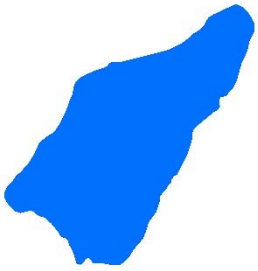
# Eddy Lake 09-0039-00 Carlton County



Eddy Lake is located 2 miles south of Barnum, MN in Carlton County. It is a small lake covering 23 acres (Table 1).

Eddy Lake has two inlets and one outlet, which classify it as a drainage lake. Water enters Eddy Lake from Mud Lake in the south and Moose Horn River in the north. The Moose Horn River exits the lake on the west side of Eddy Lake and carries water south to Mississippi River.

Water quality data have been collected on Eddy Lake from 1995-2016 (Tables 2 & 3). These data show that the lake is mesotrophic (TSI = 48) with moderately clear water conditions most of the summer and good recreational opportunities.

There is a joint Lake Association on Bear, Eddy, Hanging Horn and Little Hanging Horn lakes. They have an organized golf tournament and are involved in lake monitoring and education.

Table 1. Eddy Lake location and key physical characteristics.

| Location Data | | Physical Characteristics | |
|---|---|---|---|
| MN Lake ID: | 09-0039-00 | Surface area (acres): | 23.5 |
| County: | Carlton County | Littoral area (acres): | 9.5 |
| Ecoregion: | Northern Lakes and Forests | % Littoral area: | 40.3 |
| Major Watershed: | Kettle River | Max depth (ft), (m): | 36.3, 11.1 |
| Latitude/Longitude: | 46.476069, -92.711404 | Inlets: | 2 |
| Invasive Species: | None | Outlets: | 1 |
| | | Public Accesses: | 0 |

Table 2. Availability of primary data types for Eddy Lake.

| Data Availability | | |
|---|---|---|
| Transparency data |  | Good, enough for trend analysis |
| Chemical data |  | Low – only one year of data |
| Inlet/Outlet data |  | A volunteer is monitoring the inlet for transparency. |
| Recommendations | | For recommendations refer to page 15. |

## Lake Map

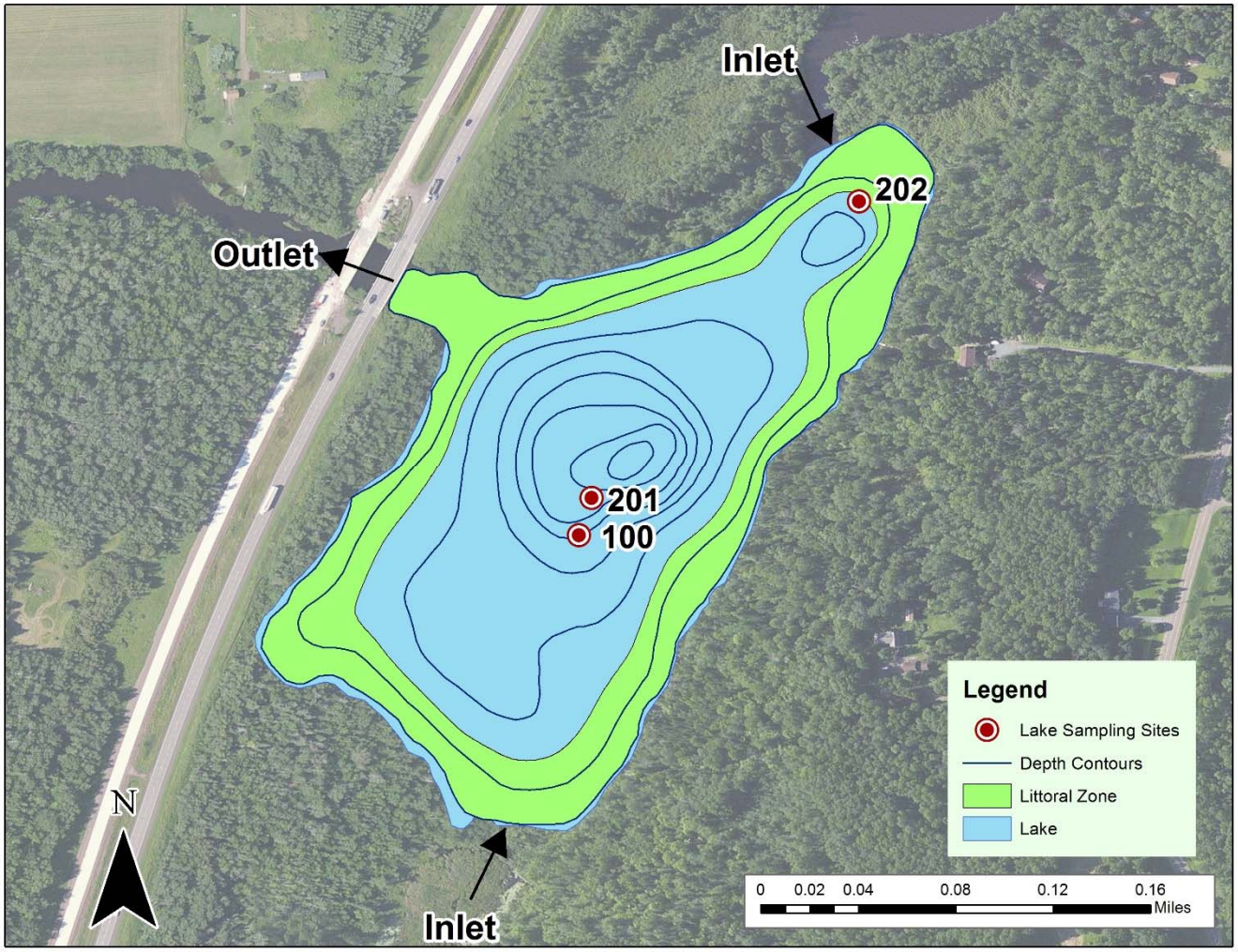



*Figure 1. Map of Eddy Lake with 2010 aerial imagery and illustrations of lake depth contour lines, sample site locations, inlets and outlets, and public access points. The light green areas in the lake illustrate the littoral zone, where the sunlight can usually reach the lake bottom, allowing aquatic plants to grow.*

*Table 3. Monitoring programs and associated monitoring sites. Monitoring programs include the Citizen Lake Monitoring Program (CLMP), MPCA Lake Monitoring Program (MPCA), and Citizens Monitoring Bacteria (CMB).*

| Lake Site | Depth (ft) | Monitoring Programs |
|---|---|---|
| 100 | 20 | MPCA: 1997 |
| 201*Primary site | 30 | CLMP: 1995-2016 |
| 202 | 15 | CMB: 2007 |

## Average Water Quality Statistics & Comparisons

The information below describes available chemical data for Eddy Lake through 2017 (Table 4). Data for total phosphorus, chlorophyll *a*, and Secchi depth are from the primary site 201.

