Hydrologic Data and Figures

Table 1. 30-Year Monthly Average Precipitation (inches)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL
0.73	.62	1.73	2.53	3.69	4.64	3.49	5.05	3.41	2.47	1.64	0.95	30.95

Source: 1981-2010, National Climatic Data Center, Station: 214176 JORDAN 1 S, MN.
https://www.ncdc.noaa.gov/cdo-web/datatools/normals

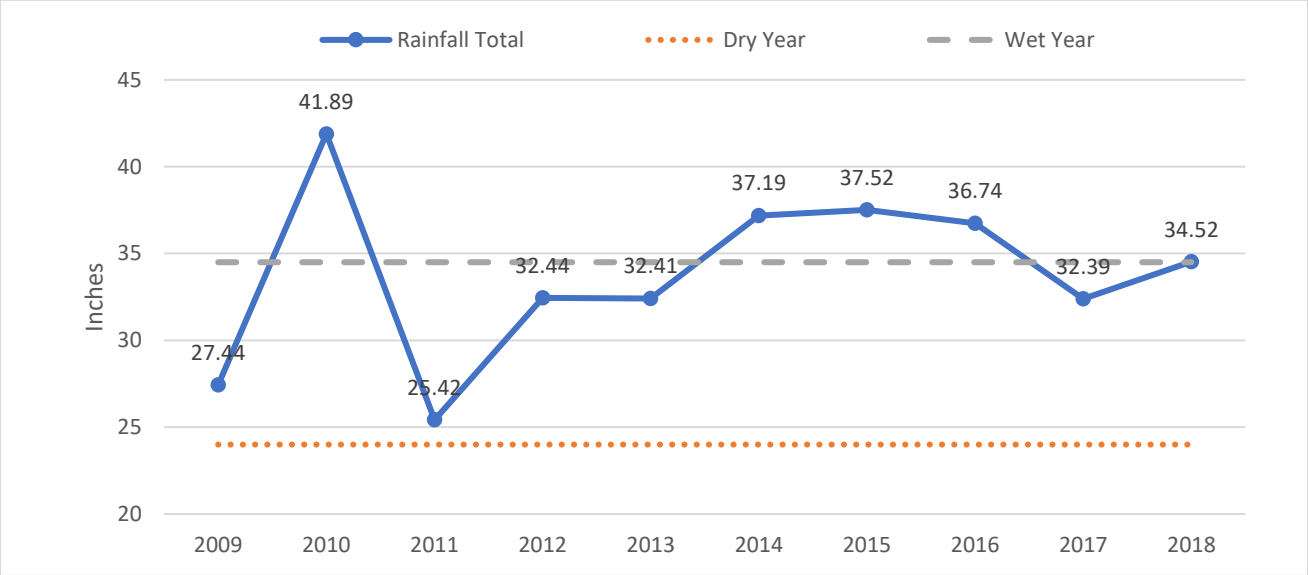


Figure 1. Ten-Year Precipitation at the Watershed District

Source: MN Climatology Working Group for dry and wet year data. Rainfall totals from volunteer rain gauge volunteer Jonathan Cohen (2009-2014) and Prior Lake City Hall rain gauge (2015-2018). To find more up-to-date precip data, visit https://www.plslwd.org/projects-and-programs/monitoring/precipitation-monitoring/.

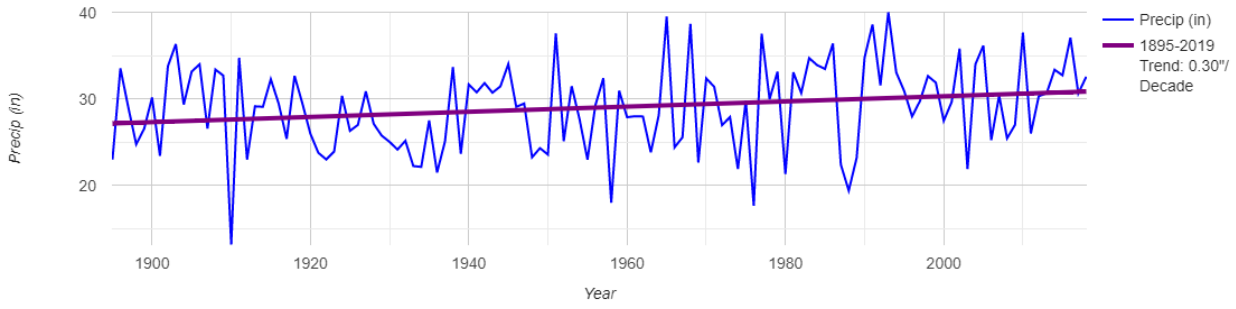


Figure 2. Annual Precipitation Totals for the Lower Minnesota River Watershed (1895-2018)

Source: https://arcgis.dnr.state.mn.us/ewr/climatetrends/#

Table 2. Approximate Monthly Evaporation from Shallow Lakes and Reservoirs (inches)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL
0.3	0.4	0.9	1.7	2.9	3.0	5.4	5.5	4.3	2.9	1.3	0.4	29.8

Source: MN Hydrology Guide 1975

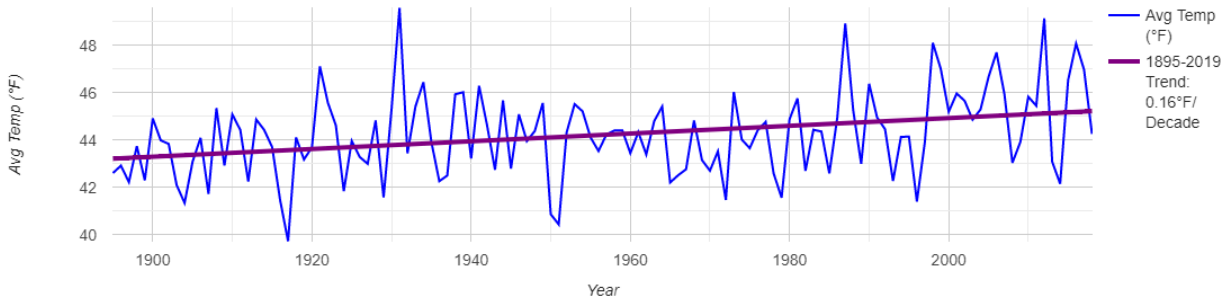


Figure 3. Average Annual Temperature for Lower Minnesota River Watershed (1895-2018)

Source: https://arcgis.dnr.state.mn.us/ewr/climatetrends/#

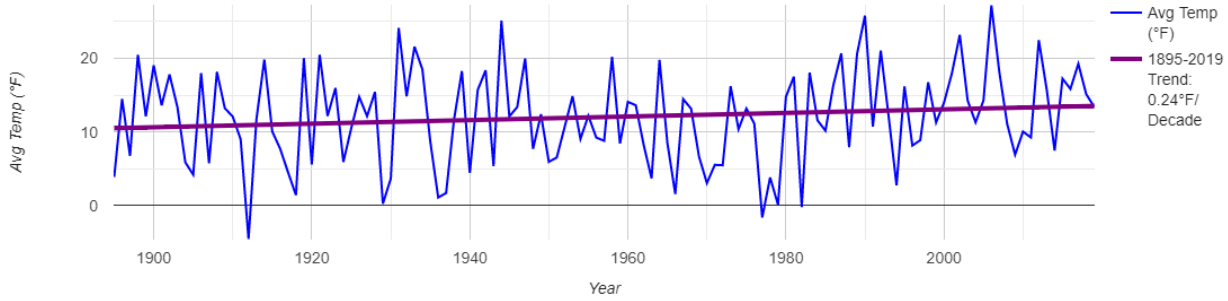


Figure 4. Average January Temperature for Lower Minnesota River Watershed (1895-2018)

Source: https://arcgis.dnr.state.mn.us/ewr/climatetrends/#

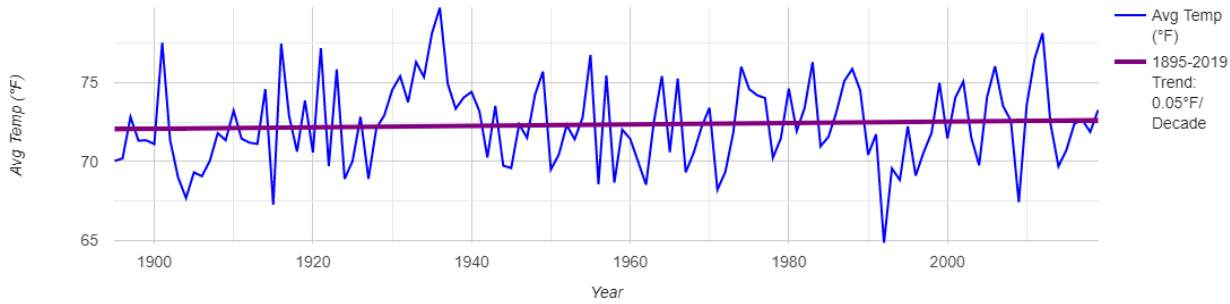


Figure 5. Average July Temperature for Lower Minnesota River Watershed (1895-2018)

Source: https://arcgis.dnr.state.mn.us/ewr/climatetrends/#

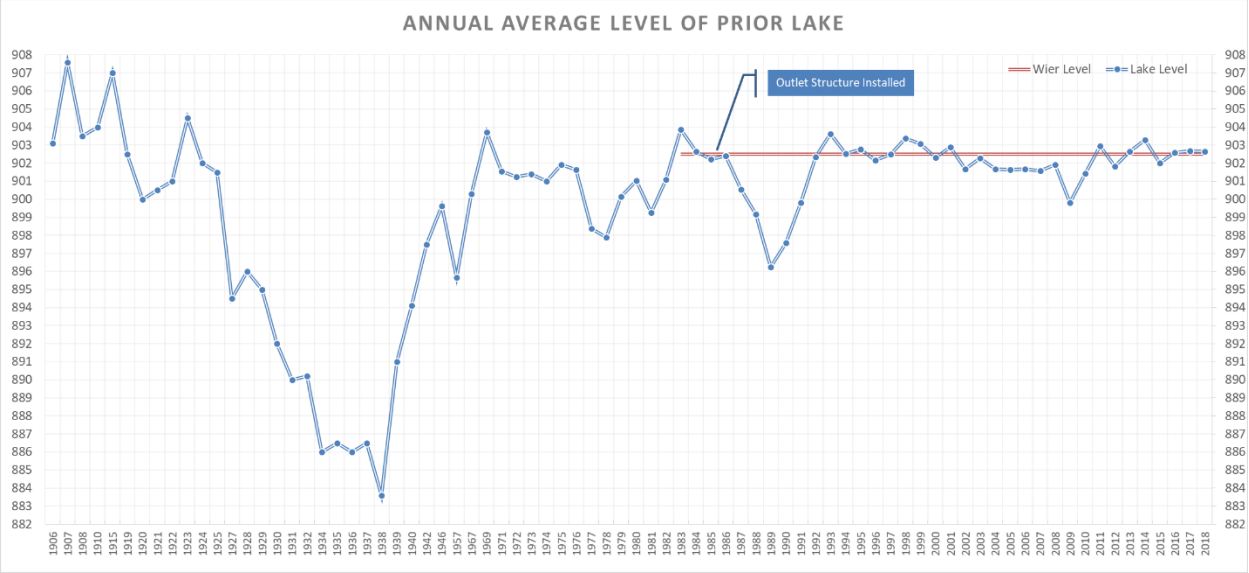


Figure 6. Historic Prior Lake Levels (1906-2018)

Source: PLSLWD website https://www.plslwd.org/waterbodies/prior-lake-lower/#lake-levels and DNR Lake Finder Website https://www.dnr.state.mn.us/lakefind/index.html.

