulate froms of phosphorus in the water column to provide a measure of lake eutrophication (nutrient enrichment). Phosphorus is communly used as an indicator of eutrophication in Minneseota lakes because it is often the limiting nutrient that drives plant and algal growth. The average growing-season concentration of TP in Ham Lake over the past 10 years (2007-2016) is 23 µg/L, which is well below the State pollutant standard of 60 µg/L for shallow lakes in the North Central Hardwood Forests ecoregion. Over the past 25 years, there has been a stable long-term trend in TP concentrations (Figure 15). Intra-annual variation in TP concentrations has however decreased over time. Although the annual average (mean) TP concentration in Ham Lake has never exceeded the State pollutant standard, maximum observed TP concentrations exceeded the State pollutant standard in roughly half of all years sampled prior to 2007, with reports as high as 210 µg/L in 2004.

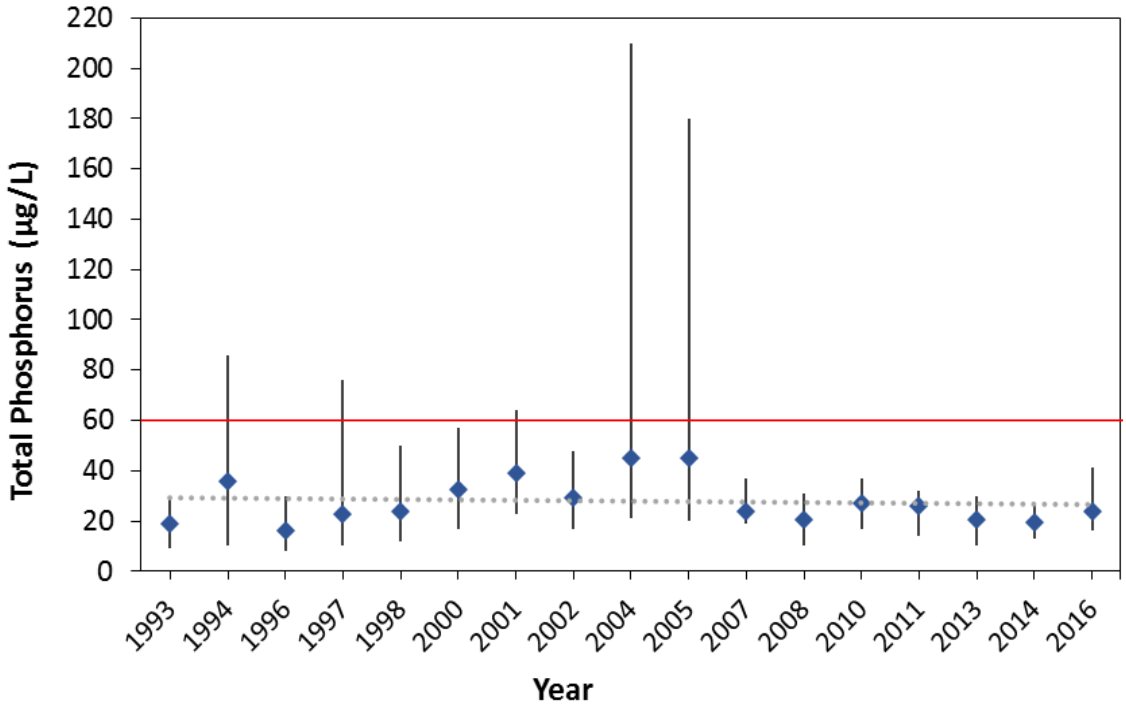

Figure 15. Average (mean) growing-season total phosphorus concentrations (µg/L) measured at the deepest point in Ham Lake from 1993 through 2016. The vertical lines represent the range between the minimum and maximum measurements each year. The solid red line indicates the State pollutant standard for shallow lakes (60 µg/L) and the dashed grey line depicts the long-term trend (linear regression).

2.5.5 Nutrient Loading

To analyze nutrient loading to Ham Lake, a watershed and lake response model for phosphorus was developed (Wenck 2014). The model assumptions, methods, and results for each component of the phosphorus budget are summarized below.

Atmospheric Load

Atmospheric inputs of phosphorus to Ham Lake from wet and dry deposition were estimated using rates set forth in the MPCA report "Detailed Assessment of Phosphorus Sources to Minnesota Watersheds" (24.9-29.0 kg/km^2-year; Barr Engineering 2004). For Ham Lake, these rates equate to annual phosphorus loads of approximately 46, 49, and 53 pounds per year for dry, average, and wet years, respectively.

Internal Load

Internal loading from lake sediments is often the result of organic sediment releasing phosphorus to the water column during anoxic conditions. Typically, water column temperature and dissolved oxygen profiles measured during the summer growing season are used to determine the volume of water under anoxic conditions. This volume is then used to calculate an anoxic factor normalized over the lake basin and reported as number of days (Nürnberg, 2004). Based on the 1984 dissolved oxygen profiles (see section 2.4.3), anoxic conditions developed below 4 meters of depth in Ham Lake throughout most of July and August, resulting in an estimated anoxic factor of 8 days.

To calculate the total internal load for a lake, the anoxic factor is multiplied by the lake surface area and an estimated or measured phosphorus release rate. A release rate of 1.0 mg/m^2/day was assumed for Ham Lake based on literature values for similar, un-impaired shallow lakes (Nurnberg, 1997). Multiplying this release rate (1.0 mg/m^2/day) by the lake area (203 acres) and the aforementioned anoxic factor (8 days) produces an estimated internal load of approximately 15 pounds per year.

Watershed Load

Watershed phosphorus load generation and delivery to Ham Lake were estimated using P8 (Walker 2013, version 3.4). The Ham Lake watershed was divided into 18 minor catchments and 9 subwatersheds (pour points) using culvert/storm sewer information and two-foot LiDAR contours. Watershed treatment devices were divided in to three categories: constructed stormwater ponds with design information, natural and/or constructed ponds with no design information, and wetlands. There are three stormwater ponds in the Ham Lake lakeshed with partial as-built design specifications available. There are several small ponds throughout the watershed with no available design specifications. These impoundments include natural and/or slightly modified surface

water features or constructed ponds that receive stormwater runoff. For these ponds, the outlet elevation was determined based on LiDAR. The permanent pool areas were estimated based on the geometry provided in a GIS basin shapefile. The basins were assumed to be 6-feet deep with a 15-inch orifice outlet. Based on aerial photos and the National Wetland Inventory (NWI), there are also several larger wetlands throughout the watershed that receive stormwater runoff from surrounding areas and likely provide some level of treatment. The outlet elevations and permanent pool area for the wetlands were determined based on LiDAR elevation information. The outlets for the wetlands were assumed to be a 15-inch orifice for modeling purposes and a depth of 0.5-feet was used to represent the permanent pool.

The percent impervious fractions and pervious curve numbers for each subwatershed were estimated using current land use and soil type information. Each land use was assigned an impervious percent based on literature values and runoff curve numbers were determined by soil type. The model was setup and run for 2007, 2008, 2010, 2011 and 2013 to predict phosphorus loading for each subwatershed (Table 6). On average, the subwatersheds with the highest phosphorus loading rate per acre were P1, P7, and P8 which consist of direct drainage to the lake from adjacent properties and drainage of the Highway 65 corridor (Table 6, Figure 3).

Table 6. P8 model predictions for TP loading to Ham lake from each subwatershed

Subwatershed	Area [acres]	2007 TP [lbs]	2008 TP [lbs]	2010 TP [lbs]	2011 TP [lbs]	2013 TP [lbs]	Average TP load [lbs/ac]
HL-1	132	40.4	33.4	57.3	76.0	34.0	0.37
HL-P2	68	5.4	4.2	9.5	11.8	5.5	0.11
HL-P3	37	2.0	1.6	4.3	7.4	2.4	0.10
HL-P4	27	1.0	0.7	2.1	3.4	1.2	0.06
HL-P5	54	7.6	6.0	12.1	14.2	7.0	0.17
HL-P6	70	7.1	5.5	12.3	15.3	7.3	0.14
HL-P7	201	34.4	26.9	55.8	67.0	33.6	0.22
HL-P8	9	4.2	3.2	6.2	6.7	3.6	0.53
HL-P9	35	3.2	2.4	5.6	7.0	3.4	0.12
Total	**633**	**105.3**	**83.9**	**165.2**	**208.8**	**98.0**	**0.21**

Final Nutrient Budget

Across all modeled years, loading from drainage area runoff represents a majority (68%) of the average annual TP load to the lake. Atmospheric loading represents the second largest source of TP (25%). Internal loading to Ham Lake is assumed to be low and accounts for only 7% of the annual average phosphorus budget (Figure 16).