Minnesota is divided into 7 ecoregions based on land use, vegetation, precipitation and geology. The Minnesota Pollution Control Agency (MPCA) has developed a way to determine the "average range" of water quality expected for lakes in each ecoregion[1] (Table 4). Eddy Lake is in the Northern Lakes and Forests Ecoregion (Figure 2).

The MPCA has developed Impaired Waters Standards for lakes in each ecoregion to determine if a lake is impaired for excess phosphorus/eutrophication (Table 4). Lakes that are over the impaired waters standards are placed on the state's Impaired Waters List[2].

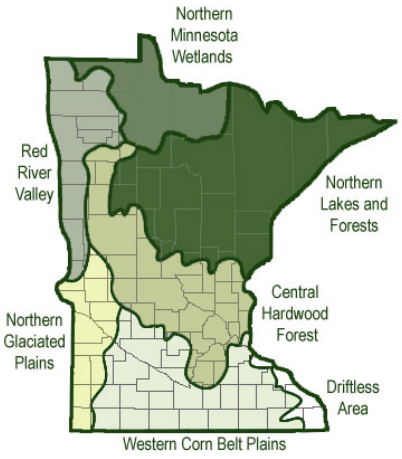



*Figure 2. Minnesota ecoregions.*

*Table 4. Water quality means compared to ecoregion ranges and impaired waters standard.*

| Parameter | Mean | Ecoregion Range[1] | Impaired Waters Standard[2] | Interpretation |
|---|---|---|---|---|
| Total phosphorus (ug/L) | 21.2 | 14 – 27 | > 30 | Phosphorus and chlorophyll *a* results are within the expected range for the Northern Lakes and Forests Ecoregion. |
| [3]Chlorophyll *a* (ug/L) | 4.4 | 4 – 10 | > 9 | |
| Chlorophyll *a* max (ug/L) | 7.9 | < 15 | | |
| Secchi depth (ft) | 6.3 | 8 – 15 | < 6.5 | |
| Dissolved oxygen | *See page 8* | | | Dissolved oxygen depth profiles show that the lake typically mixes throughout the summer, but can periodically stratify. |
| Total Kjeldahl Nitrogen (mg/L) | 0.58 | <0.4 – 0.75 | | Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms. |
| Alkalinity (mg/L) | 40.4 | 40 – 140 | | Indicates a low sensitivity to acid rain and a good buffering capacity. |
| Color (Pt-Co Units) | 70 | 10 – 35 | | Indicates water with high levels of tannins (brown stain). |
| pH | NA | 7.2 – 8.3 | | Data not available |
| Chloride (mg/L) | 2.9 | 0.6 – 1.2 | | Slightly above the expected range for the ecoregion, but still considered low level. |
| Total Suspended Solids (mg/L) | 1.6 | <1 – 2 | | Within the expected range for the ecoregion. |
| Specific Conductance (umhos/cm) | 80 | 50 – 250 | | Within the expected range for the ecoregion. |
| TN:TP Ratio | 27.5:1 | 25:1 - 35:1 | | Within the expected range for the ecoregion, and shows the lake is phosphorus limited. |

[1]The ecoregion range is the 25th-75th percentile of summer means from ecoregion reference lakes: https://www.pca.state.mn.us/quick-links/eda-guide-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 5. Water quality means and ranges for primary sites.*

| Parameters | Primary Site 201 |
|---|---|
| **Total Phosphorus Mean (ug/L):** | 21.2 |
| Total Phosphorus Min: | 15.0 |
| Total Phosphorus Max: | 26.0 |
| Number of Observations: | 5 |
| **Chlorophyll *a* Mean (ug/L):** | 4.3 |
| Chlorophyll-a Min: | 1.4 |
| Chlorophyll-a Max: | 7.9 |
| Number of Observations: | 5 |
| **Secchi Depth Mean (ft):** | 6.3 |
| Secchi Depth Min: | 4.9 |
| Secchi Depth Max: | 8.5 |
| Number of Observations: | 362 |

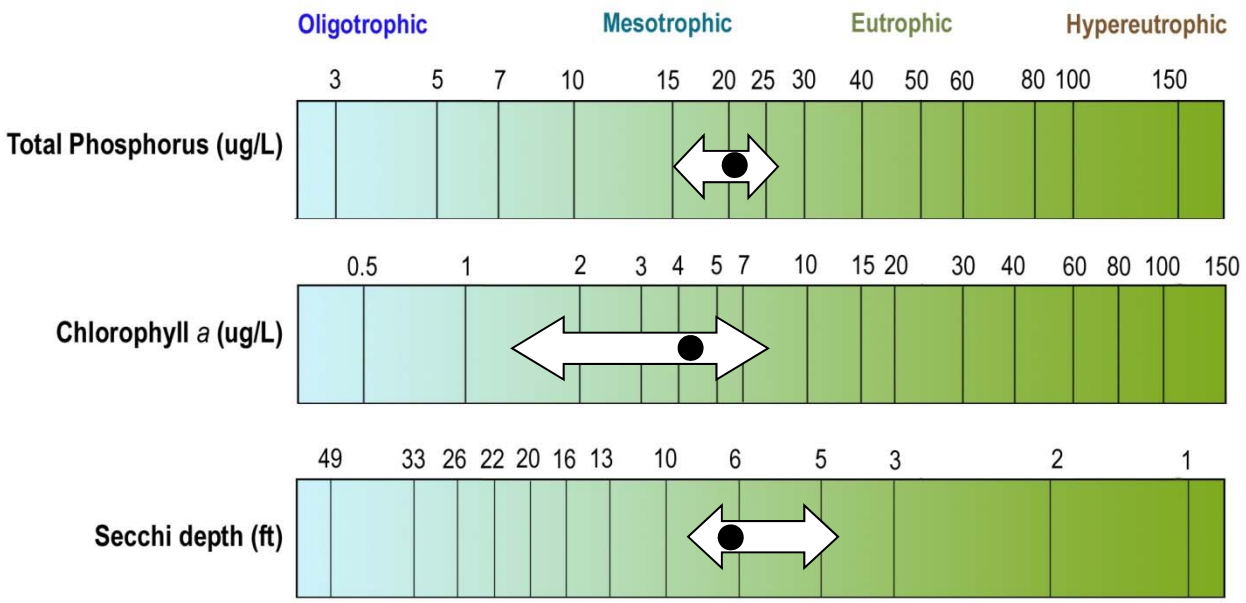



*Figure 3. Eddy Lake total phosphorus, chlorophyll a and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Primary Site 201). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. No. 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.

