VLAWMO
Vadnais Lake Area
Water Management Organization

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2018 Water Monitoring Report

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Prepared by
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VLAWMO would like to thank the volunteers for their vital role in the Citizens Lake Monitoring Program. The volunteers for 2018 were: Jim Grisim (Birch Lake), Amy Waters (Lambert Creek) Kurt Carpenter (Goose Lake) and Shannon Stewart (Tamarack Lake)

VLAWMO would also like to acknowledge and thank the following agencies for their assistance with assuring the quality of water within the watershed: St. Paul Regional Water Service, the Citizen's Lake Monitoring Program at the Minnesota Pollution Control Agency, the Lake Level Program at the Minnesota Department of Natural Resources, the Ramsey County Limnology Lab, Pace Analytical, RMB Environmental Labs, and Burns & McDonnell.

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Definitions & Abbreviations

Ammonia (NH3) – an inorganic form of nitrogen that is contained in fertilizers, septic system effluent, and animal wastes. It is also a product of bacterial decomposition of organic matter. NH3 becomes a concern if high levels of the un-ionized form are present. In this form NH3 can be toxic to aquatic organisms. The presence of un-ionized ammonia is a function of the NH3 concentration, pH, and temperature. Conversion of NH3 to NO2 by nitrification requires large quantities of oxygen which can kill aquatic organisms due to the lowered dissolved oxygen concentrations in water.

Aquatic Invasive Species (AIS) – non-native species such as zebra mussels and Eurasian watermilfoil

Birch Lake Improvement District (BLID) – Homeowner/lakeshore owners on Birch Lake in White Bear Lake MN

Chlorophyll-a (Chl A) - Chl A is a green pigment in algae. Measuring Chl A concentration gives an indication of how abundant algae are in a waterbody.

Colony Forming Units (CFU) – unit used in measuring the level of E. coli in a water sample.

Conductivity (mS/cm) - Conductivity is a good measure of salinity in water. The measurement detects chloride ions from the salt. Salinity affects the potential dissolved oxygen levels in the water. The greater the salinity, the lower the saturation point. Measurement in millisiemens per cm. 1 mS/cm = 1000 uS/cm.

Dissolved Oxygen (DO) - The concentration of molecular oxygen (O2) dissolved in water. The DO level represents one of the most important measurements of water quality and is a critical indicator of a water body's ability to support healthy ecosystems. Levels above 5 mg/L are considered optimal, and most fish cannot survive for prolonged periods at levels below 3 mg/L. Microbial communities in water use oxygen to breakdown organic materials, such as animal waste products and decomposing algae and other vegetation. Low levels of dissolved oxygen can be a sign that too much organic material is in a water body.

Ecoli – Criteria for E. coli set forth in Minn.R. 7050.0222 creek must not exceed 126 organisms per 100 ml as a geometric mean of not less than 5 samples in any calendar month, nor shall more than ten percent of all samples taken during any calendar month individually exceed 1,260 organisms per 100 ml

EQuIS - a repository for water quality, biological, and physical data and is used by state environmental agencies, EPA and other federal agencies, universities, private citizens, and many others. The MPCA uses the information entered into the database to determine the quality of the state's water bodies. If water quality standards are not met, the water body will designated as impaired and will need to have a TMDL study conducted.

Eutrophic – a water body that is high in nutrients and low oxygen content. A eutrophic lake is usually shallow, green, with limited oxygen in the bottom layer of water.

Eutrophication – The aging process by which lakes are fertilized with nutrients. Natural eutrophication will gradually change the character of a lake. Human activities can accelerate the process.

Hypereutrophic – A very nutrient-rich lake with murky water, frequent algal blooms and fish kills, foul odor, and rough fish

Definitions & Abbreviations

Impaired Waters – The Clean Water Act requires states to publish, every two years, a list of streams and lakes that are not meeting their designated uses because of excess pollutants. The list, known as the 303(d) list, is based on violations of water quality standards.

Mesotrophic – the classification between eutrophic and oligotrophic lakes. These lakes have moderately clear water, late-summer algal blooms, moderate macrophyte populations, and occasional fish kills.

Molecular Sourcing – the use of specific DNA markers to determine presence of a specific host origin of E.coli in a water sample (example, Human or Avian)

Most Probable Number (MPN) - unit used in measuring the level of E. coli in a water sample, similar to (CFU)

Nitrate (NO3) – High NO3 levels are often caused by over application of fertilizers that leach into waterbodies. Nitrate loading from water bodies in Minnesota has national implications as it is the primary chemical contributing to the hypoxia (low oxygen) zone at the mouth of the Mississippi River in the Gulf of Mexico. The Environmental Protection Agency (EPA) has a standard for nitrates in drinking water of 10ppb, infants and children are especially at risk.

Nitrite (NO2) – The second stage of the nitrogen cycle. Nitrite is poisonous to fish. Levels over 75 ug/L can cause stress in fish and greater than 500 ug/L can be toxic

Nitrogen (N) – Nitrogen is second only to phosphorus as an important nutrient for plant and algae growth. The amount of nitrogen in a water body strongly correlates to land use. Nitrogen comes from fertilizers, animal waste, sewage treatment plants and septic systems through surface runoff or groundwater sources. Nitrogen does not occur naturally in soil minerals but is a major component of all organic matter.

Nitrogen Cycle - the process of nitrogen breakdown in water. The first stage is the production of NH3. The second stage is the oxidation of NH3 into NO2 which is very poisonous to fish. The final stage is conversion of NO3 which aquatic plants use. Once the plants have used their share of NO3, bacteria change it back into a gaseous form and release it back to the atmosphere. The Nitrogen Cycle is dependent on oxygen. If a water body has low DO, organic decay of nitrogen is slower and the water will have increased interim levels of toxic products (NH3 and NO2). The cycle also moves quicker in warmer water.

Oligotrophic – a water body that is generally clear, deep, and free of weeds or large algae blooms.

Particulate Phosphorus – a form of phosphorus that is attached to sediment particles and in plant and animal fragments suspended in the water and may not be immediately available to support algae growth. Some of this phosphorus is readily available but the amount can vary.

Phosphorus (P) - Phosphorus is the primary cause of excessive plant and algae growth in lake systems. Phosphorus originates from a variety of sources, many of which are human related. Major sources include human and animal wastes, soil erosion, detergents, septic systems and runoff from farmland, yards, and streets.

Definitions & Abbreviations

Secchi Disk – a round, white, metal disk that is used to determine water clarity. It is lowered into the water until it is not visible. The depth is recorded, and then the disk is raised until it is visible. The mean value of the two readings gives the clarity.

Secchi Disk Transparency (SDT) - the term used in describing the results of a secchi reading expressed in feet or meters.

Soluble Reactive Phosphorus (SRP) – a form of phosphorus that dissolves in water and is readily available (bio-available) to algae and has an immediate effect on algae growth and DO depletion. Its concentration varies widely over short periods of time as plants take it up and release it.

St. Paul Regional Water Service (SPRWS) – Agency which assists VLAWMO with water quality testing and controls the Vadnais chain of lakes, which supplies drinking water to the city of St. Paul.

Surface Water Assessment Grant (SWAG) - Grant awarded by the PCA to help fund surface water monitoring

Total Kjehldahl Nitrogen (TKN) – The sum of NO2, NO3, and NH3 in a water body. High measurements of TKN typically results from sewage and manure discharges to water bodies.

Total Maximum Daily Load (TMDL) – Calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards and an allocation of that amount to the pollutant's source.

Total Nitrate and Nitrite Nitrogen - Nitrate (NO3) plus nitrite (NO2) as nitrogen. In lakes, most nitrate/ nitrogen is in NO3 form.

Total Phosphorus (TP) – A nutrient essential to the growth of organisms, and is commonly the limiting factor in the primary productivity of surface water bodies. Total phosphorus includes the amount of phosphorus in solution (reactive) and in particle form. Agricultural drainage, wastewater, and certain industrial discharges are typical sources of phosphorus, and can contribute to the eutrophication of surface water bodies.

Total Suspended Solids (TSS) – Very small particles remaining dispersed in a liquid due to turbulent mixing that can create turbid or cloudy conditions. A measure of the material suspended in water in mg/l. Total suspended solids (TSS) cause: a) interference with light penetration, b) buildup of sediment and c) potential reduction in aquatic habitat. Solids also carry nutrients that cause algal blooms and other toxic pollutants that are harmful to fish. Clay, silt, and sand from soils, phytoplankton (suspended algae), bits of decaying vegetation, industrial wastes, and sewage are common suspended solids.

Trophic Status Indicator (TSI) – TSI is an indicator of water quality. Lakes can be divided into three categories based on trophic state – oligotrophic, mesotrophic and eutrophic. A natural aging process occurs in lakes which cause them to change from oligotrophic to eutrophic over time and eventually fill in. Humans can accelerate this process by allowing nutrients from agriculture, lawn fertilizers, streets, septic systems, and urban storm drains to enter lakes. Trophic status is determined through TP, Chl A, and SDT measurements.

Definitions & Abbreviations

Turbidity – a water quality parameter that refers to how clear the water is. It is an indicator of the concentration of suspended solids in the water. Excessive sedimentation in streams and rivers is considered to be the major source of surface water pollution in the United States. Polluted waters are commonly turbid. Turbidity is expressed in NTU (Nephelometric Turbidity Units).

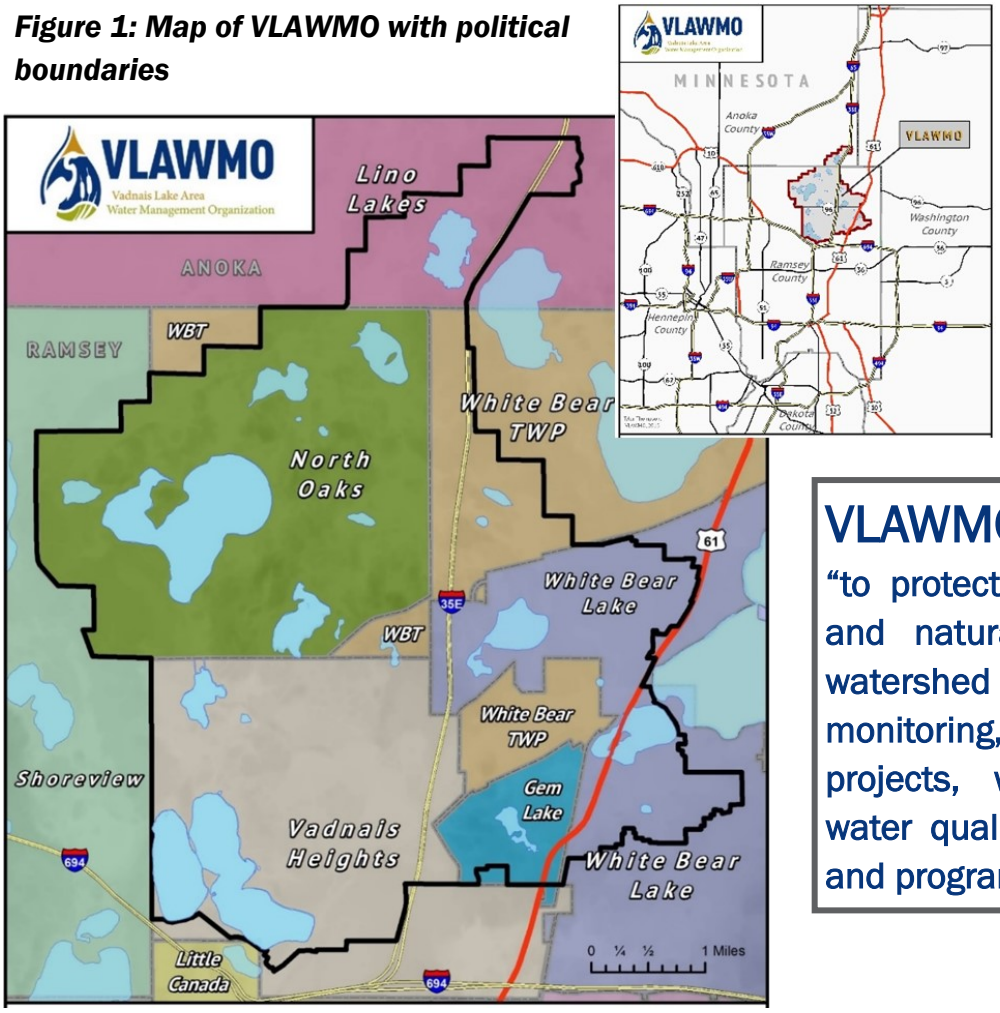
Volatile Suspended Solids (VSS) – a measure of the organic matter in suspended particles. When measured in conjunction with TSS, the proportions of organic versus mineral content of the particles can be determined.

INTRODUCTION

The Vadnais Lake Area Water Management Organization (VLAWMO) covers approximately 25 square miles in the northeast metropolitan area. The watershed encompasses the City of North Oaks and portions of the Cities of White Bear Lake, Gem Lake, Vadnais Heights, Lino Lakes, and White Bear Township. The watershed is 96% urbanized; agricultural land exists in the northern end of the boundaries. New land development is occurring near Wilkinson Lake. Data collected through this program tracks changes in water quality in conjunction with the change in land use around these water bodies.

VLAWMO works in conjunction with the St. Paul Regional Water Service (SPRWS) on water quality monitoring. The SPRWS monitors the direct surface water flow into Vadnais Lake to assure high quality drinking water for over 400,000 consumers. The SPRWS monitors the main chain of lakes (Charley Lake, Pleasant Lake, Sucker Lake and Vadnais Lake) and while VLAWMO monitors Lambert Creek which flows directly into Vadnais Lake.

Figure 1: Map of VLAWMO with political boundaries



VLAWMO's mission is

"to protect and enhance the water and natural resources within the watershed through water quality monitoring, education and outreach projects, wetland protection, and water quality enhancement projects and programs."

INTRODUCTION

VLAWMO began the Citizens Lake Monitoring Program (CLMP) in 1997 to monitor several lakes and ponds within the watershed that were identified as having local significance. CLMP volunteers have helped collect samples from 12 water bodies: Amelia Lake, Birch Lake, Black Lake, Charlie Lake, Deep Lake, Gem Lake, Gilfillan Lake, Goose Lake East, Goose Lake West, Tamarack Lake, West Vadnais Lake and Wilkinson Lake. These lakes are all shallow with average depths no greater than 9 feet. Six areas along Lambert Creek are also sampled as part of the Organization's mission to protect and improve the water-related environment. The data received from the monitoring is used by VLAWMO and the Minnesota Pollution Control Agency (MPCA) to determine the health of the state's waters.

Figure 2: Map of VLAWMO Water Resources

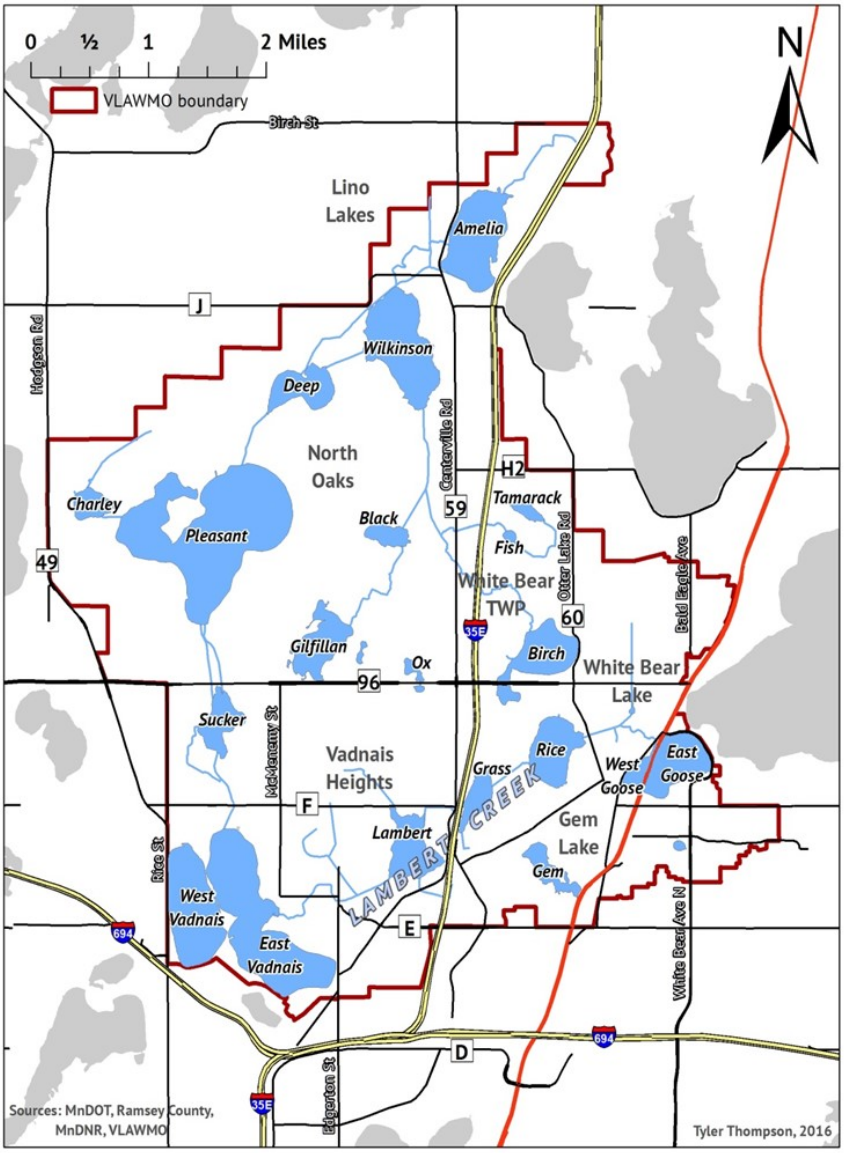
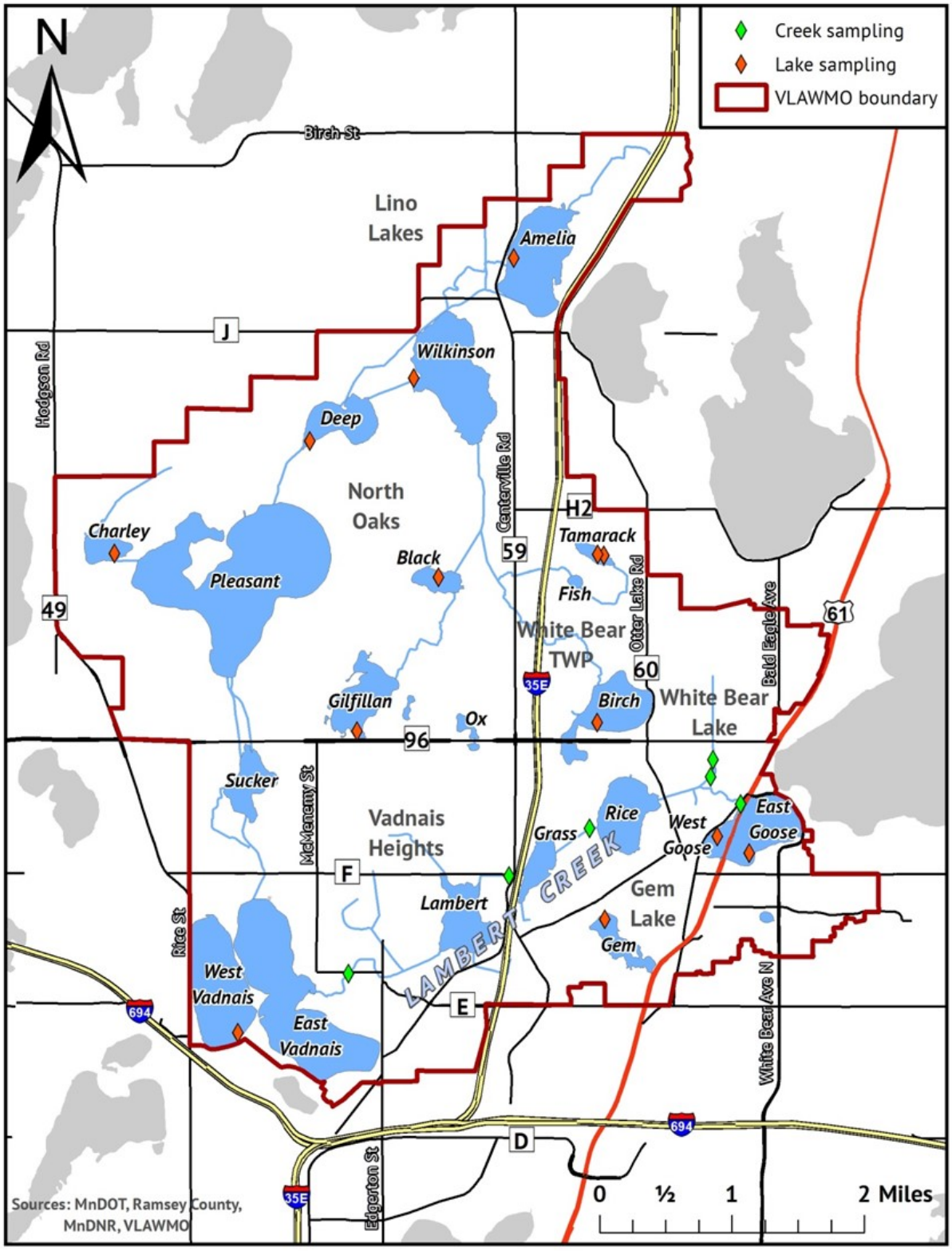


Figure 3: Monitoring Sites in VLAWMO



Impaired Water Designations

The watershed has had several water bodies listed on the MPCA 303(d) list for Impaired Waters. The SPRWS Chain of Lakes (Pleasant, Sucker and Vadnais Lakes) have all been listed for nutrient pollution, specifically mercury. These lakes have been infested with zebra mussels, an aquatic invasive species, though this is not a condition of the Impaired Waters listing. This chain of lakes is fed by the Mississippi River through a pump in Fridley, MN. Lambert Creek (including Goose Lake and Whitaker Pond) has been added to the impaired list for bacteria, specifically fecal coliform or E. coli. Gem Lake, Gilfillan Lake, Goose Lake and Wilkinson Lake, impaired for nutrients, have also been added to the study due to the PCA's new "watershed wide' approach for TMDL's to make them more efficient. These water bodies are now scheduled for a TMDL study to determine the extent of pollution and if possible, where the pollutant is coming from. VLAWMO will initiate the study for Lambert Creek, Gilfillan, Wilkinson, Goose and Gem; while SPRWS will manage the study for Pleasant, Sucker, and Vadnais. Study began fall of 2010, still in review stage.

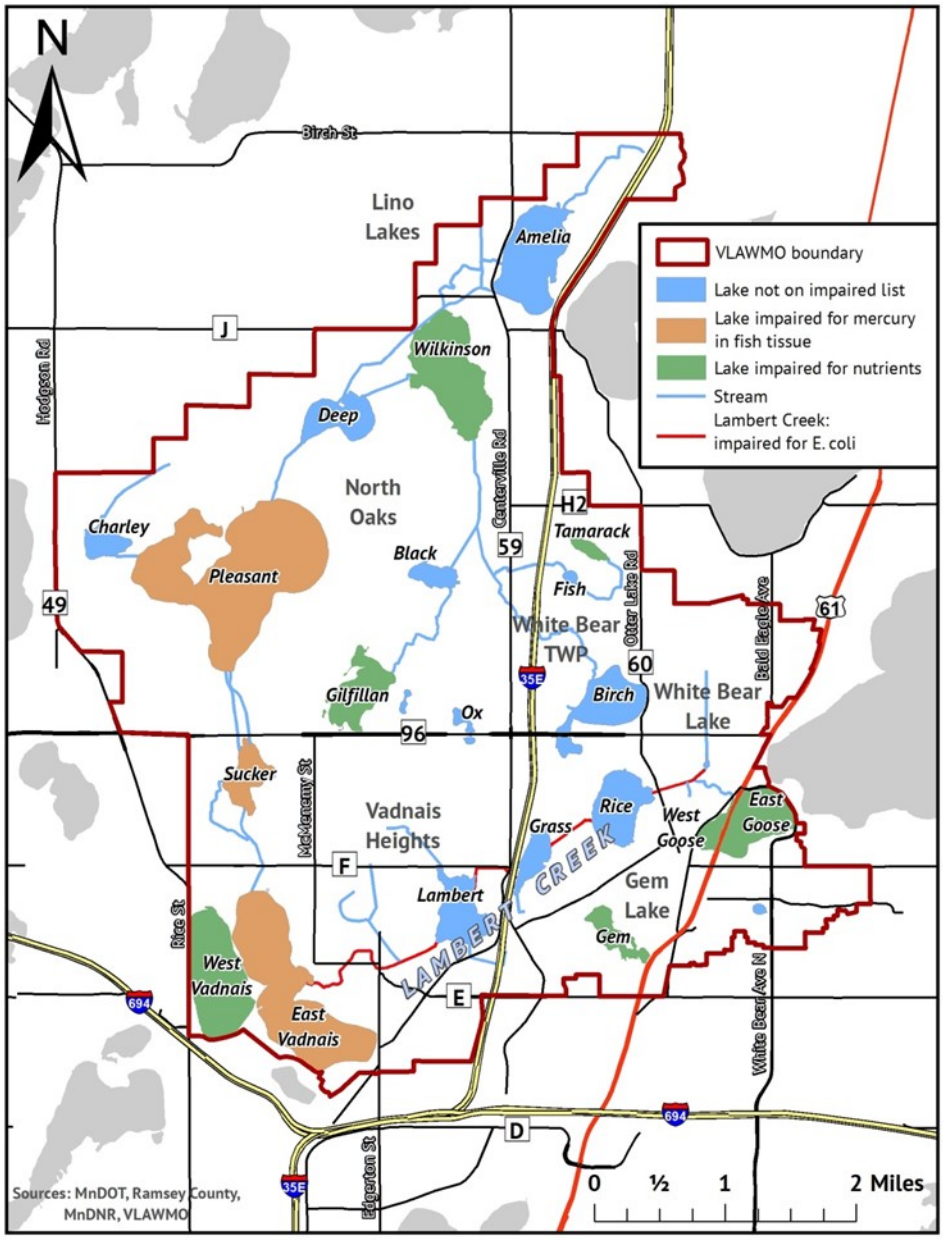


Figure 4: Waterbodies listed on the MPCA 303(d) Impaired Waters List

Typical Measurements for Lakes and Streams

VLAWMO's watershed falls within the North Central Hardwood Forest (CHF) ecoregion. This ecoregion is an area of transition between the forested areas to the north and east and the agricultural areas to the south and west. The terrain varies from rolling hills to smaller plains. Non-urbanized upland areas are forested by hardwoods and conifers. Plains include livestock pastures, hay fields and row crops such as potatoes, beans, peas and corn.

The ecoregion contains many lakes, and water clarity and nutrient levels are moderate. Land surrounding many of these lakes has been developed for housing and recreation, and the densely populated metropolitan area dominates the eastern portion of this region. Water quality problems that face many of the water bodies in the area are associated with contaminated runoff from paved surfaces and lawns.

Below are typical measurements one might find for lakes and streams in the CHF ecoregion:

Typical Lake Measurements in CHF Ecoregion

Field pH	TSS (mg/L)	NO_X (µg/L)	TP (µg/L)	Turb (NTU)	SDT (m)	Chl-a (µg/L)	TKN (µg /L)
8.6 – 8.8	2 – 6	<100	23 – 50	1 – 2	1.5 – 3.2	5 – 22	600 - 1200
Streams							
Field pH	TSS (mg/L)	NO_X (µg/L)	TP (µg/L)	Turb (NTU)	Fecal Coliform (cfu/100 ml)	Temp (˚C)	BOD (in mg/L)
7.9 – 8.3	4.8 – 16	4 - 26	6 – 15	3 – 8.5	40 – 360	2 – 21	– 3.2

The MPCA has water quality standards based on a designated use for the water body. VLAWMO's water is classified as "2B". The SPRWS chain of lakes has a stricter designation of "2Bd" due to it being the drinking water source for St. Paul. The quality of Class 2B water must be suitable for aquatic recreation of all kinds as well as to support fish and aquatic plant life. In 2008, the MPCA approved new standards which will separate deep from shallow lakes. All of the lakes VLAWMO monitors are considered shallow and therefore those standards will apply. For those parameters which the MPCA does not have standards, the federal Environmental Protection Agency (EPA) has maximum contaminant level standards. VLAWMO's goal is to have its waterbodies within these standards.

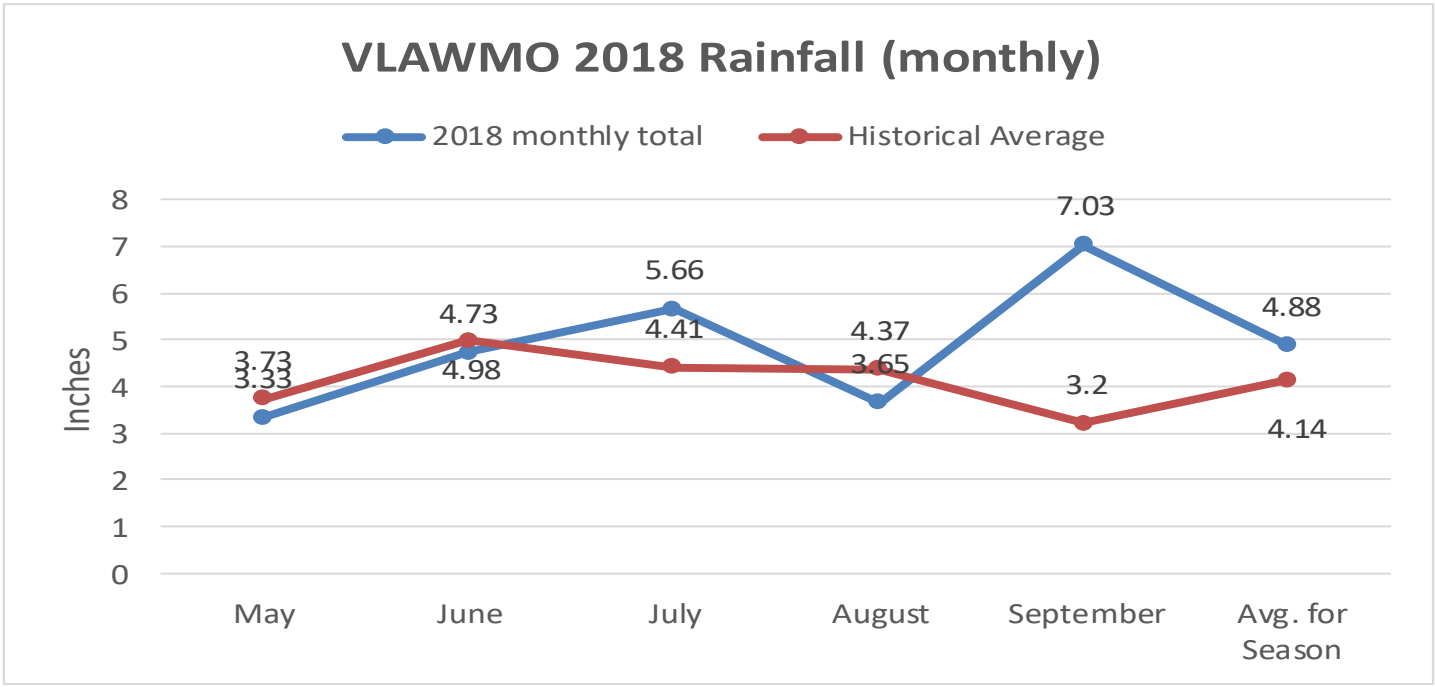
MPCA Standards Lakes					**EPA Standards**	
TP (µg/L)	Chl A (µg/L)	SDT (m)	Turb (NTU)	TSS (mg/L)	TKN (µg/L)	NO_2 (µg/L)
< 60	< 20	> 1	< 25	< 100	< 1000	< 100
MPCA Standards – Rivers and Streams					**EPA Standards**	
Fecal Coliform daily maximum (cfu/100 ml)	Chloride (Cl) chronic (mg/L)	Turb (NTU)	TSS (mg/L)	Un-ionized Ammonia (µg/L)	TKN (µg/L)	NO_2 (µg/L)
< 1260	< 230	< 25	< 100	<40	< 1000	< 100

Precipitation in 2018

Major factors influence water quality including the amount of precipitation, timing of precipitation events, and land use practices in the watershed. Long-term monitoring is necessary to characterize the impacts of various land use practices on surface water runoff within VLAWMO.

The 2018 monitoring season precipitation was above average by 0.74 inches per month and 6.15 inches below 2017 monitoring season precipitation. Above average monthly rainfall in July and September, below average in May, June and August. Precipitation moves contaminants resting on lawns, roofs, streets, and parking lots into nearby water bodies or into storm sewers that outlet into water bodies. Typically, the more precipitation that occurs, the more runoff there will be in the watershed. However, the timing and intensity of the precipitation, as well as soil types, land slopes, land uses, and other factors can influence the amount of runoff that reaches the water bodies. Lack of rain can also have an effect on the concentration of nutrients and chemicals in our water bodies. With a smaller volume of water in our water bodies, the more concentrated the nutrients and chemicals can become.

2018 Precipitation Data (in inches) Vadnais Heights City Hall Rain Gauge, Vadnais Heights, MN			
	2018 monthly total	Historical Average	Deviation
May	3.33	3.73	-0.40
June	4.73	4.98	-0.25
July	5.66	4.41	1.25
August	3.65	4.37	-0.72
September	7.03	3.2	3.83
Avg. for Season	**4.88**	**4.14**	0.74



Preliminary Analysis of Lake Data

VLAWMO staff worked with volunteers to collect samples from the lakes at two-week intervals from May through September. VLAWMO staff collected all creek samples. At the time of collection, volunteers measure water transparency with a Secchi disk (SDT), evaluate the physical and recreational conditions of the water, and if available, take a lake level reading. Samples are brought to Braun Intertec by VLAWMO staff within 24 hours for chemical analysis. Parameters measured at the lab include Phosphorus (TP &SRP), Chlorophyll-a (Chl A), total Kjeldahl Nitrogen, nitrate, ammonia and Total Suspended Solids (TSS). The data from these tests aid in the determination of the state of the water quality in a particular lake or stream and allow for monitoring of the long term health of the water body. Standards for water quality are set by the US Environmental Protection Agency (EPA) and enforced through the MPCA.

A measure of the lake health and lake age is Carlson's Trophic State Index (TSI), which measures the productivity level of a lake or degree of eutrophication. As a lake ages, it becomes more eutrophic, however human impact speeds up the process. High TSI values can relate to poorer water quality but not always. Trophic state is an absolute scale that describes the biological condition of a water body. Water quality, on the other hand, is a term used to describe the condition of a water body in relation to human needs or values

Water quality grades are given to each lake based on standards established by the Metropolitan Council. The standards give a range to each letter grade for the June – September averages of TP concentration, Chl A concentration, and SDT. The overall lake water quality grade is the average of the grades for each parameter. Other indicators of lake condition, such as aquatic plant growth or invasive species are not factored into the grades. As of 2017, the letter grades assigned to VLAWMO water bodies are as listed below:

VLAWMO Lake Grades

Lake	Grade 2018	Grade 2017	TSI Status
Amelia	B+	B+	Eutrophic
Birch	A-	B+	Mesotrophic
Black	B+	A-	Mesotrophic
Charlie	C	C+	Eutrophic
Deep	C-	C	Eutrophic
Gem	B	B	Mesotrophic
Gilfillan	C	C	Eutrophic
E. Goose	D-	D	Eutrophic - Hypereutrophic
W. Goose	D-	D	Eutrophic - Hypereutrophic
Tamarack	D-	D-	Eutrophic - Hypereutrophic
West Vadnais	D-	D-	Eutrophic - Hypereutrophic
Wilkinson	C	C	Eutrophic

Raw data and chart explaining the TSI Status of 2018 & 2017

2018 Data	avg SD (m)	Tsi (SD)	avg CHL (ug)	Tsi (CHL)	avg TP (ug)	Tsi(TP)
amelia	1.4	55	4.5	45	30	53
birch	1.8	52	5	46	25	51
black	2	50	6	48	34	55
charlie	1.5	54	14	56	78	67
deep	1.3	56	23	61	97	70
gem	1.8	52	15	57	36	56
gilfillan	0.7	65	43	67	60	63
goose east	0.4	73	79	73	172	78
goose west	0.4	73	79	73	159	77
tamarack	0.4	73	103	76	154	77
west vadnais	0.4	73	94	75	102	71
wilkinson	1.2	57	8	51	97	70

2017 Data	avg SD (m)	Tsi (SD)	avg CHL (ug)	Tsi (CHL)	avg TP (ug)	Tsi(TP)
Amelia	1.3	56	5	46	34	55
Birch	1.8	52	8	51	28	52
Black	2.1	49	3	41	18	46
Charlie	1.2	57	10	53	54	62
Deep	1.1	59	9	52	84	68
Gem	1.5	54	16	58	32	54
Gilfillan	0.7	65	25	62	58	63
Goose East	0.7	65	60	71	228	82
Goose West	0.4	73	53	70	167	78
Tamarack	0.4	73	68	72	172	78
West Vadnais	0.4	73	54	70	130	74
Wilkinson	1.2	57	9	52	105	71

A list of possible changes that might be expected in a north temperate lake as the amount of algae changes along the trophic state gradient.

