APPENDIX B: INVENTORY & ASSESSMENT

COMPREHENSIVE WATERSHED MANAGEMENT PLAN 2017-2026

VLAWMO
Vadnais Lake Area
Water Management Organization

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1. Introduction

This section of the Plan presents the basic characteristics and information about the watershed. Over 30 years of water quality monitoring data, along with multiple studies and assessments and modeling were used to create the scientific background of this plan. A physical inventory of the watershed was completed when producing the 2007 Watershed Management Plan. Those findings are located in Chapter 2 of the 2007 Plan. A summary of those findings is included here, along with updated information where appropriate. The 2007 Plan is available on the VLAWMO website and hard copies are available at VLAWMO offices.

2. Description of the Watershed

2.1 Location and Size

The VLAWMO watershed encompasses over 15,400 acres or 24.2 square miles. It is located in the northeast metro area in Ramsey and Anoka Counties. The political boundary for the watershed contains portions of White Bear Lake, White Bear Township, Vadnais Heights, Gem Lake, Lino Lakes and all of the City of North Oaks. (Figure XX). The actual subwatershed area includes portions of Shoreview and Little Canada as well (Figure XX). VLAWMO's implementation efforts will focus on projects within the political boundary while partnering with neighboring watersheds on projects that cross boundaries.

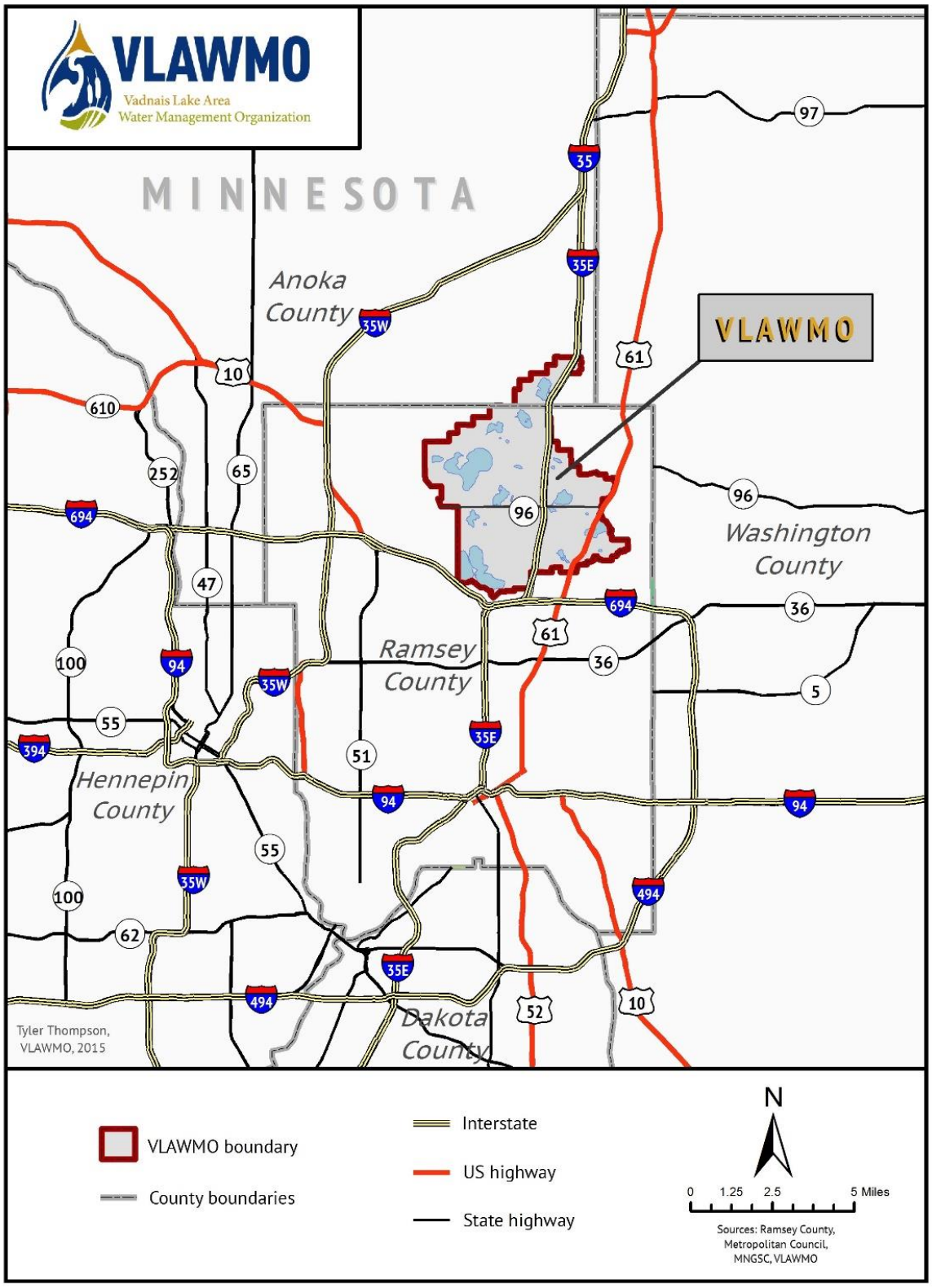
TABLE 1: POLITICAL UNITS OF VLAWMO

Community	County	Area (square miles)	Area (acres)	Percentage
Lino Lakes	Anoka	1.6	1033.4	6.7
Gem Lake	Ramsey	1.0	657.4	4.3
North Oaks	Ramsey	8.6	5506.7	35.6
Vadnais Heights	Ramsey	6.3	4029.6	26.1
White Bear Lake	Ramsey	3.6	2323.7	15.0
White Bear Township	Ramsey	3.0	1907.2	12.3
	Total	**24.2**	**15458**	**100**

2.2 Demographics of the Watershed

The population of the watershed, according to the 2010 data is approximately 28,000. There has been no significant change in population within the area since 2000. This is due to the limited amount of land still available for new residential development.

FIGURE 1: LOCATION OF VLAWMO WATERSHED



2.3 Climate

VLAWMO is located in the Humid Continental (cool summer) climate zone. The area experiences cool to warm, humid summers and cold winters. The weather can vary widely and both temperature and rainfall can change rapidly.

TABLE 2: TEMPERATURE AND PRECIPITATION AVERAGES

Month	Average Low (°F)	Average High (°F)	Mean Precip (in.)	Mean Snow (in.)
January	4	22	1.04"	13.5"
February	12	29	.79"	8.2"
March	23	41	1.86"	10.4"
April	36	57	2.31"	3.1"
May	48	70	3.24"	.1"
June	58	79	4.34"	0"
July	63	83	4.04"	0"
August	61	80	4.05"	0"
September	51	71	2.69"	0"
October	39	58	2.11"	.6"
November	25	40	1.94"	10"
December	11	26	1"	10"

Source: Intellicast.com (Historical averages for the Minneapolis area)

Rainfall data for predicting hydrology and designing hydraulic structures and facilities is presented in Table 3. It shows rainfall for various return periods (frequency) and durations for the metropolitan area, taken from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Precipitation Estimates. This statistically derived data is useful for determining critical storms and computing peak rates of runoff.

TABLE 3: RAINFALL IN MINNEAPOLIS/ST. PAUL AREA

Return Frequency	24 hour	12 hour	6 hour	3 hour	2 hour	1 hour	30 minute	15 minute
1 Year	2.45	2.12	1.89	1.61	1.44	1.16	0.891	0.64
2 Year	2.8	2.48	2.18	1.87	1.69	1.37	1.06	0.756
5 Year	3.5	3.19	2.79	2.4	2.16	1.75	1.35	0.952
10 Year	4.19	3.88	3.41	2.92	2.6	2.1	1.59	1.12
25 Year	5.31	4.99	4.44	3.75	3.31	2.63	1.95	1.37
50 Year	6.31	5.96	5.36	4.5	3.91	3.07	2.23	1.56
100 Year	7.42	7.04	6.4	5.33	4.58	3.56	2.53	1.77

Source: NOAA

Note: Precipitation listed here is for the Minneapolis-St. Paul Metropolitan area. Precipitation can vary greatly within a small geographic area.

2.4 Geology

The watershed geology can be subdivided into two basic classifications: unconsolidated glacial sediments and consolidated bedrock formations. These deposits also form a sequence of aquifers and confining units that comprise the hydrogeologic setting.

The unconsolidated glacial sediments consist of glacial deposits. Typically, the glacial deposits found in the watershed are in the form of outwash, till, stream, and lake sediments. Outwash is composed of sand and gravel deposited by former glacial meltwater streams. They form a widespread mantle of sediment which overlays bedrock formations. The glacial sediments were deposited during the Quaternary geologic period by the actions of glaciers and modified by post-glacial erosion and soil formation processes. The Grantsburg and Superior sublobes laid down a large portion of the uppermost glacial deposits between 12,000 and 20,000 years ago in the watershed.

There are two prominent geomorphic regions located in the watershed: the North Ramsey Mounds and the Anoka Sand Plain.

North Ramsey Mounds: The surface till is a highly variable, complex mixture of sandy till (Superior sublobe) and clayey fill (Grantsburg sublobe) sediments that are horizontally layered in places. Mixing is intensified on the upglacier sides of obstacles beneath the ice and near the ice margin. The till is somewhat homogeneous in the subsurface. Many small shallow channels were incised into the moraine by Grantsburg meltwater. These channels are very subtle but commonly contain peat and stream and lake sediments that were deposited during the Holocene period.

Anoka Sand Plain: This area contains fine sand that was deposited as the Grantsburg sublobe melted. The environment of deposition varied from broad outwash plain to a large shallow lake. The lake extended through the gaps in the North Ramsey Mound as narrow fingers. Sediments in former offshore positions of the lake include laminated lake clay, silt, and fine sand. Near-shore sediments of the lake are coarser.

All bedrock formations in the watershed are entirely marine sedimentary rocks of early Paleozoic age. The bedrock formations lie immediately beneath unconsolidated glacial deposits. The uppermost bedrock formations in the region are the St. Peter Sandstone, Jordan Sandstone, and Prairie du Chien Sandstone. A small area within the watershed is founded on Platteville and Glenwood formations which lie on top of the St. Peter Sandstone.

Bedrock aquifers found in the watershed are the Platteville Formation, St. Peter Sandstone, and Prairie du Chien Group. Bedrock confining layers include clayey glacial till, Glenwood Formation, and basal St. Peter Sandstone. These bedrock aquifers are not evenly distributed and do not have similar physical attributes. For detailed aquifer parameters, see the Ramsey County Groundwater Quality Protection Plan.

For more detailed information on geomorphic regions, see the Ramsey County Geologic Atlas. The atlas contains the most current and comprehensive assessment of the geologic and hydrogeologic characteristics.

2.5 Soil Information

Soils found within the watershed are summarized in Table 4 and Figure 3. The table includes the hydrologic group by the Soil Conservation Services. The hydrologic groups are used to estimate runoff from precipitation. They are rated according to infiltration capacity and assigned to one of four groups. Group A has the highest infiltration rate and Group D has the lowest infiltration rate.

Detailed descriptions of soils, such as physical, chemical, and mechanical properties, as well as development limitations, are found in the Soil Survey of Washington and Ramsey Counties, Minnesota and the Soil Survey of Anoka County, Minnesota.

TABLE 4: SOILS FOUND WITHIN VLAWMO

Soil Name	Hydrologic Group	Hydric Soil	Soil Name	Hydrologic Group	Hydric Soil
Anoka loamy fine sand	B	No	Kingsley sandy loam	B	No
Aquolls and histosols	B/D	Yes	Kratka loamy fine sand	B	Yes
Auburndale silt loam	B/D	Yes	Lake Beaches	N/A	N/A
Barronett silt loam	C/D	Yes	Lino loamy fine sand	B	No
Blomford loamy fine sand	B/D	Yes	Loamy wet land	B/D	Yes
Bluffton loam	C/D	Yes	Mahtomedi loamy sand	A	No
Braham loamy fine sand	B	No	Markey muck	A/D	Yes
Brill silt loam	C	No	Nessel fine sandy loam	B	No
Cathro muck	A/D	Yes	Nowen sandy loam	B/D	No
Chetek sandy loam	B	No	Poskin silt loam	B/D	No
Comstock silt loam	B/D	No	Prebish loam	B/D	Yes
Cut and fill soils	N/A	N/A	Rifle muck	A/D	Yes
DeMontreville loamy fine sand	B	No	Ronneby fine sandy loam	B/D	No
Duluth silt loam	C	No	Rosholt sandy loam	B	No
Dundas fine sandy loam	B/D	Yes	Seelyeville muck	A/D	Yes
Freeon silt loam	C	No	Soderville loamy fine sand	A	No
Freer silt loam	C/D	Yes	Udifluvents	B	No
Glencoe loam	D	Yes	Udorthents	N/A	No
Gotham loamy sand	A	No	Udorthents, wet substrat	B	Possible
Gravel Pit	N/A	N/A	Urban	Varying	Varying
Hayden fine sand loam	B	No	Webster loam	B/D	Yes
Isanti fine sandy loam	A/D	Yes	Zimmerman fine sand	A	No

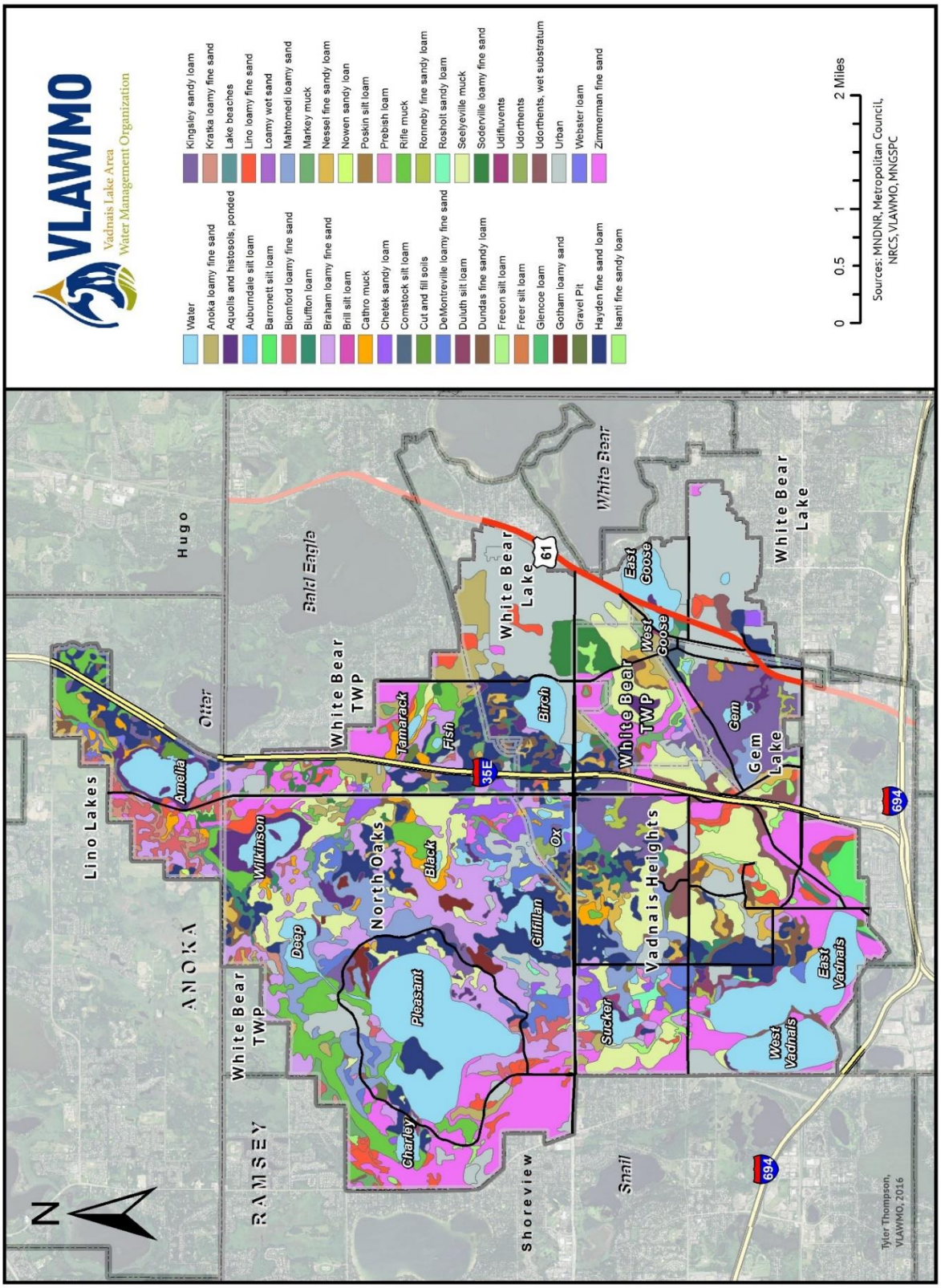
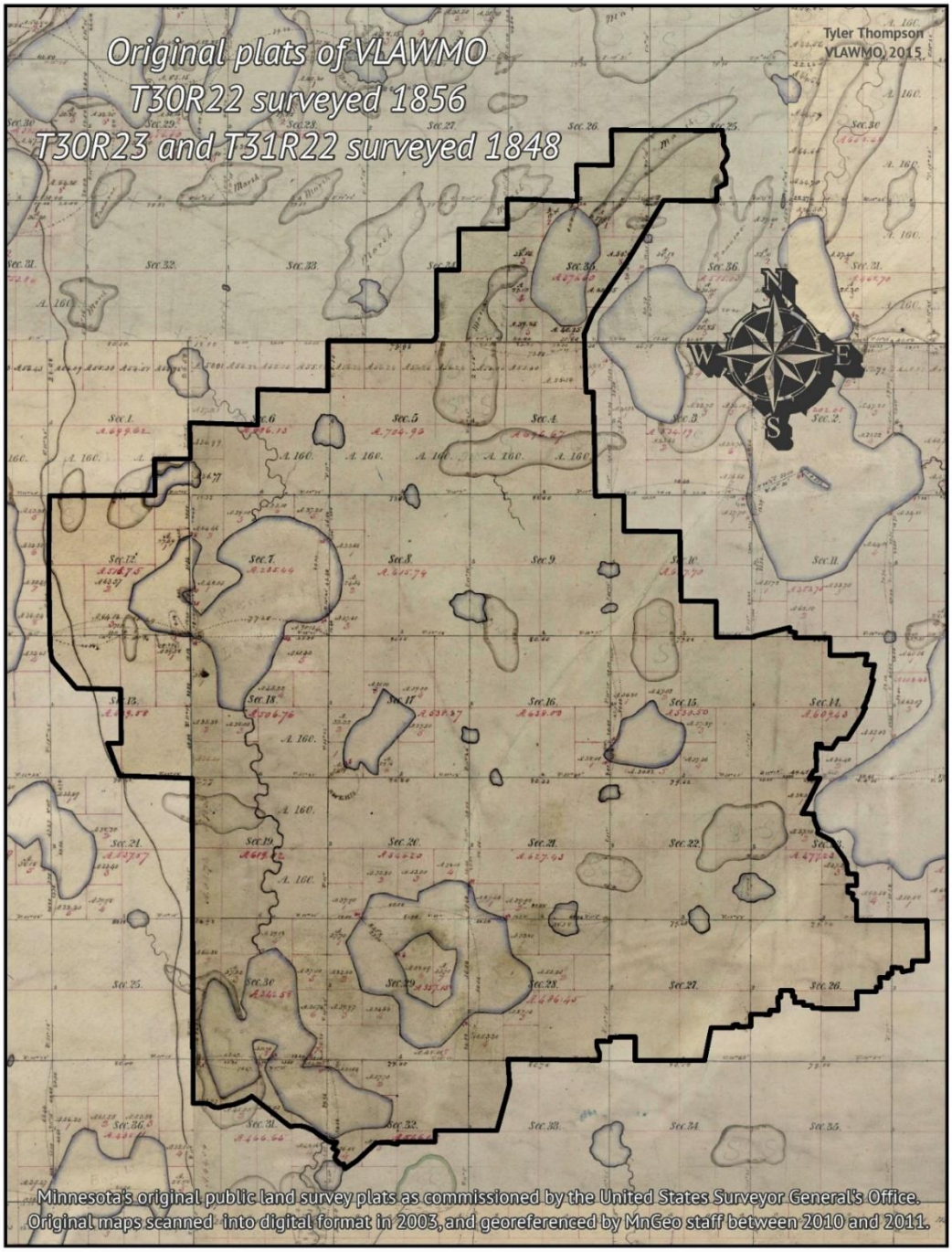


FIGURE 2: SOILS WITHIN VLAWMO

2.6 Land Use and Land Cover

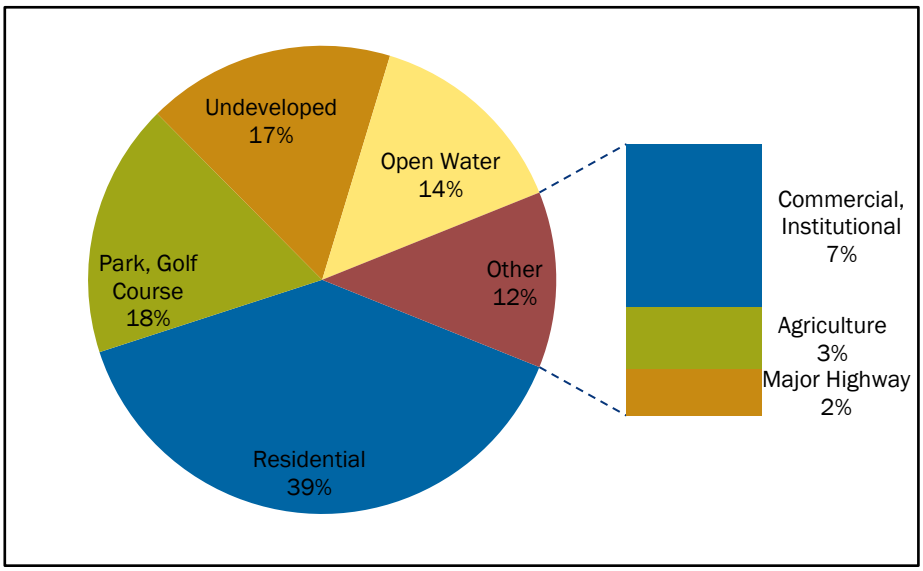
The historical land cover of the VLAWMO watershed area was typically woodland and large wetland complexes with farmland interspersed throughout. As the metropolitan area grew and expanded, many wetlands were drained and the land use shifted to a predominantly suburban land use with a mixture of residential, commercial, institutional and industrial development.

FIGURE 3: HISTORICAL PLAT MAP OF VLAWMO WATERSHED AREA (1848-1856)



As of 2010, the land within VLAWMO is nearly fully developed or used as parks and open space. The majority of undeveloped land is either protected or not suitable for development. The redevelopment of properties is an increasing activity within the watershed. VLAWMO works with its communities to ensure development meets stormwater standards.

FIGURE 4: PERCENT OF WATERSHED BY 2010 LAND USE



Source: Metropolitan Council

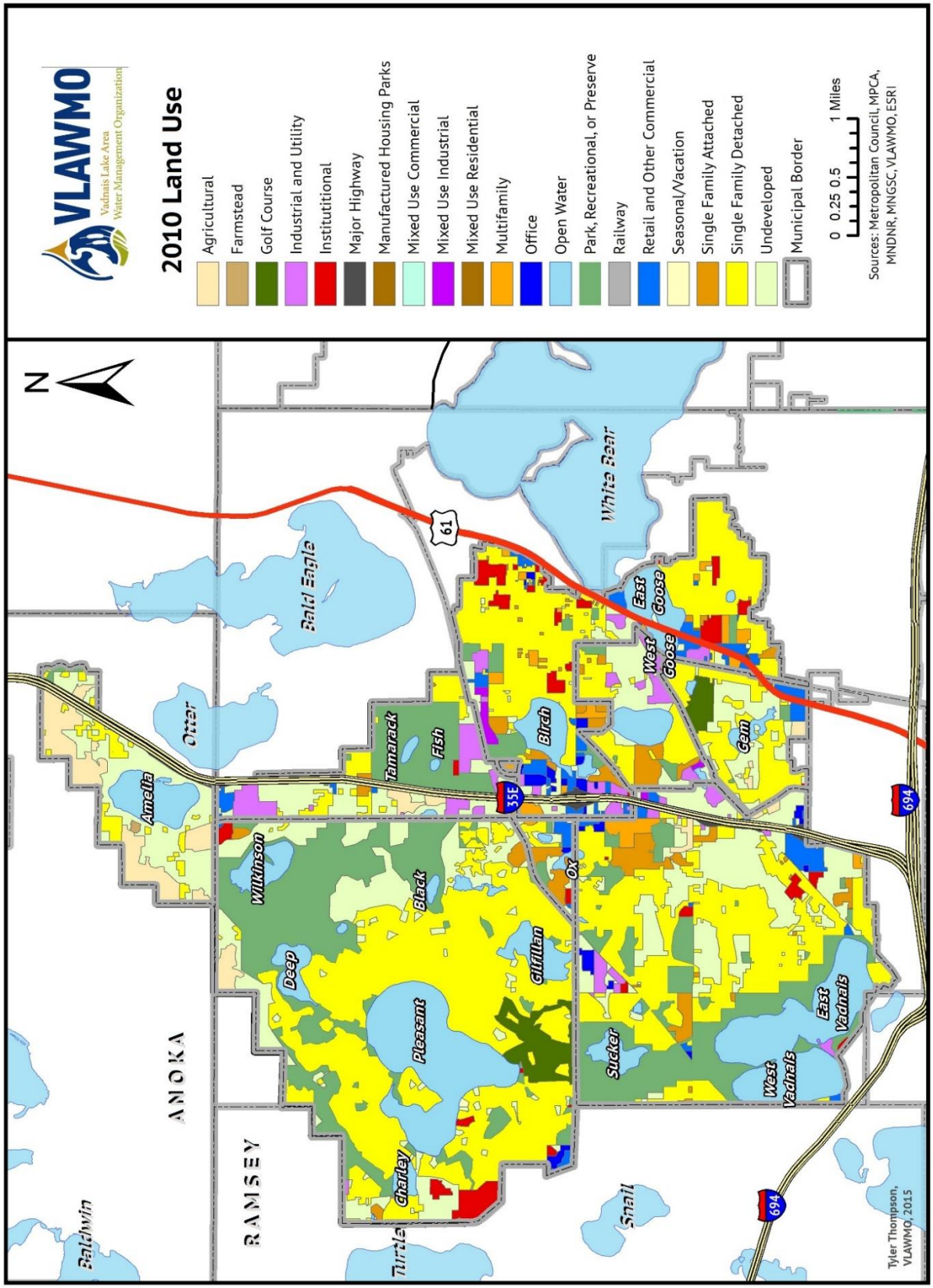


FIGURE 5: 2010 LAND USE IN VLAWMO

3. Water Resources

3.1 Lakes & Streams

VLAWMO's watershed consists of 17 lakes, Lambert Creek with its associated tributaries, and a series of minor streams and ditches (Figures 7 & 8 and Tables 5 & 6). Lambert Creek is also known as Ramsey County Ditch 14 (RCD 14) and VLAWMO was given drainage authority in 1986 to this ditch, as well as Ramsey County Ditch 13 (RCD 13). Lambert Creek/RCD 14 has been managed as a creek and is considered one by the Minnesota Pollution Control Agency (MPCA). RCD 13 is an underground storm sewer system managed by the City of White Bear Lake. RCD13 enters Lambert Creek at the City of White Bear Lake storm sewer outfall where it empties in to Whitaker Pond and outlets to Lambert Creek. Individual fact sheets have been made for 14 lakes and for Lambert Creek and are included in this section of the Appendix. Detailed information regarding the waterbodies within VLAWMO can be found on the VLAWMO website.