The annual mean transparency in Eddy Lake ranges from 5.7 to 7.1 feet (Figure 4). The annual means hover fairly close to the long-term mean. For trend analysis, see page 10. Transparency monitoring should be continued annually at site 201 in order to track water quality changes.

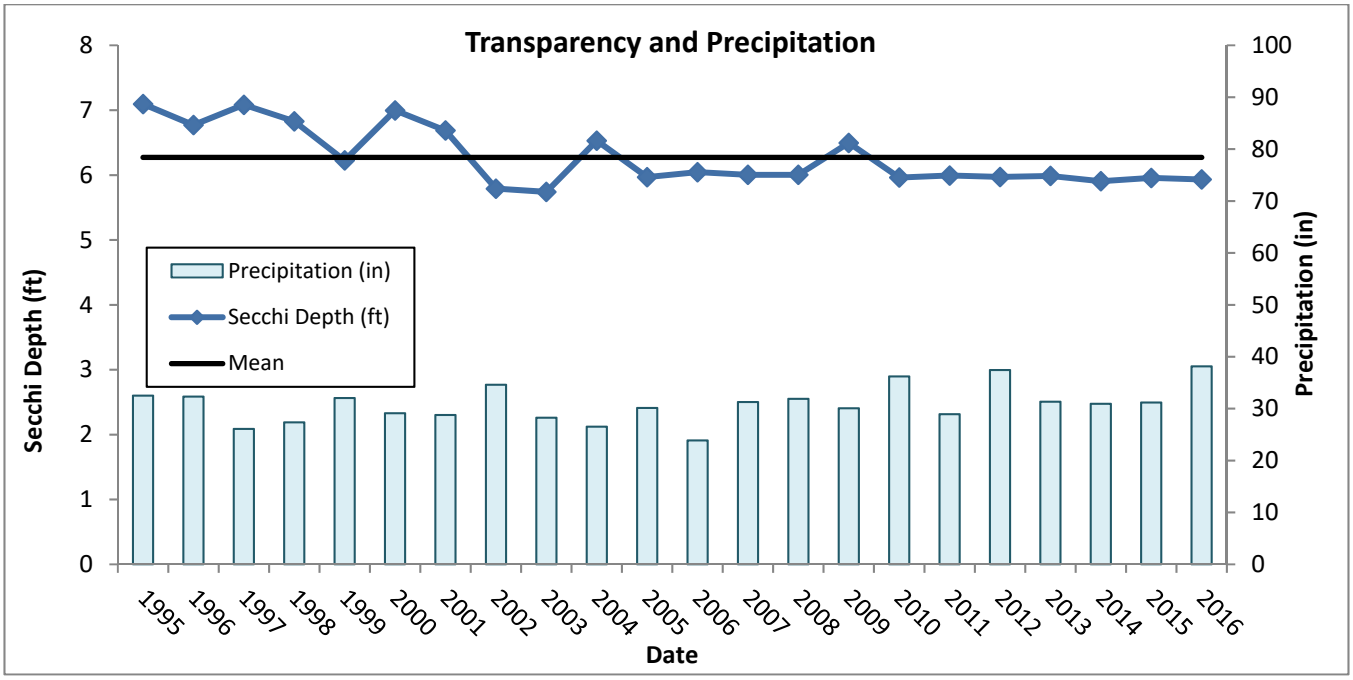



*Figure 4. Annual mean transparency compared to long-term mean transparency*

Eddy Lake transparency ranges from 4.9 to 8.5 ft at the primary site (Table 5). Figure 5 shows the seasonal transparency dynamics. Eddy Lake transparency is consistent throughout the summer and fall. This pattern could be influenced by tannins (brown stain) in the water and/or the lake's intermediate depth. During calm periods, the lake can stratify, which would show higher transparencies in May and June, declining through August. The 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 worried if their transparency is lower in August than it is in June. It is typical for a lake to vary in transparency throughout the summer.

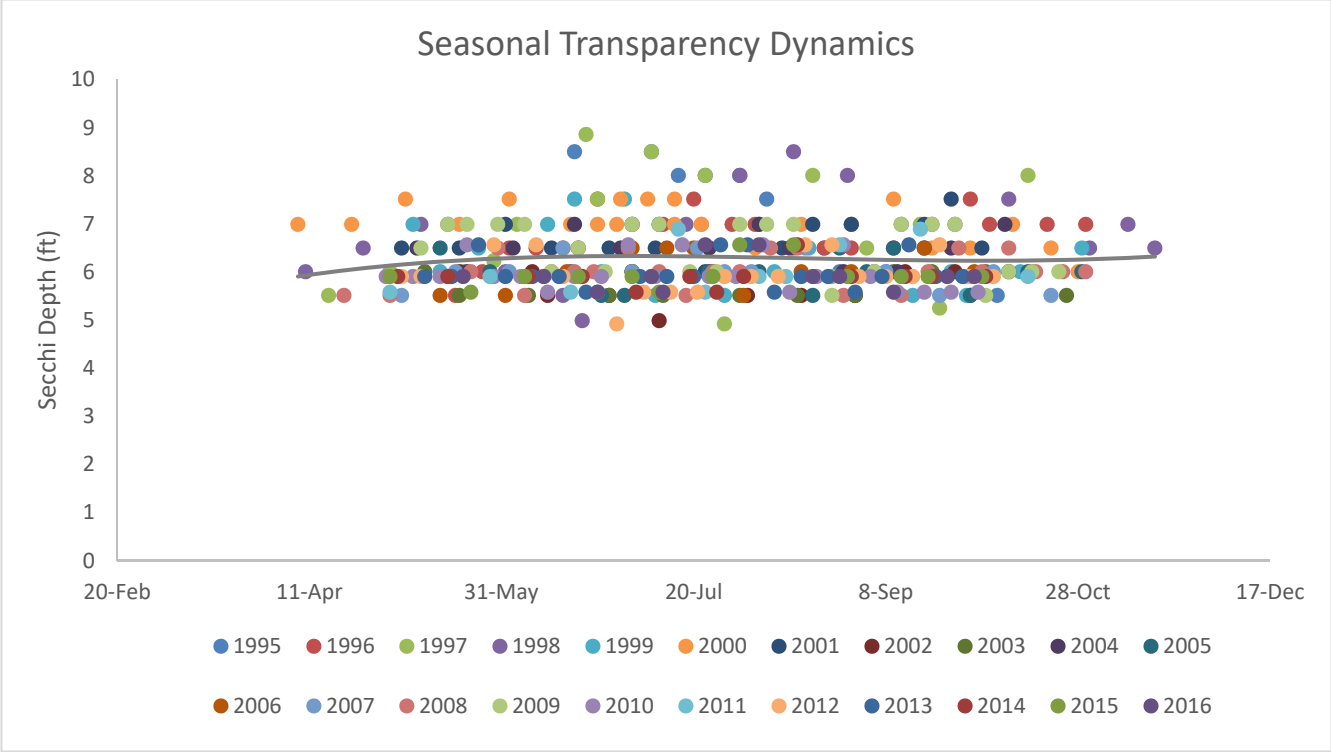



*Figure 5. Seasonal transparency dynamics and year to year comparison (Primary Site 201). The gray line represents the pattern in the data.*

## User Perceptions

When volunteers collect Secchi depth readings, they record their perceptions of the water based on the physical appearance and the recreational suitability. These perceptions can be compared to water quality parameters to see how the lake "user" would experience the lake at that time. Looking at transparency data, as the Secchi depth decreases the perception of the lake's physical appearance and recreational suitability decreases (Figures 6-7).

