Little Trout Lake 31-0394-00 ITASCA COUNTY

Lake Water Quality

Summary

Little Trout Lake is located 20.3 miles southeast of Suomi, MN in Itasca County. It is a small lake covering 86 acres (Table 1).

Little Trout Lake has one inlet and one outlet, which classify it as a drainage lake. Water enters Little Trout Lake from a stream on the west side and exits from a stream on the east of Little Trout Lake and carries water south to the Mississippi River.

Water quality data have been collected on Little Trout Lake from 1988-2015 (Tables 2 & 3). These data show that the lake is Oligotrophic (TSI = 37) with moderately clear water conditions most of the summer and excellent recreational opportunities.

Little Trout Lake is part of the Wabana Chain of Lakes Association (WCOLA). The association is involved in activities such as water quality monitoring and education.

Table 1. Little Trout Lake location and key physical characteristics.

Location Data	
MN Lake ID:	31-0394-00
County:	Itasca
Ecoregion:	Northern Lakes and Forests
Major Drainage Basin:	Mississippi R. -Grand Rapids
Latitude/Longitude:	47.43769/ -93.544464
Invasive Species:	None

Physical Characteristics	
Surface area (acres):	86
Littoral area (acres):	NA
% Littoral area:	NA
Max depth (ft), (m):	80, 24
Inlets:	1
Outlets:	1
Public Accesses:	0

Table 2. Availability of primary data types for Little Trout Lake.

Data Availability

Transparency data		Good data set from 1988, 1991, 2005-2015 through the CLMP.
Chemical data		Data from 1988, 1991, 1999, 2003, 2005, 2008, 2010 and 2014. Not enough data for a trend analysis.
Inlet/Outlet data	--	No data available.

Recommendations	**For recommendations refer to page 18.**

Lake Map

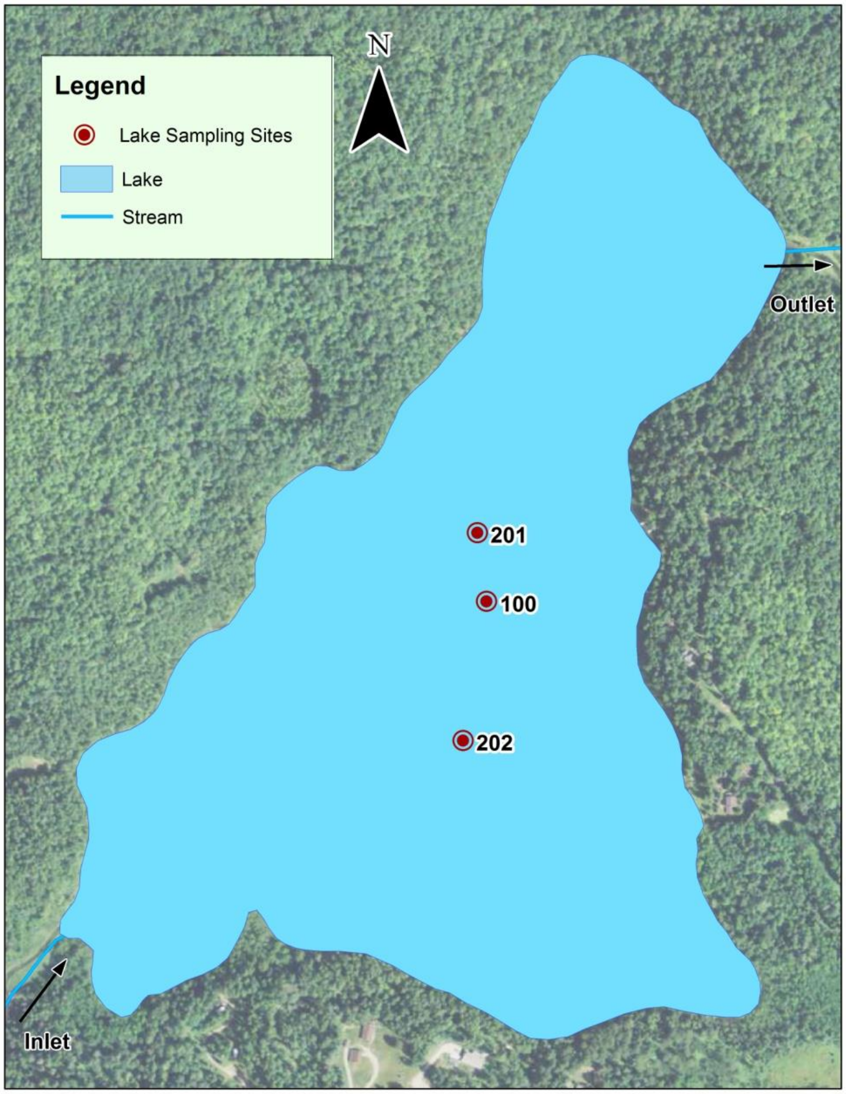


Figure 1. Map of Little Trout Lake with 2010 aerial imagery, sample site locations, inlets and outlets, and public access points.

Table 3. Monitoring programs and associated monitoring sites. Monitoring programs include the Citizen Lake Monitoring Program (CLMP), MPCA Lake Monitoring Program Project (LMPP); Big Fork Watershed Assessment (BF); Wabana Chain of Lakes (WCOLA).

Lake Site	Depth (ft)	Monitoring Programs
100	70	CLMP: 2004; LMPP: 1988, 1991
201	70	CLMP: 1988, 1990, 1992-2001, 2008
202* Primary site	80	CLMP: 1988, 1990, 2005-2015; BF: 1994, 2001-2002; WCOLA: 1999, 2003, 2005, 2008, 2010, 2014

Average Water Quality Statistics

The information below describes available chemical data for Little Trout Lake through 2015 (Table 4). Data for total phosphorus, chlorophyll *a*, and Secchi depth are from the primary site 202. Data for total phosphorus and chlorophyll *a* is from site 100.

Minnesota is divided into 7 ecoregions based on land use, vegetation, precipitation and geology. The MPCA has developed a way to determine the "average range" of water quality expected for lakes in each ecoregion. For more information on ecoregions and expected water quality ranges, see page 11. Little Trout Lake is in the Northern Lakes and Forests Ecoregion.

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)	11.7	14 – 27	> 30	Results are better than the expected range for the Northern Lakes and Forests Ecoregion.
[3]Chlorophyll *a* (ug/L)	2.1	4 – 10	> 9	
Chlorophyll *a* max (ug/L)	7.1	< 15		
Secchi depth (ft)	20.1	8 – 15	< 6.5	
Dissolved oxygen	*See page 8*			Dissolved oxygen depth profiles show that the lake mixes periodically in summer.
Total Kjeldahl Nitrogen (mg/L)	0.7	<0.4 – 0.75		Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms.
Alkalinity (mg/L)	112.5	40 – 140		Indicates a low sensitivity to acid rain and a good buffering capacity.
Color (Pt-Co Units)	10.0	10 – 35		Indicates clear water with little to no tannins (brown stain).
pH	8.3	7.2 – 8.3		Within the expected range for the ecoregion. Lake water pH less than 6.5 can affect fish spawning and the solubility of metals in the water.
Chloride (mg/L)	0.8	0.6 – 1.2		Within the expected range for the ecoregion.
Total Suspended Solids (mg/L)	1.3	<1 – 2		Indicates low suspended solids and clear water.
Specific Conductance (umhos/cm)	200.0	50 – 250		Within the expected range for the ecoregion.
TN:TP Ratio	54:1	25:1 - 35:1		Shows the lake is phosphorus limited.