TABLE 5: MAJOR LAKES WITHIN VLAWMO

Lake Name	Surface Area (acres)	Maximum Depth (feet)
Amelia	195	4
Birch	125	6
Black	11	12.5
Charley	38	21
Deep	78	11
Gem	40	17
Gilfillan	102	7
Goose – East & West	145	6
Pleasant	690	58
Sucker	61	26
Tamarack	15	10
Vadnais – East	389	58
Vadnais – West	213	9
Wilkinson	94	4.5

FIGURE 6: LAKES WITHIN VLAWMO

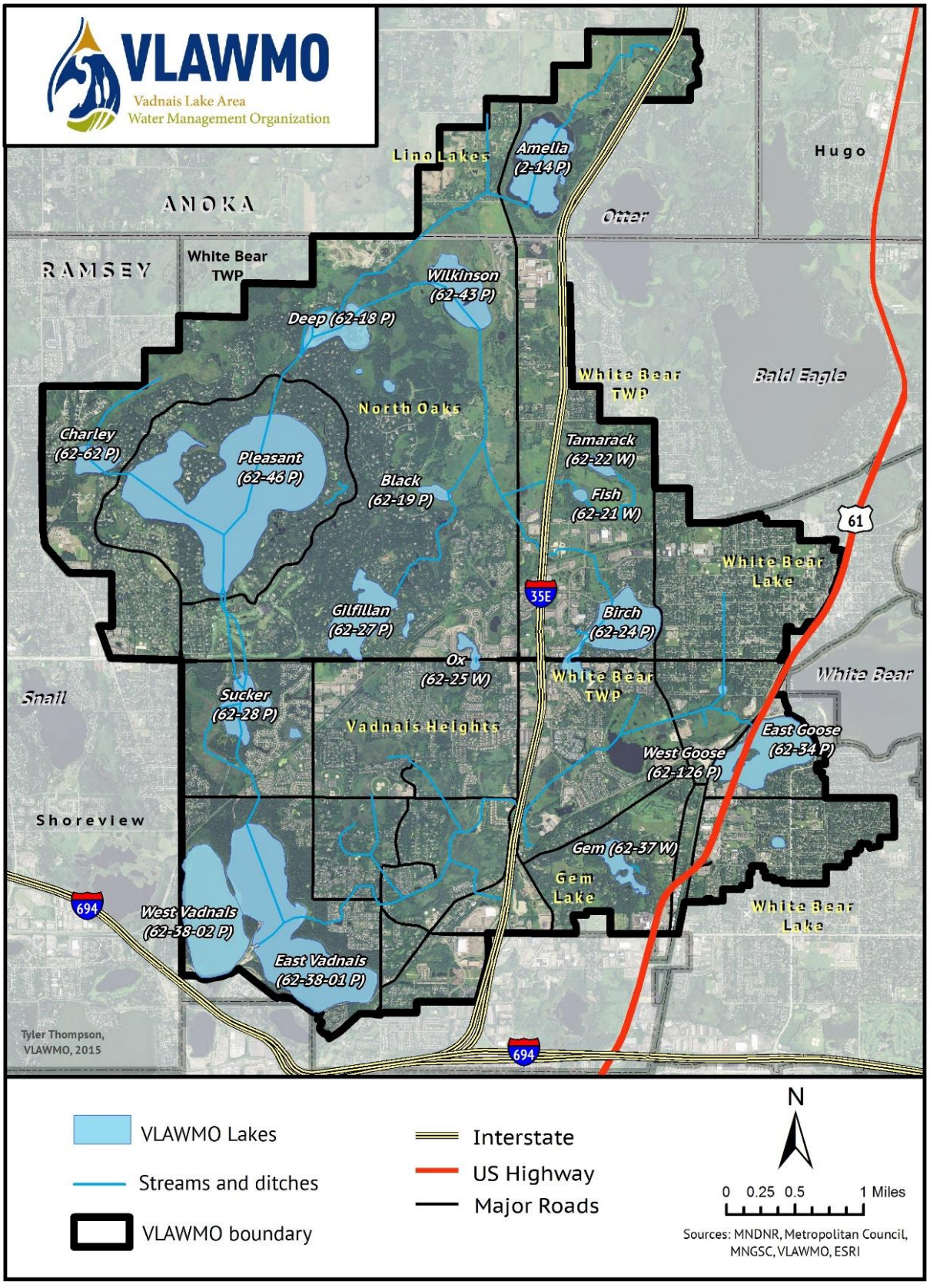
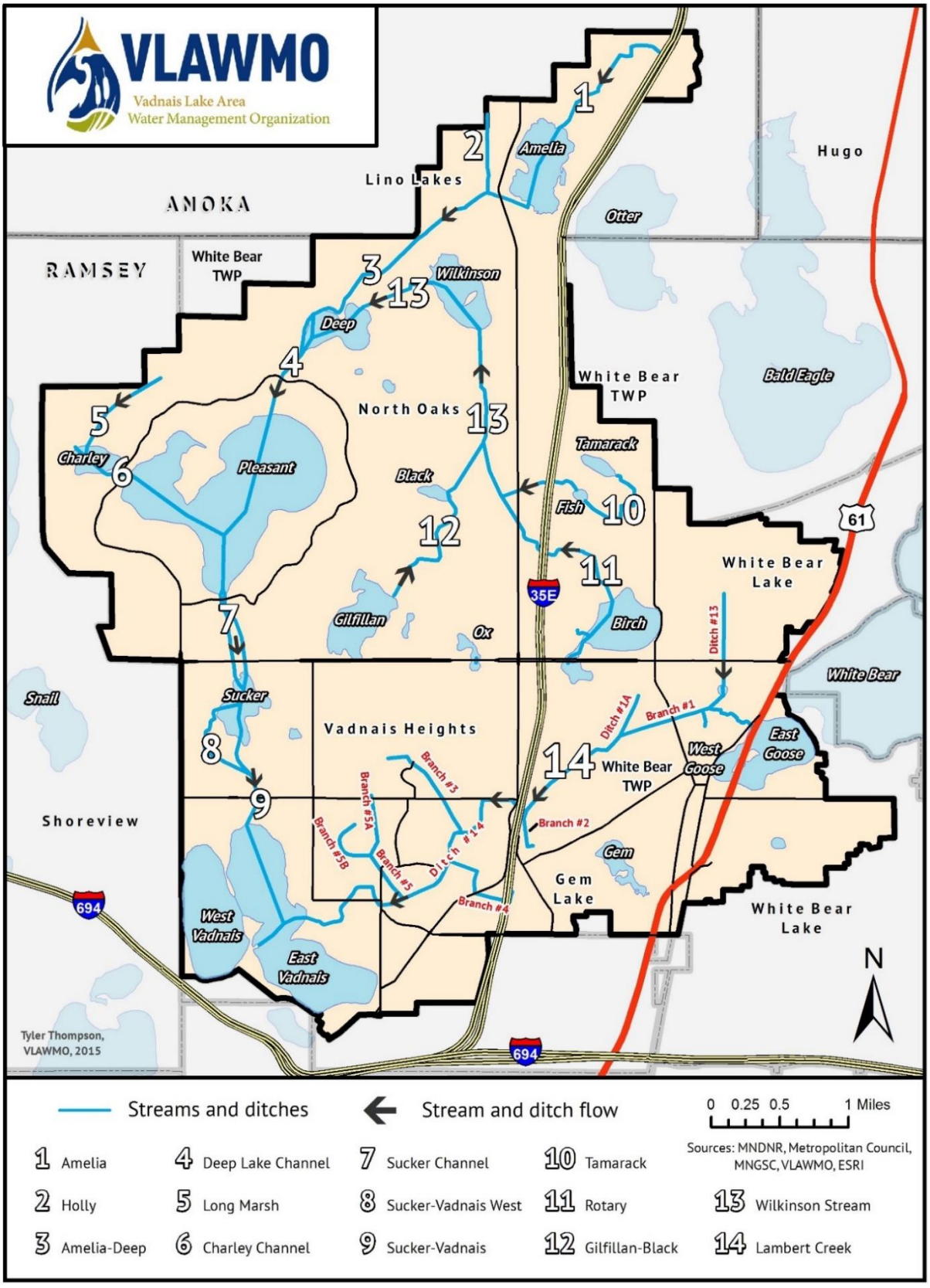


TABLE 6: STREAMS, DITCHES, & TRIBUTARIES WITHIN VLAWMO

Stream	ID#	Description
Amelia	1	North of and into Amelia
Holly	2	Tributary to Amelia-Deep
Amelia-Deep	3	Flows from Amelia to Deep
Deep Lake Channel	4	Flows from Deep to Pleasant
Long Marsh	5	Collects Long Marsh and flows to Charley
Charley Channel	6	Charley to Pleasant channel
Sucker Channel	7	Flow from Pleasant into Sucker
Sucker-Vadnais West	8	West channel from Sucker and collects into Sucker-Vadnais
Sucker-Vadnais	9	Flows south from Sucker to Vadnais
Tamarack	10	Flows from Tamarack to Fish, then into Birch Stream
Rotary	11	Flows from Birch, turns into Gilfillan-Tamarack-Wilkinson
Gilfillan-Black	12	Flows from Gilfillan to Black
Wilkinson	13	Collects Gilfillan-Black, Birch, and Tamarack into Wilkinson and outflows to Deep
Lambert Creek	14	Collects from Goose, RCD 13 and branch tributaries into East Vadnais. Also known as RCD 14

FIGURE 7: STREAMS, DITCHES, & TRIBUTARIES WITHIN VLAWMO



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AMELIA LAKE

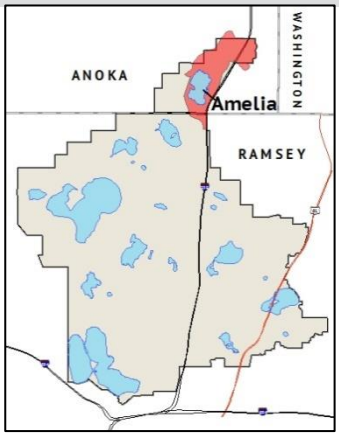
QUICK FACTS

Watershed Size	754 acres
Surface Area	195 acres
Maximum Depth	4 ft
Average Depth	3 ft

Common fish
Unknown

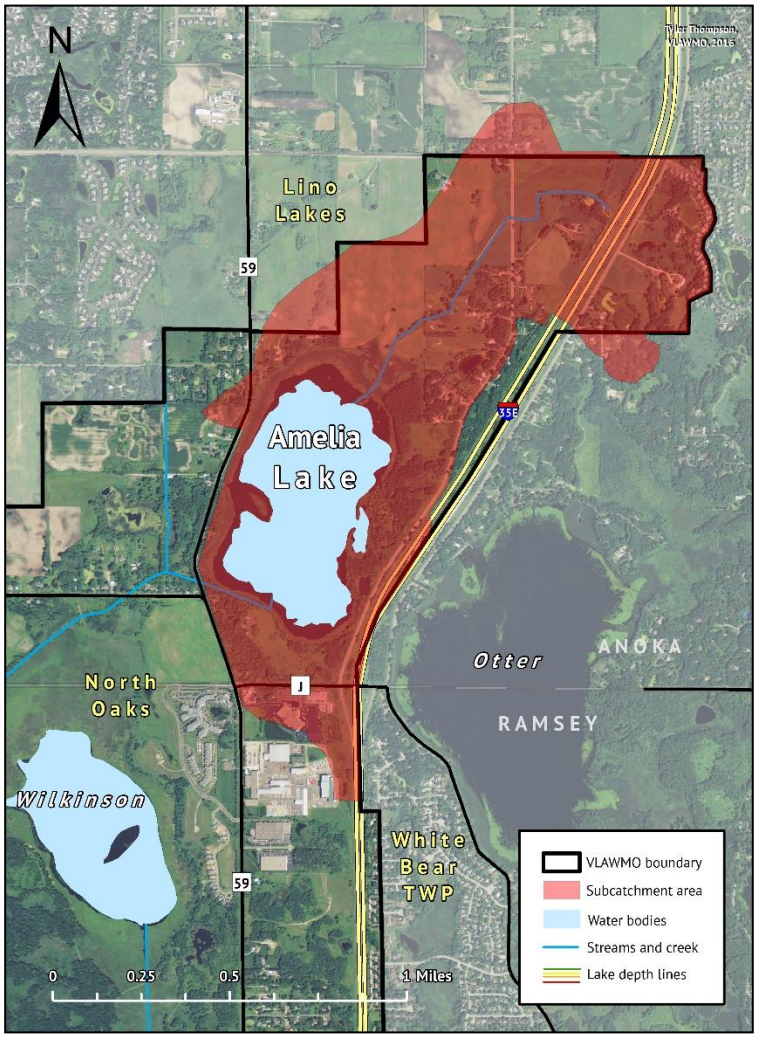
Predominant Vegetation
Unknown

Invasive Species
Unknown



LOCATION

Amelia Lake is the northern most lake within VLAWMO. It is located in the City of Lino Lakes and is surrounded by open space, agricultural land, and residential properties. A portion of Interstate 35E is within the subwatershed.

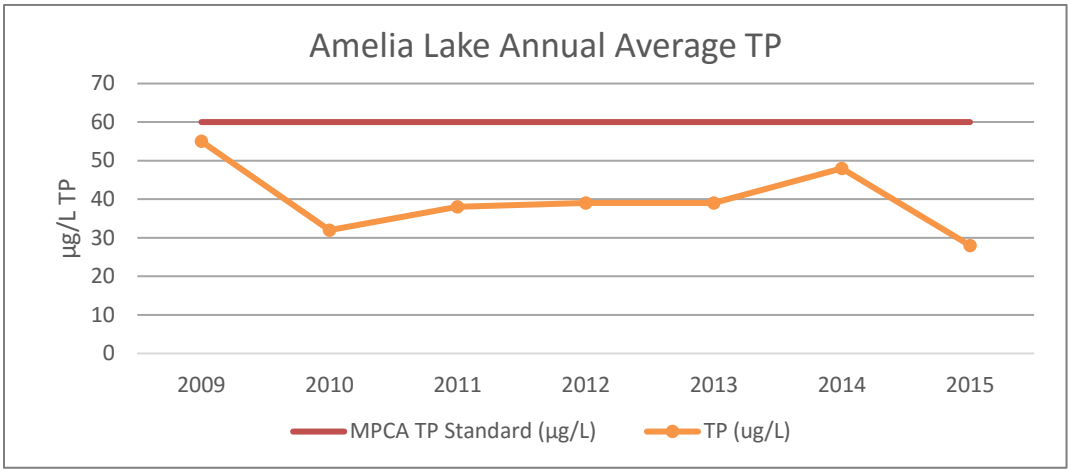


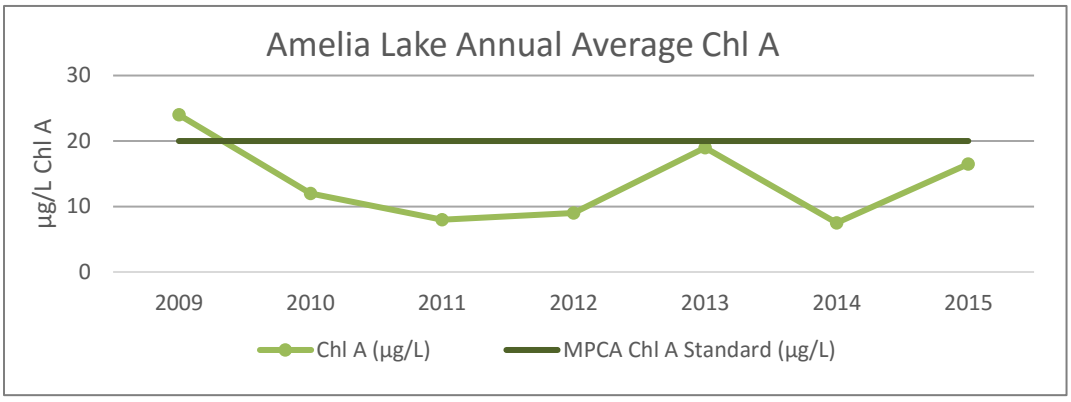
LAKE SUMMARY

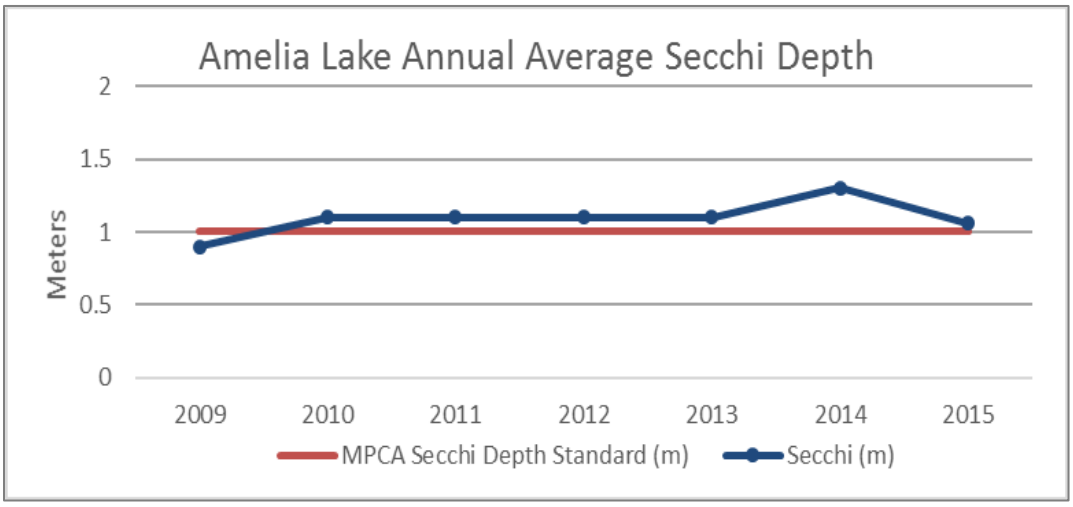
Amelia Lake's water quality currently meets all state standards and is relatively stable. Due to the agricultural land use within the subwatershed, levels of nitrogen can be a concern. The lake has not been surveyed for fish and aquatic plants at this time. When a Sustainable Lake Management Plan is written for Amelia, these studies will be conducted as well as a depth survey.

PHOSPHORUS (TP)/CHLOROPHYLL a (ChlA)/Secchi Disc

Levels for all monitoring parameters meet state standards. VLAWMO's goal is to maintain and protect the water quality of this lake. Continued monitoring will allow VLAWMO to respond efficiently if water quality starts to decline.







BIRCH LAKE

QUICK FACTS

Watershed Size	647 acres
Surface Area	125 acres
Maximum Depth	6 ft
Average Depth	3 ft

Common Fish

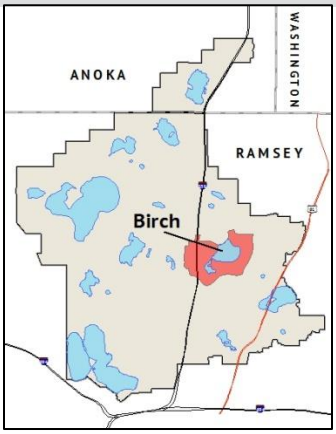
Largemouth Bass, Walleye, Yellow Perch, Black Crappies, Bluegill

Predominant Vegetation (2015)

Fern Pondweed

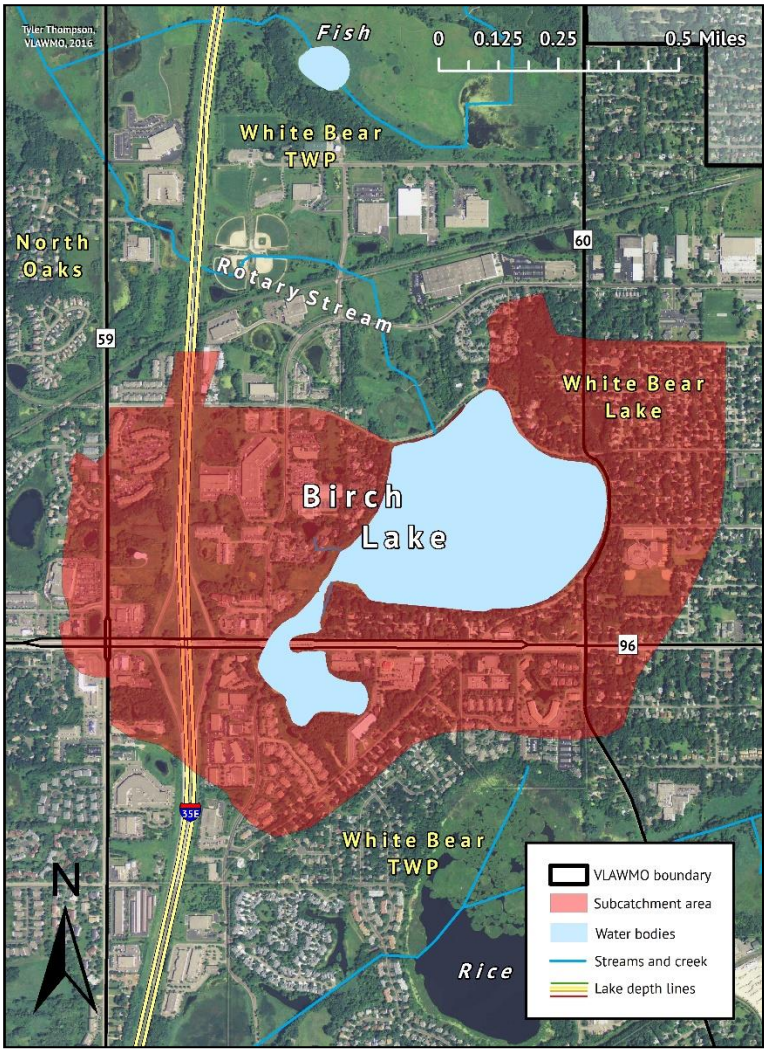
Invasive Species (2015)

Eurasian Watermilfoil



LOCATION

Birch Lake is located in the City of White Bear Lake. There is a mix of residential and commercial properties around the lake and it includes portions of County Highway 96 and Interstate 35E within the subwatershed. The lake outlets to the north.