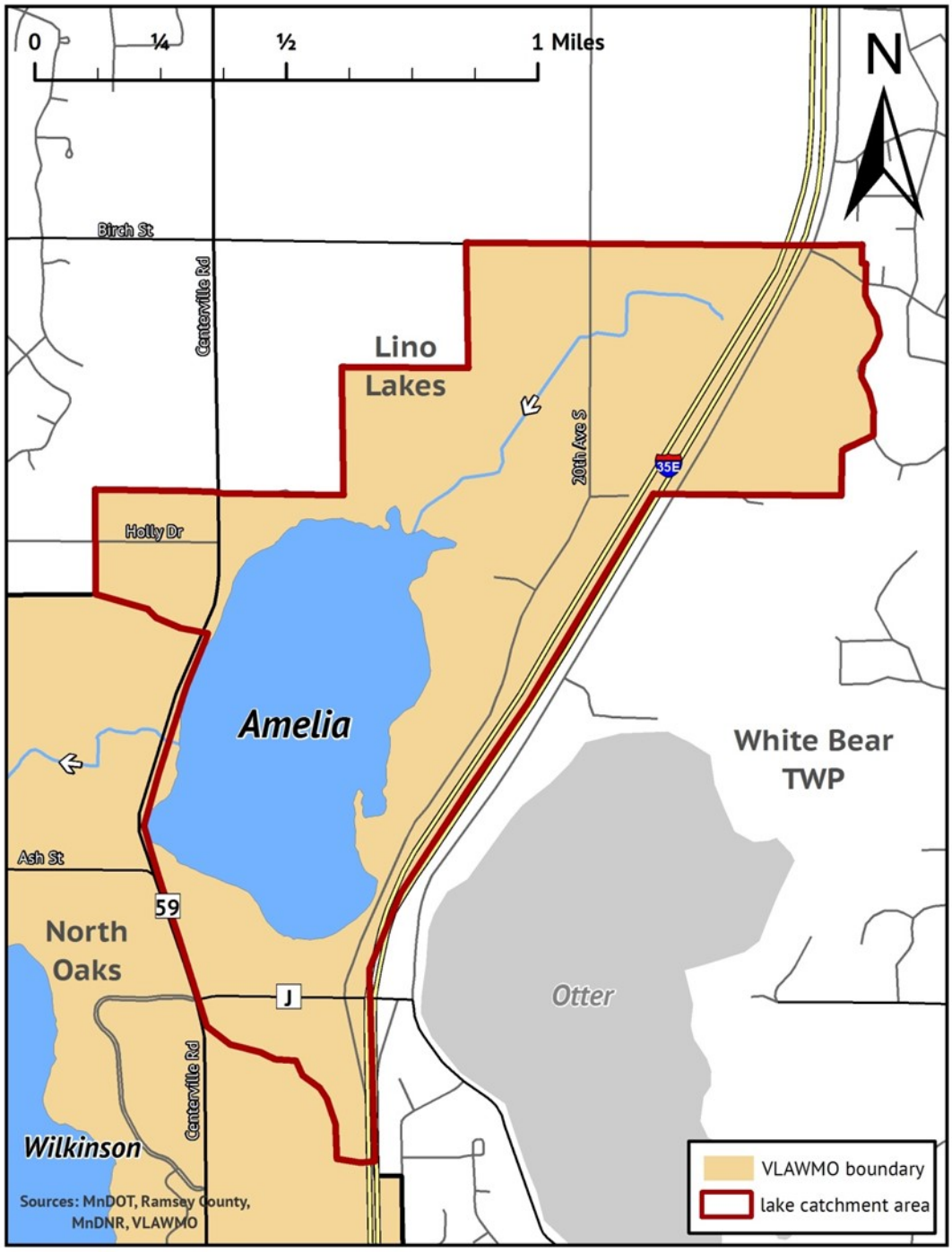
TSI	Chl (ug/L)	SD (m)	TP (ug/L)	Attributes	Water Supply	Fisheries & Recreation
<30	<0.95	>8	<6	**Oligotrophy:** Clear water, oxygen throughout the year in the hypolimnion	Water may be suitable for an unfiltered water supply.	Salmonid fisheries dominate
30-40	0.95-2.6	8>4	6<12	Hypolimnia of shallower lakes may become anoxic		Salmonid fisheries in deep lakes only
40-50	2.6-7.3	4>2	12<24	**Mesotrophy:** Water moderately clear; increasing probability of hypolimnetic anoxia during summer	Iron, manganese, taste, and odor problems worsen. Raw water turbidity requires filtration.	Hypolimnetic anoxia results in loss of salmonids. Walleye may predominate
50-60	7.3-20	2>1	24-48	**Eutrophy:** Anoxic hypolimnia, macrophyte problems possible		Warm-water fisheries only. Bass may dominate.
60-70	20-56	0.5-1	48-96	Blue-green algae dominate, algal scums and macrophyte problems	Episodes of severe taste and odor possible.	Nuisance macrophytes, algal scums, and low transparency may discourage swimming and boating.
70-80	56-155	0.25-0.5	96-192	**Hypereutrophy:** (light limited productivity). Dense algae and macrophytes		
>80	>155	<0.25	192-384	Algal scums, few macrophytes		Rough fish dominate; summer fish kills possible

VLAWMO's water resource manager completes the required data entry each year into the MPCA EQuIS program which makes the determination of impairment and opens opportunities for grants to help remedy the impairments.

2018 MONITORING RESULTS

AMELIA LAKE

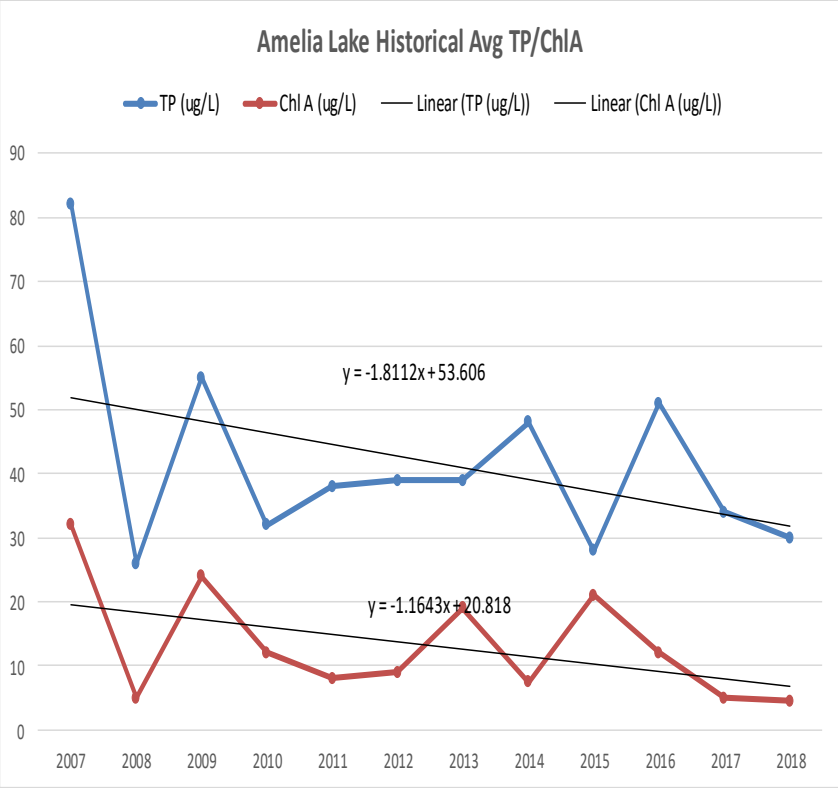
Amelia is located in Anoka County and is approximately 217 acres. Maximum depth for the lake is 4 feet. The majority of agricultural land left in the watershed is near Amelia Lake. VLAWMO staff also collected all DO and YSI parameter readings on Amelia. VLAWMO has been monitoring Amelia since 1997. As you can see from the data below the trend for both TP and ChlA has been slightly downward over the last 11yrs. Overall Amelia is below the state standard of 60ug/L for TP and 20mg/m3 for ChlA over the last eight years.



AMELIA LAKE

Amelia Lake Historical Avg TP/Chl A/ SDT			
Year	TP (ug/L)	Chl A (ug/ L)	Secchi (m)
1997	28	0	1.5
1998	36	14	1.1
1999	38	9	1.2
2000	40	12	0.9
2001	33	8	1.1
2002	34	13	1.4
2003	29	7	1.5
2004	28	0	0
2005	24	7	0
2006	36	12	0
2007	82	32	0.4
2008	26	5	1.1
2009	55	24	0.9
2010	32	12	1.1
2011	38	8	1.1
2012	39	9	1.1
2013	39	19	1.1
2014	48	7.5	1.3
2015	28	21	1.1
2016	51	12	1.1
2017	34	5	1.3
2018	30	4.5	1.4

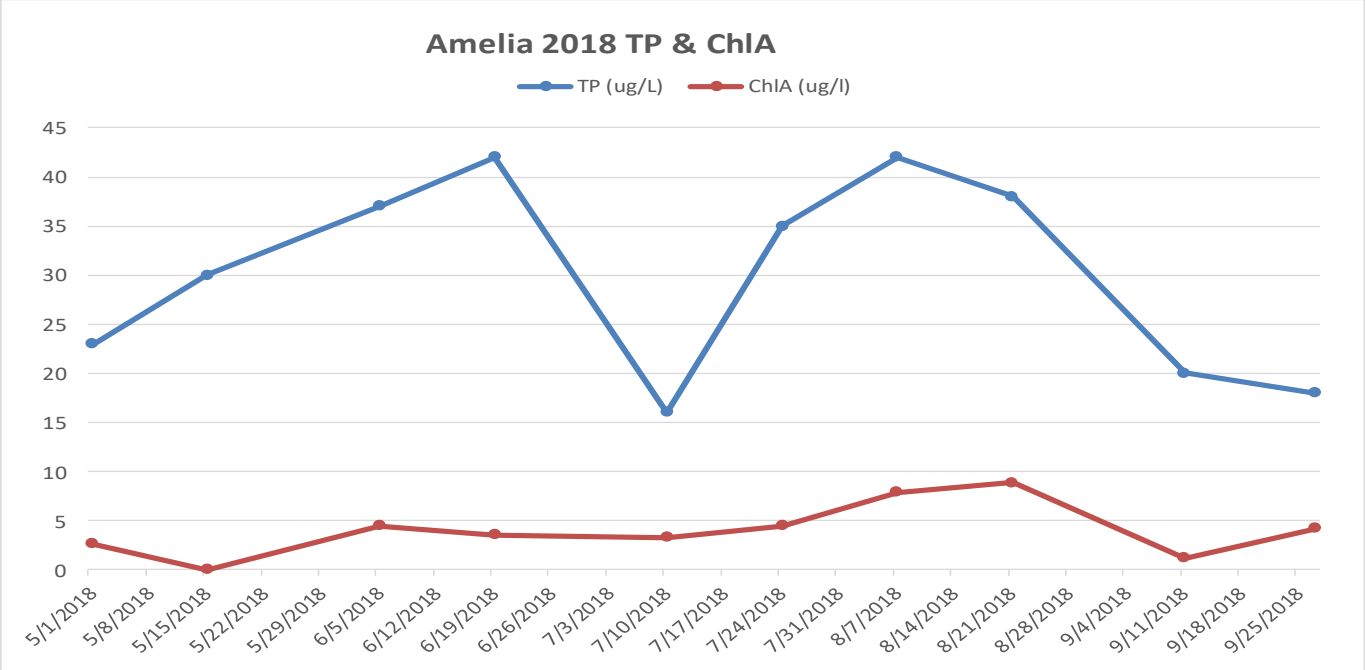
Date	Reading Depth (Bottom/ Top)	Temp °C	Conduc-tivity (mS/ cm)	DO (mg/L)	pH
5/22/2018	b	17.68	0.437	1.58	7.79
5/22/2018	t	18.18	0.431	1.64	7.74
6/21/2018	b	21.95	0.636	3.66	7.87
6/21/2018	t	23.48	0.356	6.88	8.03
9/5/2018	b	21.06	0.351	3.3	7.4
9/5/2018	t	21.13	0.347	2.53	7.44



- YSI parameters are good for Amelia Lake, no signs of concern. Red values indicate averages above state standard. Amelia has been below state standard for last 8 years

AMELIA LAKE

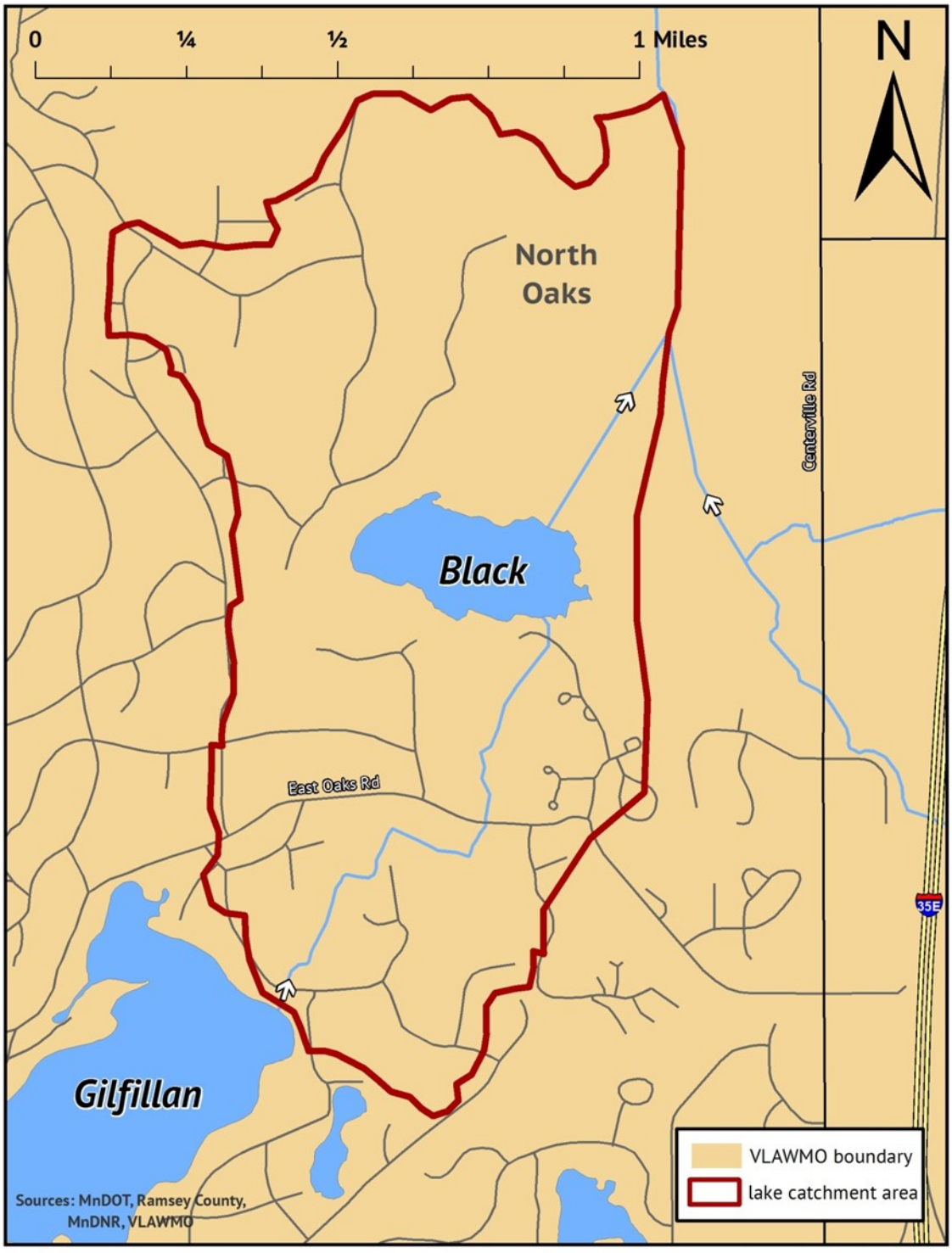
SITE	DATE	Secchi (ft)	TP (ug/L)	SRP (mg/L)	ChlA (ug/l)	TKN (mg/L)	NH3 (mg/L)	NO2+NO3 mg/L	CL (mg/L)
amelia	5/1/2018								60
amelia	5/1/2018	4	23	< 0.003	3	0.752	< 0.04	< 0.03	
amelia	5/15/2018	4	30	< 0.003	< 1				
amelia	6/5/2018		37	0.004	4	0.95	< 0.04	< 0.03	
amelia	6/19/2018	4	42	0.005	4				
amelia	7/10/2018	4	16	< 0.003	3	0.841	< 0.04	< 0.03	
amelia	7/24/2018	4	35	0.006	5				
amelia	8/7/2018	4	42	< 0.003	8	0.962	< 0.04	< 0.03	
amelia	8/21/2018	5	38	0.003	9				
amelia	9/11/2018	5	20	< 0.003	1	1.06	< 0.04	< 0.03	
amelia	9/27/2018	5	18	< 0.003	4				



- Nitrogen and ammonia levels are well below state standards for Amelia Lake as well as chloride.

BLACK LAKE

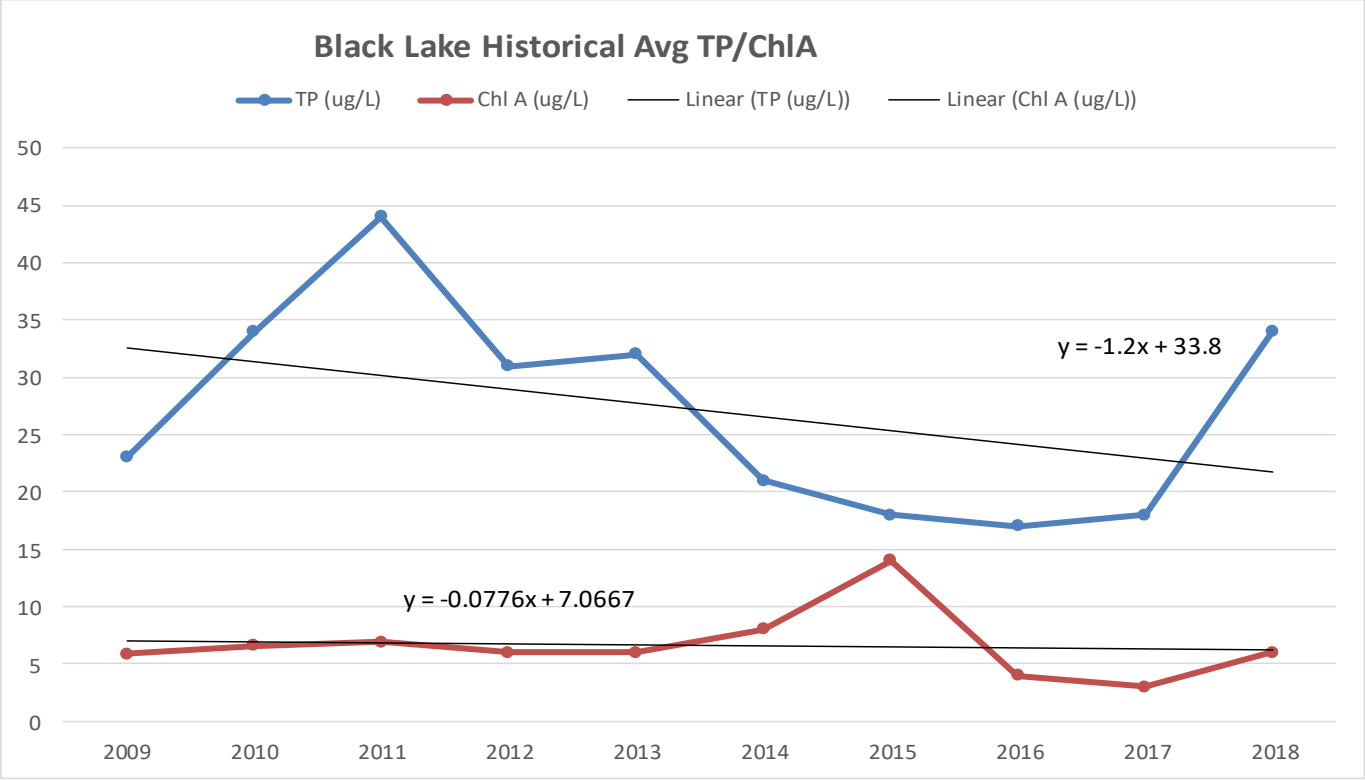
Black Lake is located in North Oaks. There is very little developed land or roads around the lake. The lake is about 10 acres and has a maximum depth of 12 feet. VLAWMO began to monitor Black Lake in 2009. Black Lake is also one of, if not the only lake left within VLAWMO that has a significant population of wild rice. Access to the lake is minimal and the lake is surrounded by private property, is very isolated and has a large wetland fringe. Black Lake is one of the healthiest lakes within VLAWMO with all lake nutrient parameters well below the state standards. An aquatic vegetation survey was completed in July 2014.



BLACK LAKE

Black Lake Historical Avg TP/Chl A/SDT			
Year	TP (ug/L)	Chl A (ug/L)	Secchi (m)
2009	23	5.9	2
2010	34	6.6	2.1
2011	44	6.9	2.3
2012	31	6	2.4
2013	32	6	2
2014	21	8	2
2015	18	14	1.6
2016	17	4	2
2017	18	3	2.1
2018	34	6	2

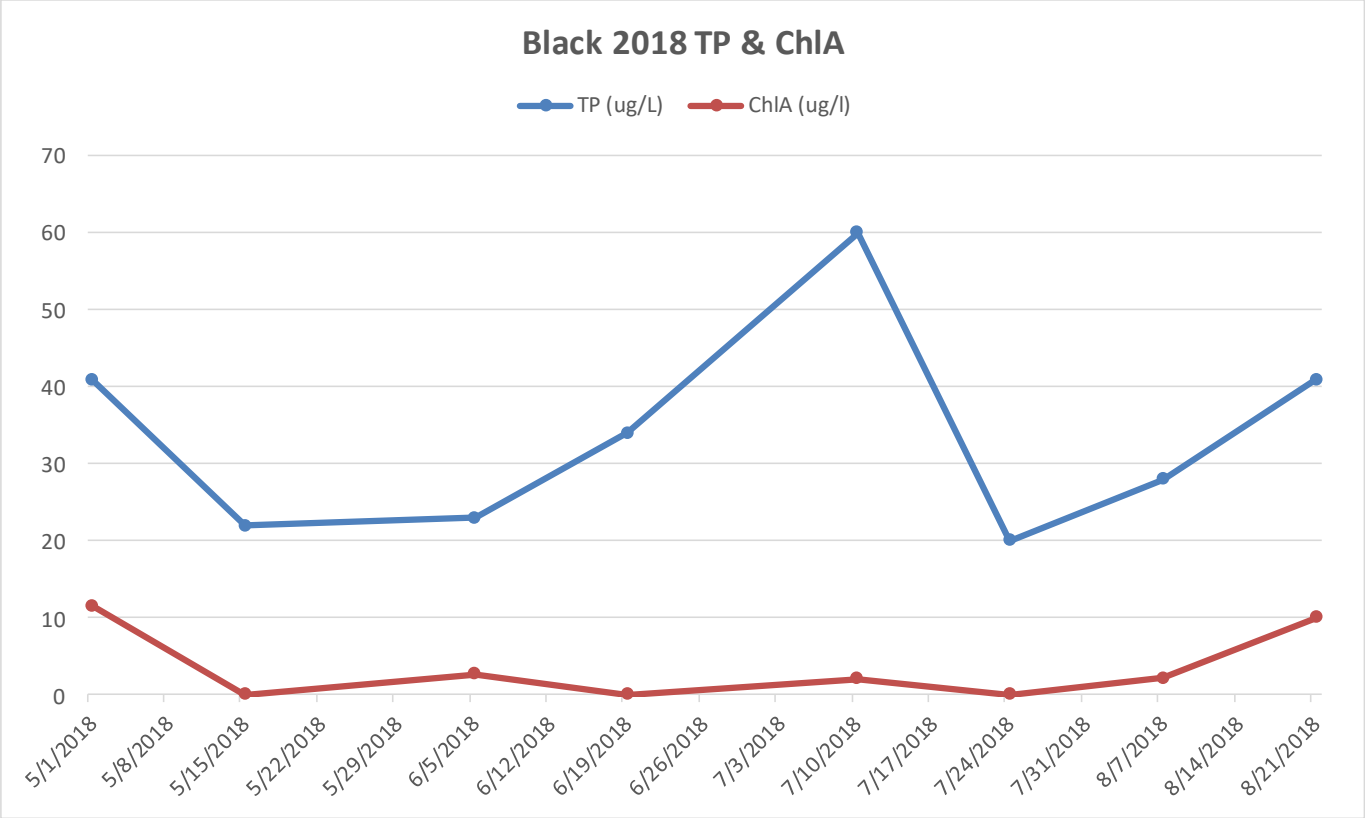
Date	Reading Depth (Bottom/ Top)	Temp °C	Conduc-tivity (mS/cm)	DO (mg/L)	pH
5/22/2018	b	6.75	0.757	1.17	7.46
5/22/2018	m	18.41	0.34	5.18	7.67
5/22/2018	t	19.17	0.34	5.56	7.69
6/21/2018	b	12.93	0.738	0.49	7.5
6/21/2018	m	22.37	0.322	5.08	7.37
6/21/2018	t	23.6	0.32	5.53	7.89
9/5/2018	b	16.79	0.613	0.83	7.41
9/5/2018	m	20.63	0.291	1.44	7.53
9/5/2018	t	21.61	0.283	2.24	7.56



- Black Lake YSI parameters are very good for this type of lake. Black Lake is around 12 ft deep and does show some signs of stratification

BLACK LAKE

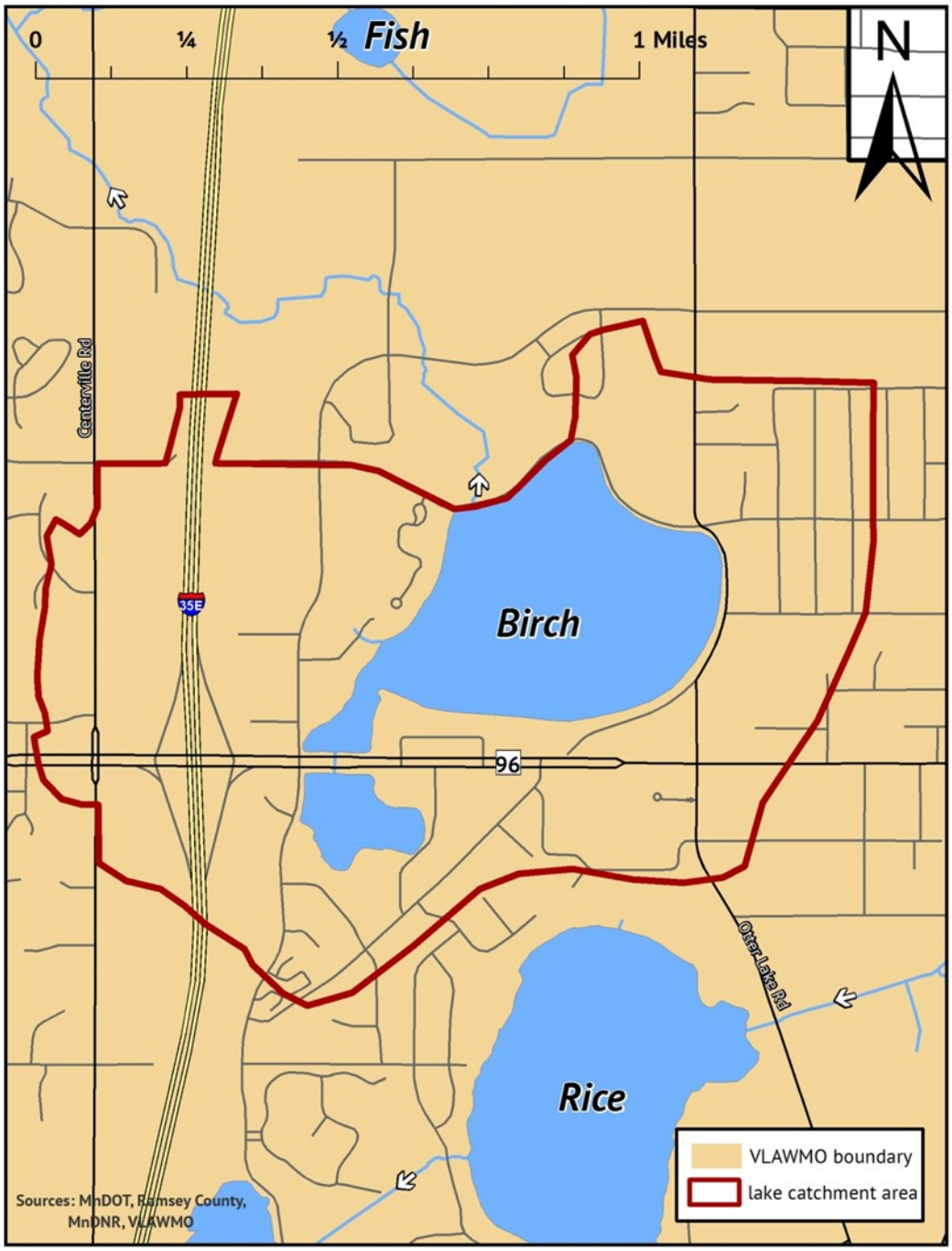
SITE	DATE	Secchi (ft)	TP (ug/L)	SRP (mg/L)	ChlA (ug/l)	TKN (mg/L)	NH3 (mg/L)	NO2+NO3 mg/L	CL (mg/L)
black	5/1/2018								20
black	5/1/2018	5.5	41	0.003	12	0.822	0.055	< 0.03	
black	5/15/2018	7	22	< 0.003	< 1				
black	6/5/2018	7	23	< 0.003	3	0.899	< 0.04	< 0.03	
black	6/19/2018	7	34	0.006	< 1				
black	7/10/2018	6	60	0.03	2	1.1	0.189	< 0.03	
black	7/24/2018	5	20	0.003	< 1				
black	8/7/2018	7	28	0.007	2	0.898	0.053	< 0.03	
black	8/21/2018	4	41	< 0.003	10				



- Nitrogen and ammonia levels are well below state standards for Black Lake as well as chloride

BIRCH LAKE

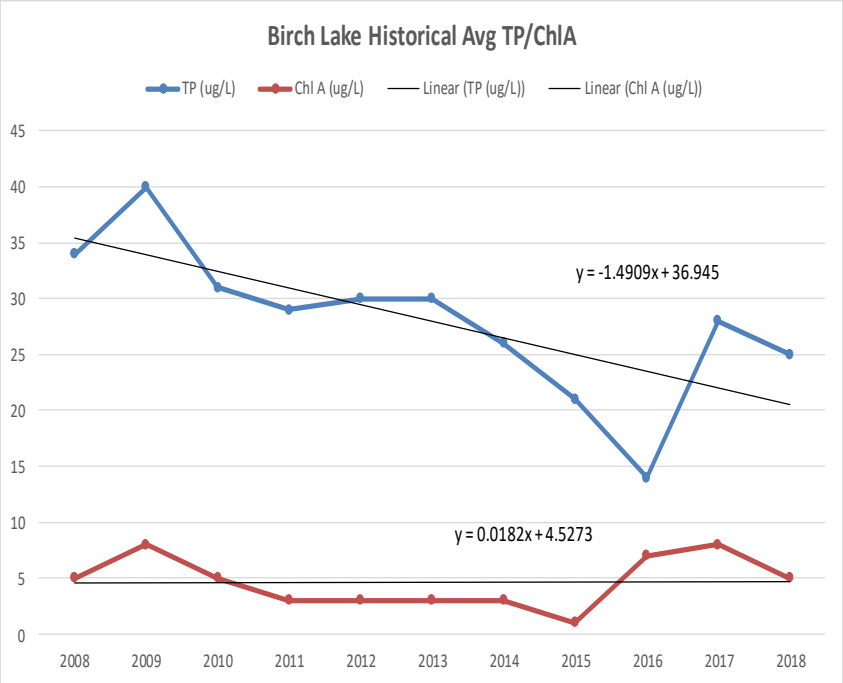
Birch Lake is located within the City of White Bear Lake and is 127 acres with a maximum depth of 6 feet. Land is completely developed around Birch Lake and there are 4 main storm sewer inlets around the lake as well as other storm inlets. Birch Lake is a rare find in the metropolitan area because of its clarity and water quality. Results of ChlA and TP are very low for such an urbanized water body. TP and ChlA have had a slight down trend the last 16 years. This is good to see especially for a metro lake because it suggests that runoff from the surrounding watershed entering the lake is also low in nutrient levels and pre-treated. Birch Lake experienced a winter fish kill in 2014. Fish survey completed fall of 2014 did not show much change to the fish population from the 2011 survey except for a lack of largemouth bass in 2014. A lake vegetation survey was also completed in 2015.



BIRCH LAKE

Birch Lake Historical Avg TP/Chl A/SDT			
Year	TP (ug/L)	Chl A (ug/L)	Secchi (m)
1997	22	14	2.4
1998	41	4	2.4
1999	31	8	2.4
2000	27	14	2.4
2001	42	8	2.4
2002	31	10	2.4
2003	35	13	2.4
2004	31	0	2.4
2005	31	4	2.4
2006	32	3	2.4
2007	41	5	2.4
2008	34	5	1.2
2009	40	8	1.1
2010	31	5	1
2011	29	3	2
2012	30	3	2
2013	30	3	2
2014	26	3	1.7
2015	21	1	1.7
2016	14	7	1.8
2017	28	8	1.8
2018	25	5	1.8

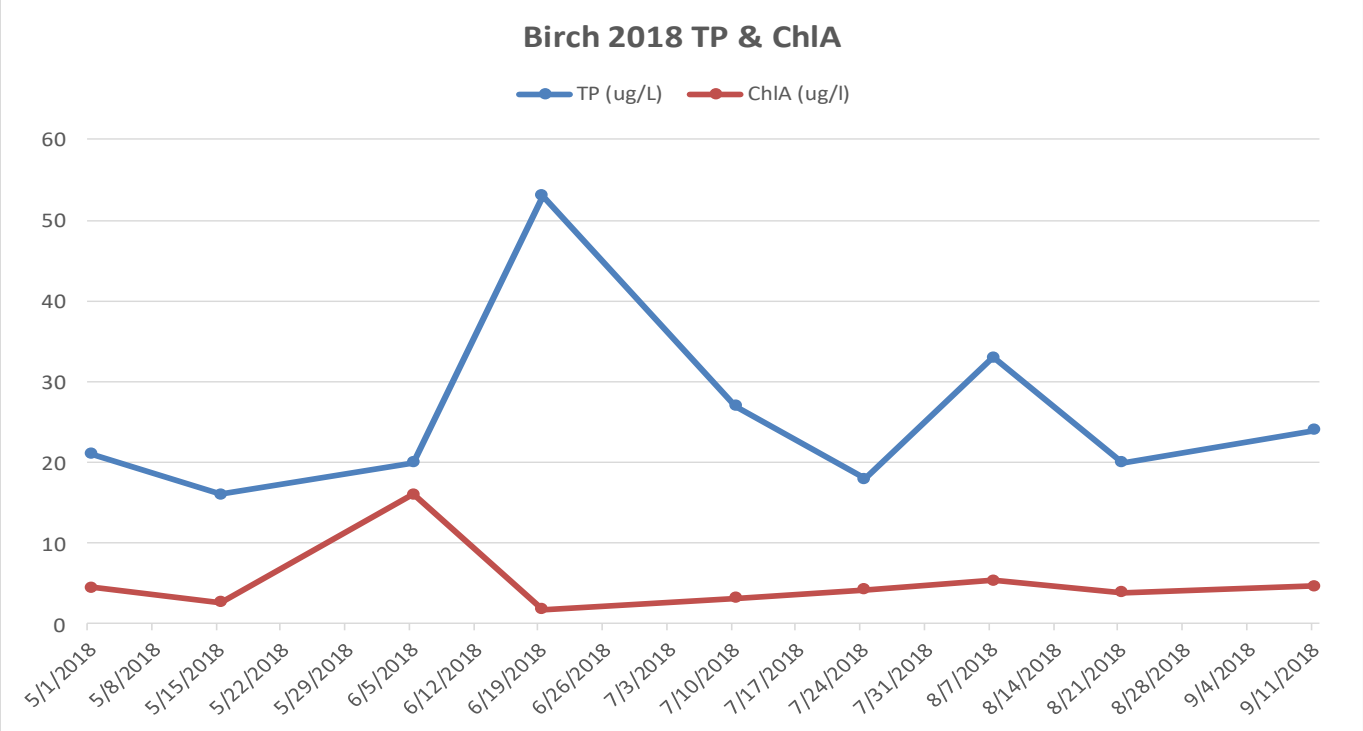
Date	Reading Depth (Bottom/ Top)	Temp °C	Conductiv-ity cm)	DO (mg/L)	pH
5/22/2018	b	18.65	0.423	7.47	8.02
5/22/2018	t	18.86	0.423	7.24	8.1
6/21/2018	b	23.52	0.415	6.21	8.24
6/21/2018	t	23.53	0.415	6.5	8.3
9/5/2018	b	22.26	0.399	4.33	7.62
9/5/2018	t	22.19	0.397	4.66	7.68



- Secchi reading for Birch is to lake bottom at sample site. Can see to bottom of lake throughout
- YSI parameters are very good for Birch Lake. Conductivity is on the high side but not unusual for a metro lake. This is most likely due to the amount of road runoff that enters Birch Lake. Winter conductivity levels are a bit higher, readings similar to 2017.