[1]The ecoregion range is the 25th-75th percentile of summer means from ecoregion reference lakes
[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 202
Total Phosphorus Mean (ug/L):	**11.7**
Total Phosphorus Min:	<5
Total Phosphorus Max:	22
Number of Observations:	32
Chlorophyll *a* Mean (ug/L):	**2.1**
Chlorophyll-a Min:	<1
Chlorophyll-a Max:	7.1
Number of Observations:	26
Secchi Depth Mean (ft):	**20.1**
Secchi Depth Min:	14.0
Secchi Depth Max:	26.0
Number of Observations:	109

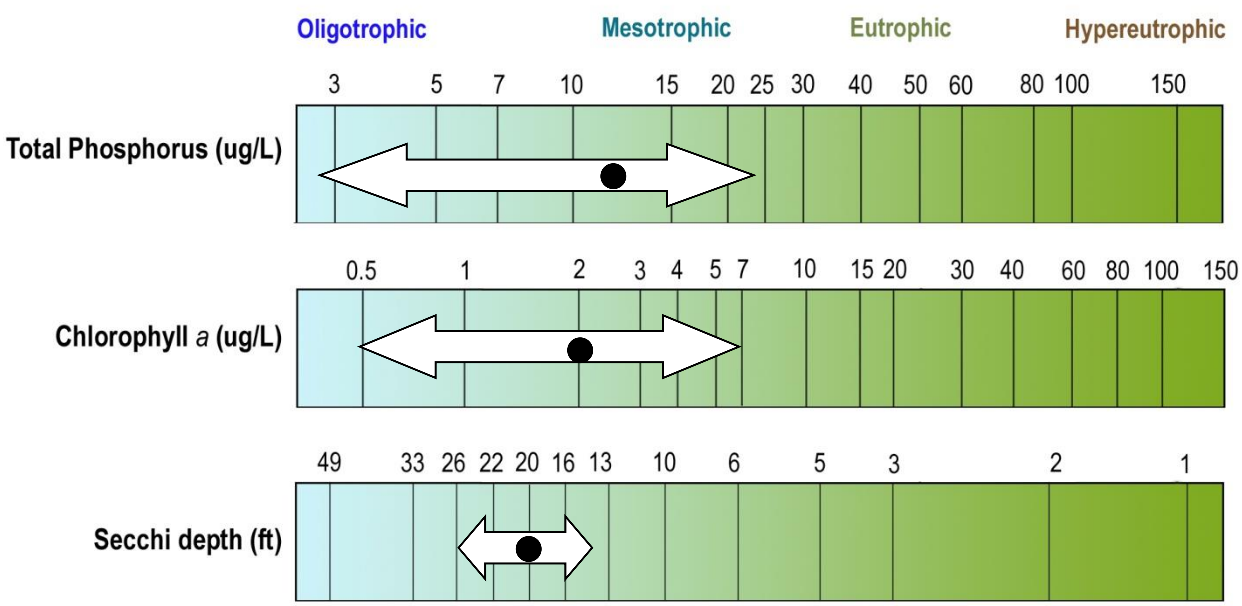


Figure 2. Little Trout Lake total phosphorus, chlorophyll a and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Primary Site 202 and 100). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (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 amount 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 Little Trout Lake ranges from 18.5 to 22.9 feet (Figure 3). 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 202 in order to track water quality changes.

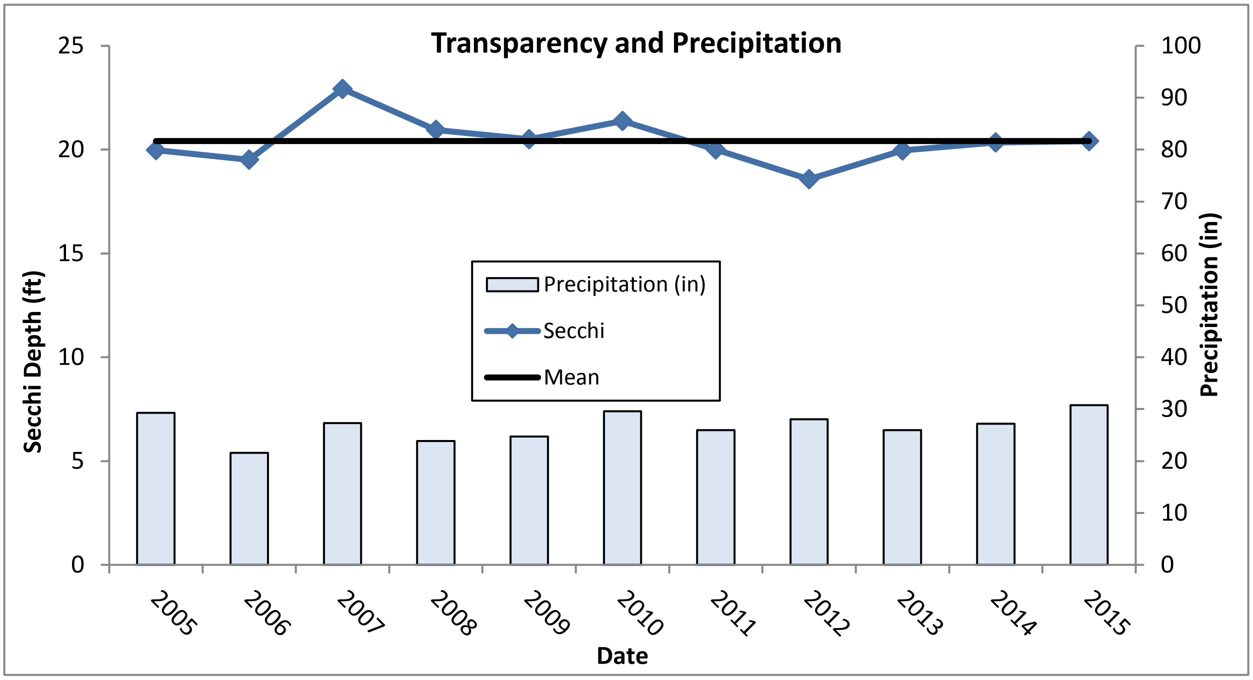


Figure 3. Annual mean transparency compared to long-term mean transparency.

Little Trout Lake transparency ranges from 14.0 to 26.0 ft at the primary site (202). Figure 4 shows the seasonal transparency dynamics. The Little Trout Lake transparency stays relatively consistent throughout the year. This transparency dynamic is typical of an oligotrophic Minnesota lake. There is not enough phosphorus for there to be algae blooms that affect transparency. 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 about why their transparency is lower in August than it is in June. It is typical for a lake to vary in transparency throughout the summer.