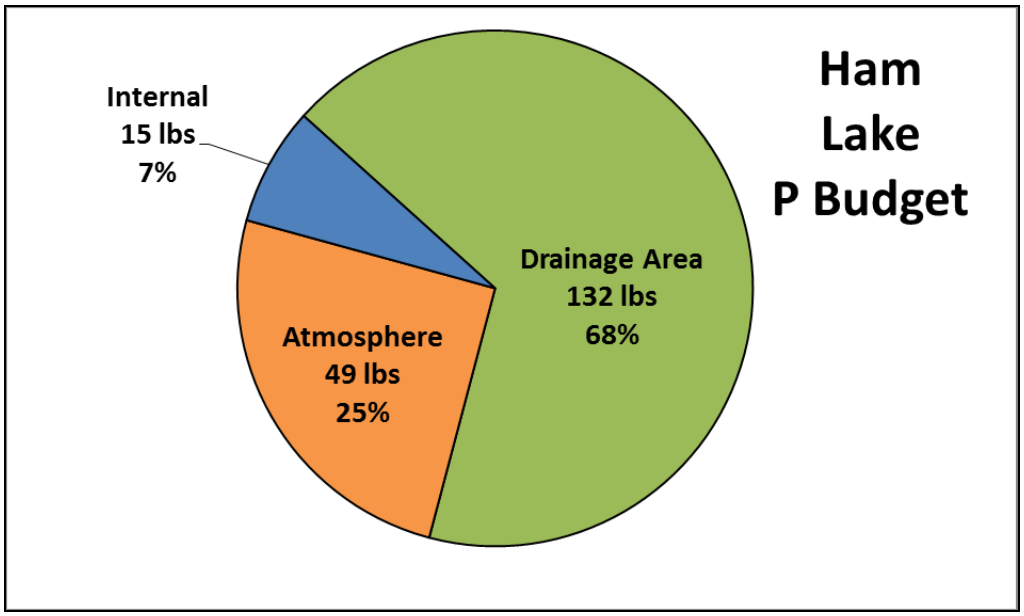

Figure 16. The annual phosphorus budget for Ham Lake averaged over all modeled years

Water Quality Response Modeling

The modeled phosphorus loading rates for Ham Lake were used as inputs in the Canfield-Bachman lake response model (1981). Predicted results from the lake response model were then compared to measured phosphorus concentrations from in-lake monitoring efforts (Figure 17). The lake response model performed well for the modeled years and is considered a reasonable representation of the nutrient dynamics in the lake and watershed.

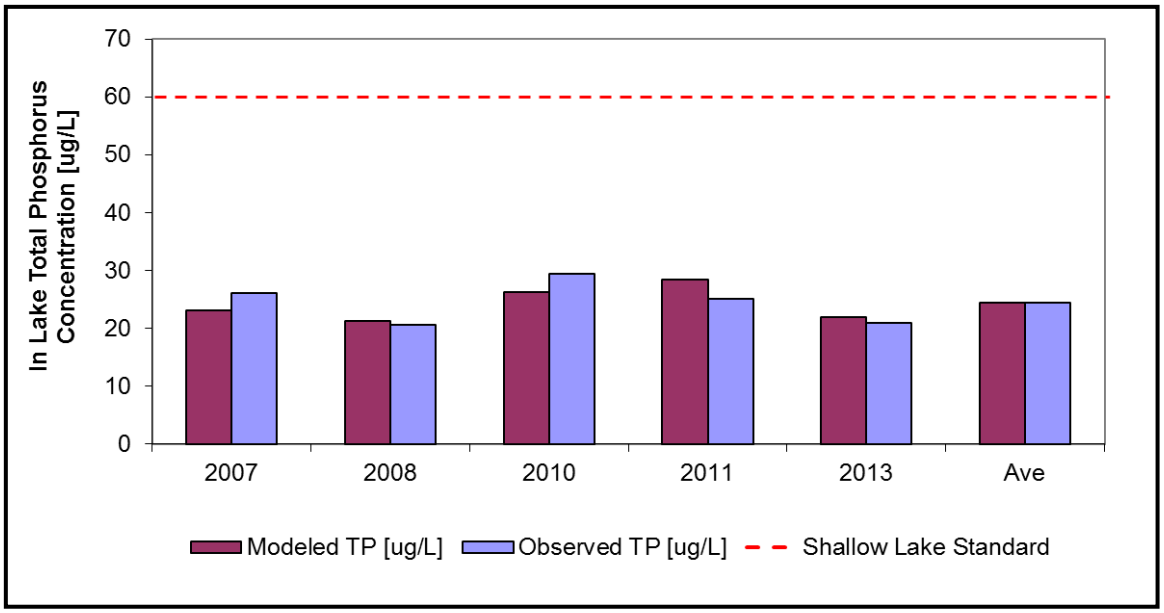

Figure 17. Phosphorus lake response model performance for Ham Lake compared to observed monitoring results

2.6 Biological Attributes of Ham Lake

2.6.1 Aquatic Macrophytes

Healthy shallow lakes are characterized by abundant and diverse macrophytes or aquatic plants. Aquatic plants are an important source of food and habitat for invertebrates, fish, and wildlife. Many aquatic organisms rely on aquatic plants for at least a portion of their life cycle. Additionally, aquatic plants promote increased water clarity and reduced algal growth by sequestering nutrients and reducing sediment resuspension through stabilization of the lake bottom. Emergent plants such as bulrush and cattails are also important for preventing shoreline erosion and intercepting overland runoff. It is however possible for aquatic plants to reach nuisance conditions and interfere with access to the lake and/or recreation, especially given the presence of excess nutrients or invasive species.

Ham Lake has a diverse macrophyte community that is comprised of numerous native species as well as two invasive species, hybrid/Eurasian watermilfoil and curlyleaf pondweed. It should be noted that Eurasian watermilfoil (*Myriophyllum spicatum*) and hybrid watermilfoil (*M. spicatum* x *sibiricum*) are grouped together in this plan because they had not been identified separately in past plant surveys due to their inability to be distinguished by visual assessment. In 2016, however, genetic testing of milfoil samples from Ham Lake by the MN DNR confirmed the presence of hybrid milfoil in 5 out of 5 samples, indicating that hybrid milfoil is likely widespread in the lake. Based on whole-lake point-intercept surveys conducted by the MN DNR Invasive Species Program in 2014, 2015, and 2016, Ham Lake supports an average of 17 submersed species (Table 7). Several additional floating-leaf, free-floating, and emergent taxa were observed during the surveys, but were not quantified. Over the past three years, despite some inter-annual variation, the average maximum depth of plant growth was 3.8 m (12.5 ft), the average percent of sampling points in the littoral zone with native vegetation present was 84%, and the average number of native plants per sampling point was 2.3 (Table 8).

In some areas of the lake, plants grow densely and to the surface. Given the water clarity and large littoral area of Ham Lake, dense plant growth is natural and is a sign of a healthy shallow lake ecosystem. To alleviate nuisance conditions and to prevent a shift in dominance from native species to invasive species, any proposed plant management activities should focus on controlling invasive species while minimizing damage to the native plant community.

Table 7. Frequency of occurrence (%) of submersed taxa within the littoral zone (<15 ft) of Ham Lake from whole-lake point-intercept surveys conducted by MN DNR Invasive Species Program staff in July 2014, September 2015, and July 2016.

Common Name (*Scientific Name*)	Frequency of Occurrence (littoral)		
	July 2014	Sept 2015	July 2016
NATIVE			
Coontail (*Ceratophyllum demersum*)	67%	79%	58%
Muskgrass/Stonewort (*Chara spp.*, etc.)	17%	21%	23%
Canadian waterweed (*Elodea canadensis*)	13%	29%	27%
Northern watermilfoil (*Myriophyllum sibiricum*)	22%	6%	
Naiad (*Najas flexilis*)	8%	4%	2%
Large-leaf pondweed (*Potamogeton amplifolius*)	9%	16%	
Variable-leaf pondweed (*Potamogeton gramineus*)	2%	1%	
Illinois pondweed (*Potamogeton illinoensis*)		6%	2%
White-stem pondweeed (*Potamogeton praelongus*)	12%	3%	
Small pondweed (*Potamogeton pusillus*)	18%		
Fern pondweed (*Potamogeton robinsii*)	3%	10%	1%
Flat-stem pondweed (*Potamogeton zosteriformis*)	60%	49%	2%
White water crowfoot (*Ranunculus aquatilis*)	2%	2%	9%
Sago pondweed (*Stuckenia pectinata*)	5%	6%	1%
Comon bladderwort (*Utricularia macrorhiza*)	32%	26%	9%
Small bladderwort (*Utricularia minor*)		8%	1%
Water celery (*Vallisneria americana*)		9%	5%
NON-NATIVE			
Eurasian watermilfoil (*Myriophyllum spicatum* [1])	22%	7%	14%
Curlyleaf pondweed (*Potamogeton crispus*)	2%	2%	<5%

[1] *Genetic testing of milfoil from Ham Lake in 2016 confirmed the presence of hybrid watermilfoil in 5 out of 5 samples (Myriophyllum sibiricum x spicatum); because invasive hybrid milfoil cannot be distinguished from Eurasian milfoil visually, all invasive milfoil is grouped together.*

Table 8. Ham Lake plant community summary statistics from whole-lake point-intercept surveys conducted by MN DNR Invasive Species Program staff in July 2014, September 2015, and July 2016.

Plant Community Attribute	July 2014	Sept 2015	July 2016
Total number of points sampled	129	124	128
Maximum depth of plant growth (m)	4	4	3.4
Percent of sample points with native vegetation	87%	94%	72%
Mean # of native plants per point	2.7	2.8	1.4
Number of native submersed species	15	17	13
Number of non-native submersed species	2	2	2
Total species richness	17	19	15

Aquatic Plant Management

In response to the discovery of invasive Eurasian watermilfoil in Ham Lake in 2013, the Ham Lake Lake Association (HLLA) has been working with the MN DNR Invasive Species program to coordinate aquatic plant management activities since 2014 (see Table 9). The first herbicide treatment in Ham Lake was conducted in July 2014 using liquid 2,4-D. This initial treatment was reported to be largely ineffective, which prompted closer investigation into whether the Eurasian watermilfoil was hybridizing with native Northern watermilfoil because hybrid milfoil can potentially be more resistant to 2,4-D. Subsequent genetic analyses confirmed that hybrid Eurasian watermilfoil (HEWM) was indeed widespread in Ham Lake. In 2015, HEWM was instead targeted using triclopyr, a systemic herbicide which has been effective at controlling hybrid milfoil. The treatment successfully controlled HEWM, but also had some non-target impacts on waterlilies. Despite the observed damage, waterlilies are still abundant in Ham Lake and their recovery is being monitored by the MN DNR. In 2016, HEWM was less prevalent and was spot-treated using a contact herbicide, diquat. As of July 2017, only a few patches of EWM were located in Ham Lake and treatment was not recommended by DNR in 2017.

