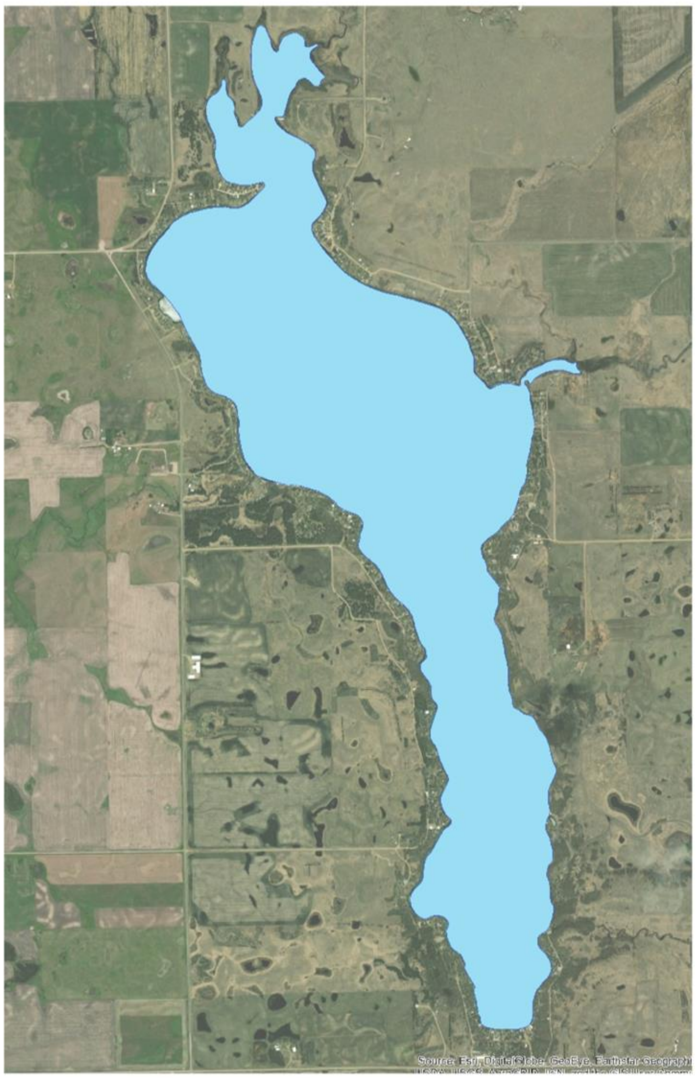
# 2019

# Pickerel Lake



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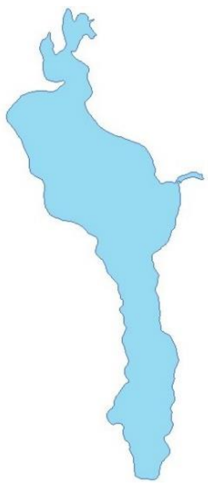
# Pickerel Lake

**22-0002-00 Day County**



Pickerel Lake is located 10 miles northeast of Webster, South Dakota in Day County. It is a large lake covering 981 acres (Table 1) with an outlet dam that prevents dramatic water level changes seen in other local lakes. Pickerel Lake is one of the deepest natural lakes in South Dakota with a maximum depth of 41 feet.

Pickerel Lake has three inlets and one outlet, which classify it as a drainage lake. Water enters Pickerel Lake from Dry Creek to the north, from Oneroad Lake to the east through perennial Chekepa Creek, and Hatchery Creek in the southeast which is primarily discharge from an old artesian well. Pickerel Creek exits the lake on the west side at the outlet weir and runs south to Waubay Lake.

Water quality data has been collected on Pickerel Lake from 1991-2019 (Table 2). These data show that the lake is eutrophic (TSI = 54) with moderately clear water conditions most of the summer, occasional algae blooms in mid-summer and fall, and good recreational opportunities. Pickerel Lake is one of the cleanest lakes in South Dakota and is very comparable with lakes in south central Minnesota for clarity, algae, and nutrient levels.

The Pickerel Lake Conservancy Association and The Northeast Glacial Lakes Project are actively involved in lake monitoring, education, and protection activities.

Table 1. Pickerel Lake location and key physical characteristics

| Location Data | |
|---|---|
| SD Lake WDN: | **22-0002-00** |
| County: | **Day County** |
| Ecoregion: | **Northern Glaciated Plains** |
| Major Watershed: | **Big Sioux River** |
| Latitude/Longitude: | **45.5167°N 97.2833°W** |
| Invasive Species: | **Curly-leaf Pondweed, Zebra Mussels** |

| Physical Characteristics | |
|---|---|
| Surface area (acres): | **981** |
| Littoral area (acres): | **Data unavailable** |
| % Littoral area: | **Data unavailable** |
| Max depth (ft), (m): | **41, 12.5** |
| Inlets: | **3** |
| Outlets: | **1** |
| Public Accesses: | **3** |

Table 2. Availability of primary data types for Pickerel Lake

| Data Availability | |
|---|---|
| Transparency data | **Good, enough for trend analysis** |
| Chemical data | **Moderate, enough phosphorus data for trend analysis** |
| Inlet/Outlet data | **Good, all three inlets are monitored with enough data for analysis** |
| Recommendations | **For recommendations refer to page 20.** |

## Lake Map

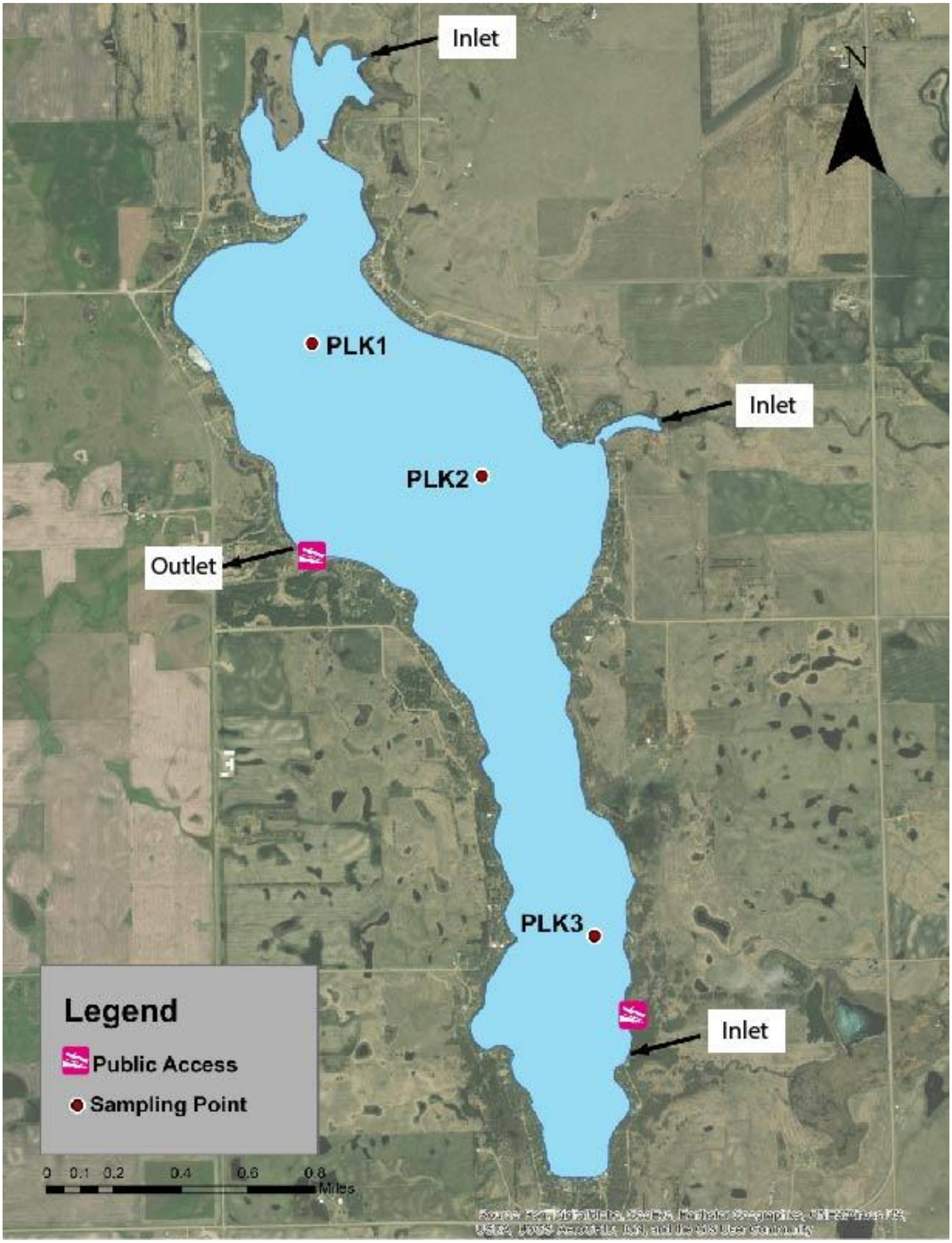



*Figure 1. Map of Pickerel Lake with sample site locations and public access points*

## Average Water Quality Statistics & Comparisons

The information below describes available chemical data for Pickerel Lake through 2019 (Table 3). Data for total phosphorus, chlorophyll *a*, and Secchi depth are from a composite of all three sample sites.

Areas of the United States are divided into ecoregions based on land use, vegetation, precipitation and geology. Based on other lakes located within an ecoregion, lake data can be compared to the "average range" of water quality expected in each ecoregion[1] (Table 3). Pickerel Lake is in the Northern Glaciated Plains ecoregion.