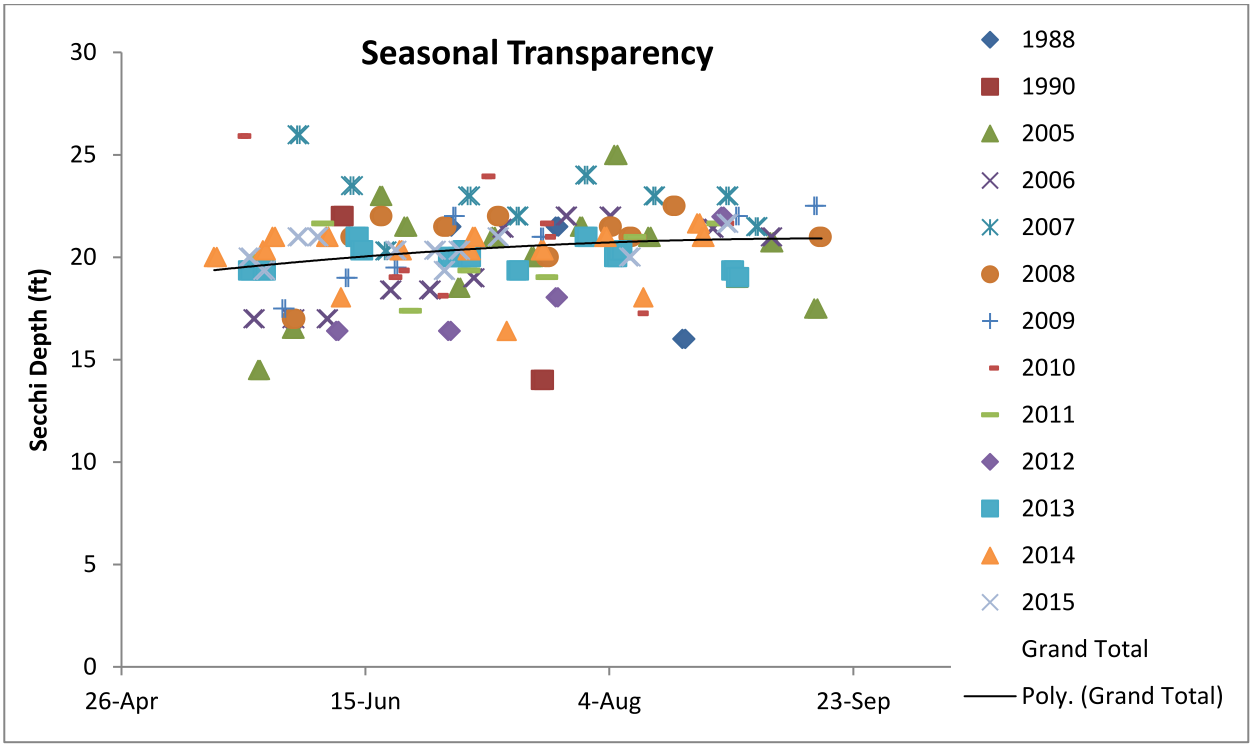


Figure 4. Seasonal transparency dynamics and year to year comparison (Primary Site 202). The black line represents the pattern in the data.

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 rating decreases. Little Trout Lake was rated as being " crystal clear" 99% of the time by samplers between 1990 and 2015 (Figure 5).

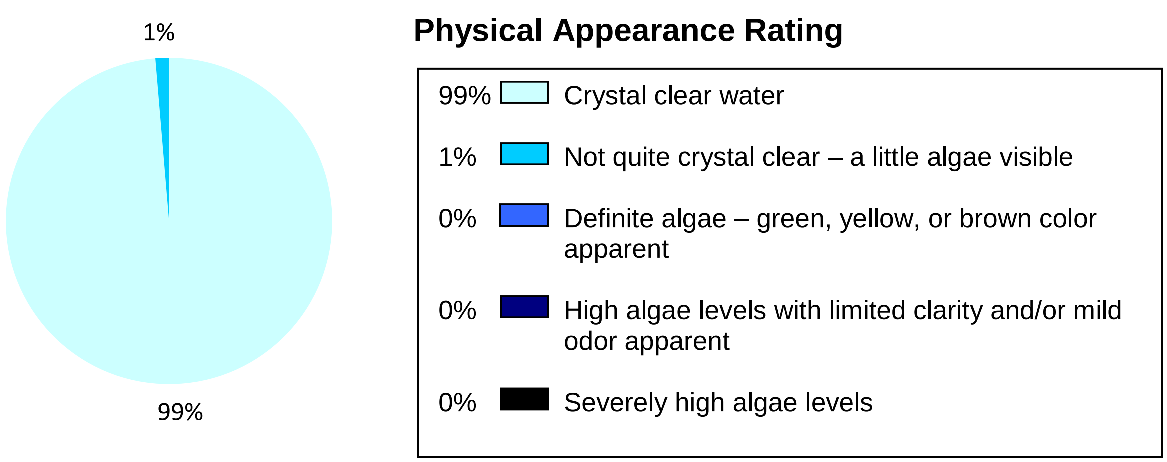


Figure 5. Little Trout Lake physical appearance ratings by samplers.

As the Secchi depth decreases, the perception of recreational suitability of the lake decreases. Little Trout Lake was rated as being "beautiful" 99% of the time from 1990 to 2015 (Figure 6).

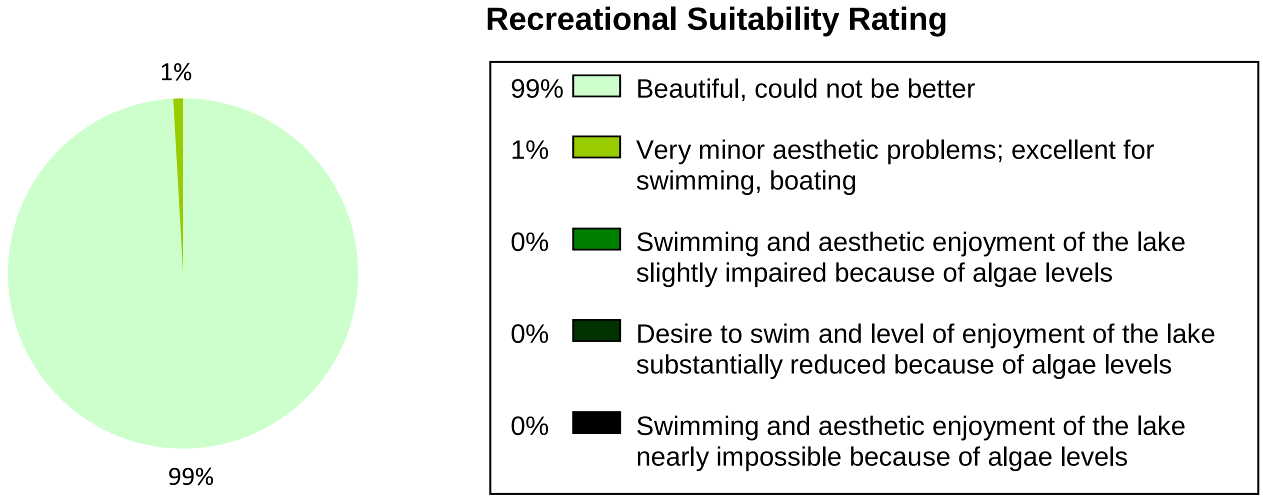


Figure 6. Recreational suitability rating, as rated by the volunteer monitor.

Total Phosphorus

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

Total phosphorus was evaluated in Little Trout Lake in 1988, 1999, 2003, 2005, 2008, 2010 and 2014. The majority of the data points fall into the oligotrophic and mesotrophic ranges (Figure 7).