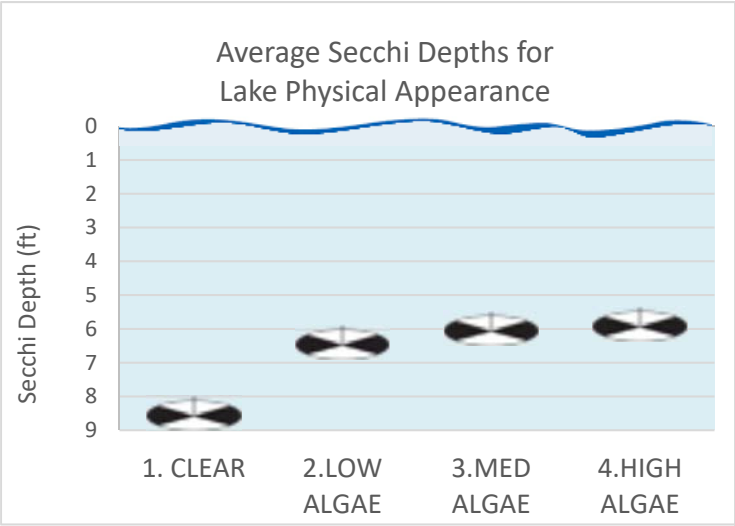



*Figure 6. Average Secchi depth (ft) for each lake physical appearance rating.*

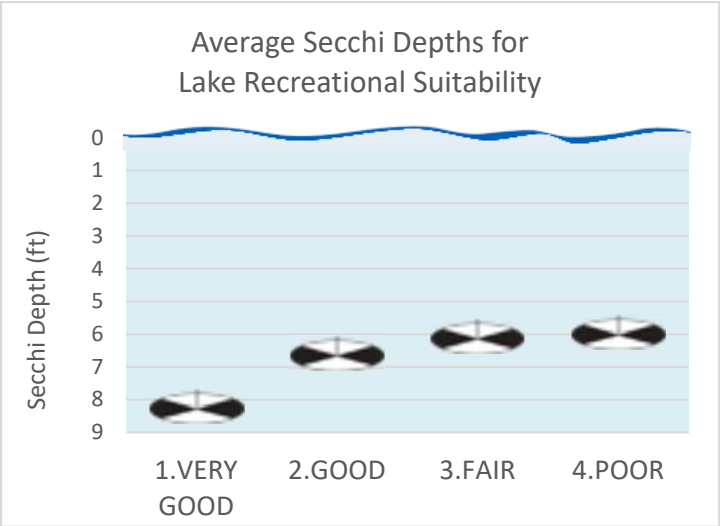



*Figure 7. Average Secchi depth (ft) for each lake recreational suitability rating.*

## Algae

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.

Chlorophyll *a* 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 Eddy Lake at site 201 in 1997 (Figure 8). Chlorophyll *a* concentrations did not go above 10 ug/L that year, indicating no algae blooms. The chlorophyll *a* concentrations increased toward the end of the summer.

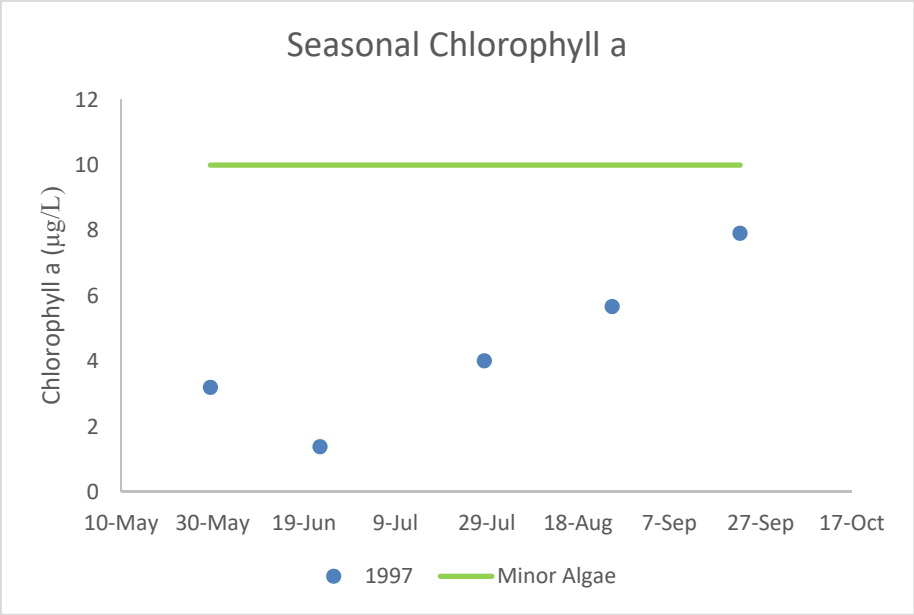



*Figure 8. Chlorophyll a concentrations (ug/L) for Eddy Lake at site 201 in 1997.*

## Phosphorus

Eddy Lake is phosphorus limited, which means that algae and aquatic plant growth is dependent upon available phosphorus.

Total phosphorus was evaluated in Eddy Lake in 1997. The data shows some seasonal variability, with the highest phosphorus in July. The majority of the data points fall into the mesotrophic range (Figure 9).

Phosphorus should continue to be monitored to track any future changes in water quality.