*Figure 2. South Dakota ecoregions*

*Table 3. Water quality means compared to ecoregion ranges*

| Parameter | Mean | Ecoregion Range[1] | Interpretation |
|---|---|---|---|
| Total phosphorus (ug/L) | 41.6 | 130 – 250 | Phosphorus and chlorophyll *a* results are lower than the expected range for lakes in the Northern Glaciated Plains Ecoregion. Pickerel Lake's results are similar to lakes in south central Minnesota |
| [3]Chlorophyll *a* (ug/L) | 10.7 | 30 – 55 | |
| Chlorophyll *a* max (ug/L) | 40 | | |
| Secchi depth (ft) | 6.4 | 1 – 4 | |
| Dissolved oxygen | *See page 11* | | Dissolved oxygen depth profiles show that the lake typically mixes throughout the summer then stratifies in early fall. |
| Total Kjeldahl Nitrogen (mg/L) | 0.87 | 1.8 – 2.3 | Indicates low levels of nitrogen to support summer algae blooms |
| pH | 8.4 | 8.3 – 8.6 | Within the expected range for the ecoregion |
| Chloride (mg/L) | ND | 0.6 – 1.2 | Data not available |
| Total Suspended Solids (mg/L) | 8.5 | 10 - 30 | Lower than the expected range for the ecoregion |
| Specific Conductance (umhos/cm) | ND | 50 – 250 | Data not available |
| TN:TP Ratio | 21:1 | 7 - 14 | Above the expected range for the ecoregion indicating nitrogen sources in the watershed. This ration shows the lake is phosphorus limited. Additional phosphorous, especially ortho-phosphorous the dissolved plant-available form, will cause rapid plant and algae growth. |

Hat [1]The ecoregion range is the 25th-75th percentile of summer means from ecoregion reference lakes: https://www.pca.state.mn.us/quick-links/edaguide-typical-minnesota-water-quality-conditions
[2]For further information regarding the Impaired Waters Assessment program, refer to http://www.pca.state.mn.us/water/tmdl/index.html
[3]Chlorophyll *a* measurements have been corrected for pheophytin
Units: 1 mg/L (ppm) = 1,000 ug/L (ppb)

## Water Quality Characteristics - Historical Means and Ranges

*Table 4. Water quality means and ranges for Pickerel Lake*

| Parameters | Composite Site |
|---|---|
| **Total Phosphorus Mean (ug/L):** | 41.6 |
| Total Phosphorus Min: | 17.0 |
| Total Phosphorus Max: | 136.0 |
| Number of Observations: | 91 |
| **Chlorophyll *a* Mean (ug/L):** | 10.7 |
| Chlorophyll-a Min: | 1.3 |
| Chlorophyll-a Max: | 40 |
| Number of Observations: | 42 |
| **Secchi Depth Mean (ft):** | 6.4 |
| Secchi Depth Min: | 2.4 |
| Secchi Depth Max: | 15.3 |
| Number of Observations: | 97 |

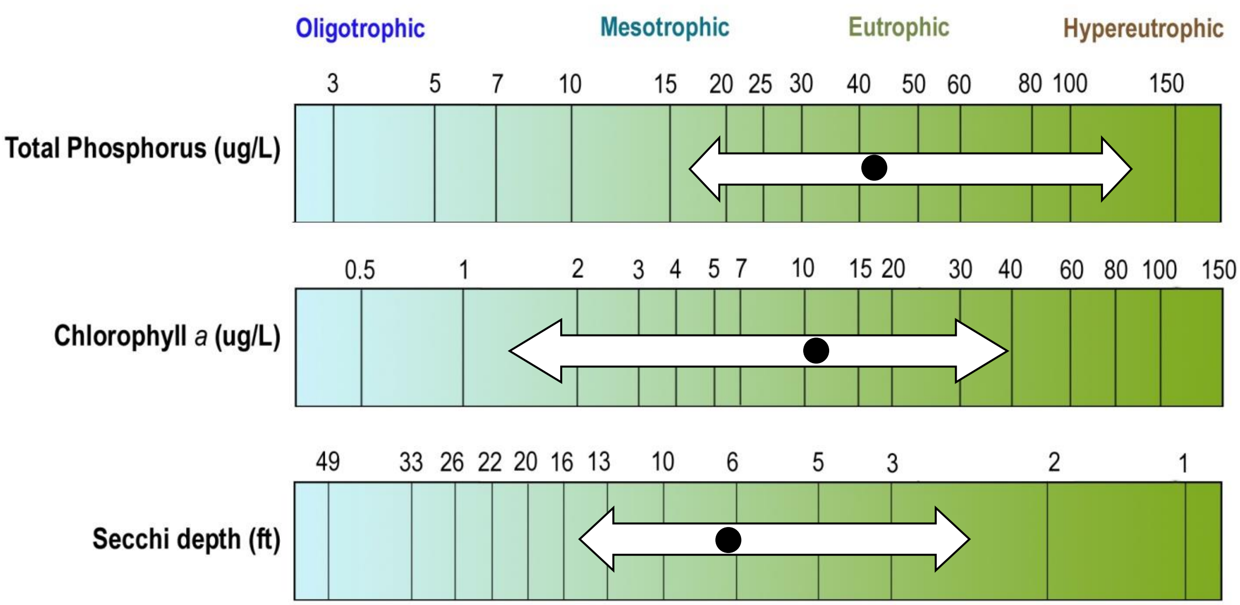



*Figure 3. Pickerel Lake total phosphorus, chlorophyll a, and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean of the three sites composited. Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. No. EPA 440/5-88-002)*

## Transparency (Secchi Depth)

Transparency is how easily light can pass through a substance. In lakes, it is how deep sunlight penetrates through the water. Plants and algae need sunlight to grow, so they are only able to grow in areas of lakes where the sun penetrates. Water transparency depends on the number of particles in the water. An increase in particulates results in a decrease in transparency. The transparency varies year to year due to changes in weather, precipitation, lake use, flooding, temperature, lake levels, etc.

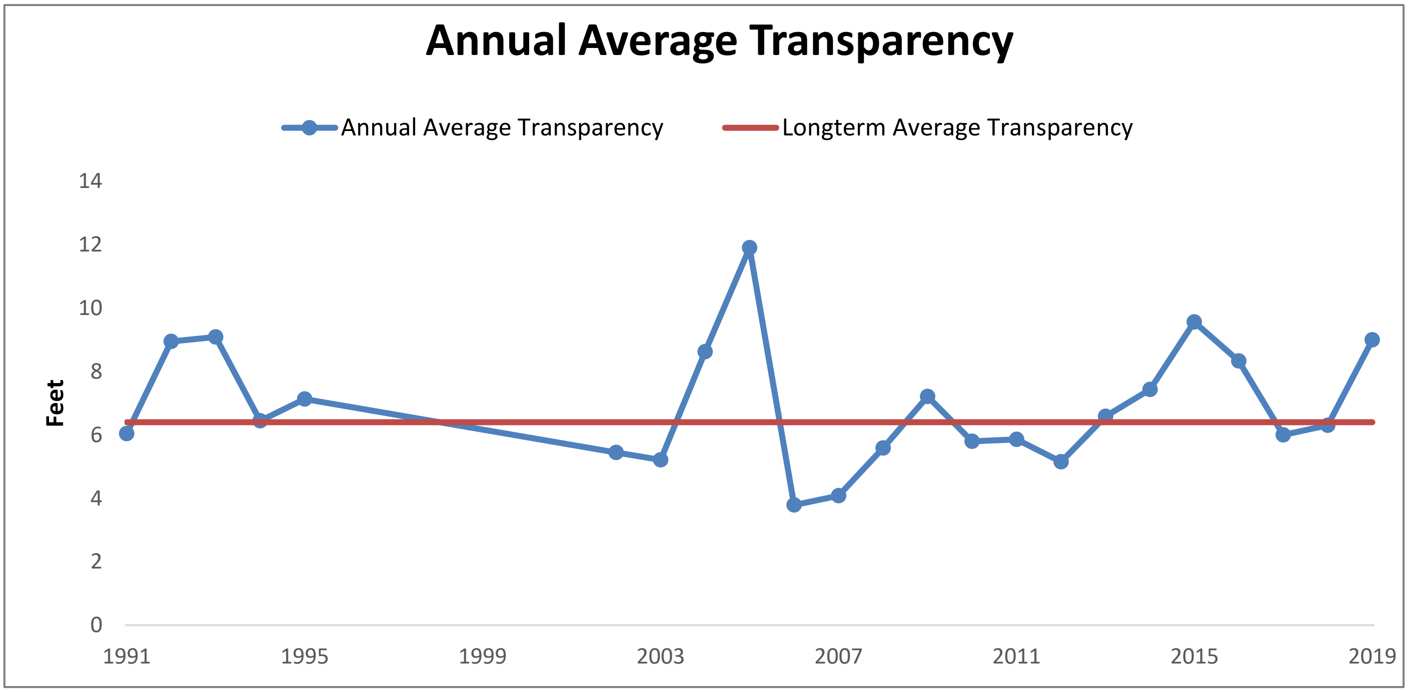
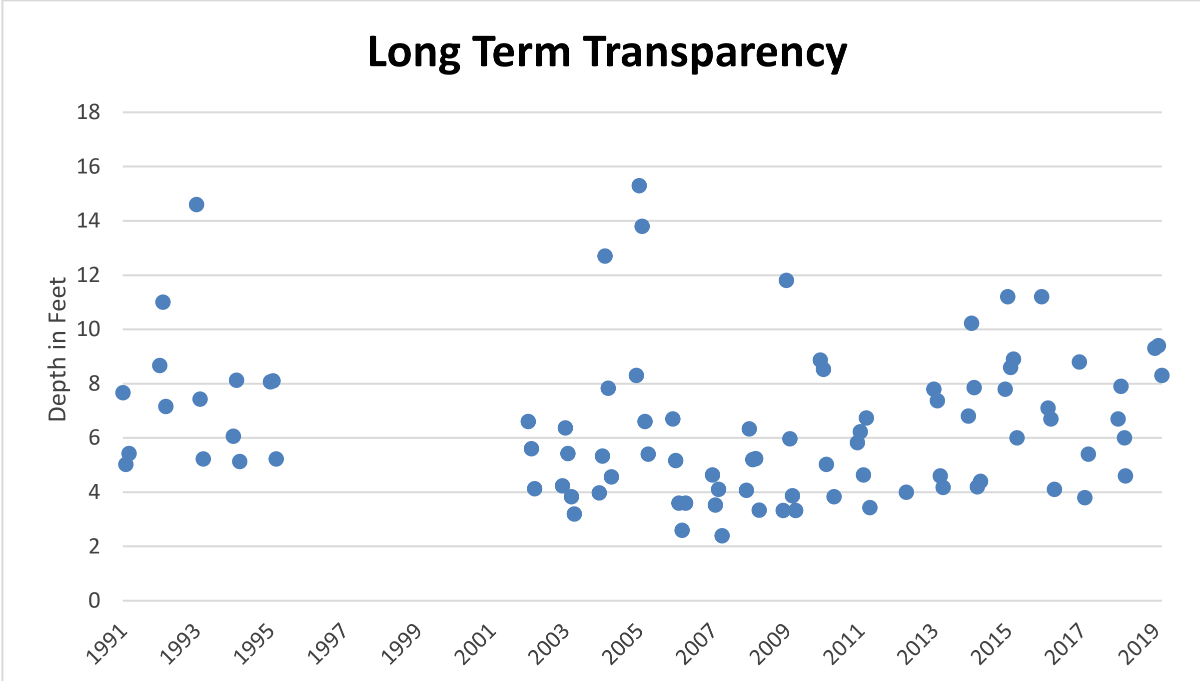



*Figure 4. Annual average transparency with long-term mean from 1991 to 2019*

Pickerel Lake transparency was monitored annually from 1991 to 2019 at site PLK2. The transparency measurements in Pickerel Lake range from 2.4 to 15.3 feet and hover fairly close to the long-term mean of 6.2 feet (Figure 4). For trend analysis, see page 13. Transparency monitoring should be continued at least monthly every summer in order to track water quality changes. Additional volunteer weekly water clarity monitoring would be useful in documenting the occurrence and persistence of algae blooms.




The water clarity in Pickerel Lake follows a typical seasonal pattern (Figure 5). Water clarity dynamics have to do with algae and zooplankton population dynamics and lake turnover. It is important for lake residents to understand the seasonal transparency dynamics in their lake so that they are not excessively worried when their transparency is lower in August than it is in June.  It is typical for a lake to vary in transparency throughout the summer. Pickerel Lake is consistently clear throughout the early summer and prone to algae blooms in later summer and fall, causing lower transparency levels.