Although the distribution of curlyleaf pondweed (CLP) in Ham Lake appears limited based on the available plant survey records (<5% frequency of occurrence; Table 9), CLP is generally not well-represented in late summer/fall plant surveys because of its unique growth cycle. CLP grows under the ice, peaks in May/June, and naturally senesces by early July. Early-season delineation maps dating back to 2014 showed that CLP is in fact widespread in Ham Lake, covering approximately 16 acres. In 2016, CLP was chemically treated in Ham Lake for the first time using endothall. The treatment was successful, but repeated annual treatments will likely be necessary for long-term control of CLP due to its reproductive structures (turions) that remain viable in the sediment for many years.

Table 9. Summary of invasive aquatic plant management activities in Ham Lake coordinated by the Ham Lake Lake Association (HEWM: hybrid/Eurasian watermilfoil; CLP: curlyleaf pondweed).

Date	Target Species	Acres Treated	Herbicide	Approx. Cost	Licensed Commercial Applicator
July 2014	HEWM	6.1	2,4-D (liquid)	$1,500	PLM Lake and Land Management Corp.
June 2015	HEWM	19.4	Triclopyr (granular)	$22,000	PLM Lake and Land Management Corp.
May 2016	CLP	13.45	Endothall	$4,500	PLM Lake and Land Management Corp.
October 2016	HEWM	11.3	Diquat	$3,500	PLM Lake and Land Management Corp.
May 2017	CLP	13.45	Endothall	$4,500	PLM Lake and Land Management Corp.

2.6.2 Fish Community

The fish community in Ham Lake has changed significantly over time, but is presently in a stable, healthy state. The first fish survey for Ham Lake was conducted in 1948. A total of 11 fish surveys have been conducted since then, with the most recent survey completed by MN DNR Fisheries in 2016. In total, 13 different species of fish have been sampled in Ham Lake (Table 10).

The fish community of Ham Lake can be described as a typical bass-panfish-northern pike assemblage that offers ample angling opportunities. This was not always the case, however, as Ham Lake used to be dominated by bullheads and invasive common carp. In the 1948 survey, MN DNR Fisheries reported, "In view of the lake's record of frequent winterkill plus its heavy carp population, it should be considered a rough fish lake at present. If rough fish should be decimated by future winterkill or rough fish removal activities, Ham lake could support numbers of northern pike and largemouth bass". Later, it was reported in 1984 that, "no carp have been sampled in Ham Lake since the rotenone treatment (fish poisoning) in 1955". To date, there are no records of common carp being sampled in standardized DNR surveys after 1955, but carp may be present in small numbers below detection. Over the past 50+ years since the rotenone treatment, Ham Lake has shown it can indeed support a healthy gamefish population (Table 10).

Table 10. A list of all fish species sampled in Ham Lake between 1948 and 2016. Average catch rates by species and gear type are reported prior to and after the 1955 rotenone treatment.

Common name (*scientific name*)	Average catch per unit effort pre-1955		Average catch per unit effort post-1955	
	Trap-net	Gill net	Trap-net	Gill net
Black bullhead (*Ameiurus melas*)	0.3		20.9	18.1
Black crappie (*Poxomis nigromaculatus*)			1.7	9.9
Bluegill (*Lepomis macrochirus*)			35.9	18.4
Brown bullhead (*Ameiurus nebulosus*)	91.3	24.0	2.5	6.7
Common Carp (*Cyprinus carpio*)	8.0	17.0		
Golden shiner (*Notemigonus crysoleucas*)				1.9
Green sunfish (*Lepomis cyanellus*)			1.9	0.5
Largemouth bass (*Micropterus salmoides*)	1.0		0.2	0.9
Northern Pike (*Esox lucius*)			0.5	7.4
Pumpkinseed sunfish (*Lepomis gibbosus*)	0.7		5.8	2.4
White sucker (*Catostomus commersonii*)	0.7			0.5
Yellow Bullhead (*Ameiurus natalis*)			2.5	6.3
Yellow Perch (*Perca flavescens*)	1.7	1.5	0.7	7.1

Catch rates of 5 most commonly sampled species are variable between years and gear types (trap-nets versus gill nets), but are generally stable since the 1980s (Figure 18). Based on the most recent survey in 2016, Ham Lake supports above average numbers of bluegill sunfish, pumpkinseed sunfish, largemouth bass, and northern pike compared to other Class 38 lakes. The average weight of largemouth bass and northern pike is also above average, but below average for sunfish. The abundance of crappie and yellow perch is below average. It should be noted that largemouth bass are not well-represented by standard DNR survey methods, but supplemental electrofishing surveys conducted in 1994 and 1999 indicate very high catch rates of largemouth bass (68 & 81 bass per hour, respectively).

Spawning habitat for largemouth bass and panfish in Ham Lake is very good, with ample sandy substrate with moderate vegetation growth. Spawning habitat for northern pike is fair to good with shallow weedy areas located in the northeast bay and near the outlet.

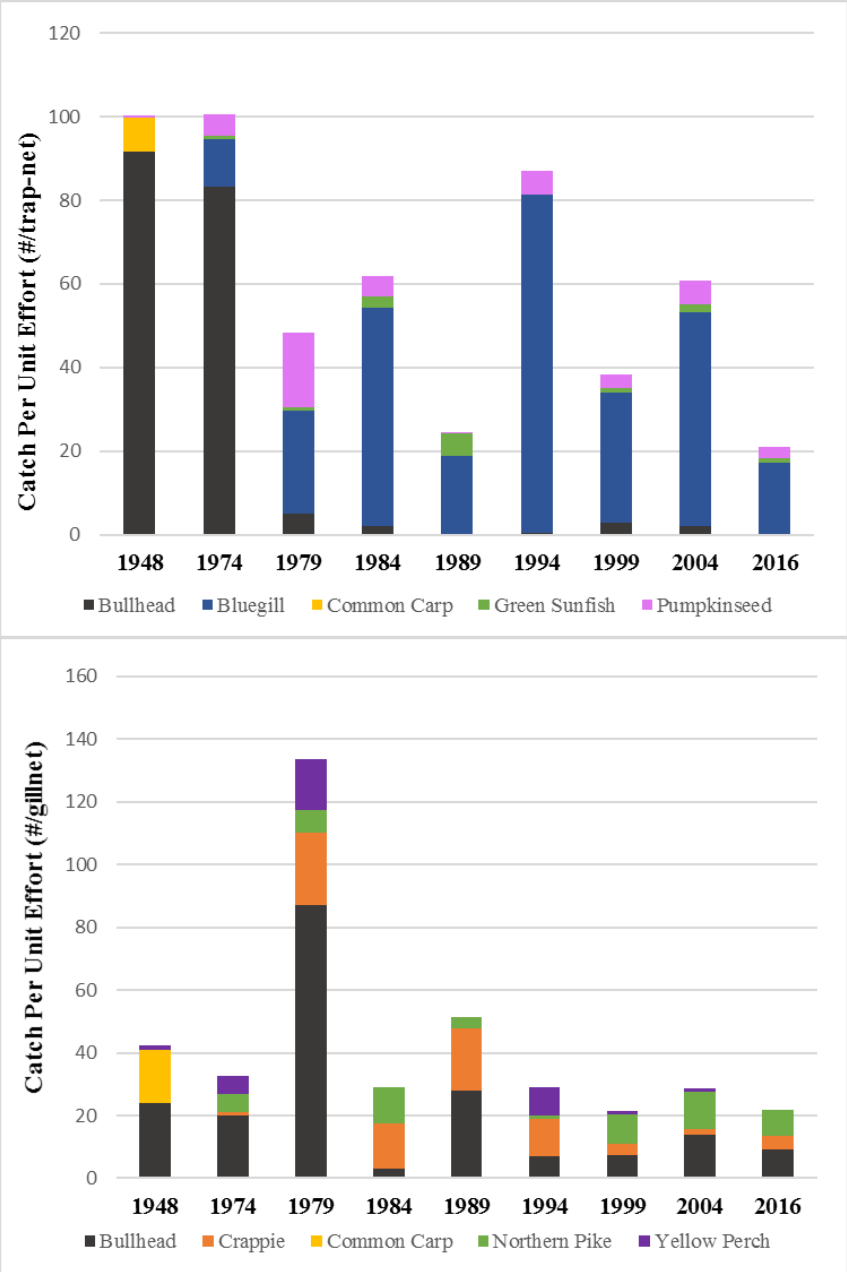

Figure 18. Catch per unit effort (# per net) of the 5 most commonly sampled fish species during standardized MN DNR trap-net surveys (upper panel) and gill net surveys (lower panel) from 1948 through 2016.

Fisheries Management

In addition to the lakewide rotenone application conducted in 1955 to control common carp, the fish community in Ham Lake has been actively managed through supplemental stocking and winter aeration. Ham Lake is managed primarily for largemouth bass and northern pike. There is a rich history of stocking activities from the 1950s through the late 1970s, including fingerlings, yearlings, and adults of largemouth bass, crappies, northern pike, and bluegill sunfish (Table 11). Most of these stocking activities followed partial winterkill events which occurred periodically in Ham Lake before the installation of a winter aeration system. It is unknown when the aerator was first operated, but a DNR aeration permit has been issued for Ham Lake since the winter of 1987-88. Presently, the City of Ham Lake operates 3 floating jet aerators located off the eastern shore of the island. DNR Fisheries records indicate that the aeration system broke down during the winter of 1996-97, resulting in a partial winterkill. Despite a decrease in abundance of some species, the fish community rebounded quickly through natural reproduction and rapid growth. No winterkill events have been reported since 1997.

Table 11. Historical fish stocking records for Ham Lake (Source: MN DNR Fisheries).