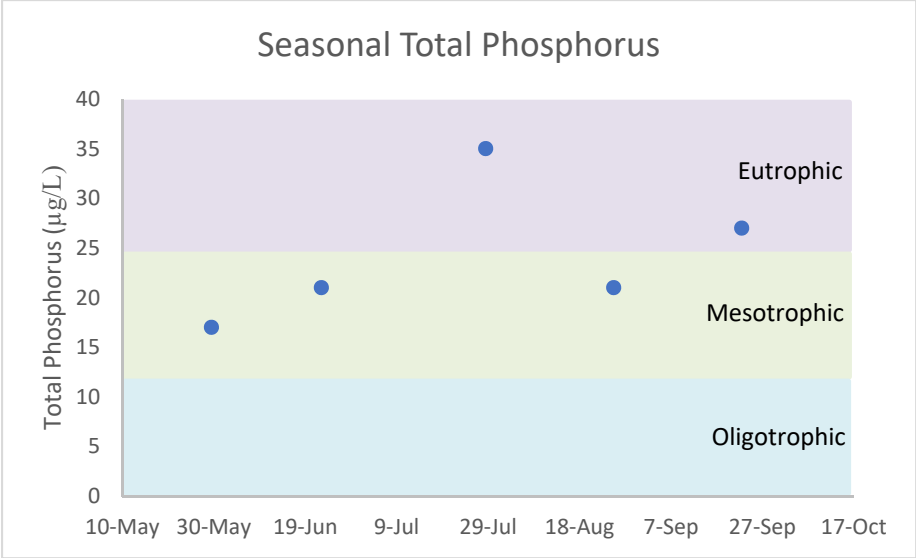
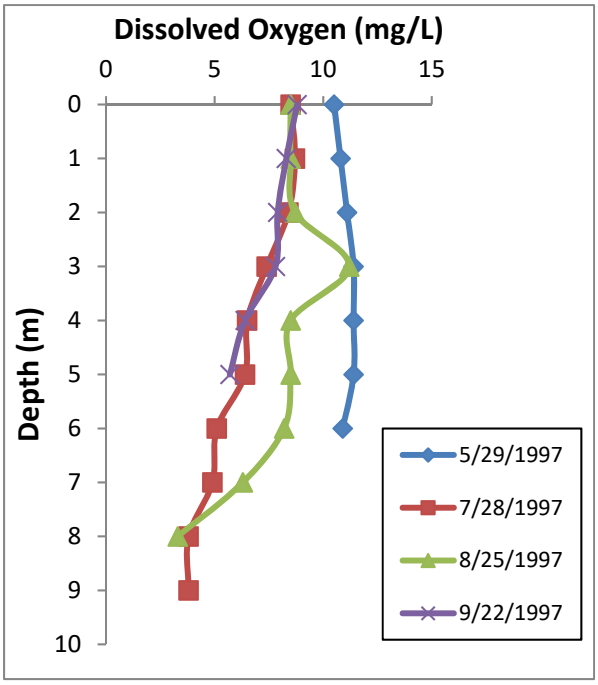



*Figure 9. Historical total phosphorus concentrations (ug/L) for Eddy Lake site 201 in 1997.*

## Oxygen




Dissolved Oxygen (DO) is the amount of oxygen dissolved in lake water. Oxygen is necessary for all living organisms to survive except for some bacteria. Living organisms breathe in oxygen that is dissolved in the water. Dissolved oxygen levels of <5 mg/L are typically avoided by game fisheries.

Eddy Lake is a moderately shallow lake, with a maximum depth of 36 feet. Dissolved oxygen profiles from data collected in 1997 at site 201 show periodic stratification developing mid-summer (Figure 10). In a moderately shallow lake, the water column never completely stratifies. Any windy day can mix up the water column causing phosphorus from the anoxic lake bottom to re-suspend into the water. This phenomenon is known as internal loading.

*Figure 10. Representative dissolved oxygen profiles from 1997 in Eddy Lake.*

## 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. Eddy Lake falls into the mesotrophic range (Tables 6, 7). The secchi TSI is higher possibly due to tannins (brown stain) in the lake.

*Table 6. Trophic State Index for Eddy Lake.*

| Trophic State Index | |
|---|---|
| **TSI Phosphorus** | 48 |
| **TSI Chlorophyll-a** | 45 |
| **TSI Secchi** | 51 |
| **TSI Mean** | 48 |
| **Trophic State:** | Mesotrophic |

*Numbers represent the mean TSI for each parameter.*

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

Eddy Lake

Eutrophication

| 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.

## Trend Analysis

For detecting trends, a minimum of 8-10 years of data with 4 or more readings per season are recommended. Minimum confidence accepted by the MPCA 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.

Eddy Lake had enough data to perform a trend analysis on transparency (Table 8). The data was analyzed using the Mann Kendall Trend Analysis.

*Table 8. Trend analysis for Eddy Lake.*

| Lake Site | Parameter | Date Range | Trend | Probability |
|---|---|---|---|---|
| 201 | Total Phosphorus | 1997 | Insufficient Data | - |
| 201 | Chlorophyll *a* | 1997 | Insufficient Data | - |
| 201 | Transparency | 1995-2015 | Decreasing Trend | 99.9% |
| 201 | Transparency | 2003-2015 | Decreasing Trend | 90.0% |

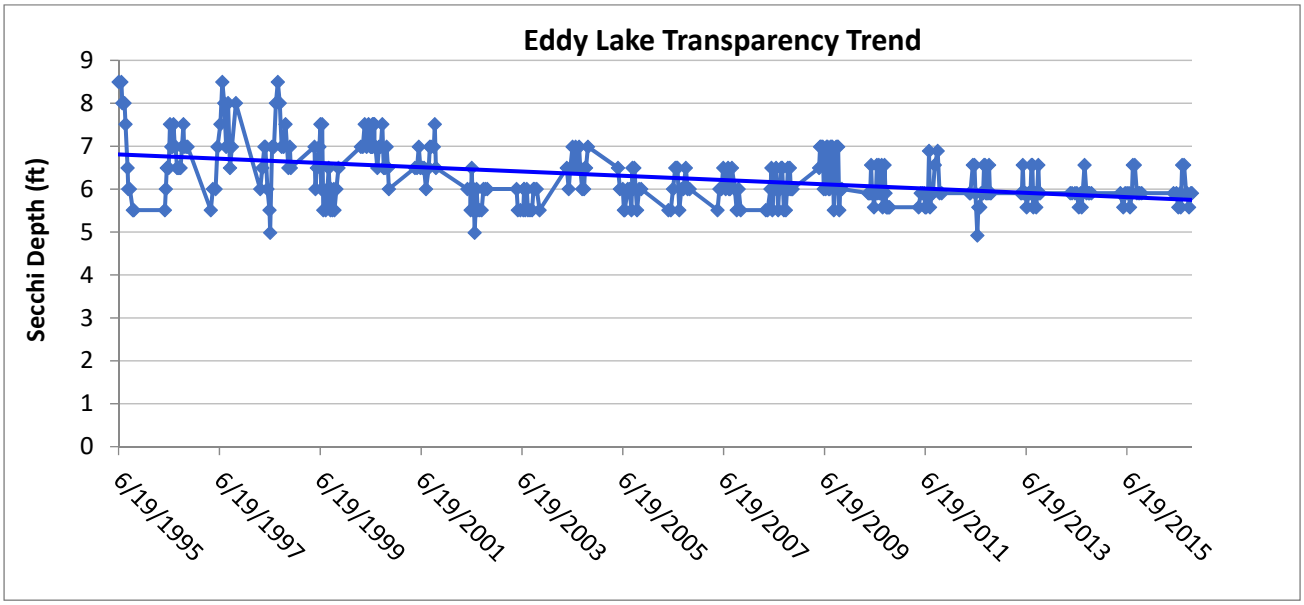



*Figure 11. Transparency (feet) trend for site 201 from 1995-2016.*

Eddy Lake shows very strong evidence for a declining transparency trend (Figure 11). It appears that since around 2002 the transparency has been lower than in the 1990s. Transparency monitoring should continue so that this trend can be tracked in future years.