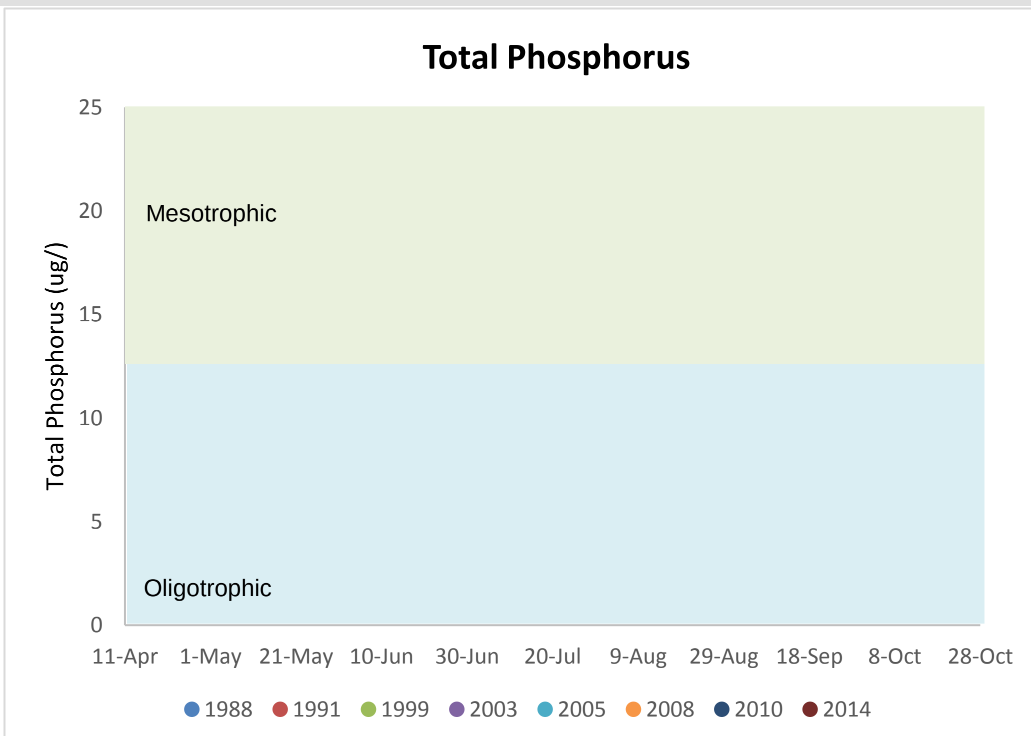


Figure 7. Historical total phosphorus concentrations (ug/L) for Little Trout Lake site 202.

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

Chlorophyll *a*

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.

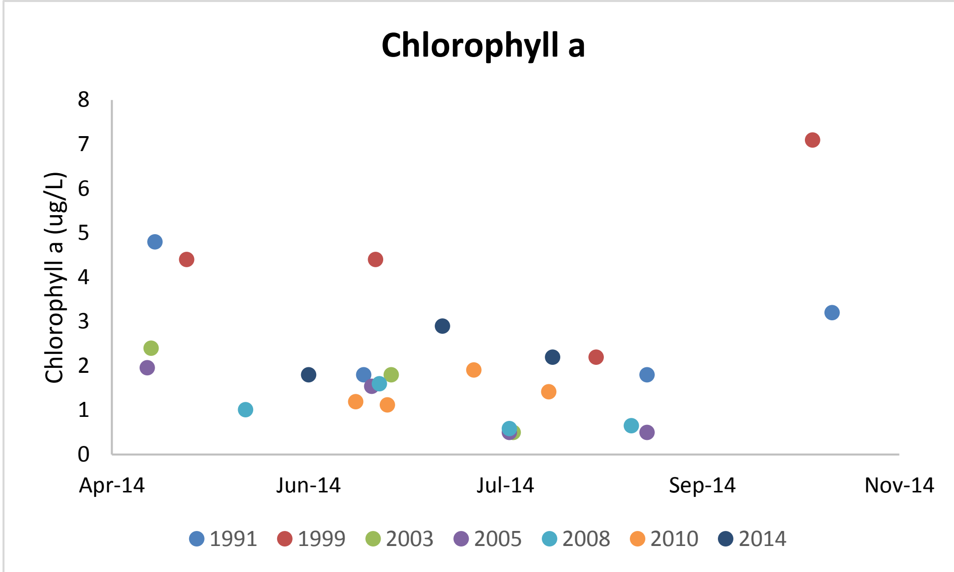
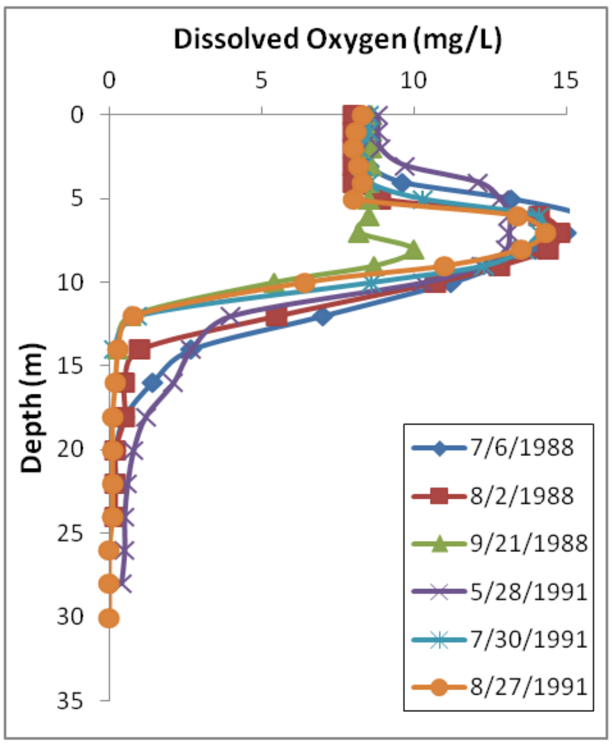


Figure 8. Chlorophyll *a* concentrations (ug/L) for Little Trout Lake.

Chlorophyll *a* was evaluated in Little Trout Lake at site 202 in 1991, 1999, 2003, 2005, 2008, 2010, 2014 (Figure 8). Chlorophyll *a* concentrations were well below 10 ug/L in both years, indicating no minor algae blooms. There was not much variation over the years monitored and chlorophyll *a* concentrations remained relatively steady over the summer.

Dissolved 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.

Little Trout Lake is a deep lake, with a maximum depth of 80 feet. Dissolved oxygen profiles from data collected in 1988 and 1991 show stratification developing mid-summer (Figure 9). The thermocline occurs at approximately 8-10 meters and the oxygen is depleted below the thermocline, which means that gamefish will be scarce below this depth. Figure 9 is a representative DO profile for Little Trout Lake and it illustrates stratification in the summer of 1988 and 1991.

Little Trout Lake is showing a metalimnetic oxygen maxima. This happens in small deep lakes where there is very strong stratification.

Figure 9. Dissolved oxygen profile for Little Trout 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.

Phosphorus (nutrients), chlorophyll *a* (algae concentration) and Secchi depth (transparency) are related. As phosphorus increases, there is more food available for algae, resulting in increased algal concentrations. When algal concentrations increase, the water becomes less transparent and the Secchi depth decreases. 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.

The mean TSI for Little Trout Lake falls into the Oligotrophic range (Figure 10). There is good agreement between the TSI for chlorophyll *a* and phosphorus, indicating that these variables are strongly related (Table 6). The transparency is lower, but this could just be due to the fact that the transparency data cover a much larger time range than the phosphorus data.