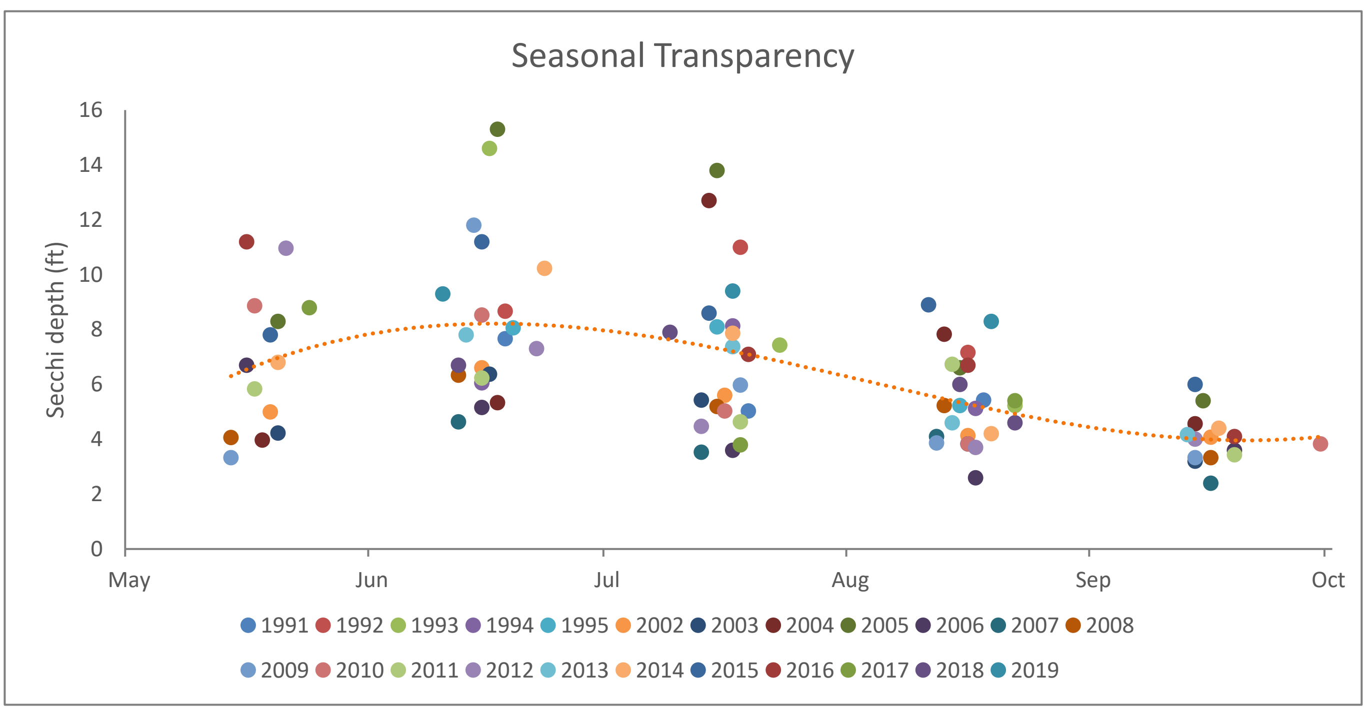



*Figure 5: Seasonal transparency for Pickerel Lake from 1991 to 2019*

## Algae

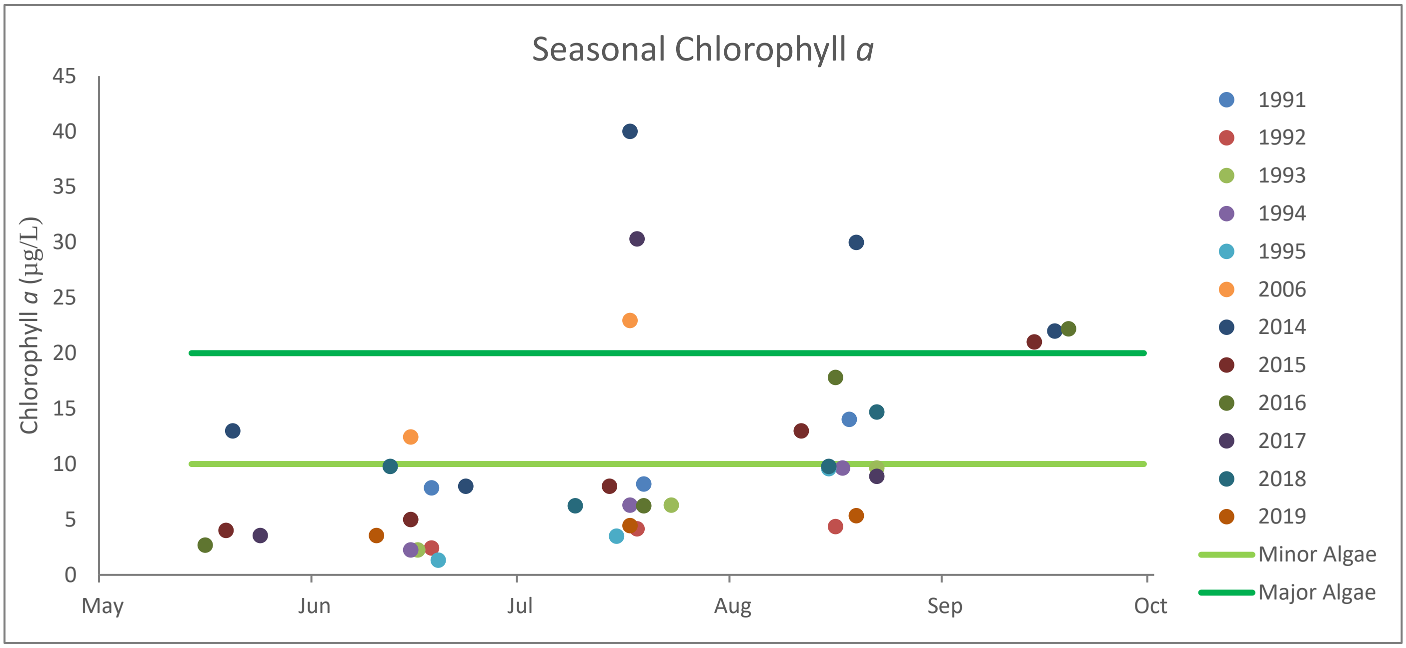
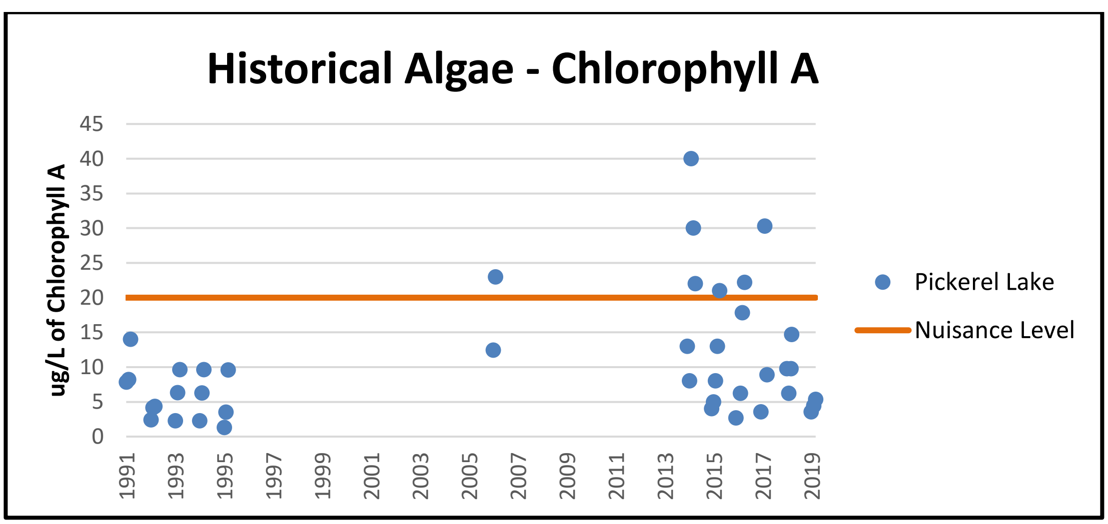



*Figure 6. Seasonal chlorophyll a concentrations (ug/L) for Pickerel Lake from 1991 to 2019*

Chlorophyll *a* is the pigment that makes plants and algae green. Chlorophyll *a* is tested in lakes to determine the algae concentration or how "green" the water is. Concentrations greater than 10 ug/L are perceived as a mild algae bloom, while concentrations greater than 20 ug/L are perceived as a nuisance.

Chlorophyll *a* was evaluated in Pickerel Lake since 1991 at the composite of the three sites (Figure 6). A majority of the samples were below the 10 µg/L level. Chlorophyll *a* concentrations above 20 ug/L were not recorded in the 1990s, indicating few summer algae blooms. Residents did note fall algae blooms in the 1980s and 1990s, but they were not reflected in the summer water quality samples. In recent years, chlorophyll *a* concentrations have occasionally exceeded nuisance levels, especially in mid to late summer. It is typical for a eutrophic lake to see increased amounts of chlorophyll *a* during the summer months.



## Phosphorus

Pickerel Lake is phosphorus limited, which means that algae and aquatic plant growth is dependent upon available phosphorus. Total phosphorus was evaluated in Pickerel Lake from 1991 to 2019 (Figure 7). There is no statistically significant trend for total phosphorus concentrations, so nutrients are stable in the most recent 18 years of consecutive data. Seasonally, phosphorus shows a typical pattern in Pickerel Lake (Figure 8). A majority of data points fall into the eutrophic range which is above 0.025 mg/l of phosphorous. During early summer months when the lake is stratified, the phosphorus is at the lowest concentration, and it increases later in the summer when lake turnover begins.