## 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 MN DNR has delineated three basic scales of watersheds (from large to small): 1) basins, 2) major watersheds, and 3) minor watersheds.

The Kettle River Major Watershed is one of the watersheds that make up the St. Croix River Basin, which drains south to the Gulf of Mexico (Figure 12).

The MN DNR also has evaluated catchments for each individual lake with greater than 100 acres surface area. These lakesheds (catchments) are the "building blocks" for the larger scale watersheds. Eddy Lake falls within lakeshed 3502400 (Figure 16). Though very useful for displaying the land and water that contribute directly to a lake, lakesheds 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 MN 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 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. |

The next step was to prioritize lakes within each of these management categories. DNR Fisheries identified high value fishery lakes, such as cisco refuge lakes. Ciscos (*Coregonus artedi)* can be an early indicator of eutrophication in a lake because they require cold hypolimnetic temperatures and high dissolved oxygen levels. These watersheds with low disturbance and high value fishery lakes are excellent candidates for priority protection measures, especially those that are related to forestry and minimizing the effects of landscape disturbance. Forest stewardship planning, harvest coordination to reduce hydrology impacts and forest conservation easements are some potential tools that can protect these high value resources for the long term.

Eddy Lake's lakeshed is classified with having 43% of the watershed protected and 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. Eddy Lake is a drainage lakeshed, which means that other lakesheds flow into it (Figure 12).

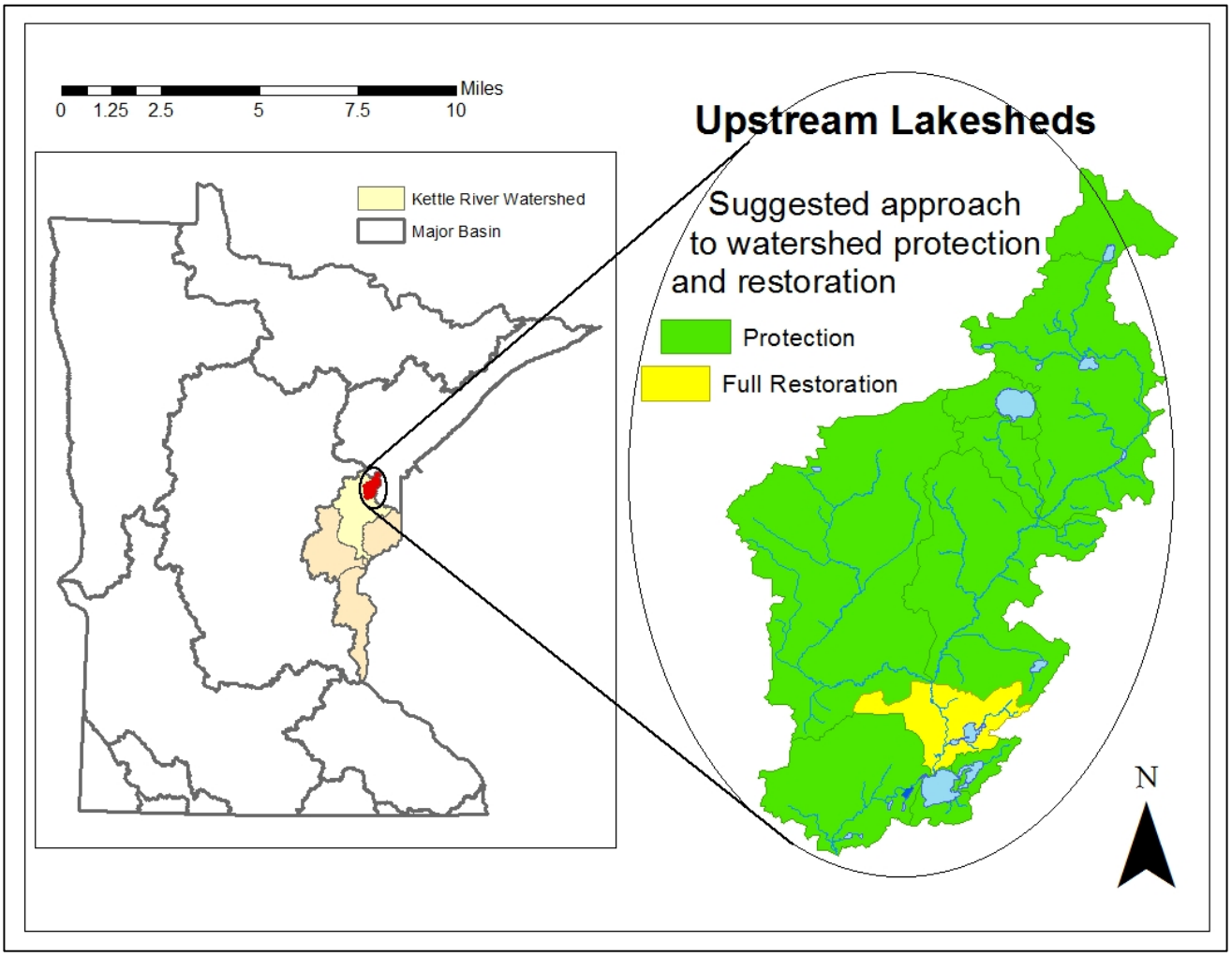



*Figure 12. Kettle River major watershed and MN basins (left), and Eddy Lake lakeshed and upstream catchments with protection suggestions (right).*

## 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. The Lake Eddy lakeshed receives water from the Moose Horn River through Hanging Horn Lake. This lakeshed map includes outflow from Eddy down the river to the town of Moose Lake.

Almost half (43%) of the Eddy Lake lakeshed is protected. This total includes water, wetlands, and publicly owned land. There are two parcels near the lakeshore that have conservation potential. They are private land over 20 acres that are less than 50% developed or agriculture. There are three animal feedlots in the lakeshed (Figure 13).