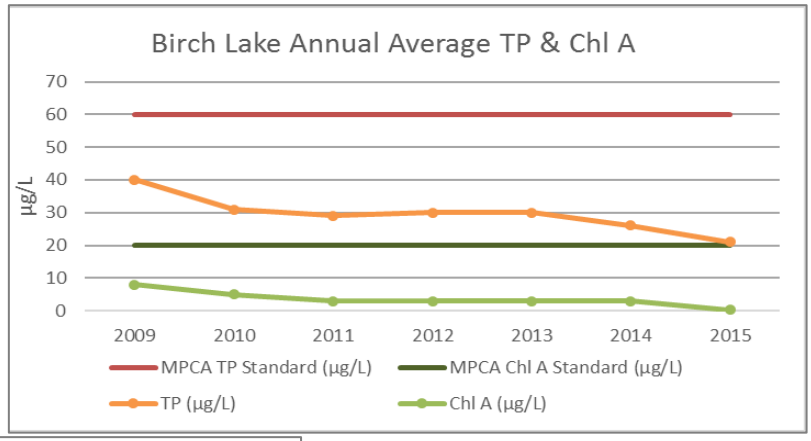


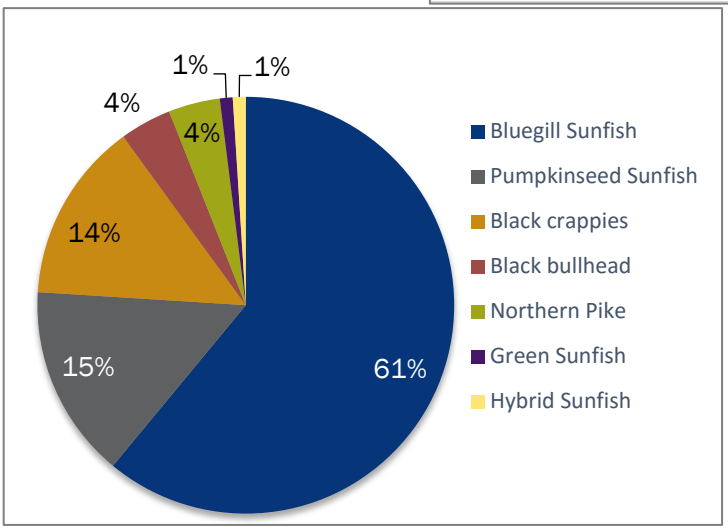
LAKE SUMMARY

Birch Lake's trophic status is excellent, with Phosphorus levels meeting state standards. All other measures of water quality are very good as well. This is rare for a metropolitan area waterbody. Birch Lake has an abundant vegetative community which helps to maintain its high water quality. Concerns raised from the Birch Lake Improvement District (BLID) about the potential for increasing chloride levels due to the lake's proximity to County Highway 96 and I-35E prompted the addition of chloride to the list of standard monitoring parameters in 2015. At this point, the levels of chloride meet state standards. All other water quality parameters are in healthy ranges as well.

PHOSPHORUS (TP) & CHLOROPHYLL a (ChlA)

As mentioned in the summary, nutrient levels in Birch meet state standaeds. The financial support and volunteer efforts from the BLID plays a large role in maintaining the health of this lake. Protecting the water quality of this lake is a priority for VLAWMO.





Fish & Aquatic Plant Surveys

The BLID conducts fish surveys to monitor populations within the lake. The BLID stocks the lake with game fish. The most recent stocking in 2015 included 2000 largemouth bass to replenish the population after a winterkill in 2014. The BLID runs an aerator in the winter to help the fish survive. Vegetation surveys are done frequently to monitor Eurasian Watermilfoil which is present in the lake but at low levels with no control is currently needed.

Project Success

VLAWMO partnered with the BLID and the City of White Bear Lake to restore an area on the northwest shoreline of Birch Lake that had visible erosion issues due to the public trying to access the lake as well as many weeds and non-native plants. From 2010 - 2012, 850 feet of shoreline was restored, which included the installation of hundreds of native plants and an access path with large stones for fishing platforms as well as a bench for viewing. Snags were left in the water to provide habitat for turtles and fish. The partnership provides funds each year for maintenance activities. This project received grant funding from the Ramsey Conservation District and the MN Department of Natural Resources.

BLACK LAKE

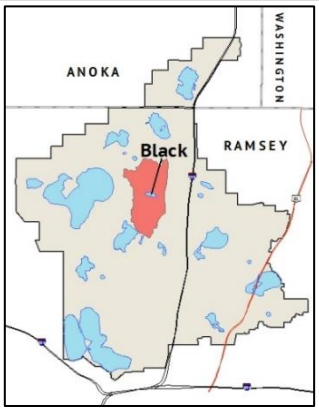
QUICK FACTS

Watershed Size	664 acres
Surface Area	11 acres
Maximum Depth	12.5 ft
Average Depth	6 ft

Common Fish
Unknown

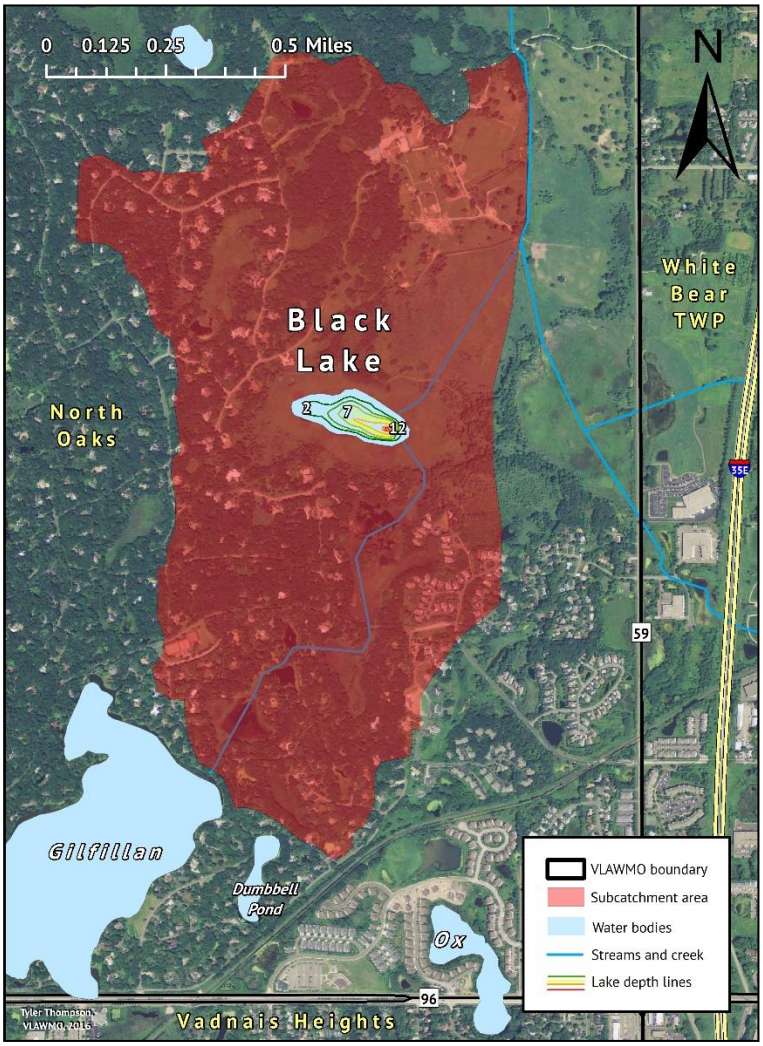
Predominant Vegetation (2014)
Coontail, White Water Lily, Chara, Sago Pondweed, Wild Rice

Invasive Species (2015)
Hybrid Cattail, Purple Loosestrife, Reed Canary Grass



LOCATION

Black Lake is located in the City of North Oaks. It is surrounded by 27 acres of cattail marsh with open space and large residential lots beyond that. The lake outlets from the southeast corner towards Mallard Pond and then on to Gilfillan Lake.

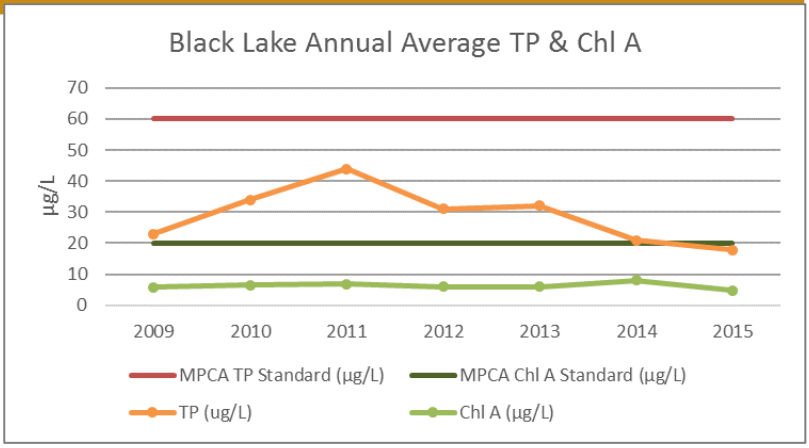


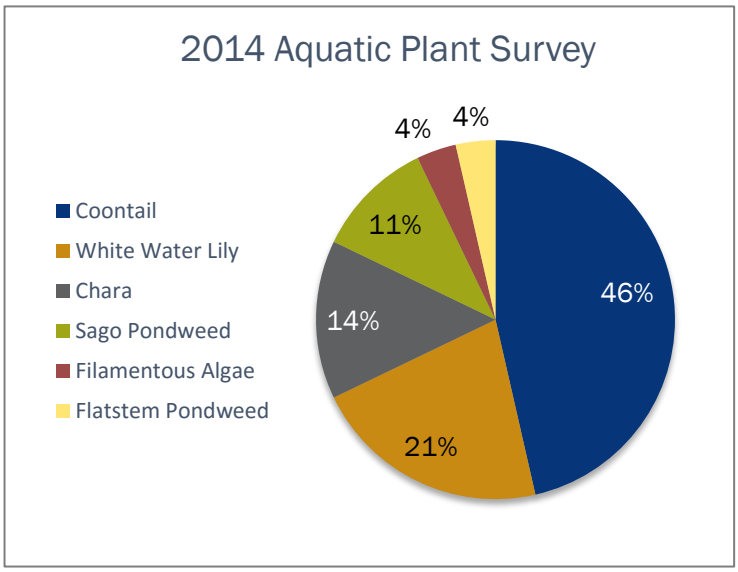
LAKE SUMMARY

Black Lake's trophic status is excellent, with all nutrient and other monitoring parameters meeting state standards. The lake is isolated and has no public access and with the thick vegetation surrounding the open water, it is difficult for staff to even access the lake during the monitoring season. This buffer provides protection and helps to filter any pollutants that may enter the lake. Black Lake receives water from Wilkinson Lake and is surrounded by a protected natural area.

PHOSPHORUS (TP) &CHLOROPHYLL a (ChlA)

Nutrient levels meet State Standards. VLAWMO's goal is to protect the high water quality of this lake. VLAWMO will continue to collect water samples to track the health of the lake.





Aquatic Plant Survey A survey was completed in 2014, along with a biovolume and depth analysis. Black Lake has abundant vegetation which is a positive factor for protecting its water quality. In 2015, another survey was conducted to determine the amount of wild rice present in the lake. Results found that 40% of the lake has wild rice present during its growing season. VLAWMO will work with the appropriate State agencies to determine if a special status should be applied to this lake.

Shoreline Vegetation Survey In July 2015, a survey was conducted to provide VLAWMO with a basic inventory of the vegetation within the large wetland surrounding Black Lake. The survey revealed 30 different plant species are in the wetland area, with hybrid cattail, Northern marsh fern, lake sedge, jewelweed, willow and reed canary grass among the most common species. Purple loosestrife, phragmites, brome grass and buckthorn were also identified around throughout the shoreline and wetland area, though not in large abundance. These plants, along with hybrid cattail and reed canary grass are invasive plant species. Staff will continue to monitor their spread and abundance.

CHARLEY LAKE

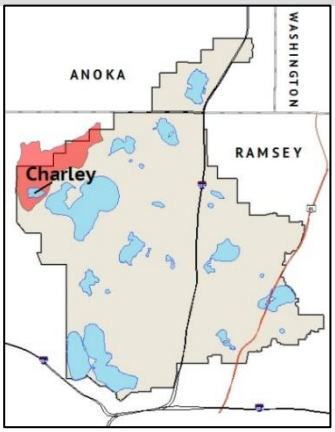
QUICK FACTS

Watershed Size	818 acres
Surface Area	38 acres
Maximum Depth	21 ft
Average Depth	5 ft

Common Fish
Carp, Walleye, Bass, Sunfish, Northern Pike

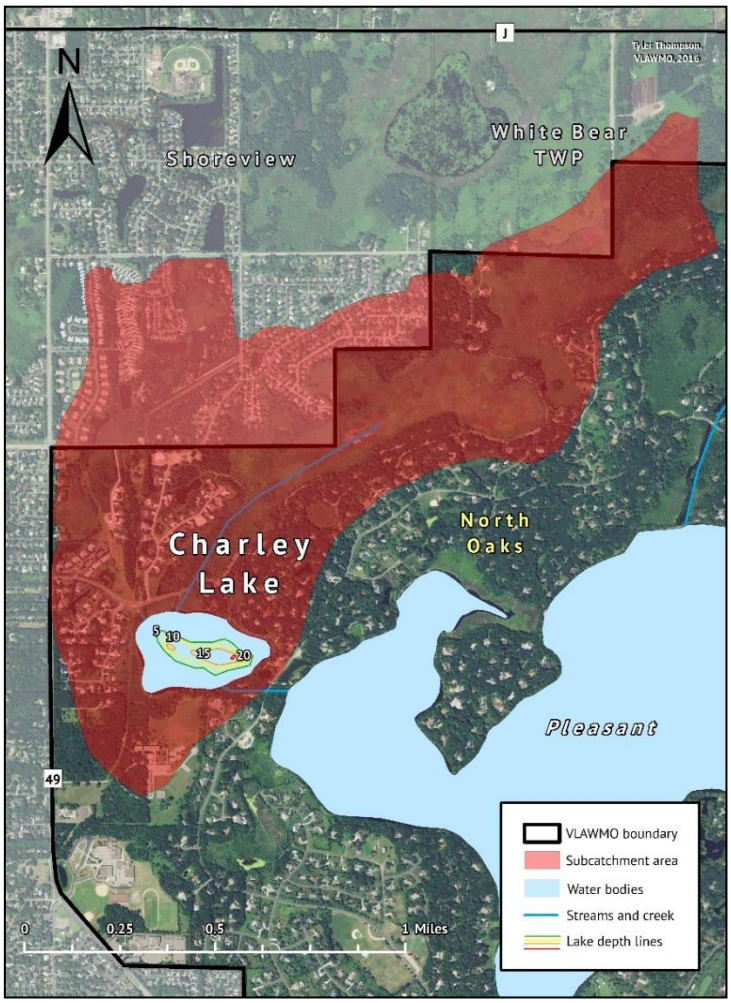
Predominant Vegetation
Unknown

Invasive Species
Zebra Mussels, Eurasian Watermilfoil



LOCATION

Charley Lake is located within the City of North Oaks and is the start of the VLAWMO Chain of Lakes which moves water from the Mississippi River to East Vadnais Lake, the drinking water reservoir for the St. Paul Regional Water Service (SPRWS). The river water enters via large pipes located in the northwest corner of the lake. The land around Charley Lake is residential and open space.

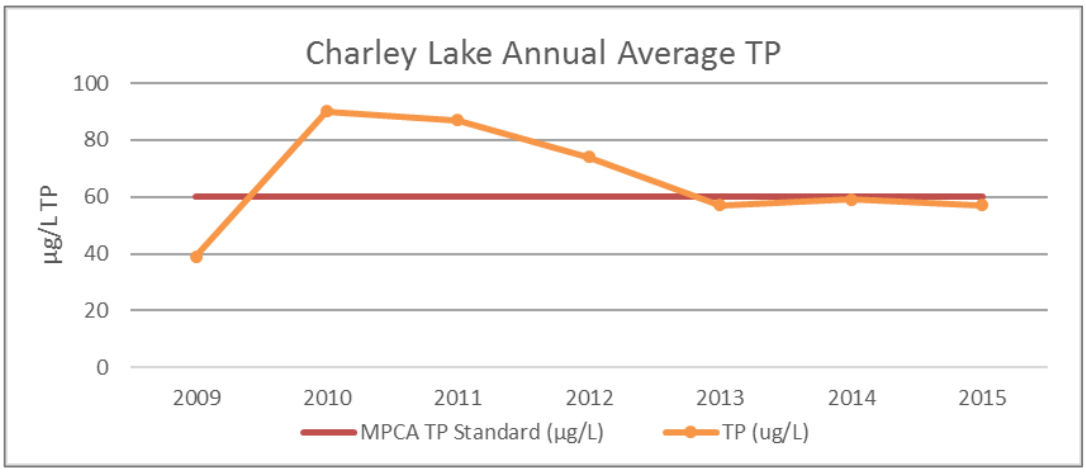


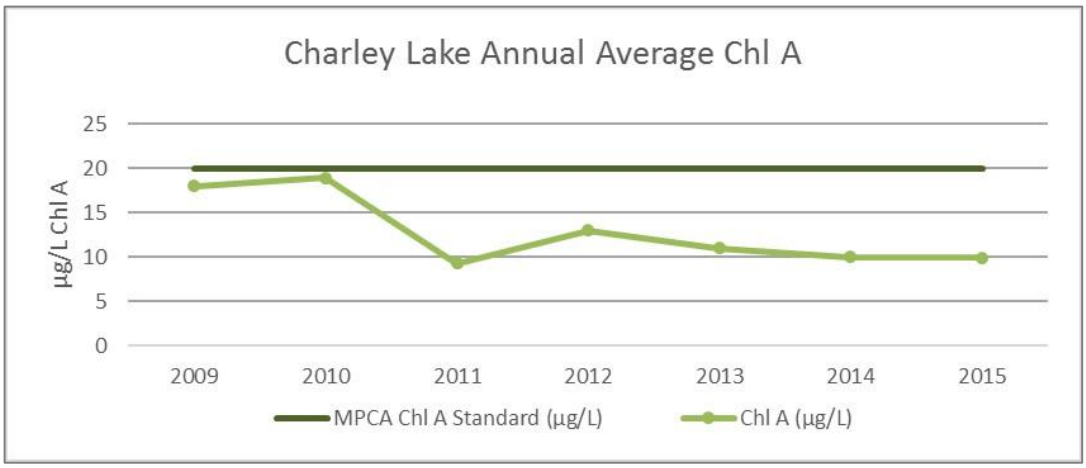
LAKE SUMMARY

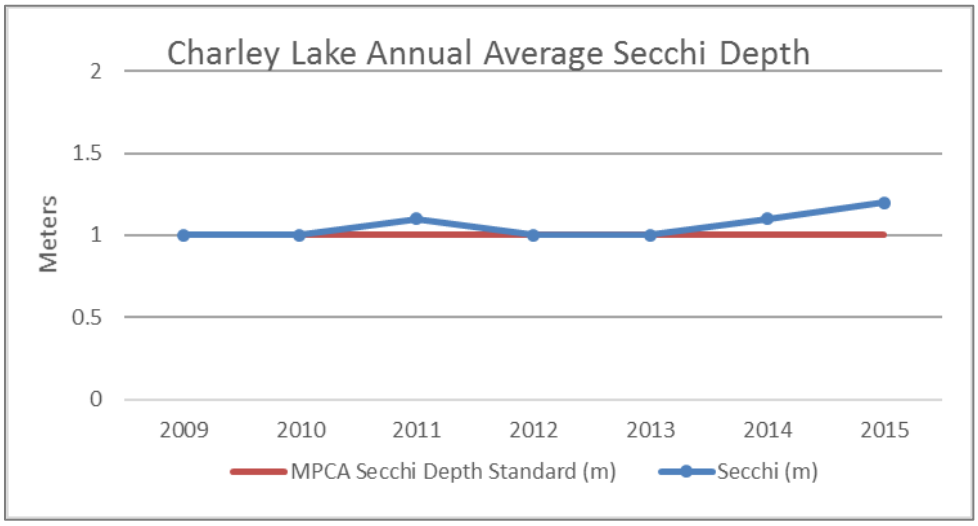
VLAWMO began water quality sampling on Charley Lake in 2009. The SPRWS pumps an average of 32 million gallons of water each day into the lake which then outlets towards Pleasant Lake. This constant influx of water could make it difficult to pinpoint any sources of nutrient loading if the lake is ever listed on the State Impaired List. As of 2016, residential development is occurring on the property to the south of the lake. Depth, vegetation and fish surveys will be conducted when the SLMP is written for this lake. It is known that the lake has zebra mussels and Eurasian Watermilfoil.

PHOSPHORUS (TP)/CHLOROPHYLL a (ChlA)/SECCHI DISC

Levels for TP and ChlA, and Secchi readings hover near or below state standards. VLAWMO's goal is to maintain and protect the water quality of this lake. Continued monitoring will allow VLAWMO to respond efficiently if water quality starts to decline. The SPRWS will be an important partner for any projects that may need to occur in the future.







DEEP LAKE

QUICK FACTS

Watershed Size	716 acres
Surface Area	78 acres
Maximum Depth	11 ft
Average Depth	5 ft

Common Fish

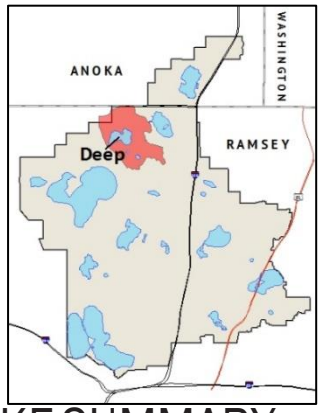
Carp, Walleye, Bass, Sunfish, Northern Pike

Predominant Vegetation

Unknown

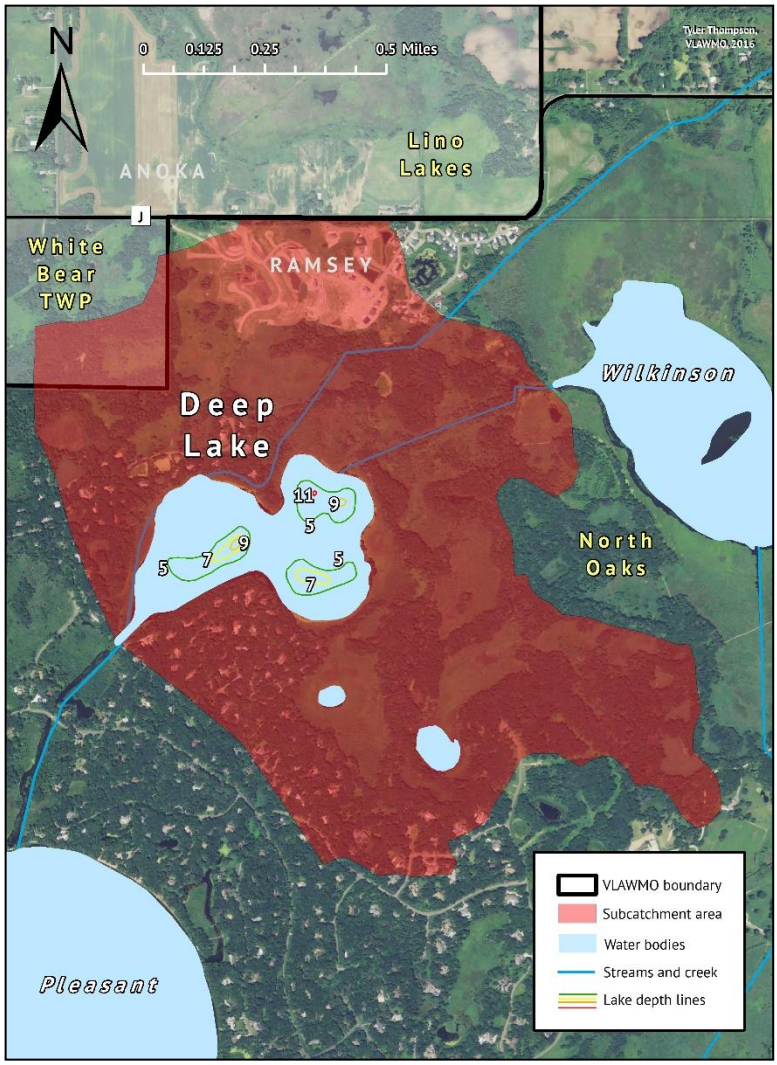
Invasive Species

Eurasian Watermilfoil



LOCATION

Deep Lake is located within the City of North Oaks. The land use around the lake is large lot residential and protected open space. By 2016, much of the land in the northern part of the subwatershed had been developed for residential use.

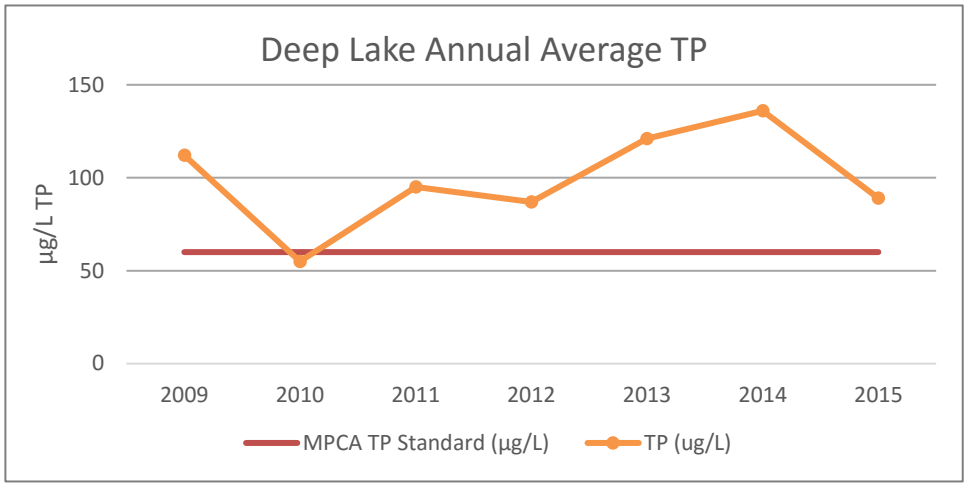


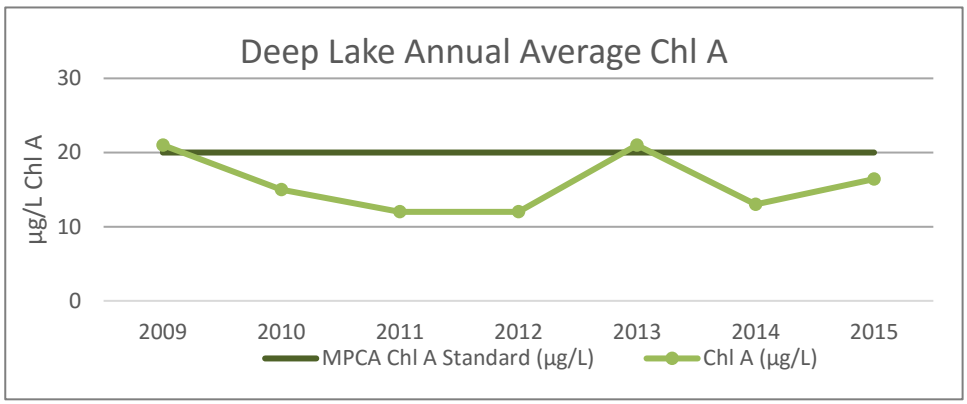
LAKE SUMMARY

Deep Lake is hydrologically connected to Wilkinson Lake to the northwest and Pleasant Lake to the southeast. Water generally flows from Deep Lake into Pleasant Lake however this flow is sometimes reversed when the St. Paul Regional Water Service (SPRWS) is pumping high rates of water into the Chain of Lakes. The Deep Lake Preservation Committee was formed in 2009 however the group hasn't been very active. Residents have expressed concern over the amount of lake vegetation that erupts each year. When the SLMP is completed for this lake, a vegetation and fish survey will be conducted as well as an updated depth survey.