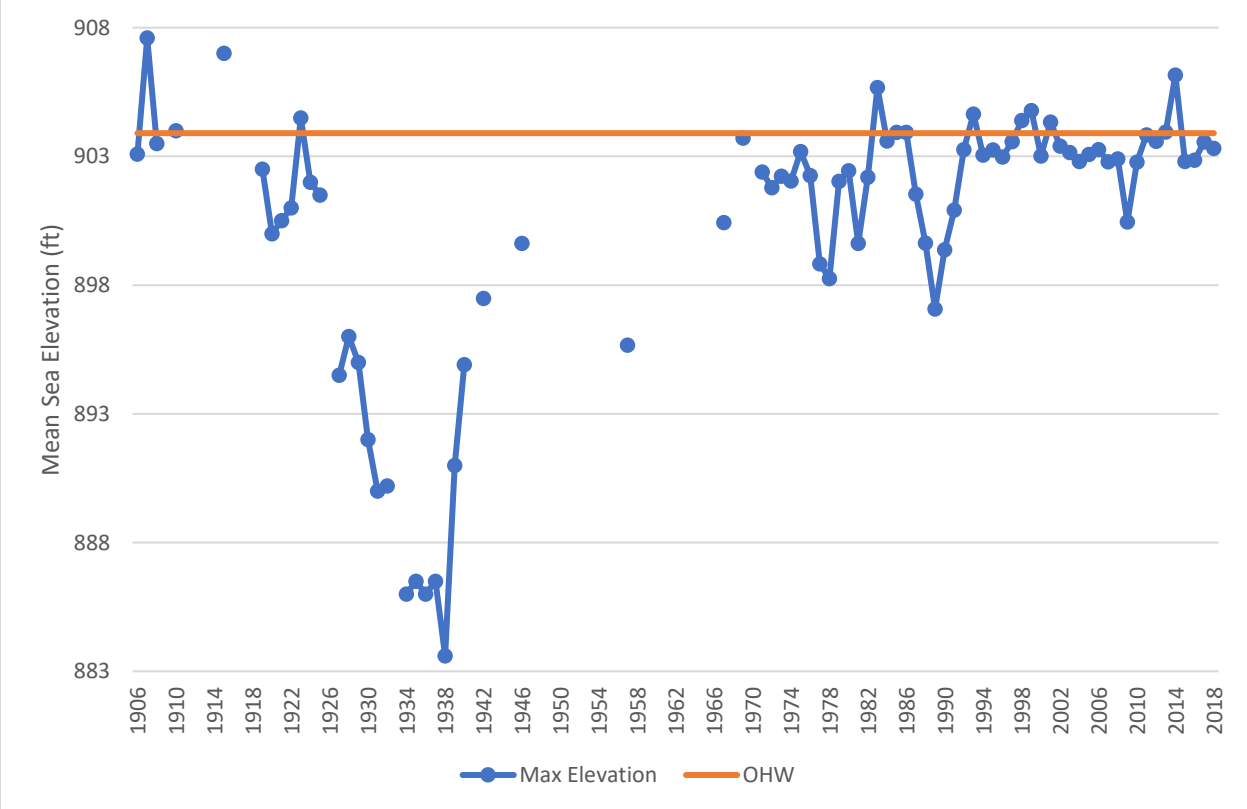


Figure 7. Maximum Recorded Prior Lake Elevations https://www.plslwd.org/waterbodies/prior-lake-lower/#lake-levels

Data in table below is averaged from 2014-2018, June through September, except Buck Lake: 2014-2017; Cates Lake: 2017; Crystal Lake: 2014; Sutton Lake: 2014-2016 and taken at outlet of lake at site ST_5D.

Secchi depth is actually a turbidity tube and max reading in t-tube is 1m, so the average would be greater than because it's not possible to average when max can't be greater than 1m; Swamp Lake: 2014-2016 and taken at outlet of lake at site ST_01. Secchi depth is actually turbidity tube and max reading in t-tube is 1m, so the average would be greater than because it's not possible to average when the maximum can't be greater than 1m; Haas Lake: 2014-2017; Lower Prior (Site 2): 2014-2017. Updated information can be found here: http://www.plslwd.org/wqdb/measurements_form.php.

Table 3. Physical Characteristics of Lakes within the District Mean Summer (June 1-Sept. 20) Values for Years 2014-2018

Lake Name	PLSLWD Tier Class[1]	MDNR Ecological Class[2]	Public Boat Access	MDNR Basin Shoreland Classification[2]	Goal: Summer Secchi Disk (m)[3]	Goal: Summer TP (µg/l)	Observed Secchi Disk (m)	Observed TP (µg/l)
Lower Prior (Site 1)	1	25	Yes	GD	≥1.4	<40	4.7	24
Lower Prior (Site 2)	1	25	Yes	GD	≥1.4	<40	2.73	25
Upper Prior	1	41	Yes	GD	≥1.0	<60	1.4	68
Spring	1	24	Yes	GD	≥1.4	<60	1.3	53
Fish	1	24	Yes	RD	≥1.4	<40	1.5	46
Pike (west)	2	N/A	No	NE	≥1.0	<60	0.9	89
Pike (east)	2	N/A	No	NE	≥1.0	<60	0.6	170
Buck	2	N/A	No	NE	≥1.0	<60	1.34	101
Crystal	3	36	No	NE	≥1.0	<60	2.05	304
Rice	3	N/A	No	NE	≥1.0	<60	N/A	N/A
Sutton	2	N/A	No	NE	≥1.0	<60	>0.83[4]	330[4]
Swamp	3	N/A	No	NE	≥1.0	<60	>0.95[4]	380[4]
Cates	3	N/A	No	NE	≥1.0	<60	2.18	23
Arctic	2	N/A	Yes	NE	≥1.0	<60	.47	124
Haas	3	N/A	No	NE	≥1.0	<60	1.06	36
Jeffers	3	N/A	No	RD	≥1.0	<60	>0.92[4]	70[4]

[1]Source: PLSLWD Water Resources Management Plan (2020)

[2]Source: https://files.dnr.state.mn.us/waters/watermgmt_section/shoreland/basins_shoreland_classifications.pdf (updated 9/24/19)

[3]Source: MPCA 303d Impairment Thresholds for North Central Hardwood Forest Lakes, shallow and deep

[4]This data was collected at the outlet of this lake, not in the deepest spot.

Table 4. Physical Characteristics of Lakes within PLSLWD

Lake	DNR Lake Number	Lake Surface Area (ac)	Total Watershed Area	Mean Depth	Max Depth	Watershed/Lake Area Ratio (ac:ac)	Lake Area/Max Depth Ratio (ac:ft)
Lower Prior	70-0026	940	18,904	13	56	20.1	16.8
Upper Prior	70-0072	375	16,038	10	43	42.8	8.7
Spring	70-0054	587	12,430	18	34	21.2	17.3
Fish	70-0069	171	699	14	28	1.4	6.1
Pike	70-0076	50	21,770	7	9	435.4	5.56
Buck	70-0065	23	3,350	3	12	145.7	1.91
Crystal	70-0061	30	1,340	NA	26	44.7	1.2
Rice	70-0060	30	665	NA	NA	22.2	NA
Sutton	70-0094	64	1,379	3	5	21.5	12.8
Swamp	70-0111	53	350	2	4	6.6	13.3
Cates	70-0018	30	NA	3	11	NA	2.7
Arctic	70-0085	33	NA	13	31	NA	1.06

Table 5. Ordinary High-Water Levels in Prior Lake-Spring Lake Watershed District

Lake	Ordinary High-Water Level (Mean Sea Elevation)
Lower Prior	903.9
Upper Prior	903.9
Spring	912.8
Fish	946.9
Pike	820.5
Buck	N/A
Crystal	943.3
Rice	946.4
Sutton	940.5
Swamp	N/A
Cates	930.4

Arctic	906.7

Source: MN DNR Lake Finder

An abundance of water quality data exists for waterbodies within the watershed. Most of the data is collected on water quality indicators and assessed using comparative analysis with Minnesota state water quality standards: specifically, total phosphorus (TP), chlorophyll-a (Chl-a), and Secchi depth.

A review of Minnesota Pollution Control Agency's website on December 18, 2018 shows the list of impaired waters located within the PLSLWD below in Table 6. Of these lakes, only Spring and Upper Prior have approved total maximum daily load (TMDL) reports and an associated TMDL implementation plan completed. Pike Lake and Fish Lake TMDL reports are currently in-progress. **Appendix B** shows a map of the lakes within the watershed along with flow paths.

List of Impaired Waters

Table 6. List of Impaired Waters

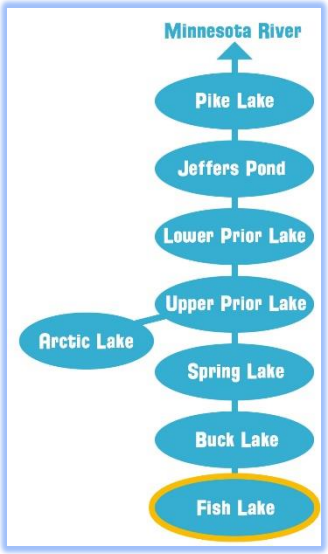
WATER BODY	YEAR LISTED	AFFECTED USE	POLLUTANT OR STRESSOR
Fish Lake	2002	Aquatic recreation	Nutrient/eutrophication biological indicators
	2006	Aquatic consumption	Mercury in fish tissue
Lower Prior Lake	2002	Aquatic consumption	Mercury in fish tissue
	2018 (draft)	*Aquatic life*	*Fishes bioassessments*
Pike Lake	2002	Aquatic recreation	Nutrient/eutrophication biological indicators
Spring Lake	1998	Aquatic consumption	Mercury in fish tissue
	2002	Aquatic recreation	Nutrient/eutrophication biological indicators
	2018 (draft)	*Aquatic life*	*Fishes bioassessments*
County Ditch 13	*2018 (draft)*	*Aquatic life*	*Fishes bioassessments*
Upper Prior Lake	2002	Aquatic consumption	Mercury in fish tissue
	2002	Aquatic recreation	Nutrient/eutrophication biological indicators

Water quality data for each of the basins is normalized to display average concentrations in June and September based on the MN Water Quality Data Collection and Assessment Guidance (2014 Assessment and Listing Cycle).

A. Water Quality in Lakes

The following subsections summarize water quality in some of the District lakes. In addition to the following section, updated water quality information can be found on the PLSLWD website in the Waterbodies tab. www.plslwd.org

1. Fish Lake



Fish Lake is a relatively small lake found in the upper watershed. Fish Lake is approximately 173 acres, has an average depth of 14 feet, and a maximum depth of 28 feet. Roughly 74 acres or 43% of the lake is considered littoral. Fish Lake is a seepage lake-outflow, meaning that there is no direct inflow to Fish Lake; rather, the hydrologic contribution is from watershed runoff and groundwater which then flows out of Fish Lake to the north towards Buck Lake.

The watershed of Fish Lake is 699 acres in size, roughly four times the size of the lake resulting in a watershed to lake ratio of 4:1 which is a relatively low ratio. The PLSLWD's 2006 Fish Lake Sustainable Management Plan shows that most of the land use within the watershed is either rural residential (29.6%) or row crop agriculture (27.6%). An analysis of available water quality data shows that for the 13-year reporting period (2004-2016), Fish Lake did not meet water quality standards for total phosphorus (TP), or chlorophyll-a (Chl-a) in 11 and 12 years respectively. The average TP concentration for Fish Lake between 2004 and 2017 was 44.06 µg/L slightly above the state standard of 40 µg/L. The average Chl-a concentration for the same period was 20.29 µg/L compared to the state standard of 14 µg/L. The Secchi depth standard of 1.4 m was met in 8 of 13 years between 2004 and 2016 and averaged 1.57 m between 2004 and 2017. The graphs below show average annual growing season concentrations for TP and Chl-a as well as Secchi depth.