BIRCH LAKE

SITE	DATE	Secchi (ft)	TP (ug/L)	SRP (mg/L)	ChlA (ug/l)	TKN (mg/L)	NH3 (mg/L)	NO2+NO3 mg/L	CL (mg/L)
Birch	1/18/2018								101
Birch	2/14/2018								102
Birch	3/12/2018								105
Birch	5/1/2018								80
Birch	5/1/2018	6	21	< 0.003	4	0.622	< 0.04	< 0.03	
Birch	5/15/2018	6	16	< 0.003	3				92.3
Birch	6/5/2018		20	< 0.003	16	0.605	0.106	< 0.03	103
Birch	6/19/2018	4	53	0.009	2				92.1
Birch	7/10/2018	5	27	< 0.003	3	1.02	< 0.04	< 0.03	92.2
Birch	7/24/2018	6	18	< 0.003	4				92.5
Birch	8/7/2018	5	33	< 0.003	5	0.899	< 0.04	< 0.03	97.3
Birch	8/21/2018	6	20	< 0.003	4				102
Birch	9/11/2018	4.5	24	< 0.003	5	0.822	< 0.04	< 0.03	87.1
Birch	9/27/2018	4.5	18	< 0.003	5				87.4

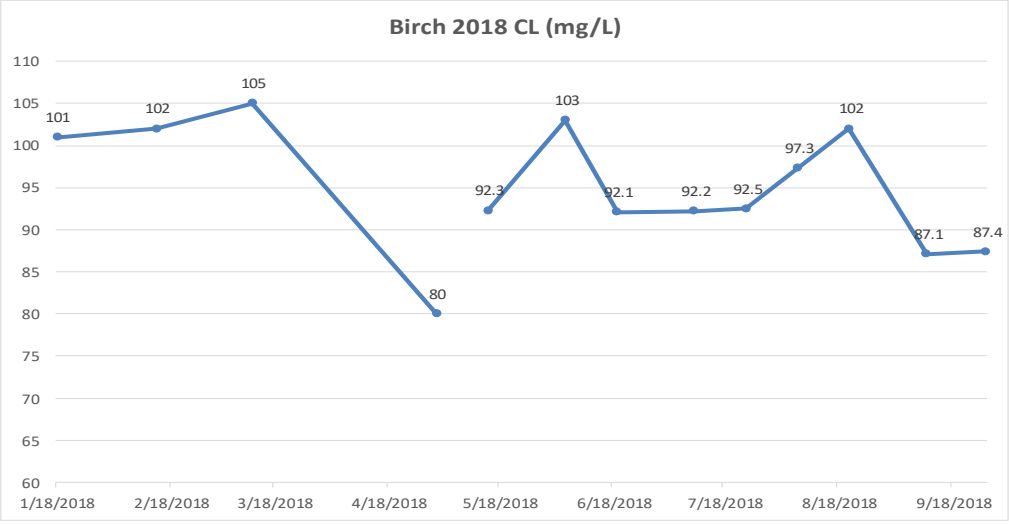


- Nitrogen and ammonia levels are well below state standards for Birch Lake. Nutrient readings similar to 2017

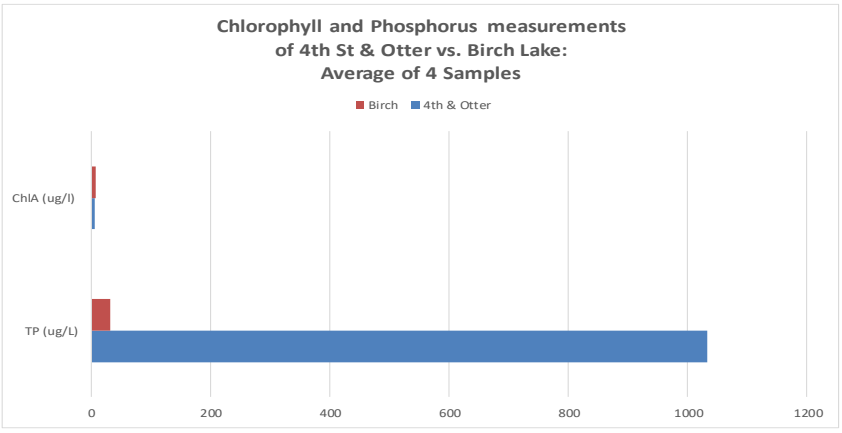
BIRCH LAKE

Lake	Date	Reading Depth (Bottom/ Top)	Temp °C	Conduc-tivity (mS/ cm)	DO (mg/L)	pH
Birch1	1/18/2018	t	1.66	0.492	4.00	6.78
Birch1	1/18/2018	b	3.38	0.483	3.01	7.03
Birch1	2/14/2018	t	1.15	0.517	1.84	7.11
Birch1	2/14/2018	b	2.85	0.504	2.82	7.21
Birch1	3/12/2018	t	0.62	0.518	1.48	7.06
Birch1	3/12/2018	b	3.44	0.535	1.25	7.32
Birch2	1/18/2018	t	2.05	0.486	3.75	6.76
Birch2	1/18/2018	b	3.53	0.474	2.87	6.58
Birch2	2/14/2018	t	0.80	0.509	2.13	6.95
Birch2	2/14/2018	b	3.96	0.487	1.18	6.86
Birch2	3/12/2018	t	0.9	0.49	1.42	6.6
Birch2	3/12/2018	b	2.59	0.504	1.02	6.45
Birch3	1/18/2018	t	3.14	0.474	2.91	6.74
Birch3	1/18/2018	b	3.49	0.47	3.11	6.75
Birch3	2/14/2018	t	2.21	0.502	0.73	6.75
Birch3	2/14/2018	b	4.08	0.491	0.81	6.76
Birch3	3/12/2018	t	1.4	0.506	1.56	6.57
Birch3	3/12/2018	b	2.84	0.5	1.17	6.37

- VLAWMO started a year round chloride program on Birch in 2015. Bi-weekly samples were taken throughout the summer and winter monthly samples taken as well. Levels average around 80 mg/l. This is well below the 230mg/l state standard.
- Storm sampler results from 4th & Otter also showed a very high level of TP entering Birch Lake during storm events both in 2017 and 2018.

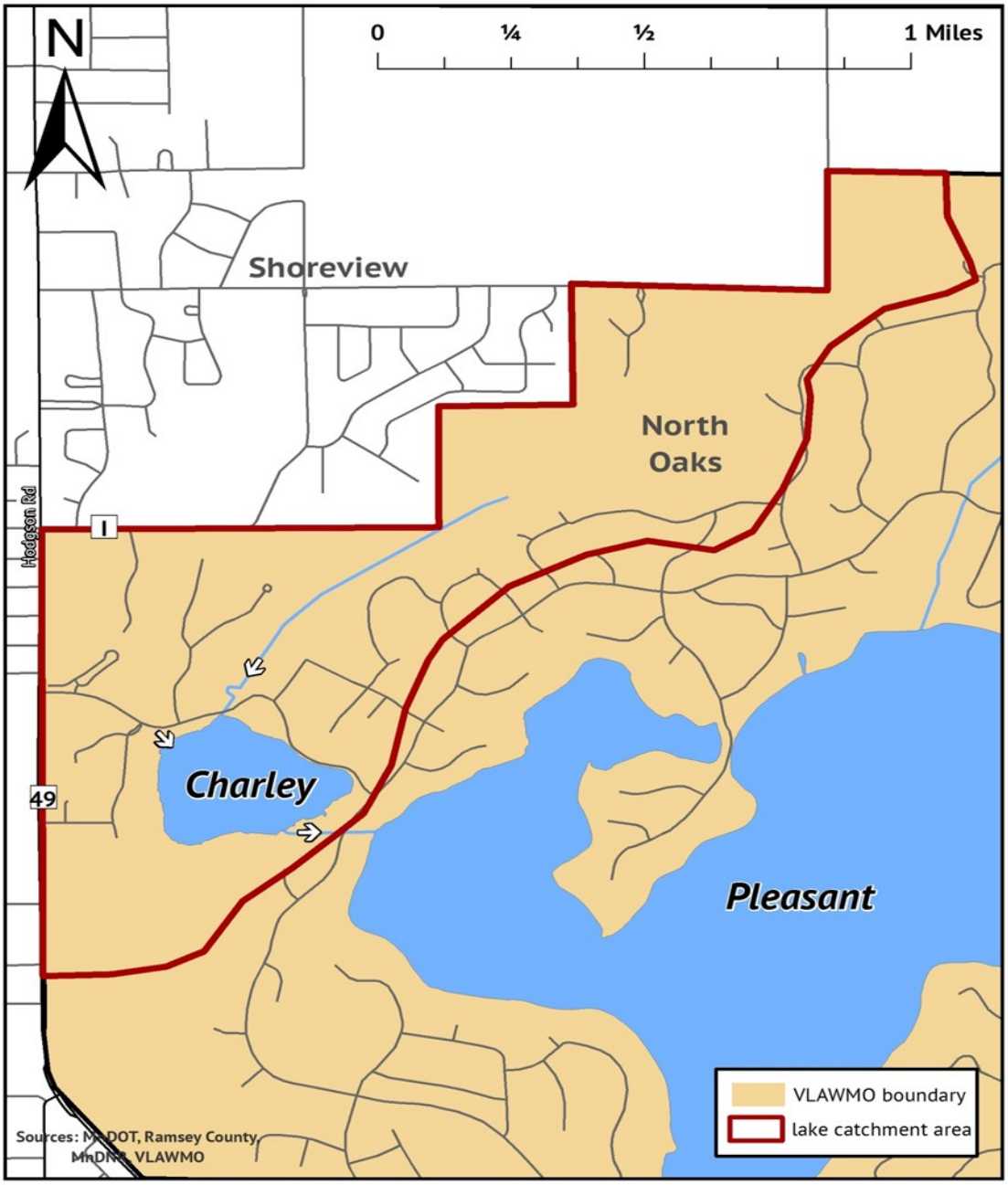


SITE	DATE	TP (ug/L)	ChlA (ug/ l)
4th & Ot-ter	6/6/2018	673	< 1
4th & Ot-ter	6/19/2018	624	3.56
4th & Ot-ter	8/7/2018	599	1.6
4th & Ot-ter	8/21/2018	2240	8.9
Birch	6/6/2018	20	16
Birch	6/19/2018	53	1.78
Birch	8/7/2018	33	5.34
Birch	8/21/2018	20	3.86



CHARLEY LAKE

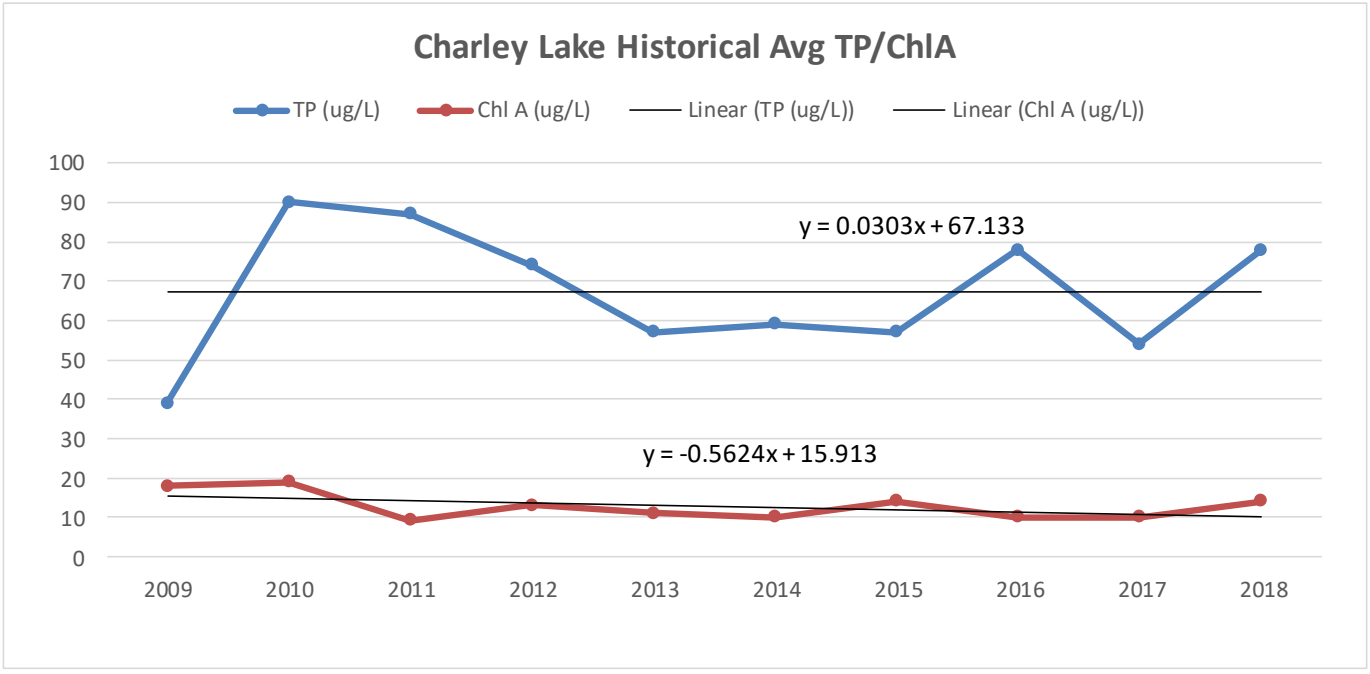
Water is pumped from the Mississippi River to Charley Lake via a 60 inch 8 mile long pipe from a pumping station in Fridley. An average of 32 million gallons of water is pumped into Charley Lake each day. Charley Lake is the start of the chain of lakes controlled by the St. Paul Water Utility. This chain of lakes supplies drinking water for more than 400,000 customers. Most of the drinking water is coming from the Mississippi River, while some comes from wells to help cool the water and reduce treatment costs. VLAWMO began sampling Charley in 2009.



CHARLEY LAKE

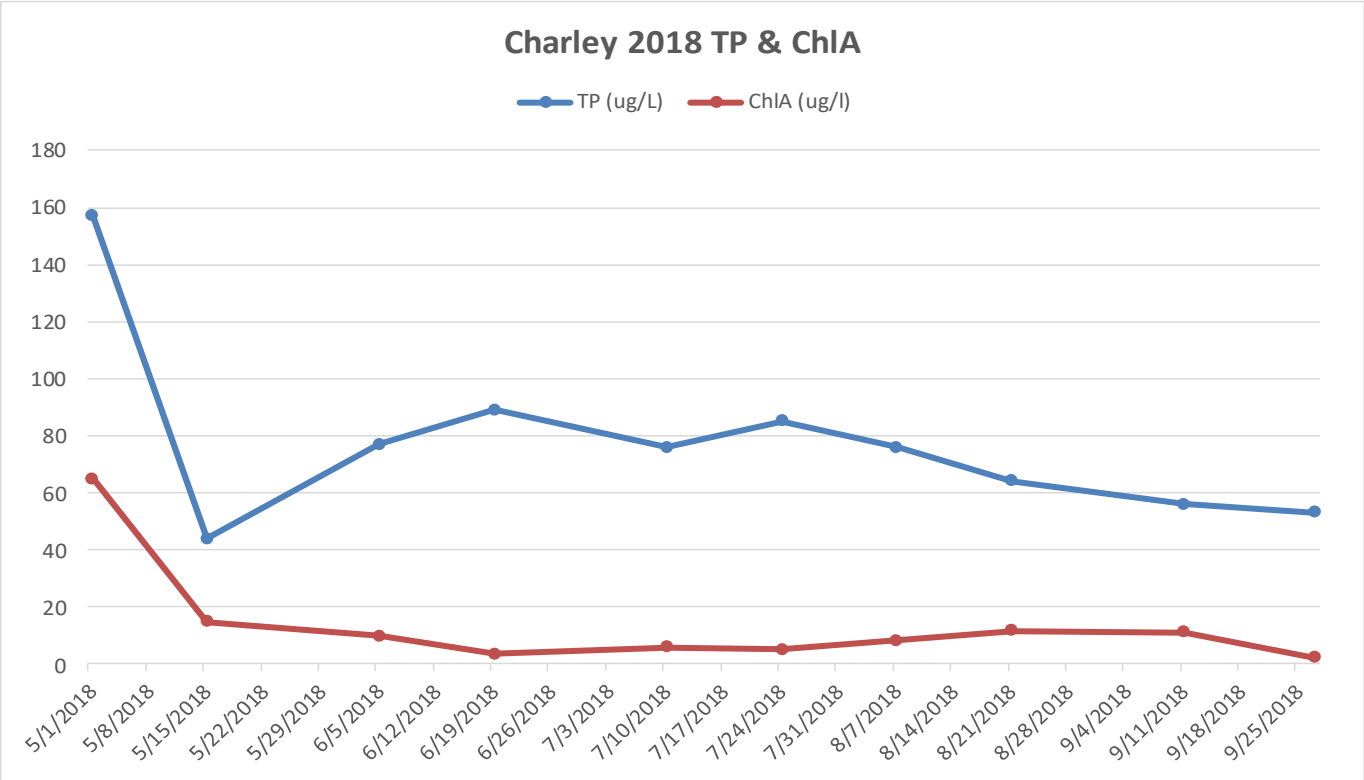
Charley Lake Historical Avg TP/Chl A/ SDT			
Year	TP (ug/L)	Chl A (ug/L)	Secchi (m)
2009	39	18	1
2010	90	18.9	1
2011	87	9.3	1.1
2012	74	13	1
2013	57	11	1
2014	59	10	1.1
2015	57	14	1.1
2016	78	10	1.2
2017	54	10	1.2
2018	78	14	1.5

Date	Reading Depth (Bottom/ Top)	Temp °C	Conduc-tivity (mS/ cm)	DO (mg/L)	pH
5/22/2018	b	18.43	0.34	6.51	7.87
5/22/2018	t	18.76	0.338	7.51	7.87
6/21/2018	b	23.28	0.338	4.42	7.87
6/21/2018	t	23.34	0.339	4.26	8
9/5/2018	b	21.88	0.352	4.91	7.11
9/5/2018	t	22.25	0.352	4.41	7.33



CHARLEY LAKE

SITE	DATE	Secchi (ft)	TP (ug/L)	SRP (mg/L)	ChlA (ug/l)	TKN (mg/L)	NH3 (mg/L)	NO2+NO3 mg/L	CL (mg/L)
charley	5/1/2018								35
charley	5/1/2018	3	157	0.004	65	1.57	< 0.04	< 0.03	
charley	5/15/2018	2.5	44	0.003	15				
charley	6/5/2018		77	0.029	10	0.792	0.045	0.58	
charley	6/19/2018	3	89	0.052	4				
charley	7/10/2018	4	76	0.036	6	0.871	< 0.04	0.525	
charley	7/24/2018	4	85	0.044	5				
charley	8/7/2018	4	76	0.03	8	0.774	< 0.04	0.329	
charley	8/21/2018	3.5	64	0.024	12				
charley	9/11/2018	4	56	0.016	11	0.875	0.086	0.116	
charley	9/27/2018	4.5	53	0.042	2				



- Charley Lake YSI parameters are good. There is a constant flow of millions of gallons of Mississippi river water through Charley Lake year round and with that these parameters seem consistent with normal metro lakes. TP levels were higher than state standard of 40ug/l for deep lakes
- Nitrogen and ammonia levels are below state standards for Charley Lake. NO3 levels are higher in Charley compared to the rest of VLAWMO lake and is most likely due to the Mississippi water that is pumped through the lake

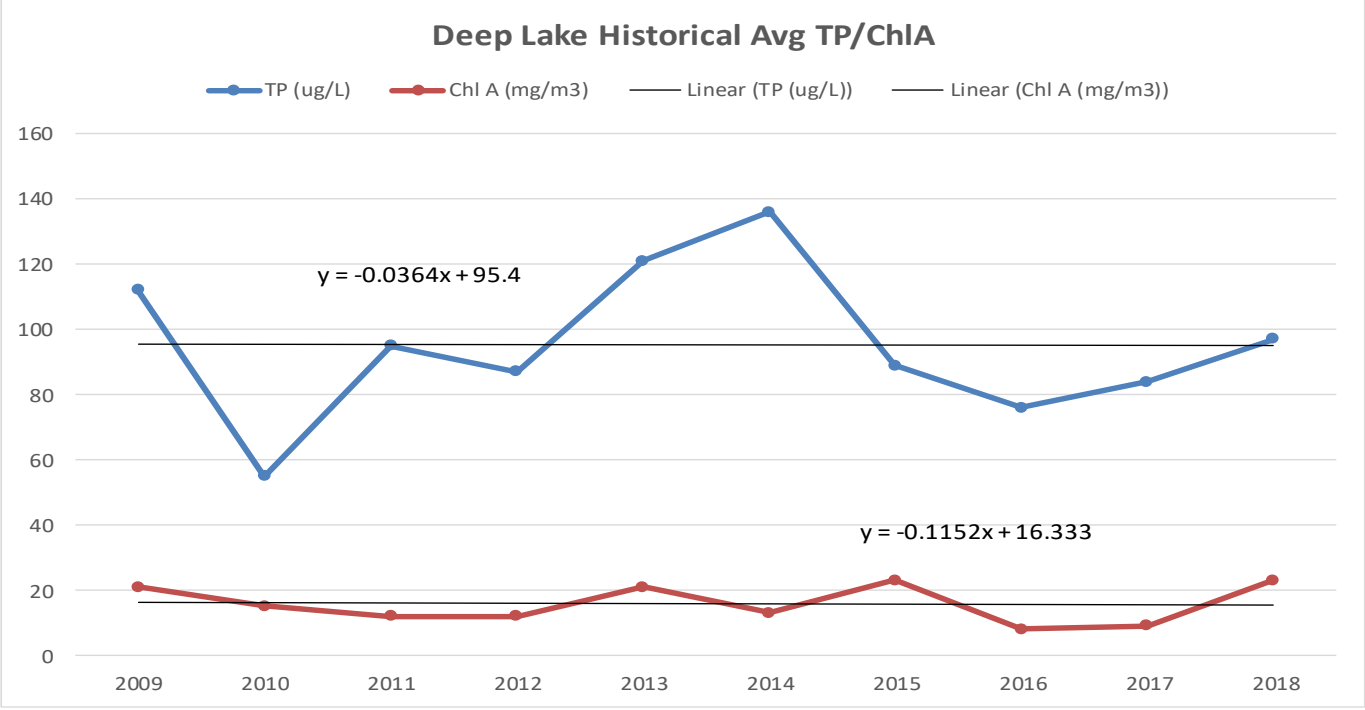
DEEP LAKE

Deep lake is a little over 80 acres and sits between and is hydro logically connected to Wilkinson Lake to the north and Pleasant Lake to the south. A channel connects the three lakes. A Deep Lake Preservation Committee was formed in 2009 by the residents living around Deep Lake to help maintain and improve the quality of the lake. All VLAWMO lakes are tested for nitrogen's and ammonia and Deep lake year over year tends to have the highest concentrations, although they are still below the standards. TP and ChlA have been trending up since sampling began in 2009. By mid to late summer Deep Lake is very weedy and this has been a concern for residents along with the high nutrients coming from Wilkinson.

DEEP LAKE

Deep Lake Historical Avg TP/Chl A/SDT			
Year	TP (ug/L)	Chl A (mg/m3)	Secchi (m)
2009	112	21	1
2010	55	15	0.9
2011	95	12	1.2
2012	87	12	1
2013	121	21	1
2014	136	13	1.1
2015	89	23	1
2016	76	8	1.1
2017	84	9	1.1
2018	97	23	1.3

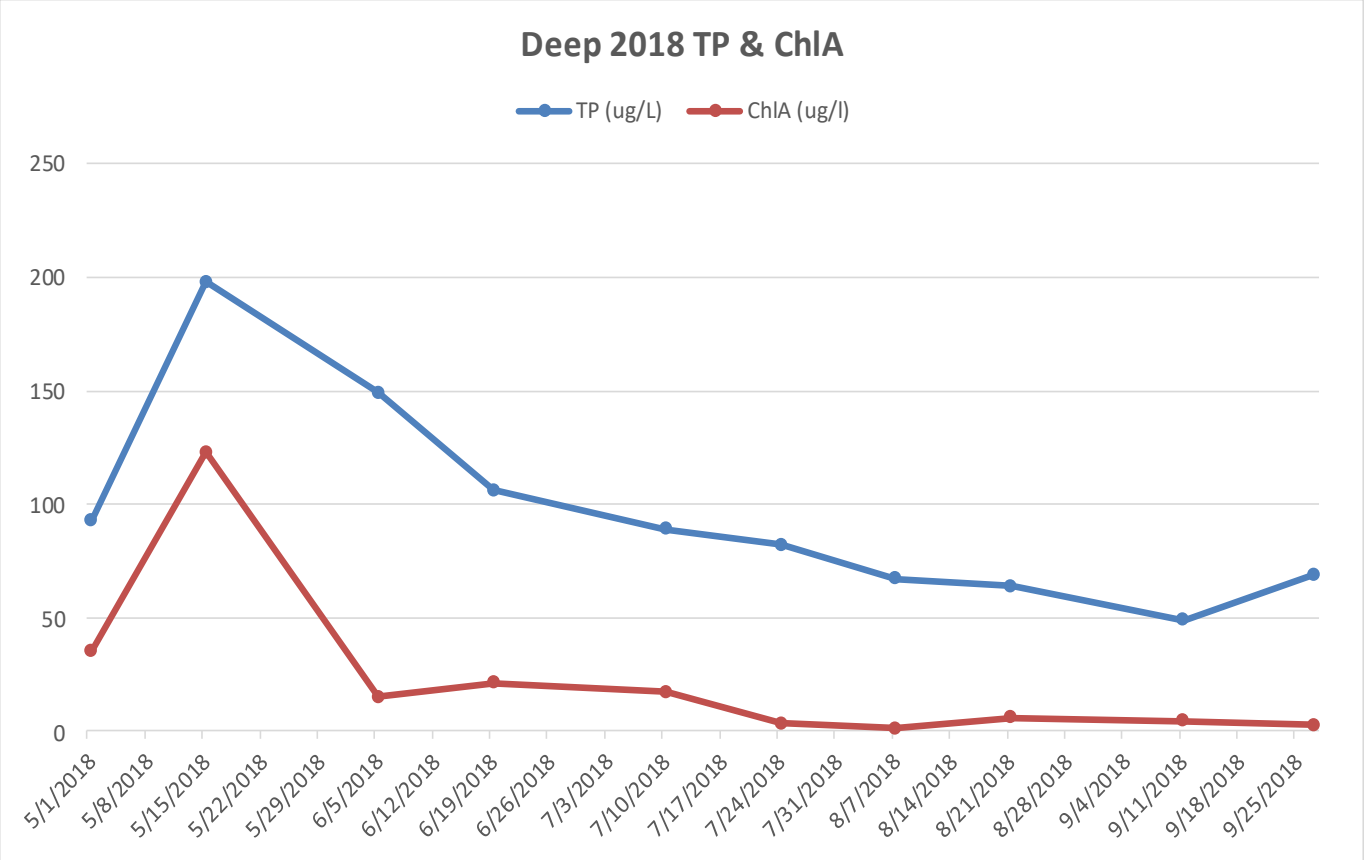
Date	Reading Depth (Bottom/ Top)	Temp °C	Conductiv-ity cm)	DO (mg/L)	pH
5/22/2018	b	19.3	0.421	7.6	7.76
5/22/2018	t	19.93	0.422	6.58	7.89
6/21/2018	b	24.06	0.402	6.47	7.85
6/21/2018	t	24.09	0.402	6.29	8.03
9/5/2018	b	21.23	0.378	2.99	7.4
9/5/2018	t	21.36	0.377	2.99	7.38



- Deep Lake YSI data is similar to that of Charlie Lake. Conductivity is on the high side. TP levels are very high with very low ChlA levels. This is unusual, TP and ChlA levels usually reflect each other, High TP = High ChlA, Low TP = Low ChlA. Charley is very weedy and this may be reducing the ChlA levels.

DEEP LAKE

SITE	DATE	Secchi (ft)	TP (ug/L)	SRP (mg/L)	ChlA (ug/l)	TKN (mg/L)	NH3 (mg/L)	NO2+NO3 mg/L	CL (mg/L)
deep	5/1/2018								41
deep	5/1/2018	3	93	0.007	36	1.08	0.17	< 0.03	
deep	5/15/2018	2.5	198	0.003	123				
deep	6/5/2018		149	< 0.003	15	1.73	< 0.04	< 0.03	
deep	6/19/2018	3	106	0.004	21				
deep	7/10/2018	3.5	89	0.02	17	1.35	< 0.04	< 0.03	
deep	7/24/2018	4.5	82	0.03	3				
deep	8/7/2018	4	67	0.021	1	1.12	0.042	< 0.03	
deep	8/21/2018	4.5	64	0.028	6				
deep	9/11/2018	4.5	49	0.01	4	1.16	0.044	< 0.03	
deep	9/27/2018	4.5	69	0.031	3				

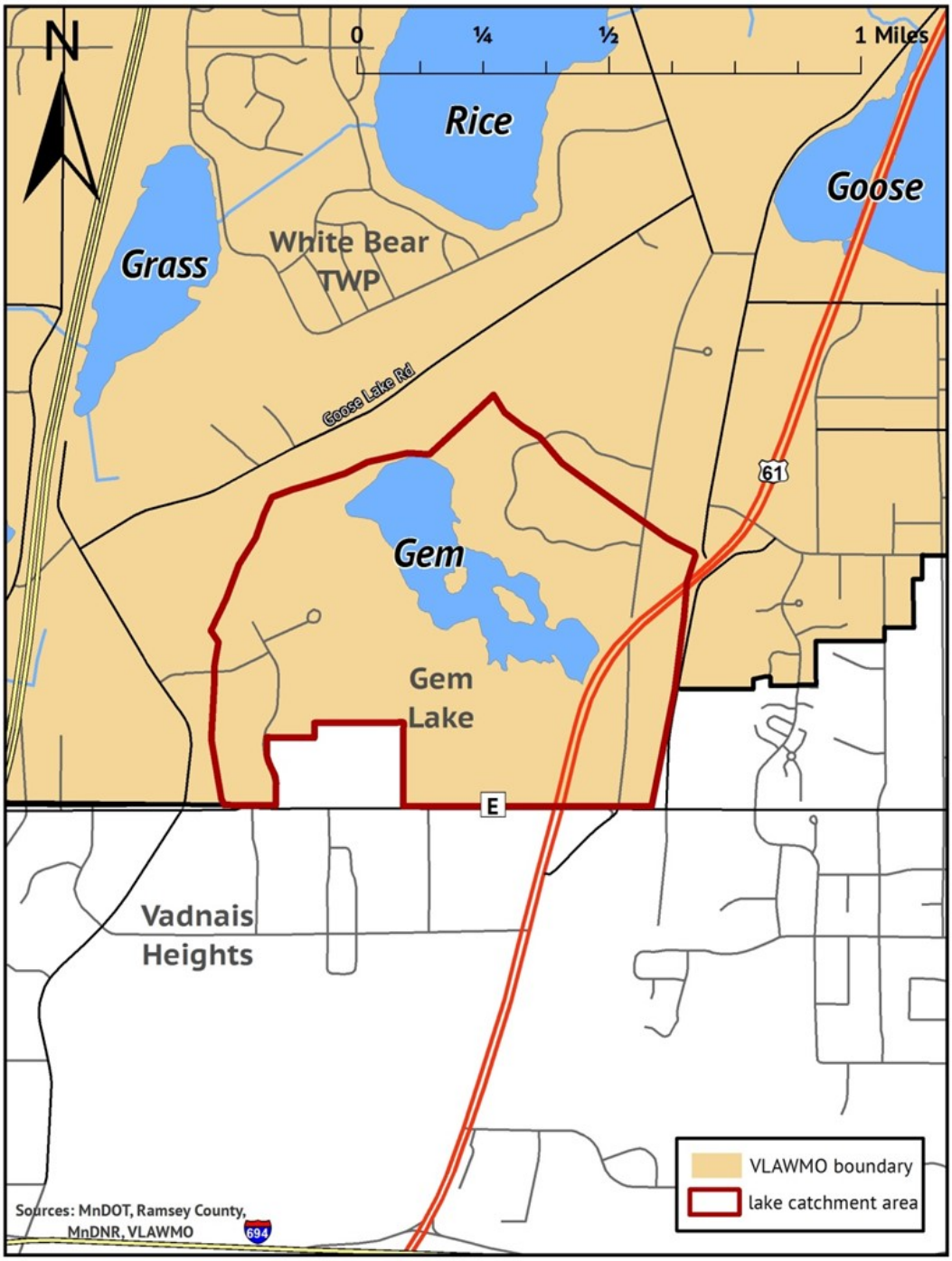


- Nitrogen and ammonia levels are below state standards for Deep Lake

GEM LAKE

Gem Lake is within the City of Gem Lake and has no public access. It is 25 acres in size and is 17 feet deep. There has been development along portions of the lake in recent years. In 2000, volunteers noticed a distinct algae bloom and noted that water clarity was getting poorer. Over the 16 years of monitoring data there is a slight up trend in TP levels with a slight down trend in ChlA levels.

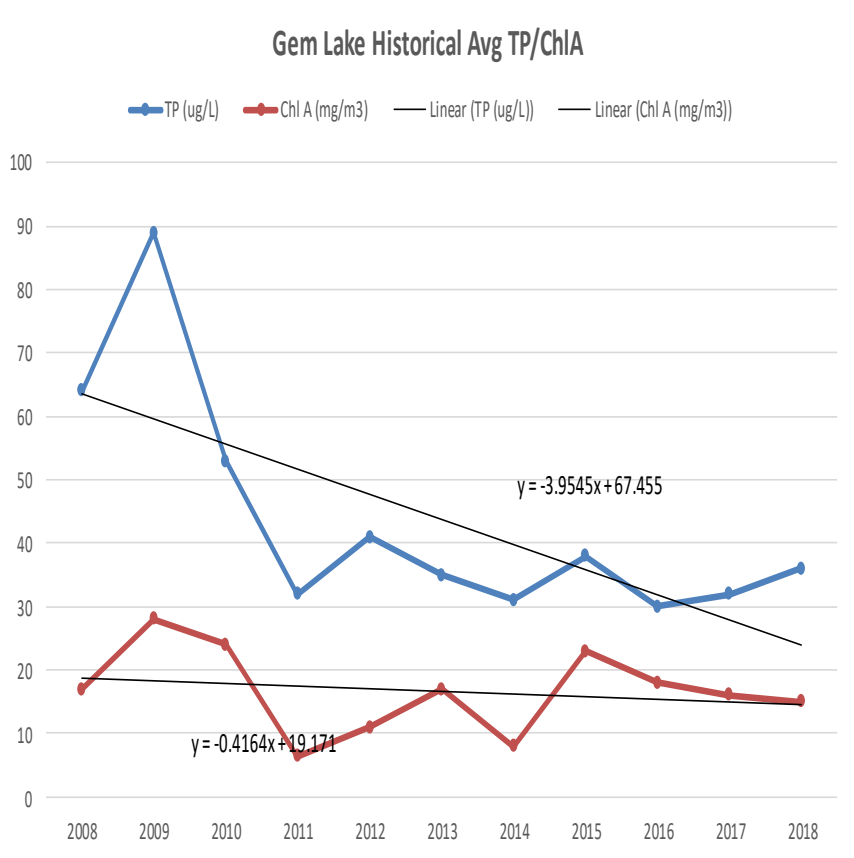
Gem Lake has also been included on the Lambert Creek TMDL study for nutrient impairment. Recent years of monitoring data have shown a reduction in nutrient levels to below state standards. MNDOT's Hwy 61 ditch work in 2011 improved the water quality going into Gem Lake. In 2018 Gem Lake was delisted from the MN PCA's impaired waters list.