PHOSPHORUS (TP) & CHLOROPHYLL a (ChlA)

Deep Lake's nutrient levels demonstrate an unusual relationship. TP levels of Deep are high and do not meet state standards but ChlA levels are low and do meet state standards. Generally, if TP is high, then ChlA is high as well. One explanation for this occurrence could be that the abundant vegetation in Deep Lake helps to reduce the ChlA levels.





PROJECT SUCCESS

In fall 2015, VLAWMO worked with the Ramsey Conservation District and the North Oaks Homeowners Association to restore a portion of the channel between Deep and Pleasant Lake. The banks of the channel showed signs of erosion and a combination of rip rap and native vegetation was used to secure the bank and prevent further erosion. A crew from the Conservation Corps of Minnesota and Iowa performed much of the labor and North Oaks volunteers have been providing maintenance.

GEM LAKE

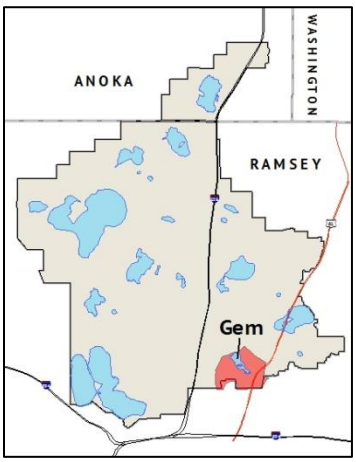
QUICK FACTS

Watershed Size	363 acres
Surface Area	40 acres
Maximum Depth	17 ft
Average Depth	7 ft

Common Fish (2011)
Black Crappies

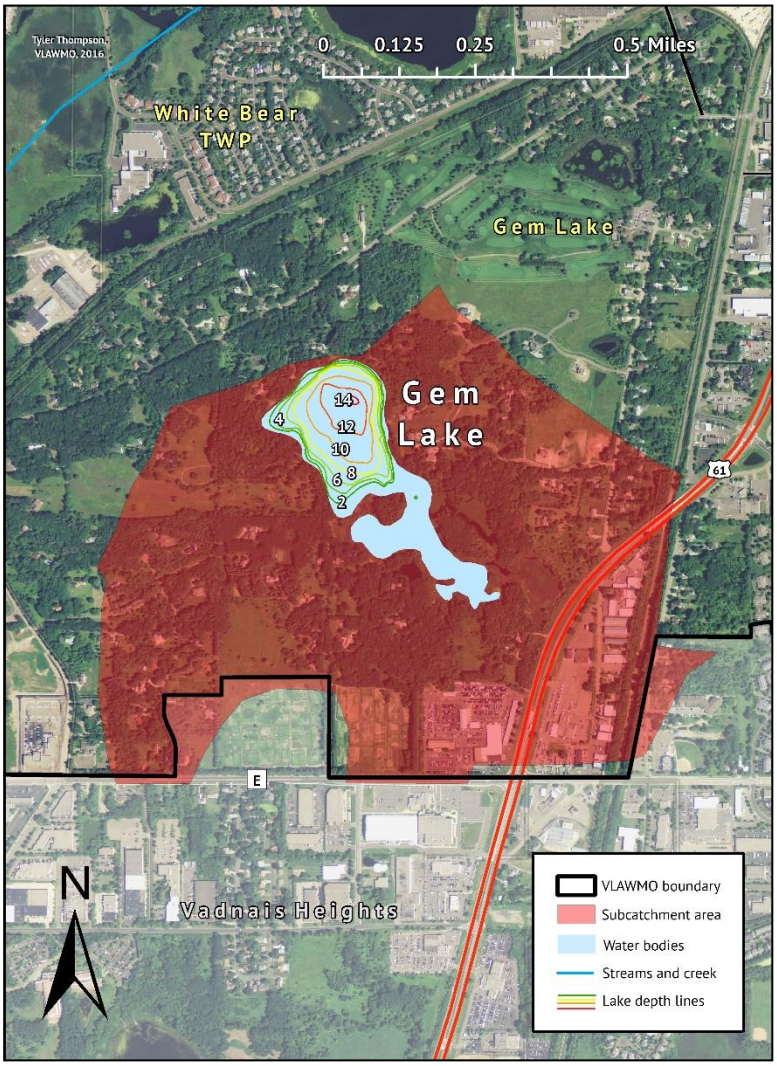
Predominant Vegetation (2010)
Clasping Leaf Pondweed, Pickeral Weed, White Water Lily

Invasive Species
None



LOCATION

Gem Lake is located in the City of Gem Lake. There is a mix of residential, industrial and commercial properties around the lake within the subwatershed and includes a portion of Highway 61.

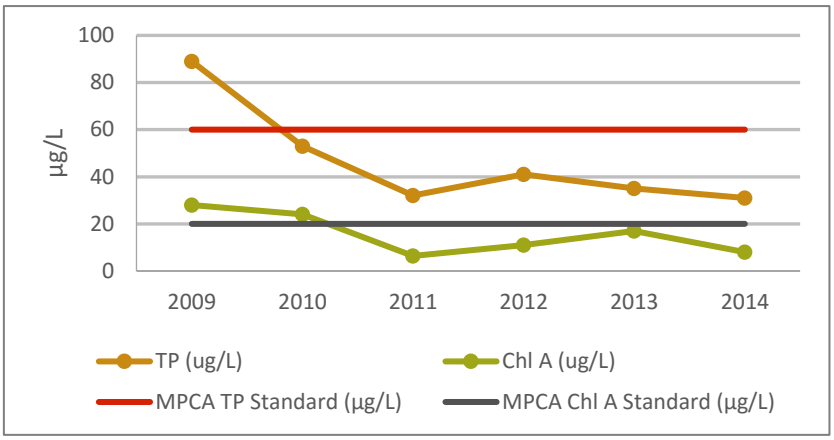


LAKE SUMMARY

Gem Lake is unique in that it doesn't outlet to any other waterbodies within VLAWMO. It would require an immense amount of rain for it to overflow from its subwatershed. Due to the privacy of the lake, it is common to find abundant waterfowl and wildlife. Although Gem Lake is on the State Impaired Waters list due to high nutrients, the water quality has improved enough that it may be taken off the Impaired List in the near future. A factor in its improvement may be from reconstructed swales along Highway 61.

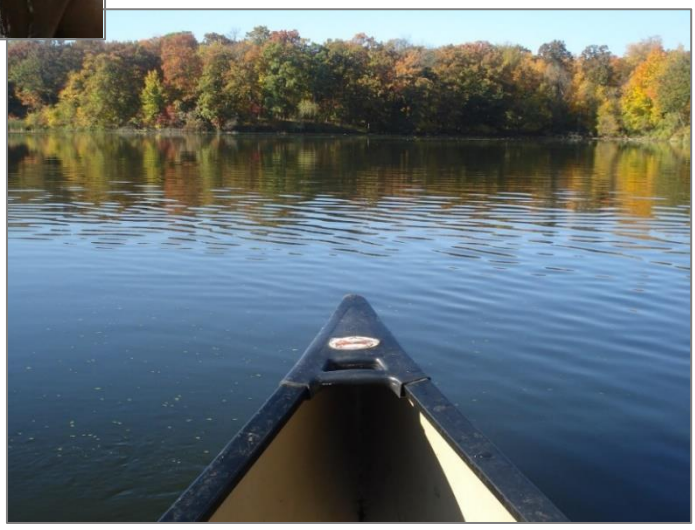
PHOSPHORUS (TP) & CHLOROPHYLL a (ChlA)

Gem Lake's nutrient levels have met state standards since 2010. If this continues, staff will work with the State to remove this lake from the Impaired Waters List. Staff will continue to monitor the lake and will focus on maintaining the good water quality.



Fish & Aquatic Plant Surveys

A 2011 fish survey found that Gem Lake is made up mostly of black crappies. Due to its shallow depth, it likely experiences a winterkill which could eliminate this fish species. Minnows are also present in the lake. An aquatic plant survey in 2010 found 3 native plants and no invasive species. Plants are only found around the perimeter of the lake where light is able to penetrate.



TMDL Information

The TP reduction assigned for Gem Lake is 24%. As stated before, the water quality information since 2010 shows that Gem Lake is now below State Standards and therefore may come off of the Impaired List in the near future without further intervention.

Future Projects

Due to the improved water quality, the goal for this lake is to protect it. An update to the fish and aquatic plant surveys will be done, most likely when the next SLMP is written. Additionally, a depth survey using BioBase or other type of equipment will be conducted. BMP projects may occur when buildings in the Hoffman Road area are redeveloped.

GILFILLAN LAKE

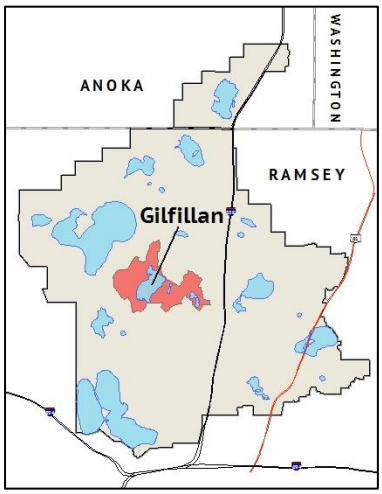
QUICK FACTS

Watershed Size	631 acres
Surface Area	102 acres
Maximum Depth	7 ft
Average Depth	4 ft

Common Fish
Walleye

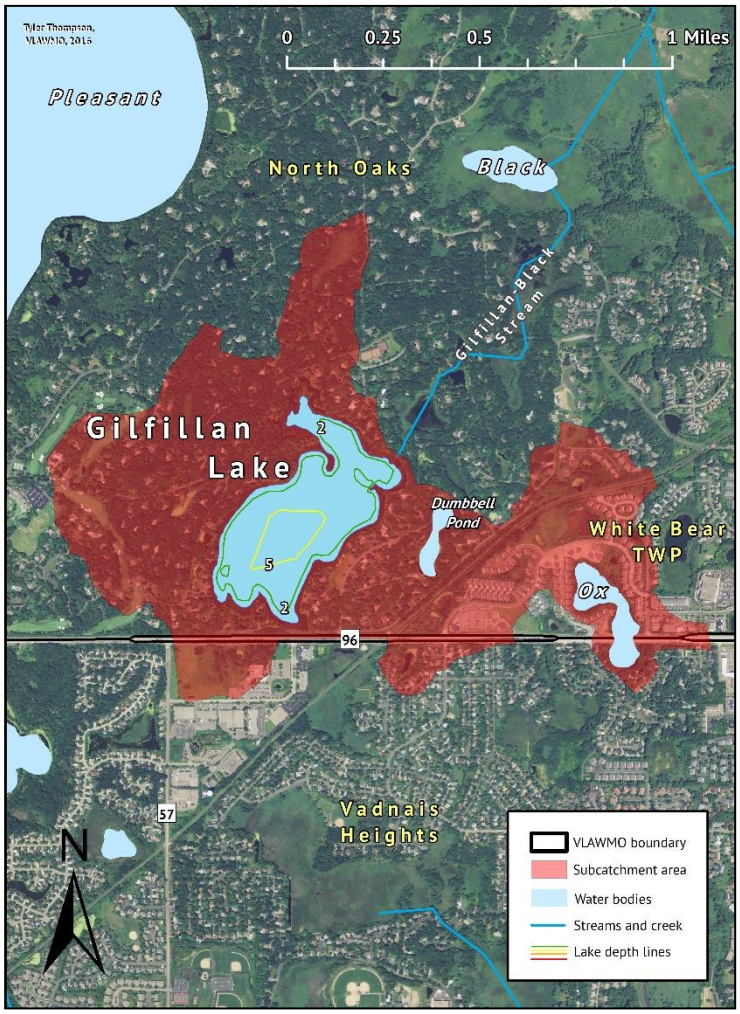
Predominant Vegetation (2009)
Najas, Elodea, White Water Lily

Invasive Species
None indicated



LOCATION

Gilfillan Lake is located in the City of North Oaks near the center of the VLAWMO watershed area. Gilfillan Lake is surrounded by private homes with one large open lot belonging to the North Oaks Home Owners Association. The lake outlets to the north into Teal Pond.

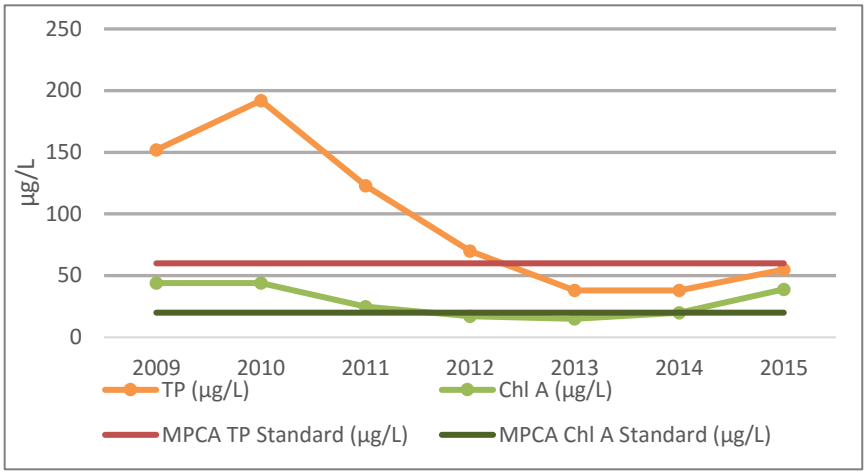


LAKE SUMMARY

Gilfillan is on the State Impaired Waters List for high levels of nutrients. The water quality of Gilfillan has recently been meeting standards which is likely due to increased water volume supplied via a pipe from the Mississippi River, beginning in 2012. VLAWMO will continue to track the water quality to determine if the lower nutrient levels persist or if it starts to climb again.

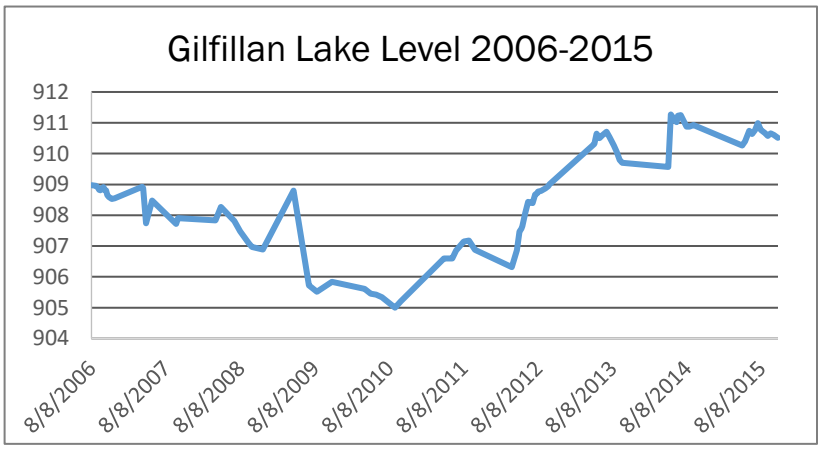
PHOSPHORUS (TP) & CHLOROPHYLL a (ChlA)

Nutrient levels have met state standards since lake augmentation began in 2012. This may be to the dilution of the existing lake water. Continued monitoring will determine the long term trend.



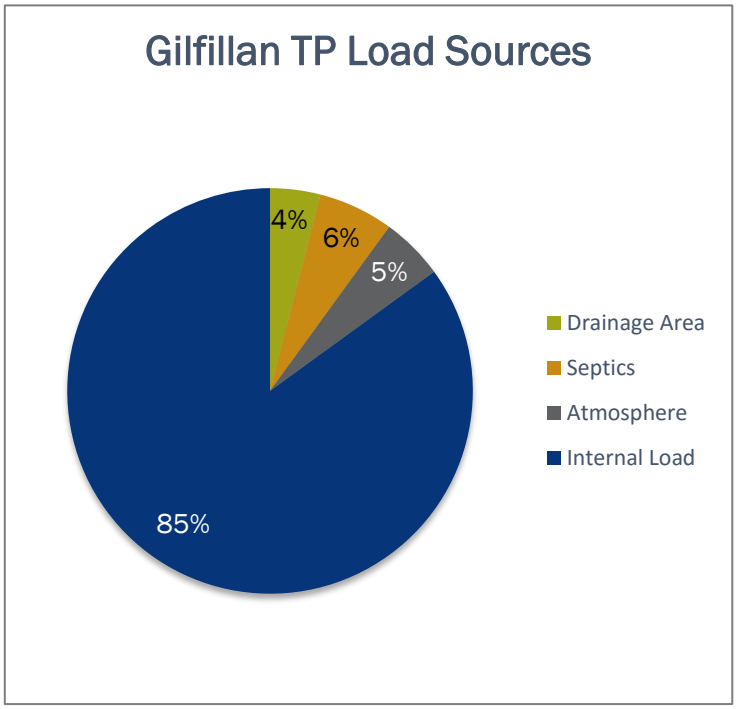
Lake Level

Due to concerns regarding decreasing lake levels, the residents around Gilfillan paid for the installation of an underground pipe and began to receive water in 2012 from the Mississippi River which is supplied by the St. Paul Regional Water Service. Water was pumped periodically the first two years until the lake reached the desired level.



TMDL Information

Gilfillan requires a 62% TP reduction (264 lbs/year) to meet TMDL goals. Internal loading is the largest contributor of TP and can come from lake bottom sediments which release Phosphorus. The loss of native plants, rough fish activity, and wind action can stir up sediment, increasing TP. Wasteload allocations apply to the communities of North Oaks, Vadnais Heights, and White Bear Township. Reduction efforts will focus on the internal load. Since augmentation began, the levels of nutrients has decreased to within or near Standards. VLAWMO will continue to monitor and assess the long term trends for the lake and then determine if further action is needed.



GOOSE LAKE – EAST & WEST

QUICK FACTS

Watershed Size	920 acres
Surface Area	145 acres
Maximum Depth	6 ft
Average Depth	4-6 ft

Common Fish (2012)

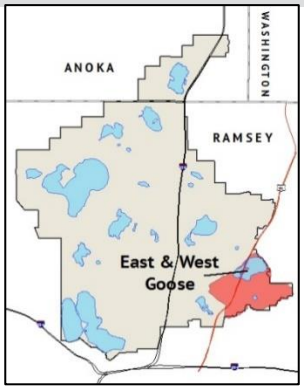
Bluegill Sunfish, Bullheads, Perch, Crappies, Bass

Predominant Vegetation (2014)

Canada Waterweed, Curly Leaf Pondweed

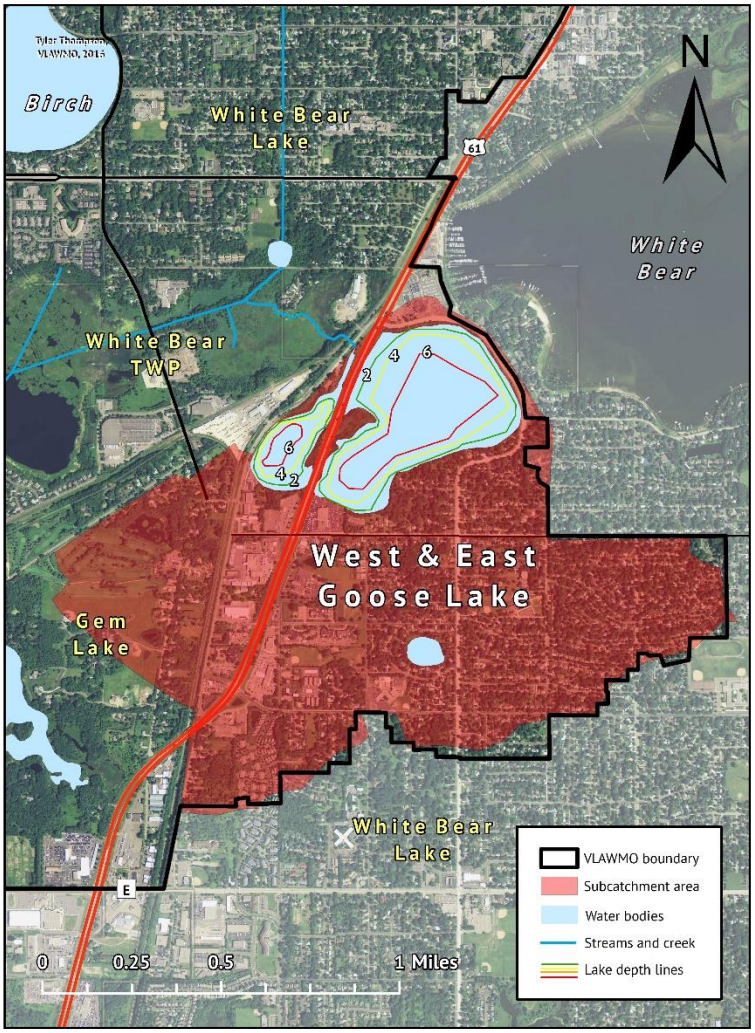
Invasive Species (2014)

Curly Leaf Pondweed, Purple Loosestrife



LOCATION

Goose Lake is located in the City of White Bear Lake. There is a mix of residential, industrial and commercial properties around the lake and part of a golf course within the subwatershed. Highway 61 cuts the lake into its east and west sections with culverts under the highway creating a connection. The lake outlets on the northern tip of West Goose into the headwaters of Lambert Creek.

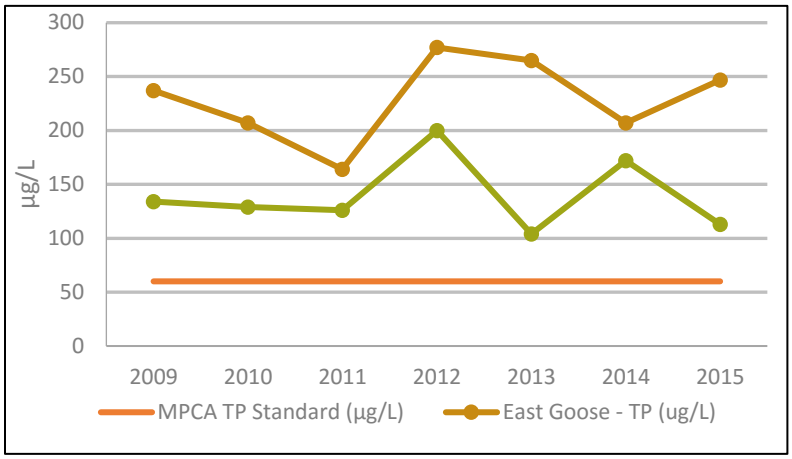


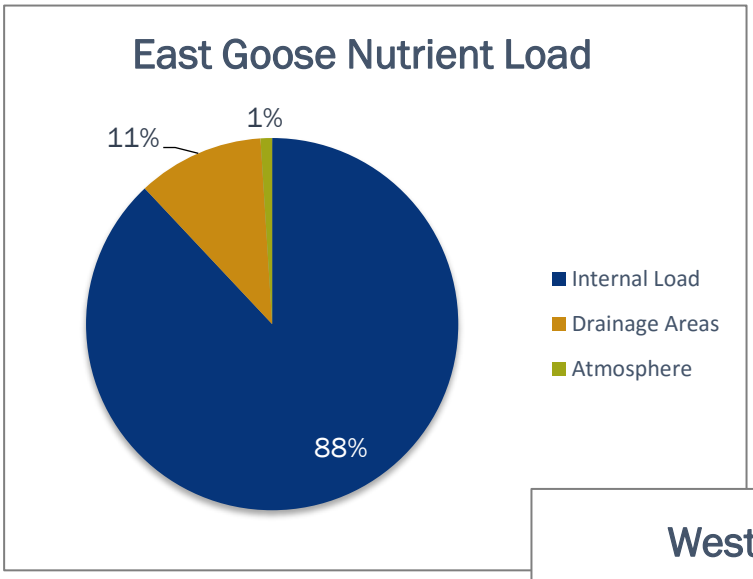
LAKE SUMMARY

Goose Lake is on the State Impaired Waters list due to high nutrients. Studies are still being done to determine the best course of action to bring down TP levels. Unique factors affecting the water quality include: the historical discharge of treated wastewater to the lake, the constant flow of water entering West Goose from a nearby business with a permit for the activity, and the actions of a local waterski club that frequently uses the lake through the warm months.