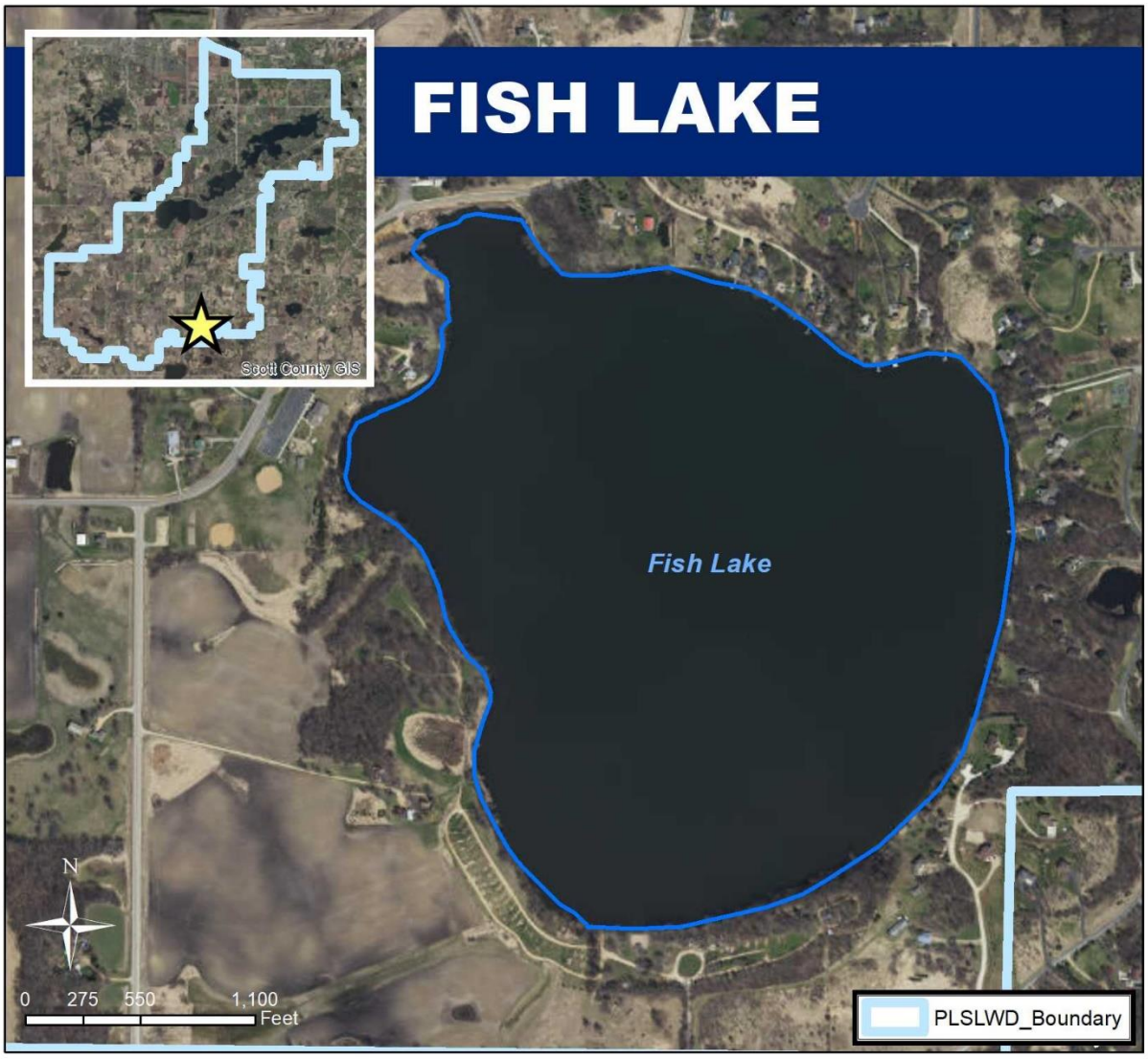


Figure 8. Map of Fish Lake

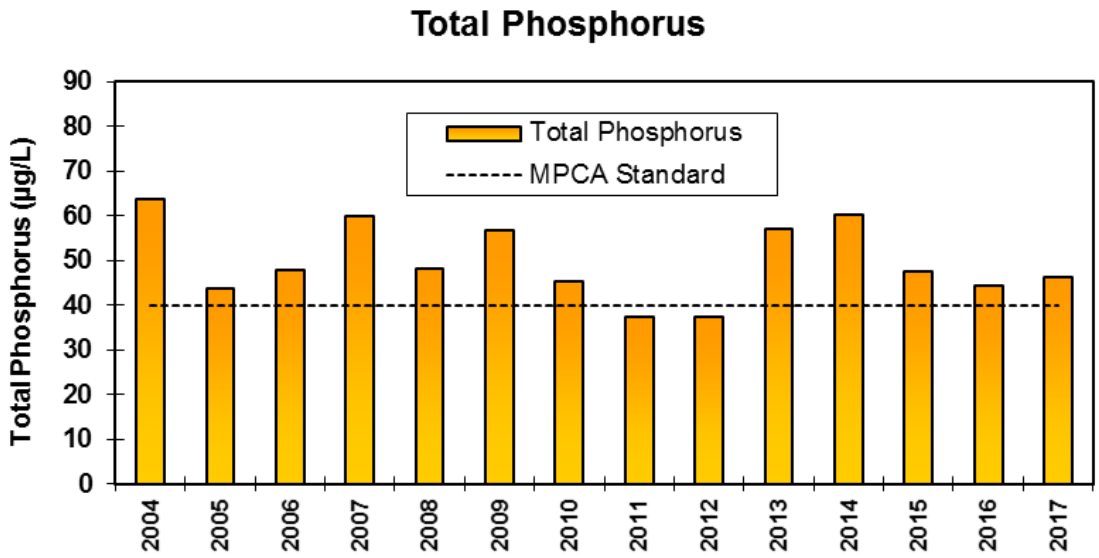


Figure 9. Summary of Total Phosphorus Data in Fish Lake

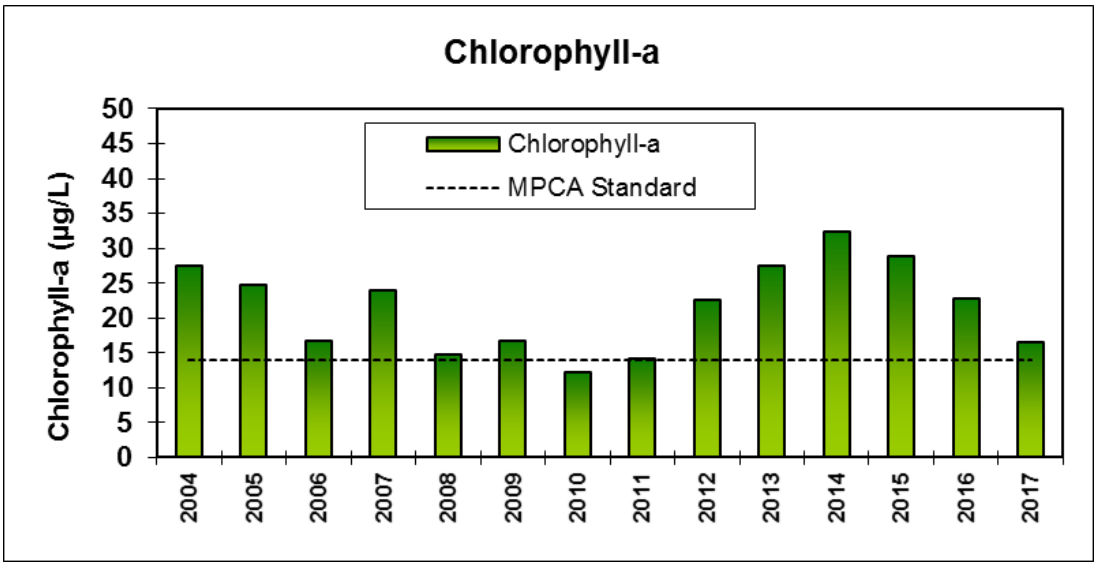


Figure 10. Summary of Chlorophyll-a Data in Fish Lake

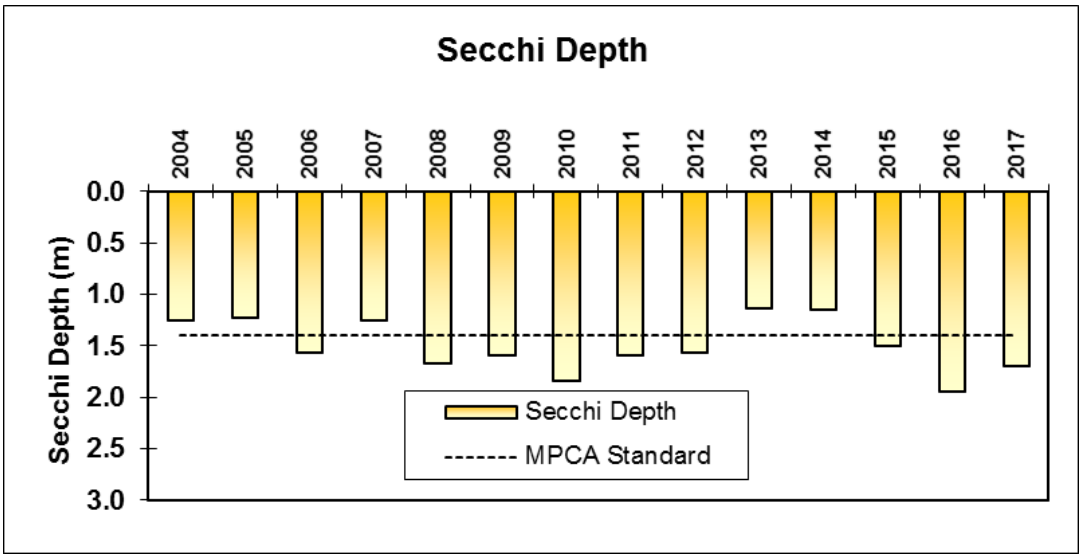
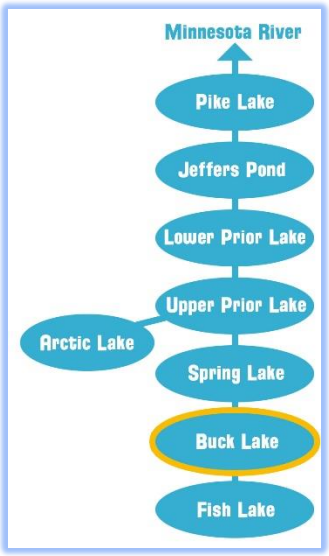


Figure 11. Summary of Secchi Depth Data in Fish Lake

2. Buck Lake



Buck Lake is a small lake (23 acres) located downstream of Fish Lake in the upper watershed. The maximum depth is 9 feet; no numerical average depth given but average depth is noted as shallow. It is assumed, based on maximum depth that the entire lake is littoral.

Buck Lake receives water from the connecting channel to Fish Lake and from the watershed to the east. Buck Lake then outflows to the north through a large wetland complex to Spring Lake. The watershed to lake ratio for Buck Lake is quite high: ~837:1, which may result in a large amount of phosphorus loading to Buck Lake from the surrounding watershed. Water quality data for Buck Lake suggests that Secchi depth and TP standards are not consistently met, but Chl-a is quite low when compared to results for Secchi and TP. The average growing season TP concentration for Buck Lake between 2014 and 2017 was 112.56 µg/L, almost twice the state standard of 60 µg/L. Secchi depth met the state standard of >1 m in 2014-2017 with an average depth of 1.33 m. Chl-a growing season concentrations were consistently low, averaging 10.8 µg/L between 2014 and 2017, with only one year (2016) exceeding the standard and had an average growing season concentration of 20.18 µg/L. Supplemental data collected as part of a feasibility study for a chemical treatment system downstream of Buck Lake, indicate that dissolved oxygen levels in Buck Lake as well as its inflows and outflows are quite low (<1 mg/L). The graphs below show average annual growing season concentrations for TP and Chl-a as well as Secchi depth.