GEM LAKE

Gem Lake Historical Avg TP/Chl A/SDT			
Year	TP (ug/L)	Chl A (mg/m3)	Secchi (m)
1997	54	23	1.2
1998	33	24	
1999	26	16	1.2
2000	36	17	1.1
2001	56	12	1.8
2002	39	25	1.3
2003	52	20	1.4
2004	49	0	1.5
2005	43	26	0
2006	63	25	0
2007	48	33	1.1
2008	64	17	1.5
2009	89	28	1.3
2010	53	24	1.4
2011	32	6.4	2.1
2012	41	11	2
2013	35	17	2
2014	31	8	2.9
2015	38	23	2.2
2016	30	18	1.6
2017	32	16	1.5
2018	36	15	1.8

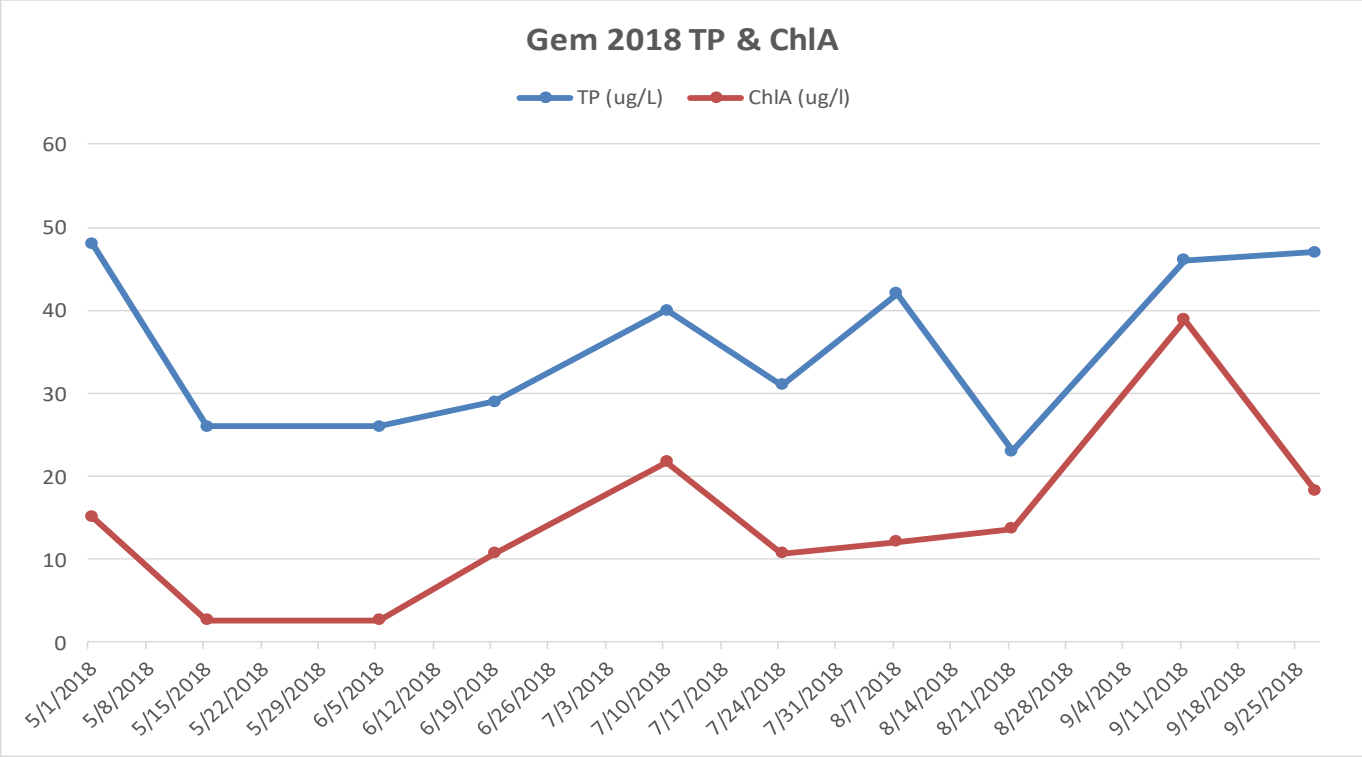
Date	Reading Depth (Bottom/ Middle/ Top)	Temp °C	Conduc-tivity (mS/cm)	DO (mg/L)	pH
5/22/2018	b	9.29	0.177	1.44	7.42
5/22/2018	m	15.79	0.177	8.14	7.58
5/22/2018	t	18.56	0.181	6.91	7.62
6/21/2018	b	13.14	0.182	0.56	7.78
6/21/2018	m	21.83	0.183	4.87	7.69
6/21/2018	t	23.98	0.181	6.04	8.17



- YSI data is similar to that of other metro lakes. Conductivity is pretty low which is good and usually Gem Lake shows signs of stratification. At 17ft, Gem is one of the deepest lakes VLAWMO monitors. TP and ChlA levels are well below state standards for the 7th year in a row. Hwy 61 was redone in 2011 and MNDOT did work on the ditches along the Hwy. That work seems to have benefited the water quality in Gem

GEM LAKE

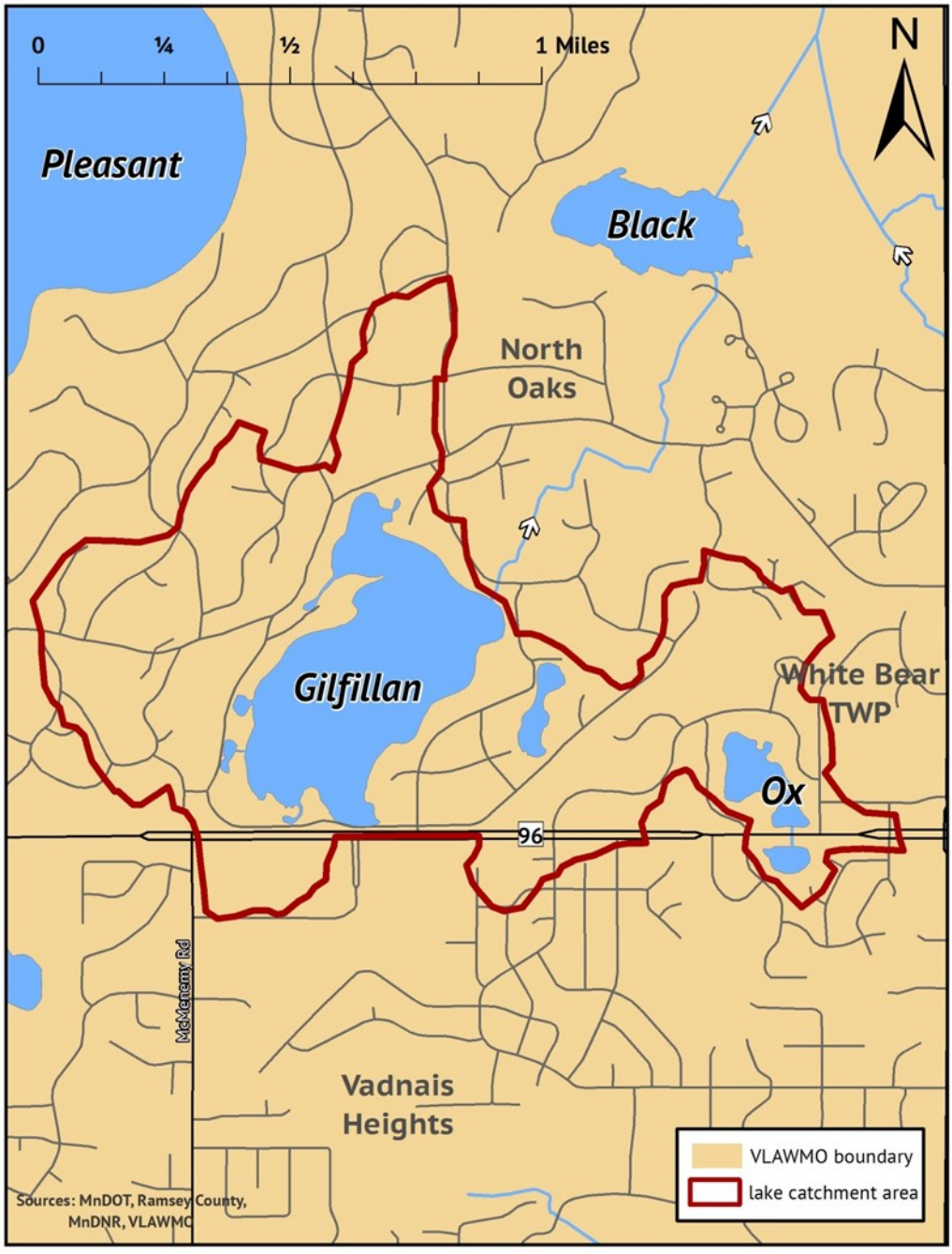
SITE	DATE	Secchi (ft)	TP (ug/L)	SRP (mg/L)	ChlA (ug/l)	TKN (mg/L)	NH3 (mg/L)	NO2+NO3 mg/L	CL (mg/L)
gem	5/1/2018								34
gem	5/1/2018	5	48	< 0.003	15	0.786	0.503	0.066	
gem	5/15/2018	7.5	26	< 0.003	3				
gem	6/5/2018		26	< 0.003	3	0.593	< 0.04	< 0.03	
gem	6/19/2018	6	29	< 0.003	11				
gem	7/10/2018	4	40	< 0.003	22	1.13	< 0.04	< 0.03	
gem	7/24/2018	6	31	< 0.003	11				
gem	8/7/2018	7	42	< 0.003	12	0.749	< 0.04	< 0.03	
gem	8/21/2018	9	23	< 0.003	14				
gem	9/11/2018	2.75	46	< 0.003	39	1.11	< 0.04	< 0.03	
gem	9/27/2018	5	47	< 0.003	18				



- Nitrogen and ammonia levels are below state standards for Gem Lake.

Gilfillan Lake

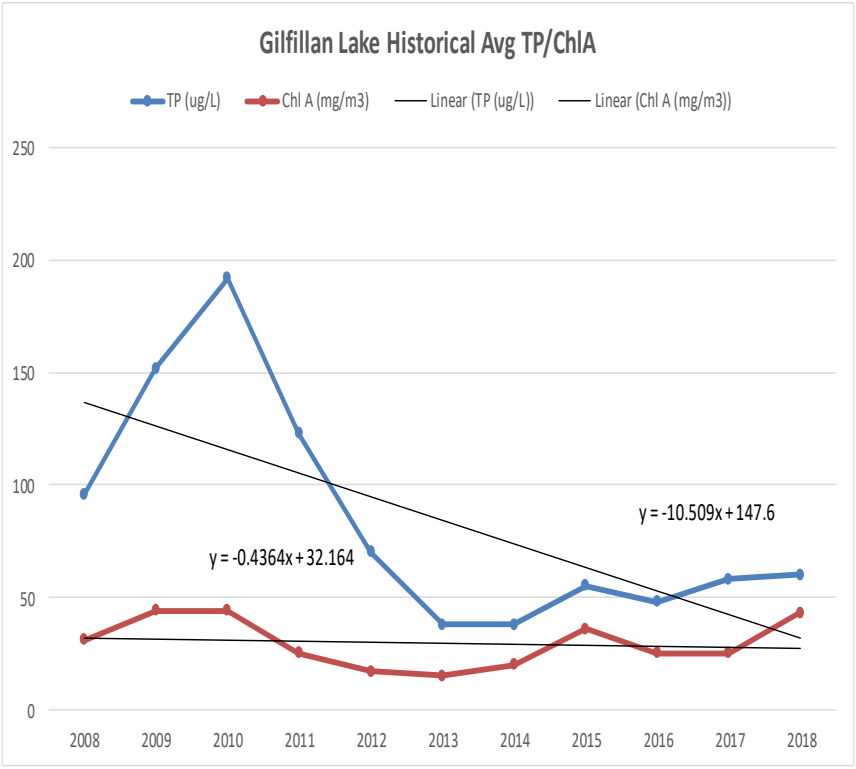
Gilfillan Lake is located within the City of North Oaks and is surrounded by homes. It is 110 acres with a maximum depth of 6 feet. The Minnesota Department of Natural Resources has used the lake for walleye stocking nursery in the past. According to available information, there has not been any fish stocking activity for a few years other than homeowners socking minnows. Gilfillan is one of four VLAWMO lakes that are part of the TMDL study due to nutrient impairment. The City of North Oaks and the SPRWS have been pumping water from Pleasant Lake to Gilfillan Lake to increase water levels. The pump, filter and piping were installed fall of 2011, pumping began spring of 2012. The increased water level (about 4.5ft) has significantly reduced nutrient levels in the lake, although they are still above state standards. The pumps have been turned on in the spring the last few years to make sure everything was working properly and were then shut off for the season due to high water. Water level stayed close to the max elevation of 910ft for the summer.



Gilfillan Lake

Gilfillan Lake Historical Avg TP/Chl A/SDT			
Year	TP (ug/L)	Chl A (mg/m3)	Secchi (m)
1997	96	32	0.5
1998	47	44	0.5
1999	72	23	0
2000	35	47	0
2001	84	20	0
2002	81	43	0.4
2003	44	25	1.4
2004	58	0	0
2005	52	8	0
2006	91	19	0
2007	100	33	0.7
2008	96	31	0.5
2009	152	44	0.4
2010	192	44	0.4
2011	123	25	0.4
2012	70	17	0.8
2013	38	15	1
2014	38	20	0.8
2015	55	36	0.6
2016	48	25	0.7
2017	58	25	0.7
2018	60	43	0.7

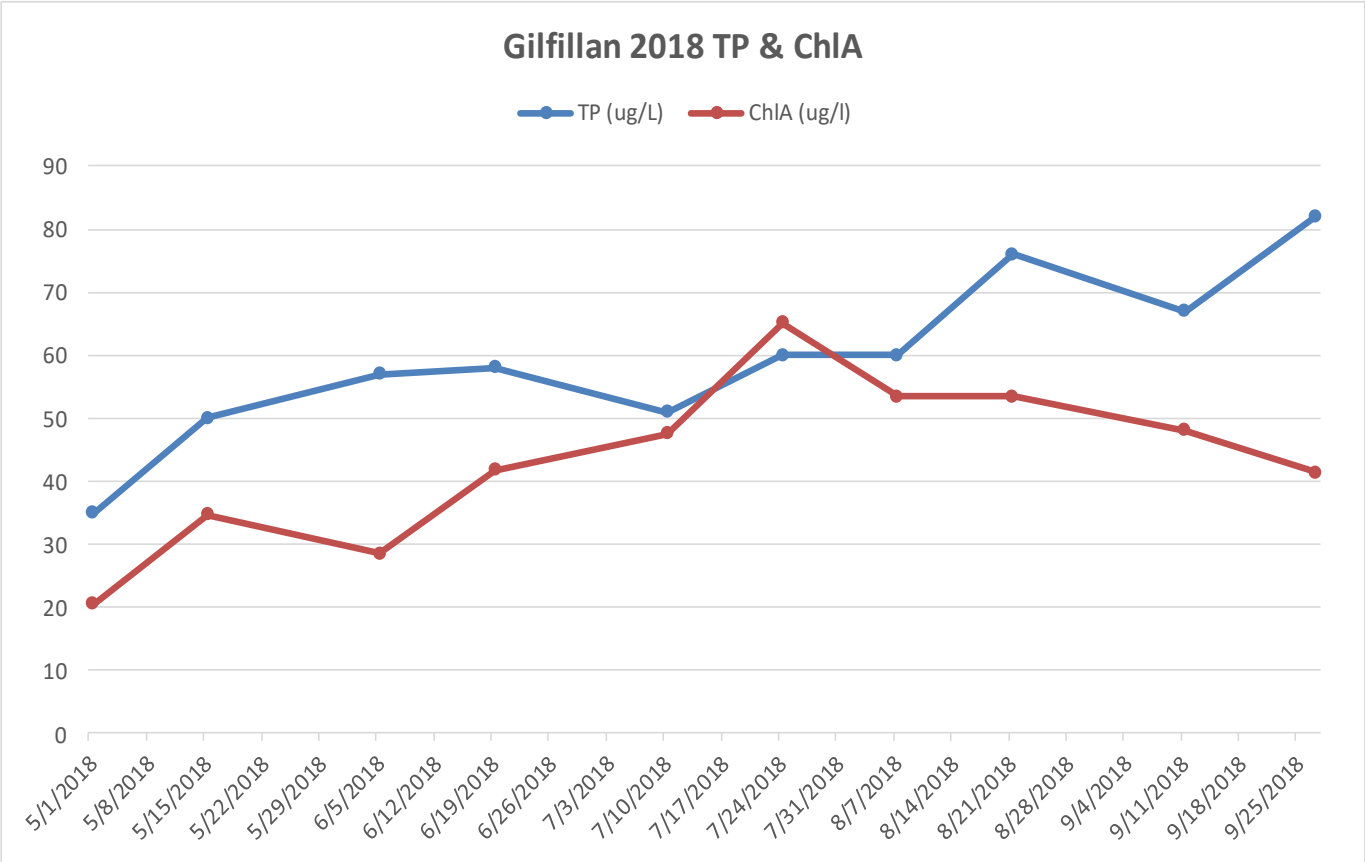
Date	Reading Depth (Bottom/ Top)	Temp °C	Conduc-tivity (mS/cm)	DO (mg/L)	pH
5/22/2018	b	16.62	0.291	0.85	7.65
5/22/2018	t	19.26	0.282	7.04	7.81
6/21/2018	b	23.3	0.294	3.69	7.86
6/21/2018	t	24.14	0.286	6.13	8.02
9/5/2018	b	22.32	0.292	5.03	7.32
9/5/2018	t	22.34	0.292	5.24	7.62



- Gilfillan Lake YSI data is similar to that of other metro lakes. Conductivity is pretty low and is consistent with other lakes that don't receive much or any road runoff. Inlet data is from 2012, shows below state standard Tp levels being pumped into main lake. Since augmentation began again in 2012, lake nutrients have dropped substantially. This could very well be due to the 4+ft of Pleasant Lake water added to Gilfillan in 2012. Since 2012 very little augmentation has taken place to the lake due to natural precipitation keeping the lake at the residents desired elevation of around 910ft. Nutrient levels are slightly rising from the lows at the start of augmentation.

Gilfillan Lake

SITE	DATE	Secchi (ft)	TP (ug/L)	SRP (mg/L)	ChlA (ug/l)	TKN (mg/L)	NH3 (mg/L)	NO2+NO3 mg/L	CL (mg/L)
gilfillan	5/1/2018								31
gilfillan	5/1/2018	3	35	< 0.003	21	1.78	0.533	< 0.03	
gilfillan	5/15/2018	2	50	< 0.003	35				
gilfillan	6/5/2018		57	< 0.003	29	1.48	< 0.04	< 0.03	
gilfillan	6/19/2018	2	58	< 0.003	42				
gilfillan	7/10/2018	1.5	51	< 0.003	48	1.99	0.091	< 0.03	
gilfillan	7/24/2018	1.5	60	< 0.003	65				
gilfillan	8/7/2018	1.5	60	< 0.003	53	1.95	< 0.04	< 0.03	
gilfillan	8/21/2018	2	76	< 0.003	53				
gilfillan	9/11/2018	2	67	< 0.003	48	1.9	< 0.04	< 0.03	
gilfillan	9/27/2018	2	82	< 0.003	41				



- Nitrogen and ammonia levels are below state standards for Gilfillan Lake

Goose Lake

Goose Lake is located in White Bear Lake and is 145 acres with a maximum depth of 7 feet. The land use is largely residential and industrial around the lake and Highway 61 cuts through the lake. The old White Bear Lake sewage treatment plant discharged to Goose Lake for almost 50 years. A sediment study conducted in 1989 found that there was PCB contamination as well as high levels of cadmium, lead, and zinc. Another sediment study should be conducted to look for any changes in the last 20 years.

Though the lake is connected via culverts under the highway, VLAWMO began to assess the lake on each side of the road to track any differences between the two water bodies. In years past, only the east side of the lake was monitored. In 2006, VLAWMO began to collect samples from the west side. Both East and West Goose Lake are included in the Lambert Creek TMDL for nutrient impairment.

Groundwater used to cool equipment at the Kohler Mix Company is continuously discharging into the south end of West Goose Lake year round at a rate of 500 gallons/minute. This seems to be "flushing" the west side of the lake and could be a major reason the west side of the lake has consistently had better water quality compared to the east side over the years. The north end of West Goose discharges through a weir into Lambert Creek which flows into East Vadnais Lake, the drinking water reservoir for the SPRWS.

Approximately 16,000lbs of bullhead were removed out of both basins in 2013. The main source of nutrient issues in Goose Lake is from internal loading. Rough fish (bullhead, carp, sucker) suspend nutrients in the water column while foraging for food. We hope to see a decrease in nutrient levels over the next few years due to the rough fish removal. Spring of 2015 nets were be placed in the lake again to make sure the fish harvest was successful. BioBase surveys were done on both basins in 2014 to monitor the aquatic vegetation.

The 2017 fish survey showed the rough fish removal worked and bullhead numbers are still low and seem to be in check. Plans are moving forward for a number of projects in and around the Goose Lake subwatershed in the next few years to address water quality.

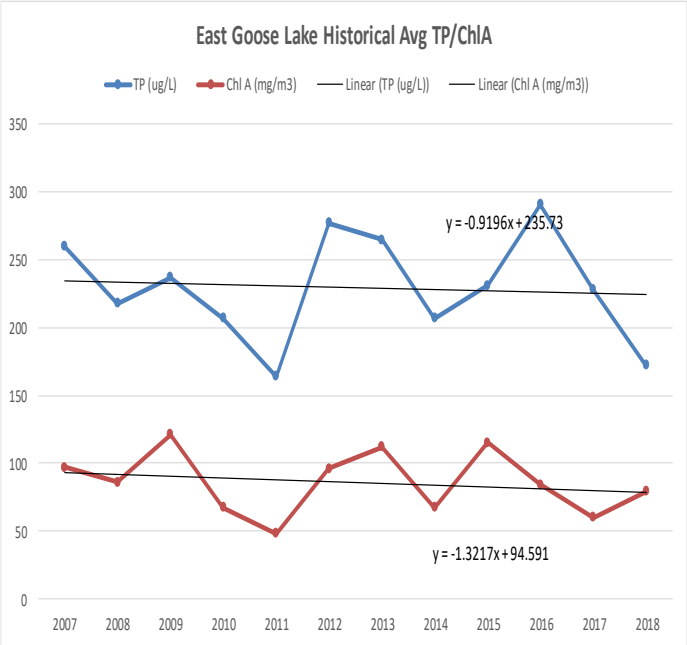
Goose Lake

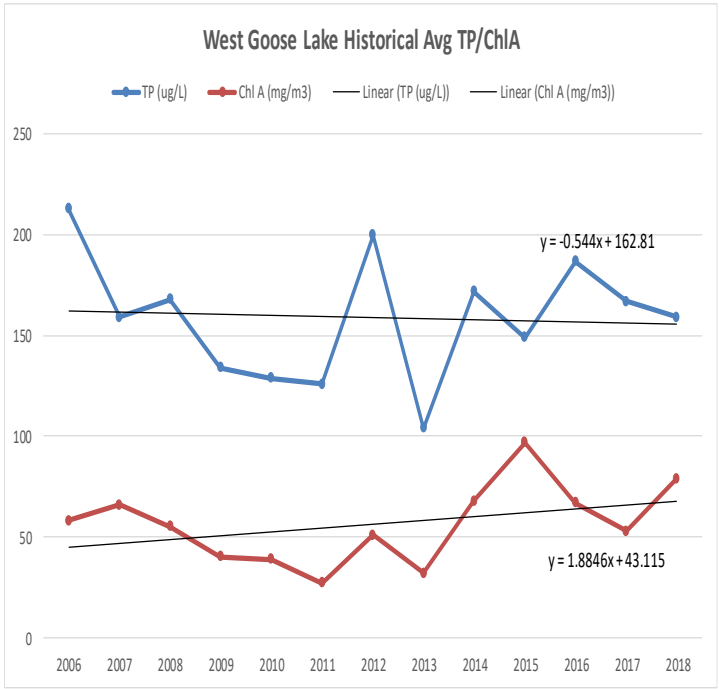

0
¼
½
1 Miles
N
Birch
96
White Bear
LAMBERT CREEK
Rice
White Bear TWP
East Goose
West Goose
Gem Lake
61
White Bear Lake
Gem
E
White Bear Ave
VLAWMO boundary
lake catchment area
Sources: MnDOT, Ramsey County, MnDNR, VLAWMO

Goose Lake

East Goose Lake Historical Avg TP/Chl A/SDT			
Year	TP (ug/L)	Chl A (mg/m3)	Secchi (m)
1997	21	134	0.4
1998	17	93	0.2
1999	475	56	0.3
2000	49	154	0.3
2001	603	28	0.3
2002	613	170	0.2
2003	342	66	0.3
2004	526	0	0
2005	407	38	0
2006	392	81	0
2007	260	97	0
2008	218	86	0.3
2009	237	121	0.3
2010	207	67	0.3
2011	164	48	0.3
2012	277	96	0.2
2013	265	112	0.5
2014	207	67	0.4
2015	231	115	0.6
2016	291	84	0.5
2017	228	60	0.7
2018	172	79	0.4

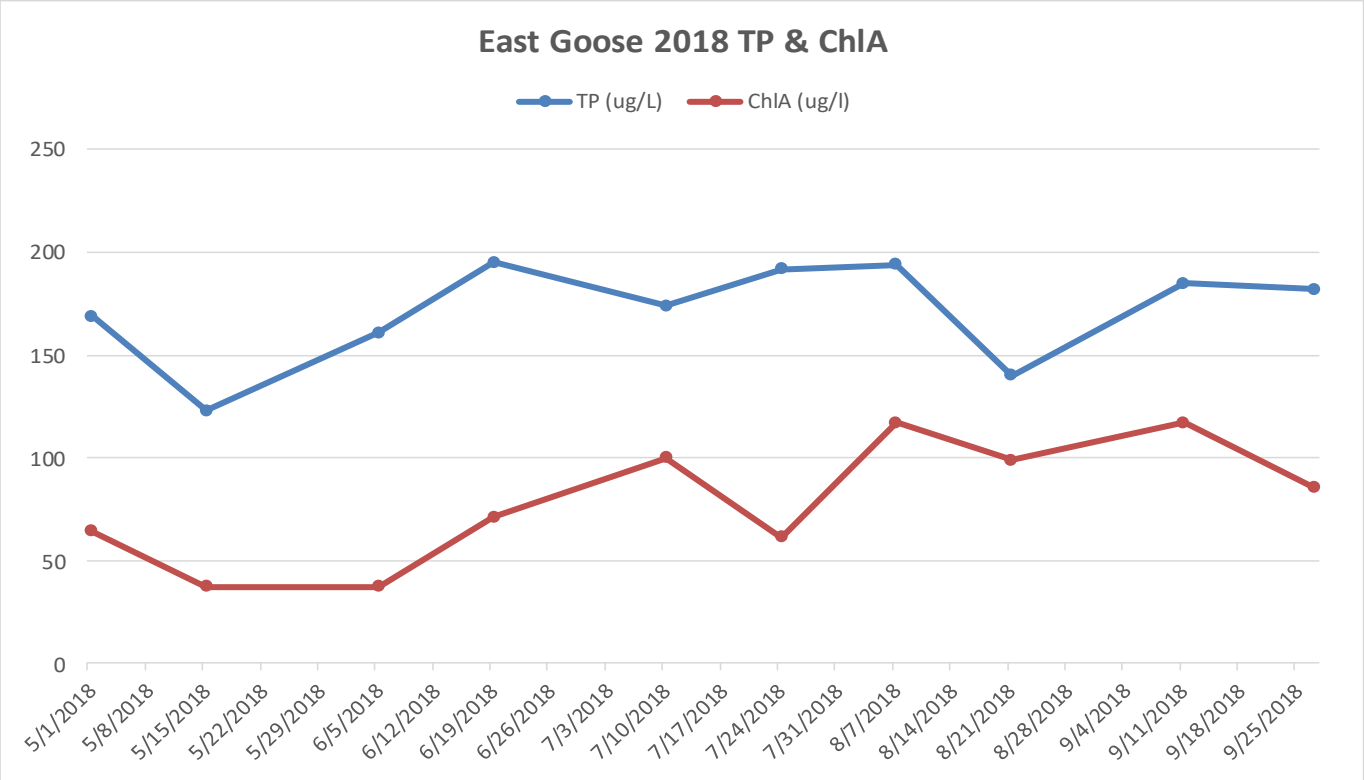
West Goose Lake Historical Avg TP/Chl A/SDT			
Year	TP (ug/L)	Chl A (mg/m3)	Secchi (m)
2006	213	58	
2007	159	66	
2008	168	55	0.3
2009	134	40	0.5
2010	129	39	0.5
2011	126	27	0.8
2012	200	51	0.7
2013	104	32	1
2014	172	68	0.5
2015	149	97	0.5
2016	187	67	0.4
2017	167	53	0.4
2018	159	79	0.4





Goose Lake

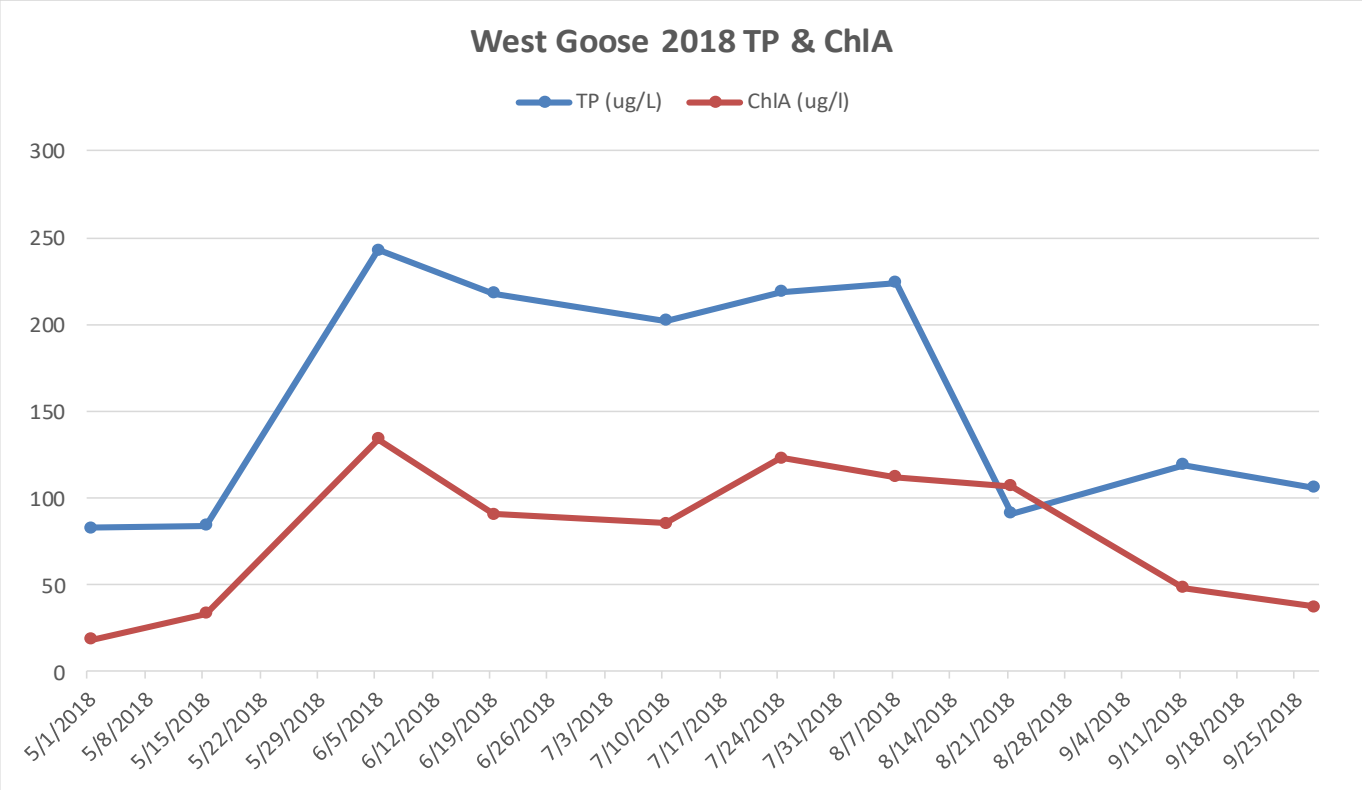
SITE	DATE	Secchi (ft)	TP (ug/L)	SRP (mg/L)	ChlA (ug/l)	TKN (mg/L)	NH3 (mg/L)	NO2+NO3 mg/L	CL (mg/L)	Iron (ug/L)
east goose	5/1/2018								90	
east goose	5/1/2018	2	169	0.007	64	1.75	0.129	< 0.03		701
east goose	5/15/2018	2	123	< 0.003	37					260
east goose	6/5/2018		161	< 0.003	37	1.48	< 0.04	< 0.03		0.7
east goose	6/19/2018	1	195	< 0.003	71					653
east goose	7/10/2018	1	174	< 0.003	100	2.79	< 0.04	< 0.03		507
east goose	7/24/2018	0.75	192	< 0.003	61					604
east goose	8/7/2018	1	194	< 0.003	117	3.18	< 0.04	< 0.03		496
east goose	8/21/2018	1	140	< 0.003	99					672
east goose	9/11/2018	1	185	< 0.003	117	2.95	< 0.04	< 0.03		688
east goose	9/27/2018	1	182	< 0.003	85					678



- East Goose Lake YSI data is similar to that of other metro lakes.
- Iron levels are well above standards for West Goose Lake. West side levels are slightly lower than the East side levels, overall they are pretty similar considering the big difference in nutrient levels between the two basins even though they are connected.

Goose Lake

SITE	DATE	Secchi (ft)	TP (ug/L)	SRP (mg/L)	ChlA (ug/l)	TKN (mg/L)	NH3 (mg/L)	NO2+NO3 mg/L	CL (mg/L)	Iron (ug/L)
west goose	5/1/2018								50	
west goose	5/1/2018	3	83	< 0.003	19	1.59	0.747	0.047		270
west goose	5/15/2018	2	84	< 0.003	33					498
west goose	6/5/2018		243	< 0.003	134	2.67	< 0.04	< 0.03		0.51
west goose	6/19/2018	1	218	< 0.003	91					970
west goose	7/10/2018	0.75	202	< 0.003	85	2.12	0.207	< 0.03		771
west goose	7/24/2018	0.5	219	0.01	123					769
west goose	8/7/2018	0.5	224	0.003	112	3.04	< 0.04	< 0.03		326
west goose	8/21/2018	0.5	91	0.003	107					805
west goose	9/11/2018	1	119	0.007	48	2.13	< 0.04	< 0.03		381
west goose	9/27/2018	1.5	106	< 0.003	37					< 0.5



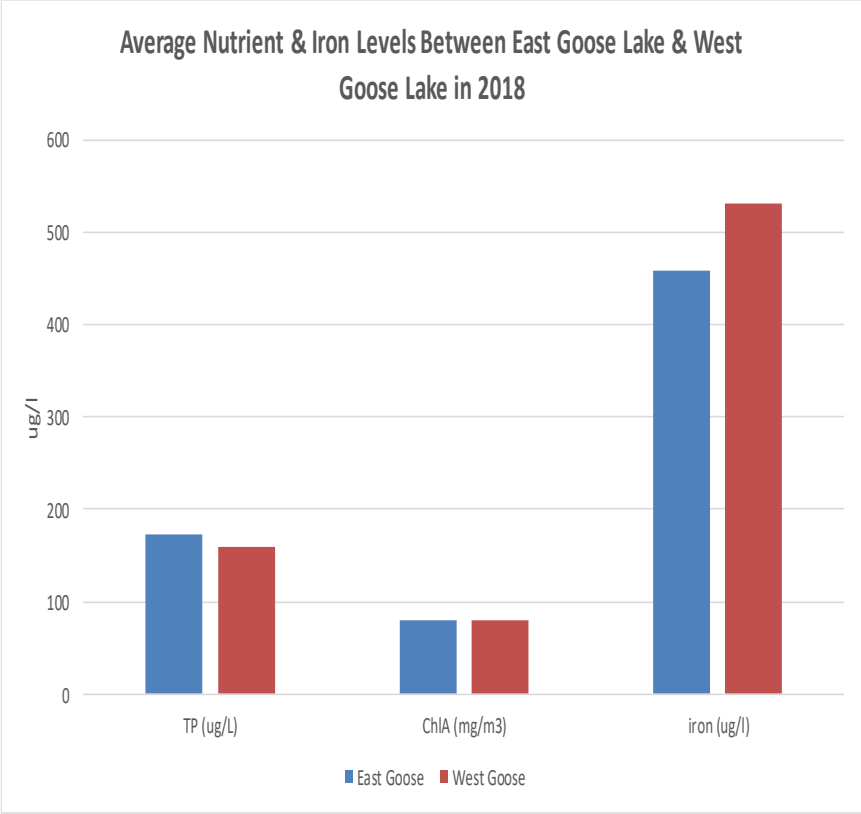
- West Goose Lake YSI data is similar to that of East Goose Lake
- Iron levels are well above standards for East Goose Lake 300 ug/l
- Both the East and West side are showing long term downward trends for both TP & ChlA. This is a good sign but both these water bodies are still well above state standards.
- Comparison of water quality between the two basins above shows that Goose Lake West has better average TP and Chla levels compared to Goose Lake East, however both basins are still above PCA standards. TMDL will focus on strategies to move these two basins closer to state standards. Rough fish removal by VLAWMO along with new road construction projects around the lake by the City of White Bear Lake will hopefully help with both the external and internal nutrient loading to the lake reducing overall nutrient levels in the lake.