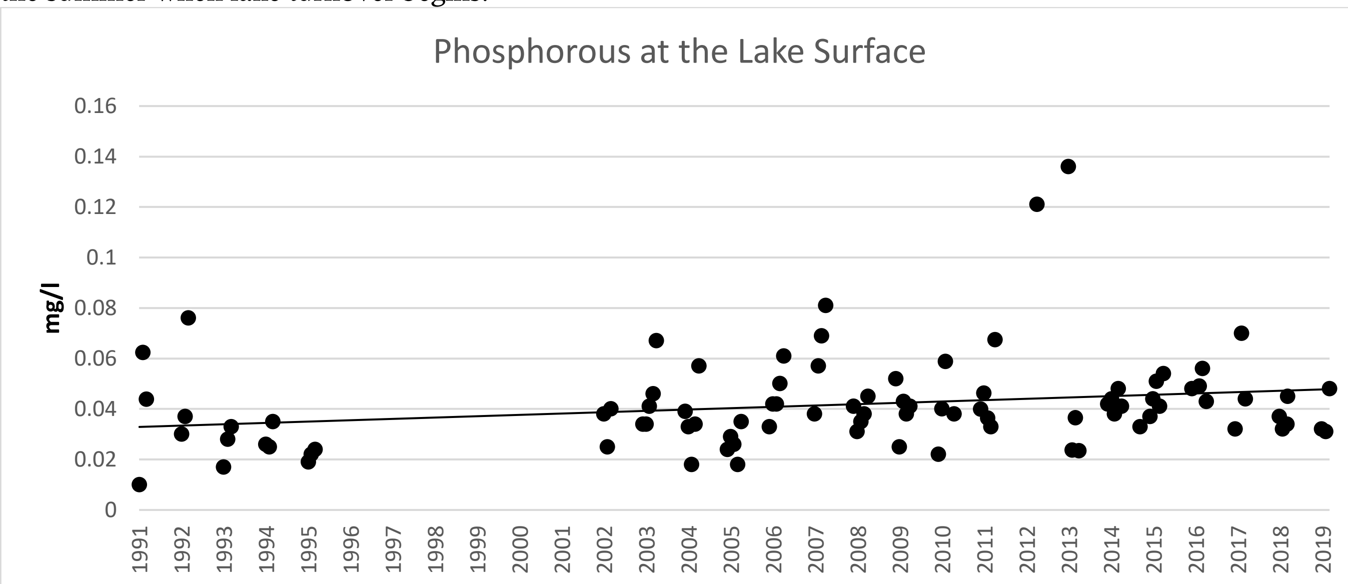



*Figure 7. Historical total phosphorus concentrations in surface samples from 1991 to 2019*

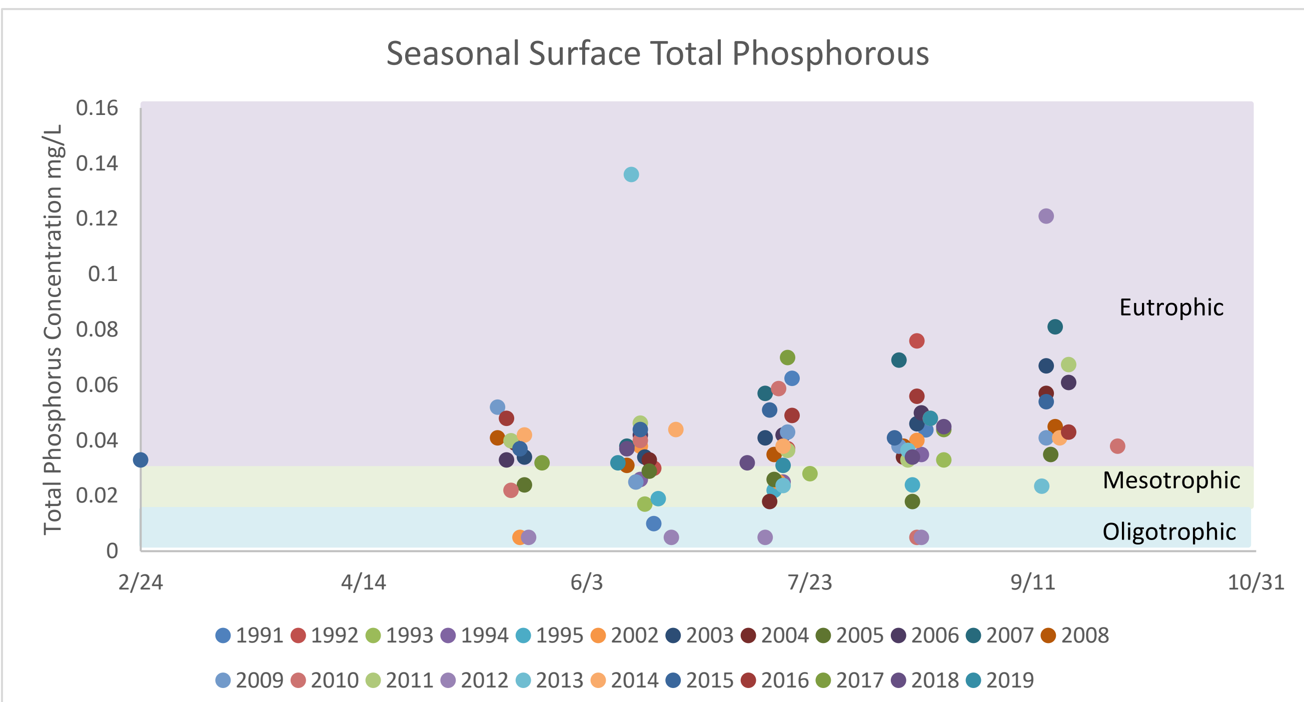



*Figure 8. Seasonal phosphorus dynamics in surface samples from 1991 to 2019*

The biggest changes are being seen at the lake bottom where levels of plant available dissolved phosphorous have increased with statistical significance (Figure 9). Both total phosphorus and dissolved phosphorus were analyzed using data collected from the bottom of the lake. Using a Mann-Kendall statistical test, there is a statistically significant short-term trend (Table 8) indicating increasing dissolved phosphorus concentrations at the lake bottom.

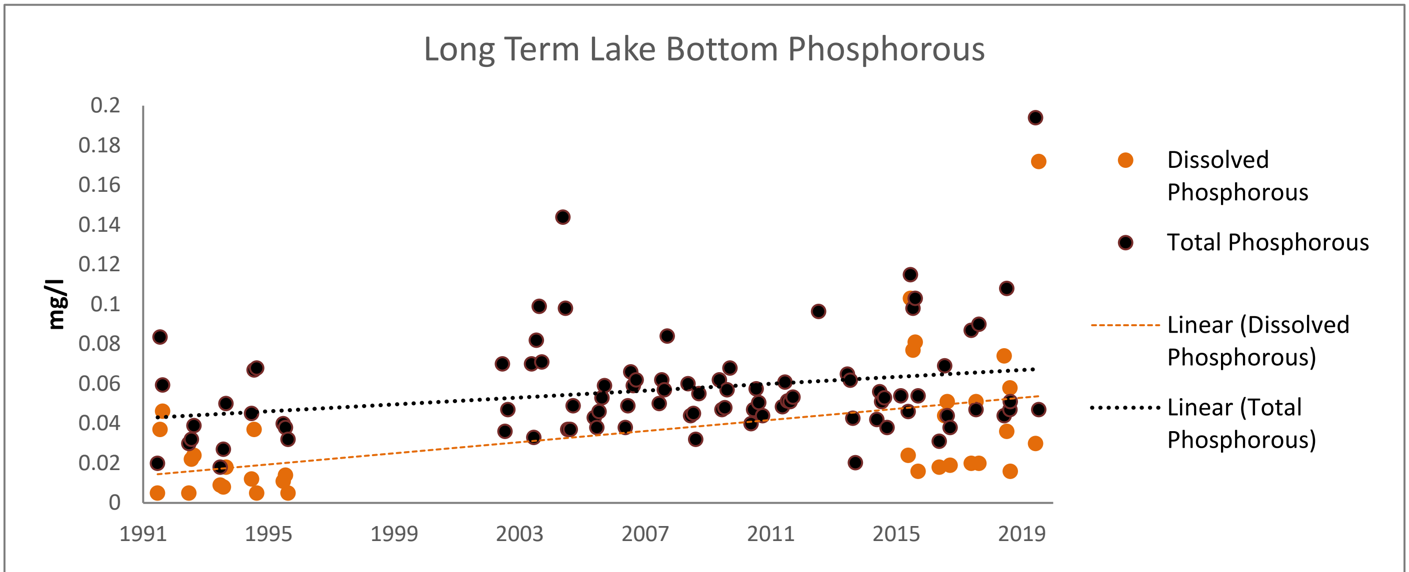



*Figure 9: Total phosphorous and dissolved phosphorous as measured at the lake bottom from 1991 to 2019*

Accumulated nutrients can be stored in a lake by binding to bottom sediments. The measure of phosphorous at the lake bottom is a good indicator of how well a lake is storing nutrients and how much is being released into the water. Levels of phosphorous at the lake bottom also reflect how much oxygen is available in the water. High loads of nutrients can deplete oxygen levels and alter the lake's nutrient storage process. This can make additional phosphorous available to plants and algae that was previously stored in the bottom sediments. This process, known as internal loading, causes elevated levels of dissolved phosphorous near the lake bottom that can cause weed growth and algae blooms if it mixes into the water column.

The phosphorous concentrations in the samples taken at the bottom of Pickerel Lake have reflected this internal loading pattern. When dissolved oxygen levels have declined, phosphorous has been released from the lake bottom. The samples from the 1990s show only small increases of phosphorous during periods of low oxygen. In more recent years, phosphorous levels when oxygen is depleted are much higher than when oxygen is available. Monitoring available phosphorus through cores of the lake sediments would allow for comparisons with the previously collected samples.

## Oxygen

Dissolved Oxygen (DO) is the amount of oxygen available in lake water. Oxygen is necessary for all living organisms to survive except for some bacteria. Dissolved oxygen levels of <5 mg/L are typically avoided by game fisheries. While the surface of the lake stays well oxygenated, the bottom layers can run out.

As organic matter decays, natural iron compounds bind with phosphorus, storing it in lake sediments. The process of decomposition also consumes oxygen, if the supply of dissolved oxygen gets too low then the bottom of a lake can become anoxic – oxygen depleted. These areas of oxygen depletion allow phosphorus to be released from the sediments back into the water as dissolved phosphorus. In very deep lakes, this anoxic layer is often restricted to the lake bottom until fall turnover due to stratification which is the layering of warm light upper water on top of cool dense lower water. In moderately deep lakes the water column can temporarily stratify. While stratified the lower water can become depleted of oxygen and nutrients released from the lake sediments. A windy day can then mix up the water, causing phosphorus from the anoxic lake bottom to resuspend into the water. This process is known as internal nutrient loading and can cause rapid algae blooms. Moderately deep lakes still turnover in fall and spring causing some nutrient recycling. Shallow lakes usually stay well mixed all summer due to wind action and then turnover as water temps cool in the fall.