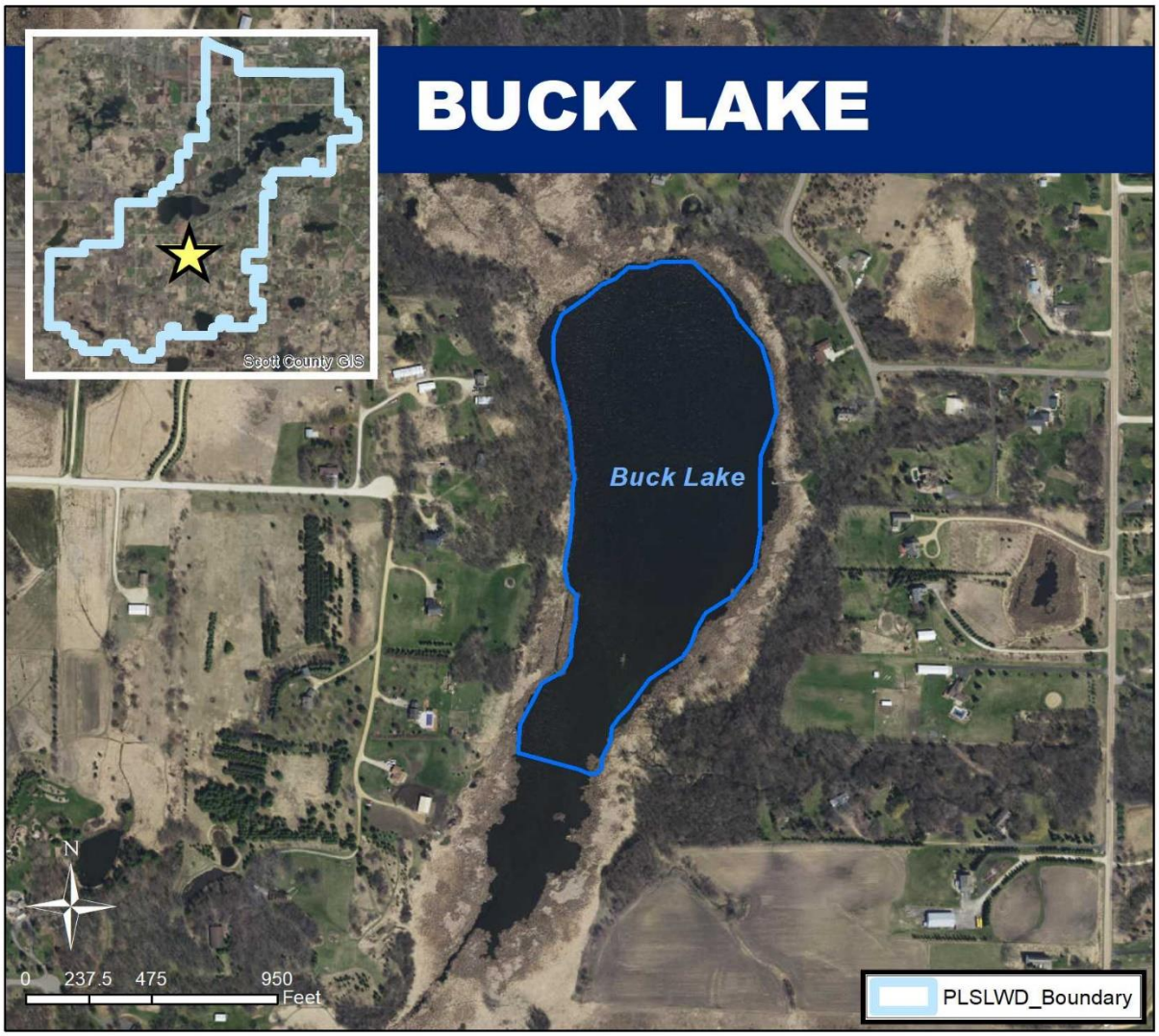


Figure 12. Map of Buck Lake

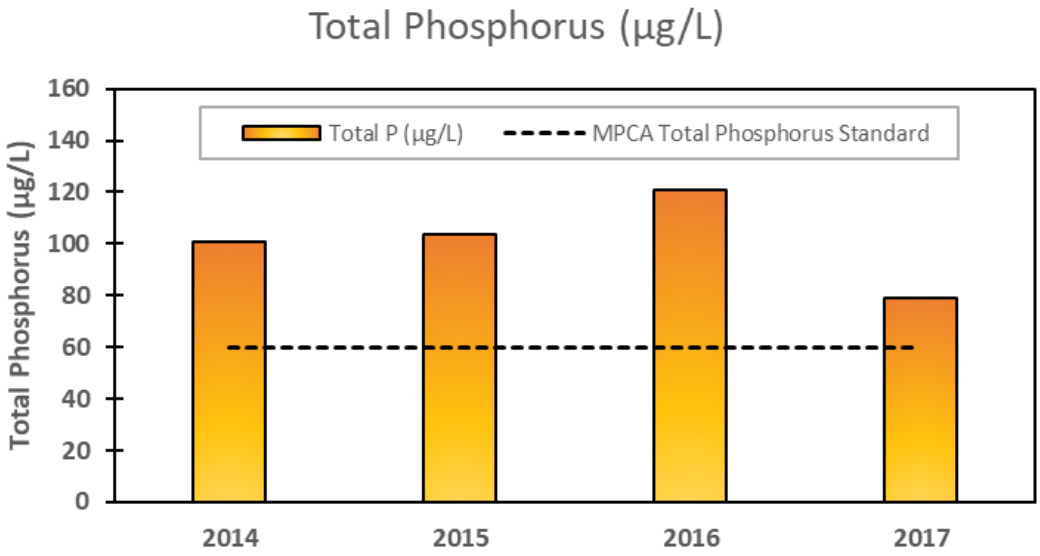


Figure 13. Summary of Total Phosphorus Data in Buck Lake

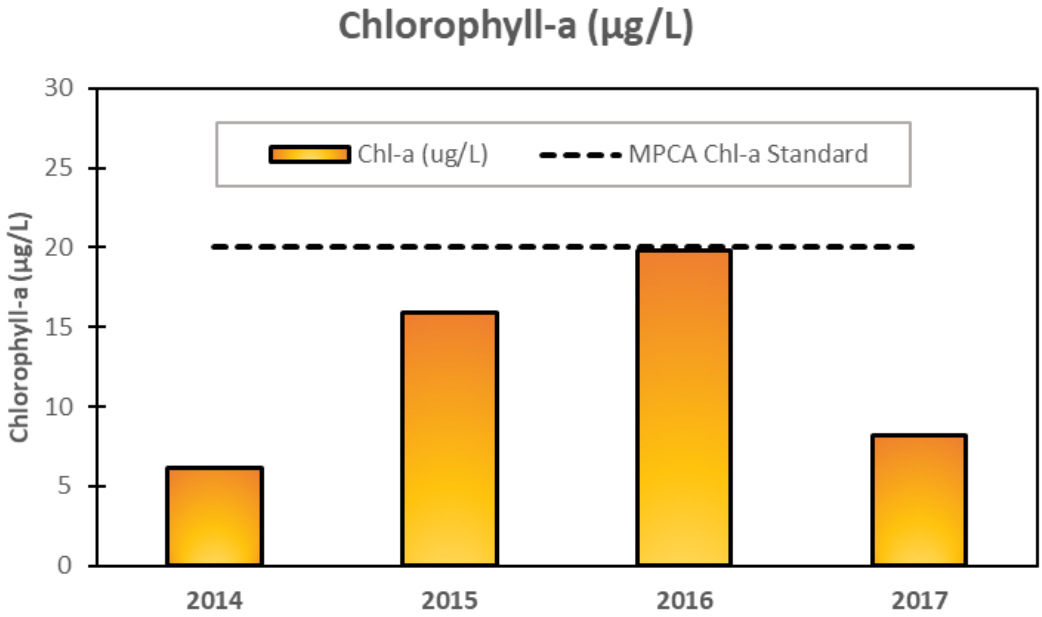


Figure 14. Summary of Chlorophyll-a Data in Buck Lake

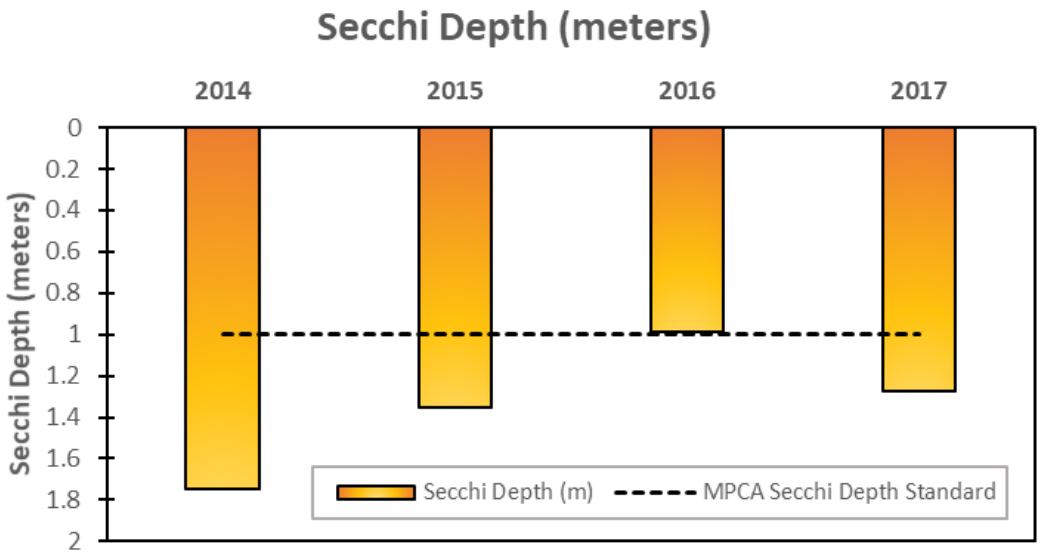
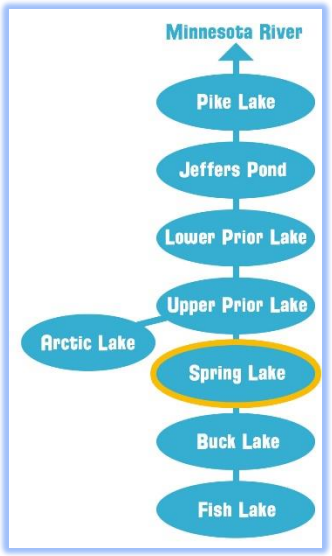


Figure 15. Summary of Secchi Depth Data in Buck Lake

3. Spring Lake



Spring Lake is the second largest basin in the District. The maximum depth is 34 feet with an average depth of 18 feet, roughly half (49% or 290 acres) is identified as the littoral area.

The watershed is quite large (12,340 acres) with a watershed to lake ratio of 20:1, which is a moderate ratio. However, as the dominant land use is a mix of urban and agriculture, external loading of phosphorus may be elevated.

Spring Lake has three major inflows located primarily on its southern and western sides. The 12/17 wetland on the northwest side of the lake also contributes to the overall water budget. County Ditch 13 provides the largest contribution to external load. Spring Lake outlets on its eastern side via a small channel which connects to Upper Prior Lake.

The ten-year average for phosphorus levels on Spring Lake were 118 ug/L when the Spring Lake and Upper Prior Lake TMDL Implementation Plan was first completed in 2012. The plan recommended that an 83% reduction in phosphorus was necessary to meet in-lake water quality standards and suggested that an alum treatment would help temporarily reduce the internal loading in the lake. The treatment was intended to buy time until loading from the upper watershed could be better managed. The first phase of an alum treatment was completed in 2014 which helped Spring Lake reduce its total phosphorus levels to 86.7 ug/L on a ten-year average. However, the TP levels continue to increase each year following the treatment and it is not a permanent solution to the nutrient loading and eutrophication of Spring Lake.

In 2016, a revised site-specific standard of 60 ug/L of total phosphorus (vs. the original 40 ug/L) and 20 ug/L of Chl-a (vs. the original 14 ug/L) for Spring Lake was approved by the EPA. However, even after the alum treatment, Spring Lake fails to consistently meet these standards with a ten-year average of 86.7 ug/L of total phosphorus and 45.34 ug/L of Chl-a. The graphs below show average annual growing season concentrations for TP, Chl-a and Secchi depth.