Goose Lake

East Goose	Reading Depth (Bottom/ Top)	Temp °C	Conduc-tivity (mS/cm)	DO (mg/L)	pH
5/1/2018	b	10.3	0.383	10.41	7.58
5/1/2018	t	10.87	0.383	10.42	7.47
5/15/2018	b	17.06	0.396	9.22	7.88
5/15/2018	t	17.61	0.396	9.72	8.09
6/5/2018	b	21.14	0.402	7.04	10.49
6/5/2018	t	21.33	0.402	7.21	10.41
6/19/2018	b	23.87	0.377	6.01	8.64
6/19/2018	t	23.97	0.377	6.56	8.77
7/10/2018	b	26.6	0.379	5.97	8.55
7/10/2018	t	26.83	0.384	7.05	8.83
7/24/2018	b	24.7	0.359	6.24	8.51
7/24/2018	t	25.6	0.371	8.02	8.83
8/7/2018	b	23.89	0.354	5.14	8.21
8/7/2018	t	24.69	0.365	8.12	8.61
8/21/2018	b	23.96	0.365	5.27	8.21
8/21/2018	t	23.98	0.366	5.53	8.31
9/11/2018	b	20.13	0.346	7.42	8.21
9/11/2018	t	20.73	0.349	8.07	8.3
9/27/2018	b	15.25	0.31	8.42	7.73
9/27/2018	t	15.25	0.31	8.36	7.51

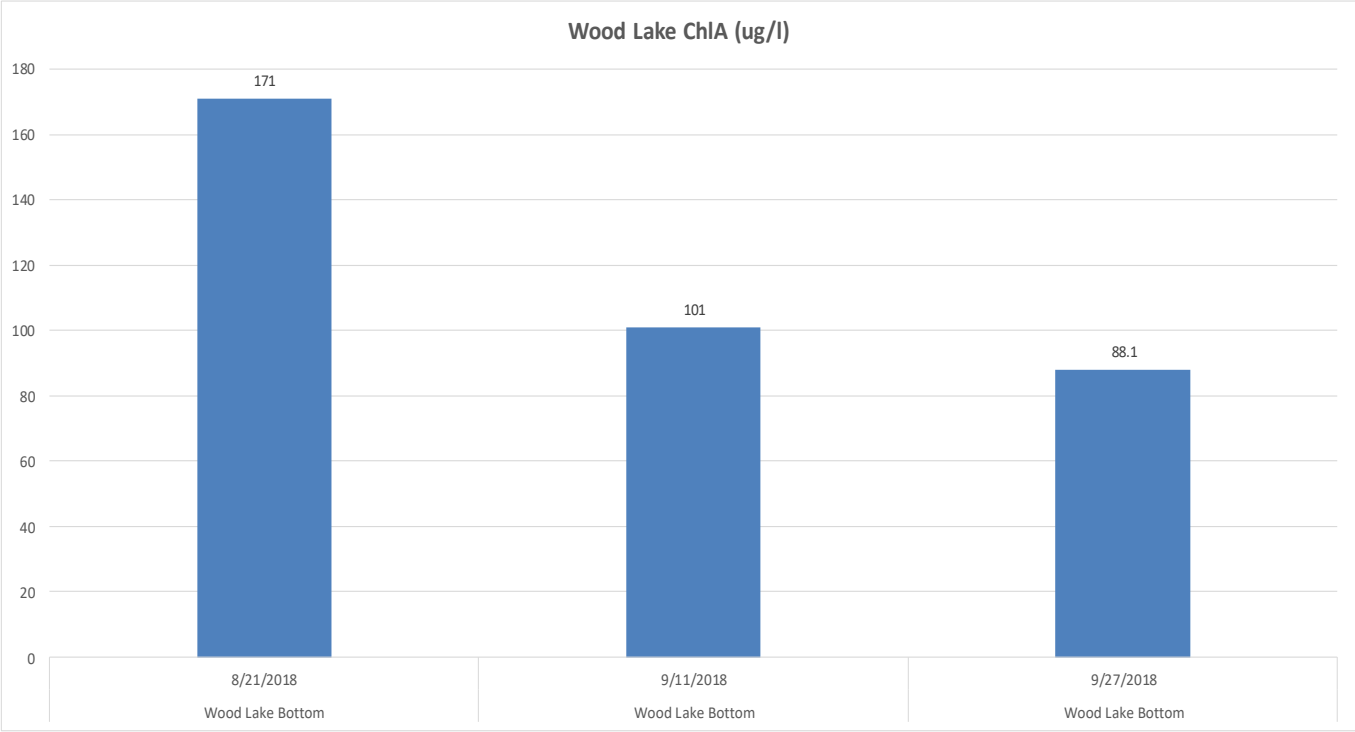
West Goose	Reading Depth (Bottom/ Top)	Temp °C	Con-ductivity (mS/	DO (mg/L)	pH
5/2/2017	B	8.17	0.322	9.12	5.34
5/2/2017	T	8.12	0.323	9.03	5.29
6/6/2017	B	22.2	0.311	6.8	8.85
6/6/2017	T	22.29	0.311	6.81	8.95
6/20/2017	B	21.93	0.31	6.25	9.05
6/20/2017	T	22.06	0.31	6.26	9.09
7/11/2017	B	26.32	0.3	7.3	9.18
7/11/2017	T	27.05	0.299	8.15	9.38
8/8/2017	B	22.41	0.304	7.37	10.71
8/8/2017	T	22.55	0.304	7.99	11.15
8/22/2017	B	20.59	0.306	5.71	8.19
8/22/2017	T	21.86	0.305	7.23	8.43
9/12/2017	B	19.80	0.300	7.13	9.73
9/12/2017	T	20.77	0.295	9.00	9.87
9/26/2017	B	21.34	0.294	6.64	9.08
9/26/2017	T	21.35	0.294	6.54	9.05

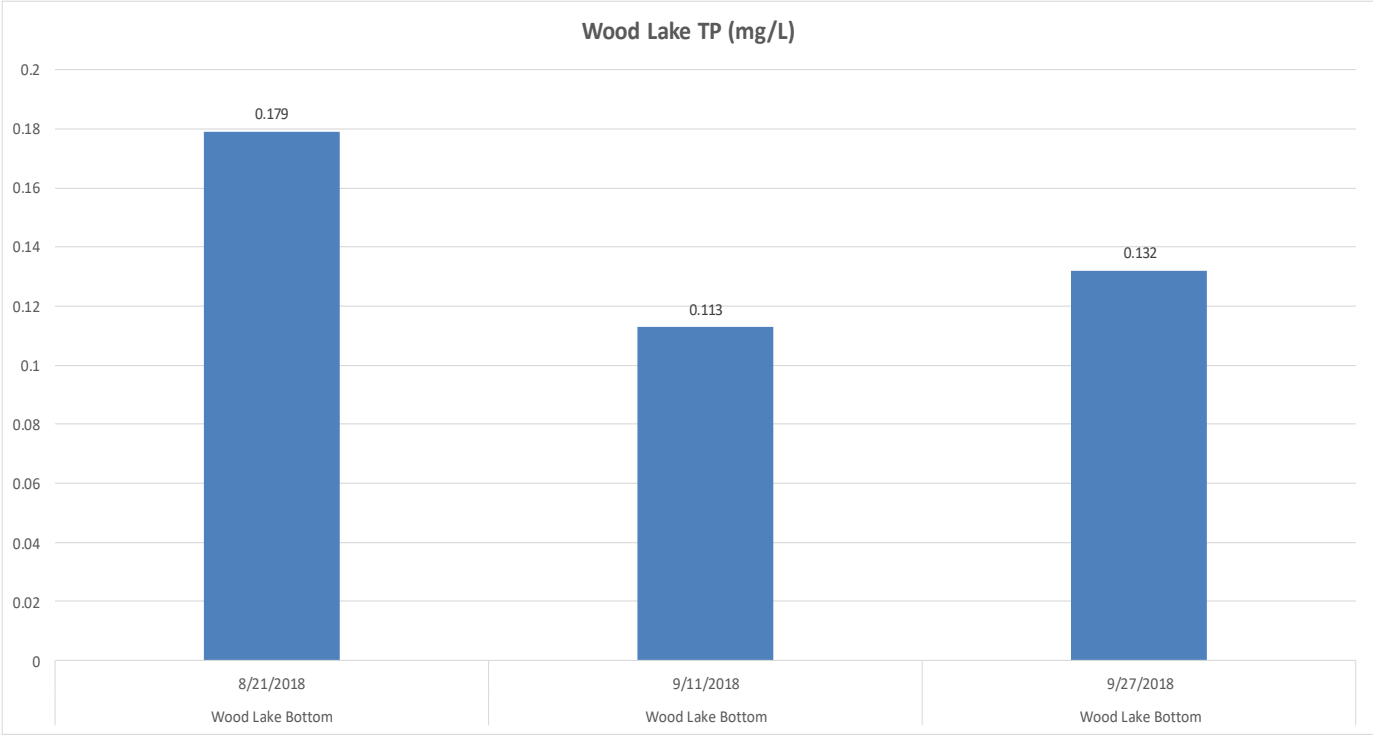
	TP (ug/L)	ChlA (mg/	iron (ug/l)
East Goose	172	79	458
West	159	79	532



Goose Lake-Wood Lake

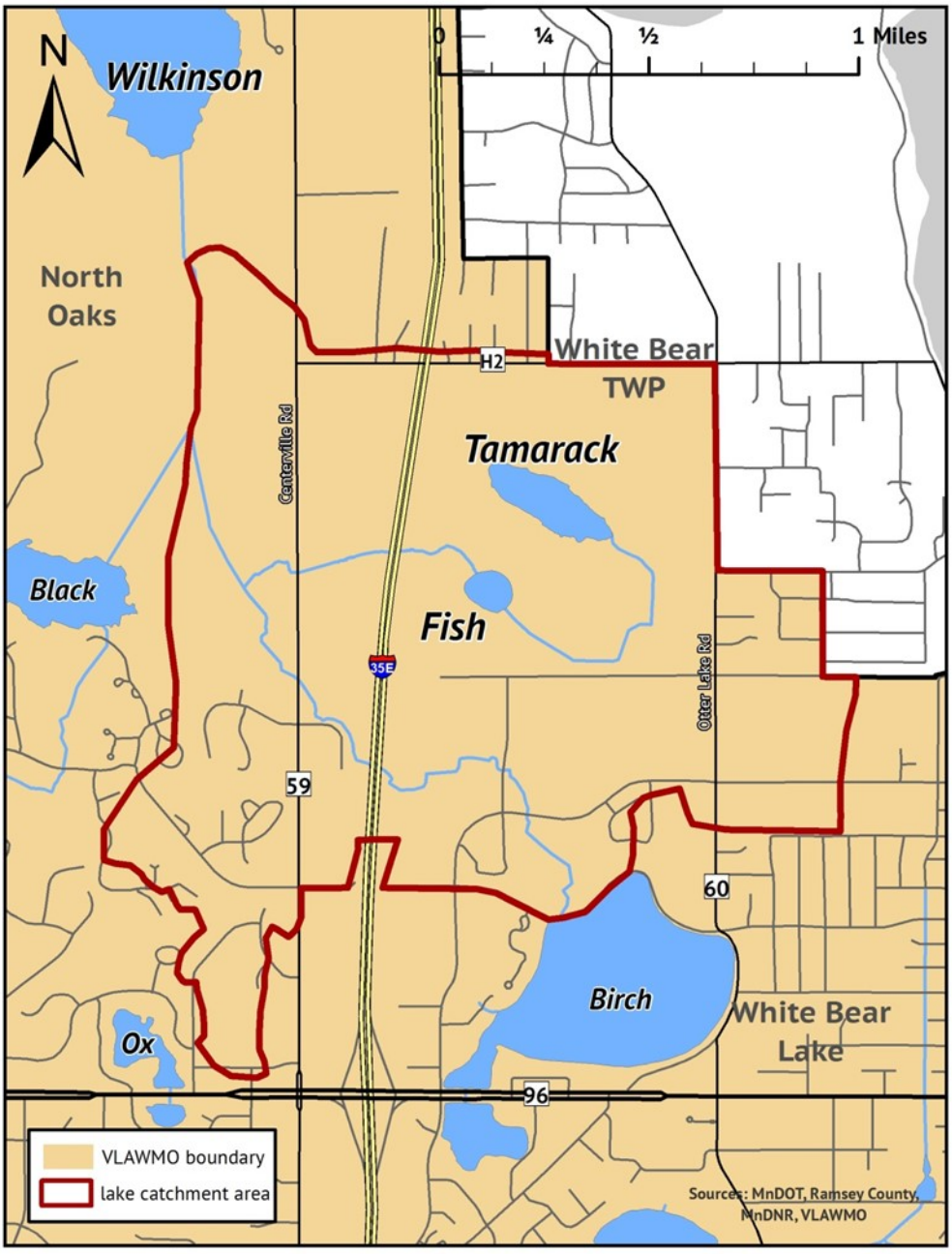
SITE	DATE	Secchi (ft)	TP (mg/L)	SRP (mg/L)	Iron (ug/L)	ChlA (ug/l)	TKN (mg/L)	NH3 (mg/L)	NO2+NO3 mg/L
Wood Lake Bottom	8/21/2018	1	0.179	< 0.003	212	171	3.83	0.362	< 0.03
Wood Lake Bottom	9/11/2018	1	0.113	< 0.003	214	101	2.29	0.048	< 0.03
Wood Lake Bottom	9/27/2018	1.5	0.132	< 0.003	< 0.5	88.1	2.26	0.594	0.043





Tamarack Lake

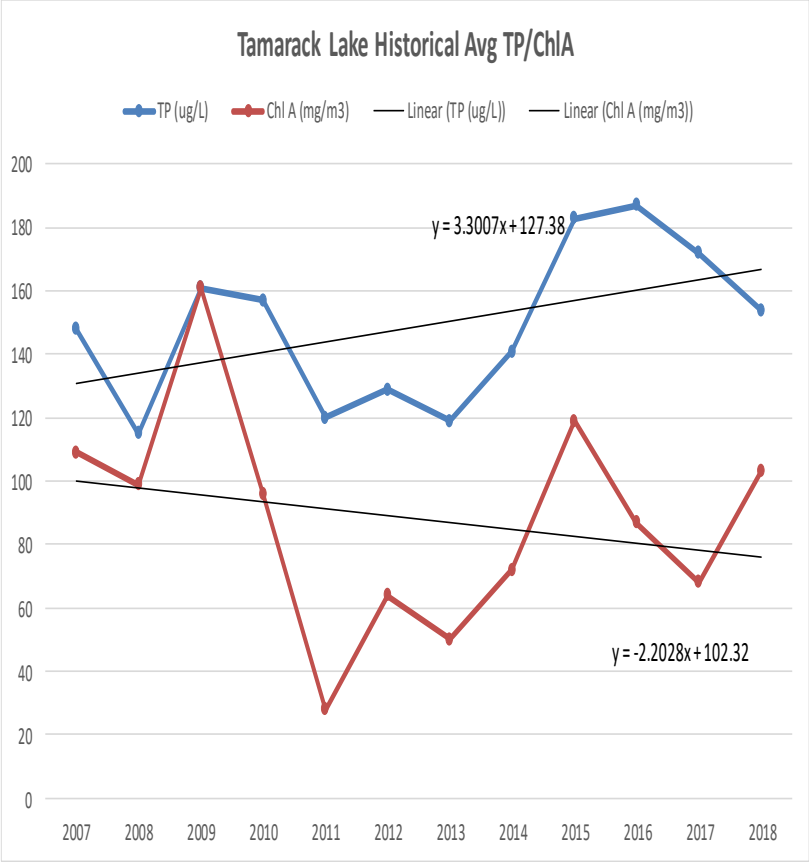
Tamarack Lake is part of the Tamarack Nature Center. It is 86 acres with a maximum depth of 10 feet. As there is no boat access, samples are taken from the observation dock on the southeast side of the lake. Ramsey County restored a large ditched wetland downstream of Tamarack and upstream of Fish Lake, as part of a wetland-banking project in 1997. Tamarack Lake is one of 4 lakes listed as impaired for nutrients on the 2010 Lambert Creek TMDL study. Internal loading is the major reason for the impairment. This is a very isolated lake with a large natural buffer, runoff from Hwy 35E will make its way to Tamarack on the west side after going through a large wetland. Historically Tamarack was surrounded by farmland. TP & ChlA levels are extremely high and show little sign of lowering. In the summer of 2013 VLAWMO installed a floating island on the lake. The island was planted with native vegetation. The root systems that develop below the island create a large surface area for highly beneficial microbes allowing for increased nutrient uptake and reduction in overall nutrient levels in the lake.



Tamarack Lake

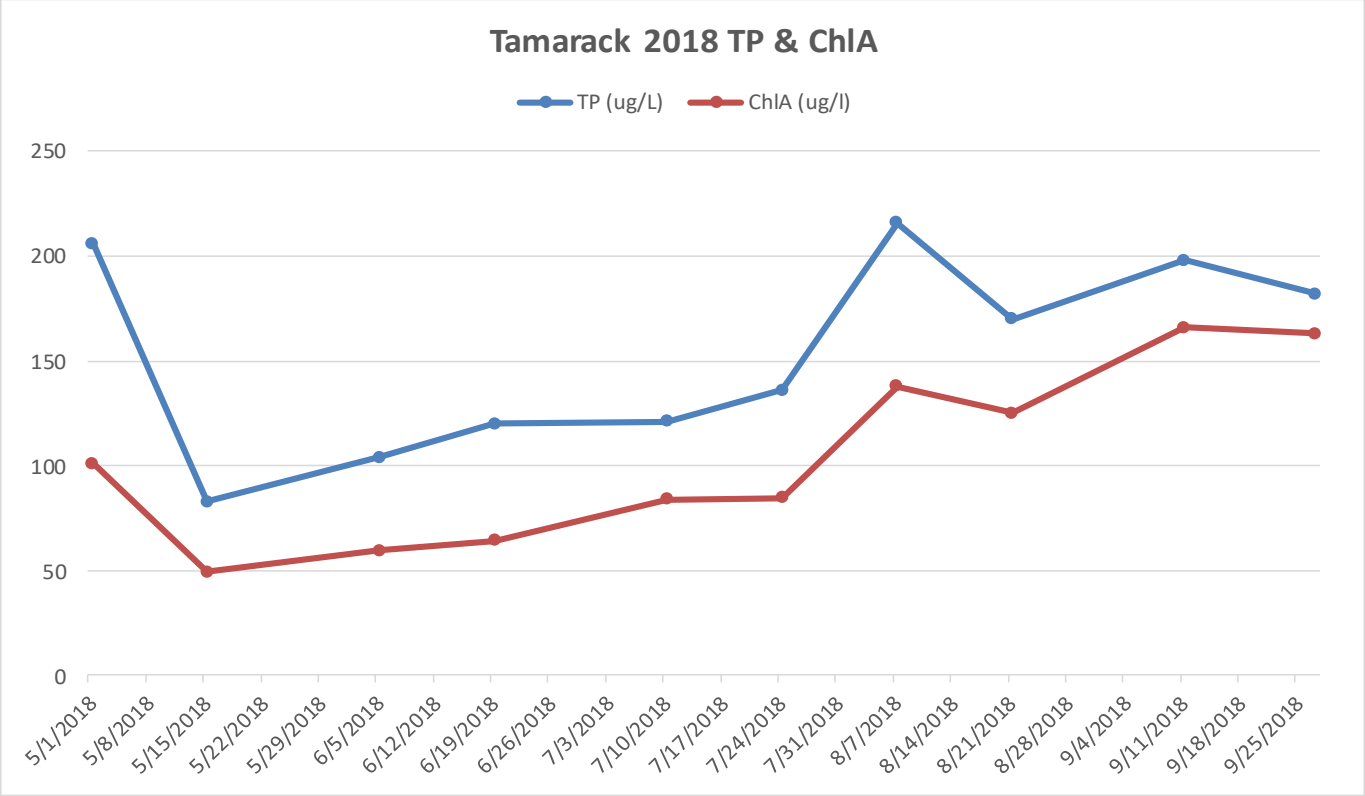
Tamarack Lake Historical Avg TP/ChlA/SDT			
Year	TP (ug/L)	Chl A (mg/m3)	Secchi (m)
1997	17	180	0.2
1998	54	32	0.5
1999	90	26	0.4
2000	60	27	0.4
2001	132	37	0.4
2002	164	120	0.4
2003	168	95	0.3
2004	96	0	0.8
2005	143	65	0
2006	136	38	0
2007	148	109	0.5
2008	115	99	0.3
2009	161	161	0.2
2010	157	96	0.2
2011	120	28	0.6
2012	129	64	0.4
2013	119	50	0.5
2014	141	72	0.5
2015	183	119	0.4
2016	187	87	0.4
2017	172	68	0.4
2018	154	103	0.4

Tamarack	Reading Depth (Bottom/ Top)	Temp °C	Conduc-tivity (mS/cm)	DO (mg/L)	pH
5/22/2018	b	18.84	0.39	6.11	7.99
5/22/2018	t	18.94	0.388	6.27	8.04
6/21/2018	b	23.31	0.403	3.25	7.82
6/21/2018	t	24.15	0.398	5.03	7.96
9/5/2018	b	21.85	0.358	4.45	7.33
9/5/2018	t	21.89	0.357	4.4	7.76



Tamarack Lake

SITE	DATE	Secchi (ft)	TP (ug/L)	SRP (mg/L)	ChlA (ug/l)	TKN (mg/L)	NH3 (mg/L)	NO2+NO3 mg/L	CL (mg/L)
tamarack	5/1/2018								40
tamarack	5/1/2018	1.5	206	0.007	101	2.98	0.766	< 0.03	
tamarack	5/15/2018	1.5	83	< 0.003	49				
tamarack	6/5/2018		104	< 0.003	60	1.63	< 0.04	< 0.03	
tamarack	6/19/2018	1.5	120	< 0.003	64				
tamarack	7/10/2018	1	121	< 0.003	84	2.24	0.063	< 0.03	
tamarack	7/24/2018	1.5	136	0.004	85				
tamarack	8/7/2018	1	216	< 0.003	138	3.22	< 0.04	< 0.03	
tamarack	8/21/2018	1	170	< 0.003	125				
tamarack	9/11/2018	1	198	< 0.003	166	2.94	< 0.04	< 0.03	
tamarack	9/27/2018	1	182	0.01	163				



- Tamarack Lake YSI data is similar to that of similar metro lakes, nutrient levels are very high especially for an isolated lake with significant buffers. Internal loading is most likely the cause of these high levels
- Nitrogen and ammonia levels are below state standards for Tamarack Lake and similar to the rest of the VLAWMO lakes

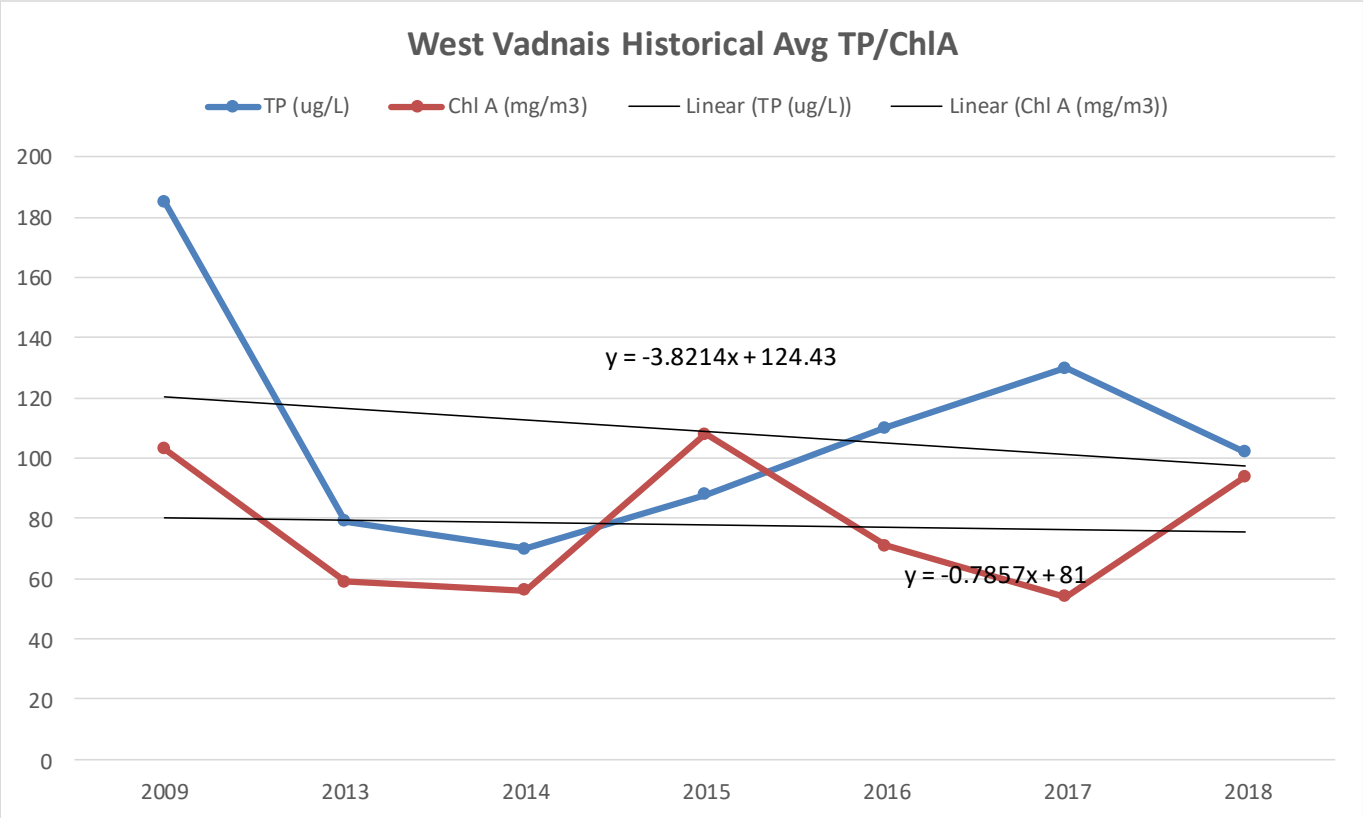
West Vadnais

West Vadnais Lake is located in the southwest corner of the watershed. Its neighbor, East Vadnais Lake, receives in lake treatment by the Saint Paul Water Authority (SPRWS) as a measure to protect the drinking water supply. Even though these lakes are right next to each other they are not connected and have drastically different water quality. The SPRWS monitors East Vadnais Lake. VLAWMO monitored West Vadnais for part of 2009 and began full monitoring in 2013. West Vadnais is on the 2014 impaired waters list for nutrients.

West Vadnais

West Vadnais Historical Avg TP/Chl A/SDT			
Year	TP (ug/L)	Chl A (mg/m3)	Secchi (m)
2009	185	103	0.4
2013	79	59	0.4
2014	70	56	0.5
2015	88	108	0.3
2016	110	71	0.3
2017	130	54	0.4
2018	102	94	0.4

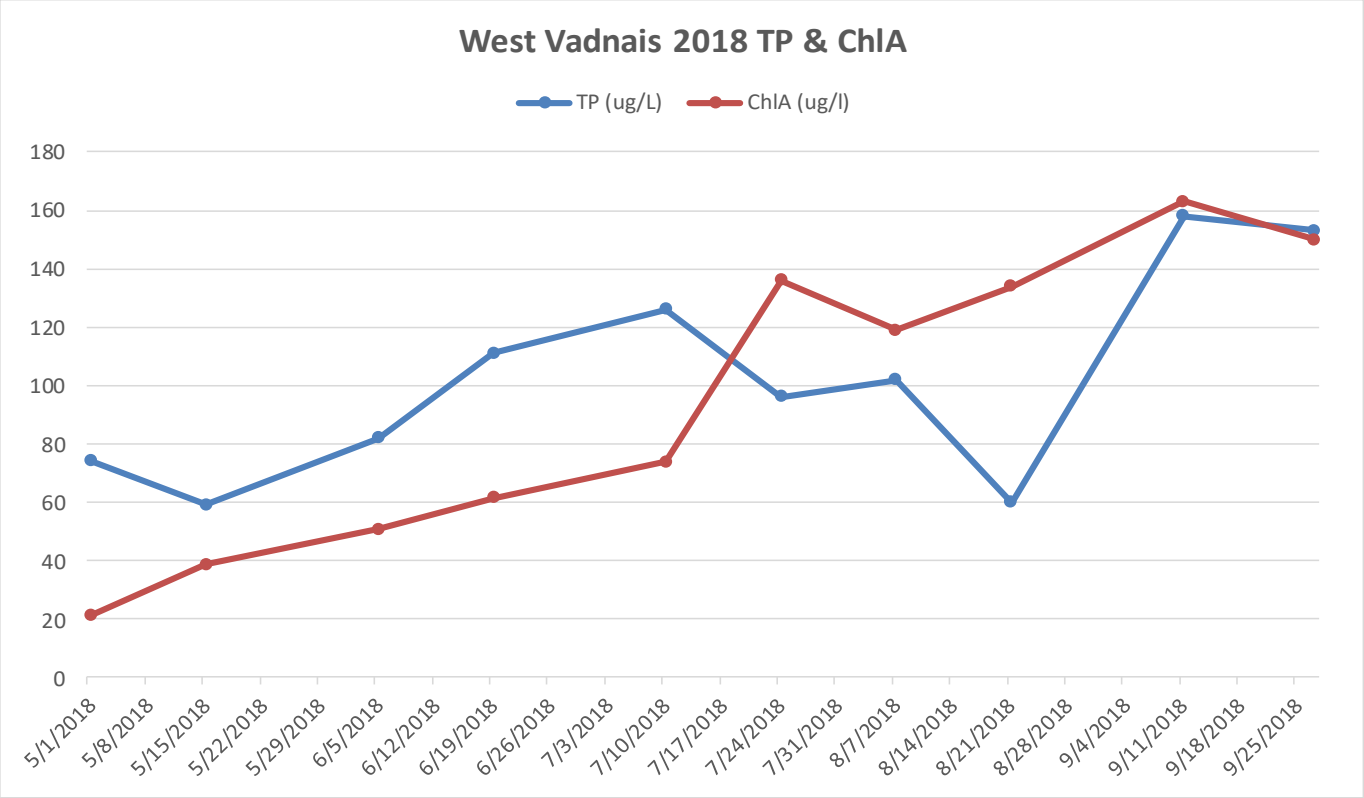
Date	Reading Depth (Bottom/ Top)	Temp °C	Conduc-tivity (mS/cm)	DO (mg/ L)	pH
5/22/2018	b	17.72	0.437	1.71	7.7
5/22/2018	t	19.08	0.421	5.97	7.72
6/21/2018	b	23.56	0.393	6.19	8.13
6/21/2018	t	23.71	0.389	7.31	8.26
9/5/2018	b	22.17	0.394	4.47	7.77
9/5/2018	t	22.14	0.394	4.46	7.86



- West Vadnais Lake YSI data is similar to that of similar metro lakes, DO's are slightly lower on average than the rest of VLAWMO lakes, Conductivity is on the high side for VLAWMO lakes

West Vadnais

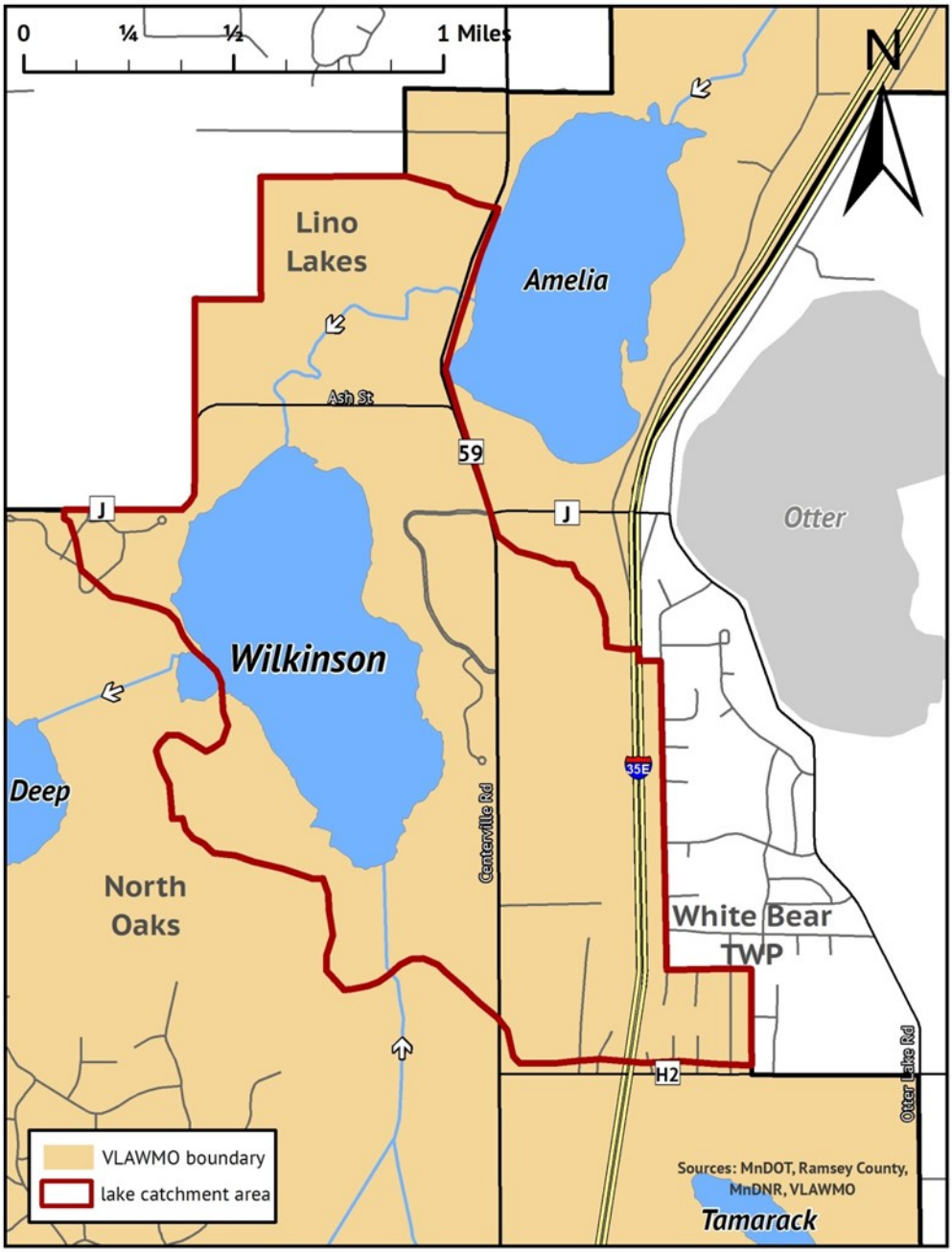
SITE	DATE	Secchi (ft)	TP (ug/L)	SRP (mg/L)	ChlA (ug/l)	TKN (mg/L)	NH3 (mg/L)	NO2+NO3 mg/L	CL (mg/L)
west vadnais	5/1/2018								65
west vadnais	5/1/2018	3	74	0.004	21	2.14	1.12	0.056	
west vadnais	5/15/2018	2.5	59	< 0.003	39				
west vadnais	6/5/2018		82	< 0.003	51	1.88	< 0.04	< 0.03	
west vadnais	6/19/2018	1.5	111	< 0.003	61				
west vadnais	7/10/2018	1	126	< 0.003	74	2.18	< 0.04	< 0.03	
west vadnais	7/24/2018	1	96	< 0.003	136				
west vadnais	8/7/2018	1	102	< 0.003	119	2.36	< 0.04	< 0.03	
west vadnais	8/21/2018	0.75	60	< 0.003	134				
west vadnais	9/11/2018	0.75	158	< 0.003	163	1.98	0.07	< 0.03	
west vadnais	9/27/2018	0.75	153	0.004	150				



- Nitrogen and ammonia levels are below state standards for West Vadnais Lake and similar to the rest of the VLAWMO lakes.

Wilkinson Lake

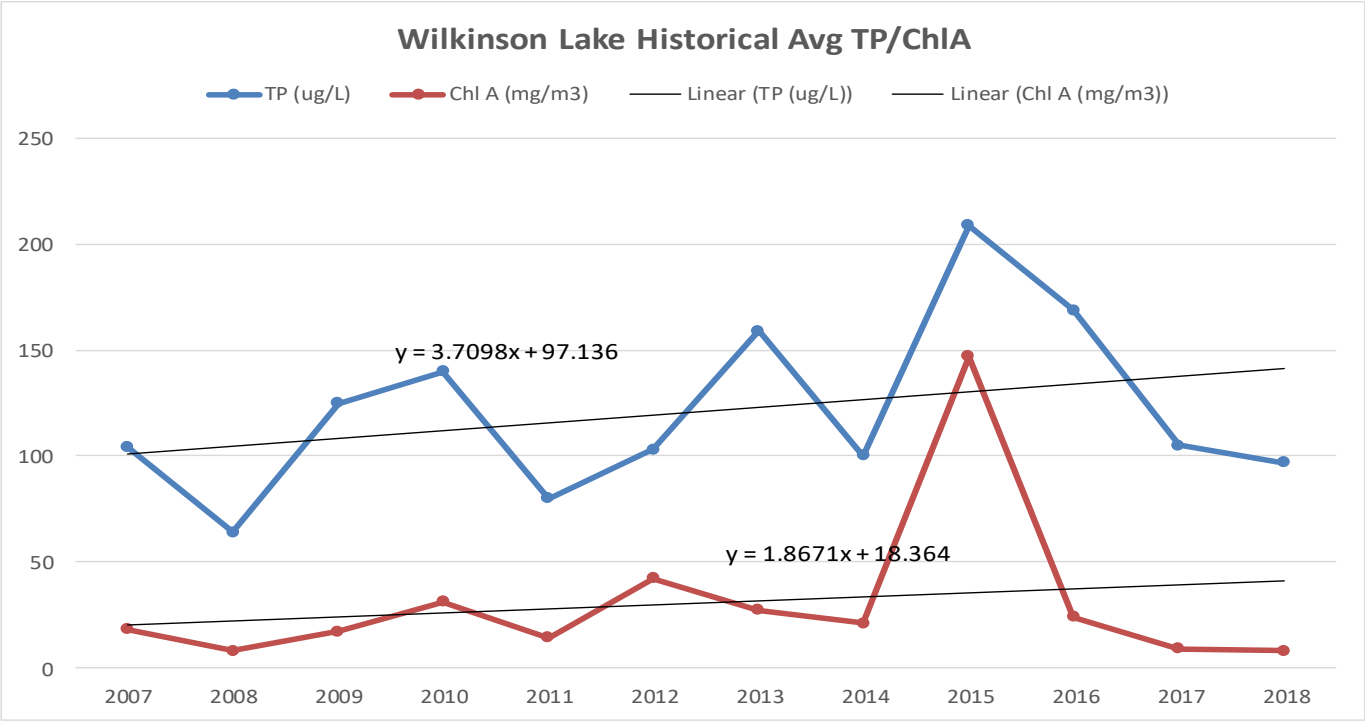
Wilkinson Lake was part of the James J. Hill experimental farm and is now part of the Minnesota Land Trust, which preserves the land in a natural condition. The City of North Oaks required 150-foot buffer between the lake edge and any structures. The property on the northwest side of the lake is currently being developed. The North Oaks Company has spent considerable time and effort over the years to restore the lake including the installation of a fish barrier to attempt to keep the rough fish from destroying the natural vegetation and waterfowl habitat and to improve water quality. The lake has also had two drawdowns to kill the carp. Wilkinson is the fourth lake within VLAWMO to be on the 2010 impaired waters list for nutrients and is part of the on-going Lambert Creek TMDL study. Farmland runoff and internal loading seem to be the main factors to the poor water quality. Water quality has not changed much over the last 16 years of monitoring, but a noticeable spike in average TP levels has occurred the last three years. TP levels are still within the 16 year monitoring range.