Year	Species	Number	Size	Remarks
1978	Northern Pike	7178	Fingerling	
1973	Northern Pike	5000	Fingerling	5 pounds
1972	Crappie	266	Adult	From White Bear Lake
	Sunfish	2172	Adult	From White Bear Lake
	Largemouth Bass	21736	Fingerling	71.5 pounds
1971	Northern Pike	1559	Yearling	
1968	Northern Pike	268	Yearling	
	Sunfish	1400, 5075	Yearling, Adult	200 pounds
1967	Northern Pike	29, 1027, 10000	Adult, Yearling, Fngrl	
1966	Northern Pike	278, 16	Yearling, adult	
	Sunfish	2000	Yearling	
1965	Sunfish	450	Adult	
	Crappie	450	Adult	
	Northern Pike	615	Yearling	
1963	Northern Pike	384	Yearling	
1962	Northern Pike	30, 722, 6000	Adult, Yearling, Fngrl	
	Largemouth Bass	2	Adult	
	Crappie	1200	Adult	
	Sunfish	300	Adult	
1961	Northern Pike	5400	Fingerling	
1960	Northern Pike	3044	Adult	
	Sunfish	1500	Adult	
1956	Sunfish	9721, 14850	Adult, Yearling	
	Crappie	1100, 10210	Adult, Yearling	
	Northern Pike	464	Adult	
1954	Northern Pike	130	Adult	
	Crappie	160	Adult	
	Largemouth Bass	200	Fingerling	

2.7 Social Attributes of Ham Lake

2.7.1 Demographics

Based on 2016 census data, there is an estimated 442 individuals residing within the Ham Lake lakeshed, an increase from an estimated 378 residents in 2000. There are 293 parcels located within the lakeshed, with 71 parcels characterized as lakefront property. The median age of Ham Lake residents is 40 years old and the median household income is approximately $92,000. Lake-based economic activities include recreational activities such as fishing, boating, camping, and swimming.

2.7.2 Lake Use

Based on MN DNR Fisheries survey data from 1980, the most popular recreational uses on Ham Lake include fishing, pleasure boating via pontoons and runabouts, use of non-motorized crafts such as inflatable rafts and canoes, and water skiing. A follow-up survey in 1999 quantified the number and type of watercrafts owned by lake residents; fishing boats were the most prevalent, followed by pontoons, paddleboats, and canoes (Figure 19). A creel survey conducted by MN DNR Fisheries in 2004-05 found angling pressure to be relatively high compared to other area lakes at 101.5 hours per acre (MN DNR 2006). Ham Lake is also a popular ice fishing destination and supports an average of 26 ice houses per year (Figure 20). Based on 2016 Anoka County watercraft inspection data, Ham Lake is heavily used, with an average of 2.19 boats per hour utilizing the public access. Ham Lake is the 6th most visited lake in Anoka County after Coon, George, East Twin, Linwood, and Centerville Lakes.

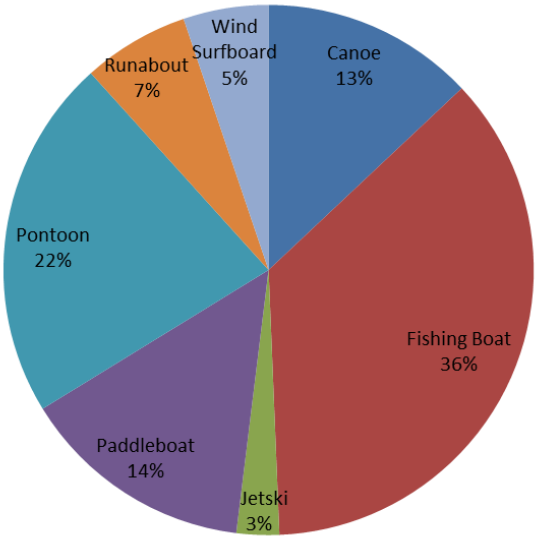

Figure 19. Breakdown of watercraft (n=77) ownership by lakeshore resident (Source: MN DNR Fisheries, 1999).

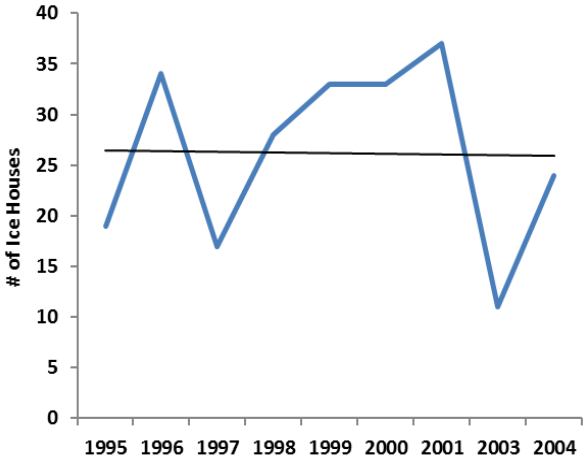

Figure 20. The number of ice fishing houses observed on Ham Lake from 1995 through 2004 (Source: MN DNR Fisheries, 2004).

3.0 Management Priorities, Objectives, & Actions

3.1 Identification of Issues & Concerns

The issues and concerns facing Ham Lake were identified based on input from three committees (i.e., Steering, Technical, & Advisory) as well as professional judgment by CCWD staff. The Steering Committee consisted of members of the Ham Lake Lake Association (HLLA); feedback on issue identification and plan development was collected at regular HLLA meetings. The Technical Committee was comprised of local natural resource specialists with expertise in hydrology, water quality, aquatic invasive species, fisheries, and civil engineering. The Advisory Committee included representatives of local and state organizations and agencies. Committees were convened in fall of 2016 for issue identification and summer of 2017 to review and refine the resulting implementation strategy.

Participants were asked to consider a list of potential broad lake management issues (i.e., aquatic vegetation, fisheries, invasive species, recreation, water quality, & wildlife) and to identify any specific concerns relevant to Ham Lake in each category. The resulting management issues and concerns identified are listed below in no particular order:

1. **Aquatic Vegetation (excluding AIS; see #2 below)**
    I. Nuisance growth and the associated buildup of detritus/muck (esp. cattails)
    II. Lack of planned comprehensive assessments
2. **Aquatic Invasive Species**
    I. Nuisance growth/expansion of established invasive species (HEWM & CLP)
    II. Potential new invaders entering Ham Lake
3. **Water Quality**
    I. The occurrence of blue-green algae (cyanobacteria) blooms
    II. Possible pollution from failing septic systems
4. **Recreation**
    I. Potential use conflicts as development occurs (e.g. congestion)
    II. The potential for the construction of new wells in Blaine to lower lake levels[1]
5. **Fisheries**
    I. Possible overfishing/stunting of the bass and panfish populations[2]

[1]Lake level drawdown caused by the construction of new wells in Blaine was ruled out as a concern due to the direction of groundwater flow (SE) and Ham Lake being outside the area of impact.

[2]Based on the 2016 MN DNR Fisheries Lake Survey Report, it was determined that Ham Lake's bass-panfish community is presently healthy (abundance & size structures were within the normal range for Class 38 lakes) and no management actions are needed at this time; regular monitoring by MN DNR Fisheries will continue.

3.2 Management Objectives & Actions

For each identified concern facing Ham Lake, management objectives and recommended actions to meet those objectives have been outlined. These objectives and management actions are presented below for each concern along with relevant background information specific to Ham Lake. A detailed implementation plan assigning roles to organizations and a timeline can be found in Section 4.0.

3.2.1 Concern 1: Aquatic Vegetation

Specific Concerns Identified

- Nuisance growth and the associated buildup of detritus/muck (especially cattails)
- Lack of planned comprehensive plant assessments

Background

Healthy shallow lakes are characterized by diverse and abundant submersed and emergent vegetation. Aquatic plants not only provide habitat for invertebrates, fish, and wildlife, but also contribute to water quality by filtering runoff, stabilizing sediment, and sequestering nutrients. Without abundant aquatic vegetation, shallow lakes are generally dominated by algae (phytoplankton) and have poor clarity. Despite the importance of aquatic vegetation, it is also recognized that dense plant growth (both native and exotic invasive species) may interfere with the recreational use and enjoyment of Ham Lake by limiting access to open water and/or impeding certain activities such as swimming and water skiing.

Several Ham Lake users were concerned about the current extent of cattails around the lake, possible future expansion of the cattail fringe limiting access to open water, and an increase in detritus/muck from increased cattail growth and decay. Concerns were also raised about the extent of waterlilies and surface-matted vegetation in shallow areas. It should be noted that due to differences in aquatic plant management regulations for controlling invasive plants versus native plants, invasive plants are discussed separately in Section 3.2.2. Additionally, although narrow-leaved cattail (*Typha angustifolia*) and hybrid cattail (*Typha* x *glauca*) are not native to MN, all emergent plants (including cattails) are treated equally under the MN DNR aquatic plant management rule (MR 6280.0250). Where cattails impair access, individual homeowners may apply for a lifetime permit to maintain a 15 ft wide channel extending to open water for as long as they own their property. Large-scale or lakewide cattail control would however require the development of a lake vegetation management plan (LVMP) and issuance of a variance under MN Rule 6280.1000. Issuance of Aquatic Plant Management (APM) permits requires sufficient justification and may be denied if the proposed control area is determined to naturally support abundant aquatic plants (e.g. shallow bay).

Another concern that was raised regarding aquatic vegetation in Ham Lake was the lack of systemic comprehensive plant surveys. Past plant survey records for Ham Lake are extremely limited which makes it difficult to draw conclusions about how the plant community has changed over time. Although Ham Lake presently supports a healthy, diverse aquatic plant community, the recent invasion by hybrid/Eurasian milfoil and subsequent herbicide treatments may pose a threat to the health of the plant community. Since 2014, annual whole lake point-intercept surveys have been conducted by the MN DNR Invasive Species Program, but there are no guarantees that annual surveys will continue. Depending on the type and scale of future APM activities, plant surveys may or may not be required as part of the MN DNR permitting process.