PHOSPHORUS (TP)

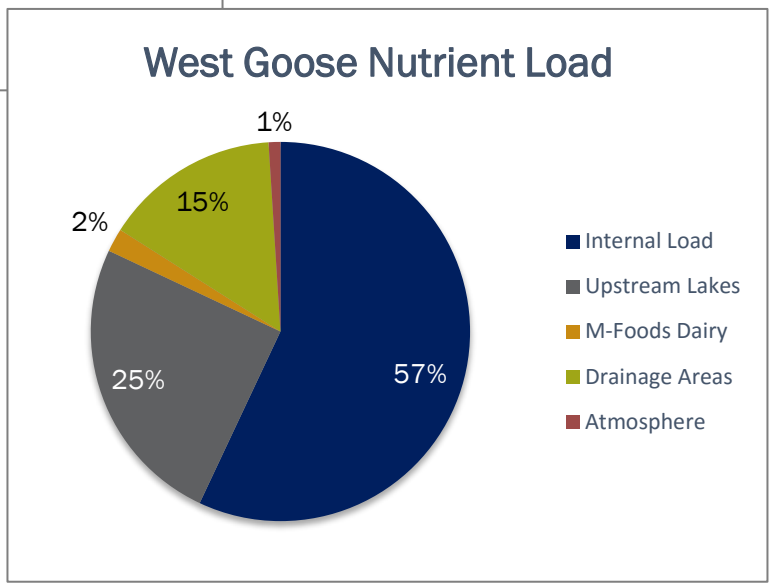
Levels of TP and Chl A do not meet state standards on both East and West Goose Lakes. The presence of blue-green algae is not an uncommon occurrence in the summer, especially on East Goose Lake.





TMDL Information

East Goose is required to reduce TP by 91% and West Goose by 70%. The MS4s affected by this and who must contribute to water quality improvement efforts include the Cities of Gem Lake & White Bear Lake, as well as Ramsey County and the MN Dept. of Transportation. For both lakes, internal loading is the largest source of TP, likely due to the historical discharge of wastewater from a treatment plant.



TMDL Activities

A rough fish survey was conducted in 2012 and determined that there were a large amount of bullheads in both lakes. Bullheads stir up lake sediment, therefore releasing TP. From 2012 to 2015, nearly 19,000 pounds of bullheads were removed from the lakes. A sediment core analysis completed in 2015 on the lakes and the findings will help determine further steps in reducing TP. A shoreline restoration project on West Goose is planned. The feasibility of an alum treatment is being considered. With either of these projects, the cooperation with the local waterski club which uses the lakes frequently will be necessary in order to achieve successful management of the lake.

PLEASANT LAKE

QUICK FACTS

Watershed Size	1852 acres
Surface Area	690 acres
Maximum Depth	58 ft

Common Fish

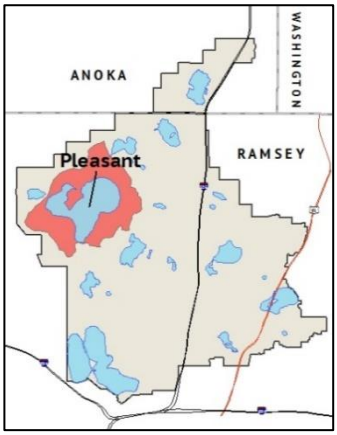
Walleye, Bass, Crappie, Northern, Carp, Muskie, Panfish

Predominant Vegetation

Coontail

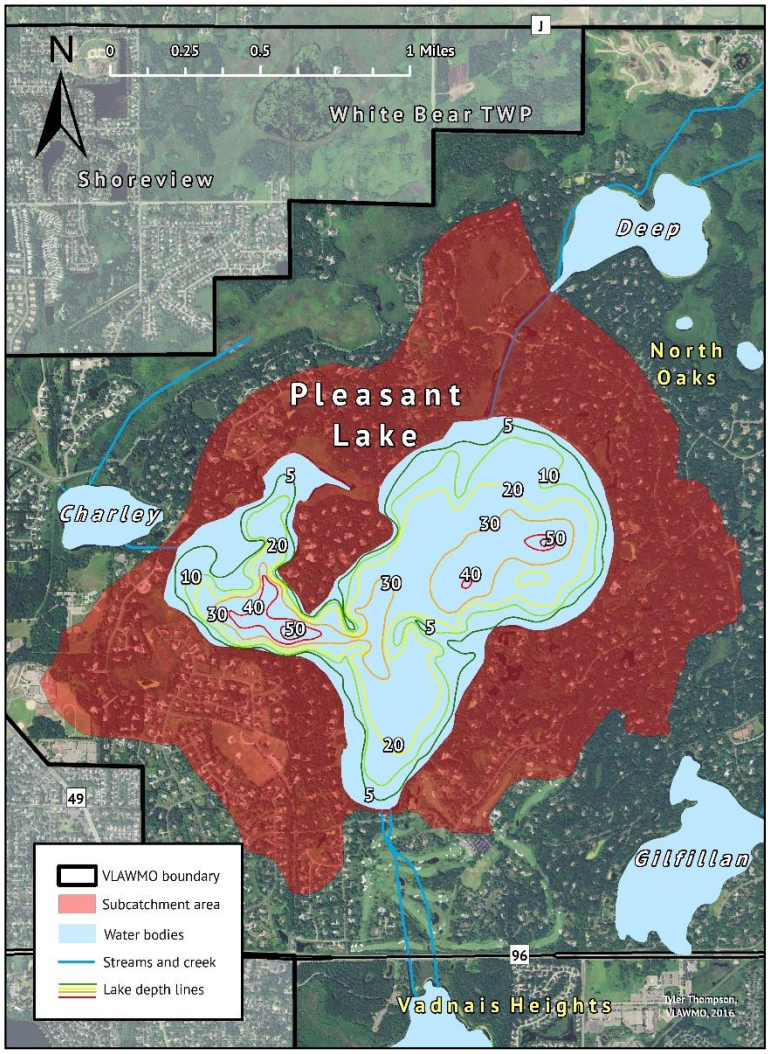
Invasive Species

Zebra Mussels, Curlyleaf Pondweed, Eurasian Watermilfoil



LOCATION

Pleasant Lake is located within the City of North Oaks. Land use around the lake is primarily residential properties with large lots. Pleasant receives water from Charley Lake and Deep Lake and outlets to the south into Sucker Lake.

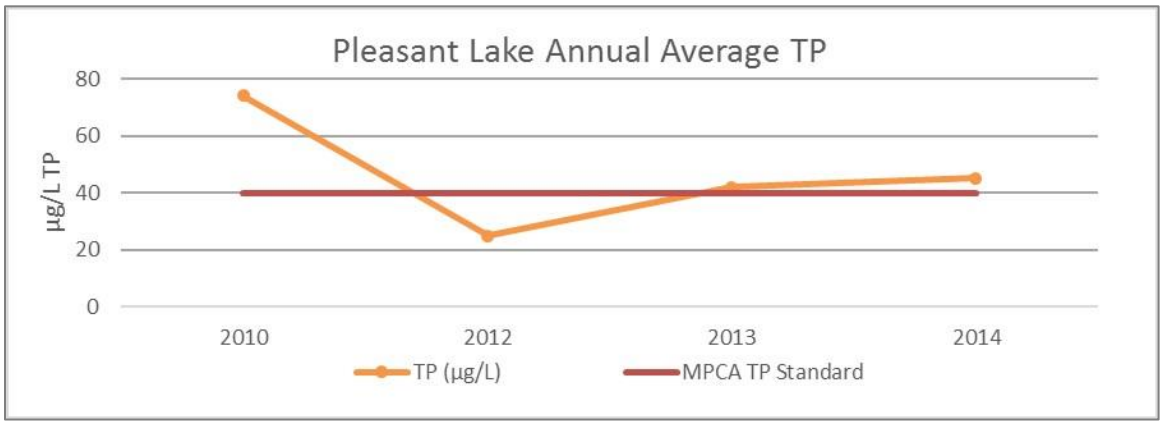


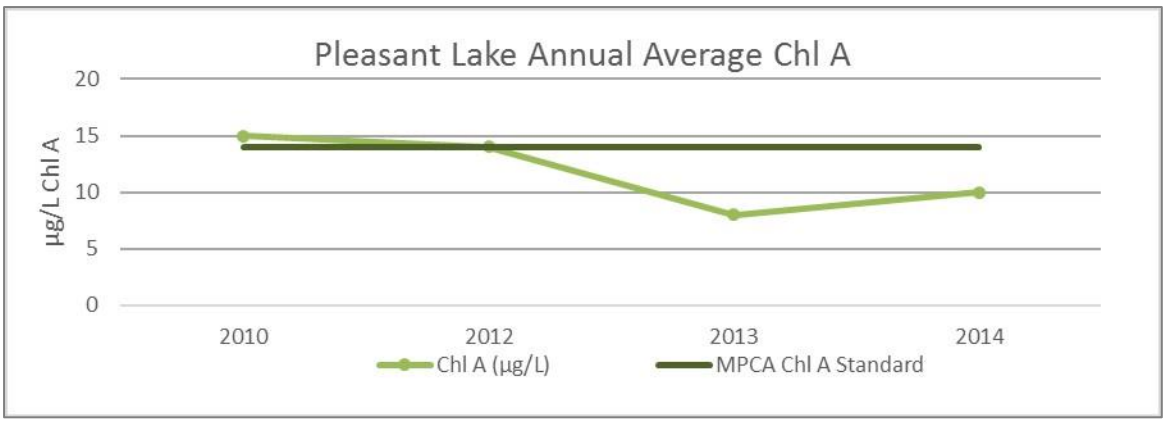
LAKE SUMMARY

Pleasant Lake is managed by the St. Paul Regional Water Service (SPRWS) and is part of the chain of lakes that moves water through VLAWMO to East Vadnais Lake. East Vadnais Lake is the drinking water reservoir for the City of St. Paul and surrounding suburbs. SPRWS collects water quality information for Pleasant Lake. Due to it being part of the chain transporting drinking water, there is no motorized recreational use allowed on the lake. An oxygenation system was installed in 2013 to address high TP levels in the lake.

PHOSPHORUS (TP)/CHLOROPHYLL a (ChlA)/Secchi Disc

Levels for TP and ChlA meet state standards. It was listed on the 2014 Impaired Waters List, however it may be taken off due to the better water quality results in recent years. The installation of the oxygenator system appears to have made a positive impact on the nutrient levels. Secchi disc readings also meet state standards which is another positive water quality indicator. The SPRWS collects the water quality data for this lake, therefore we are limited to what data is available.





SUCKER LAKE

QUICK FACTS

Watershed Size	1085 acres
Surface Area	61 acres
Maximum Depth	26 ft

Common Fish

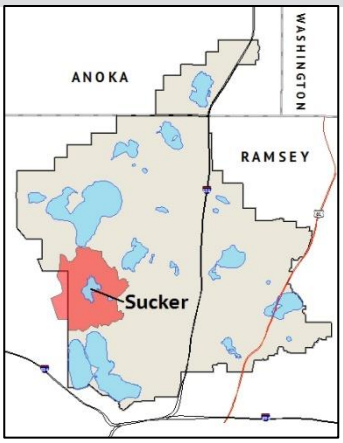
Walleye, Crappie, Bass, Northern, Panfish

Predominant Vegetation

Unknown

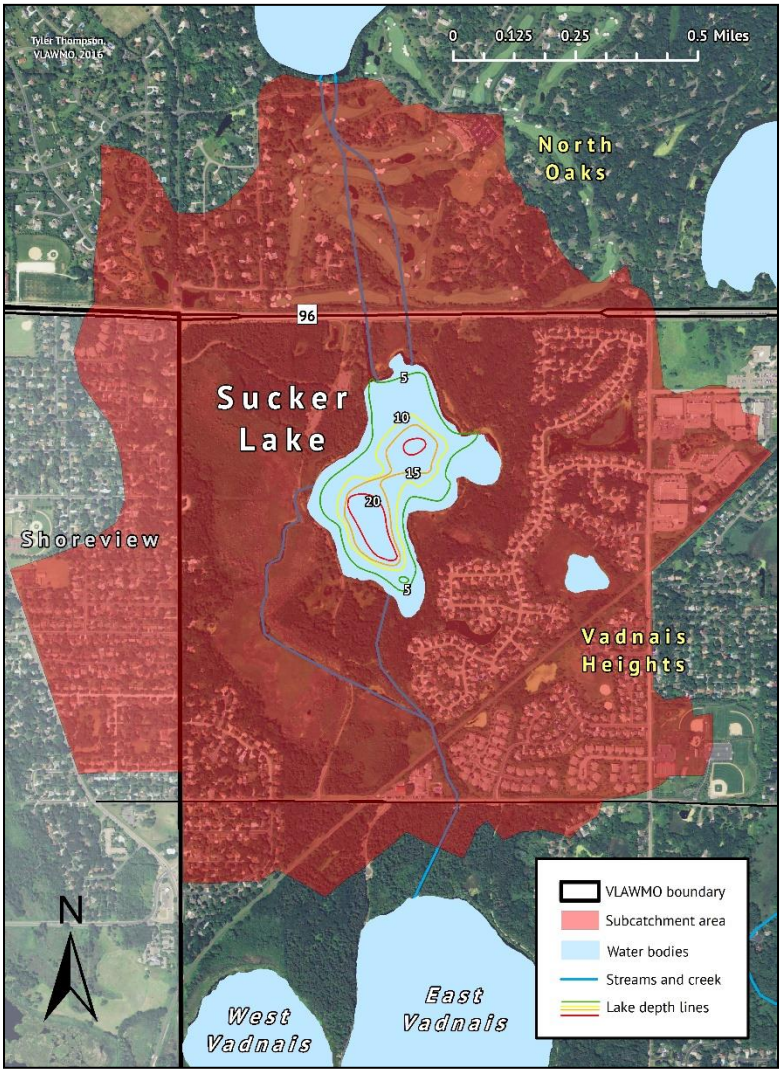
Invasive Species

Zebra Mussels, Eurasian watermilfoil



LOCATION

Sucker Lake is within the City of Vadnais Heights, and the surrounding land is a park managed by Ramsey County. Other land use outside of the immediate surroundings includes, residential, industrial, commercial, and a golf course.



LAKE SUMMARY

Sucker Lake is part of the chain of lakes within VLAWMO that transports water from the Mississippi River to East Vadnais Lake, the drinking water reservoir for 400,000 metro customers. The lake is managed by the St. Paul Regional Water Service (SPRWS). Limited information is available for Sucker Lake. The SPRWS has determined that the water quality can be inferred based on the data obtained from the lakes directly upstream (Pleasant) and downstream (East Vadnais) of Sucker. No motorized use is allowed on the lake.

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TAMARACK LAKE

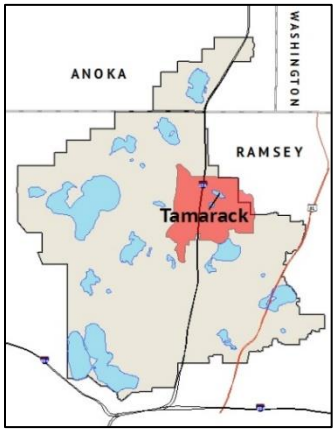
QUICK FACTS

Watershed Size	1290 acres
Surface Area	15 acres
Maximum Depth	10 ft
Average Depth	4 ft

Common Fish
Minnow, Bullhead

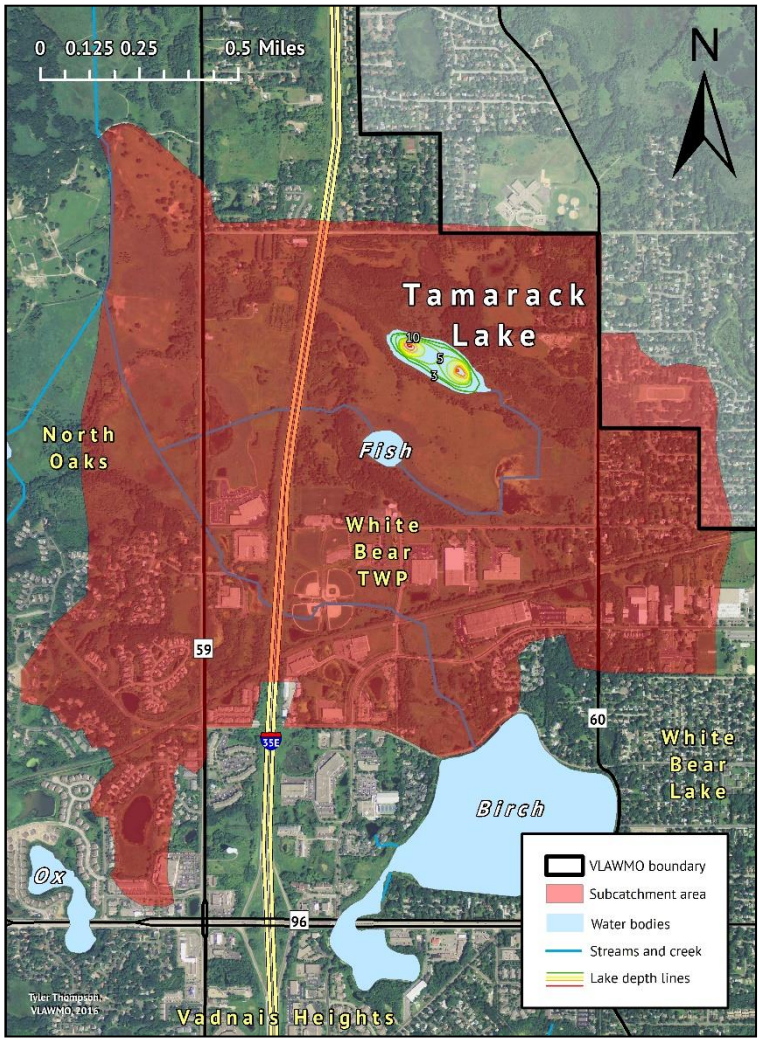
Predominant Vegetation (2008)
Sago Pondweed, Coontail, Najas flexilus, White Water Lily

Invasive Species
None



LOCATION

Tamarack Lake is located within a nature center in White Bear Township and is part of a large subwatershed that includes Interstate 35E as well as residential and commercial developments. Fish Lake is also located on the nature center property, however no active monitoring occurs on Fish Lake due to difficult accessibility.

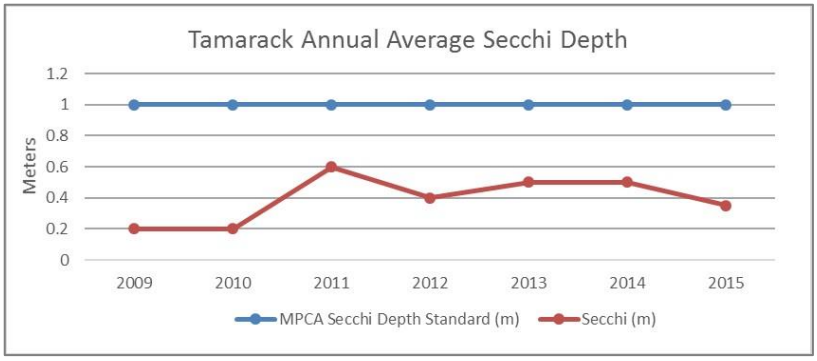


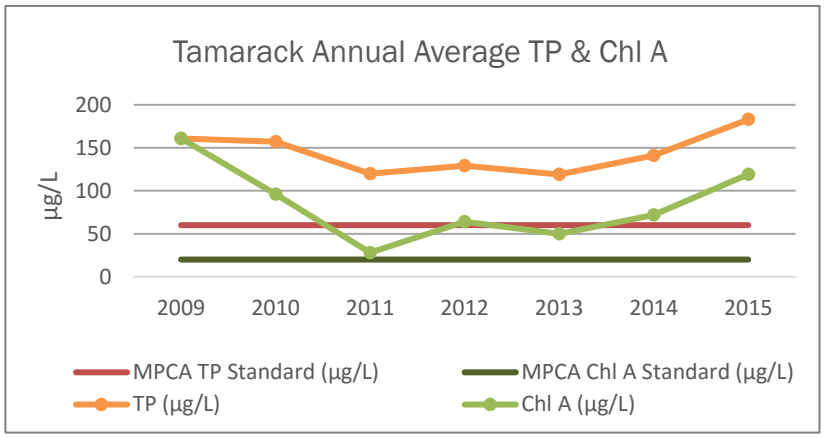
LAKE SUMMARY

The drainage area for Tamarack is primarily natural open space and wetlands. Water flows from Tamarack towards Fish Lake and then into a stream going north to Wilkinson Lake. Tamarack has been included on the State Impaired Waters List for high nutrients. Because of the large natural buffer around the lake, the cause of the high levels is likely to be internal loading.

PHOSPHORUS (TP) & CHLOROPHYLL a (ChlA)

Monitoring data shows nutrient levels consistently high in Tamarack Lake. The lake has poor Secchi readings as well and in the summer, algae is abundant.





Depth Surveys

In 2008, staff performed depth surveys of Tamarack and Fish Lakes. It was thought that Tamarack had a contour shaped like a bathtub with a consistent depth of no more than 6 feet. However, the survey revealed that there are two deeper pockets in the lake which could allow for some fish to survive over the winter. Fish Lake has a shallow edge that quickly drops down to approximately 16 feet. A tiny pocket of 18 feet was found in the center of the lake. It is possible that game fish could live in Fish Lake.

Projects

VLAWMO installed a floating island on Tamarack Lake in 2014 to be used as an educational tool as well as help water quality. Studies have shown that floating islands can absorb nutrients from the water which can lower TP levels. The island is planted with native vegetation and provides habitat for the birds and wildlife at the nature center. VLAWMO also participates in educational programs at Tamarack Nature Center, most recently with the successful Dragonfly Monitoring program for both kids and adults.

EAST VADNAIS LAKE

QUICK FACTS

Watershed Size	889 acres
Surface Area	389 acres
Maximum Depth	58 ft

Common Fish

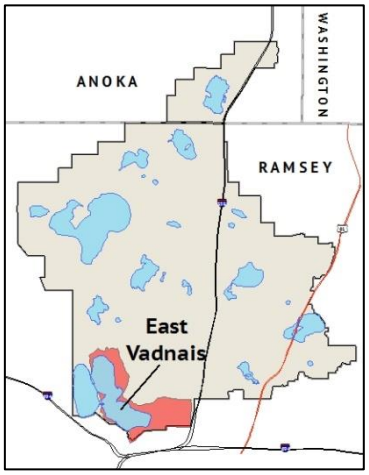
Walleye, Bass, Northern, Channel Catfish, Crappie, Carp, Sucker, Perch

Predominant Vegetation

Unknown

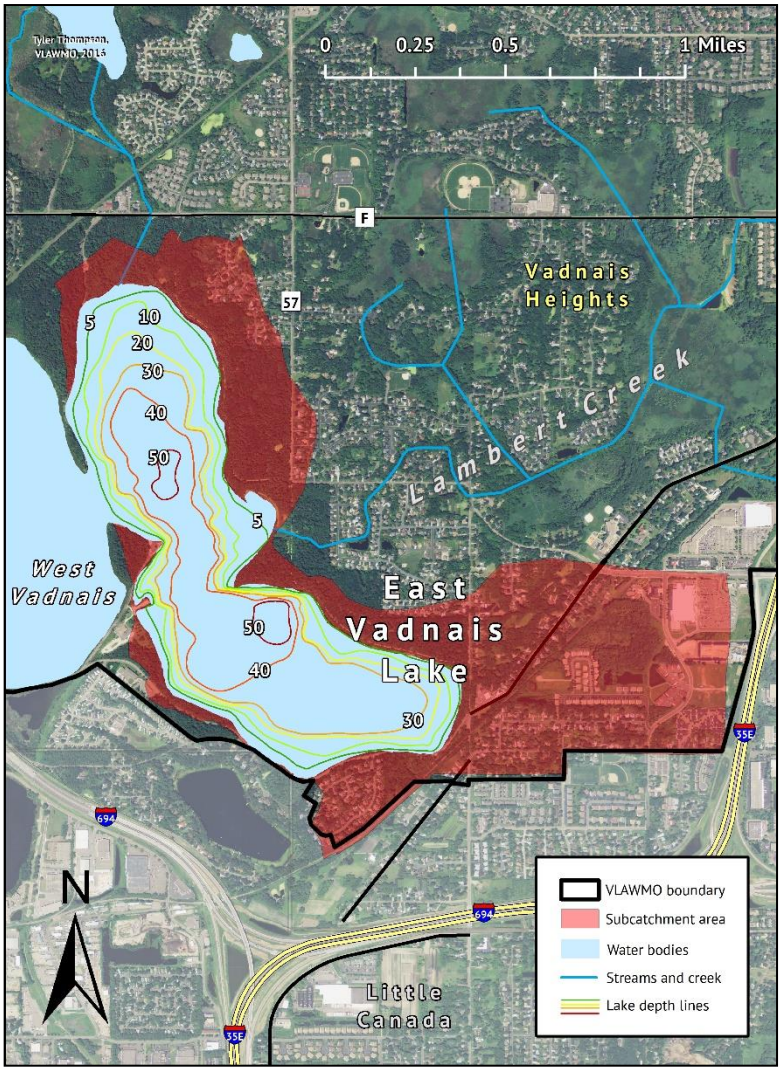
Invasive Species

Zebra Mussels, Eurasian watermilfoil



LOCATION

East Vadnais Lake is within the City of Vadnais Heights, and is the end point for the flow of water within VLAWMO. The land immediately surrounding the lake is protected parkland with residential properties beyond that.