Wilkinson Lake

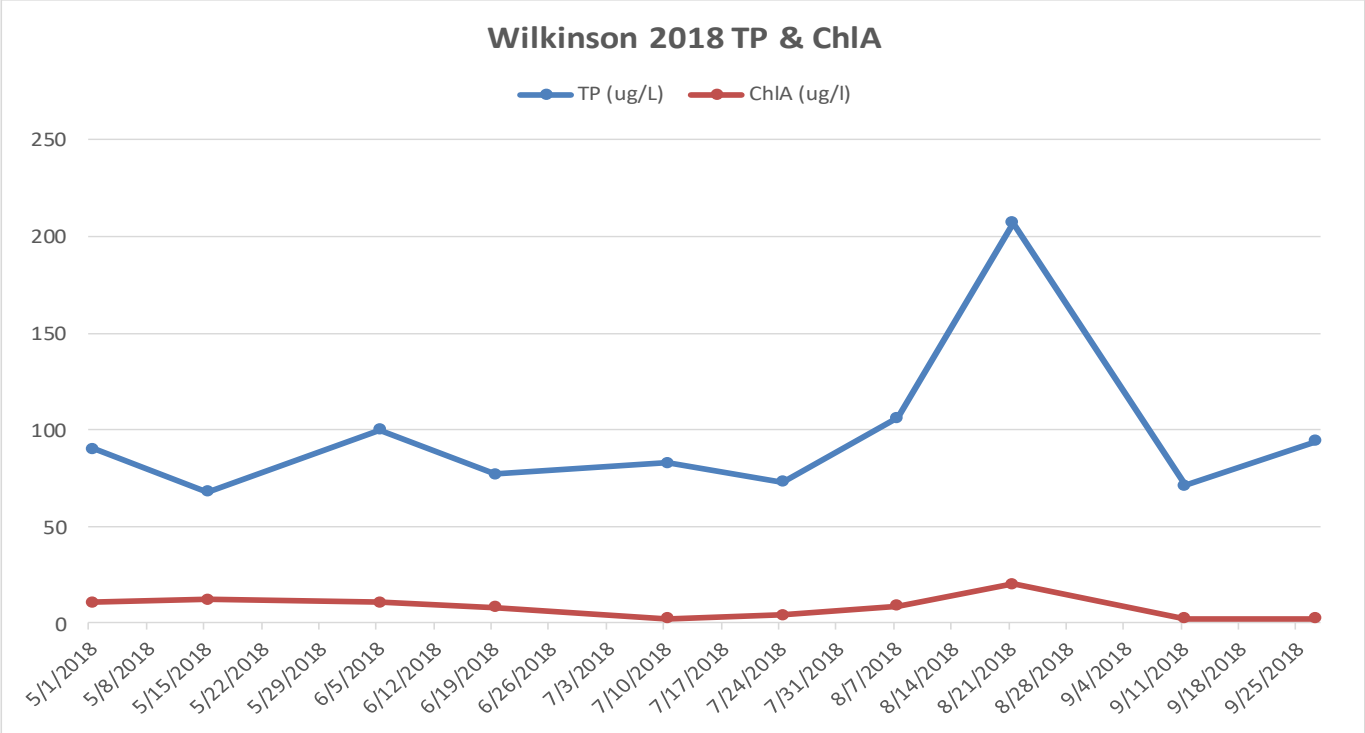
Wilkinson Lake Historical Avg TP/Chl A/SDT			
Year	TP (ug/L)	Chl A (mg/m3)	Secchi (m)
1998	48	26	1.1
1999	62	8	0
2000	38	34	0
2001	299	99	0.2
2002	107	40	0
2003	130	18	0
2004	72	0	0
2005	183	52	0
2006	96	10	0
2007	104	18	0.9
2008	64	8	0.3
2009	125	17	1
2010	140	31	0.8
2011	80	14	1
2012	103	42	0.9
2013	159	27	0.9
2014	100	21	0.9
2015	209	147	0.5
2016	169	24	1.1
2017	105	9	1.2
2018	97	8	1.2

Date	Reading Depth (Bottom/ Top)	Temp °C	Conduc-tivity (mS/cm)	DO (mg/ L)	pH
5/22/2018	b	18.18	0.433	5.83	7.75
5/22/2018	t	18.89	0.432	5.22	7.71
6/21/2018	b	23.01	0.36	4.63	7.97
6/21/2018	t	23.52	0.361	6.83	8.14
9/5/2018	b	21.47	0.424	2.5	7.36
9/5/2018	t	21.61	0.424	1.95	7.42



Wilkinson Lake

SITE	DATE	Secchi (ft)	TP (ug/L)	SRP (mg/L)	ChlA (ug/l)	TKN (mg/L)	NH3 (mg/L)	NO2+NO3 mg/L	CL (mg/L)
wilkinson	5/1/2018								48
wilkinson	5/1/2018	2.5	90	0.008	11	0.781	0.16	< 0.03	
wilkinson	5/15/2018	4	68	0.009	12				
wilkinson	6/5/2018		100	0.011	11	1.09	< 0.04	< 0.03	
wilkinson	6/19/2018	3	77	0.008	8				
wilkinson	7/10/2018	4	83	0.026	2	1.13	< 0.04	< 0.03	
wilkinson	7/24/2018	5	73	0.015	4				
wilkinson	8/7/2018	4.5	106	0.02	9	1.39	0.099	< 0.03	
wilkinson	8/21/2018	3	207	0.062	20				
wilkinson	9/11/2018	4	71	0.014	2	1.4	0.266	< 0.03	
wilkinson	9/27/2018	4	94	0.049	2				

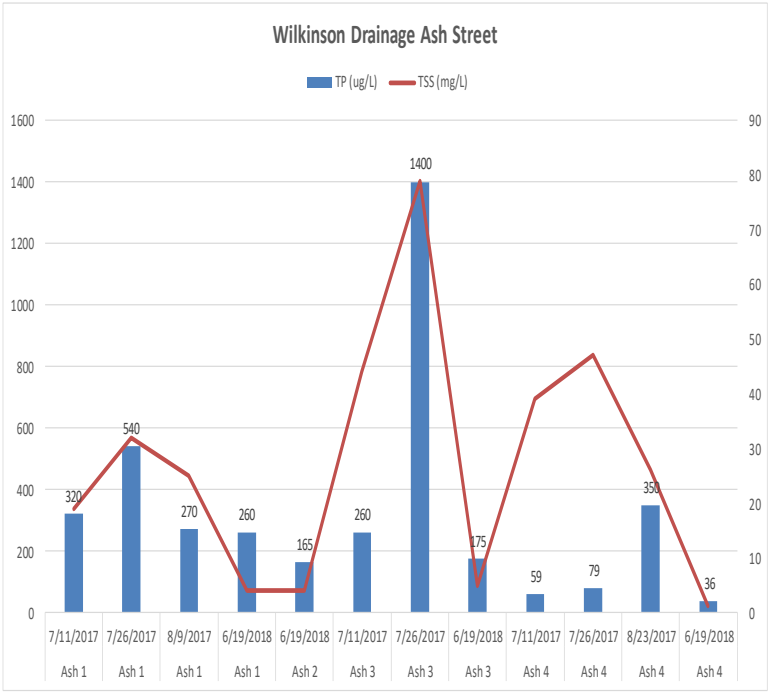


- Nitrogen and ammonia levels are below state standards for Wilkinson Lake and similar to the rest of the VLAWMO lakes. TP levels have increased dramatically over the last two years but are still within the 16 year monitoring range
- Wilkinson Lake YSI data is similar to that of similar metro lakes, DO's are slightly lower on average than the rest of VLAWMO lakes, Conductivity is on the high side for VLAWMO lakes.

Wilkinson Lake

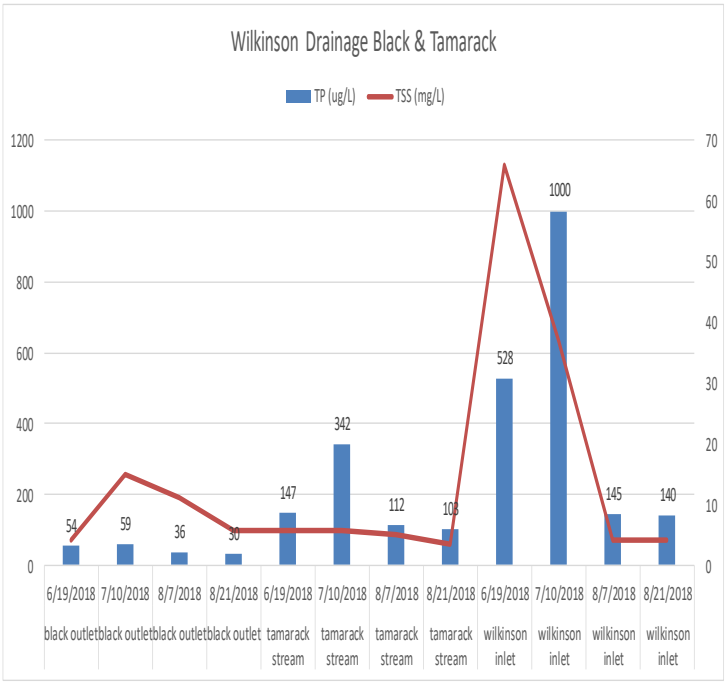
Site	Date	TP (ug/L)	TSS (mg/L)
Ash 1	7/11/2017	320	19
Ash 1	7/26/2017	540	32
Ash 1	8/9/2017	270	25
Ash 1	6/19/2018	260	4
Ash 2	6/19/2018	165	4
Ash 3	7/11/2017	260	44
Ash 3	7/26/2017	1400	79
Ash 3	6/19/2018	175	4.8
Ash 4	7/11/2017	59	39
Ash 4	7/26/2017	79	47
Ash 4	8/23/2017	350	26
Ash 4	6/19/2018	36	1.2

- Storm samples were taken in drainage between Amilia and Wilkinson Lakes and indicate nutrient loading to Wilkinson, very high TP levels from wetland complex

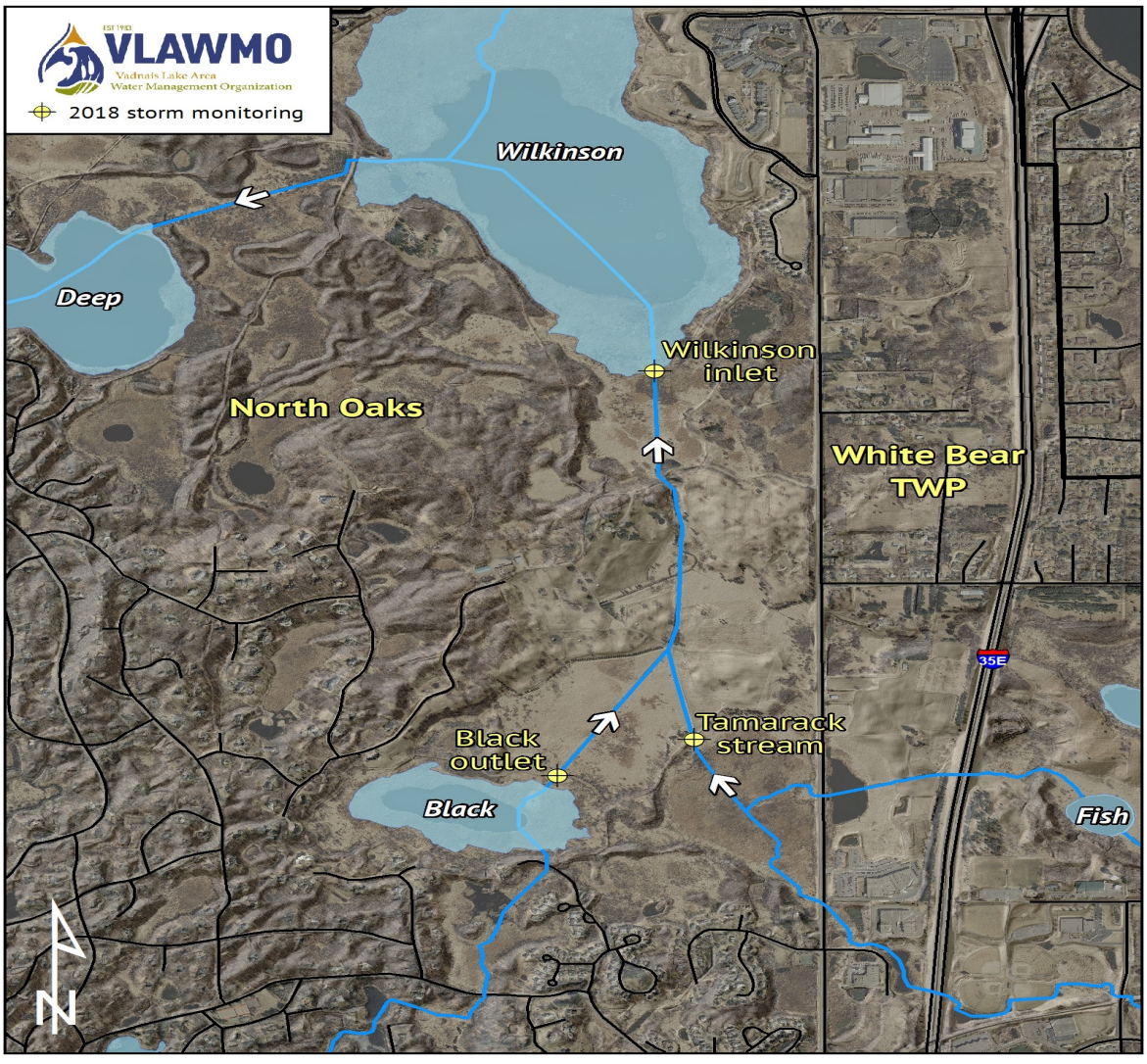


Wilkinson Lake

Site	Date	TP (ug/L)	TSS (mg/L)
black outlet	6/19/2018	54	4
black outlet	7/10/2018	59	15
black outlet	8/7/2018	36	11
black outlet	8/21/2018	30	5.6
tamarack stream	6/19/2018	147	5.6
tamarack stream	7/10/2018	342	5.6
tamarack stream	8/7/2018	112	5
tamarack stream	8/21/2018	103	3.4
wilkinson inlet	6/19/2018	528	66
wilkinson inlet	7/10/2018	1000	37
wilkinson inlet	8/7/2018	145	4
wilkinson inlet	8/21/2018	140	4

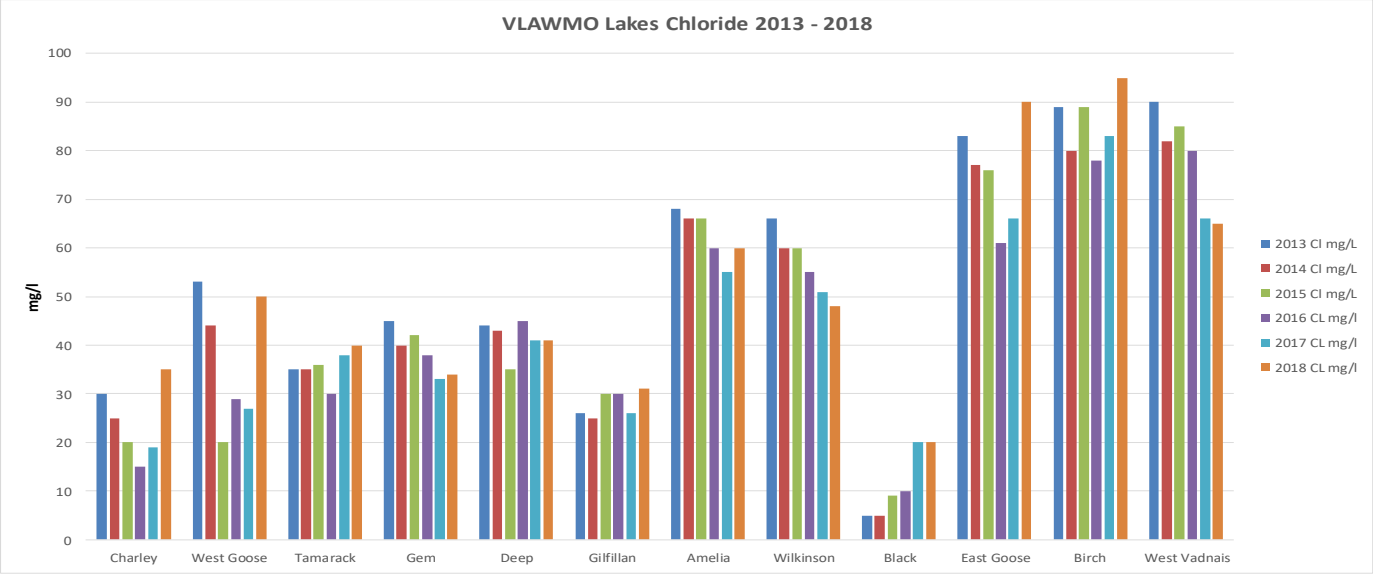


- Storm samples were taken in drainage between Black and Wilkinson Lakes and indicate nutrient loading to Wilkinson, very high TP levels from wetland complex just south of Wilkinson.



Lake Comparison Chloride

	2010 Cl mg/L	2011 Cl mg/L	2012 Cl mg/L	2013 Cl mg/L	2014 Cl mg/L	2015 Cl mg/L	2016 CL mg/l	2017 CL mg/l	2018 CL mg/l
Charley	16	20	22	30	25	20	15	19	35
West Goose	30	44	29	53	44	20	29	27	50
Tamarack	34	34	32	35	35	36	30	38	40
Gem	35	40	44	45	40	42	38	33	34
Deep	42	45	35	44	43	35	45	41	41
Gilfillan	42	41	40	26	25	30	30	26	31
Amelia	60	75	71	68	66	66	60	55	60
Wilkinson	60	54	57	66	60	60	55	51	48
Black	9	10	8	5	5	9	10	20	20
East Goose	90	95	76	83	77	76	61	66	90
Birch	95	100	89	89	80	89	78	83	95
West Vadnais				90	82	85	80	66	65



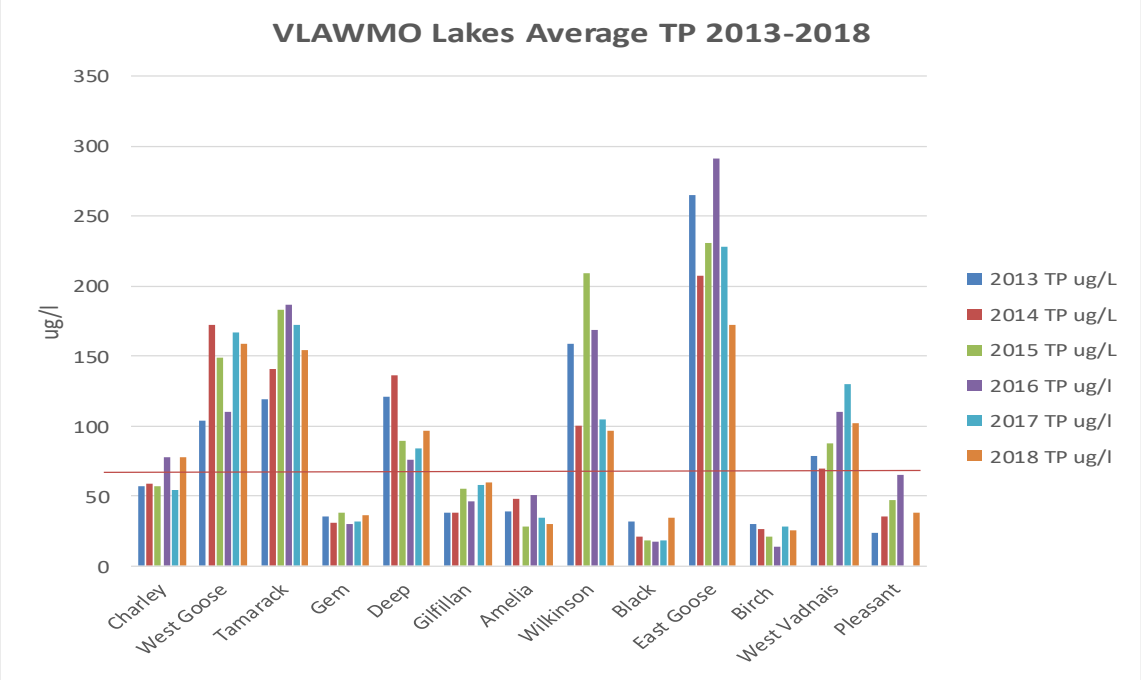
- **Chloride Standards**

Chronic Exposure Standard—4 day average > 230 mg/l
Acute Exposure Standard—1 hour > 860 mg/l
Impairment Threshold—Two or more exceedances in a three year period having at least five data points

- VLAWMO staff takes Lake Chloride readings in the spring right after ice-off. The samples are taken from the middle of the lake. 2018 was the ninth year of VLAWMO's chloride program. The lakes with the highest chloride levels are typically the lakes that receive the most street/storm water runoff. Most of our cities have gone to an all salt mix for winter ice control and future monitoring will be interesting to see how that will affect the chloride levels in VLAWMO lakes.

Lake Comparison Total Phosphorus (TP)

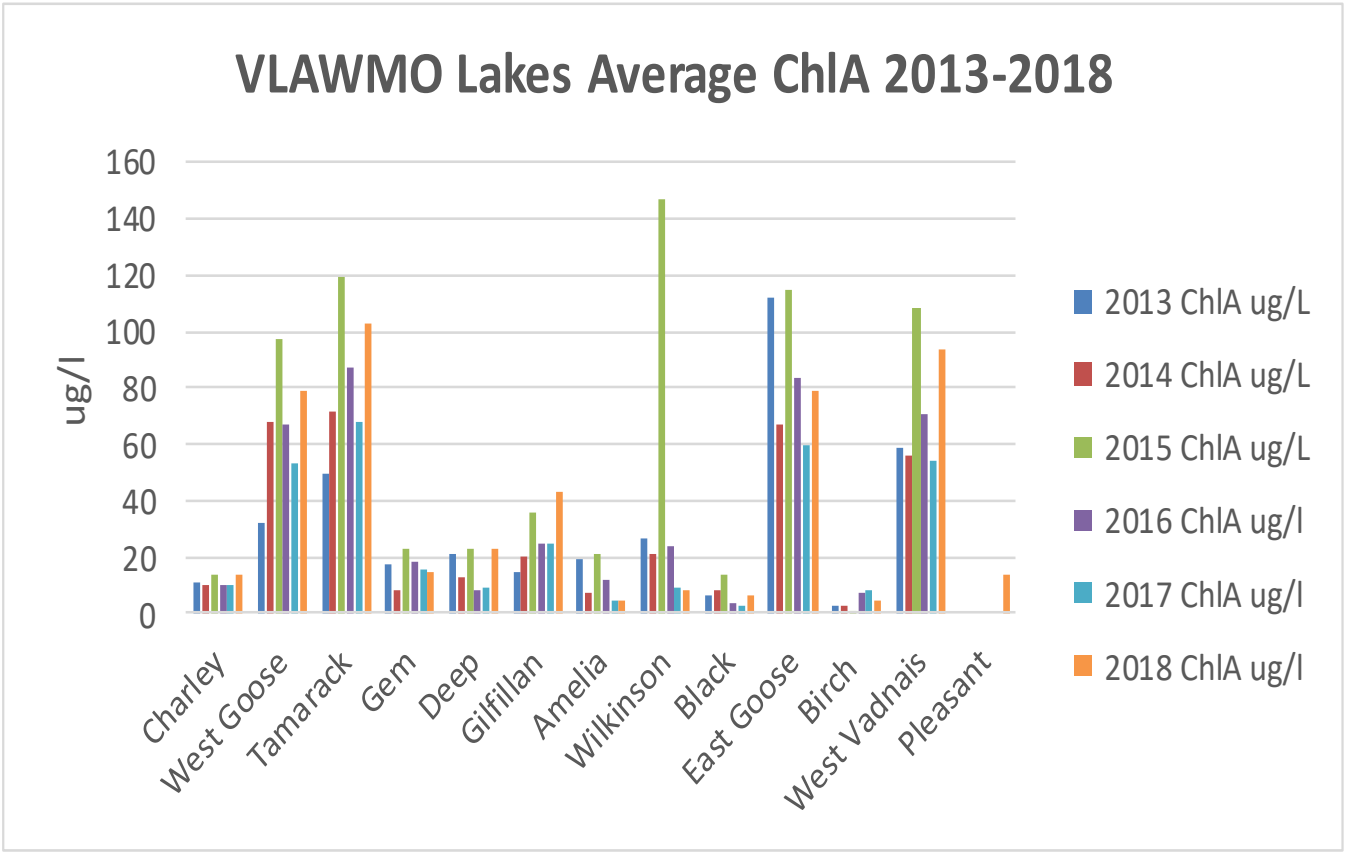
	2010 TP ug/L	2011 TP ug/L	2012 TP ug/L	2013 TP ug/L	2014 TP ug/L	2015 TP ug/L	2016 TP ug/l	2017 TP ug/l	2018 TP ug/l
Charley	90	87	74	57	59	57	78	54	78
West Goose	129	126	200	104	172	149	110	167	159
Tamarack	157	120	129	119	141	183	187	172	154
Gem	53	32	41	35	31	38	30	32	36
Deep	55	95	87	121	136	89	76	84	97
Gilfillan	192	123	70	38	38	55	46	58	60
Amelia	32	38	39	39	48	28	51	34	30
Wilkinson	140	80	103	159	100	209	169	105	97
Black	34	44	31	32	21	18	17	18	34
East Goose	207	164	277	265	207	231	291	228	172
Birch	31	29	30	30	26	21	14	28	25
West Vadnais				79	70	88	110	130	102
Pleasant				24	35	47	65		38



The red line marks the State Standard; when a water body becomes impaired.

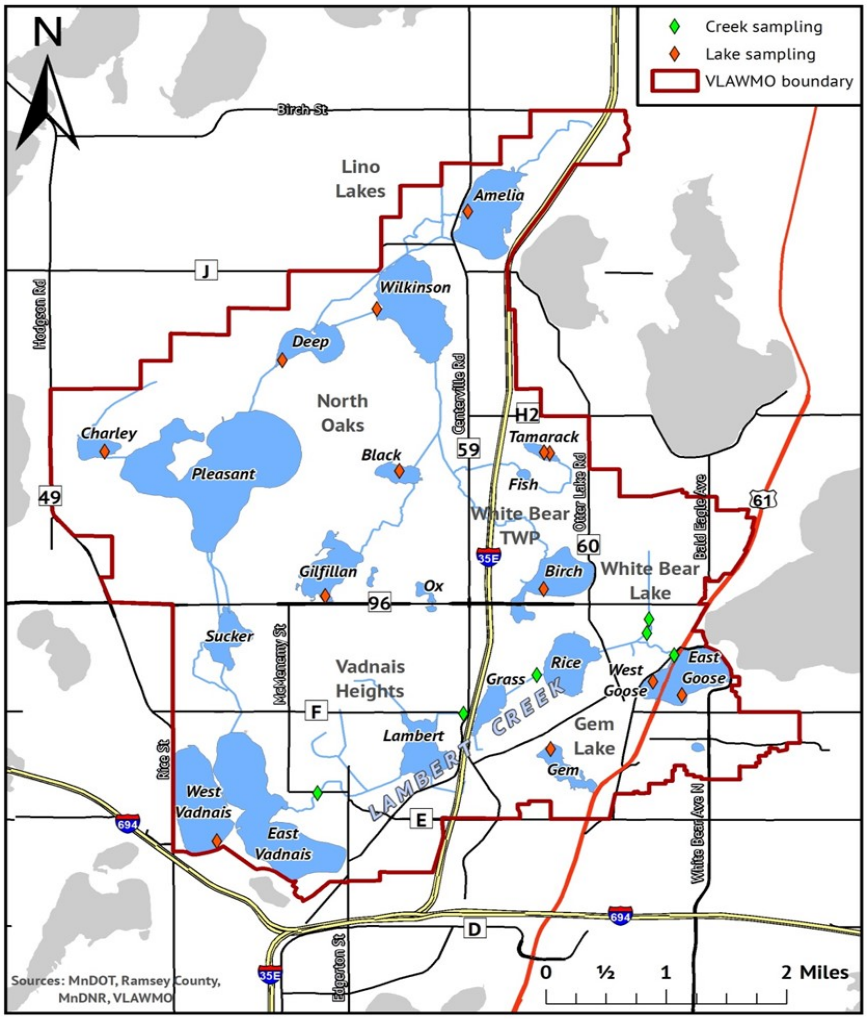
Lake Comparison ChlA

	2010 ChlA ug/L	2011 ChlA ug/L	2012 ChlA ug/L	2013 ChlA ug/L	2014 ChlA ug/L	2015 ChlA ug/L	2016 ChlA ug/l	2017 ChlA ug/l	2018 ChlA ug/l
Charley	18.9	9.3	13	11	10	14	10	10	14
West Goose	39	27	51	32	68	97	67	53	79
Tamarack	96	28	64	50	72	119	87	68	103
Gem	24	6.4	11	17	8	23	18	16	15
Deep	15	12	12	21	13	23	8	9	23
Gilfillan	44	25	17	15	20	36	25	25	43
Amelia	12	8	9	19	7.5	21	12	5	4.5
Wilkinson	31	14	42	27	21	147	24	9	8
Black	6.6	6.9	6	6	8	14	4	3	6
East Goose	67	48	96	112	67	115	84	60	79
Birch	5	3	3	3	3	1	7	8	5
West Vadnais				59	56	108	71	54	94
Pleasant									14



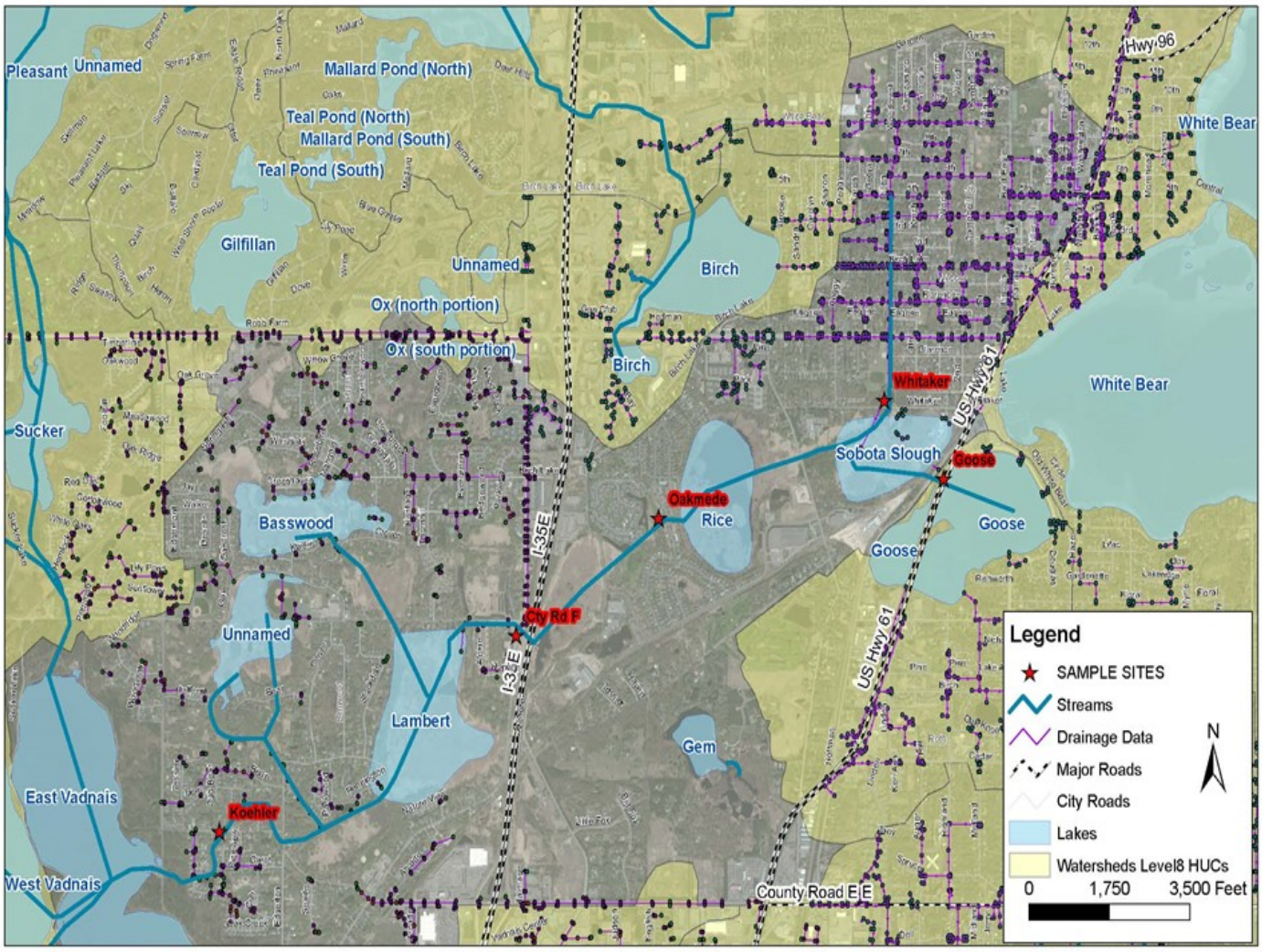
Lake Levels

Lake Elevations 2018						
	Gilfillan	Birch	Gem	Goose	Wilkinson	
gauge reading start	2.04	1.12	1.48	0.94		
lake level start 5/10/2017	911.44	920.17	947.53	924.21		
0.00 out	909.04	919.05	946.05	923.27		
5/15/2018	911.4	920.13	947.47	924.15	1.85	
6/5/2018	910.99	920.12	947.37	924.14	1.85	
6/19/2018	911.14	920.36	947.59	924.62	1.9	
7/10/2018	910.94	920.22	947.78	924.45	1.88	
7/24/2018	910.86	920.26	947.76	924.39	1.9	
8/7/2018	911.08	920.12	947.65	924.3	1.87	
8/21/2018	910.54	920.86	947.43	924.08	1.63	
9/5/2018		920.27				
9/12/2018	910.59	920.12	947.54	924.15	1.78	
9/27/2018	910.79	920.58	948.03	924.53	2.12	
10/10/2018		920.63				
10/17/2018	910.79	920.47				
yearly in-crease/ decrease	**0.65**	**0.3**	**0.5**	**0.32**	**0.27**	



Lambert Creek

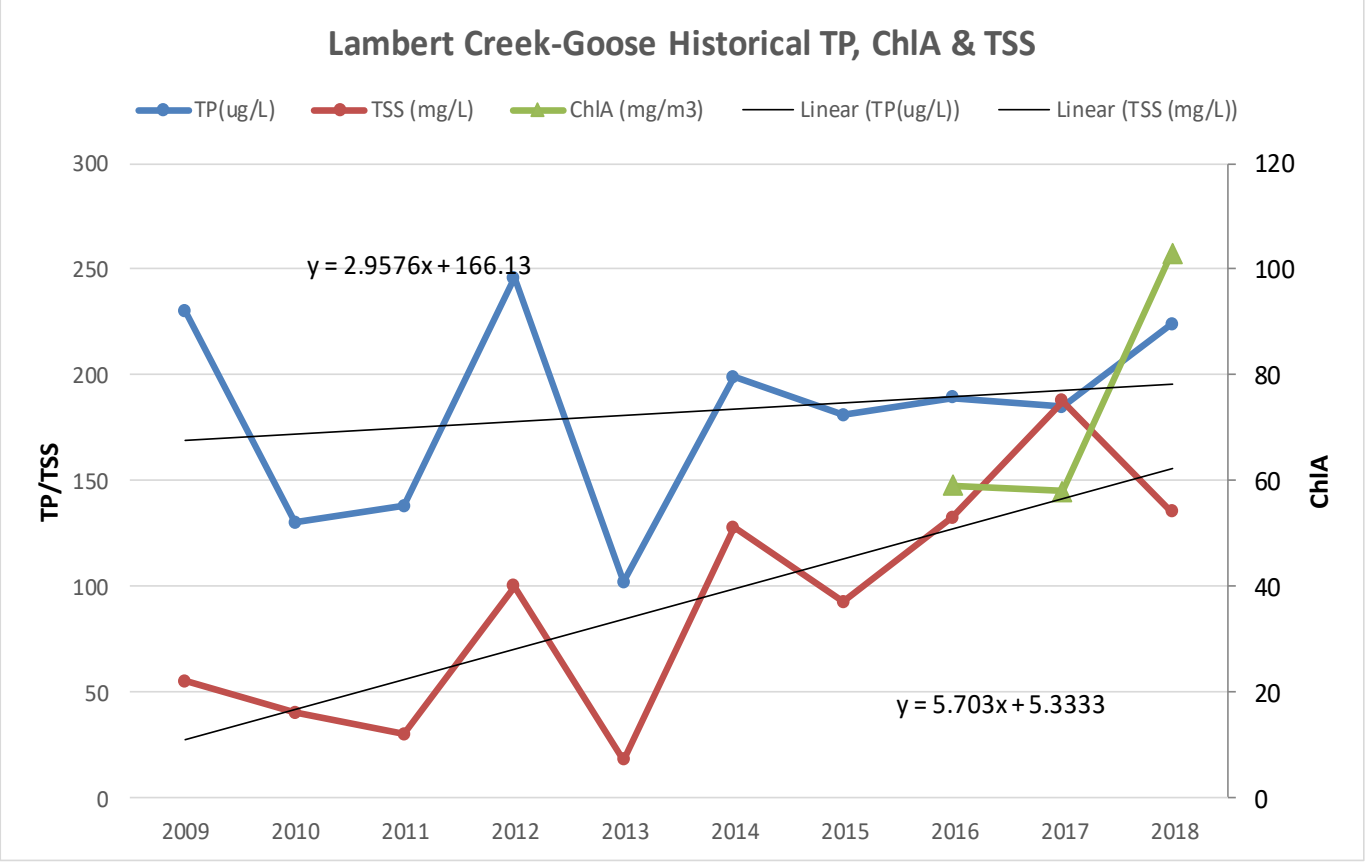
Samples are collected by VLAWMO staff at six sites along Lambert Creek on a bi-weekly basis May through September. The six sites noted in charts and graphs are: Goose Lake, WBL storm sewer, Whitaker Pond, Oakmede, County Rd F, and Kohler Rd. The samples are analyzed by Pace Analytical for TP, SRP, TKN, NH3, N03, TSS. VLAWMO staff collects pH, conductivity, DO and temperature readings at all locations except the WBL storm sewer. Creek flow is also collected at the flumes along with a flow meter in the WBL storm sewer. This information will also help with the TMDL process and allows us to set baselines to compare with future monitoring data.