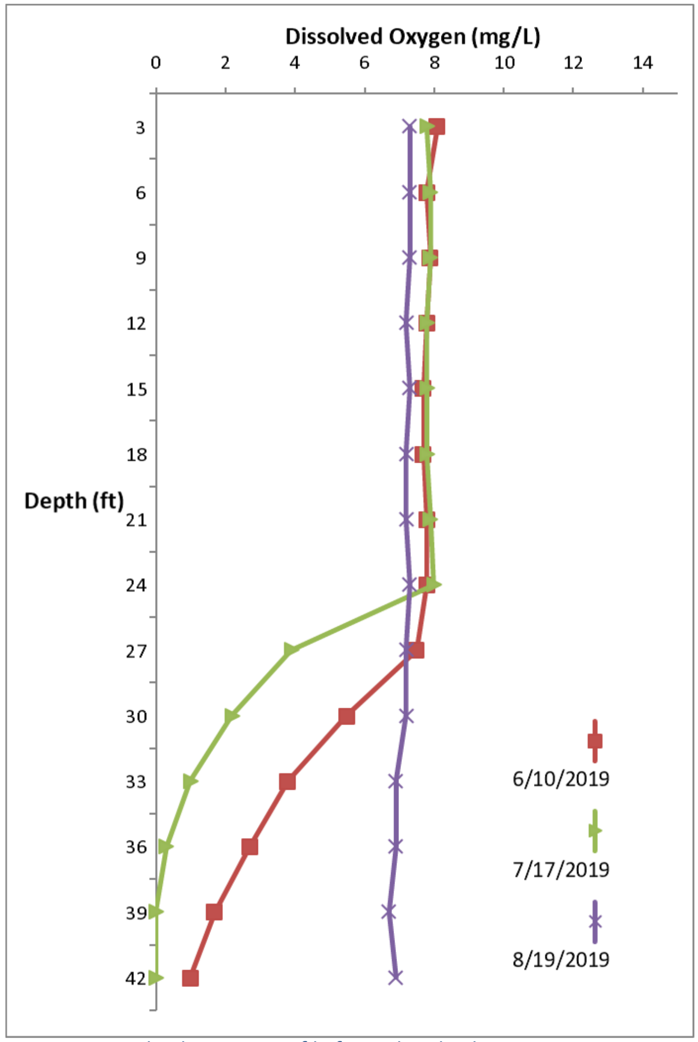



*Figure 10. Dissolved oxygen profile for Pickerel Lake in 2019*

Pickerel Lake is a moderately deep lake, with a maximum depth of 41 feet. Dissolved oxygen profiles from data collected in 2019 at site PLK2 show stratification in June and July. While a lake is stratified, it is typical for the bottom of a deep lake to become low in oxygen, anoxic. If the lake mixes again oxygen is replenished at the bottom of the lake and nutrient rich water can be cycled through the lake. Many lakes only mix twice a year at spring and fall turnover. Some lakes mix more often due to their shallow nature and wind mixing. Based on the oxygen and temp profile in 2019 Pickerel Lake stratified in early summer and then mixed again around mid-August prior to the actual fall turnover.

From 2002 to 2019, dissolved oxygen readings show mid-summer anoxic periods occurring more frequently. In the 1990s, anoxic conditions were observed in late summer or early fall. From 2002 to 2010, anoxic conditions were only observed on 2 summer sampling trips. In more recent years, oxygen levels have become depleted at the lake bottom by mid-summer with 12 occurrences in the past ten years, including two June anoxia events (Table 5).

Lakes stratify when the upper water warms significantly faster then the water near the bottom. The wind is always mixing the lake water helping to keep temperatures even. Stratification is more likely in years when temperatures warmup quickly and wind speeds are average. In years with a long slow spring and above average wind speeds Pickerel Lake is likely to stay well mixed all summer and only experience internal nutrient release during fall turnover. In recent years Pickerel Lake has been experiencing mid-summer stratification and anoxic conditions followed by wind induced mixing events. This can release plant-available dissolved phosphorous from the lake bottom back into the water, triggering algae blooms, rooted algae, and aquatic plant growth. When this new growth dies additional oxygen is consumed which can contribute to another anoxic period.

| | June | July | August |
|---|---|---|---|
| 2002 | | | |
| 2003 | | | |
| 2004 | | | |
| 2005 | | X | |
| 2006 | | | |
| 2007 | | | |
| 2008 | | | |
| 2009 | | | X |
| 2010 | | | |
| 2011 | | X | |
| 2012 | | X | |
| 2013 | | X | X |
| 2014 | | | X |
| 2015 | X | X | X |
| 2016 | | | |
| 2017 | | X | |
| 2018 | X | | X |
| 2019 | | X | |

*Table 5: Anoxic conditions observed in Pickerel Lake from 2002 to 2019*

## Trophic State Index (TSI)

TSI is a standard measure or means for calculating the trophic status or productivity of a lake. More specifically, it is the total weight of living algae (algae biomass) in a waterbody at a specific location and time. Three variables, chlorophyll a, Secchi depth, and total phosphorus, independently estimate algal biomass.

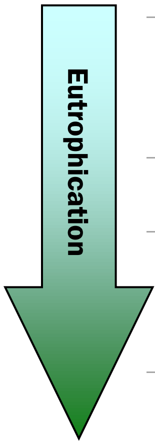
If all three TSI numbers are within a few points of each other, they are strongly related. If they are different, there are other dynamics influencing the lake's productivity, and TSI mean should not be reported for the lake. Pickerel Lake falls into the eutrophic range (Tables 6, 7).

*Table 6. Trophic State Index for Pickerel Lake*

| Trophic State Index | |
|---|---|
| **TSI Phosphorus** | 58 |
| **TSI Chlorophyll-a** | 54 |
| **TSI Secchi** | 50 |
| **TSI Mean** | 54 |
| **Trophic State:** | Eutrophic |

*Numbers represent the mean TSI for each parameter.*

Pickerel Lake




| TSI | Attributes | Fisheries & Recreation |
|---|---|---|
| <30 | **Oligotrophy:** Clear water, oxygen throughout the year at the bottom of the lake, deep cold water. | Trout fisheries dominate. |
| 30-40 | Bottom may become anoxic (no oxygen). | Trout fisheries in deep lakes only. Walleye, Cisco present. |
| 40-50 | **Mesotrophy:** Water moderately clear most of the summer. May be "greener" in late summer. | No oxygen at the bottom of the lake results in loss of trout. Walleye may predominate. |
| 50-60 | **Eutrophy:** Algae and aquatic plant problems possible. "Green" water most of the year. | Warm-water fisheries only. Bass may dominate. |
| 60-70 | Blue-green algae dominate, algal scums and aquatic plant problems. | Dense algae and aquatic plants. Low water clarity may discourage swimming and boating. |
| 70-80 | **Hypereutrophy:** Dense algae and aquatic plants. | Water is not suitable for recreation. |
| >80 | Algal scums, few aquatic plants. | Rough fish (carp) dominate; summer fish kills possible. |

Source: Carlson, R.E. 1997. A trophic state index for lakes. *Limnology and Oceanography*. 22:361-369.

*Table 7. Trophic state index attributes and their corresponding fisheries and recreation characteristics*

## Trend Analysis

For detecting trends, a minimum of 8-10 years of consecutive data with 4 or more readings per season are recommended. Minimum confidence accepted by the Minnesota Pollution Control Agency is 90%. This means that there is a 90% chance that the data are showing a true trend and a 10% chance that the trend is a random result of the data. Only short-term trends can be determined with just a few years of data, because there can be different wet years and dry years, water levels, weather, etc, that affect the water quality naturally.

Pickerel Lake had sufficient data to perform a trend analysis for phosphorous and transparency from 2003 to 2019 (Table 8). Chlorophyll *a* data did not have 8 consecutive years of data, so a trend could not be run. Continuing to monitor the chlorophyll *a* in the next few years will allow for future analysis. The data was analyzed using the Mann-Kendall Trend Analysis. No statistically significant trends were detected for total phosphorus or transparency, but there is a trend of increasing levels of dissolved phosphorus which indicates declining water quality.

| Parameter | Date Range | Water Quality Trend | Probability | Significance |
|---|---|---|---|---|
| Total Phosphorus | 2002-2019 | Stable | - | |
| Dissolved Phosphorus | 2002-2019 | Declining | 99.9% | Additional fertility feeds algae and plants, leading to nuisance conditions and low oxygen levels. |
| Transparency | 2003-2019 | Stable | - | |

*Table 8. Trend analysis for Pickerel Lake*

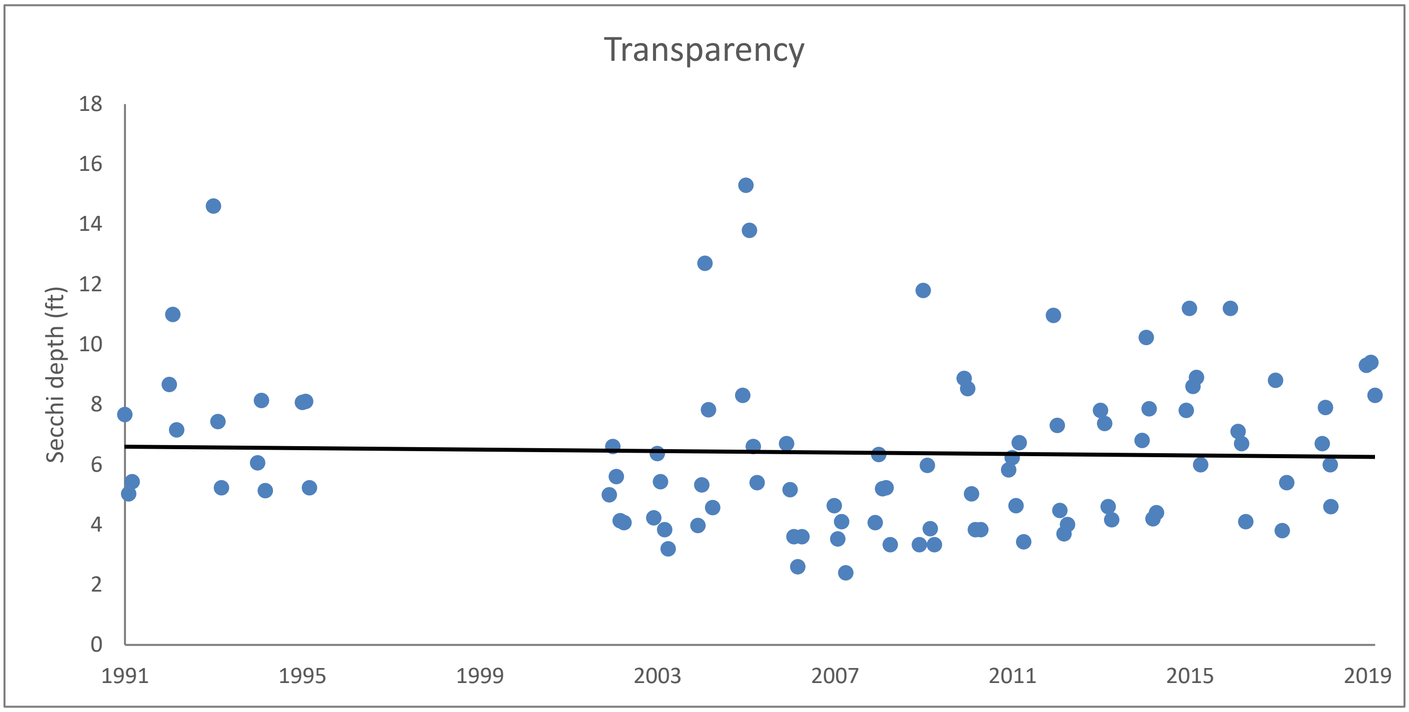



*Figure 11: Transparency measurements with long-term mean from 1991 to 2019*

## Lakeshed

Understanding a lakeshed requires an understanding of basic hydrology. A watershed is defined as all land and water surface area that contribute excess water to a defined point. The Minnesota DNR has delineated three basic scales of watersheds (from large to small): 1) basins, 2) major watersheds, and 3) minor watersheds.