Oligotrophic lakes (TSI 0-39) are characteristic of extremely clear water throughout the summer and sandy or rocky shores. They are excellent for recreation. Some very deep oligotrophic lakes are able to support a trout fishery.

Table 6. Trophic State Index for Little Trout

Trophic State Index	Site 202
TSI Total Phosphorus	40
TSI Chlorophyll-a	38
TSI Secchi	34
TSI Mean	37
Trophic State:	Oligotrophic

Numbers represent the mean TSI for each parameter.

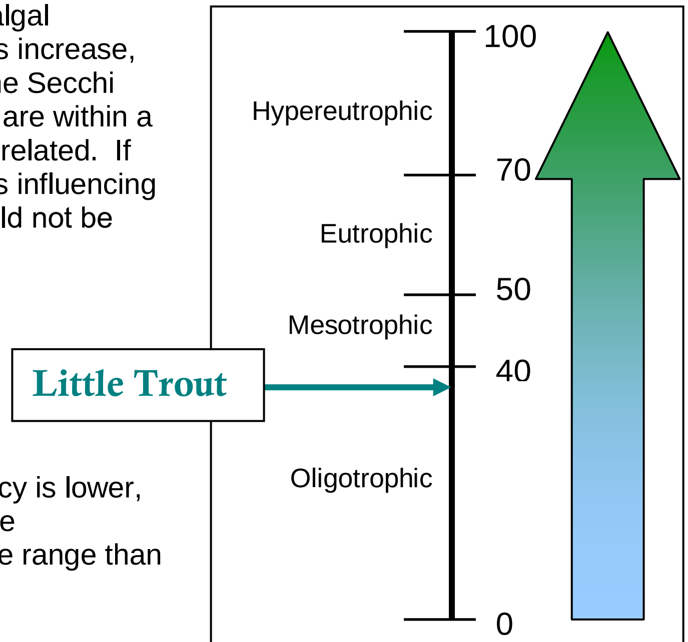


Figure 10. Trophic state index chart with corresponding trophic status.

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

TSI	Attributes	Fisheries & Recreation
<30	Oligotrophy: Clear water, oxygen throughout the year at the bottom of the lake, very deep cold water.	Trout fisheries dominate
30-40	Bottom of shallower lakes 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.

Little Trout 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 Little Trout Lake.

Lake Site	Parameter	Date Range	Trend
100	Total Phosphorus	1988, 1991, 1999, 2003, 2005, 2008, 2010, 2014	Insufficient data
100	Chlorophyll *a*	1988, 1991, 1999, 2003, 2005, 2008, 2010, 2014	Insufficient data
202	Transparency	1988, 1991, 2005-2015	No Trend

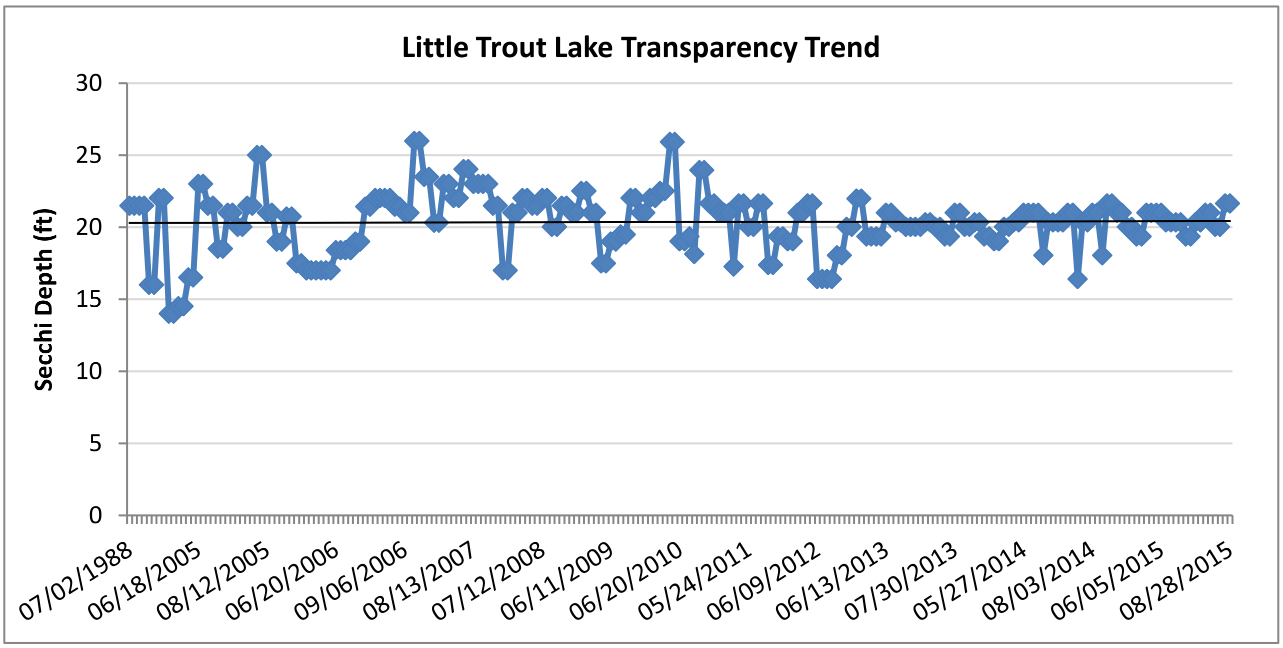


Figure 11. Transparency (feet) trend for site 202 from 1988-2015.

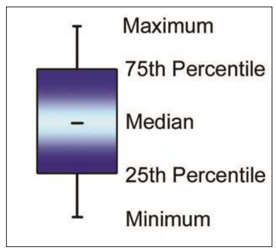
Little Trout Lake shows no evidence of a transparency trend (Figure 11). This means the lake is stable. Transparency monitoring should continue so that future trends can be tracked.

Ecoregion Comparisons

Minnesota is divided into 7 ecoregions based on land use, vegetation, precipitation and geology (Figure 12). The MPCA has developed a way to determine the "average range" of water quality expected for lakes in each ecoregion. From 1985-1988, the MPCA evaluated the lake water quality for reference lakes. These reference lakes are not considered pristine, but are considered to have little human impact and therefore are representative of the typical lakes within the ecoregion. The "average range" refers to the 25th - 75th percentile range for data within each ecoregion. For the purpose of this graphical representation, the means of the reference lake data sets were used.

Figure 12. Minnesota Ecoregions.

Little Trout Lake is in the Northern Lakes and Forests. The mean total phosphorus, chlorophyll *a* and transparency (Secchi depth) for Little Trout Lake are better than the ecoregion ranges (Figure 13).