LAKE SUMMARY

East Vadnais Lake is the drinking water reservoir for the City of St. Paul. It receives water from the Mississippi River via a chain of lakes within the VLAWMO area and the lake is managed and monitored by the St. Paul Regional Water Service (SPRWS). Water leaves the lake via underground pipe to the water treatment plant in Roseville and is then distributed to over 400,000 customers in the City of St. Paul and surrounding suburbs. No recreational use is allowed on the lake, aside from shoreline fishing, primarily along the western shore. An oxygenation/aeration system is used in the lake to help reduce TP levels.

APPENDIX B: INVENTORY & ASSESSMENT

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WEST VADNAIS LAKE

QUICK FACTS

Watershed Size	394 acres
Surface Area	213 acres
Maximum Depth	9 ft
Average Depth	7 ft

Common Fish

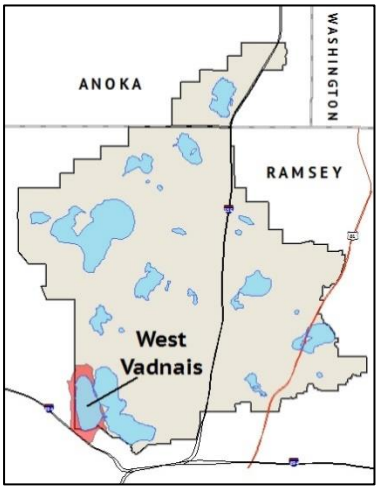
Bullhead, Panfish

Predominant Vegetation

Unknown

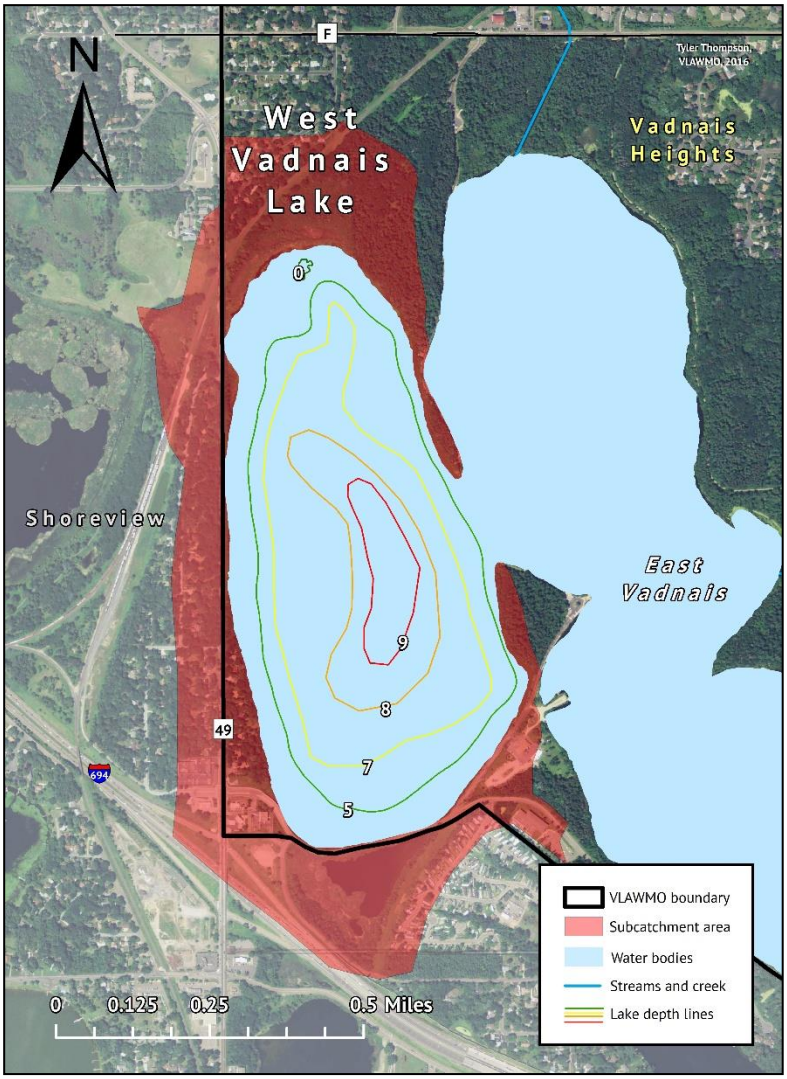
Invasive Species

Zebra mussel, Eurasian watermilfoil



LOCATION

West Vadnais Lake is located in the southwest corner of the VLAWMO watershed. It is an isolated waterbody with a very small subwatershed area. The land use is park property and residential. No connection to East Vadnais.

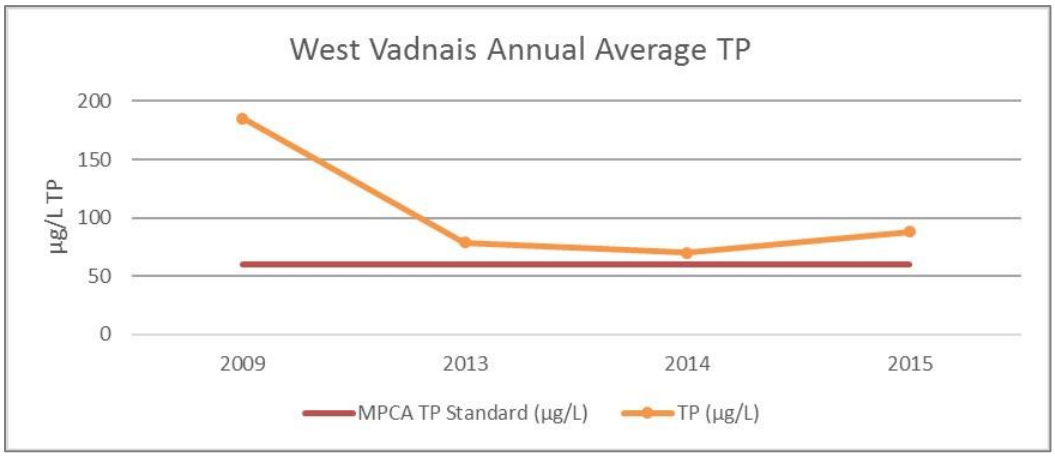


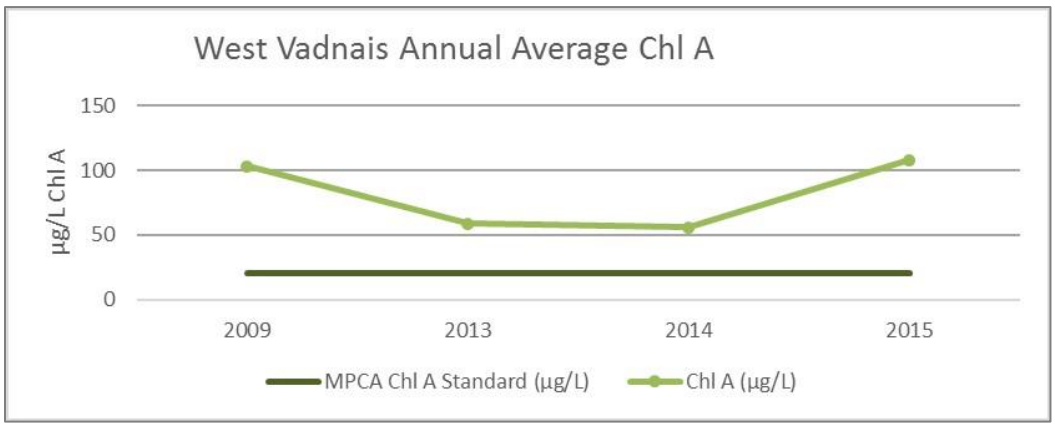
LAKE SUMMARY

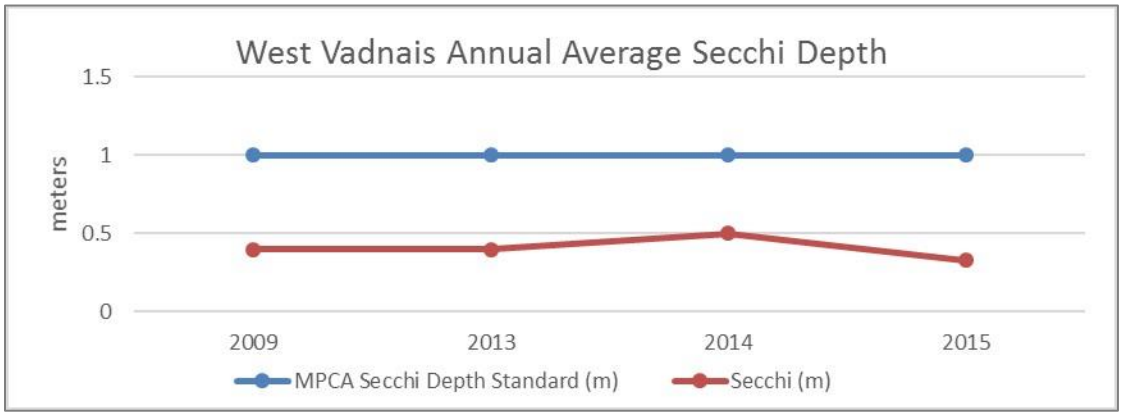
West Vadnais Lake has limited monitoring data. Samples were collected by a volunteer in 2009 and staff collected the samples since 2013. Further information is needed to better understand the ecology of the lake. Water quality monitoring will continue along with possible vegetation, fish and sediment surveys.

PHOSPHORUS (TP) & CHLOROPHYLL a (ChlA) & Secchi Disc

Levels for TP and ChlA do not meet state standards and the lake is on the Impaired Waters List.







WILKINSON LAKE

QUICK FACTS

Watershed Size	1108 acres
Surface Area	94 acres
Maximum Depth	4.5 ft
Average Depth	3 ft

Common Fish (2010)

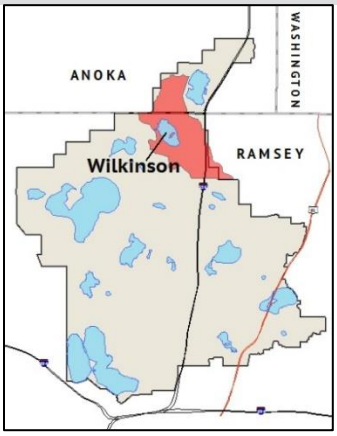
Northern Pike, Carp

Predominant Vegetation (2010)

Water Lily, Coontail, Blanket Weed

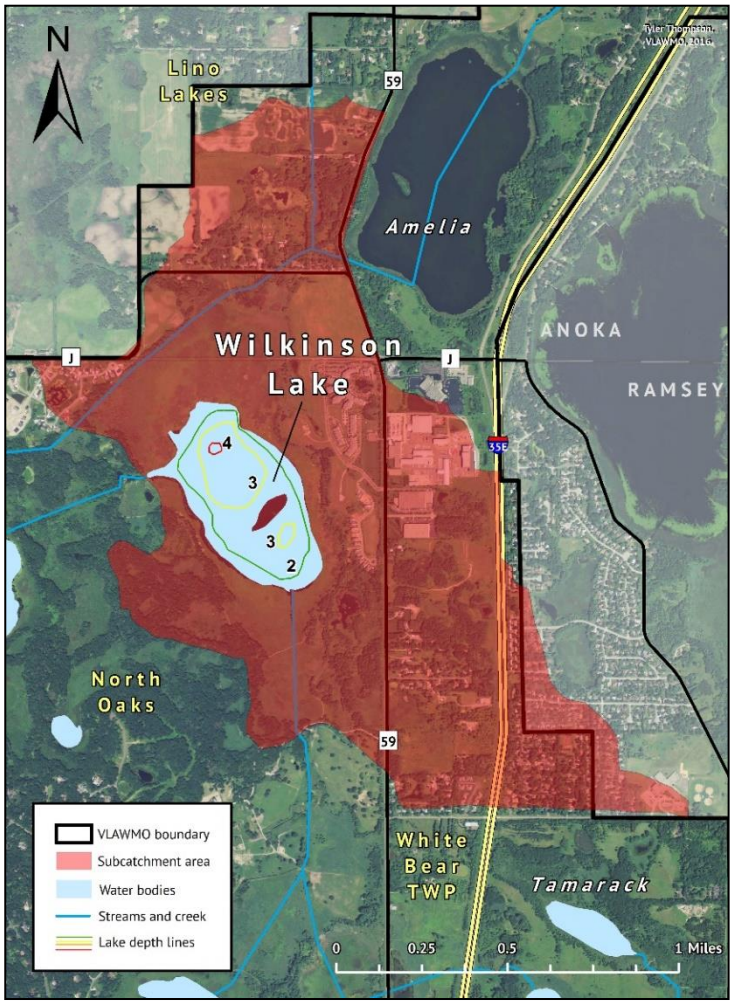
Invasive Species

None



LOCATION

Wilkinson Lake is located within the City of North Oaks. A portion of Interstate 35E is within the subwatershed area. The land use around the lake is mainly multi-family residential, commercial, industrial and protected open space. There are plans for more multi-family senior housing with possible commercial use to the north of the current development.

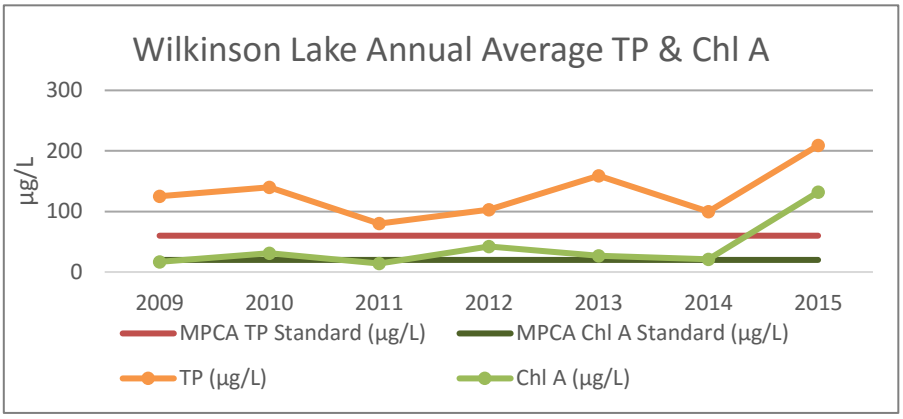


LAKE SUMMARY

Wilkinson Lake is a shallow waterbody that is part of the Minnesota Land Trust and has protected open space surrounding it. Due to high nutrient levels, it has been listed on the State Impaired Waters List and a TMDL has been completed. When the SLMP report was completed in 2011, a depth map and aquatic plant survey were completed for the lake. A fish barrier was installed in 1994 at the western outlet of Wilkinson to prevent carp from entering the lake. It is likely that some have gotten through the barrier but a formal survey would be needed to ascertain the population. Northern Pike were seen in 2010 when staff were performing surveys.

PHOSPHORUS (TP) & CHLOROPHYLL a (ChlA)

Wilkinson's TP and Chl A levels do not meet state standards. There was a rise in nutrient levels in 2015 which VLAWMO staff will watch closely to see if the trend continues. Expanded monitoring to measure nutrient loading from watershed sources began in 2016.



TMDL

Working with available data and information, it was determined that the majority of the TP loading for Wilkinson comes from the surrounding drainage area. Wilkinson requires a 63% reduction in TP to be within State Standards. The MS4s that will be involved with the restoration of this lake include: MNDOT, Anoka County, Ramsey County, and the communities of White Bear Township, Lino Lakes, North Oaks, and White Bear Lake. The expansion of monitoring for this lake will help pinpoint where BMPs could be installed to help reduce the nutrient input. A fish survey could also provide information towards determining the role of internal loading for this lake.

WILDLIFE OBSERVATIONS

The habitat provided by Wilkinson and the surrounding protected area attracts a wide variety of waterfowl. An osprey nest is located on the western edge of the lake and nearby residents have reported the presence of Bald Eagles, Trumpeter Swans, Loons, Wood Ducks, Common Goldeneye, Bufflehead, Hooded Merganser, Northern Shoveler, Gadwall, and Mallards. In the fall the lake can have hundreds of diving birds and ducks stopping by on their way south for the winter. Additionally, beavers and mink are seen regularly, as well as hundreds of dragonflies.

LAMBERT CREEK

QUICK FACTS

Watershed Size	3658 acres
Length	4.5 miles

Water Quality Impairment

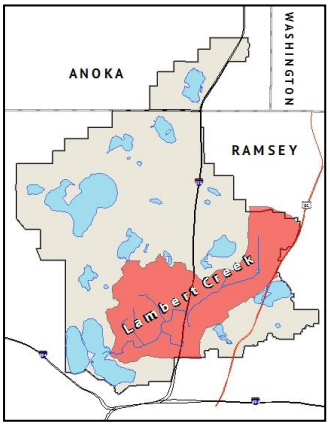
Fecal Coliform – E.coli

Communities Involved

White Bear Lake, White Bear Township, Vadnais Heights, Ramsey County

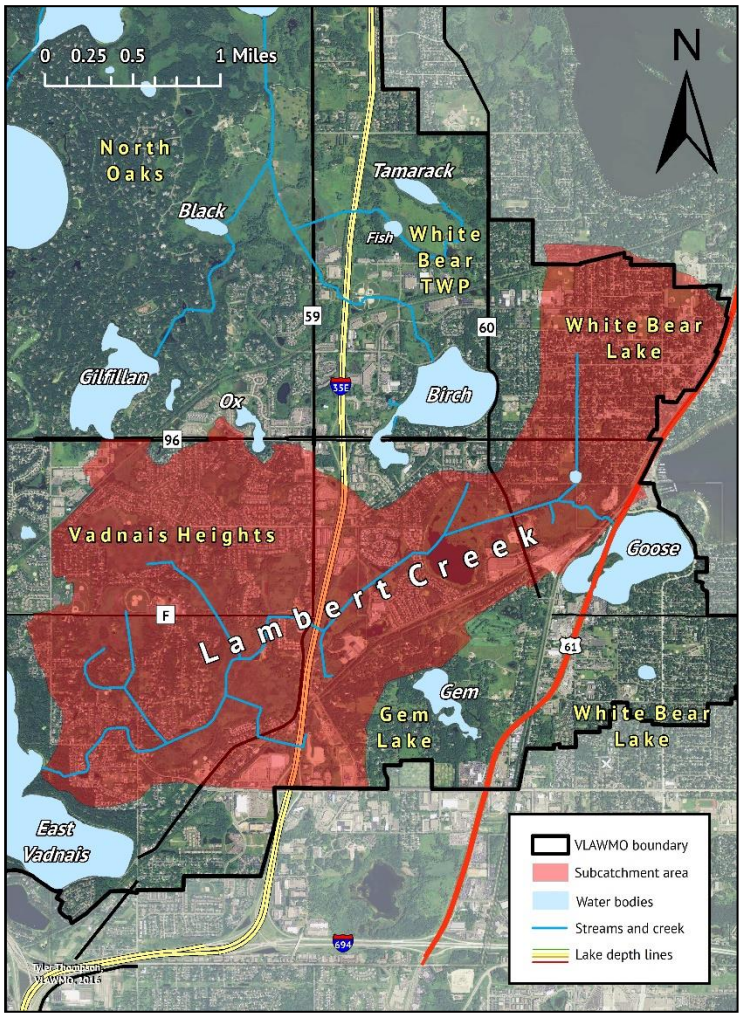
Monitoring Information

6 grab sample sites, continuous flow at one site, 3 flumes for snapshot flow measurements



LOCATION

Lambert Creek flows through the southern part of the watershed with its headwaters at West Goose Lake and its outlet at East Vadnais Lake. Lambert Creek is also known as County Ditch 14 and receives waters from side streams and storm sewers and flows through numerous wetland complexes.

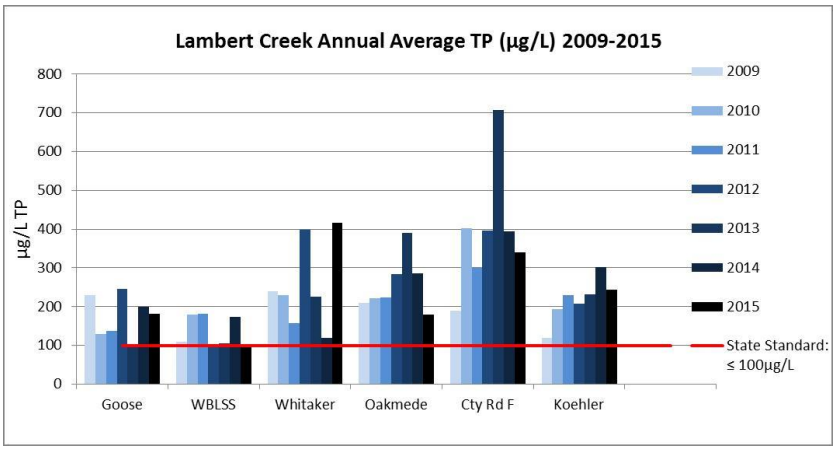


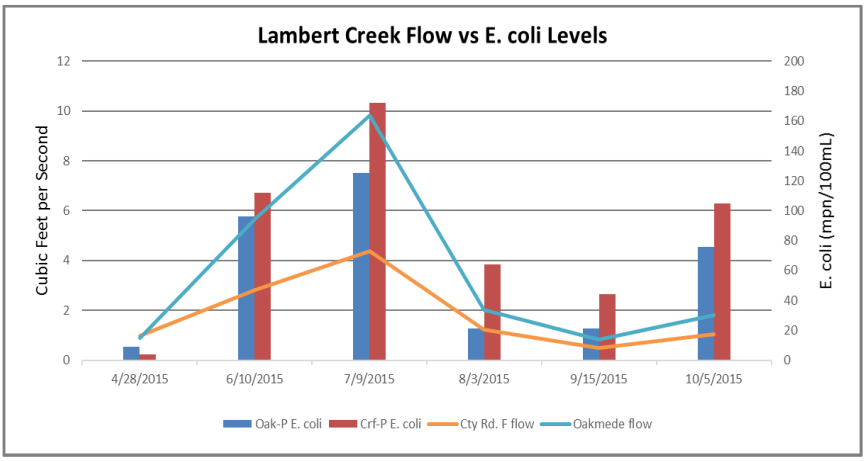
WATER QUALITY SUMMARY

Lambert Creek is monitored on a bi-weekly basis from May through September. Samples are collected at six sites throughout the creek and analyzed for typical parameters. Additionally, samples are collected at five sites to be analyzed for E.coli. Lastly, flow rates are calculated at 3 flume sites, along with continuous flow monitoring at the Whitaker Pond site. The creek is on the Impaired List for bacteria and staff have been doing specialized sampling to help determine the source which would direct our restoration efforts. Many water quality projects have been implemented over the years throughout the subwatershed to help reduce nutrient levels in partnership with the St. Paul Regional Water Service and the Ramsey Conservation District.

PHOSPHORUS (TP)

TP in Lambert Creek does not meet state standards. However, over the course of the last 20 years, the nutrient has gone done, most likely from several BMPs installed throughout the stretch of the creek. Further improvements will occur as funding and opportunities arise.





E.coli Monitoring

VLAWMO monitors the creek for E.coli and has done a TMDL study due to its listing on the Impaired Waters List for bacteria levels above the State Standard. Beginning in 2014, staff have been collecting separate samples as part of a source ID study to help determine the best projects and programs to help reduce bacteria levels in the creek.

Project Success

VLAWMO restored the banks of Lambert Creek at the Oakmede site in 2012-2014. The site was overgrown with trees and weeds and the banks were eroding. The site was cleared of invasive and excess vegetation and soil lifts were installed to stabilize the banks. Native shrubs, trees and perennials were installed. Water quality levels were better in 2015 at this site and staff hopes to see that trend continue. Funding support for this project came from a Clean Water Legacy Grant, in partnership with the Ramsey Conservation District.

3.3 Wetlands

The U.S. Fish and Wildlife Service produced wetland maps through aerial photo interpretation as part of the National Wetland Inventory (NWI) in the 1970s. In 2013, the MN Department of Natural Resources (DNR) updated the NWI using more sophisticated GIS methods. Based on the updated NWI inventory, there are 1137 wetlands (including lakes) covering approximately 27.6% of the watershed.

Information regarding the process used to update the NWI inventory can be found on the DNR website: http://www.dnr.state.mn.us/eco/wetlands/index.html.