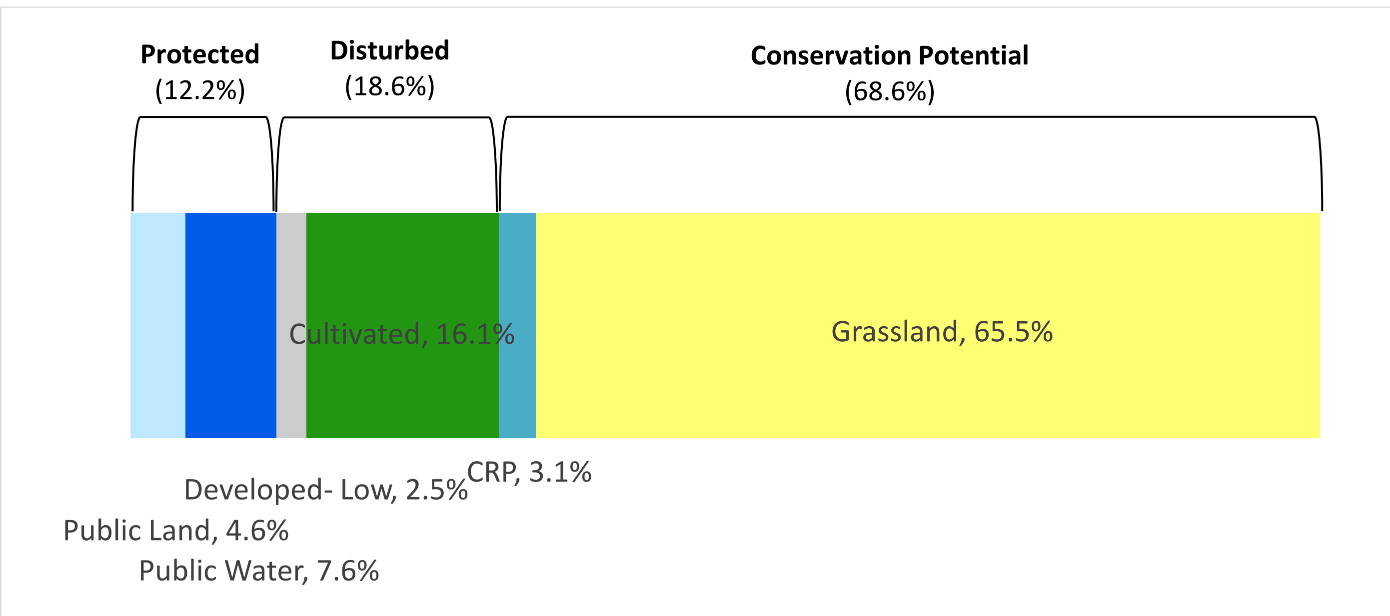
The Big Sioux River Major Watershed is one of the watersheds that make up the Missouri River Basin, which drains south to the Gulf of Mexico. The Waubay Lakes Basin is part of the Big Sioux River watershed, and Pickerel Lake's lakeshed is in the Waubay Lakes Basin. These lakesheds (catchments) are the "building blocks" for the larger scale watersheds. Lakesheds are very useful for displaying the land and water that contribute directly to a lake, but they are not always true watersheds because they may not show the water flowing into a lake from upstream streams or rivers. While some lakes may have only one or two upstream lakesheds draining into them, others may be connected to a large number of lakesheds, reflecting a larger drainage area via stream or river networks.

In an effort to prioritize protection and restoration efforts of fishery lakes, the Minnesota DNR has developed a ranking system by separating lakes into two categories based on their lakeshed: those needing protection and those needing restoration. Modeling by the DNR Fisheries Research Unit suggests that total phosphorus concentrations increase significantly over natural concentrations in lakes that have a watershed with disturbance greater than 25%. Therefore, lakes with watersheds that have less than 25% disturbance need protection and lakes with more than 25% disturbance need restoration (Table 9). Watershed disturbance was defined as having urban, agricultural and mining land uses. Watershed protection is defined as publicly owned land, public water, wetlands, or conservation easement.

*Table 9. Suggested approaches for watershed protection and restoration of DNR-managed fish lakes in Minnesota*

| Watershed Disturbance (%) | Watershed Protected (%) | Management Type | Comments |
|---|---|---|---|
| < 25% | > 75% | Vigilance | Sufficiently protected -- Water quality supports healthy and diverse native fish communities. Keep public lands protected. |
| | < 75% | Protection | Excellent candidates for protection -- Water quality can be maintained in a range that supports healthy and diverse native fish communities. Disturbed lands should be limited to less than 25%. |
| 25-60% | n/a | Full Restoration | Realistic chance for full restoration of water quality and improve quality of fish communities. Disturbed land percentage should be reduced and BMPs implemented. |
| > 60% | n/a | Partial Restoration | Restoration will be very expensive and probably will not achieve water quality conditions necessary to sustain healthy fish communities. Restoration opportunities must be critically evaluated to assure feasible positive outcomes. |

According to the 2016 National Land Cover Data Set, Pickerel Lake's lakeshed is classified with having 12.2% of the watershed protected and 18.6% of the watershed disturbed (Figure 13). Therefore, this lakeshed should have a protection focus. Goals for the lake should be to limit any increase in disturbed land use and maintain protected lands. Forest stewardship planning, harvest coordination to reduce hydrology impacts and forest conservation easements are some potential tools that can protect Pickerel Lake for the long term.



## Land use and Ownership

Activities that occur on the land within the lakeshed can greatly impact a lake. Land use planning helps ensure the use of land resources in an organized fashion so that the needs of the present and future generations can be best addressed. Pickerel Lake receives water from Dry Creek to the north, Oneroad Lake through Chekepa Creek to the east, and Hatchery Creek to the southeast.

Around one eighth (12.2%) of the Pickerel Lake lakeshed is protected. This total includes open water and wetlands. There are two areas along Dry and Chekepa Creeks just upstream from the lake that could be targeted for potential sedimentation and nutrient removal ponds. There are three animal feedlots in the lakeshed, only one of which is currently in use. Each feedlot has cooperated in the installation of runoff reduction projects starting as early as the 1970's.

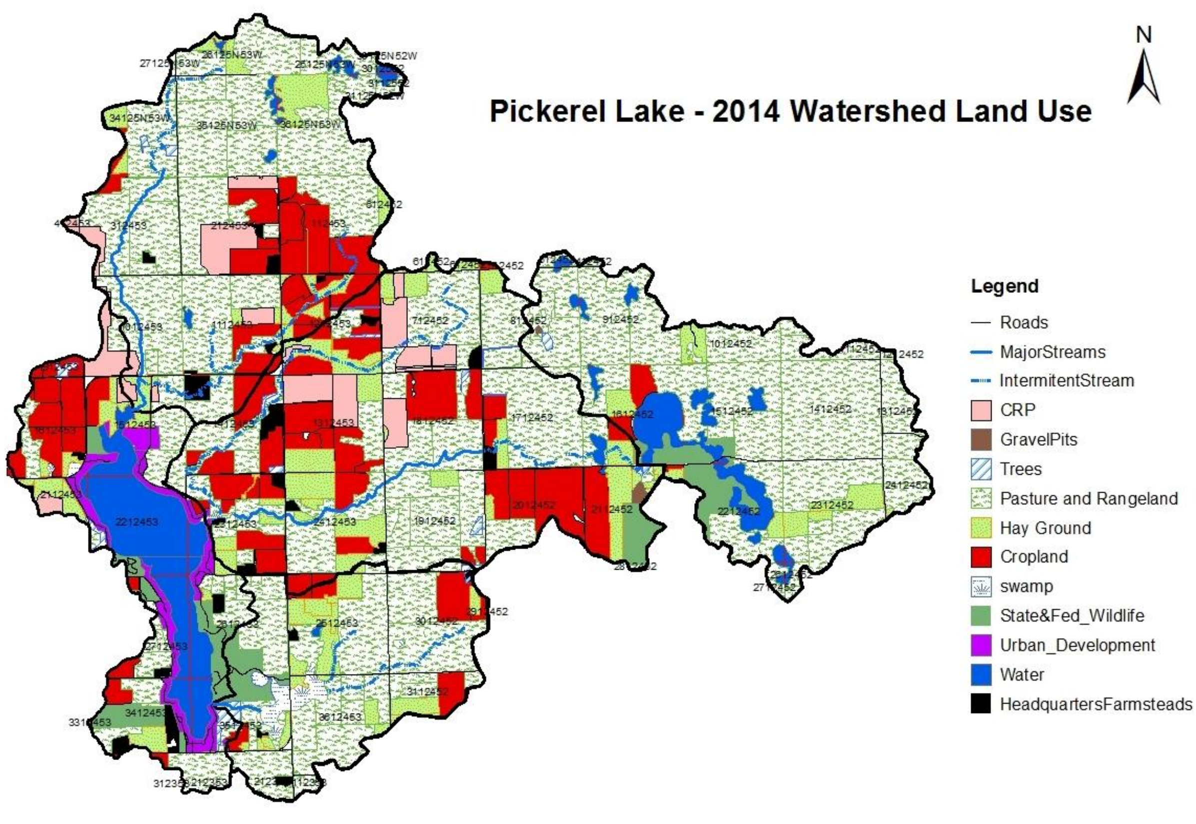



*Figure 12. Land use and ownership in the Pickerel Lake lakeshed*

The lakeshed vitals table identifies where to focus organizational and management efforts for each lake (Table 10). Criteria were developed using limnological concepts to determine the effect to lake water quality.

**KEY**

● Possibly detrimental to the lake
◉ Warrants attention
○ Beneficial to the lake

*Table 10. Pickerel Lake lakeshed vitals*

| Lakeshed Vitals | | Rating |
|---|---|---|
| **Lake Area** | 981 acres | descriptive |
| **Littoral Zone Area** | Data unavailable | descriptive |
| **Lake Max Depth** | 41 ft | descriptive |
| **Lake Mean Depth** | 16 ft | ◉ |
| **Water Residence Time** | 5 years | ● |
| **Miles of Stream** | 53.4 | descriptive |
| **Inlets** | 3 | ◉ |
| **Outlets** | 1 | ○ |
| **Major Watershed** | Big Sioux River | descriptive |
| **Minor Watershed** | Waubay Lakes Basin | descriptive |
| **Ecoregion** | Northern Glaciated Plains | descriptive |
| **Total Lakeshed to Lake Area Ratio** (total lakeshed includes lake area) | 23:1 | ◉ |
| **Standard Watershed to Lake Basin Ratio** (standard watershed includes lake areas) | Data unavailable | Not Available |
| **Wetland Coverage** | 6% | ○ |
| **Aquatic Invasive Species** | Curly Leaf Pondweed, Zebra Mussels | ● |
| **Public Drainage Ditches** | Data unavailable | Not Available |
| **Public Lake Accesses** | 3 | ◉ |
| **Miles of Shoreline** | 10.1 | descriptive |
| **Shoreline Development Index** | 2.3 | ● |
| **Public Land to Private Land Ratio** | Data unavailable | Not Available |
| **Development Classification** | Recreational Development | ◉ |
| **Miles of Road** | 52.8 | descriptive |
| **Municipalities in lakeshed** | None | ○ |
| **Forestry Practices** | None | ○ |
| **Feedlots** | 3 | ● |
| **Sewage Management** | Sanitary Sewer | ○ |
| **Lake Management Plan** | None | ◉ |
| **Lake Vegetation Survey/Plan** | None | ◉ |

## Tributary Monitoring

Pickerel Lake has very good tributary data collected at sites along the streams that feed into the lake. On Dry Creek just north of Pickerel Lake is Site 1. Sampling locations on Chekepa Creek include Site 3 the north branch and Site 4 the east branch from One Road Lake. These three sites represent the primary inlets into the lake. Hatchery Creek at site 5 has very low nutrient levels and is not a significant source of nutrients to the lake. There are not enough consecutive years of data to run statistical trends on the tributary data, but most of the phosphorus and suspended solids values are comparable year to year. The expected ranges for streams in the Northern Glaciated Plains region are 0.09 – 0.25 mg/L for phosphorus and 11 – 63 mg/L for suspended solids.