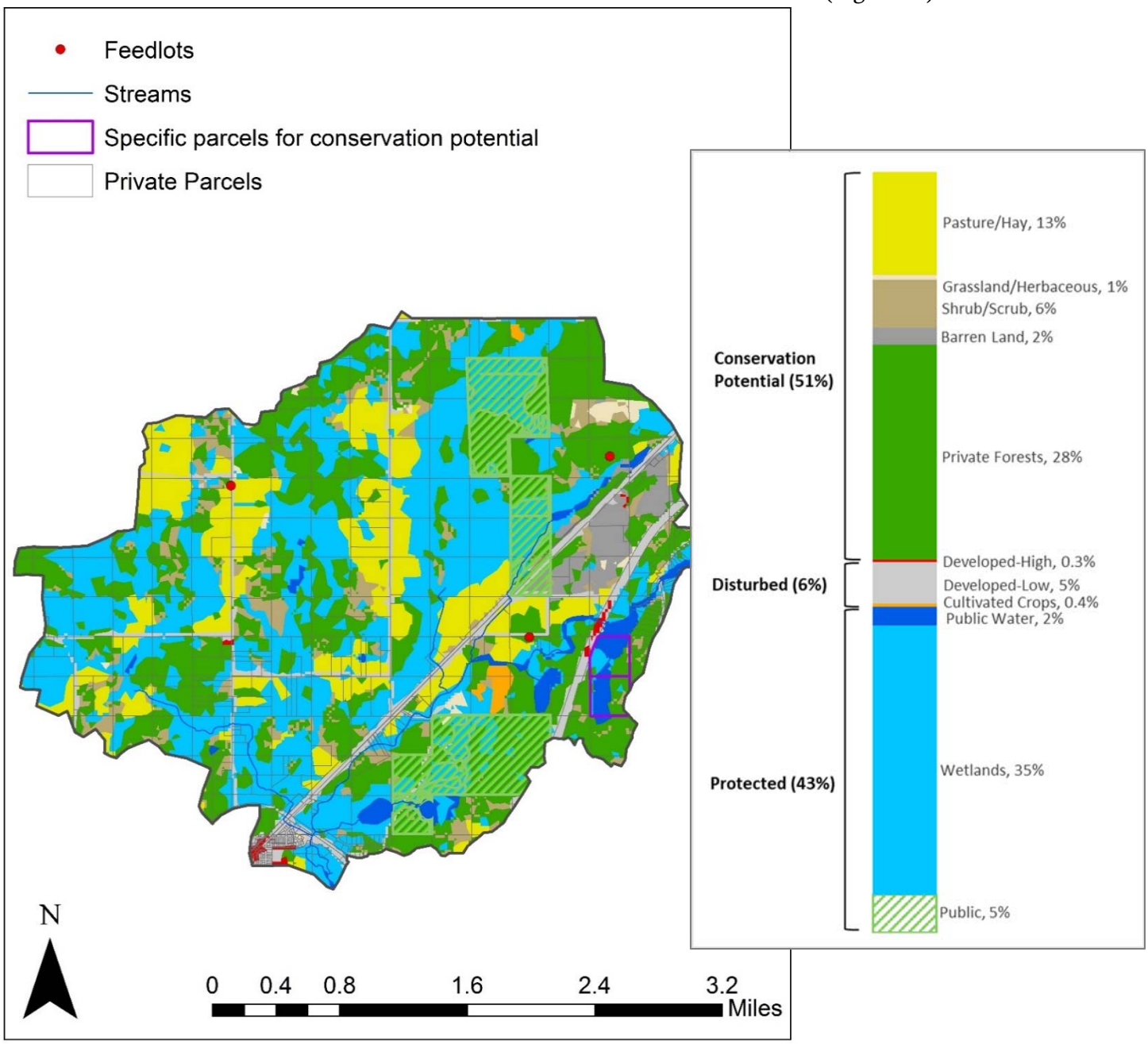



*Figure 13. Land use and ownership in the Eddy Lake lakeshed.*

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. Eddy Lake lakeshed vitals table.*

| Lakeshed Vitals | | Rating |
|---|---|---|
| **Lake Area** | 23.5 acres | descriptive |
| **Littoral Zone Area** | 9.5 acres | descriptive |
| **Lake Max Depth** | 36.3 ft. | descriptive |
| **Lake Mean Depth** | NA | Not available |
| **Water Residence Time** | NA | Not available |
| **Miles of Stream** | 8.6 | descriptive |
| **Inlets** | 2 | |
| **Outlets** | 1 | |
| **Major Watershed** | 35 – Kettle River | descriptive |
| **Minor Watershed** | 35023 | descriptive |
| **Lakeshed** | 3502300 | descriptive |
| **Ecoregion** | Northern Lakes and Forest | descriptive |
| **Total Lakeshed to Lake Area Ratio** (total lakeshed includes lake area) | 14:1 | |
| **Standard Watershed to Lake Basin Ratio** (standard watershed includes lake areas) | 270:1 | |
| **Wetland Coverage** | 35% | |
| **Aquatic Invasive Species** | None | |
| **Public Drainage Ditches** | None | |
| **Public Lake Accesses** | 0 | |
| **Miles of Shoreline** | 0.9 | descriptive |
| **Shoreline Development Index** | 1.37 | |
| **Public Land to Private Land Ratio** | 0.1:1 | |
| **Development Classification** | Natural Environment | |
| **Miles of Road** | 19.5 | descriptive |
| **Municipalities in lakeshed** | Moose Lake | |
| **Forestry Practices** | None | |
| **Feedlots** | 3 | |
| **Sewage Management** | Compliance inspections are required for subsurface sewage treatment systems at point-of-sale or permit application in shoreland areas | |
| **Lake Management Plan** | None | |
| **Lake Vegetation Survey/Plan** | None | |

## Eddy Lake, Status of the Fishery (DNR, 8/3/1998)

Eddy lake is 23 acres and is located 3 miles north of Moose Lake, MN along Interstate Highway 35. Access is via the Moose Horn River from Hanging Horn Lake, however this access can be difficult during low water periods. The maximum depth is 37 feet with 83 percent of the lake being less than 15 feet deep. Population assessments have been conducted on Eddy Lake in 1974 and 1980, and an initial survey was conducted in 1967. The fish population is mainly comprised of bluegill, pumpkinseed sunfish, and white sucker. Both catch rates and growth rates are typical for bluegill when compared to populations from other lakes in the Duluth area. There is a strong year class which should recruit into the fishery in 2000. Twenty-six percent of the bluegills sampled were 6.0 inches or longer and the average size of all bluegills sampled was 5.4 inches. Pumpkinseed sunfish were the most abundant fish sampled. Scale samples were not taken and growth parameters were not evaluated. However, 18 percent of the pumpkinseed sunfish sampled were 6.0 inches or greater and the average size was 5.0 inches. Northern pike and black crappie populations are currently low, however, both species have historically been more abundant. Catch from the one-quarter inch trapnets suggests that largemouth bass, black crappie, and yellow perch had successful reproduction in 1998. Adult largemouth bass have never been captured in standard sampling gear in any of the previous assessments or surveys. Other species sampled during this survey include green sunfish, rock bass, common shiner, spottail shiner, shorthead redhorse, silver redhorse, and yellow bullhead.