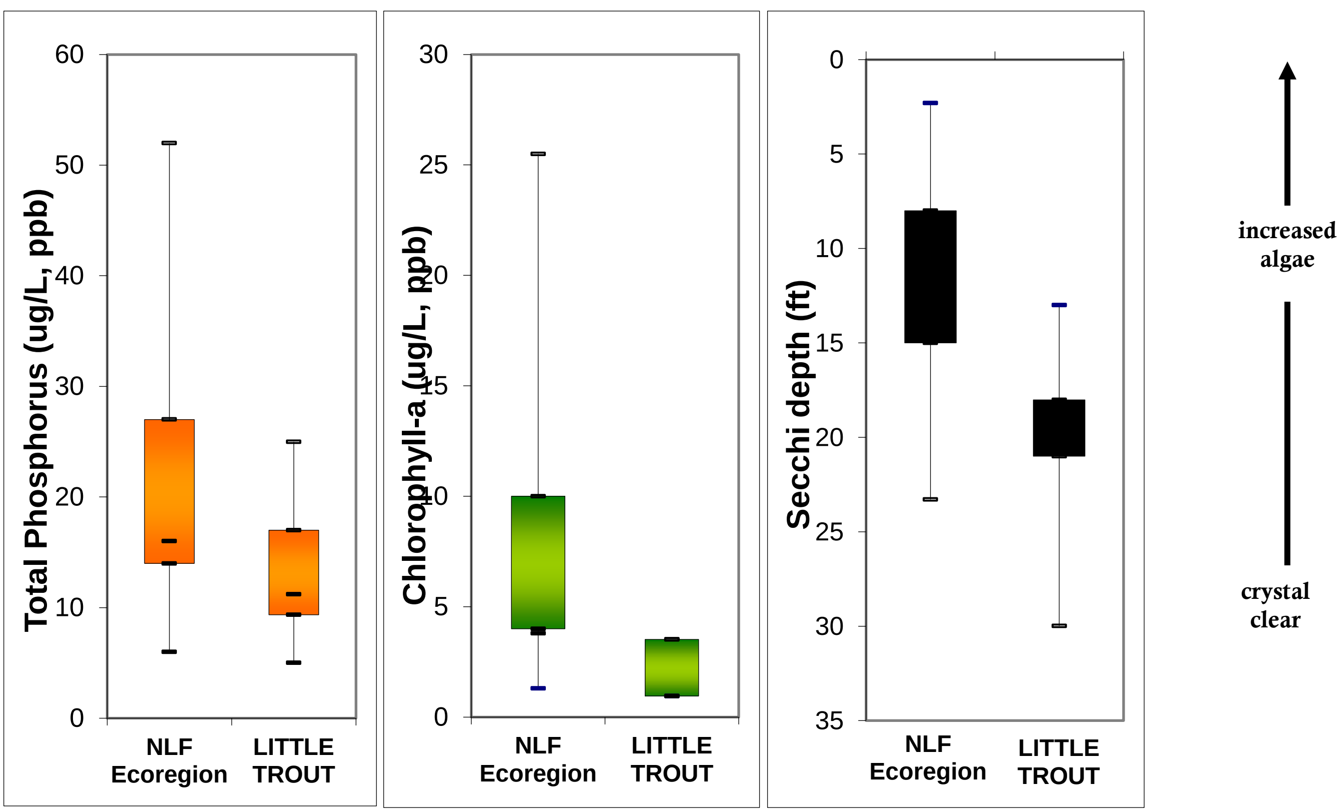


Figure 13. Little Trout Lake ranges compared to Northern Lakes and Forest Ecoregion ranges. The Little Trout Lake total phosphorus and chlorophyll *a* ranges are from 29 and 10 data points, respectively, collected in May-September of 1988,1991,1999,2003,2005,2008,2010. The Little Trout Lake Secchi depth range is from 467 data points collected in May-September of 1988,1990-2015.

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 Mississippi River Grand Rapids Major Watershed is one of the watersheds that make up the Mississippi River Basin, which drains south to the Gulf of Mexico (Figure 14). This major watershed is made up of 133 minor watersheds. Little Trout Lake is located in minor watershed 09047 (Figure 15).

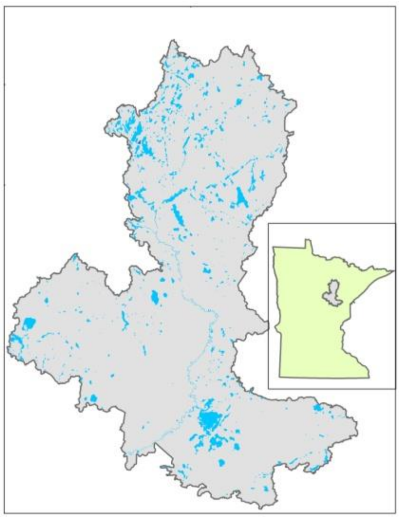


Figure 14. Major Watershed.

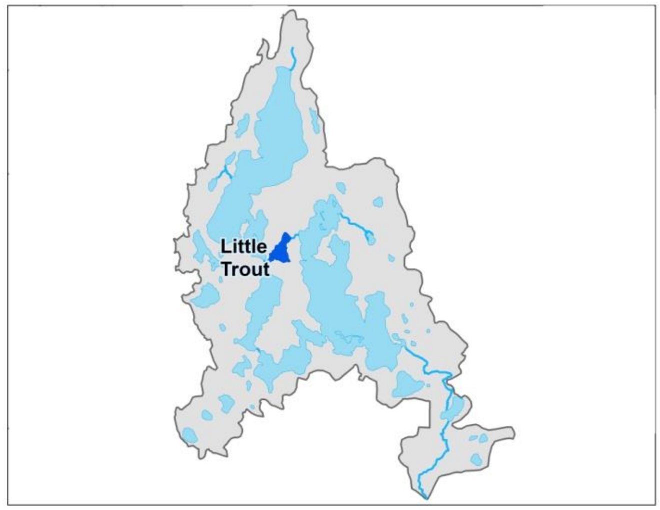


Figure 15. Minor Watershed.

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. Little Trout Lake falls within lakeshed 0904703 (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. For further discussion of Little Trout Lake 's watershed, containing all the lakesheds upstream of the Little Trout Lake lakeshed, see page 17. The data interpretation of the Little Trout Lake lakeshed includes only the immediate lakeshed as this area is the land surface that flows directly into Little Trout Lake.

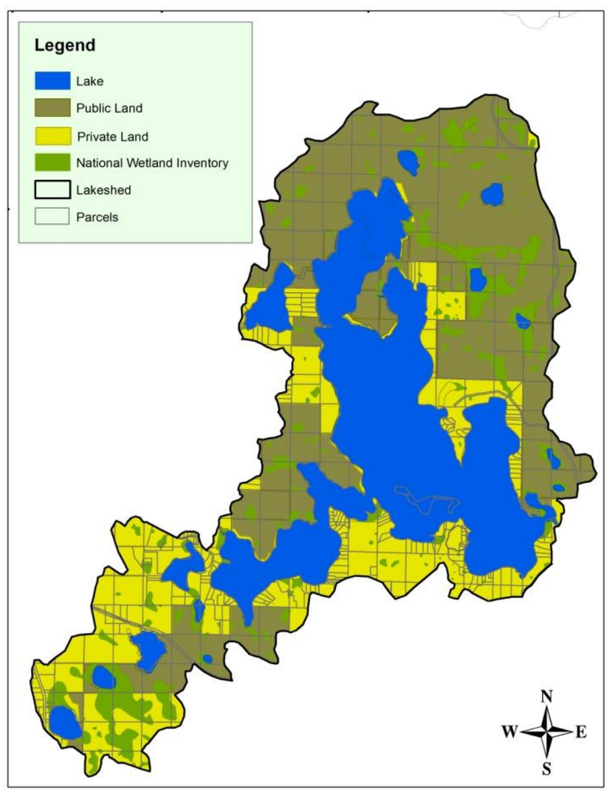


Figure 16. Little Trout Lake lakeshed (0904703) with land ownership, lakes, wetlands, and rivers illustrated.