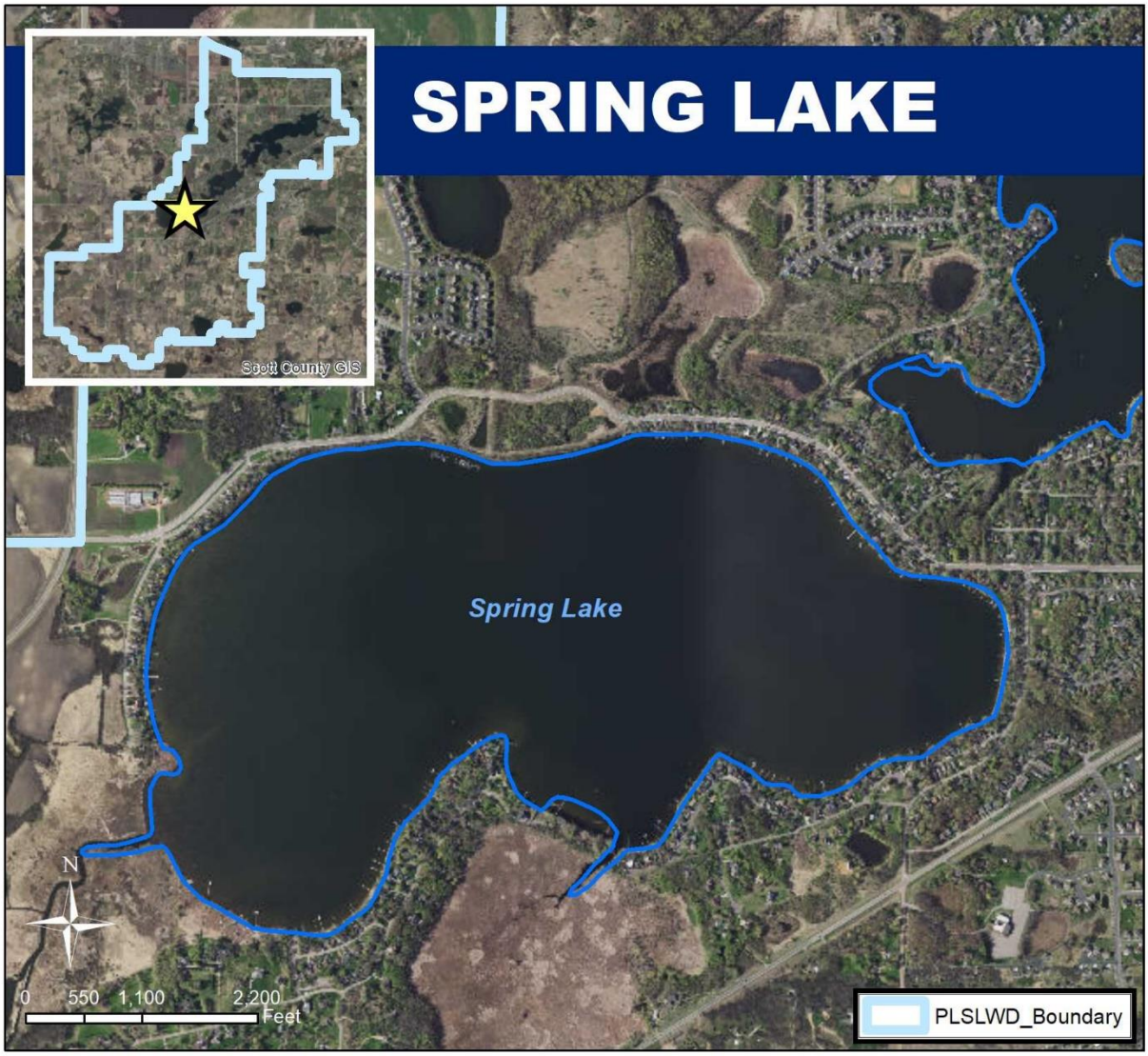


Figure 16. Map of Spring Lake

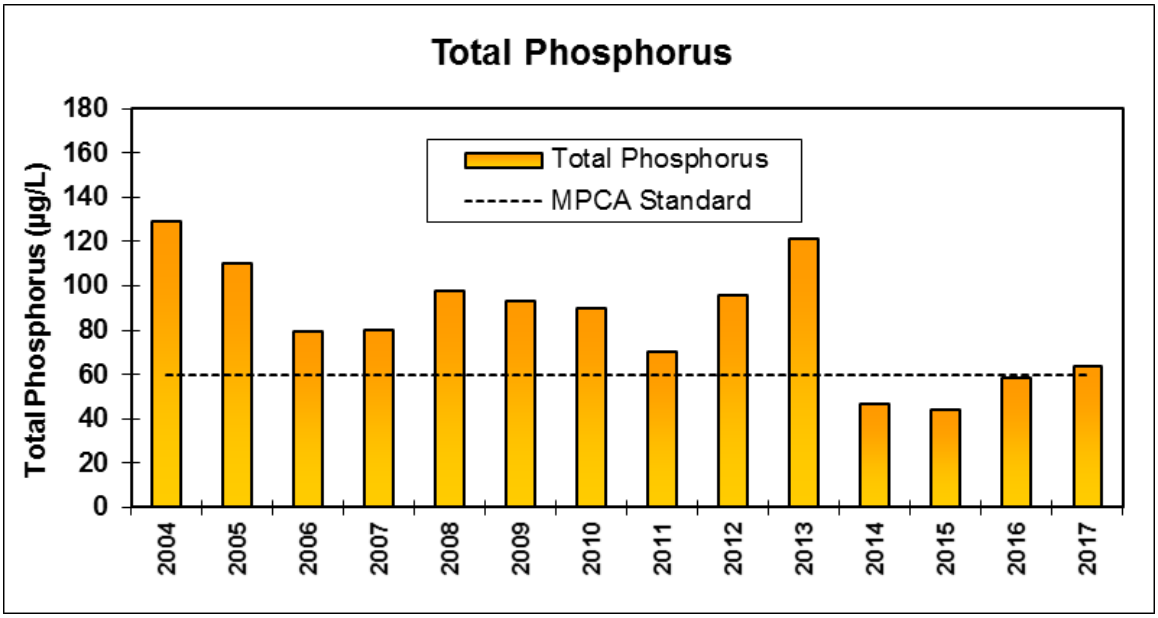


Figure 17. Summary of Total Phosphorus Data in Spring Lake

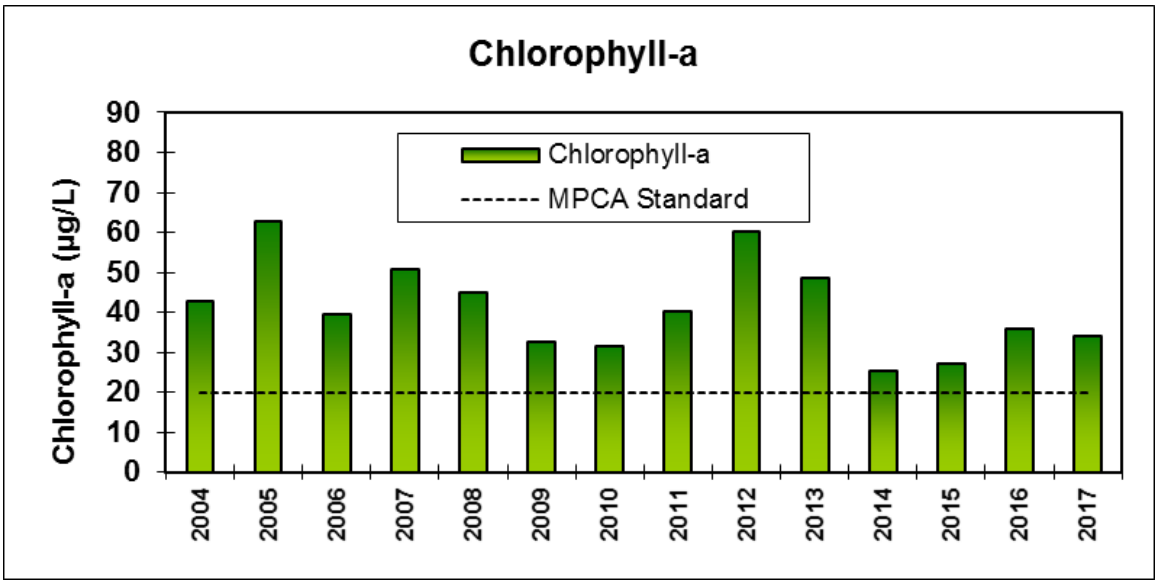


Figure 18. Summary of Chlorophyll-a Data in Spring Lake

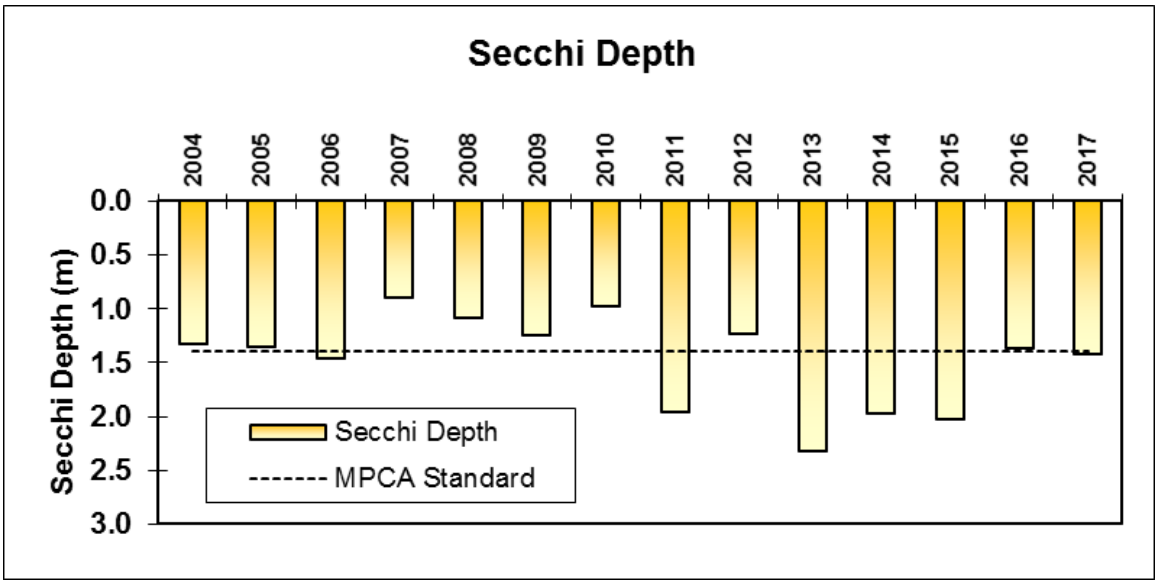
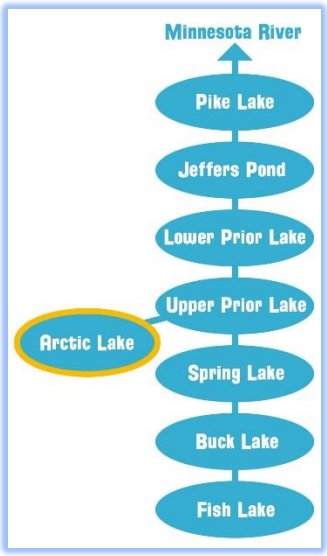


Figure 19. Summary of Secchi Depth Data in Spring Lake

4. Arctic Lake

Arctic Lake is 33 acres in size with a maximum depth of 30 feet and an average depth of 9.5 feet. Arctic Lake flows into Upper Prior Lake, entering a large shallow bay on the north side of the lake through a man-made channel.

Arctic Lake's watershed is 507 acres resulting in a 15:1 watershed to lake ratio, which is relatively small. Most of the watershed (56%) is composed of wetlands and woodlands with the remaining portions of the watershed composed of residential, prairie, water, open space, and cropland. Data provided by the Shakopee Mdewakanton Sioux Community (SMSC) Land Department shows eutrophic conditions persist in Arctic Lake. The 10-year average concentration for TP (2008-2017) is 127.5 µg/L, three times the state standard of 40 µg/L. The 10-year Chl-a concentrations for the same time period was 61.1 µg/L, roughly four times the standard value of 14 µg/L. Secchi depth, calculated as 0.43 m, did not meet the state standard (>1.4 m) over the 10-year monitoring period of 2008-2017. The graphs below show average annual growing season concentrations for TP and Chl-a as well as Secchi depth.