Lambert Creek—Goose

Lambert Creek-Goose			
Year	TP(ug/L)	TSS (mg/L)	ChlA (mg/
2009	230	22	
2010	130	16	
2011	138	12	
2012	246	40	
2013	102	7	
2014	199	51	
2015	181	37	
2016	189	53	59
2017	185	75	58
2018	224	54	103

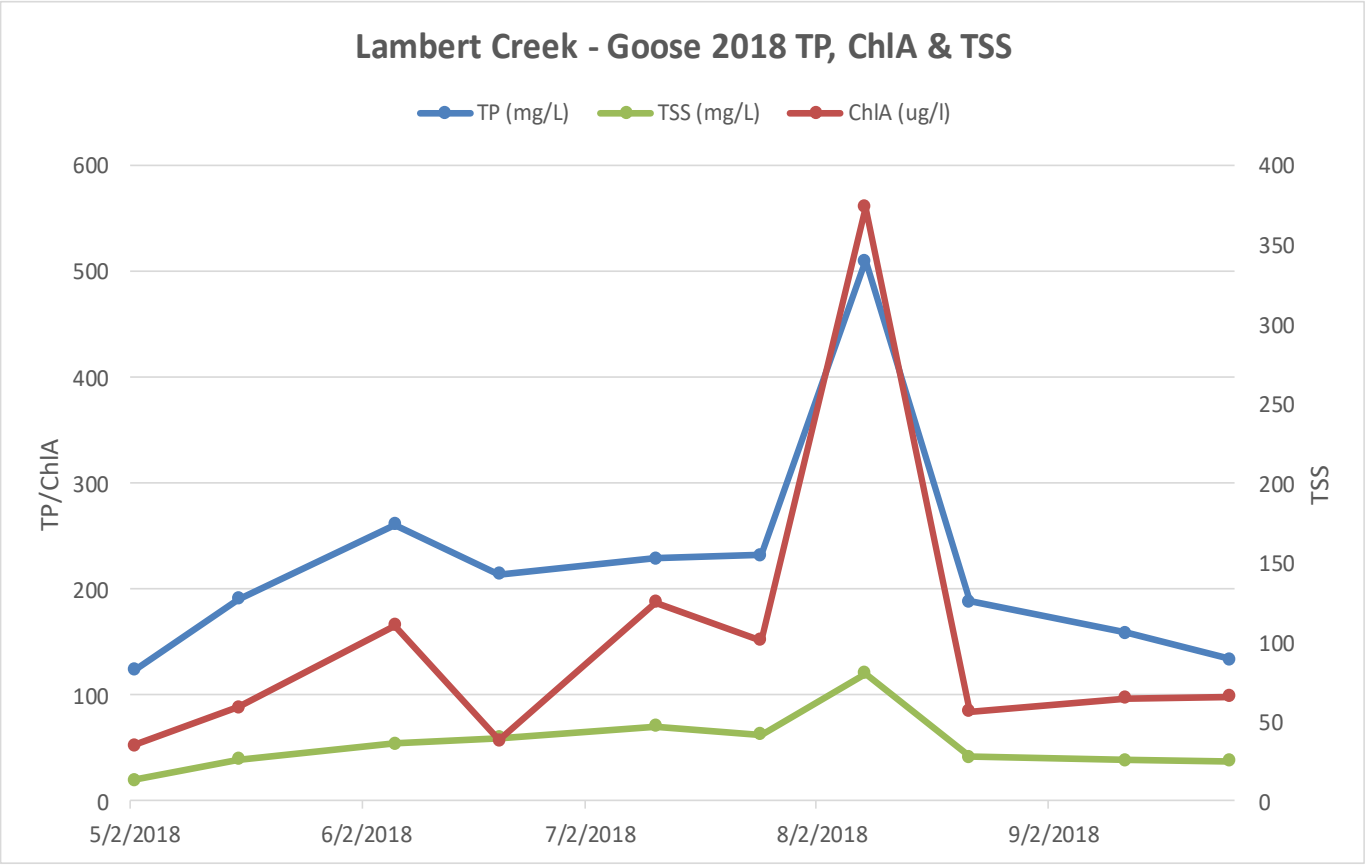
Date	Temp °C	Conductivity (mS/cm)	DO (mg/L)	pH
4/28/2018	12.9	0.762	11.34	8
5/29/2018	28.5	0.753	9.36	8.18
6/9/2018	22.2	0.356	6.4	8.41
6/24/2018	25.4	0.756	10.89	9.04
7/15/2018	30.5	0.756	13.17	9.00
7/21/2018	25.6	0.757	9.91	8.91
8/3/2018	23.7	0.755	10.23	8.83
8/11/2018	26.5	0.760	6.82	8.27
9/5/2018	21.4	0.761	5.8	7.90
9/17/2018	18.4	0.760	10.69	8.39
10/15/2018	8.4	0.760	12.92	7.99
10/23/2018	7.6	0.767	10.80	8.01
11/3/2018	6.6	0.759	13.03	8.01
11/18/2018	1.4	0.759	9.74	7.46



- LC-Goose Lake was a little above the state standards for TP and similar to 2016. State standard is 130 ug/l. State standard for TSS is 14mg/l. LC-Goose TSS was much higher than state standard

Lambert Creek—Goose

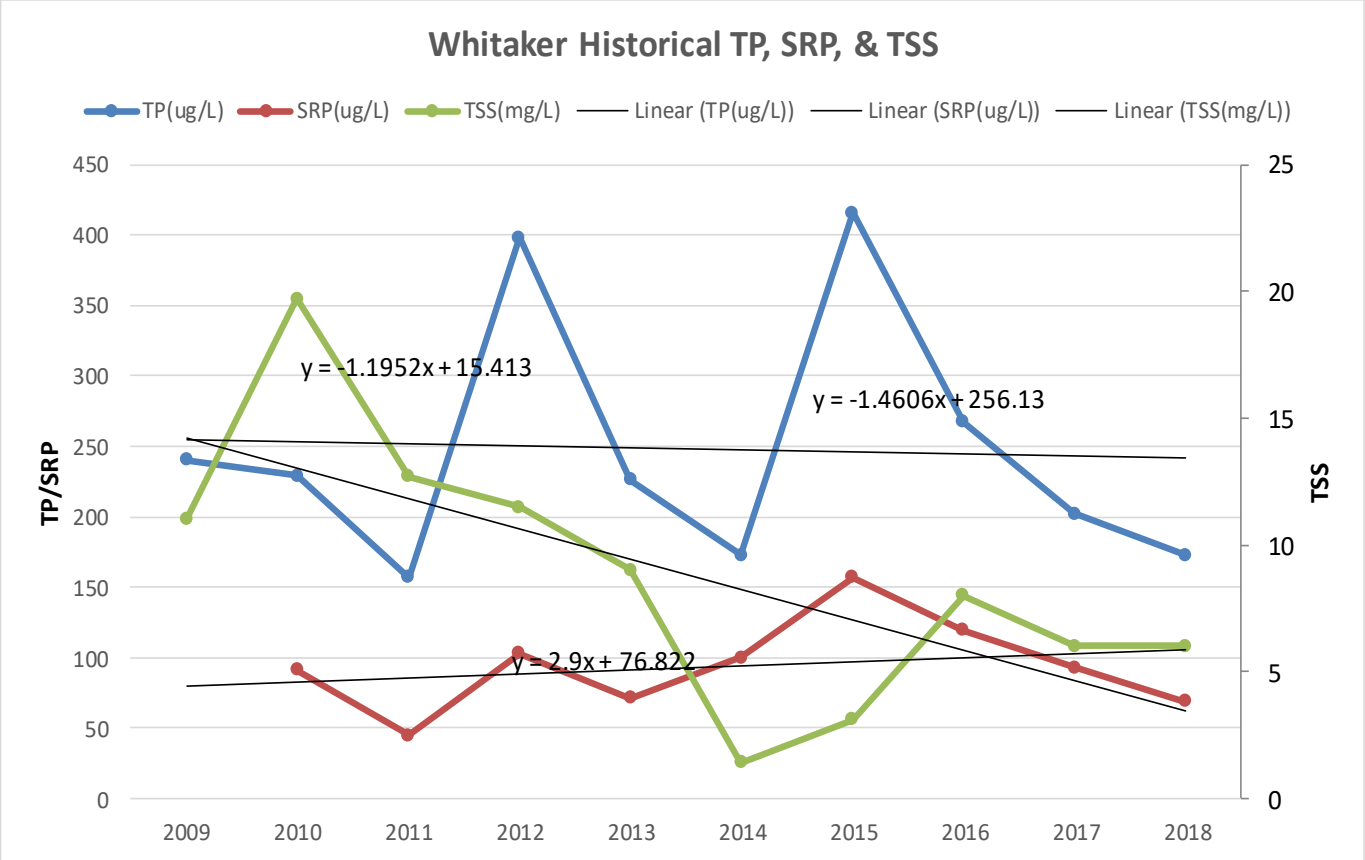
SITE	DATE	TP (mg/L)	ChlA (ug/l)	TSS (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2+NO3 mg/L	CL (mg/L)
lc-goose	4/12/2018							45
lc-goose	4/20/2018							60
lc-goose	5/2/2018	123	35	19	1.52	0.435	0.069	
lc-goose	5/16/2018	190	59	38				
lc-goose	6/6/2018	261	110	53	3.39	< 0.04	0.042	
lc-goose	6/20/2018	214	37	59				
lc-goose	7/11/2018	229	125	70	2.79	< 0.04	< 0.03	
lc-goose	7/25/2018	232	101	62				
lc-goose	8/8/2018	510	374	120	2.84	0.05	< 0.03	
lc-goose	8/22/2018	188	56	41				
lc-goose	9/12/2018	158	64	38	2.49	< 0.04	< 0.03	
lc-goose	9/26/2018	133	65	37				



Lambert Creek—Whitaker

Whitaker				
Year	TP(ug/L)	SRP(ug/L)	TSS(mg/L)	ChlA (mg/
2009	240		11	
2010	229	91	19.7	
2011	157	45	12.7	
2012	398	103	11.5	
2013	226	71	9	
2014	173	100	1.4	
2015	416	157	3.1	
2016	267	119	8	8
2017	202	93	6	3
2018	173	69	6	21

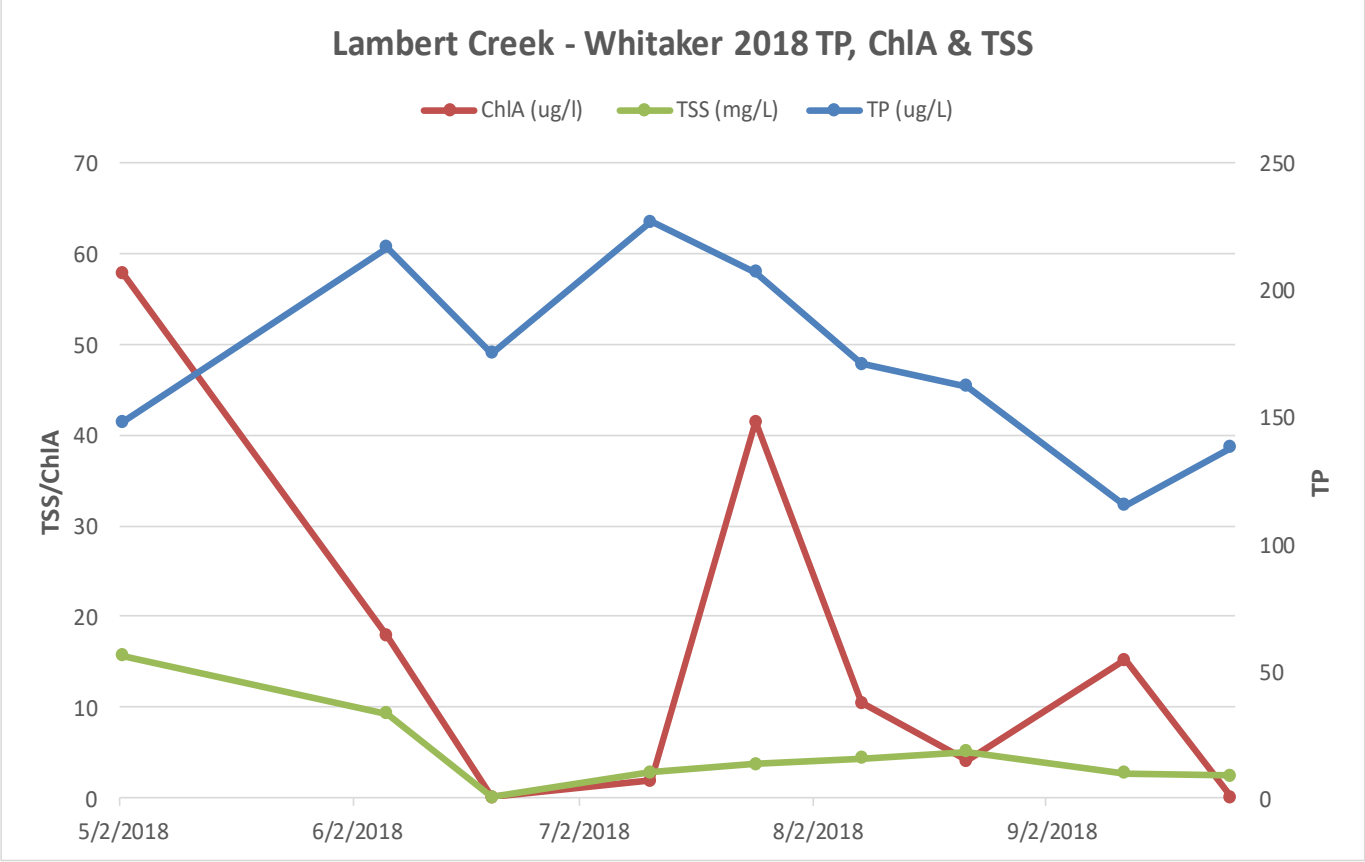
Date	Temp °C	Conductivity (mS/cm)	DO (mg/L)	pH
4/28/2018	14.4	0.763	10.31	7.71
5/29/2018	24.4	0.754	0.60	8.00
6/9/2018	20.7	0.422	0.95	7.77
6/24/2018	20.4	0.756	5.45	8.08
7/15/2018	25.3	0.757	0.21	7.79
7/21/2018	22.6	0.758	2.02	8.21
8/3/2018	21.5	0.755	5.02	7.82
8/11/2018	23.9	0.760	1.79	7.88
9/5/2018	20.6	0.761	4.86	7.71
9/17/2018	16.2	0.761	3.12	7.71
10/15/2018	8.6	0.760	6.98	7.88
10/23/2018	8.3	0.767	9.08	7.99
11/3/2018	7.5	0.759	2.42	7.76
11/18/2018	1.4	0.759	8.21	7.21



- Whitaker Pond on average for the last 9 years is above state standards for TP. State standard is 130 ug/l. State standard for TSS is 14mg/l. Since the forebay was installed in 2011 TSS has dropped, indicating the forebay is functioning as designed.

Lambert Creek—Whitaker

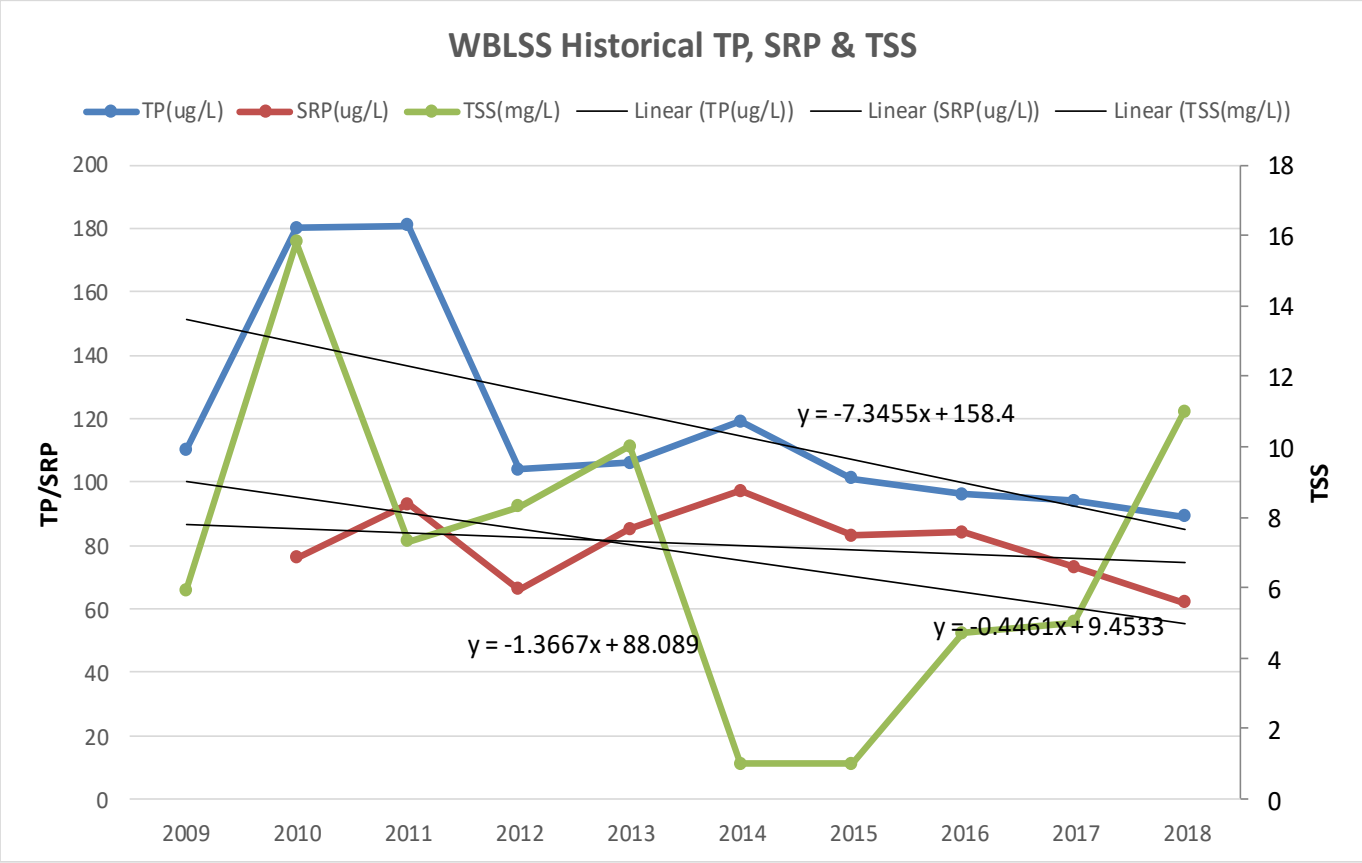
SITE	DATE	TP (ug/L)	ChlA (ug/l)	TSS (mg/L)	SRP (ug/L)	TKN (mg/L)	NH3 (mg/L)	NO2+NO3 mg/L	CL (mg/L)
whitaker	4/12/2018								401
whitaker	4/20/2018								380
whitaker	5/2/2018	148	58	16	3	1.43	0.131	1.53	
whitaker	6/6/2018	217	18	9	45	0.949	0.084	0.073	
whitaker	6/20/2018	175	< 1	< 1	133				
whitaker	7/11/2018	227	2	3	115	1.76	1.16	0.156	
whitaker	7/25/2018	207	42	4	29				
whitaker	8/8/2018	171	10	4	105	0.992	0.573	0.33	
whitaker	8/22/2018	162	4	5	55				
whitaker	9/12/2018	115	15	3	35	0.902	0.328	0.438	
whitaker	9/26/2018	138	< 1	2	98				



Lambert Creek—WBLSS

White Bear Lake Storm Sewer				
Year	TP(ug/L)	SRP(ug/L)	TSS(mg/L)	ChlA (mg/
2009	110		5.9	
2010	180	76	15.8	
2011	181	93	7.3	
2012	104	66	8.3	
2013	106	85	10	
2014	119	97	1	
2015	101	83	1	
2016	96	84	4.7	5
2017	94	73	5	1
2018	89	62	11	4

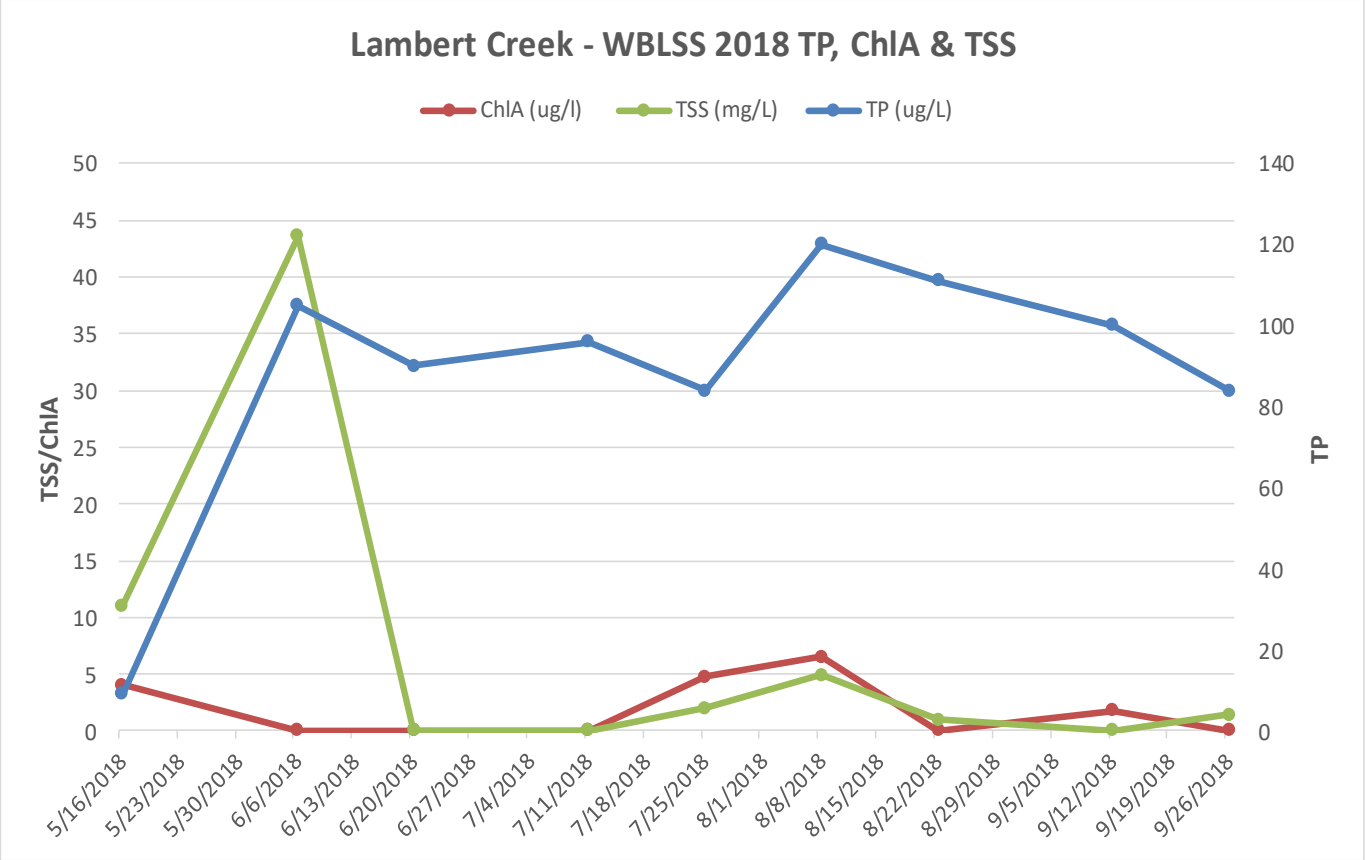
Date	Temp °C	Conductivity (mS/cm)	DO (mg/L)	pH
4/28/2018	7.0	0.762	12.44	7.92
5/29/2018	12.0	0.753	9.21	7.98
6/9/2018	13.4	0.334	8.57	7.50
6/24/2018	20.6	0.756	6.13	7.94
7/15/2018	16.7	0.757	8.01	7.67
7/21/2018	17.0	0.757	8.59	8.49
8/3/2018	18.4	0.755	6.54	7.68
8/11/2018	17.0	0.760	8.93	7.98
9/5/2018	18.8	0.761	6.87	7.48
9/17/2018	15.5	0.760	9.38	7.61
10/15/2018	11.8	0.760	9.6	7.81
10/23/2018	10.5	0.767	6.45	7.93
11/3/2018	12.4	0.759	8.27	7.73
11/18/2018	3.3	0.759	8.34	7.18



- Since 2012 WBLSS is below state standards for TP. State standard is 130 ug/l. State standard for TSS is 14mg/l. SRP is also tested at this site. Both TP and TSS are showing a downtrend, SRP levels have been fairly consistent since monitoring began in 2010 showing a slight up-trend.

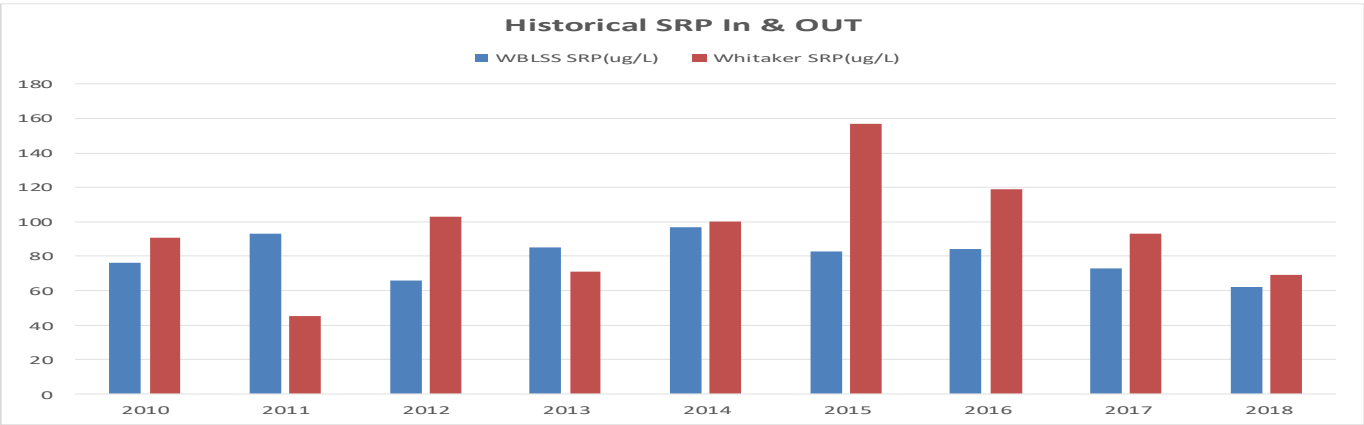
Lambert Creek—WBLSS

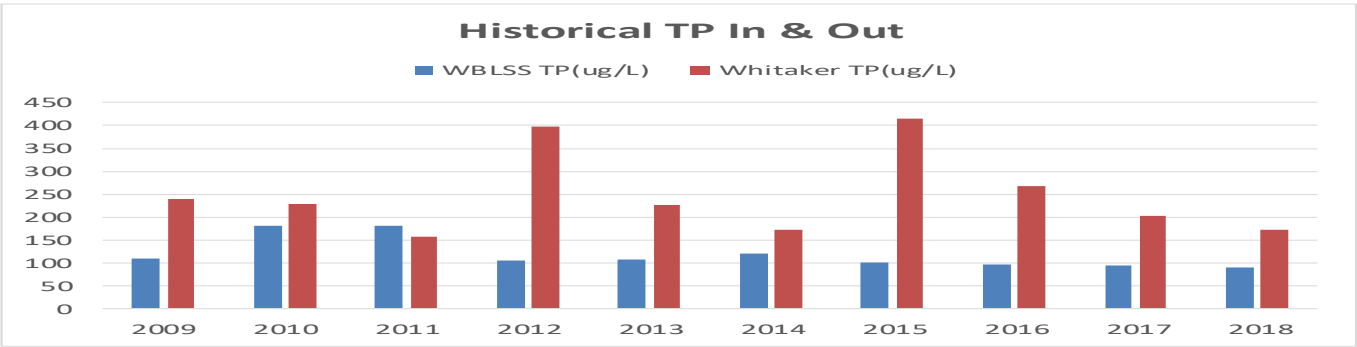
SITE	DATE	TP (ug/L)	ChlA (ug/l)	TSS (mg/L)	SRP (ug/L)	TKN (mg/L)	NH3 (mg/L)	NO2+NO3 mg/L	CL (mg/L)
WBLSS	4/12/2018								146
WBLSS	4/20/2018								160
WBLSS	5/16/2018	9	4	11	71				
WBLSS	6/6/2018	105	< 1	44	11	0.4	0.078	0.466	
WBLSS	6/20/2018	90	< 1	< 1	81				
WBLSS	7/11/2018	96	< 1	< 1	95	0.376	< 0.04	5.64	
WBLSS	7/25/2018	84	5	2	16				
WBLSS	8/8/2018	120	7	5	29	0.9	0.216	0.765	
WBLSS	8/22/2018	111	< 1	1	91				
WBLSS	9/12/2018	100	2	< 2	94	0.521	< 0.04	5.07	
WBLSS	9/26/2018	84	< 1	1	74				

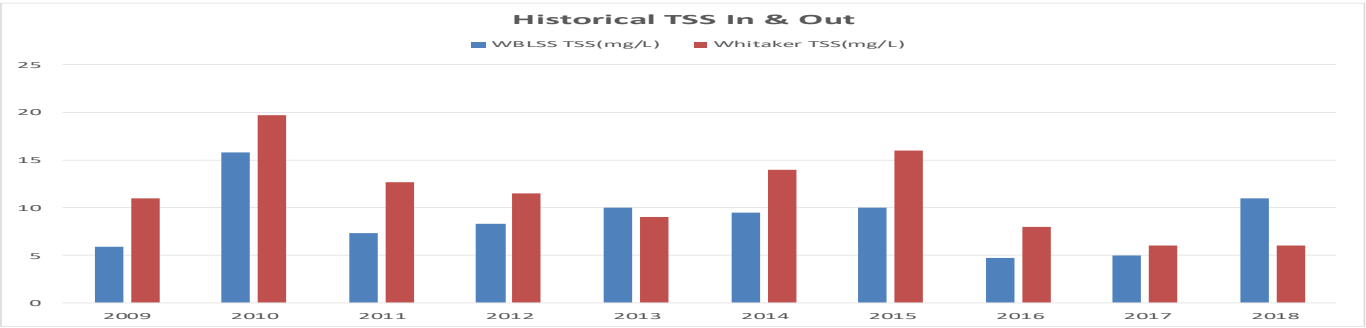


Lambert Creek—WBLSS

	WBLSS TP (ug/L)	Whitaker TP (ug/L)		WBLSS SRP (ug/L)	Whitaker SRP(ug/L)		WBLSS TSS (mg/L)	Whitaker TSS(mg/L)
2009	110	240	**2009**			**2009**	5.9	11
2010	180	229	**2010**	76	91	**2010**	15.8	19.7
2011	181	157	**2011**	93	45	**2011**	7.3	12.7
2012	104	398	**2012**	66	103	**2012**	8.3	11.5
2013	106	226	**2013**	85	71	**2013**	10	9
2014	119	173	**2014**	97	100	**2014**	9.5	14
2015	101	416	**2015**	83	157	**2015**	10	16
2016	96	267	**2016**	84	119	**2016**	4.7	8
2017	94	202	**2017**	73	93	**2017**	5	6
2018	89	173	**2018**	62	69	**2018**	11	6





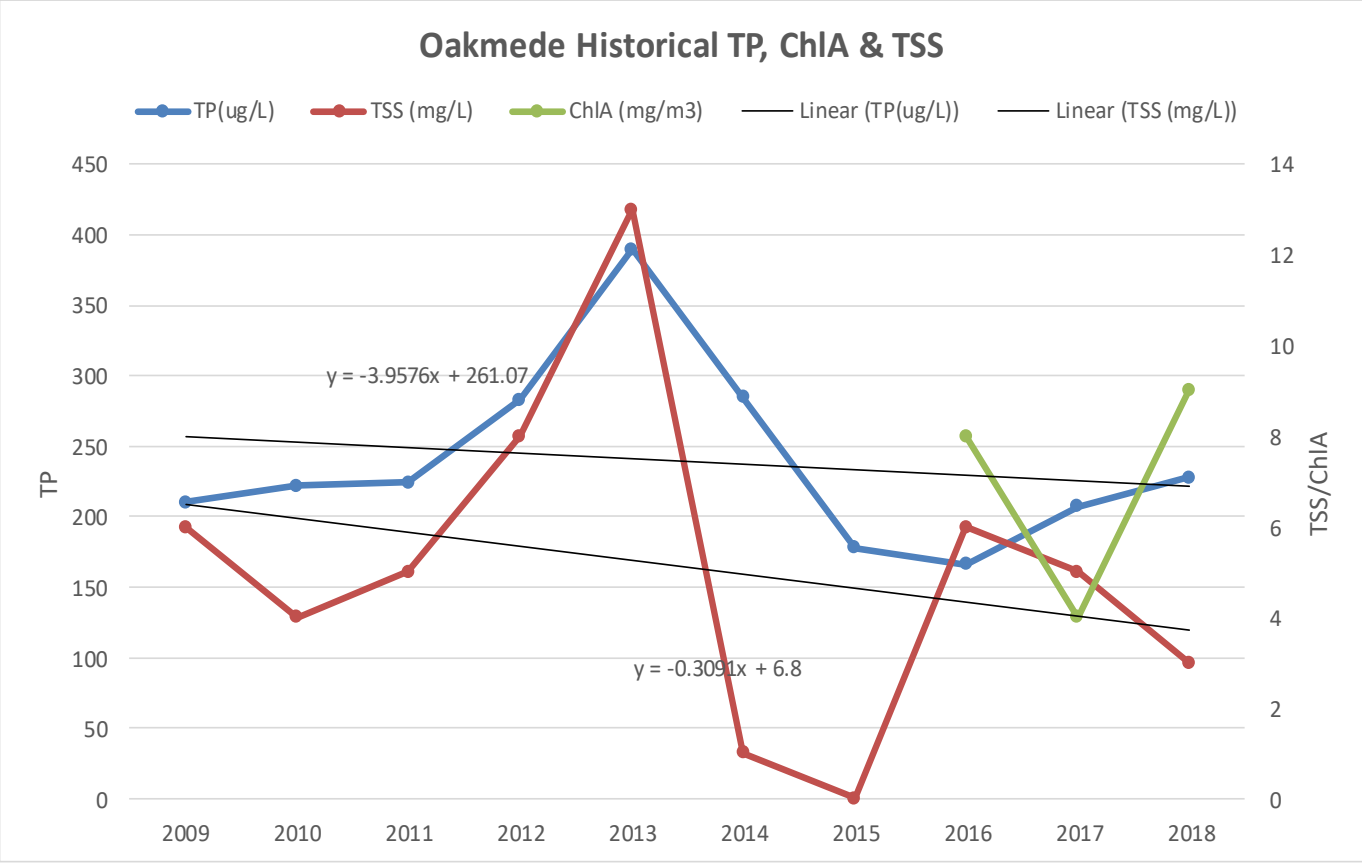


- The above graphs are the average year to year comparisons of nutrient levels entering Whitaker Pond from the WBLSS and leaving Whitaker Pond.

Lambert Creek—Oakmede

Oakmede			
Year	TP(ug/L)	TSS (mg/L)	ChlA (mg/
2009	210	6	
2010	222	4	
2011	224	5	
2012	283	8	
2013	390	13	
2014	285	1	
2015	178	0	
2016	166	6	8
2017	207	5	4
2018	228	3	9

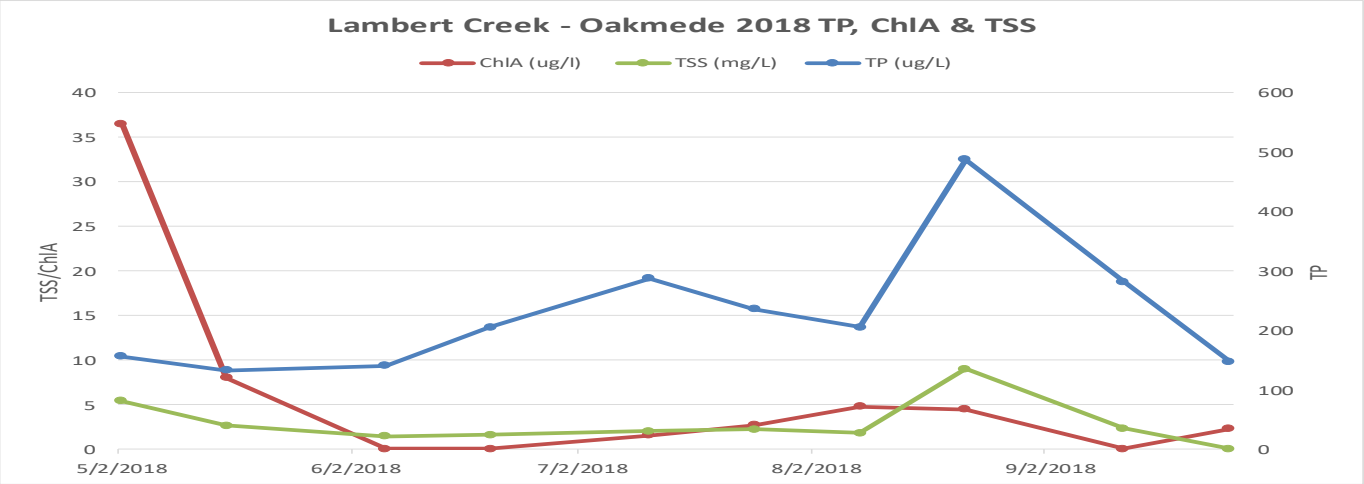
Date	Temp °C	Conductivity (mS/cm)	DO (mg/L)	pH
4/28/2018	7.7	0.763	16.41	7.80
5/29/2018	27.0	0.754	5.52	8.06
6/9/2018	22.3	0.635	4.25	7.81
6/24/2018	24.3	0.756	4.53	7.83
7/15/2018	27.3	0.757	4.57	7.82
7/21/2018	24.6	0.758	5.73	8.10
8/3/2018	23.2	0.755	4.53	8.01
8/11/2018	26.2	0.760	4.49	7.86
9/5/2018	22.1	0.761	4.88	7.73
9/17/2018	17.5	0.761	6.52	8.00
10/15/2018	8.1	0.760	10.81	7.98
10/23/2018	7.3	0.767	11.54	8.14
11/3/2018	7.3	0.759	9.94	7.97
11/18/2018	0.9	0.759	9.68	7.36



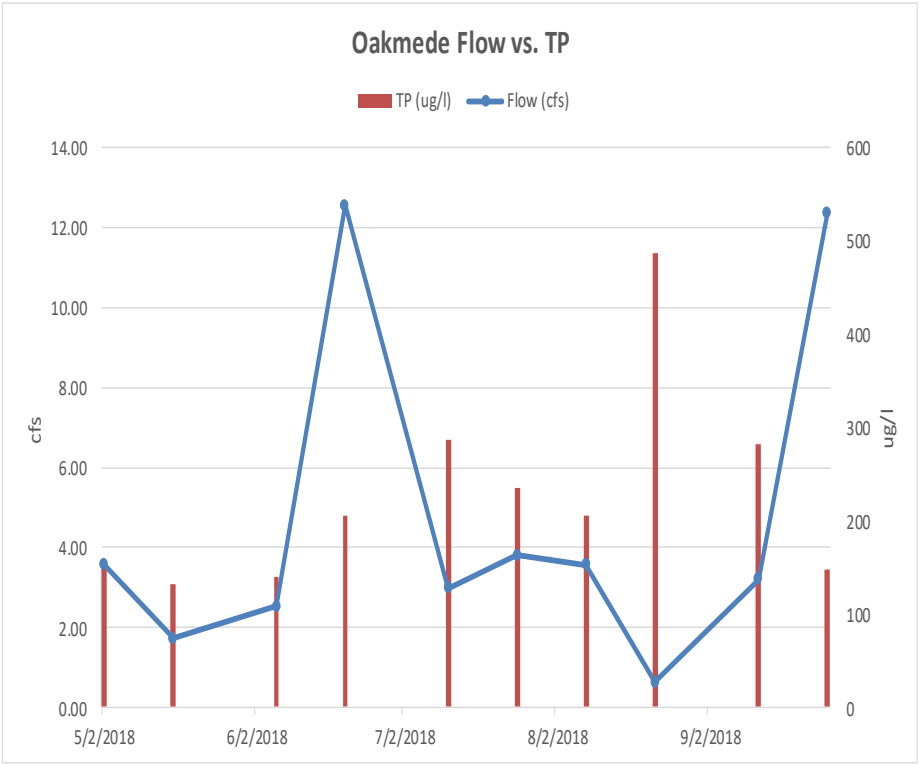
- LC-Oakmede has been well above state standards for TP over the last 9 years of monitoring, but has shown a down trend since 2013. State standard 130 ug/l State standard for TSS is 14mg/l, LC-Oakmede is below state standard for the last 8 years.