TABLE 7: WETLAND SIZE DISTRIBUTION IN VLAWMO, INCLUDING LAKES (NWI DATA)

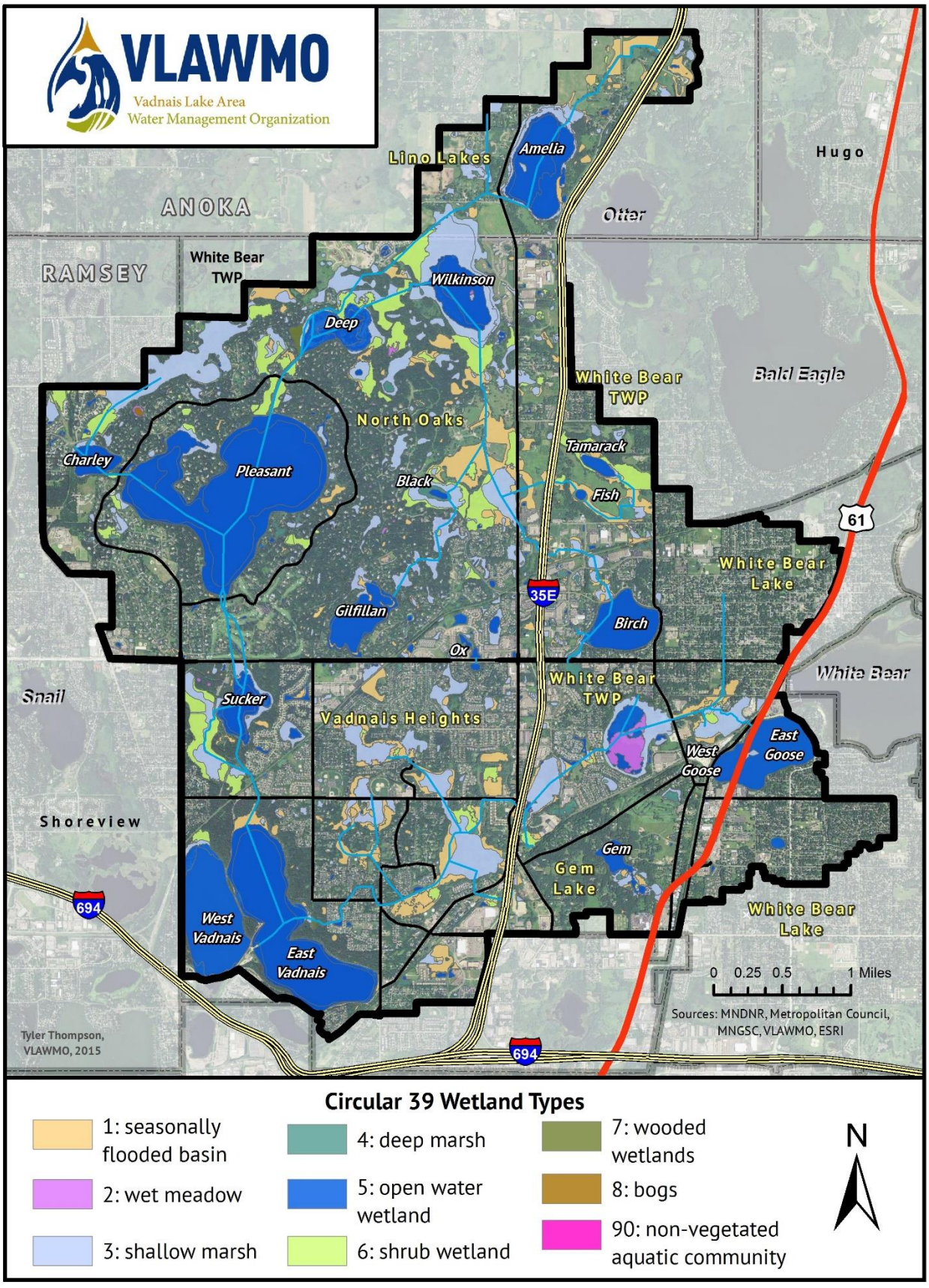
Wetland Size	Number	% of Total
< 1 acre	704	62%
1-5 acres	285	25.1%
5-10 acres	65	5.7%
10-15 acres	26	2.3%
> 15 acres	57	4.9%
Total	1137	

There are two common classification schemes to identify wetland type: the U.S. Fish and Wildlife Service's Circular 39 system, and a replacement classification system referred to as the Cowardin system. Circular 39 was originally developed to classify wetlands for waterfowl habitat use. The Cowardin system is a tiered classification system based on landscape position, substrate, flooding regime, and vegetation. The Cowardin system has been adopted by many agencies but Circular 39 is still commonly used due to its simplicity.

TABLE 8: CIRCULAR 39 CLASSIFICATION OF VLAWMO WETLANDS, INCLUDING LAKES (NWI DATA)

Circular 39 Class	Number	Acres	% of Total Acres
1: seasonally flooded basin	247	701.8	14.33%
2: wet meadows	15	46.1	0.94%
3: shallow marshes	397	1387.3	28.33%
4: deep marshes	172	134.3	2.74%
5: open water wetlands	221	2158.2	44.08%
6: shrub wetlands	79	453.1	9.25%
7: wooded wetlands	2	8.6	0.18%
8: bogs	1	1.6	0.03%
90: non-vegetated aquatic community	3	5.6	0.12%
Total	1137	4896.4	

FIGURE 8: NWI INVENTORIED WETLANDS (2013)



APPENDIX B: INVENTORY & ASSESSMENT

VLAWMO completed a Comprehensive Wetland Management Plan in December 2001 to determine the functional assessment and management classification for approximately 25% of the wetlands, including the major lakes in the watershed. The methods now used to determine wetland functions and management class are more detailed than what was used for the 2001 assessment and any project involving a possible impact to a wetland is reviewed using the newest methods. The 2001 assessment provides valuable information as to the health of the wetlands that were part of that study. An updated assessment of wetlands is planned during the next 10 years in order to ascertain if the functions of those wetlands have increased, decreased, or remained the same. Further information regarding the 2001 plan can be found on the VLAWMO website.

VLAWMO is the Wetland Conservation Act (WCA) authority for the watershed and is involved whenever there is development or other activities which occur near or in a wetland. VLAWMO requires a professional delineator to determine wetland boundaries. If it is deemed that there may be an impact to a wetland or to determine the required setbacks, information regarding four critical functions (floral diversity, wildlife habitat, water quality, and aesthetics and recreation) is entered into the Minnesota Routine Assessment Methodology for Evaluating Wetland Functions (MnRAM) program to determine the management class for a wetland. Each particular management class has requirements that must be met in order for a project to proceed. VLAWMO's water management policy discusses its WCA role which is available on the VLAWMO website. As discussed in the main body of the Plan, the policy will be updated in 2016.

Further information regarding wetland delineation and management can be found on the Board of Water and Soil Resources (BWSR) website.

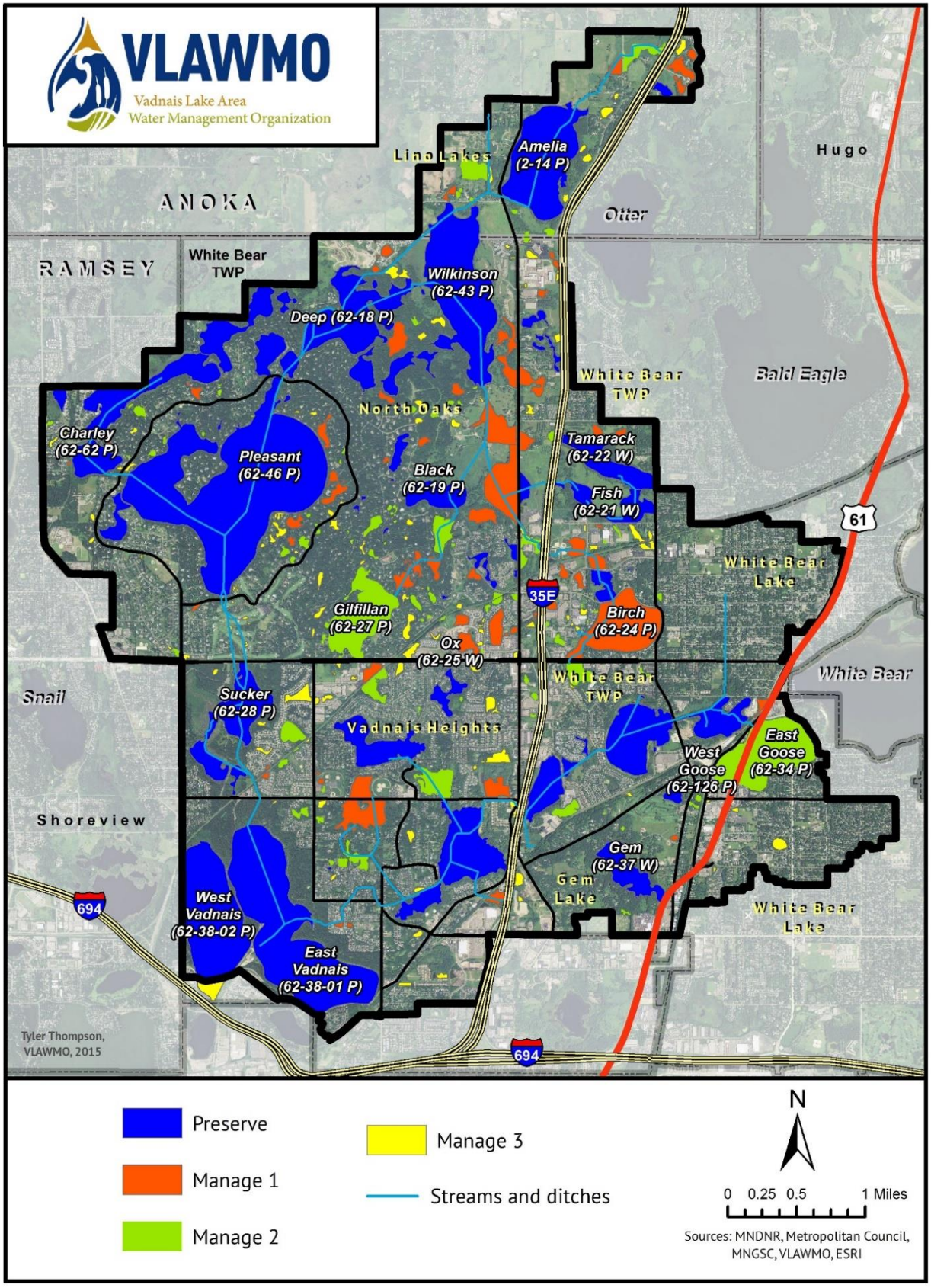
TABLE 9: WETLAND MANAGEMENT CLASSIFICATIONS

Management Class	Description
Preserve	High quality natural basins, quality adjacent uplands, valued for floral diversity, unique habitat, and water quality functions.
Manage 1	Moderate quality basins, some receiving direct storm water, valued for at least one of the valued functions.
Manage 2	Slightly impacted to moderate quality basins, most receiving storm water, and low vegetative diversity to monotype.
Manage 3	Wetlands created for storm water management or highly impacted natural basins

TABLE 10: MANAGEMENT CLASS RESULTS OF VLAWMO INVENTORIED WETLANDS

Management Class	Number	Acres	% of Total Acres
Preserve	50	3102	73%
Manage 1	83	517	12%
Manage 2	94	476	11%
Manage 3	118	174.1	4%
Total	345	4269.1	

FIGURE 9: VLAWMO INVENTORIED WETLANDS



3.4 Drainage Patterns

Approximately half of the watershed is drained by the former Ramsey County ditch system. In 1916, Ramsey County constructed Ditch 13 (RCD 13) and Ditch 14 (RCD 14). In 1927, the Ramsey County Board authorized the construction of a branch ditch system consisting of multiple laterals (No. 1, 1A, 2, 3, 4, 5, 5A, and 5B), connecting to Lambert Creek. Drainage authority for RCD 13 and RCD 14 were transferred to VLAWMO by Ramsey County in 1986. RCD 13 is now part of the White Bear Lake Storm Sewer System (WBLSS). RCD 14 is now known as Lambert Creek and managed as such.

Gem Lake Subwatershed: Gem Lake is surrounded by homes on large lots. A portion of Highway 61, on the east side of the subwatershed drains to Gem Lake. The subwatershed is contained and does not discharge to other subwatersheds.

Lambert Creek-Goose Lake Subwatershed: East and West Goose Lakes receive stormwater runoff primarily from land to the north and south. The lakes are connected by culverts which run underneath Highway 61. The headwaters for Lambert Creek is located at the northern point of West Goose Lake. The creek flows southwest through White Bear Township and Vadnais Heights to East Vadnais Lake. RCD 13 consists of underground storm sewers from a mainly residential part of the City of White Bear Lake and drains into Whitaker Pond and then into Sobota Slough, the first in a series of wetlands along Lambert Creek. Rice Lake and Grass Lake in White Bear Township and Vadnais Heights, respectively, are the next two wetlands in the chain. The final large wetland in the Lambert Creek Basin is Lambert Lake. The final section of Lambert Creek tends to be deep and narrow as it winds through another residential area. It enters East Vadnais Lake about midway on the eastern side. Several branch ditches feed Lambert Creek. Although part of the Lambert Creek Subwatershed, the East and West Goose catchment is generally treated as its own management area when developing water quality projects and programs.

Birch Lake Subwatershed: Birch Lake drains north to the Tamarack/Wilkinson Subwatershed. This subwatershed is within the City of White Bear Lake and White Bear Township. Birch Lake receives stormwater from mostly residential and commercial runoff via storm drains. It also receives runoff from 35E and County Road 96.

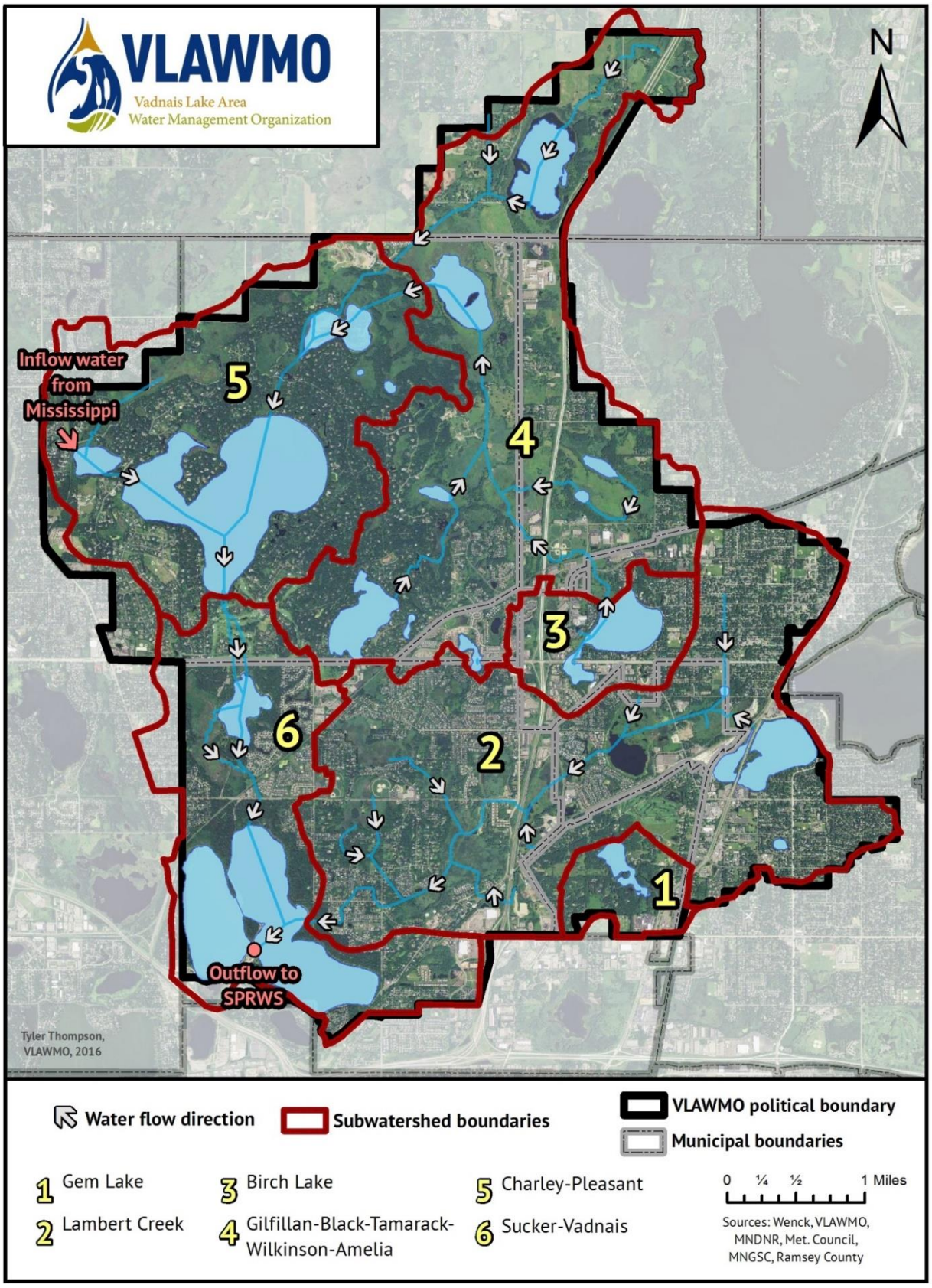
Gilfillan-Tamarack-Black-Wilkinson-Amelia Subwatershed: Drainage from Amelia Lake to the north and Gilfillan Lake to the south eventually discharges to the Pleasant-Charley-Deep Lake Subwatershed, just west of Wilkinson Lake. This large subwatershed includes the far northern part of VLAWMO, including Lake Amelia in Lino Lakes. In 2011, a connection to Gilfillan Lake was constructed at the channel between Pleasant and Sucker Lakes to augment Gilfillan's lake level with Mississippi River water supplied by the SPRWS. The cost associated with the pipe and water use is managed by the City of North Oaks in conjunction with the Gilfillan Lake Association. Augmentation of Gilfillan began in fall 2011 and continued through 2012. As of February 2016, there has not been a need to augment. Gilfillan Lake is just north of County Road 96, at the southern extent of the subwatershed. From Gilfillan, water flows through a system of ponds to the north, eventually to Black Lake. Ditches connect Amelia, Wilkinson, and Black Lake in North Oaks.

Pleasant-Charley-Deep Subwatershed: Pleasant Lake and Charley Lake are part of the SPRWS water supply chain. Approximately 35 million gallons of water per day enters Charley Lake via a pipe from the Mississippi River which then moves to Pleasant Lake. The subwatershed generally drains south, discharging to the Sucker-Vadnais Subwatershed. There are also hydrologic connections (pipelines) owned by the SPRWS that can take water from Otter Lake and Centerville Lake in the Rice Creek Watershed and from the Mississippi River. Diversions from Rice Creek are infrequent and have not been needed for a number of years. Diversions from the Mississippi River are continuous and average approximately 70 percent of the supply to the SPRWS system

Sucker-Vadnais Subwatershed: Water from Pleasant Lake drains to the south into Sucker Lake and then on to East Vadnais Lake. The SPRWS maintains an intake for the City of Saint Paul water supply on East Vadnais Lake. West Vadnais Lake does not receive water from East Vadnais Lake. Runoff from land primarily to the north drains to West Vadnais and it has been known to outlet to the west towards Grass Lake as well as south towards Gervais Lake.

In general, all water diverted or flowing through the watershed to East Vadnais Lake is diverted to the SPRWS system such that there is no discharge from the watershed.

FIGURE 10: SUBWATERSHED BOUNDARIES & DRAINAGE PATTERNS IN VLAWMO



3.5 Stormwater System

Local communities are required to develop Local Water Plans (LWP). LWPs will include information on the storm sewer drainage systems and resulting discharge rates and include a map of the storm water system. The map should include the direction of flow and identify existing storm water ponds, storage, and the location of stormwater outfalls. The LWPs should also analyze peak flow rates and storage volume capacity for each subwatershed. Those plans are available at city offices and at the VLAWMO office for reference.

3.6 Flood Levels and Peak Discharges

There are currently no serious flood prone areas within VLAWMO. Questions regarding flood levels are referred to the municipalities. Further floodplain information can be found in the 2007 Plan.

4. Water Quality Conditions

4.1 Condition Summary

The VLAWMO monitoring program is discussed at length in Chapter 3 of the Plan. VLAWMO began a water quality monitoring program in 1997 which currently includes 11 lakes and multiple stations along Lambert Creek. The SPRWS collects water quality information on Pleasant Lake and East Vadnais Lake. The SPRWS infers the water quality of Sucker Lake based on the conditions of Pleasant Lake (upstream) and East Vadnais Lake (downstream). Monitoring parameters and other information is included in the Core Activities section of the Plan. Ten years of results of the three basic monitoring parameters for the lakes monitored by VLAWMO are summarized in tables within this section of the Appendix. Results identified in red indicate that State Standards are not being met for that particular parameter. Rules are set for the number of samples required to determine an average for each year and the most recent 10 years are assessed to determine an Impairment status. Further information about Impaired Waters is found in Section 4.2 of the Appendix.

Complete water quality information can be found in the annual monitoring reports posted on the VLAWMO website and reported in the State of Minnesota's water quality database. Staff collect water samples along Lambert Creek as well measure flow throughout the sampling season.

Lake grades are assessed annually based standards are established by the Metropolitan Council. The standards give a range to each letter grade for the June-September averages of TP, ChlA, and SDT. The overall lake grade is the average of the grades for each parameter. Other indicators of lake condition, such as aquatic plant growth of invasive species are not factored into the grades. Based on the lake grades, the water quality on VLAWMO's lakes has improved slightly since the previous Water Plan was written, however there are still several lakes that are in need of further restoration.

TABLE 11: VLAWMO LAKE GRADES (2015)

Lake	Grade	TSI Status
Amelia	B	Eutrophic
Birch	B+	Mesotrophic
Black	B+	Mesotrophic
Charlie	C	Eutrophic
Deep	C-	Eutrophic
Gem	B	Mesotrophic
Gilfillan	C+	Eutrophic
E. Goose	D-	Eutrophic - Hypereutrophic
W. Goose	D	Eutrophic
Tamarack	D	Eutrophic - Hypereutrophic
Wilkinson	D	Eutrophic

VLAWMO also monitors lake levels on Birch, West Goose, Gilfillan, and Gem Lakes and the results are submitted to the DNR.

FIGURE 11: MONITORING LOCATIONS IN VLAWMO

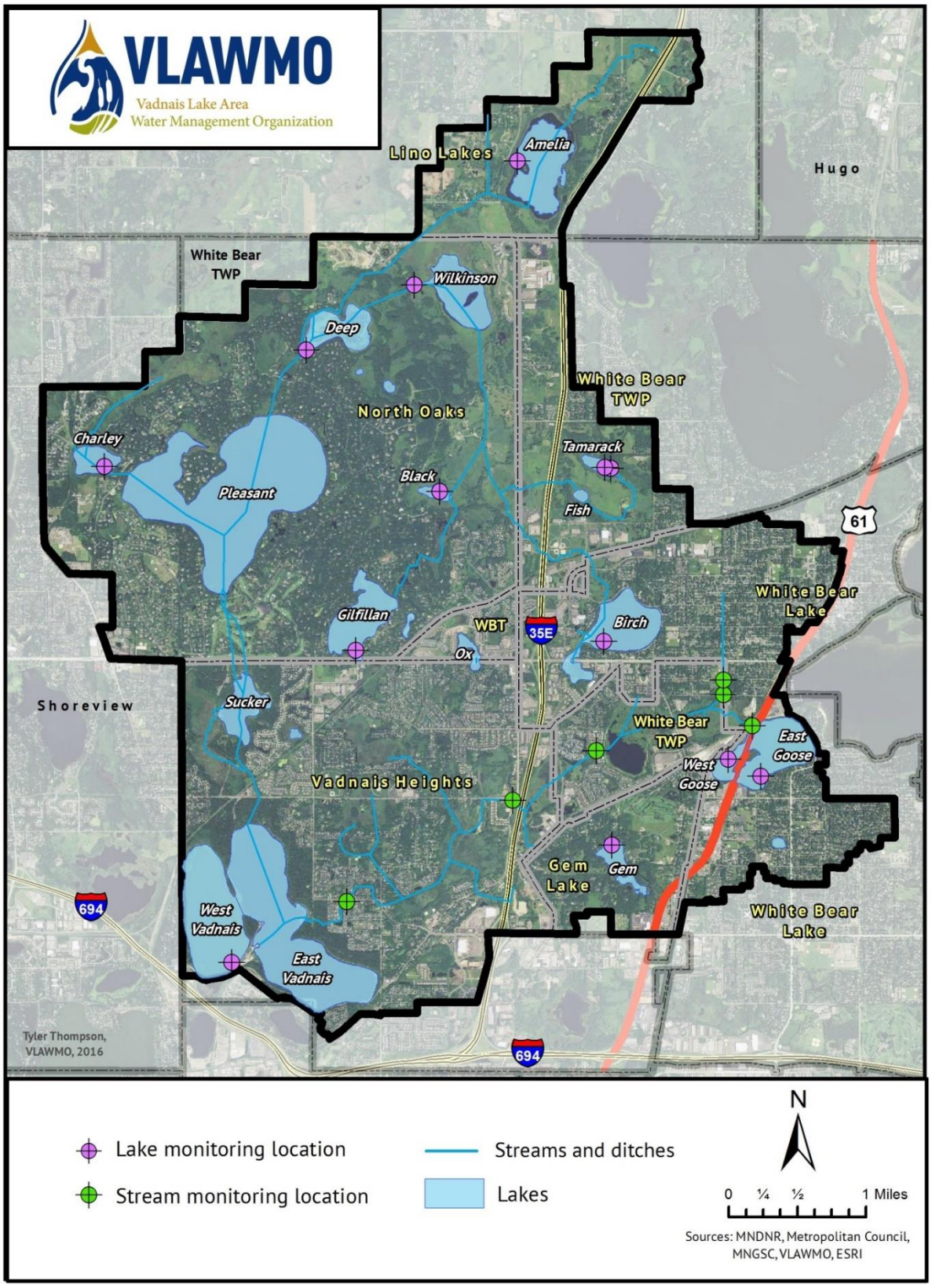


TABLE 12: AVERAGE SECCHI DISC TRANSPARENCY (M) MAY-SEPTEMBER (2006-2015) - LAKES

Year	Amelia Lake	Birch Lake	Black Lake	Charley Lake	Deep Lake	Gem Lake	Gilfillan Lake	East Goose Lake	West Goose Lake	Tamarack Lake	Wilkinson Lake	West Vadnais Lake
2006		2.4										
2007	0.4	2.4				1.1	0.7			0.5	0.9	
2008	1.1	1.2				1.5	0.5	0.3	0.3	0.3	0.3	
2009	0.9	1.1	2	1	1	1.3	0.4	0.3	0.5	0.2	1	0.4
2010	1.1	1	2.1	1	0.9	1.4	0.4	0.3	0.5	0.2	0.8	
2011	1.1	2	2.3	1.1	1.2	2.1	0.4	0.3	0.8	0.6	1	
2012	1.1	2	2.4	1	1	2	0.8	0.2	0.7	0.4	0.9	
2013	1.1	2	2	1	1	2	1	0.5	1	0.5	0.9	0.4
2014	1.3	1.7	2	1.1	1.1	2.9	0.8	0.4	0.5	0.5	0.9	0.5
2015	1.1	1.7	1.6	1.1	1	2.2	0.6	0.6	0.5	0.4	0.5	0.3