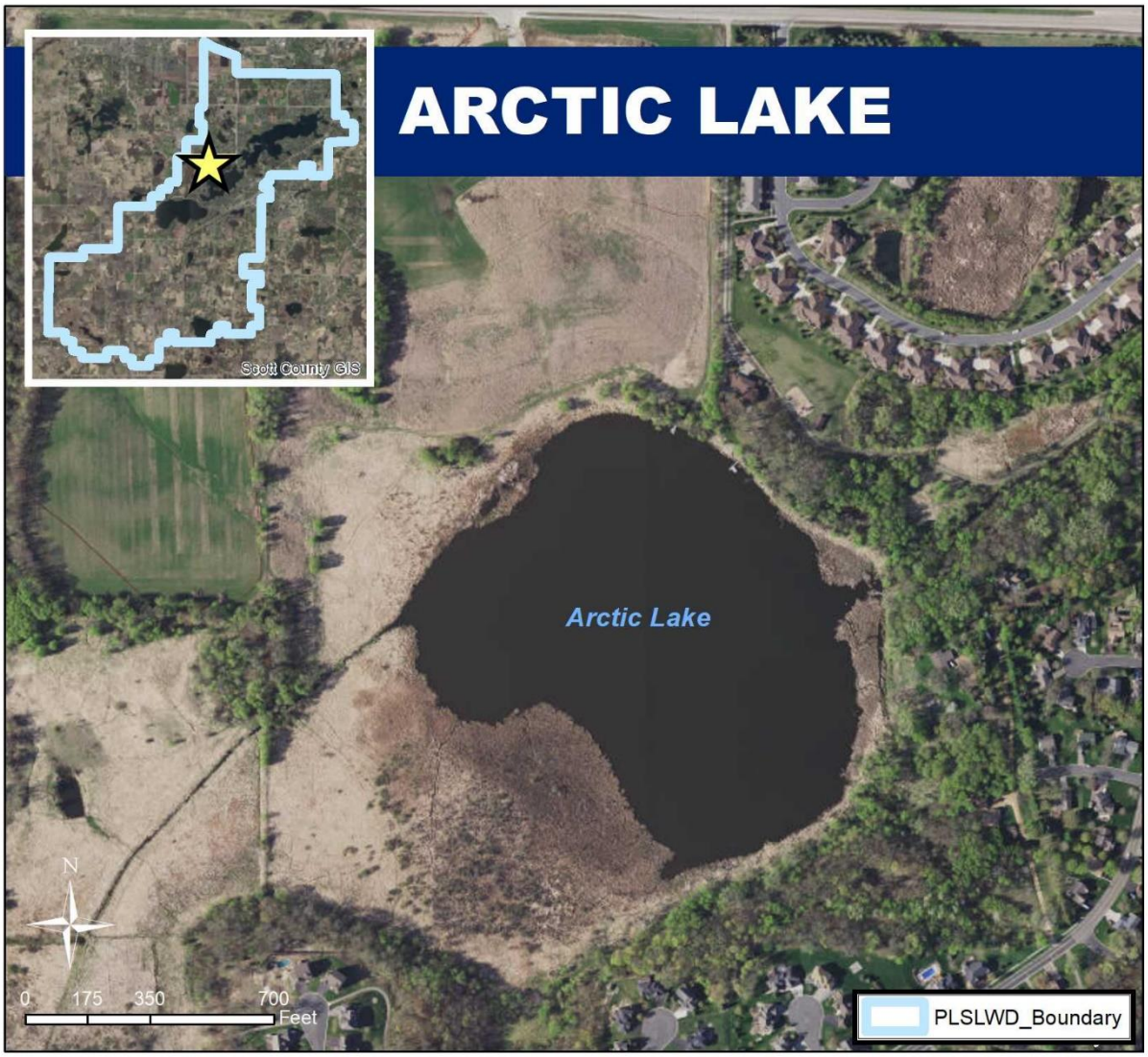


Figure 20. Map of Arctic Lake

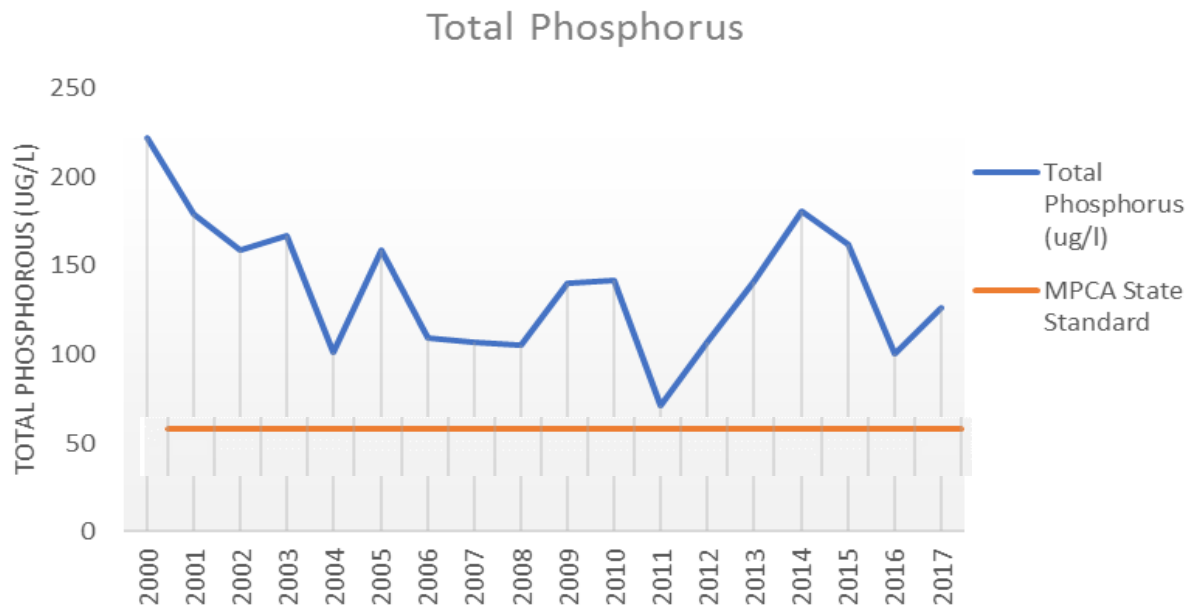


Figure 21. Summary of Total Phosphorus Data in Arctic Lake

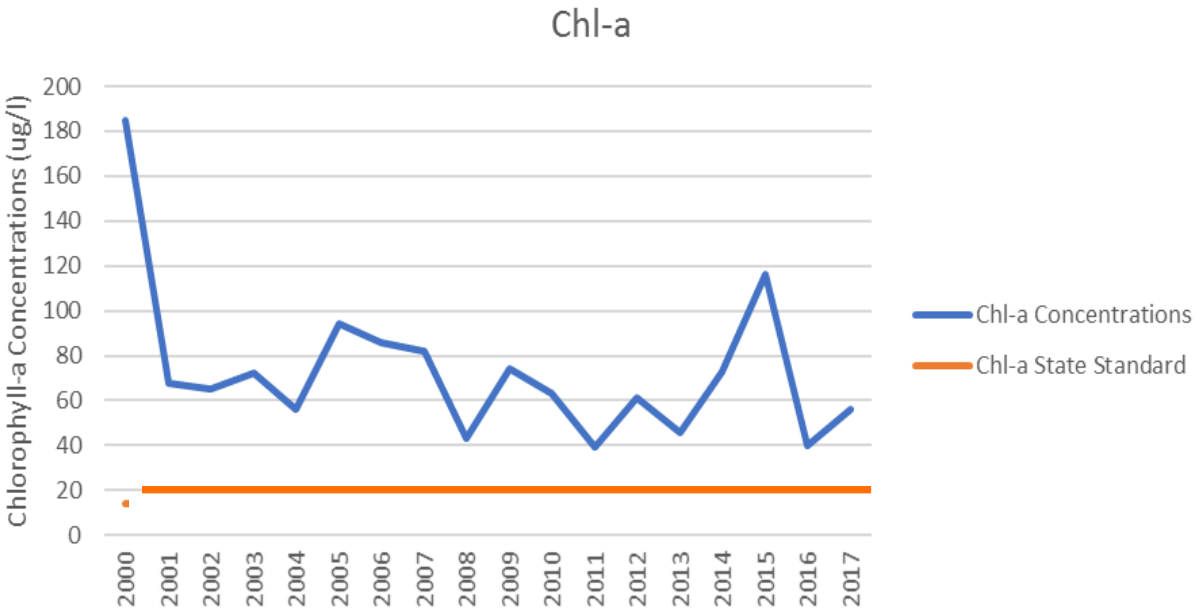


Figure 22. Summary of Chlorophyll-a Data in Arctic Lake

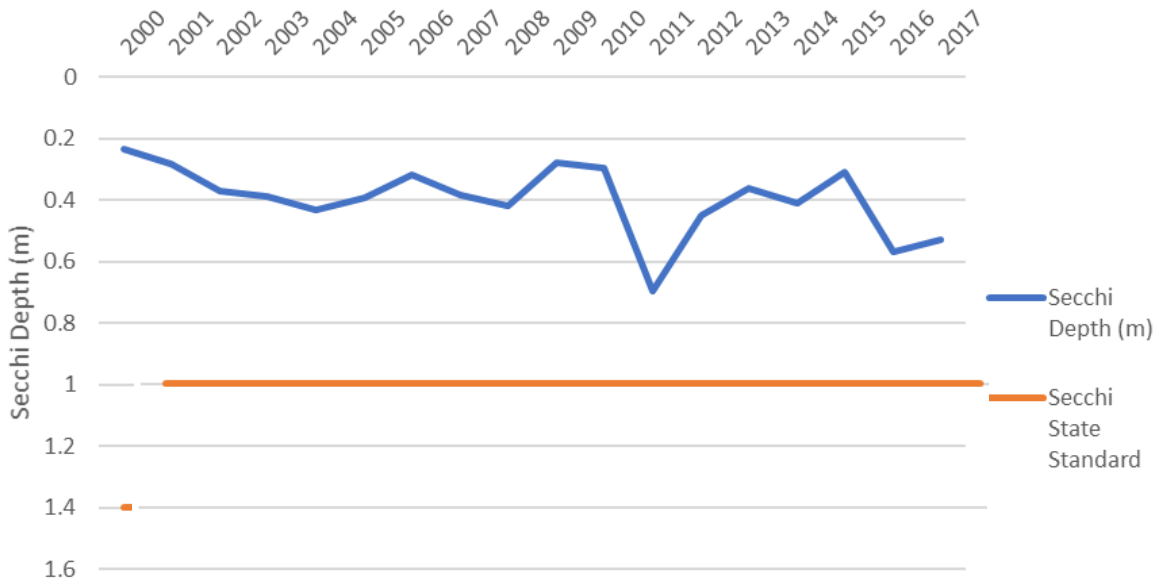
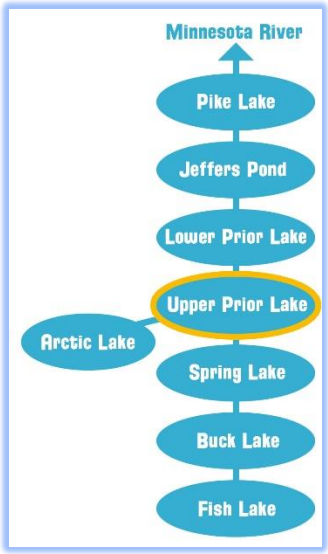


Figure 23. Summary of Secchi Depth Data in Arctic Lake

5. Upper Prior Lake



Upper Prior Lake is 416 acres in size with a maximum depth of 43 feet and an average depth of 10 feet. The littoral zone covers 329 acres or 79% of the basin.

The lake receives water from Spring and Arctic Lakes as well as from a small drainage area on the east side of the lake. The watershed is 16,038 acres resulting in a watershed ratio of 38:1, which is large considering that most of the watershed is urban and agriculture, like Spring Lake. Upper Prior is impaired for excess nutrients (listed in 2012) due to phosphorus levels. The 10-year average TP concentration is 63.96 µg/L, while the Chl-a average concentration is 32.69 µg/L; these both exceed their site-specific standards of 60 µg/L and 20 µg/L respectively. The 10-year average Secchi depth is 1.68 m, which meets the site-specific standard of 1.0 m. This standard for Secchi depth has been met on Upper Prior in all 10 of the past 10 years. The graphs below show average annual growing season concentrations for TP and Chl-a as well as Secchi depths.