Lambert Creek—Oakmede

SITE	DATE	TP (ug/L)	ChlA (ug/l)	TSS (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2+NO3 mg/L	CL (mg/L)
oakmede	4/12/2018							129
oakmede	4/20/2018							160
oakmede	5/2/2018	156	37	5	0.958	< 0.04	< 0.03	
oakmede	5/16/2018	132	8	3				
oakmede	6/6/2018	140	< 1	1	0.702	0.095	0.046	
oakmede	6/20/2018	205	< 1	2				
oakmede	7/11/2018	287	2	2	0.90	0.09	< 0.03	
oakmede	7/25/2018	236	3	2				
oakmede	8/8/2018	205	5	2	0.842	0.062	< 0.03	
oakmede	8/22/2018	488	4	9				
oakmede	9/12/2018	282	< 1	2	0.767	0.149	< 0.03	
oakmede	9/26/2018	147	2	< 1				



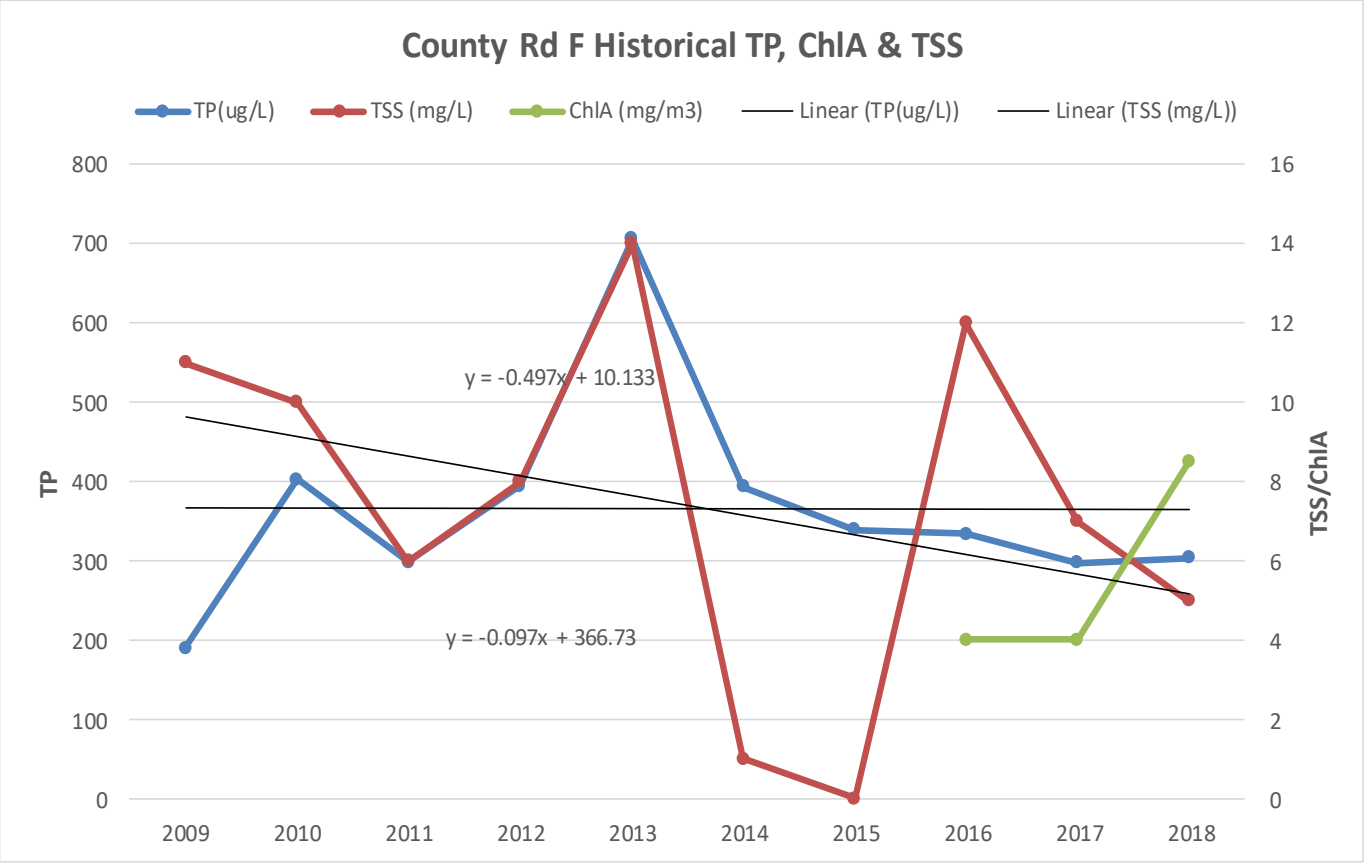
Date	Flow (cfs)	TP (ug/l)
5/2/2018	3.56	156
5/16/2018	1.73	132
6/6/2018	2.53	140
6/20/2018	12.57	205
7/11/2018	2.97	287
7/25/2018	3.80	236
8/8/2018	3.56	205
8/22/2018	0.62	488
9/12/2018	3.20	282
9/26/2018	12.38	147



Lambert Creek—Cty Rd F

County Road F			
Year	TP(ug/L)	TSS (mg/L)	ChlA (mg/
2009	190	11	
2010	403	10	
2011	299	6	
2012	395	8	
2013	707	14	
2014	393	1	
2015	339	0	
2016	334	12	4
2017	298	7	4
2018	304	5	8.5

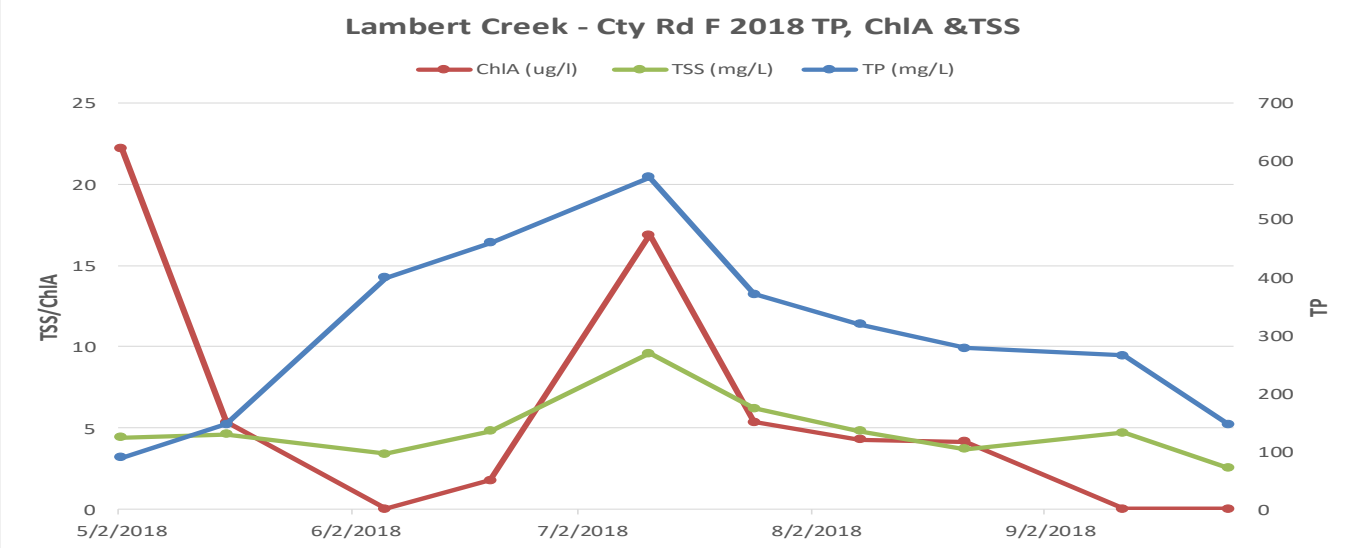
Date	Temp °C	Conductivity (mS/cm)	DO (mg/L)	pH
4/28/2018	9.1	0.763	10.46	7.89
5/29/2018	23.8	0.754	6.33	7.97
6/9/2018	20.1	0.660	5.95	7.83
6/24/2018	22.9	0.757	5.30	7.89
7/15/2018	24.7	0.757	4.55	7.93
7/21/2018	24.3	0.758	5.09	8.00
8/3/2018	20.2	0.755	4.51	8.16
8/11/2018	22.4	0.761	3.36	7.88
9/5/2018	19.8	0.761	4.83	7.80
9/17/2018	17.9	0.762	5.24	8.10
10/15/2018	9.0	0.761	9.31	8.23
10/23/2018	6.7	0.767	10.54	8.38
11/3/2018	6.2	0.759	10.44	8.00
11/18/2018	1.2	0.759	8.79	7.42



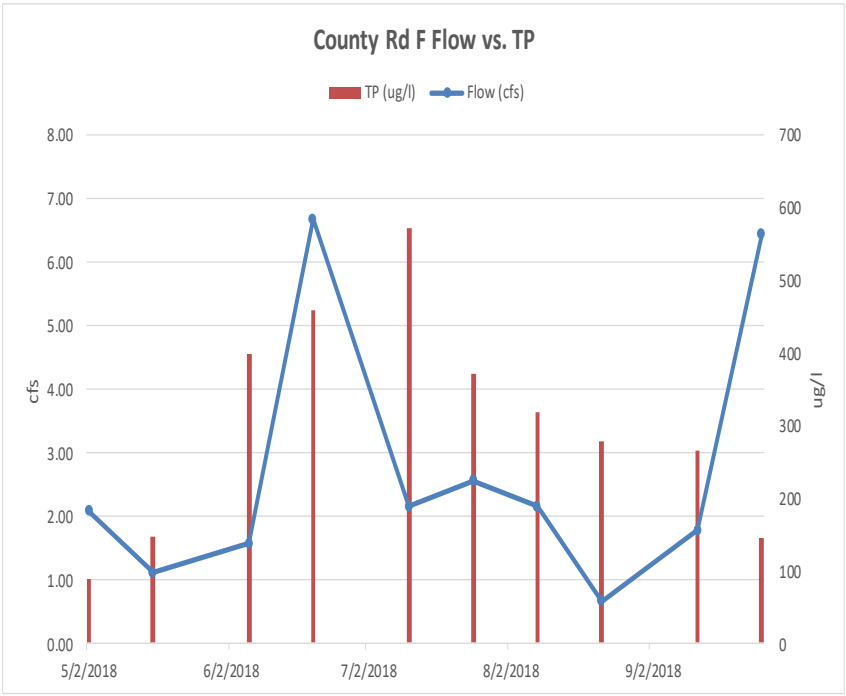
- LC-Cty Rd. F has been well above state standards for TP over the last 9 years of monitoring. This is the highest level of TP out of all six sampling sites on the creek. State standard is 130 ug/l. State standard for TSS is 14mg/l. MNDOT did work on 35E and the ditch running into the creek during 2016. Ponds and structures were added to the ditch to address flow. Time will tell

Lambert Creek—Cty Rd F

SITE	DATE	TP (mg/L)	ChlA (ug/l)	TSS (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2+NO3 mg/L	CL (mg/L)
cty rd F	4/12/2018							126
cty rd F	4/20/2018							175
cty rd F	5/2/2018	89	22	4	0.836	0.049	0.048	
cty rd F	5/16/2018	146	5	5				
cty rd F	6/6/2018	399	< 1	3	0.798	0.084	0.044	
cty rd F	6/20/2018	459	2	5				
cty rd F	7/11/2018	573	17	10	1.0	< 0.04	< 0.03	
cty rd F	7/25/2018	371	5	6				
cty rd F	8/8/2018	319	4	5	0.711	0.05	< 0.03	
cty rd F	8/22/2018	278	4	4				
cty rd F	9/12/2018	265	< 1	5	0.78	0.094	< 0.03	
cty rd F	9/26/2018	145	< 1	3				



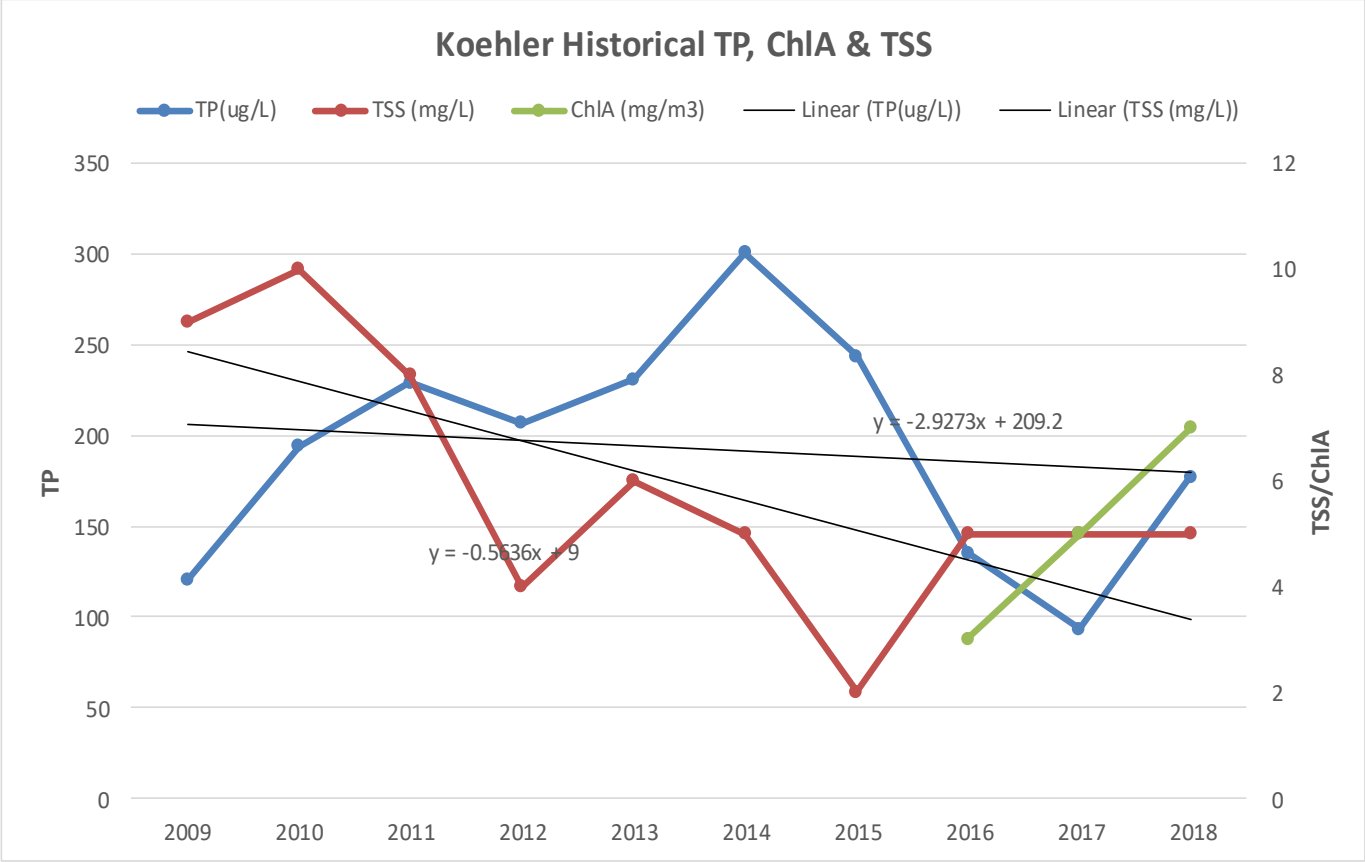
Date	Flow (cfs)	TP (ug/l)
5/2/2018	2.08	89
5/16/2018	1.11	146
6/6/2018	1.56	399
6/20/2018	6.67	459
7/11/2018	2.15	573
7/25/2018	2.56	371
8/8/2018	2.15	319
8/22/2018	0.65	278
9/12/2018	1.78	265
9/26/2018	6.44	145



Lambert Creek—Koehler

Koehler			
Year	TP(ug/L)	TSS (mg/L)	ChlA (mg/
2009	120	9	
2010	194	10	
2011	229	8	
2012	207	4	
2013	231	6	
2014	301	5	
2015	244	2	
2016	135	5	3
2017	93	5	5
2018	177	5	7

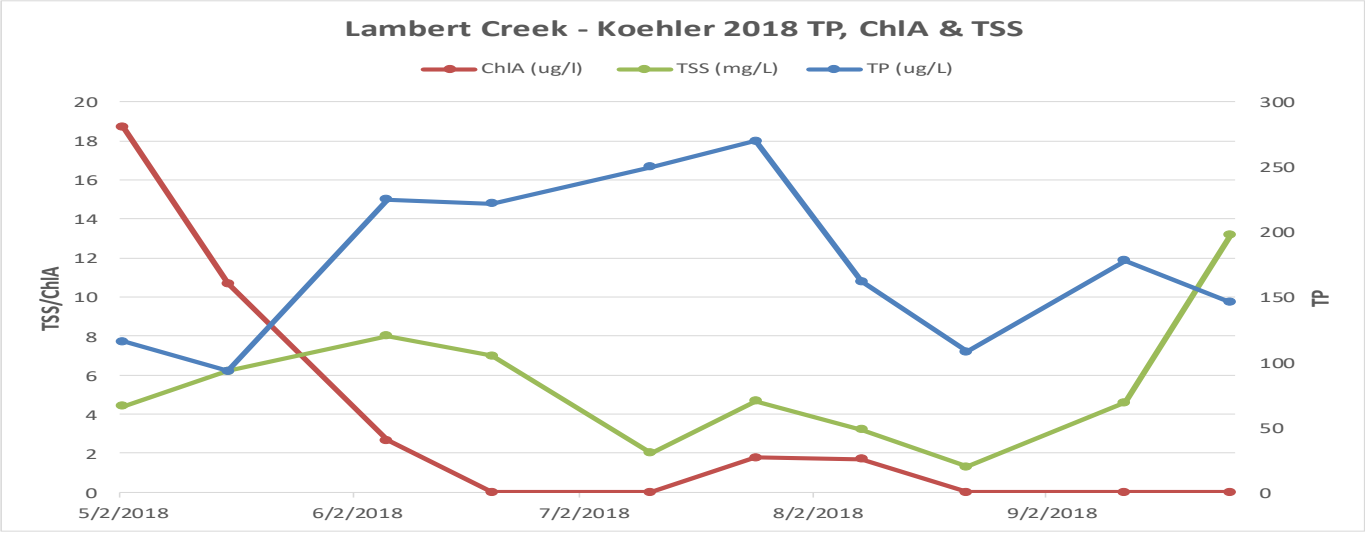
Date	Temp °C	Conductivity (mS/cm)	DO (mg/L)	pH
4/28/2018	8.4	0.763	10.79	8.01
5/29/2018	20.3	0.754	5.69	8.10
6/9/2018	18.0	0.768	6.25	8.00
6/24/2018	21.7	0.757	4.94	8.05
7/15/2018	23.3	0.758	2.21	8.25
7/21/2018	22.8	0.758	4.96	7.93
8/3/2018	19.1	0.755	7.01	8.42
8/11/2018	20.9	0.761	5.92	7.75
9/5/2018	19.2	0.762	3.58	8.36
9/17/2018	14.4	0.762	4.79	8.41
10/15/2018	7.1	0.761	11.23	8.20
10/23/2018	6.2	0.768	11.36	8.44
11/3/2018	6.2	0.760	11.64	8.02
11/18/2018	0.6	0.759	10.80	7.37



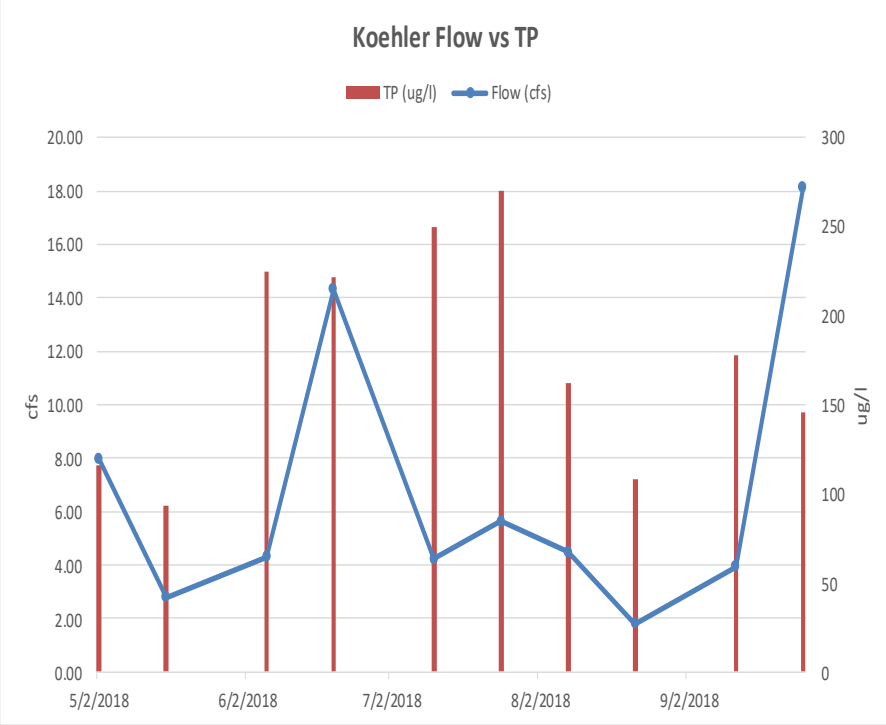
- State standard is 130 ug/l. State standard for TSS is 14mg/l. Stream bank restoration was done in 2011 and have noticed improvement in TSS levels over the years since restoration

Lambert Creek—Koehler

SITE	DATE	TP (ug/L)	ChlA (ug/l)	TSS (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2+NO3 mg/L	CL (mg/L)
koehler	4/12/2018							220
koehler	4/20/2018							251
koehler	5/2/2018	116	19	4	1.5	0.636	0.212	
koehler	5/16/2018	93	11	6				
koehler	6/6/2018	225	3	8	1.46	0.332	0.181	
koehler	6/20/2018	222	< 1	7				
koehler	7/11/2018	250	< 1	2	1.08	0.21	0.07	
koehler	7/25/2018	270	2	5				
koehler	8/8/2018	162	2	3	0.875	0.138	0.07	
koehler	8/22/2018	108	< 1	1				
koehler	9/12/2018	178	< 1	5	1.05	0.244	0.13	
koehler	9/26/2018	146	< 1	13				

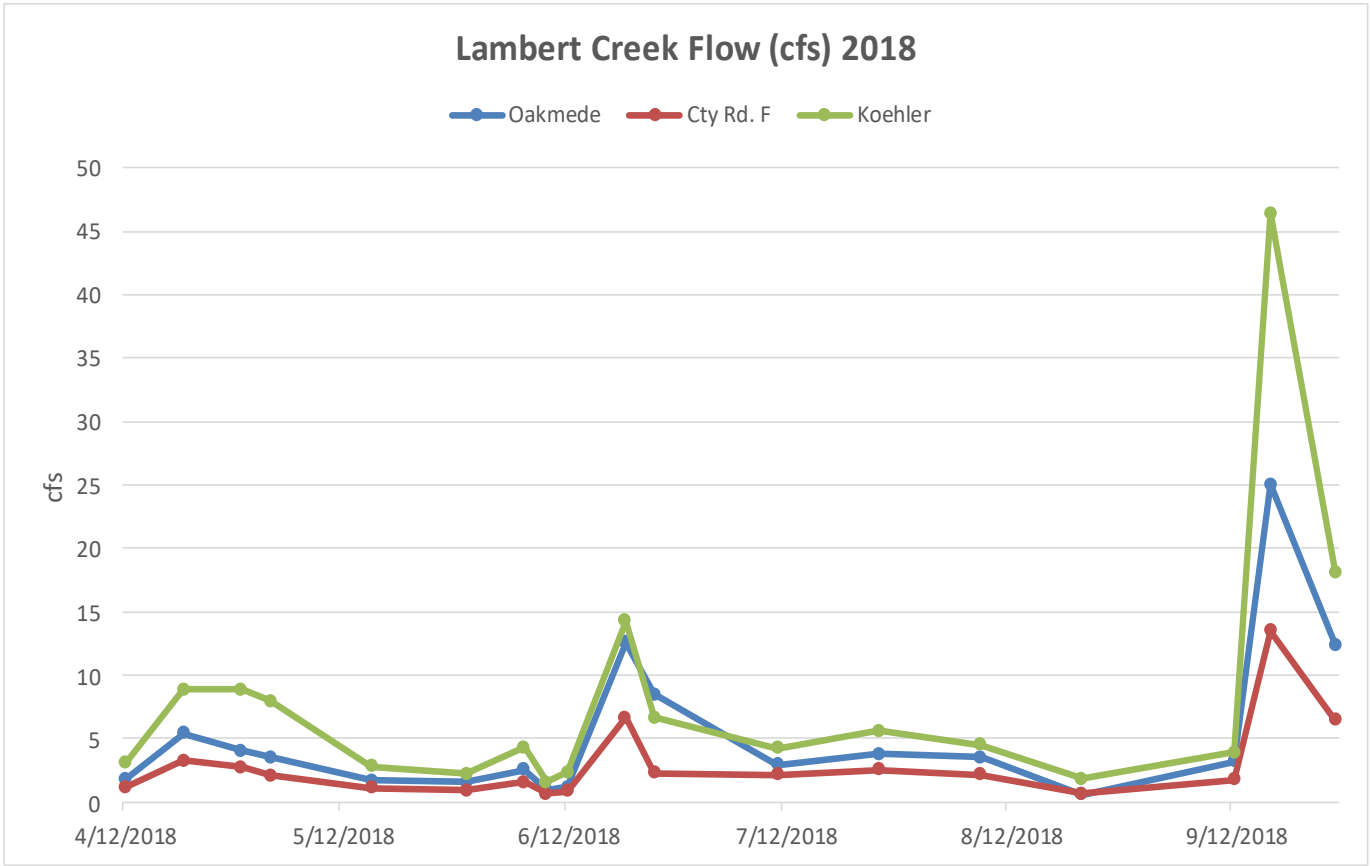


Date	Flow (cfs)	TP (ug/l)
5/2/2018	7.97	116
5/16/2018	2.80	93
6/6/2018	4.31	225
6/20/2018	14.32	222
7/11/2018	4.22	250
7/25/2018	5.63	270
8/8/2018	4.49	162
8/22/2018	1.81	108
9/12/2018	3.95	178
9/26/2018	18.13	146



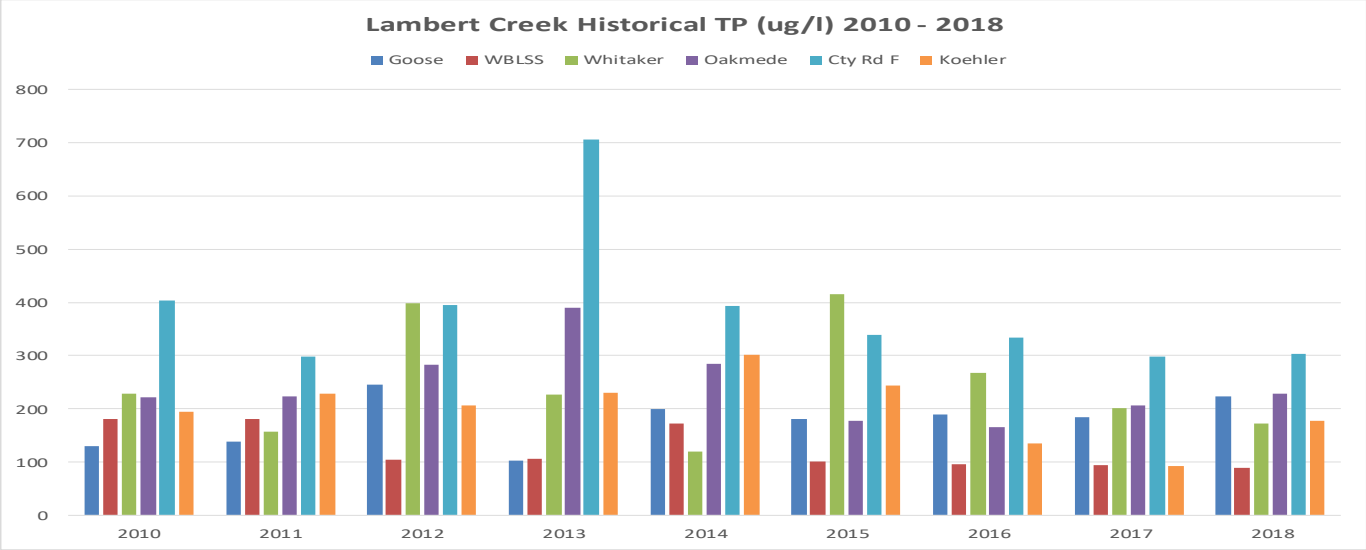
Lambert Creek Flow

Date	Oakmede	Cty Rd. F	Koehler
4/12/2018	1.82	1.17	3.12
4/20/2018	5.39	3.25	8.89
4/28/2018	4.05	2.72	8.89
5/2/2018	3.56	2.08	7.97
5/16/2018	1.73	1.11	2.80
5/29/2018	1.54	0.93	2.22
6/6/2018	2.53	1.56	4.31
6/9/2018	0.97	0.65	1.56
6/12/2018	1.20	0.87	2.36
6/20/2018	12.57	6.67	14.32
6/24/2018	8.46	2.31	6.66
7/11/2018	2.97	2.15	4.22
7/25/2018	3.80	2.56	5.63
8/8/2018	3.56	2.15	4.49
8/22/2018	0.62	0.65	1.81
9/12/2018	3.20	1.78	3.95
9/17/2018	25.05	13.50	46.43
9/26/2018	12.38	6.44	18.13
10/10/2018	13.54	7.75	29.59
10/15/2018	6.86	4.59	8.89
10/23/2018	2.86	1.92	4.67

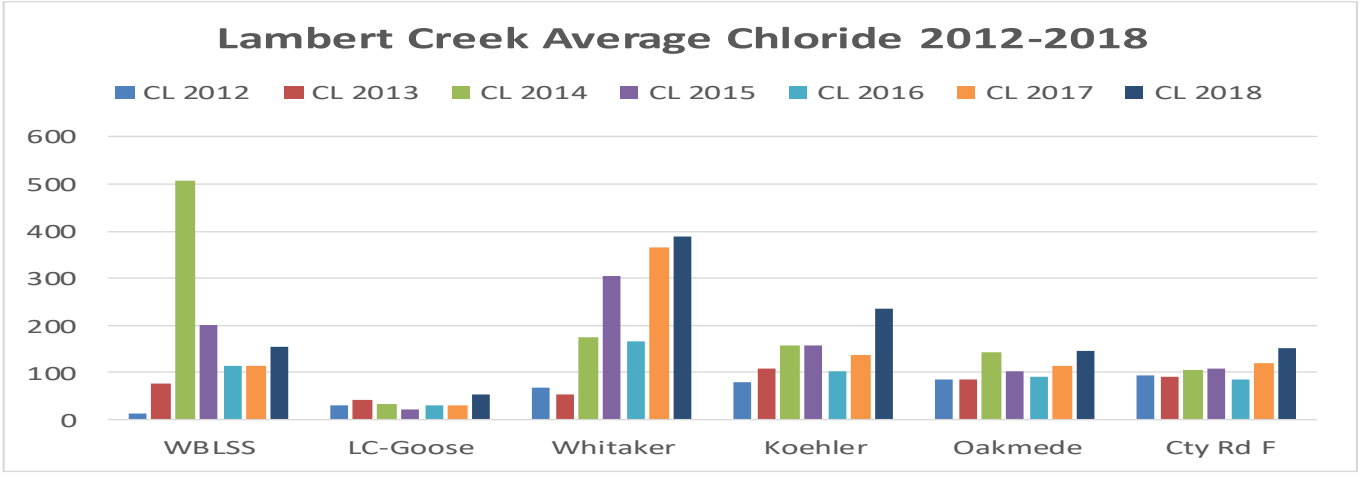


Lambert Creek Comparison

Lambert Creek Average Yearly Tp (ug/L) 2010-2018									
	2010	2011	2012	2013	2014	2015	2016	2017	2018
Goose	130	138	246	102	199	181	189	185	224
WBLSS	180	181	104	106	173	101	96	94	89
Whitaker	229	157	398	226	119	416	267	202	173
Oakmede	222	224	283	390	285	178	166	207	228
Cty Rd F	403	299	395	707	393	339	334	298	304
Koehler	194	229	207	231	301	244	135	93	177



SITE	CL 2012	CL 2013	CL 2014	CL 2015	CL 2016	CL 2017	CL 2018
WBLSS	11.1	76	507.5	200	113	113	153
LC-Goose	30.9	40.5	32.75	20	30	31	53
Whitaker	67.5	52	175.5	305	167	365	390
Koehler	79.2	107.5	157	158	101	136	234
Oakmede	84.0	85.5	141.75	101	90	115	145
Cty Rd F	92.4	90.5	104	107	85	119	151



2018 Monitoring Highlights

- Gem Lake's chemistry has improved over the last 6 years which coincides with the work that was done on Highway 61 and the reconstructed grass swales flowing into the lake. Water quality parameters are below state standards. The MNPCA is currently looking into delisting Gem Lake from the impaired list.
- Gilfillan is also on the Impaired List. Since the augmentation system went in (2012) to raise the water level, the water quality has improved (most likely due to dilution). We have been told that no augmentation has occurred the last 6 years so it has been maintaining its water level on its own. Nutrient levels have been slightly rising over the last six years near state standards.
- East Goose and West Goose still have very high nutrient levels. Bullhead removal did not make the water quality impact we hoped, but it did reduce nutrient levels a little, and a 2017 fish survey indicated the bullhead population is still under control. Sediment cores and enhanced sampling were done in 2017 for possible future alum treatment. Wood Lake was also studied in depth for a spent lime pilot project to reduce TP levels. Project to begin in 2019.
- Wilkinson's phosphorus is well over state standards but Chlorophyll A is well below standard. Wilkinson acts more like a wetland and therefore what goes on in the watershed has a greater effect on the chemistry. A special study was done on the wetland complex connecting Amelia to Wilkinson and results indicate nutrient loading from that system. A special study was also done on the south complex to Wilkinson Lake from Black Lake. This area also showed high nutrient numbers.
- Tamarack's numbers are still high. The floating wetland has not shown any effect as of yet. VLAWMO did not sample the island in 2018. We will revisit and sample in a few years to see if there has been any effect on water quality. Opinion is the island was undersized.
- The automated storm sampler was installed at 4th and Otter Lake Rd for the second year. This area drains stormwater into Birch Lake. Results again showed very high nutrient levels during storms.
- The wetland treatment system at Whitaker was completed and 3 storm events were sampled. Results showed great reductions in E. coli and nutrients.
- Chloride levels overall were similar to last year. We have been sampling for 9 years and there have been no significant changes within the lakes. Black Lake has the lowest levels. Birch Lake and East Goose are the highest which makes sense due to the proximity to major roads. All of the lakes are below the current State standards. The creek samples are difficult to catch because it has to be done when water is flowing. Year round chloride sampling on Birch Lake was done for the third year and levels have stayed steady