Management Needs

1. Ensure the ongoing collection of high-quality data on the aquatic plant community to establish baseline information and enable assessment of lake health and management activities
2. Gain a better understanding of the recreational demands on the lake and the nature of any conflicts caused by nuisance plant growth to ensure a balance between maintaining a healthy aquatic plant community and supporting recreational uses

Management objectives

1. Maintain up-to-date records of the extent, composition, richness, & diversity of the aquatic plant community
2. Determine whether dense cattail and/or native plant growth is substantially interfering with recreational uses and the nature and scope of the interference
3. If warranted, identify and implement appropriate aquatic plant management (APM) activities to enhance recreational uses in accordance with MN DNR rules

Management Actions

1. Conduct high resolution, whole-lake point-intercept plant surveys a minimum of once every other year
2. Conduct a comprehensive survey of lake users (residents & visitors) that collects quantifiable information on recreational uses and any issues or conflicts
3. Conduct any necessary follow-up investigations based on the results of the lake users survey (e.g. quantify historical cattail extent and rate of expansion)
4. Control nuisance aquatic plant growth as needed using approved methods (e.g. herbicides, mechanical control)
5. Develop a lake vegetation management plan and apply for a variance for offshore or lakewide control of nuisance growth if needed (i.e. for emergent or floating-leaf species or when cumulative treatment area exceeds 15% of the littoral area for chemical control or 50% of littoral area for mechanical control).

3.2.2 Concern 2: Aquatic Invasive Species

Specific Concerns Identified

- Nuisance growth/expansion of the aquatic invasive species that are already established in Ham Lake: hybrid/Eurasian watermilfoil and curlyleaf pondweed
- The possibility for new invaders such as zebra mussels or starry stonewort to enter and establish in Ham Lake

Hybrid/Eurasian watermilfoil

Curlyleaf pondweed

Background

Aquatic invasive species (AIS) are non-native species that spread quickly from their point of introduction and cause harm. Damage caused by AIS includes ecological impacts such as reduced abundance and diversity of native species, degraded habitat, and altered nutrient cycling and food webs. AIS can also lead to economic impacts such as increased management costs, damage to infrastructure, loss of tourism dollars, and diminished property values. For these reasons, AIS are the subject of statewide management efforts aimed at controlling existing infestations and preventing further spread and establishment of new infestations.

Two species of aquatic invasive plants are presently established in Ham Lake: Eurasian/hybrid watermilfoil (HEWM) and curlyleaf pondweed (CLP). HEWM was first discovered in 2013 and has been managed with herbicides annually since 2014 (see Table 9). The extent of dense, surface-matted HEWM growth in Ham Lake was 6 ac in 2014, 19.5 ac in 2015, 11 ac in 2016, and less than 1 ac in 2017. To date, the HEWM management efforts organized by the Ham Lake Lake Association have successfully kept HEWM from expanding and dominating the plant community. Without active management, conditions are suitable for HEWM to grow throughout the entire littoral area (up to 191 acres). It is not known when CLP was first introduced to Ham Lake, but spring delineation maps from 2014 and 2016 documented 16 ac and 13.5 ac of CLP extent, respectively. In 2016, CLP was chemically treated in Ham Lake for the first time. The treatment was successful, but repeated annual treatments will likely be necessary for long-term control of CLP due to its reproductive structures (turions) that can remain viable in the sediment for many years.

In addition to established species, Ham Lake is also threatened by the possible introduction and establishment of new AIS. According to the Minnesota Aquatic Invasive Research Center at the University of Minnesota, there are nearly three dozen AIS already present in MN or at high-risk of establishing and causing detrimental impacts. Because AIS are often difficult or impossible to eradicate or control once established, management efforts should focus on preventing introductions and rapidly detecting and responding to new infestations. Preventing AIS introductions requires addressing the pathways of spread. Common pathways of AIS spread in inland MN lakes include recreational boats and gear, release of bait, aquarium dumping, and natural dispersal

Several state and local organization have AIS programs that benefit Ham Lake. The MN DNR, for example, leads statewide education and outreach efforts and enforces various laws aimed at preventing AIS spread. At the local level, Anoka County Parks administers a watercraft inspection program using AIS Prevention Aid funding from the State. In 2016 alone, trained watercraft inspectors were stationed at the Ham lake public access for over 300 hours and inspected a total of 655 incoming and outgoing boats. Additionally, the Coon Creek Watershed District contracts the Anoka Conservation District to conduct comprehensive visual surveys twice per year designed to detect the introduction of any new species as early as possible. The CCWD also administers a volunteer monitoring program where 7 Ham Lake residents hang a zebra mussel sampling plate from their dock and check it once per month. The public access is monitored by CCWD staff. In the event that a new AIS is detected in Ham Lake, local partners will need to coordinate a response plan and secure funding. The CCWD has established a contingency fund to enable a timely response to new infestations in the event of an introduction.

Whether responding to new introductions or managing established AIS, it is of vital importance to consider the non-target impacts of any management activities. There is a need to minimize the ecological and economic harm caused by invasive populations without compromising the health of native biotic communities. For established populations of AIS, eradication is rarely possible or practical, so management efforts should focus on containment or control that minimizes the risk of spread and maintains populations below levels which cause impairment to native biodiversity, habitat, and other beneficial uses such as recreation.

Management Needs

1. Minimize the recreational impact and other economic and ecological harm caused by established invasive populations without compromising the health of native plant, fish, and wildlife communities
2. Prevent the spread of established AIS from Ham Lake to other uninfested waters
3. Prevent new infestations of AIS from successfully establishing in Ham Lake by identifying and mitigating pathways of spread, enhancing early detection efforts, and rapidly responding to new infestations when feasible

Management objectives

1. Minimize surface-matted conditions of HEWM & CLP using selective control methods so recreational activities are not generally hindered
2. Limit the combined spatial extents of HEWM & CLP to a maximum of 15% of the littoral area (28 acres) using selective control methods
3. Maintain the presence of native vegetation at ≥70% of the littoral zone sampling points, a species richness of ≥15 submersed taxa, and mean native species per sampling point of ≥1.5
4. Prevent the introduction and/or successful establishment of new invaders

Management Actions

1. Conduct annual delineation surveys of established AIS
2. Selectively control established AIS in accordance with MN DNR permit guidelines
3. Conduct high resolution, whole-lake point-intercept plant surveys a minimum of once every other year (as proposed for Concern 1; not a duplicated effort)
4. Continue AIS information, education, & outreach programming
5. Administer a watercraft inspection program at the public access for incoming and outgoing boats
6. Conduct AIS early detection surveys following MN DNR protocols twice per year (early-season & late-season)
7. Administer the volunteer-based zebra mussel spotter program with at least 8 sampling plates being checked monthly
8. In the event of a detection of a new AIS, initiate and execute an appropriate rapid response (e.g. quarantine and chemically treat an isolated infestation of zebra mussels)

3.2.3 Concern 3: Water Quality

Specific Concerns Identified

- The occurrence of blue-green algae (cyanobacteria) blooms & associated safety risks
- Possible pollution from failing septic systems

A blue-green algae bloom observed at the Ham Lake Campground in August 2014

Background

Ham Lake experiences periodic blue-green algae blooms. Blue-green algae or cyanobacteria are types of bacteria found throughout the world that photosynthesize like algae. Blue-green algae can produce toxins known as "cyanotoxins" that pose threats to human and animal health. Not all blooms are toxic, but there is no visual way to predict the toxicity of an algal bloom. When cyanotoxins are present, humans and animals can become sick if they have contact with, swallow, or inhale water or airborne water droplets. Symptoms from acute exposure to cyanotoxins include skin rash, eye irritation, headache, vomiting, and diarrhea. Long-term chronic exposure to cyanotoxins can lead to nerve and liver damage. Domestic pets, livestock, and wildlife have died after exposure to blue-green algal blooms.

Blue-green algal blooms generally form in warm, shallow, stagnant, nutrient-rich waters. Blooms typically appear blueish-green in color, but can sometimes contain brown, orange, and red coloration as well. Blooms are often described as looking like spilled green paint or pea soup and may emit an unpleasant swampy odor. Once a bloom has formed, there is no short-term solution. Chemical treatment of a blue-green algae bloom may kill the cyanobacteria, but any cyanotoxins contained in the cells will be released, resulting in increased toxicity levels. The key to reducing the occurrence of algal blooms is to improve overall water quality by reducing nutrient inputs to the lake. Phosphorus and nitrogen inputs to Ham Lake can be reduced by limiting fertilizer applications, maintaining a vegetated buffer strip at the lake's edge, keeping lawn clippings, leaves,

and other yard waste out of the storm sewers, properly disposing of pet waste, preventing soil erosion, and properly maintaining septic systems.

In addition to fueling algal and plant growth by contributing excess nutrients to the lake, leaky septic systems may pose additional threats to Ham Lake. Poorly maintained septic systems can leak untreated sewage into surface waters and/or the shallow groundwater that directly feeds the lake which may result in elevated levels of *E. coli* (*Escherichia coli*) bacteria and other harmful pathogens. The status of septic systems within the Ham Lake lakeshed is presently unknown. There is a City of Ham Lake ordinance (Ordinance 14-07, Article 11-450) that requires every subsurface sewage treatment system (SSTS) to be inspected at least once every three years and a report to be filed with the City Building Official, but this record is incomplete.

The water quality of Ham Lake is currently monitored on a rotating schedule, at least 2 years out of every 3 years. Ham Lake is monitored for total phosphorus, chlorophyll-a, water clarity, turbidity, temperature, dissolved oxygen, conductivity, salinity, and pH. Measurements are taken every two weeks from May through September at the deepest point in the lake. Because there is no public swimming beach on Ham Lake, it has not been monitored for *E. coli*. Supplemental *E. coli* monitoring and an inventory of the status of septic systems in the lakeshed is recommended for Ham Lake based on the concerns raised by stakeholders.