Development pressure is increasing around the shorelines and within the watersheds of many Minnesota 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, contact the nearest Area Fisheries office or go to the following website: www.dnr.state.mn.us/shorelandmgmt

See the link below for specific information on gillnet surveys, stocking information, and fish consumption guidelines. http://www.dnr.state.mn.us/lakefind/showreport.html?downum=09003900

## Key Findings and Recommendations

**Monitoring Recommendations**
Transparency monitoring at site 201 should be continued annually. It is important to continue transparency monitoring weekly or at least bimonthly every year to enable year-to-year comparisons and trend analyses. Phosphorus and chlorophyll a monitoring should continue at site 201, as the budget allows, to track future water quality trends.

**Overall Conclusions**
Eddy Lake is a mesotrophic lake (TSI = 48) with evidence of a declining long-term trend in water clarity. The total phosphorus, chlorophyll *a* and transparency ranges are within the ecoregion ranges (Table 4).

About a third (33.4%) of the lakeshed land area is forested. Almost half of the lakeshed is protected (43%), which includes public ownership, wetlands, and open water. Only 6% of the lakeshed is disturbed, which includes high and low levels of development (Figure 13).

**Phosphorus Loading and Priority Impacts**
Eddy Lake is at a disadvantage because it has such a large watershed, which means there are additional lakesheds that contribute water from upstream areas. It also has the Moose Head River flowing through it. This means that the land practices upstream are likely the main impact to the lake's water quality.

With the river flowing through the lake, it likely has a short residence time, which means that many of the nutrients flowing into the lake also flush out.

*Table 11. Watershed characteristics.*

| | |
|---|---|
| **Lakeshed to Lake Area Ratio** (lakeshed includes lake area) | 14:1 |
| **Watershed to Lake Area Ratio** (watershed includes lake areas) | 270:1 |
| **Number of Upstream Lakes** | 13 |
| **Headwaters Lake?** | No |
| **Inlets / Outlets** | 2 / 1 |
| **Water Residence Time** | NA |

A third of the lakeshed is covered with wetlands, which is good for water storage and filtration (Figure 13). Protecting the wetlands will help maintain water levels and water storage, reduce flooding, and filter runoff during large storm events.

It is difficult to determine what could be causing the declining trend in transparency. Data show that since 2002 the transparency has been lower than it was in the 1990s (Figure 11). A trend analysis of more recent data (2003-2015) also shows a declining trend (Table 8). One possible cause could be the cumulative effects from the large watershed and land practices within it.

Figure 13 shows the city of Moose Lake in the Eddy Lakeshed, but it is downstream from Eddy Lake, so likely does not impact Eddy Lake.

**Best Management Practices Recommendations**

The management focus for Eddy Lake should be to protect the current water quality and the lakeshed. Efforts should be focused on managing and/or decreasing the impact caused by current and additional development, including second tier development, and impervious surface area. Project ideas include protecting land with conservation easements, enforcing county shoreline ordinances, shoreline restoration, rain gardens, and septic system maintenance.

## Eddy Lake Goals

1. Protection Focus: minimize disturbed land uses and maintain protected lands
2. Manage phosphorus loading from **the watershed**, Table 12
3. Focused BMPs per land type: Table 12

*Table 12. Best Management Practices Table specific to Eddy Lake (refer to Figure 13 for locations)*

| Category | Land use type | Conservation project ideas | Results | Who | Contact for help |
|---|---|---|---|---|---|
| Conservation Potential Land | Private forests (28%, 1834 acres) | Forest stewardship planning, 3rd party certification, SFIA, local woodland cooperatives. | Conserve and protect current forest cover. | • Individual Property Owners | Carlton SWCD (218) 384-3891 https://carltonswcd.org |
| | Pasture/hay (13%, 871 acres) | 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. | • Individual Property Owners | Natural Resources Conservation Service 218-720-5209 |
| Disturbed Land | Cultivated crops (0.4%, 29 acres) | Restore wetlands; Conservation Reserve Program (CRP), Cover Crops, | Reduce water runoff and soil erosion, better water storage. | • Individual Property Owners | Natural Resources Conservation Service 218-720-5209 |
| | Developed, low intensity (5.5%, 355 acres) | Shoreline buffers, rain gardens. | Reduce water runoff and shoreline erosion. | • Individual Property Owners | Carlton SWCD (218) 384-3891 https://carltonswcd.org |
| | Developed, high intensity (0.3%, 19 acres) | Sediment basins, rain gardens, shoreline buffers, stormwater retention. | Reduce water runoff into streams and lakes. | • Individual Property Owners<br>• Cities<br>• Lake Associations | Carlton SWCD (218) 384-3891 https://carltonswcd.org |

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 significantly less phosphorus (lbs/acre/year) than developed land cover (Table 12).

Over a quarter of the lakeshed is privately owned forested uplands (Table 12). Forested uplands can be managed with Forest Stewardship Planning, 3rd party certification, SFIA, and local woodland cooperatives. Contact the Soil and Watershed Conservation District for options for managing private forests.

The lakeshed still has large undeveloped shoreline parcels (Figure 13). Because a lot of undeveloped private land still exists, there is a great potential for protecting this land with conservation easements and aquatic management areas (AMAs). Conservation easements can be set up easily and with little cost with help from organizations such as the Board of Soil and Water Resources and the Minnesota Land Trust. AMAs can be set up through the local DNR fisheries office.

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 a whole 100 foot frontage is not necessary and can contribute to additional algae blooms.

*Table 13. Organizational contacts and reference sites*

## Organizational contacts and reference sites

| | |
|---|---|
| Hanging Horn Lakeshore Management Association | P.O. Box 192 Barnum, MN 55707 |
| DNR Fisheries Office | 5351 North Shore Drive, Duluth, MN 55804<br>218-302-3264, duluth.fisheries@state.mn.us |
| Regional Minnesota Pollution Control Agency Office | 525 Lake Avenue South, Suite 400, Duluth, MN 55802<br>218-723-4660<br>https://www.pca.state.mn.us/about-mpca/duluth-office |
| Carlton County Soil and Water Conservation District | 808 3rd St, Carlton, MN 55718<br>(218) 384-3891, https://carltonswcd.org/ |
| Carlton County | 301 Walnut Ave, Carlton, MN 55718<br>http://carltoncountymn.govoffice3.com/ |