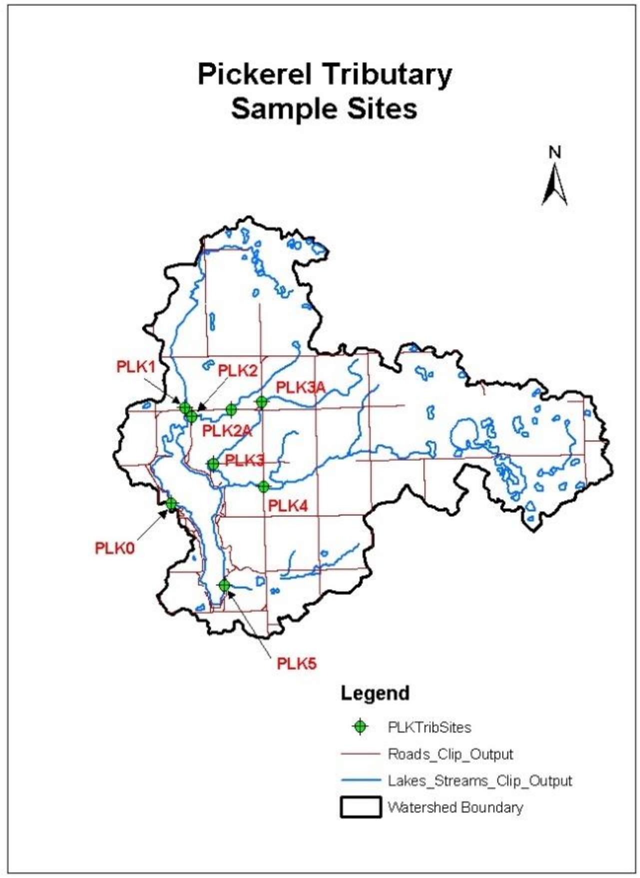



*Figure 13: Stream sample sites in tributaries to Pickerel Lake*

In all of the samples at Dry Creek Site 1, there are low levels of phosphorus and suspended solids, regardless of the year (Figures 14, 15). The annual average phosphorus concentrations are on the low end of the expected range, and a majority of the suspended solids samples were well below the expected range.

At Site 3 on Chekepa Creek, phosphorus and suspended solids were occasionally slightly elevated in 2008 and 2009 (Figures 16, 17). In more recent years, levels of both parameters have declined and fall within or below the expected regional range.

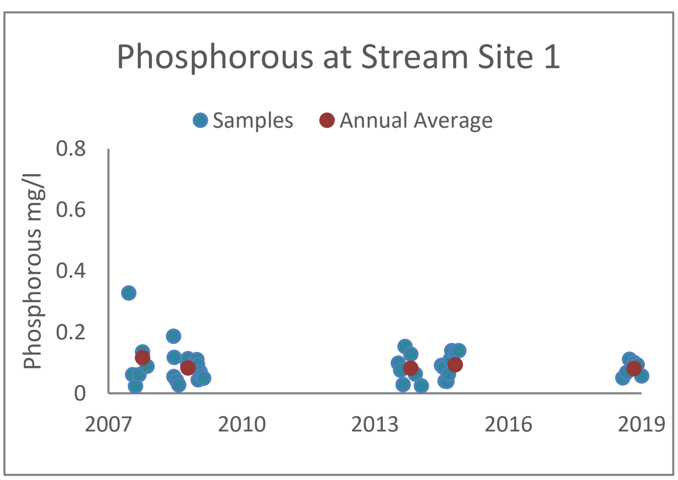



*Figure 14: Phosphorus concentrations at Stream Site 1 Dry Creek from 2008 to 2019*

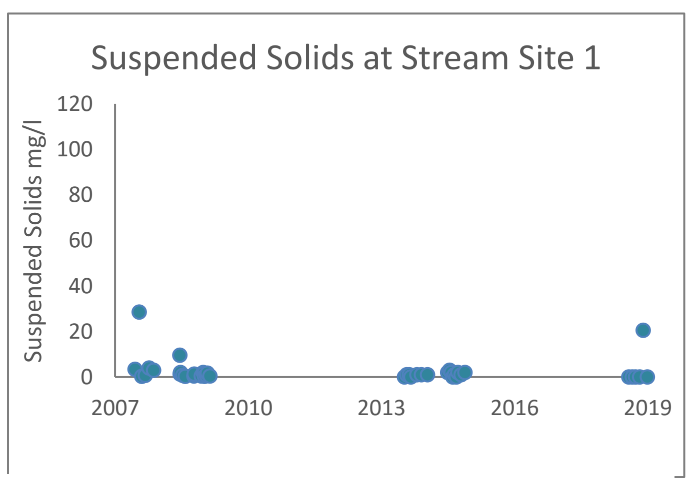



*Figure 15: Total suspended solid concentrations for Stream Site 1 Dry Creek from 2008 to 2019*

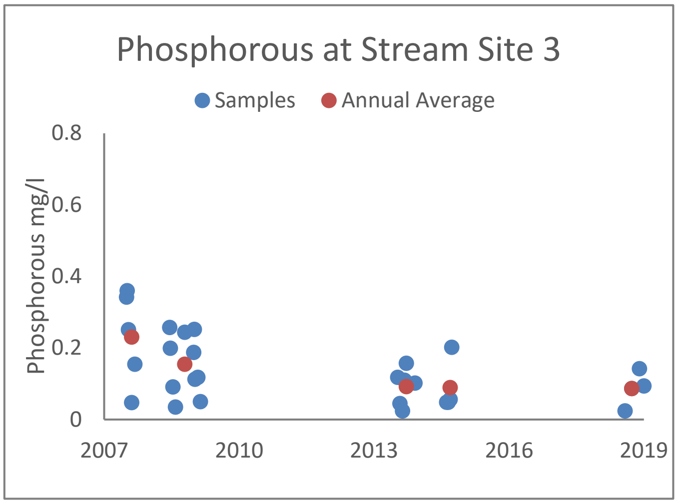



*Figure 17: Total Phosphorous concentrations for Stream Site 3 Chekepa Creek from 2008 to 2019*

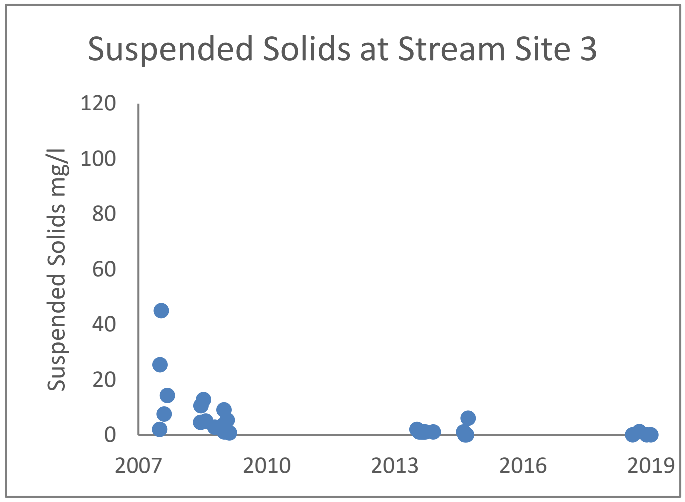



*Figure 17: Total suspended solid concentrations for Stream Site 3 Chekepa Creek from 2008 to 2019*

Chekepa Creek Site 4 had the highest levels of all three sites for both phosphorous and suspended solids (Figures 18, 19). This input is likely the most influential source of nutrients to Pickerel Lake. In 2008, both parameters had samples with very high values, but the average concentrations were still within the ecoregion range. The levels of phosphorous were much lower in 2014 while the levels of suspended solids remained elevated. By 2019, levels of both phosphorous and suspended solids were low and below the expected range.

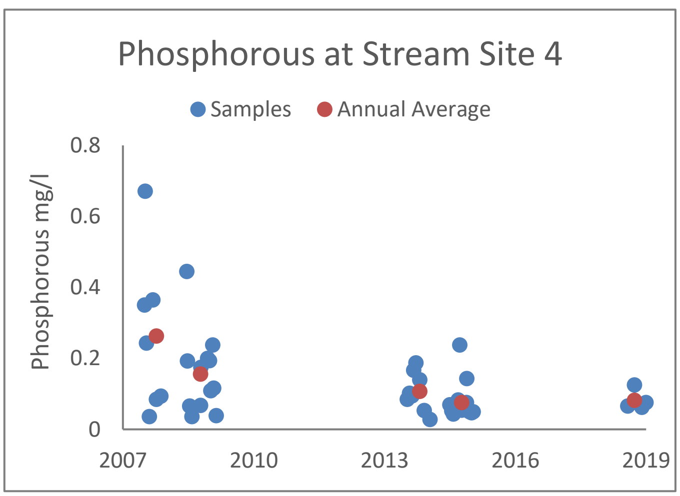



*Figure 18: Phosphorus concentrations at Stream Site 4 Chekepa Creek from 2008 to 2019*

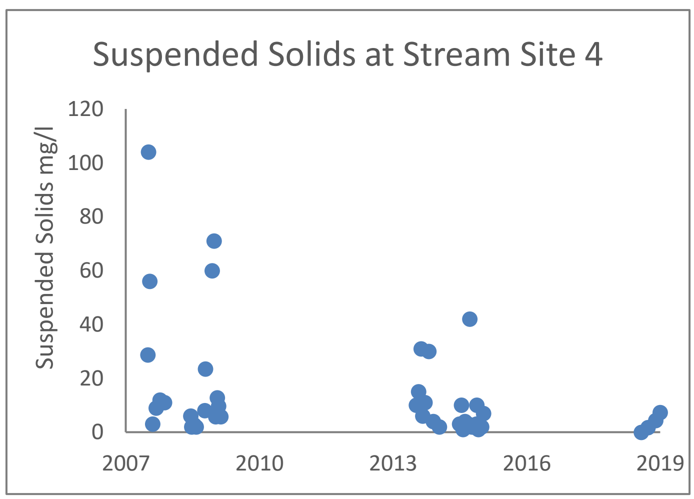



*Figure 19: Total suspended solid concentrations for Stream Site 4 Chekepa Creek from 2008 to 2019*

## Pickerel Lake, 2019 Survey Summary SD G&F

Note: Curly leaf pondweed, an invasive species, has been found in Pickerel Lake. Care should be taken by all user groups to prevent its spread. For information regarding curlyleaf pondweed and other aquatic invasive species please visit https://sdleastwanted.sd.gov/

Pickerel Lake, located 6.0 miles northeast of Grenville, is managed as a multi-species fishery including panfish (i.e., black crappie, bluegill, and yellow perch), smallmouth bass and walleye; other fish species (e.g., northern pike, white bass, etc.) also contribute to the fishery.