The lakeshed vitals table identifies where to focus organizational and management efforts for each lake (Table 9). 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 9. Little Trout Lake lakeshed vitals table.

Lakeshed Vitals		**Rating**
Lake Area (acres)	86	descriptive
Littoral Zone Area (acres)	NA	descriptive
Lake Max Depth (feet)	80	descriptive
Lake Mean Depth (feet)	NA	NA
Water Residence Time	NA	NA
Miles of Stream	1.3	descriptive
Inlets	1	Warrants attention
Outlets	1	Warrants attention
Major Watershed	Mississippi R. –Grand Rapids	descriptive
Minor Watershed	09047	descriptive
Lakeshed	0904703	descriptive
Ecoregion	Northern Lakes and Forests	descriptive
Total Lakeshed to Lake Area Ratio (total lakeshed includes lake area)	4	Warrants attention
Standard Watershed to Lake Basin Ratio (standard watershed includes lake areas)	12	Beneficial to the lake
Wetland Coverage (NWI) (acres)	648.2	Beneficial to the lake
Aquatic Invasive Species	None	Beneficial to the lake
Public Drainage Ditches	0	Beneficial to the lake
Public Lake Accesses	0	Beneficial to the lake
Miles of Shoreline	1.9	descriptive
Shoreline Development Index	1.46	Beneficial to the lake
Public Land to Private Land Ratio	1.5:1	Beneficial to the lake
Development Classification	Recreational Development	Warrants attention
Miles of Road	18.6	descriptive
Municipalities in lakeshed	None	Beneficial to the lake
Forestry Practices	None	Beneficial to the lake
Feedlots	0	Beneficial to the lake
Sewage Management	Individual Waste Treatment Systems (septic systems and holding tanks)	Warrants attention
Lake Management Plan	WCOLA, 2016	Beneficial to the lake
Lake Vegetation Survey/Plan	None	Warrants attention

Land Cover / Land Use

The 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 basic purpose of land use planning is to ensure that each area of land will be used in a manner that provides maximum social benefits without degradation of the land resource.

Changes in land use, and ultimately land cover, impact the hydrology of a lakeshed. Land cover is also directly related to the land's ability to absorb and store water rather than cause it to flow overland (gathering nutrients and sediment as it moves) towards the lowest point, typically the lake. Impervious intensity describes the land's inability to absorb water, the higher the % impervious intensity the more area that water cannot penetrate in to the soils. Monitoring the changes in land use can assist in future planning procedures to address the needs of future generations.

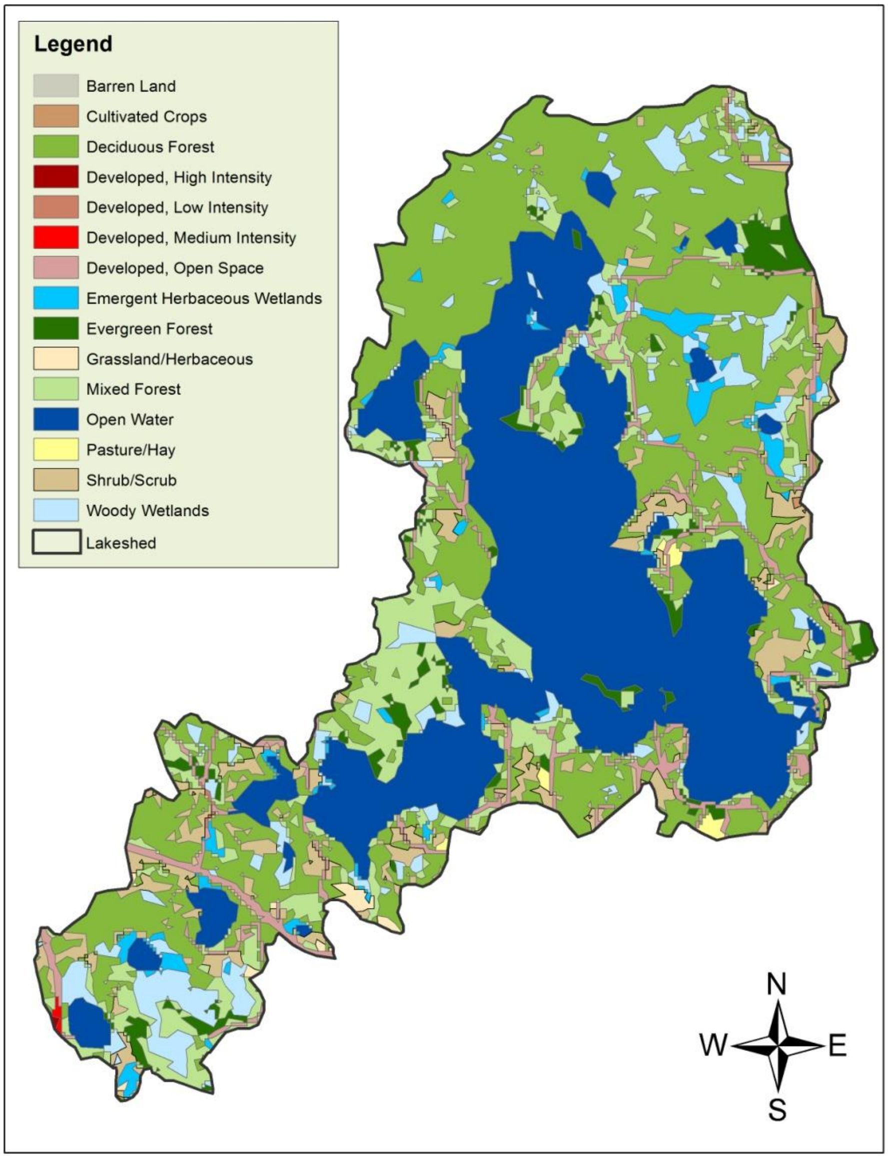


Figure 17. Little Trout Lake lakeshed (0904703) land cover (NLCD 2011).

Phosphorus export, which is the main cause of lake eutrophication, depends on the type of land cover occurring in the lakeshed. Figure 17 depicts the land cover in Little Trout Lake's lakeshed.

The National Land Cover Dataset (NLCD) has records from 2001 and 2011. Table 10 describes Little Trout Lake's lakeshed land cover statistics and percent change from 2001 to 2011. Overall, there was not much change over this decade or from 1990-2000 (Table 11)

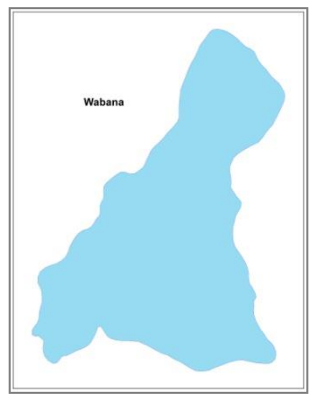
Table 10. Little Trout Lake's lakeshed land cover statistics and % change from 2001 to 2011 (Data Source: NLCD).