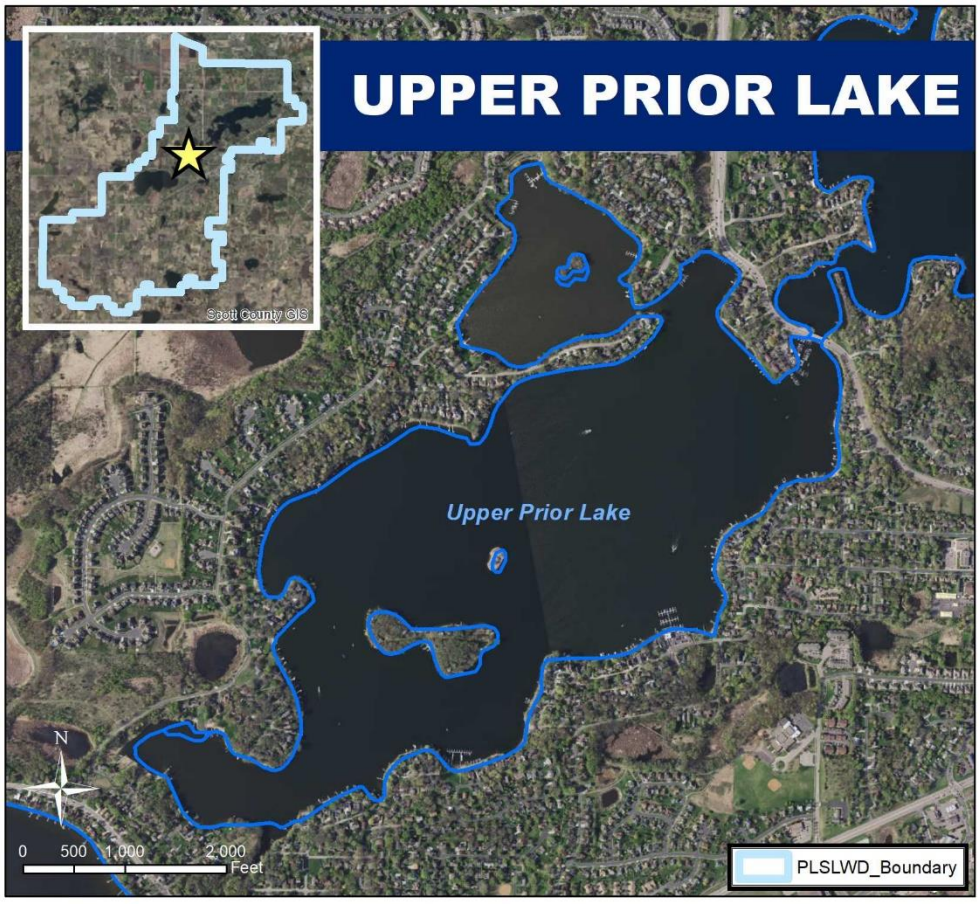


Figure 24. Map of Upper Prior Lake

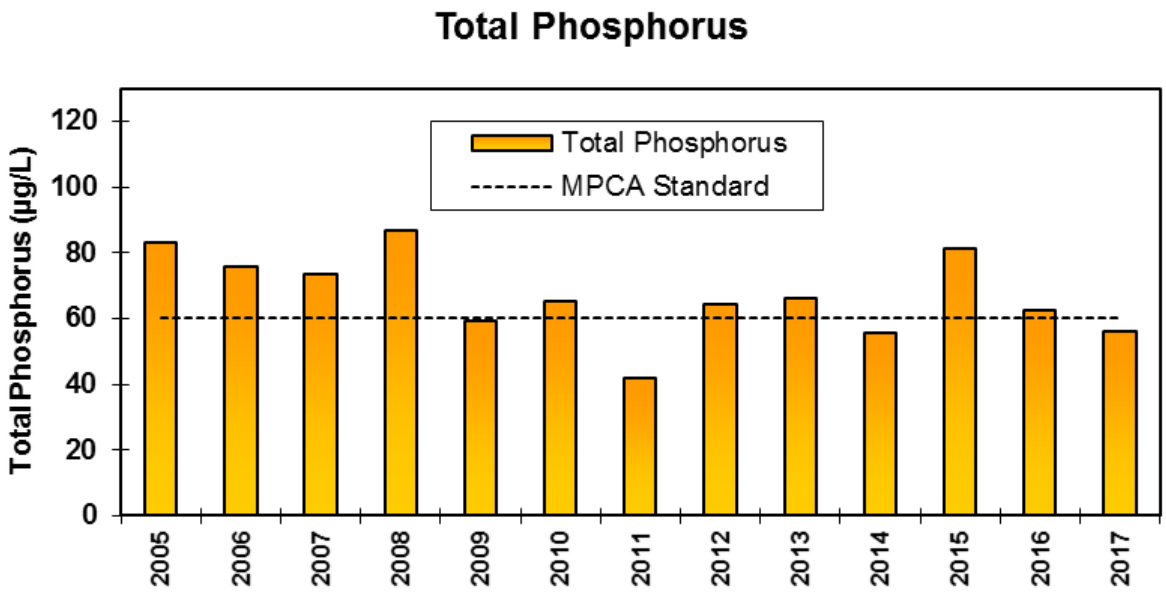


Figure 25. Summary of Total Phosphorus in Upper Prior Lake

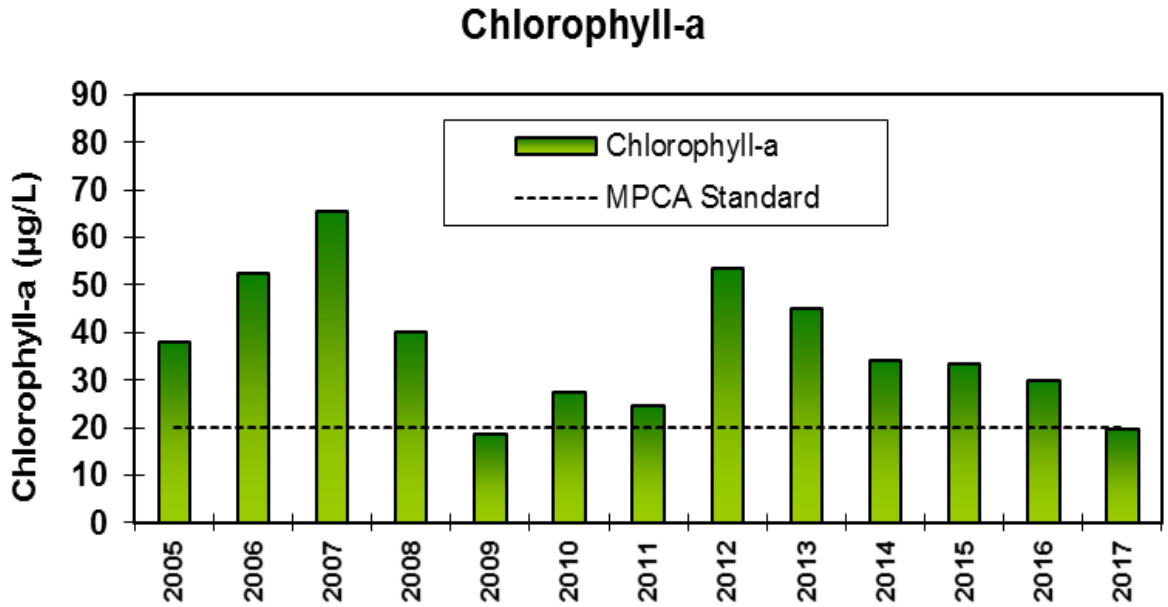


Figure 26. Summary of Chlorophyll-a in Upper Prior Lake

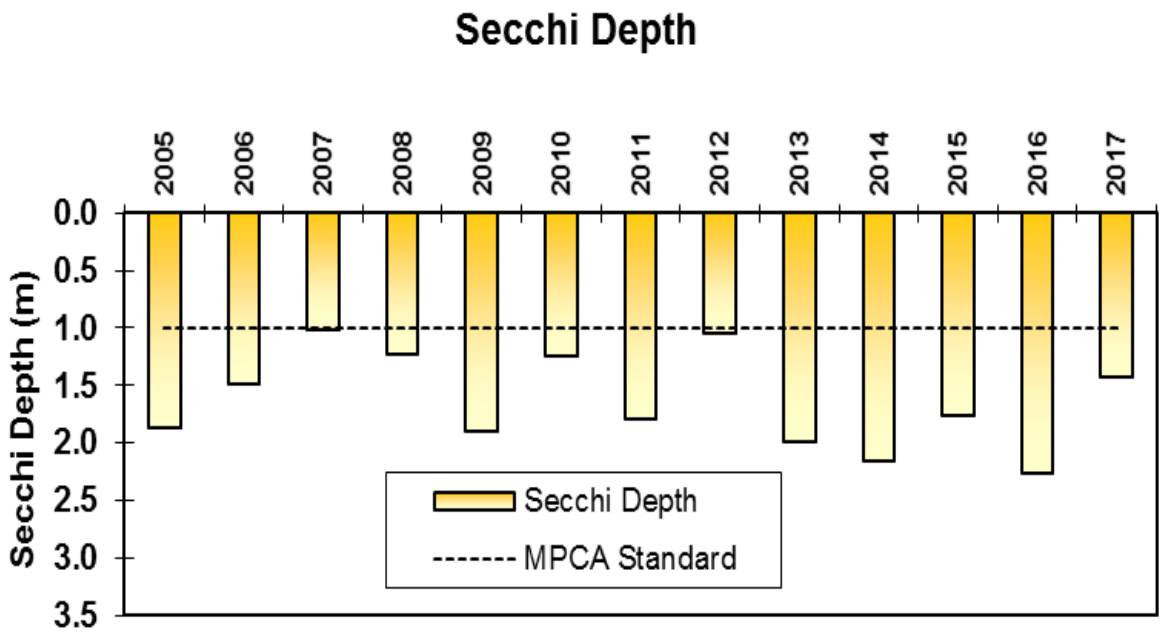
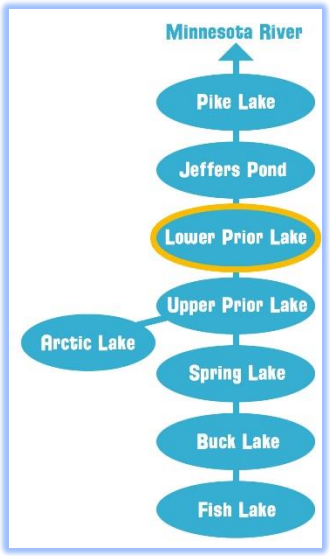


Figure 27. Summary of Secchi Depth in Upper Prior Lake

6. Lower Prior Lake



Lower Prior Lake is the largest basin in the watershed at 940 acres. It has a maximum depth of 56 feet and an average depth of 13 feet; roughly 39% of the lake or 373 acres is in the littoral zone.

Water flows into Lower Prior from Upper Prior under the County Highway 21 Bridge and is the only major inflow; the remaining hydrology is derived from direct drainage from adjacent upland areas. The lake's outlet is the Prior Lake Outlet Channel (PLOC) located along the western portion of the lake. The watershed of Lower Prior is 18,904 acres, resulting in a moderately sized 20:1 watershed to lake ratio. Lower Prior is characterized by excellent water quality. Lower Prior has met the state standards for TP, Chl-a, and Secchi depth between 2005 and 2017. The average TP concentration for 2006-2017 is 24 µg/L, the average concentration for Chl-a for the same time period is 7.68 µg/L, and the average Secchi depth is 3.76 m. The time period includes 2006 and 2007 since no measurements were recorded in 2013 and 2014. Based on this data, Lower Prior should be afforded elevated protection status. The graphs below show average annual growing season concentrations for TP and Chl-a as well as Secchi depth.

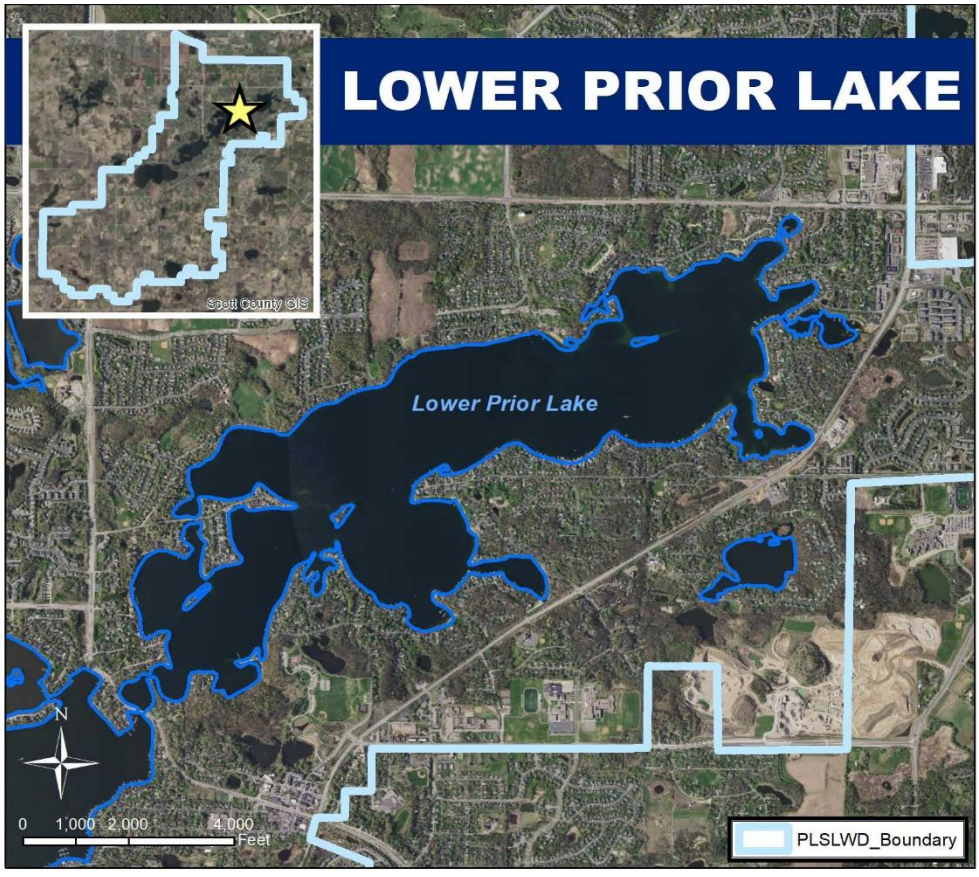


Figure 28. Map of Lower Prior Lake

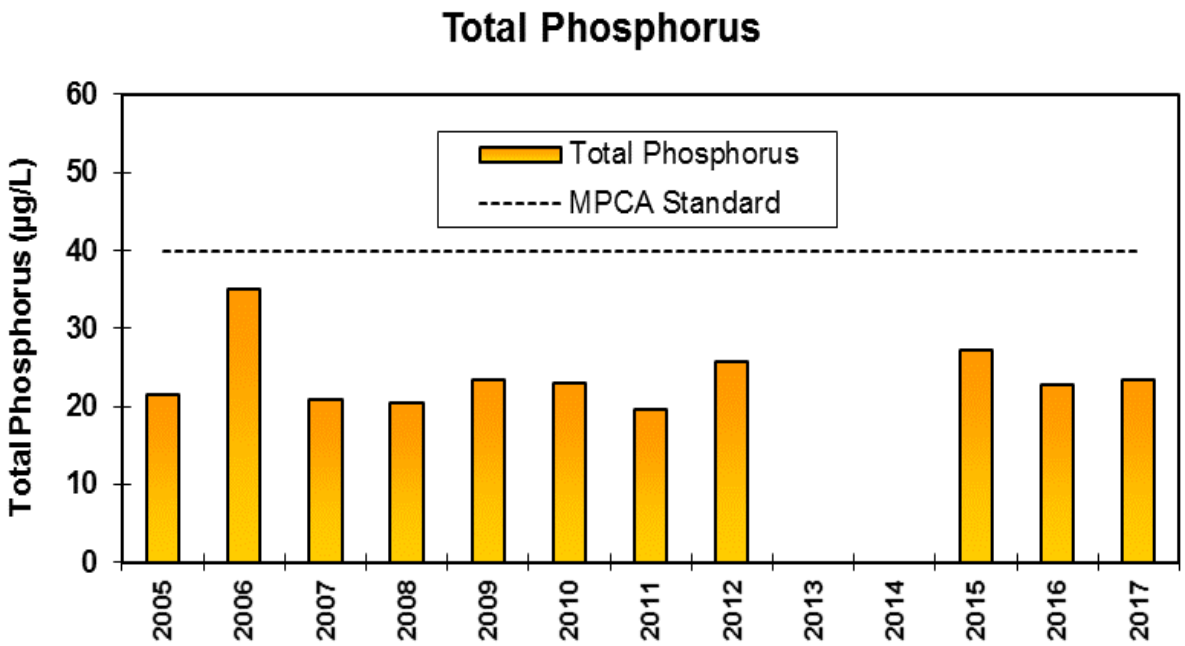


Figure 29. Summary of Total Phosphorus in Lower Prior Lake

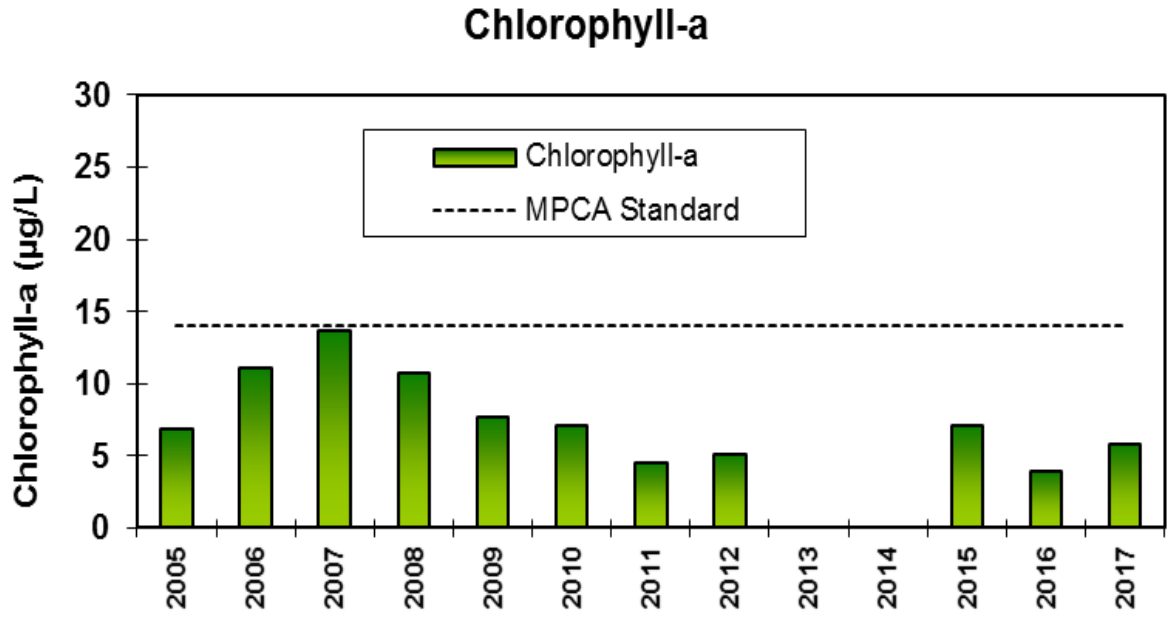


Figure 30. Summary of Chlorophyll-a in Lower Prior Lake

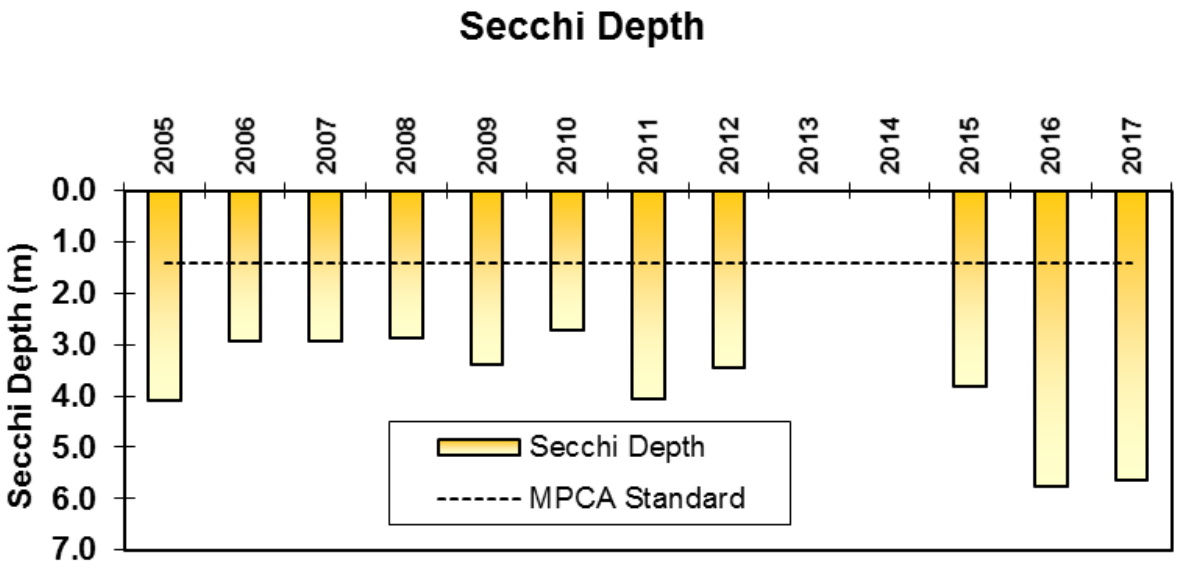
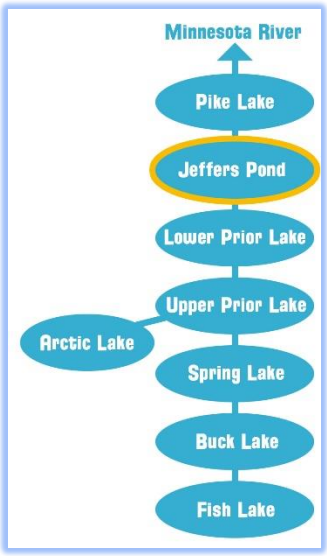


Figure 31. Summary of Secchi Depth in Lower Prior Lake

7. Jeffers Pond



Jeffers Pond is located downstream of Lower Prior along the PLOC. Jeffers Pond is divided into two basins (East and West Jeffers) separated by a narrow land bridge. The PLOC flows into the south side of West Jeffers and flows out on the north side of East Jeffers. The basins are connected by a series of cascading streams. Jeffers is 39 acres in size with a maximum depth of 70 feet in the western basin (no average depth listed, and the total acreage includes both basins).