- Black crappie. Black crappies were not abundant (0.7/frame net) in 2019. Sampled fish ranged in length from 4.7 to 12.2 inches and four cohorts (2004, 2010, 2016, and 2017) were represented, each by eight or fewer individuals.

- Bluegill. The 2019 frame net CPUE was the highest recorded in surveys from 2010 to 2019. At 24.5/frame net, relative abundance was considered moderate to high. Sampled bluegills ranged in length from 3.5 to 8.7 inches; 92% were >6.0 inches and 15% were >8.0 inches. Fish from three consecutive year classes (2015 - 2017) were present; those from the 2016 cohort were the most abundant accounting for 80% of bluegills in the sample. Growth appears to be good with a mean length at capture value of 8.3 inches at age 4.

- Northern pike. Northern pike numbers were higher in 2019 than 2018. At 2.5/gill net, relative abundance was considered moderate to high. Sampled northern pike ranged in length from 18.1 to 29.9 inches, 87% were >21.0 inches and 3% were 28 inches and longer.

- Smallmouth bass. More smallmouth bass were sampled in 2019 (59.0/hour) than 2018 (6.0/hour). The increase was likely not related to population changes but rather improved sampling conditions in 2019. Sampled smallmouth bass ranged in length from 8.7 to 19.3 inches, 83% were >11.0 inches and 37% were 14.0 inches or longer. Of those <14.0 inches nearly 70% (30 of 43 individuals) were from the 2015 (age-4) year class. In 2019, age-4 fish had a mean length at capture of 13.0 inches, which is higher than age-4 mean lengths at capture reported from 2011 to 2015 (11.1 to 12.0 inches).

- Walleye. At 5.2/gill net, relative abundance was considered moderate in 2019. Gill net captured walleyes ranged in length from 10.2 to 28.0 inches, most (74%) were >15.0 inches and 18% were 20.0 inches or longer. Individuals from 10 year classes (2004, 2006, 2008, 2010, 2011, and 2013 – 2017) were present; those from the 2013 (age 6), 2015 (age 4) and 2017 (age 2) cohorts, which coincided with small fingerling stockings, were the most abundant accounting for >70% of fish in the sample. Since 2010, mean length at capture of age-4 fish has ranged from 12.7 to 17.4 inches. In 2019, the mean length at capture for age-4 fish was 16.5 inches.

- Yellow perch. The 2019 mean gill net CPUE of 16.1 suggested moderate relative abundance. Sampled yellow perch ranged in length from 4.7 to 11.8 inches, of those >5.0 inches 32% were >8.0 inches and 4% were 10.0 inches or longer. Individuals from five year classes (2012 and 2014 - 2017) were present, those from the 2016 (age-3) cohort were the most abundant accounting for more than half (51%) of fish in the sample. Growth tends to be slow to moderate as mean length at capture values for age-3 yellow perch have ranged from 7.6 to 8.8 inches since 2010. In 2019, the mean length of age-3 fish was 7.6 inches.

For more detailed results see the computer generated South Dakota Statewide Fisheries Survey for Pickerel Lake at https://apps.sd.gov/GF56FisheriesReports/ExportPDF.ashx?ReportID=17799

Development pressure is increasing around the shorelines and within the watersheds of many lakes. This development can degrade water quality and impact valuable shoreline habitat. Native shoreline vegetation provides habitat for fish and wildlife, filters harmful nutrients, and protects against shoreline erosion. Lakeshore owners can minimize their impact on the shoreline and maintain a more natural setting while actually decreasing annual maintenance. For more information on how to accomplish this, go to the following website: www.dnr.state.mn.us/shorelandmgmt

## Key Findings and Recommendations

**Monitoring Recommendations**
Transparency monitoring at the primary sites should be continued annually. It is important to continue transparency monitoring, possibly weekly but at least monthly every summer to enable year-to-year comparisons and trend analyses. Weekly volunteer secchi disc readings would help identify the occurrence and duration of algae blooms and any trends over time. Phosphorus, dissolved phosphorous, Total Kjeldhal Nitrogen, and chlorophyll *a* monitoring should continue, as the budget allows, to track future water quality trends. Currently the streams sites have fairly low nutrient and sediment levels. Stream site monitoring could be reduced to once every few years or as concerns arise. The good long term data set will allow any new samples to be compared with past observations.

**Overall Conclusions**
Pickerel Lake is a eutrophic lake (TSI = 54) with stable total phosphorus and transparency trends, in the last 18 years. The total dissolved phosphorus levels have been increasing over time indicating a declining water quality trend with 99.9% confidence. Recent chlorophyll measurements are higher than results observed in the 1990s but may be similar to what was observed in the 1980s based on anecdotal reports.

Approximately one eighth of the lakeshed is protected (12.2%), which includes public land and open water. About 19% of the lakeshed is disturbed, which is mainly cropland, lakeshore development, and low density developed areas like roads (Figure 12). Undisturbed areas in the lakeshed should be protected by paying landowners to maintain the existing habitat and utilizing conservation easements through groups such as Ducks Unlimited or other state, local, or federal groups.

**Phosphorus Loading and Priority Impacts**
Pickerel Lake is at a disadvantage because it retains much of the nutrients and sediment that wash into it. There is one additional lakeshed that contributes water from upstream areas and several streams flow into Pickerel Lake. This means that the land practices upstream likely impact to the lake's water quality.

*Table 11. Watershed characteristics*

| | |
|---|---|
| **Lakeshed to Lake Area Ratio** (lakeshed includes lake area) | 23:1 |
| **Watershed to Lake Area Ratio** (watershed includes lake areas) | Data unavailable |
| **Number of Upstream Lakes** | 1 |
| **Headwaters Lake?** | No |
| **Inlets / Outlets** | 3 / 1 |
| **Water Residence Time** | 5 years |

Only 6% of the lakeshed is covered with wetlands, which does not provide very much water storage and filtration (Figure 12). Protecting and restoring wetlands will help maintain water levels and water storage, reduce flooding, and filter runoff during large storm events.

Pickerel Lake has a moderate amount of surface inflow and some springs discharging groundwater into the lake. The large lake size and deep depths give the water a moderate residence time in the lake, likely 5 or more years. Most lakes retain at least half of the nutrients that flow into the lake in their bottom sediments. Pickerel Lake likely retains 75% of the annual nutrient load into the lake.

Data show that summer algae blooms are now worse than they were in the 1990s. It is likely that phosphorous release from the lake bottom sediments is causing the summer algae blooms that are being observed. The cumulative effects from the large watershed and land practices have aged the lake, resulting in greater oxygen demand in the deep portions of the lake. As the bottom water layers run out of oxygen, dissolved reactive phosphorous is released from the lake sediments. This phosphorous is available for uptake and causes aquatic plant and algae growth. An analysis of the dissolved phosphorous data collected at the lake bottom shows an increase with current levels four times higher than in the 1990s (Figure 9).

## Best Management Practices Recommendations

The management focus for Pickerel Lake should be to protect the water quality by implementing nutrient and runoff reduction BMPs in the lakeshed and investigating the possibility for hypolimnetic withdrawal. Efforts should be focused on managing and/or decreasing the impacts caused by agriculture, current and additional development, nutrient-saturated wetlands, and impervious areas. Project ideas include treating runoff in regional nutrient removal ponds, conservation cropping systems, hypolimnetic withdrawal to remove nutrient rich water from the lake bottom when oxygen is absent, shoreline restoration, rain gardens, and infiltration systems.

### Pickerel Lake Goals

1. Protection Focus: minimize disturbed land uses and maintain protected lands
2. Manage phosphorus loading from **nearshore** (Table 12)
3. Implement regional sedimentation and nutrient removal ponds
4. Manage phosphorous release from lake sediments by removing bottom water, hypolimnetic withdrawal, or alum application

*Table 12. Best Management Practices specific to Pickerel Lake (refer to Figure 12 for locations)*

| Category | Land use type | Conservation project ideas | Results | Who | Contact for help |
|---|---|---|---|---|---|
| Conservation Potential | Pasture/grassland/CRP 68.6% | Conservation Reserve Program (CRP), maintain vegetative cover, plant trees, conservation easements, grassed waterways, ditch buffers, maintain/restore wetlands. | Reduce water runoff and soil erosion, better water storage. Treat runoff with iron enhanced media to remove dissolved phosphorous. | • Individual Property Owners<br>• Regional treatment ponds could be pursued by the Pickerel Lake Conservancy | Day County Conservation District (605) 345-4661 |
| Disturbed Land | Cultivated crops 16.1% | Restore wetlands; Conservation Reserve Program (CRP), Cover Crops | Reduce water runoff and soil erosion, better water storage. Treat runoff in regional ponds that include iron enhanced media to remove dissolved phosphorous. | • Individual Property Owners<br>• Regional treatment ponds could be pursued by the Pickerel Lake Conservancy | Day County Conservation District (605) 345-4661 |
| | Developed, low intensity 2.5% | Shoreline buffers, tree planting, rain gardens. | Reduce water runoff and shoreline erosion. | • Individual Property Owners<br>• Pickerel Lake Conservancy | Day County Conservation District (605) 345-4661 |
| | Developed, high intensity (0.01%, 2 acres) | Infiltration trenches, permeable pavements, tree planting, rain gardens, shoreline buffers, stormwater retention. | Reduce water runoff into streams and lakes. | • Individual Property Owners<br>• Pickerel Lake Conservancy | Day County Conservation District (605) 345-4661 |

The current lakeshore homeowners can lessen their negative impact on water quality by installing or maintaining the existing trees on their properties. Forested uplands contribute about 10% as much phosphorus (lbs/acre/year) than developed land.

The lakeshed still has a few undeveloped shoreline parcels (Figure 12). There is the great potential for protecting this land with conservation easements or public ownership. Conservation easements can be set up easily and at little cost with help from organizations such as the The Nature Conservancy and Ducks Unlimited. Public land purchases can be pursued through the local Game and Fish office, Pheasants Forever, and other partners.

Native aquatic plants stabilize the lake's sediments and tie up phosphorus in their tissues. When aquatic plants are uprooted from a shallow lake, the lake bottom is disturbed, and the phosphorus in the water column gets used by algae instead of plants. This contributes to "greener" water and more algae blooms. Protecting native aquatic plant beds will ensure a healthy lake and healthy fishery. If a swimming area is necessary in front of people's docks, clear only a small area of plants. Clearing the whole frontage of a lake lot is not necessary and can contribute to additional algae blooms.

## Organizational contacts and reference sites

| | |
|---|---|
| Pickerel Lake Conservancy | Grenville, SD 57239<br>info@pickerellakeconservancy.org |
| South Dakota Game & Fish Office | 603 East 8th Ave, Webster, SD 57274<br>605-345-3381 |
| South Dakota Department of Environment & Natural Resources | 523 E Capitol Ave, Pierre, SD 57501<br>605-773-3151 |
| Northeast Glacial Lakes Watershed Project | info@neglwatersheds.org<br>605-345-4661 |
| Day County Conservation District | 600 E Highway 12, Ste 1 Webster, Sd 57274<br>(605) 345-4661 |

*Table 13. Organizational contacts and reference sites*