Management Needs

1. Minimize the threat to human and animal health caused by blue-green algal blooms and failing septic systems
2. Ensure non-degradation of Ham Lake's water quality parameters

Management objectives

1. Reduce the health and safety risks associated with blue-green algae by promoting a "when in doubt, stay out" message to minimize interactions with potentially harmful blooms
2. Reduce the occurrence of blue-green algae blooms by reducing nutrient inputs
3. Identify and mitigate any pollution caused by failing septic systems
4. Ensure the water quality of Ham Lake continues to meet State pollution standards (TP <60 µg/L, Chlorophyll-a <20 µg/L, & Secchi transparency >1.0 m)

Management Actions

1. Promote a "when in doubt, stay out" message through education and outreach efforts
2. Promote lake-friendly practices intended to reduce nutrient runoff through education and outreach efforts (e.g. reduce fertilizer use, properly dispose of yard & pet waste)
3. Inspect and maintain the stormwater infrastructure in the drainage area
4. Inventory the status of all septic systems in the lakeshed, enforce compliance regulations, and promote grant and loan programs to address failing systems
5. Continue the water quality and lake level monitoring program for Ham lake
6. Conduct supplemental monitoring for *E. coli* or other relevant indicators to evaluate possible septic system pollution

3.2.4 Concern 4: Recreation/Lake Use Conflicts

Specific Concerns Identified

- Potential lake use conflicts as development occurs

Background

Ham Lake is presently facing increasing development pressure. There are several vacant parcels and large parcels surrounding the lake that could be sub-divided and developed in the near future. Surface water use conflicts may arise as the demands on a limited resource increase. Based on 2016 Anoka County watercraft inspection data, Ham Lake is already used heavily with an average of 2.19 boats per hour utilizing the public access. Ham Lake is the 6th most visited lake in Anoka County after Coon, George, East Twin, Linwood, and Centerville Lakes.

Management Needs

1. Ensure that Ham Lake continues to provide the desired beneficial uses (e.g. recreation, aesthetics, wildlife habitat) for all lake users without compromising the health of the lake or the safety of the public

Management objectives

1. Identify and rectify any current lake use conflicts
2. Address future conflicts as they arise

Management Actions

1. Conduct a comprehensive survey of lake users (residents & visitors) that collects quantifiable information on recreational uses and any lake-related issues or conflicts (as proposed for Concern 1; not a duplicated effort)
2. Ensure open lines of communication between lake users and resource management organizations/agencies regarding current and future conflicts
3. Establish use restriction ordinances to alleviate conflicts if applicable and desired (e.g. no-wake rules, special fishing regulations, etc.)

4.0 Implementation Strategy

Implementation of the management actions identified for Ham Lake in Section 3.0 will be a collaborative effort between several organizations and agencies. Below, the key organizations that play a role in the management of Ham Lake are introduced, roles and responsibilities of each organization are assigned, and a 5-year implementation schedule is proposed along with estimated costs. Roles have been divided into four categories: 1) Lead, 2) Finance, 3) Technical Assistance, and 4) Regulatory Oversight.

4.1 Organizations

In addition to individual lakefront property owners and lake users, six local and state organizations have direct roles in the management of Ham Lake. Other agencies, such as the Minnesota Pollution Control Agency and Metropolitan Council, are involved in monitoring the condition of lakes and streams across the region, but do not have programs or policies specifically for Ham Lake. This Plan discusses only the organizations and agencies with direct roles in the management of Ham Lake:

1. Ham Lake Lake Association (HLLA)
2. City of Ham Lake
3. Coon Creek Watershed District (CCWD)
4. Anoka Conservation District (ACD)
5. Anoka County (Anoka Co.)
6. Minnesota Department of Natural Resources (MN DNR)

4.1.1 Ham Lake Lake Association

1904 N Ham Lake Drive NE
Ham Lake MN 55304
https://www.facebook.com/HamLakeLakeAssn

The Ham Lake Lake Association (HLLA) is a 501(c)3 non-profit organization established by lakeshore owners with the mission of preserving the quality and health of Ham Lake for natural and recreational use by all who live on and visit the lake. One of the HLLA's primary goals is to raise awareness and funds for the ongoing management of aquatic invasive plants. HLLA has been working cooperatively with the MN DNR to control invasive Eurasian watermilfoil and curlyleaf pondweed since 2014. HLLA meets regularly and provides a forum for discussing lake-related issues and concerns and planning management actions.

4.1.2 City of Ham Lake

15544 Central Avenue NE
Ham Lake, MN 55304
http://www.ci.ham-lake.mn.us/

The City of Ham Lake has an estimated population of 16,221. Through various programs such as Public Works, Parks/Forestry, and Planning & Zoning, City staff manages stormwater infrastructure, operates the winter aeration, maintains the City park and public access on the southwest shoreline of the lake, and regulates Subsurface Sewage Treatment Systems and development in the lakeshed.

4.1.3 Coon Creek Watershed District

12301 Central Avenue NE, Suite 100
Blaine, MN 55434
www.cooncreekwd.org

The Coon Creek Watershed District is a special purpose unit of government charged with managing the water resources within a 107-square mile area of Anoka County. The CCWD mission is to manage the groundwater and surface water drainage systems to prevent property damage, maintain hydrologic balance, and protect water quality for the safety & enjoyment of citizens and the preservation & enhancement of wildlife habitat. The District operates several programs that directly relate to Ham Lake including Development and Regulation, Water Quality Research & Monitoring, Public & Government Relations, Operation & Maintenance, and Planning. Through these programs, CCWD regulates land-disturbing activities and wetlands in the lakeshed, inspects and maintains stormwater infrastructure, provides water-related educational information and involvement opportunities, finances the monitoring of Ham Lake's hydrology and water quality, and develops long-range plans to protect and enhance local water resources.

4.1.4 Anoka Conservation District

1318 McKay Dr NE, Suite 300
Ham Lake, MN 55304
www.anokaswcd.org

The Anoka Conservation District (ACD) is a non-regulatory county level subdivision of state government that provides technical and financial assistance to manage local natural resources. The mission of ACD is to conserve and enhance the natural resources of Anoka County by conducting monitoring and analysis, informing landowners and local government in natural resource management, and leveraging technical and financial

resources to promote nature resource stewardship practices. ACD operates several programs in cooperation with other agencies or individuals which directly pertain to Ham Lake. ACD conducts precipitation, hydrology, water quality, and AIS early detection monitoring and works with individual property owners to promote lake-friendly practices such as erosion control, native shoreline plantings, and installation of rain gardens.

4.1.5 Anoka County

Parks & Recreation Department
Activity Center, Bunker Hills Regional Park
550 Bunker Lake Blvd NW
Andover, MN 55304
http://www.anokacounty.us/372/Parks-Recreation

As part of Anoka County's mission to serve it citizens in a respectful, innovative, and fiscally responsible manner, the Parks & Recreation department administers an aquatic invasive species prevention program funded by State Aid (Minnesota Statute 477A.19). The AIS prevention program provides multiple benefits to Ham Lake including AIS education & outreach materials and events, assistance with citizen monitoring efforts, grant opportunities for AIS prevention activities, and the staffing of the public access with trained watercraft inspectors. It should be noted that the AIS Prevention Aid distributed to counties by the State is presently only guaranteed through 2018 and the fate of the Anoka County AIS Program beyond 2018 is unknown.

4.1.6 Minnesota Department of Natural Resources

500 Lafayette Road
St. Paul, MN 55155-4040
www.dnr.state.mn.us

The Minnesota Department of Natural Resources is a statewide agency charged with conserving and managing state natural resources. The mission of the MN DNR is to work with citizens to conserve and manage the state's nature resources, to provide outdoor recreation opportunities, and to provide for commercial uses of natural resources in a way that creates a sustainable quality of life. The MN DNR is divided into six divisions: Ecological & Water Resources (EWR), Enforcement, Fish & Wildlife, Forestry, Lands & Minerals, and Parks & Trails. The EWR and Fish & Wildlife divisions have the most direct roles in the active management of Ham Lake through the Invasive Species, Watercraft Inspection, Lake Hydrology, and Fisheries Programs. These programs include management activities related to lake levels, AIS prevention, aquatic plant management, and fisheries management. Additionally, the MN DNR provides regulatory oversight and enforcement of numerous natural resources statutes and rules.

4.2 Implementation Schedule

An overview of the 5-year implementation schedule for each management strategy identified during the Ham Lake planning process is provided in Table 12. Costs have been estimated for each management strategy and specific roles have been assigned to one or more relevant organizations. Costs, roles, and an implementation schedule are reported for each identified concern facing Ham Lake (Section 4.2.1; Tables 13-16) and for each organization (Section 4.2.2; Tables 17-22).

Table 12. The proposed 5-year implementation schedule for all management strategies identified during the Ham Lake lake management planning process.

Concern	Management Activity	2018	2019	2020	2021	2022
Aquatic Vegetation	Conduct point-intercept surveys at least every other year	X	TBD	X	TBD	X
	Comprehensive lake users survey	X				
	Follow-up investigation(s) based on lake user survey results		X	X		
	Control of nuisance aquatic plant growth as needed (not incl. AIS)		TBD	TBD	TBD	TBD
	If needed, develop lake vegetation management plan/apply for variance		TBD	TBD	TBD	TBD
Aquatic Invasive Species	Conduct annual delineation surveys of established AIS (HEWM & CLP)	X	X	X	X	X
	Conduct annual selective control of established species	X	X	X	X	X
	Conduct point-intercept surveys at least every other year*	X	TBD	X	TBD	X
	Continue AIS prevention education & outreach programming	X	X	X	X	X
	Continue watercraft inspection program at public access	X	X	X	X	X
	Conduct AIS early detection surveys twice per year	X	X	X	X	X
	Continue Zebra Mussel Spotter program	X	X	X	X	X
	Initiate & execute an appropriate rapid response to new infestations	TBD	TBD	TBD	TBD	TBD

Concern	Management Activity	2018	2019	2020	2021	2022
Water Quality	Promote "when in doubt, stay out" message for blue-green algae blooms	X	X	X	X	X
	Promote lake-friendly landscape practices to reduce nutrient runoff	X	X	X	X	X
	Inspect & maintain stormwater infrastructure in lakeshed	X	X	X	X	X
	Inventory septic systems in lakeshed			X		
	Enforce SSTS compliance & promote grant/loan fix-up programs	X	X	X	X	X
	Continue water quality and lake level monitoring program	X	X	X	X	X
	Conduct supplemental monitoring for *E. coli/* septic pollution indicators	X	TBD	TBD	TBD	TBD
Recreation	Comprehensive lake users survey*	X				
	Ensure open lines of communication between lake users and managers regarding lake use conflicts	X	X	X	X	X
	Establish use restriction ordinances if applicable (e.g. no-wake zone)	TBD	TBD	TBD	TBD	TBD

**Management strategy is applicable to multiple concerns and is listed twice, but does not represent a duplicated effort.*

4.2.1 Implementation Plan Summarized by Concern

Table 13. Estimated costs and assigned roles for implementing management strategies to address aquatic vegetation concerns in Ham Lake.