No water quality or fisheries information is available for Jeffers Pond; however anecdotal information suggests that carp are present in Jeffers Pond.

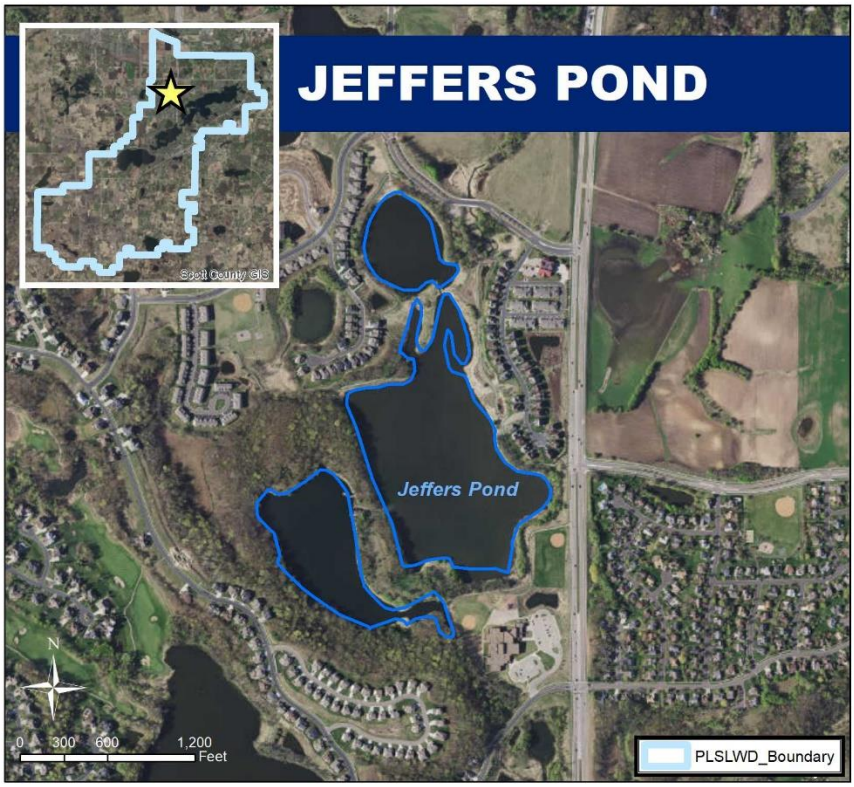


Figure 32. Map of Jeffers Pond

8. Pike Lake

Pike Lake is the downstream-most basin in the watershed; located along the PLOC at the northern end and bottom of the watershed. Pike is 50 acres in size with a maximum depth of 9 feet and an average depth of 7 feet, resulting in the entire basin being littoral. The west side of Pike Lake is part of the PLOC and receives constant flow through the system. The east side of Pike Lake is more stagnant and receives runoff from the nearby feedlot and agricultural lands across the road to the east, creating a contrast in water quality between the two sides.

The contributing watershed to Pike Lake is 21,770 acres resulting in a watershed to lake ratio of 435:1, which is quite large and most of the watershed is composed of urban or agricultural use.

Pike Lake is currently listed as impaired for nutrients but does not currently have an approved TMDL or associated implementation plan. Available water quality data suggests extremely elevated TP and Chl-a concentrations in Pike Lake. Data from two sampling locations (Pike East and Pike West) taken between 2012 and 2017 show that the average TP concentration for that time period was 170 and 102 µg/L respectively, while Chl-a concentrations were 73 and 36 µg/L. Secchi depth for the same time period was 0.66 m for Pike East and 0.89 m for Pike West. All parameters exceed the state standards for the entire time period. Sampling completed by the Science Museum of Minnesota as part of a phosphorus release study for Pike and Fish Lakes indicate the dissolved oxygen (DO) concertation at the bottom of the profile, just above the sediments, was very low (<1 mg/L). Note this was not a composite measurement of the entire profile at the sampling point, so DO levels within upper portions of the profile could be higher. The graphs below show average annual growing season concentrations for TP and Chl-a as well as Secchi depth.

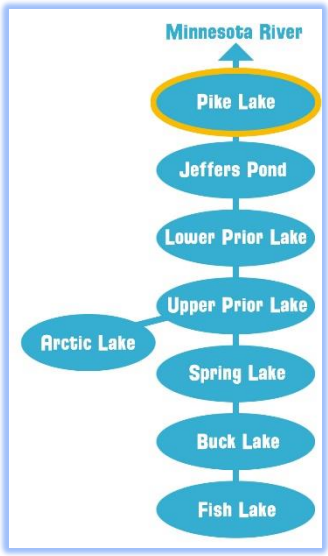


Figure 33. Map of Pike Lake

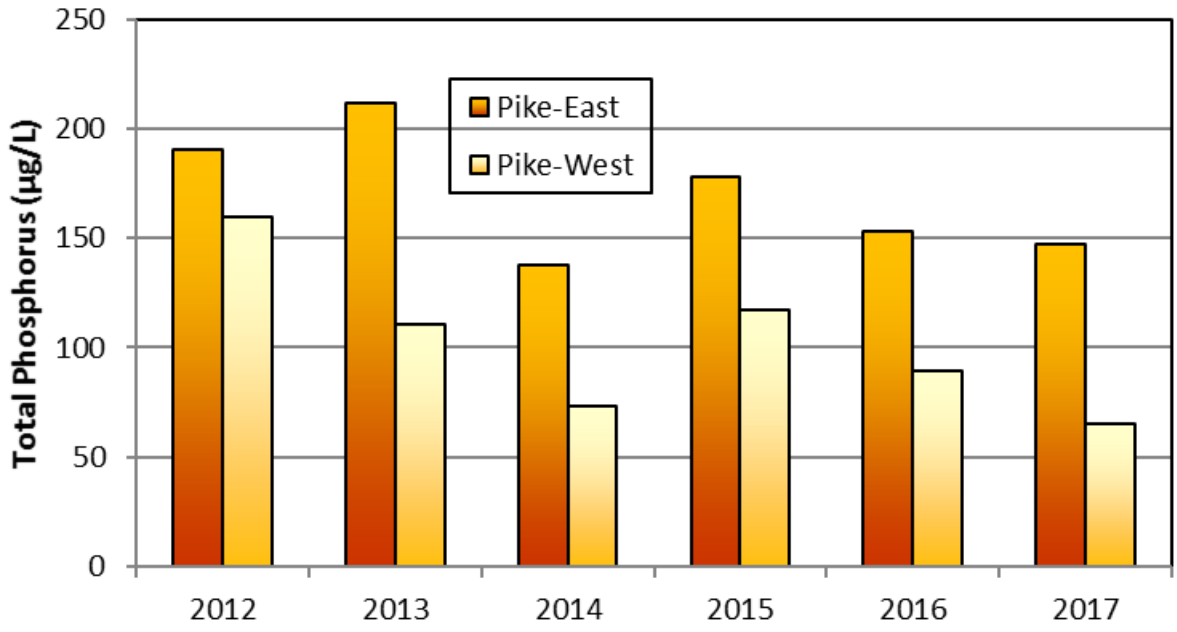


Figure 34. Summary of Total Phosphorus in Pike Lake

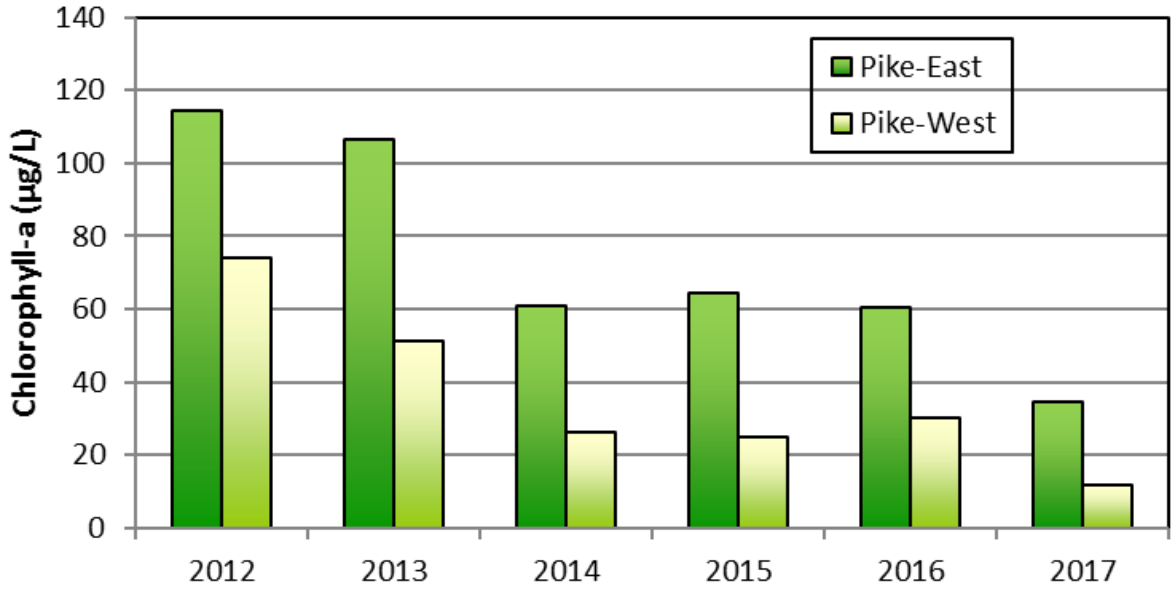


Figure 35. Summary of Chlorophyll-a in Pike Lake

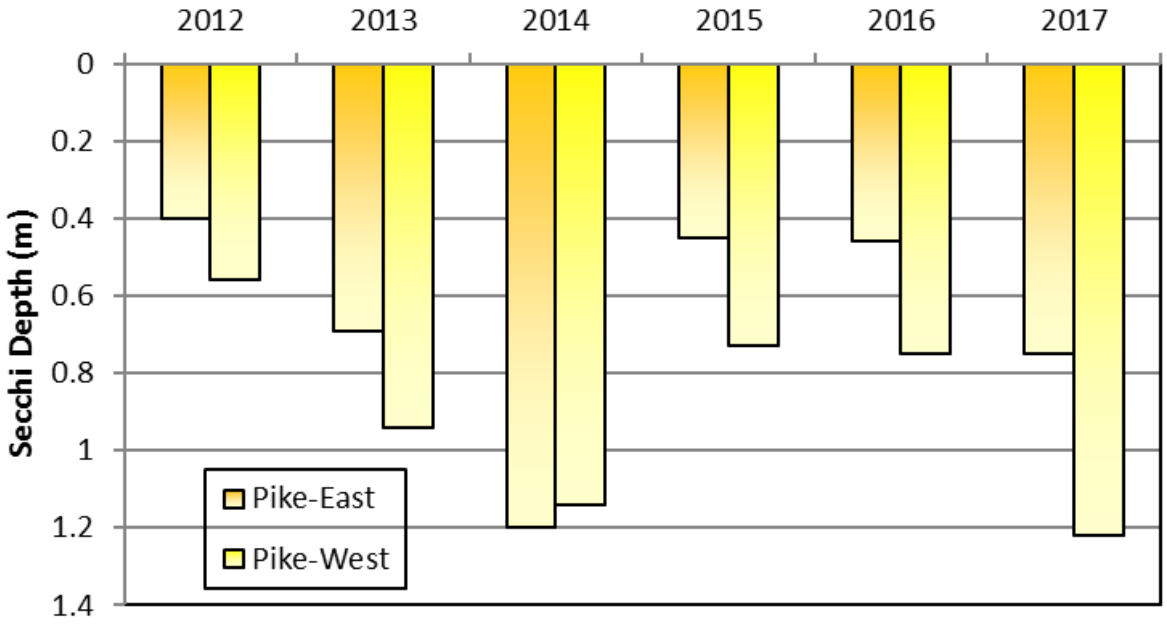


Figure 36. Summary of Secchi Depth in Pike Lake