Note: Red indicates not meeting State Standards

TABLE 13: AVERAGE TOTAL PHOSPHORUS (UG/L) MAY-SEPTEMBER (2006-2015) – LAKES

Year	Amelia Lake	Birch Lake	Black Lake	Charley Lake	Deep Lake	Gem Lake	Gilfillan Lake	East Goose Lake	West Goose Lake	Tamarack Lake	Wilkinson Lake	West Vadnais Lake
2006	36	32				63	91	392	213	136	96	
2007	82	41				48	100	260	159	148	104	
2008	26	34				64	96	218	168	115	64	
2009	55	40	23	39	112	89	152	237	134	161	125	185
2010	32	31	34	90	55	53	192	207	129	157	140	
2011	38	29	44	87	95	32	123	164	126	120	80	
2012	39	30	31	74	87	41	70	277	200	129	103	
2013	39	30	32	57	121	35	38	265	104	119	159	79
2014	48	26	21	59	136	31	38	207	172	141	100	70
2015	28	21	18	57	89	38	55	231	149	183	209	88

Note: Red indicates not meeting State Standards

TABLE 14: AVERAGE TOTAL CHLOROPHYLL A (UG/L) MAY-SEPTEMBER (2006-2015) – LAKES

Year	Amelia Lake	Birch Lake	Black Lake	Charley Lake	Deep Lake	Gem Lake	Gilfillan Lake	East Goose Lake	West Goose Lake	Tamarack Lake	Wilkinson Lake	West Vadnais Lake
2006	12	3				25	19	81	58	38	10	
2007	32	5				33	33	97	66	109	18	
2008	5	5				17	31	86	55	99	8	
2009	24	8	5.9	18	21	28	44	121	40	161	17	103
2010	12	5	6.6	18.9	15	24	44	67	39	96	31	
2011	8	3	6.9	9.3	12	6.4	25	48	27	28	14	
2012	9	3	6	13	12	11	17	96	51	64	42	
2013	19	3	6	11	21	17	15	112	32	50	27	59
2014	7.5	3	8	10	13	8	20	67	68	72	21	56
2015	21	1	14	14	23	23	36	115	97	119	147	108

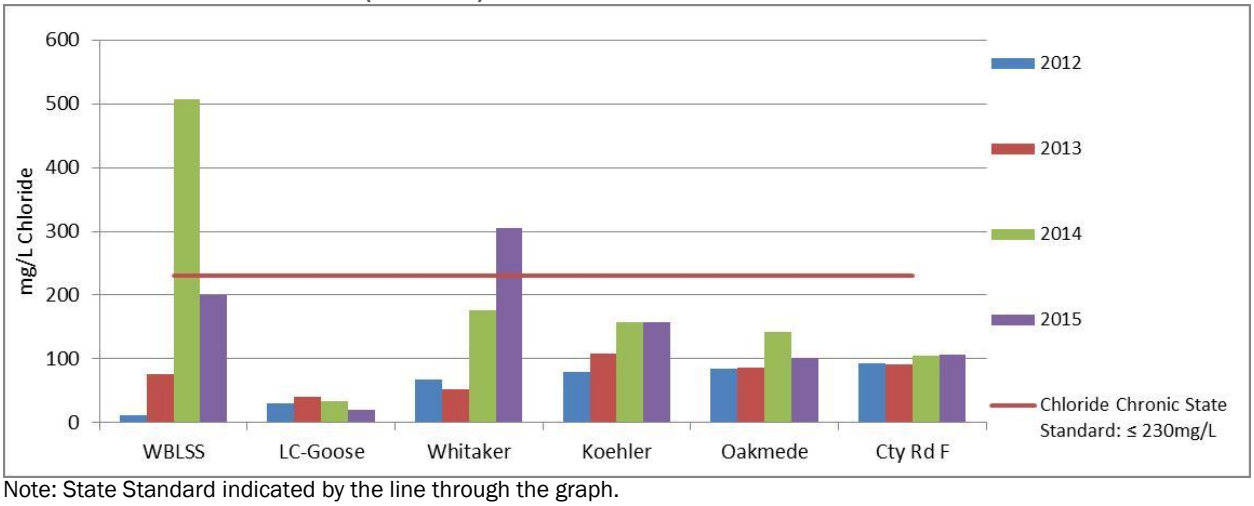
Note: Red indicates not meeting State Standards

TABLE 15: HISTORICAL TP (UG/L) AND TSS (MG/L) ON LAMBERT CREEK

Monitoring Station	Goose		WBLSS		Whitaker		Oakmede		Cty Rd F		Koehler	
Year	TP	TSS	TP	TSS	TP	TSS	TP	TSS	TP	TSS	TP	TSS
2009	230	22	110	5.9	240	11	210	6	190	11	120	9
2010	130	16	180	15.8	229	19.7	222	4	403	10	194	10
2011	138	12	181	7.3	157	12.7	224	5	299	6	229	8
2012	246	40	104	8.3	398	11.5	283	8	395	8	207	4
2013	102	7	106	10	226	9	390	13	707	14	231	6
2014	199	51	119	9.5	173	1.4	285	1	393	1	301	5
2015	181	37	101	10	416	3.1	178	0	339	0	244	2

Note: Red indicates not meeting State Standards

FIGURE 12: LAMBERT CREEK CHLORIDE LEVELS (2012-2015)



Note: State Standard indicated by the line through the graph.

4.2 Impaired Waters

The Federal Clean Water Act requires States to adopt water quality standards to protect our waters. These standards define how much of a pollutant can be in surface water and/or groundwater while still allowing it to meet its designated uses, such as drinking water, fishing, swimming, irrigation, or industrial purposes. The Clean Water Act requires States to publish an updated list of streams and lakes that are not meeting their designated uses because of excess pollutants. The list, known as the 303(d) list or the Impaired Waters list, is based on those water quality standards.

TABLE 16: MPCA WATER QUALITY STANDARDS FOR SHALLOW LAKES IN THE NORTH CENTRAL HARDWOOD FOREST ECOREGION

MPCA Standards Lakes – Shallow Lakes			
TP (µg/L)	Chl A (mg/L)	SDT (m)	Chloride - chronic (mg/L)
< 60	< 20	> 1	< 230

MPCA Standards Lakes – Deep Lakes			
TP (µg/L)	Chl A (mg/L)	SDT (m)	Chloride - chronic (mg/L)
≤40	≤14	≥1.4	< 230

MPCA Standards – Rivers and Streams						
Fecal Coliform daily maximum (cfu/100 ml)	Chloride - chronic (mg/L)	TP (µg/L)	Chl A (mg/L)	DO flux (mg/L)	BOD_5 (mg/L)	TSS (mg/L)
< 1260	< 230	≤100	≤18	≤3.5	≤2	≤30

Waters that are Impaired undergo a Total Maximum Daily Load (TMDL) process which involves the following phases:

1. Assessment & listing.
2. TMDL study to determine the sources of pollution or stressor, a determination of the maximum amount allowed, and an allocation of that maximum amount to various sources.
3. Implemetnation plan developoment that sets forth strategies for reducing pollutant loading or alleviating the stressor.
4. Monitoring the effectiveness of the implementation efforts.

As of 2014, ten lakes in VLAWMO are on the Impaired Waters List as well as Lambert Creek. The TMDL process has been completed for Gem, Gilfillan, Goose East, Goose West, and Wilkinson were listed as Impaired for Aquatic Recreational Use due to above standard levels of TP. Lambert Creek is impaired due to levels of bacteria which is evaluated by the use of *E. coli* measurements. The SPRWS is addressing the nutrient impairment on Pleasant Lake. The TMDL Study and Implementation Plan are available on the VLAWMO website and is used to guide efforts towards improving these waterbodies. More information about the water quality standards and protections are found in Minnesota Rules Chapter 7050, Waters of the State.

TABLE 17: IMPAIRED WATERS OF VLAWMO

Waterbody	Impairment
Gem	Nutrients
Gilfillan	Nutrients
Goose-East	Nutrients
Goose-West	Nutrients
Pleasant	Nutrients & Mercury
Sucker	Mercury
Tamarack	Nutrients
Vadnais-East	Mercury
Vadnais-West	Nutrients
Wilkinson	Nutrients
Lambert Creek	Pathogens *(E.coli)*

Municipal Separate Storm Sewer System (MS4) partners are assessed a Waste Load Allocation (WLA) that applies to any watershed loads to the particular waterbody (as opposed to internal loading). For the lakes with a completed TMDL, the assigned categorical WLAs are as follows:

TABLE 18: ANNUAL WLAS ASSIGNED TO MS4S FOR VLAWMO WATERBODIES WITH COMPLETED TMDL STUDY

			MS4s								
Lake	WLA (lbs/yr)	M-Foods Dairy	Anoka County	Gem Lake City	Lino Lakes City	MN DOT	North Oaks City	Ramsey County	Vadnais Heights City	White Bear Lake City	White Bear Township
Gem	47.0	-	-	23.9	-	5.2	-	9.0	-	8.9	-
Goose – East	78.7	-	-	2.2	-	7.9	-	3.9	-	64.7	-
Goose – West	40.0	24.7	-	2.8	-	3.6	-	1.6	-	7.3	-
Gilfillan	17.0	-	-	-	-	-	14.7	0.5	0.1	-	1.7
Wilkinson	179.4	-	0.1	-	1.2	47.2	26.4	1.8	-	35.1	67.6

TABLE 19: ASSIGNED BACTERIAL WLAS FOR LAMBERT CREEK

	MS4 Wasteload Allocation (Billions of org) (Daily)						
Critical Condition	City of Gem Lake	MN DOT	Ramsey County	City of Vadnais Heights	City of White Bear Lake	White Bear Township	Total Waste Load
High Flow	0.68	1.17	0.56	8.78	3.74	0.45	15.38
Wet	0.21	0.36	0.17	2.73	1.16	0.15	4.78
Mid-Range	0.10	0.17	0.08	1.28	0.55	0.07	2.25
Dry	0.04	0.06	0.03	0.45	0.19	0.02	0.79
Low Flow	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FIGURE 13: MAP OF IMPAIRED WATERS IN VLAWMO

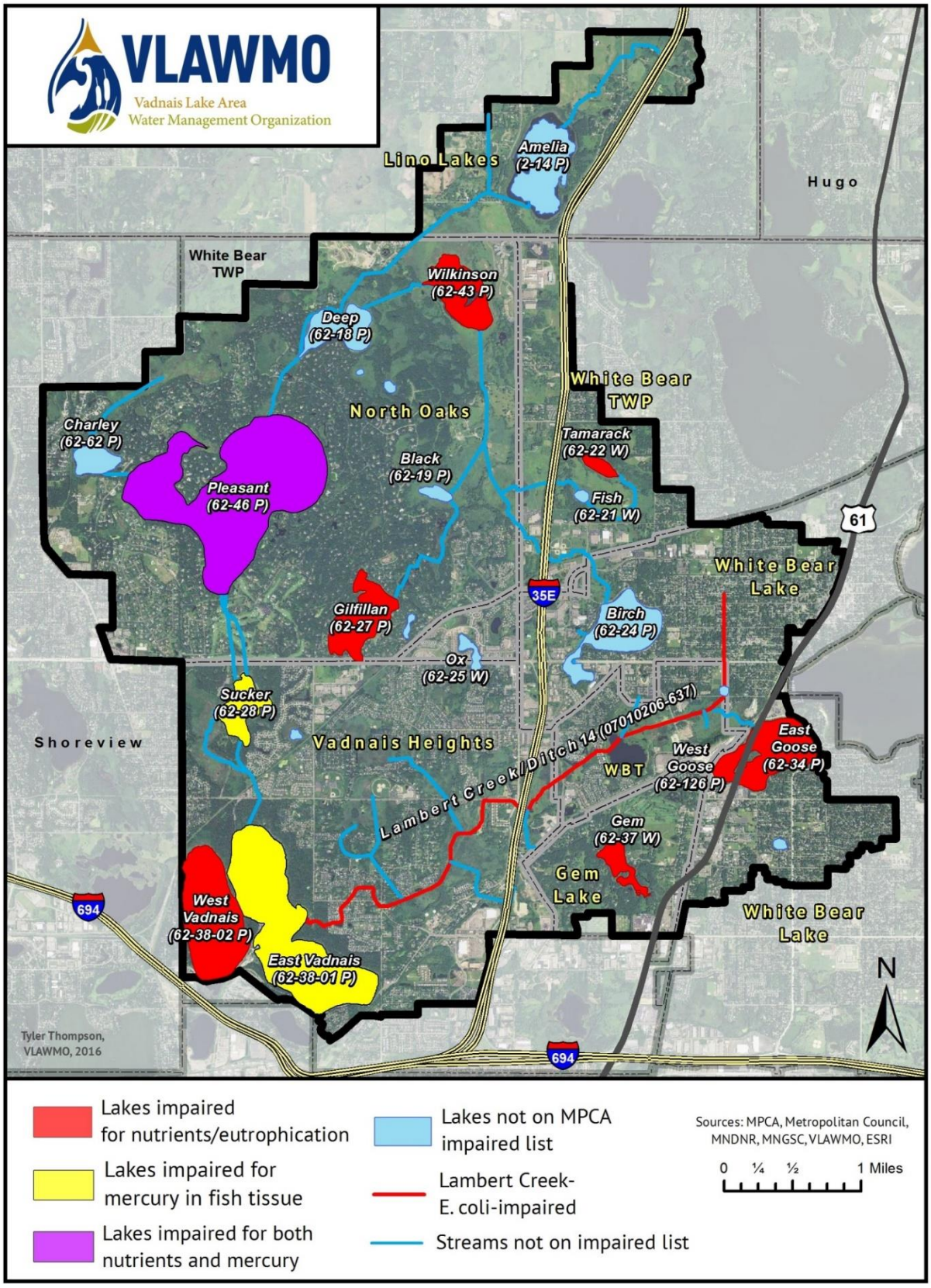


FIGURE 14: GEM LAKE NUTRIENT LOADS BY SOURCE

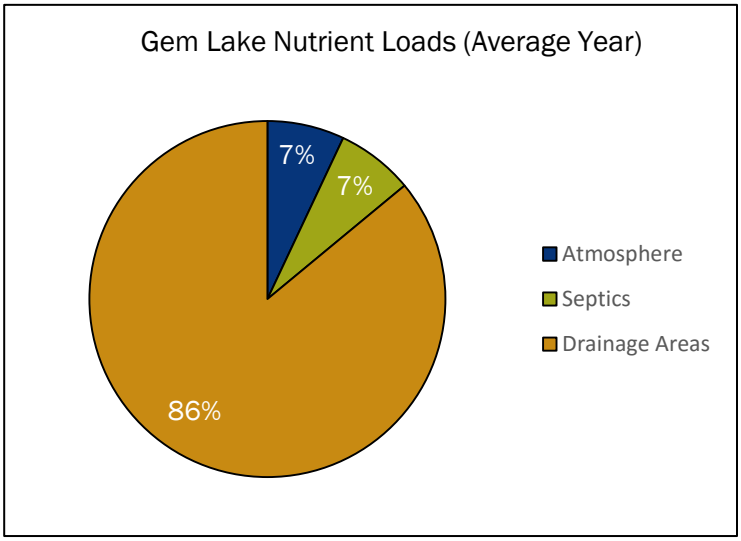


FIGURE 15: GILFILLAN LAKE NUTRIENT LOADS BY SOURCE

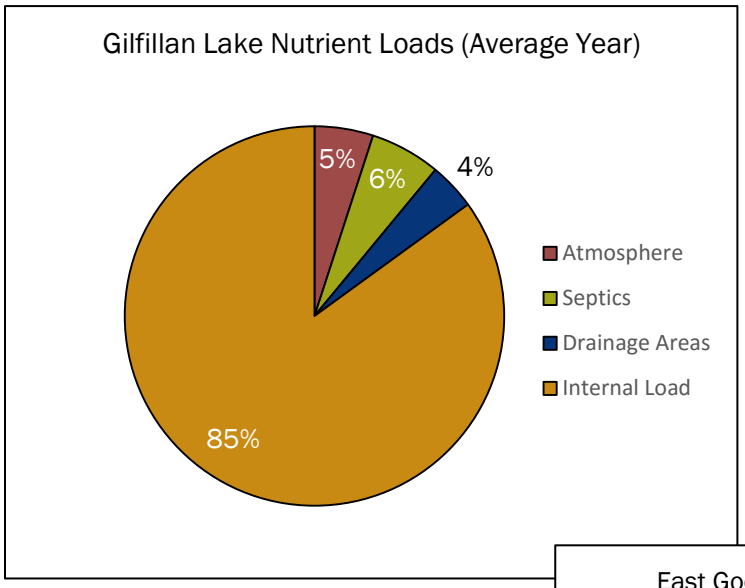


FIGURE 16: EAST GOOSE LAKE NUTRIENT LOADS BY SOURCE

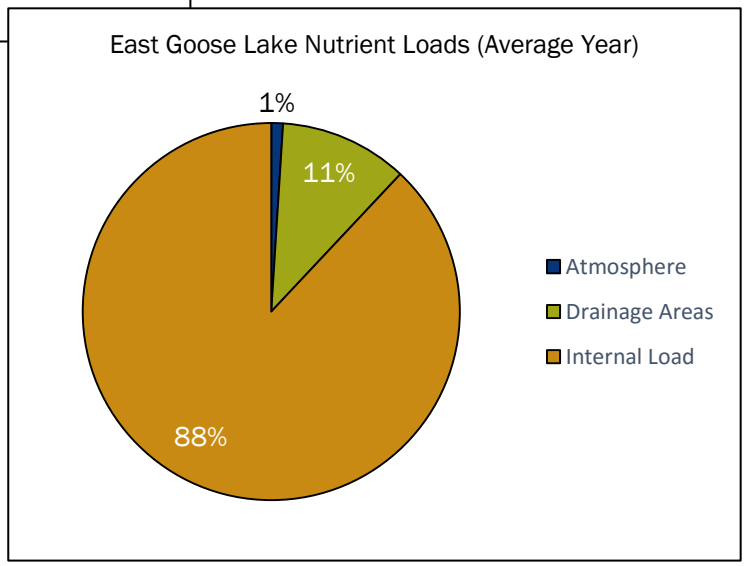


FIGURE 17: WEST GOOSE LAKE NUTRIENT LOADS BY SOURCE

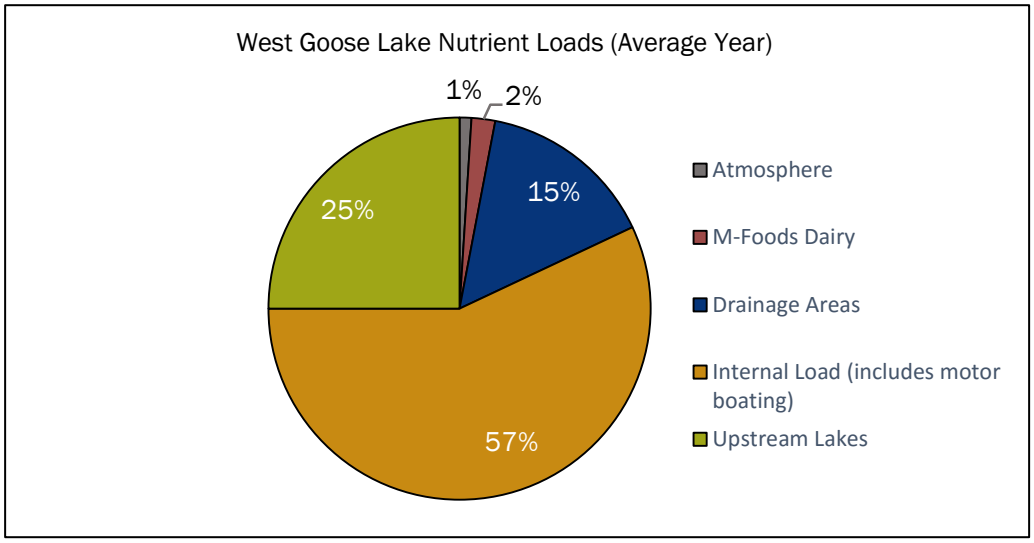
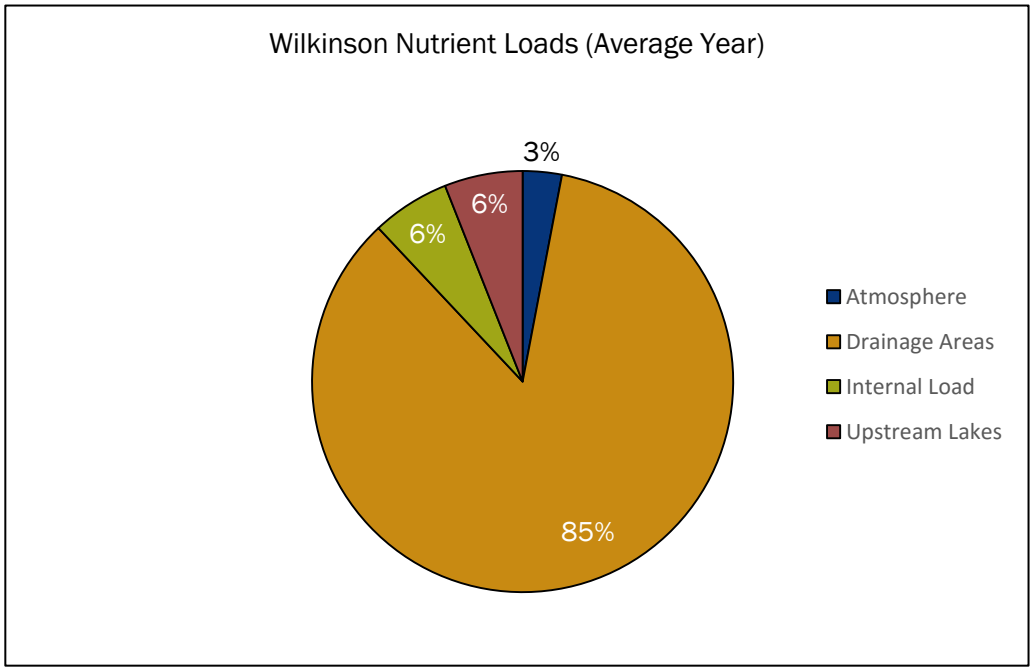


FIGURE 18: WILKINSON LAKE NUTRIENT LOADS BY SOURCE



4.3 Exotic Species

Eurasian water milfoil (*Myriophyllum spicatum L.*), Curlyleaf Pondweed (*Potamogeton crispus*), Common Carp (*Cyprinus carpio)*, and Zebra Mussels (*Dreissena polymorpha*) are exotic species present in VLAWMO.

TABLE 20: EXOTIC SPECIES PRESENCE ON VLAWMO LAKES

Exotic Species	Confirmed Presence
Eurasian water milfoil	Birch, Charley, Deep, Pleasant, Sucker, East Vadnais, West Vadnais
Curlyleaf Pondweed	East Goose, West Goose, Pleasant
Common Carp	Charley, Deep, Pleasant, Sucker, East Vadnais, Wilkinson
Zebra Mussels	Charley, Deep, Pleasant, Sucker, East Vadnais, West Vadnais

Eurasian water milfoil is an herbaceous perennial plant with a trailing growth habit. Eurasian water milfoil is a highly aggressive aquatic plant that can form dense mats which congest waterways and crowd out native aquatic plants. This growth can impair recreational uses of waterways including boating, swimming, and fishing. Dense growth of Eurasian water milfoil can alter and degrade the habitat of native fish and other wildlife.

Curlyleaf Pondweed is an exotic plant that forms surface mats that interfere with aquatic recreation. It usually grows early in the spring and dies back in the summer. The plant usually drops to the lake bottom by early July, which is usually the time of surveys. Curlyleaf Pondweed was the most severe nuisance aquatic plant in the Midwest until Eurasian water milfoil appeared.

Common Carp are domesticated ancestors of a wild form native to the Caspian Sea region and Asia. Common Carp degrade shallow lakes by causing excessive turbidity, which can lead to declines in waterfowl and important native fish species. Common Carp was introduced by unintentional release in 1879.

Zebra mussels are small, fingernail-sized animals that attach to solid surfaces in water. Female zebra mussels can produce 100,000 to 500,000 eggs per year. Zebra mussels are native to Eastern Europe and Western Russia and were brought over to the Great Lakes in the ballast water of ships. The zebra mussels present in VLAWMO waters is believed to have entered via the Mississippi River water pumped into the SPRWS Chain of Lakes. Zebra mussels can attach to boat motors and boat hulls as well as to rocks, swim rafts and ladders where swimmers can cut their feet on the mussel shells, and can clog irrigation intakes and other pipes. Zebra mussels also can impact the environment of lakes and rivers where they live. They eat tiny food particles that they filter out of the water, which can reduce available food for larval fish and other animals, and cause aquatic vegetation to grow as a result of increased water clarity. Zebra mussels can also attach to and smother native mussels. VLAWMO places zebra mussel traps in 4 lakes (Goose Lake, Birch Lake, Gilfillan Lake, Wilkinson Lake), as well as 1 location on Lambert Creek (just below the Koehler flume) to check if they have spread to other parts of the watershed.