Management Activity	Unit Cost	5-Yr Cost	Role	Organization
Conduct point-intercept surveys	~$2,000	$6,000-$10,000	Finance/Lead Finance Finance	DNR (if scheduled) HLLA (if req. by permit) CCWD (if not req.)
Comprehensive lake users survey	~$1,000 + staff time	$1,000	Finance/Lead Assist	CCWD HLLA, City, Anoka Co.
Follow-up investigation(s) based on survey results	Staff time		Finance/Lead Tech. Assist	CCWD ACD
Control nuisance plant growth	Variable	?	Finance/Lead Reg. Oversight	HLLA, Landowners DNR
Develop Lake Vegetation Management Plan	Staff time		Lead Assist	DNR HLLA, CCWD, ACD

Table 14. Estimated costs and assigned roles for implementing management strategies to address aquatic invasive species concerns in Ham Lake.

Management Activity	Unit Cost	5-Yr Cost	Role	Organization
Conduct annual delineation surveys of established AIS (n=2)	~$550 per species	$5,500	Finance/Lead Finance	DNR (if scheduled) HLLA (if req. by permit)
Conduct annual selective control of established AIS	Up to $30K AVG: $9K	$45,000	Finance/Lead Finance Finance Reg. Oversight Tech. Assist	HLLA City DNR/Anoka Co. Grants DNR CCWD, ACD
Conduct point-intercept surveys*	~$2,000	$6,000-$10,000	Finance/Lead Finance Finance	DNR (if scheduled) HLLA (if req. by permit) CCWD (if not req.)
Continue AIS education & outreach programming	Staff time		Finance/Lead	CCWD, Anoka Co, DNR
Continue watercraft inspection program	$11.50/hr + Staff time	?	Finance/Lead	Anoka Co.
Conduct AIS early detection surveys twice per year	~$300 per survey	$3,000	Finance/Lead Tech. Assist	CCWD ACD
Continue Zebra Mussel Spotter program	~$100/ year	$500	Finance/Lead Tech. Assist	CCWD Anoka Co.
Execute rapid response for new infestations	Variable, up to $50K	?	Lead Finance Reg. Oversight Tech. Assist	DNR/ CCWD CCWD, Anoka Co, City, HLLA DNR ACD

***Management strategy is applicable to multiple concerns and is listed twice, but does not represent a duplicated effort.*

Table 15. Estimated costs and assigned roles for implementing management strategies to address water quality concerns in Ham Lake.

Management Activity	Unit Cost	5-Yr Cost	Role	Organization
Promote "when in doubt, stay out" for blue-green algae blooms	Staff time		Collaborate	All
Promote lake-friendly landscape practices to reduce nutrient runoff	Staff time		Finance/Lead Assist	ACD, CCWD HLLA
Inspect & maintain stormwater infrastructure	Varies + Staff time	?	Finance/Lead	City, CCWD
Inventory status of septic systems in lakeshed & enforce compliance regs.	~$10,000 + Staff time	$10,000	Finance/Lead Finance	City State or County grants?
Continue water quality and lake level monitoring program	WQ: $1,800/yr Hydro: $300/yr	$6,900	Finance/Lead Tech Assist.	CCWD ACD
Conduct supplemental monitoring for *E. coli*	$25/sample + staff time	$250 +	Finance/Lead	CCWD

Table 16. Estimated costs and assigned roles for implementing management strategies to address recreation concerns in Ham Lake.

Management Activity	Unit Cost	5-Yr Cost	Role	Organization
Comprehensive lake users survey*	~$1,000 + staff time	$1,000	Finance/Lead Assist	CCWD HLLA, City, Anoka Co.
Ensure open lines of communication between lake users and managers regarding conflicts	Staff time		Collaborate	All
Establish use restriction ordinances if applicable (e.g. no-wake zone)	Staff time		Lead Reg. oversight Tech. Assist	City DNR CCWD

***Management strategy is applicable to multiple concerns and is listed twice, but does not represent a duplicated effort.*

4.2.2 Implementation Plan Summarized by Organization

Ham Lake Lake Association

HLLA's implementation responsibilities and costs will depend largely on the state of the aquatic plant community, its impacts on the beneficial uses of the lake (recreational, aesthetic, & aquatic life), and DNR aquatic plant management (APM) permit requirements. The lake users survey planned for 2018 and any follow-up investigations planned for 2019 and 2020 will help determine if any control of nuisance native plants or emergent cattails is warranted and permissible under DNR APM rules. The extent of invasive HEWM and CLP growth in future years will also drive management costs. If large scale native or invasive plant control is needed, a DNR lake vegetation management plan (LVMP) and variance will be required. Often, a LVMP and variance requires the permittee to conduct delineation surveys for each managed species and an annual whole-lake point-intercept survey. The introduction of any new AIS to Ham Lake and possible subsequent control efforts pose additional costs that are difficult to predict. It is recommended that HLLA establishes a contingency fund dedicated to responding to new invasions of AIS.

In addition to any funds set aside for an AIS rapid response contingency fund or for control of nuisance native plants, estimated annual costs to HLLA range from $7,670 to $9,670 with a total 5-year cost up to $46,350 (Table 17). It should be noted that Anoka County grant funds may be available to partially fund invasive plant control activities, but are not guaranteed. The DNR grant program for AIS control has been discontinued.

Table 17. Summary of the Ham Lake Lake Association's implementation responsibilities

Management Activity	Role	2018	2019	2020	2021	2022	Total
Conduct point-intercept surveys	Finance if req. by permit		$2000?	$2000?	$2000?	$2000?	**$8,000**
Control nuisance native plant growth if needed	Finance		$?	$?	$?	$?	**$?**
Develop Lake Vegetation Management Plan if needed	Assist		TBD	TBD	TBD	TBD	**$0**
Delineation surveys of established AIS	Finance if req. by permit	$1,100	$1,100	$1,100	$1,100	$1,100	**$5,500**
Control established AIS	Finance portion	$6,570	$6,570	$6,570	$6,570	$6,570	**$32,850**
AIS Information & outreach	Assist	X	X	X	X	X	**$0**
Rapid response to new AIS infestations when feasible	Finance portion	$?	$?	$?	$?	$?	**$?**
Promote lake-friendly practices to reduce nutrients	Collaborate	X	X	X	X	X	**$0**
Ensure open lines of comm. regarding lake use conflicts	Collaborate	X	X	X	X	X	**$0**
Total		**$7,670**	**$9,670**	**$9,670**	**$9,670**	**$9,670**	**$46,350**

City of Ham Lake

A large portion of the lake management costs allocated to the City is for conducting a one-time comprehensive inventory of the status of septic systems in the lakeshed at an estimated cost of $10,000. Additionally, it is proposed that the City funds a portion of invasive plant control efforts up to $2,430 a year. This amount was calculated based on the proportion of Ham Lake lakeshore owned by the City (27%; Figure 7) multiplied by the average annual AIS control costs incurred over the past 4 years ($9,000; Table 9). The introduction of any new AIS to Ham Lake and possible subsequent control efforts pose additional costs that are difficult to predict. It is recommended that the City establishes a contingency fund dedicated to responding to new invasions of AIS.

In addition to any funds set aside for an AIS rapid response contingency fund or for stormwater management costs incurred by the City as part of MS4 requirements, estimated annual costs to the City are $2,430 plus a one-time cost of $10,000 for a total 5-year cost of $19,720 (Table 18).

Table 18. Summary of the City of Ham Lake's implementation responsibilities

Management Activity	Role	2018	2019	2020	2021	2022	Total
Comprehensive lake users survey	Assist	X					**$0**
Control established AIS	Finance a portion	$2430	$2430	$2430	$2430	$2430	**$12,150***
Rapid response to new AIS infestations when feasible	Finance a portion	$?	$?	$?	$?	$?	**$?**
Promote "when in doubt, stay out" for blue-green algae blooms	Collaborate	X	X	X	X	X	**$0**
Inspect & maintain stormwater infrastructure	Lead/Finance	$?	$?	$?	$?	$?	**$?**
Inventory status of septic systems in lakeshed & enforce compliance regulations	Lead/Finance			$10,000			**$10,000**
Ensure open lines of comm. regarding lake use conflicts	Collaborate	X	X	X	X	X	**$0**
Establish use restriction ordinances if applicable	Lead	X?	X?	X?	X?	X?	**$0**
Total		**$2,430**	**$2,430**	**$12,430**	**$2,430**	**$2,430**	**$22,150**

*Cost determined based on the proportion of shoreline owned by the City (27%) multiplied by the annual average AIS treatment costs incurred on Ham Lake since 2014 ($9,000 per year).

Coon Creek Watershed District

The lake management costs allocated to the CCWD are largely for regular monitoring activities (water quality, lake levels, AIS detection, plant surveys) or for one-time studies such as the lake use survey and subsequent follow-up investigations. The introduction of any new AIS to Ham Lake and possible subsequent control efforts pose additional costs that are difficult to predict. In 2014, CCWD established a contingency fund dedicated to responding to new invasions of AIS and it is recommended that this fund remain in place.

In addition to the $10,000 AIS rapid response contingency fund set aside for Ham Lake and programmatic costs (staff time) for drainage system inspections and information/ outreach efforts, estimated annual costs to the CCWD range from $1,000 to $4,800 for a total 5-year cost of up to $15,650 (Table 19).

Table 19. Summary of the Coon Creek Watershed District's implementation responsibilities

Management Activity	Role	2018	2019	2020	2021	2022	Total
Conduct point-intercept surveys	Finance if not req. by permit			$2000?		$2000?	**$4000**
Comprehensive lake users survey	Lead/finance	$1,000					**$1000**
Follow-up investigation(s) based on survey results	Lead/finance		$?	$?			**$?**
Develop Lake Vegetation Management Plan if needed	Tech. Assist		TBD	TBD	TBD	TBD	**$0**
Selective Control of est. AIS	Tech. Assist	X	X	X	X	X	**$0**
Continue AIS education & outreach programming	Collaborate	X	X	X	X	X	**$0**
AIS early detection surveys	Lead/finance	$600	$600	$600	$600	$600	**$3000**
Zebra Mussel Spotter program	Lead/finance	$100	$100	$100	$100	$100	**$500**
Execute rapid response for AIS	Finance portion	$?	$?	$?	$?	$?	**$?**
Promote "when in doubt, stay out" for blue-green algae	Collaborate	X	X	X	X	X	**$0**
Promote lake-friendly landscape practices to reduce nutrient runoff	Collaborate	X	X	X	X	X	**$0**
Inspect stormwater infrastructure	Lead/finance	$?	$?	$?	$?	$?	**$?**
Continue water quality and lake level monitoring program	Lead/finance	$300	$2100	$2100	$300	$2100	**$6900**
Conduct monitoring for *E. coli*	Lead/finance	$250	$?	$?	$?	$?	**$250**
Ensure open lines of comm. regarding lake use conflicts	Collaborate	X	X	X	X	X	**$0**
Establish use restriction ordinances if applicable	Tech. Assist	TBD	TBD	TBD	TBD	TBD	**$0**
Total		**$2250**	**$2800**	**$4800**	**$1000**	**$4800**	**$15,650**

Anoka Conservation District

The lake management responsibilities prescribed to ACD are largely in the form of providing technical assistance with monitoring, planning, and education/ outreach activities. There are no direct costs allocated to ACD, but ACD does provide significant in-kind support via staff time (Table 20).

Table 20. Summary of the Anoka Conservation District's implementation responsibilities

Management Activity	Role	2018	2019	2020	2021	2022	Total
Follow-up investigation(s) based on survey results	Tech. Assist		X	X			**$0**
Develop Lake Vegetation Management Plan if needed	Tech. Assist		TBD	TBD	TBD	TBD	**$0**
Selective Control of est. AIS	Tech. Assist	X	X	X	X	X	**$0**
AIS early detection surveys	Tech. Assist	X	X	X	X	X	**$0**
Execute rapid response for AIS if needed	Tech. Assist	TBD	TBD	TBD	TBD	TBD	**$0**
Promote "when in doubt, stay out" for blue-green algae blooms	Collaborate	X	X	X	X	X	**$0**
Promote lake-friendly landscape practices to reduce nutrient runoff	Collaborate	X	X	X	X	X	**$0**
Continue water quality and lake level monitoring program	Tech. Assist	X	X	X	X	X	**$0**
Ensure open lines of comm. regarding lake use conflicts	Tech. Assist	X	X	X	X	X	**$0**
Total		**$0**	**$0**	**$0**	**$0**	**$0**	**$0**

Anoka County

The lake management responsibilities prescribed to the County largely stem from their existing AIS Prevention Program administered by the Parks & Recreation Department and funded by State aid ($140,000 in 2017). The AIS Prevention Program includes many county-wide activities that directly benefit Ham Lake (watercraft inspection program, AIS education/outreach programming, grant program) although the direct costs for Ham Lake itself have not been broken down (Table 21). Based on 2016 data, it is estimated that $4,175 will be spent to staff the Ham Lake Public Access with a watercraft inspector ($11.50/hr * 363 hrs). Anoka Co. also set aside a portion of the State aid money as a contingency fund for responding to possible new invasions of AIS in 2016 and 2017, but the fate of this fund in the future is unknown. It is strongly recommended that Anoka Co. continue to maintain this AIS rapid response contingency fund.

Table 21. Summary of Anoka County's implementation responsibilities

Management Activity	Role	2018	2019	2020	2021	2022	Total
Comprehensive lake users survey	Assist	X					**$0**
Selective control of established AIS	Finance portion (grant program)	$?	$?	$?	$?	$?	**$?**
Continue AIS education & outreach programming	Lead/Finance	$?	$?	$?	$?	$?	**$?**
Zebra Mussel Spotter program	Tech. Assist	X	X	X	X	X	**$0**
Continue watercraft inspection program	Lead/Finance	4,175?	$?	$?	$?	$?	**$4175?**
Execute rapid response for AIS	Finance portion	$?	$?	$?	$?	$?	**$?**
Promote "when in doubt, stay out" for blue-green algae blooms	Collaborate	X	X	X	X	X	**$0**
Ensure open lines of comm. regarding lake use conflicts	Collaborate	X	X	X	X	X	**$0**
Total		**4,175?**	**$?**	**$?**	**$?**	**$?**	**$4,175?**

Minnesota Department of Natural Resources

The lake management responsibilities prescribed to the MN DNR (Table 22) stem from their existing statewide programs. The MN DNR implements many statewide activities that directly benefit Ham Lake (e.g. plant and fish surveys, watercraft inspections, AIS education/outreach, grant programs, regulatory oversight, enforcement), however, the direct costs for management activities for Ham Lake itself have not been broken down. Since the discovery of invasive HEWM in Ham Lake in 2013, the MN DNR has conducted annual invasive plant delineation surveys and whole-lake point-intercept plant surveys that provide a great benefit to the lake (an estimated value of $3,100 per year if hired out to private consultant). If the MN DNR discontinues plant surveys on Ham Lake, responsibility will shift to HLLA or CCWD depending on APM permit requirements and management needs.

Table 22. Summary of MN Dept. of Natural Resources' implementation responsibilities

Management Activity	Role	2018	2019	2020	2021	2022	Total
Conduct point-intercept surveys	Lead/finance if scheduled	X	X?	X?	X?	X?	**$?**
Control nuisance native plant growth if needed	Regulatory oversight		TBD	TBD	TBD	TBD	**$?**
Develop Lake Vegetation Management Plan if needed	Lead/ collaborate		TBD	TBD	TBD	TBD	**$?**
Delineation surveys of established AIS	Lead/finance if scheduled	X?	X?	X?	X?	X?	**$?**
Control established AIS	Regulatory oversight	X	X	X	X	X	**$?**
AIS Information & outreach	Collaborate	X	X	X	X	X	**$?**
Rapid response to new AIS infestations when feasible	Lead/ Reg. oversight	TBD	TBD	TBD	TBD	TBD	**$?**
Promote "when in doubt, stay out" for blue-green algae blooms	Collaborate	X	X	X	X	X	**$0**
Ensure open lines of comm. regarding lake use conflicts	Collaborate	X	X	X	X	X	**$0**
Establish use restriction ordinances if applicable	Regulatory oversight	TBD	TBD	TBD	TBD	TBD	**$0**
Total		**$?**	**$?**	**$?**	**$?**	**$?**	**$?**

5.0 References

Barr Engineering. 2004. Detailed Assessment of Phosphorus Sources to Minnesota Watersheds. Prepared for the Minnesota Pollution Control Agency, St. Paul, MN.

Canfield, D. E. Jr, and R. W. Bachmann. 1981. Prediction of Total Phosphorus Concentrations, Chlorophyll-a, and Secchi Depths in natural and artificial lakes. Can. J. Fish. Aquat. Sci. 38: 414-423

Minnesota Department of Natural Resources. 1993. Anoka Sandplain Regional Hydrogeologic Assessment.

Minnesota Department of Natural Resources. 2004. Lake Survey Report for Ham Lake DOW #02-0053-00. Division of Fish and Wildlife.

Minnesota Department of Natural Resources. 2006. A creel survey of Coon Lake and Ham Lake, Anoka County, MN.

Minnesota Department of Natural Resources. 2016. Ham Lake, Anoka County: 2016 Aquatic Vegetation Report. Invasive Species Program, Division of Ecological and Water Resources.

Minnesota Department of Natural Resources. 2016. Lake Survey Report for Ham Lake. Division of Fish and Wildlife, Survey ID 13101623253492000.

Minnesota Department of Natural Resources. 2017. Fish Consumption Guidelines for Ham Lake. Retrieved from: http://www.dnr.state.mn.us/lakefind/fca/report.html?downum=02005300

Minnesota Department of Natural Resources. 2017. Lake Water Level Report for Ham Lake. Retrieved from: http://www.dnr.state.mn.us/lakefind/showlevel.html?downum=02005300

Nürnberg, G. 1997. Coping with water quality problems due to hypolimnetic anoxia in central Ontario lakes. Water Quality Research Journal of Canada. 32 (2) pp 391-405.

Nürnberg, G. 2004. Quantified Hypoxia and Anoxia in Lakes and Reservoirs. The Scientific World Journal 4: 42-54.

Setterholm, Dale, R. 2013. C-27 Geologic Atlas of Anoka County, Minnesota [Part A]. Minnesota Geological Survey. Retrieved from the University of Minnesota Digital Conservancy. http://hdl.handle.net/11299/116119

Walker, W. W., Jr. 2013. Program for Predicting Polluting Particle Passage thru Pits, Puddles, and Ponds (P8). Concord Massachusetts.