Land Cover	2001 Acres	Percent	2011 Acres	Percent	% Change 2001 to 2011
Cultivated Crops	3.85	0.05	3.41	0.04	-0.01
Deciduous Forest	2905.44	35.78	2892.54	35.62	-0.16
Developed, High Intensity	0	0	1.24	0.02	0.02
Developed, Low Intensity	12.04	0.15	11.41	0.14	-0.01
Developed, Medium Intensity	2.64	0.03	4.33	0.05	0.02
Developed, Open Space	310.83	3.83	309.10	3.81	-0.02
Emergent Herbaceous Wetlands	164.37	2.02	167.50	2.06	0.04
Evergreen Forest	229.97	2.83	227.61	2.80	-0.03
Grassland/Herbaceous	3.94	0.05	30.44	0.37	0.32
Mixed Forest	948.60	11.68	920.87	11.34	-0.34
Pasture/Hay	24.64	0.30	23.55	0.29	-0.01
Shrub/Scrub	486.73	5.99	509.03	6.27	0.28
Woody Wetlands	489.64	6.03	482.01	5.94	-0.09
Open Water	2538.57	31.26	2538.22	31.25	-0.01
Total Area	8121.25		8121.25		

Table 11. Little Trout Lake development area and % change from 1990-2000 (Data Source: UMN Landsat).

Category	1990 Acres	Percent	2000 Acres	Percent	% Change 1990 to 2000
Total Impervious Area	26	0.47	33	0.57	0.1
Urban Acreage	239	2.94	240	2.96	0.02

Demographics



Little Trout Lake is classified as a Recreational Development lake. Recreational Development lakes usually have between 60 and 225 acres of water per mile of shoreline, between 3 and 25 dwellings per mile of shoreline, and are more than 15 feet deep.

The Minnesota Department of Administration Geographic and Demographic Analysis Division extrapolated future population in 5-year increments out to 2035. Compared to Itasca County as a whole, Wabana Township has a higher growth projection (Figure 18). (source: http://www.demography.state.mn.us)

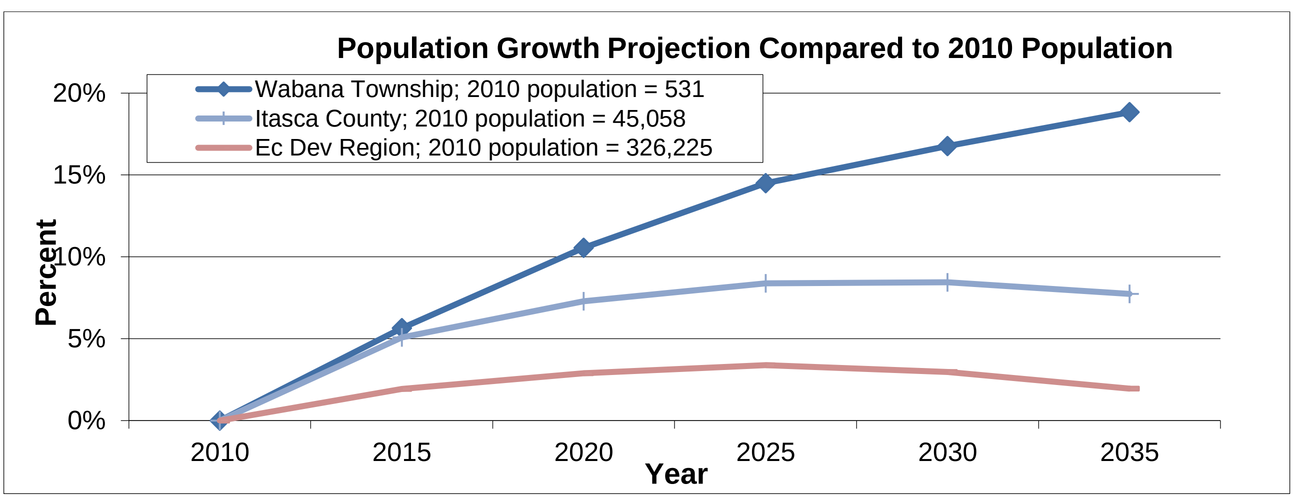


Figure 18. Population growth projection for adjacent townships and Itasca County.

Lakeshed Water Quality Protection Strategy

Each lakeshed has a different makeup of public and private lands. Looking in more detail at the makeup of these lands can give insight on where to focus protection efforts. The protected lands (easements, wetlands, public land) are the future water quality infrastructure for the lake. Developed land and agriculture have the highest phosphorus runoff coefficients, so this land should be minimized for water quality protection.

The majority of the private land within Little Trout Lake's lakeshed is forested upland (Table 12). This land can be the focus of development and protection efforts in the lakeshed.

Table 12. Land ownership, land use/land cover, estimated phosphorus loading, and ideas for protection and restoration in the lakeshed (Sources: County parcel data and the 2011 National Land Cover Dataset).

	Private (26.15)						Public (41.8)		
	Developed	**Agriculture**	**Forested Uplands**	**Other**	**Wetlands**	**Open Water**	**County**	**State**	**Federal**
Land Use (%)	2.49	0.29	16.93	3.51	2.94	32.05	0	9.83	31.97
Runoff Coefficient Lbs of phosphorus/acre/year	0.45 – 1.5	0.26 – 0.9	0.09		0.09		0.09	0.09	0.09
Estimated Phosphorus Loading Acreage x runoff coefficient	89 - 298	6 - 21	121.8		21.11		0	70.68	229.99
Description	Focused on Shoreland	Cropland	Focus of develop-ment and protection efforts	Open, pasture, grass-land, shrub-land	Protected				
Protection and Restoration Ideas	Shoreline restoration	Restore wetlands; CRP	Forest stewardship planning, 3rd party certification, SFIA, local woodland cooperatives		Protected by Wetland Conservation Act		County Tax Forfeit Lands	State Forest	National Forest

DNR Fisheries approach for lake protection and restoration

Credit: Peter Jacobson and Michael Duval, Minnesota DNR Fisheries

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, 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 13). Watershed disturbance was defined as having urban, agricultural and mining land uses. Watershed protection is defined as publicly owned land or conservation easement.

Table 13. 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.

Little Trout Lake's lakeshed is classified with having 72% of the watershed protected and 3% of the watershed disturbed (Figure 19). Therefore, this lakeshed should have a protection focus. Goals for the lake should be to limit any increase in disturbed land use. Little Trout Lake has eight upstream lakesheds(Figure 20).

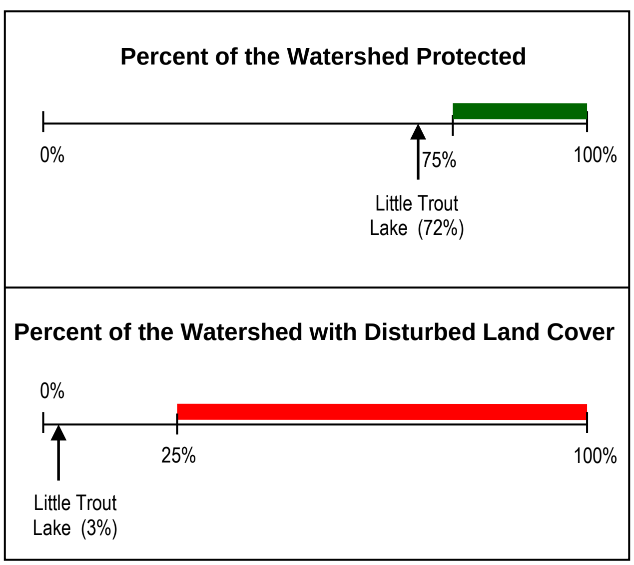


Figure 19. Little Trout Lake's lakeshed percentage of watershed protected and disturbed.

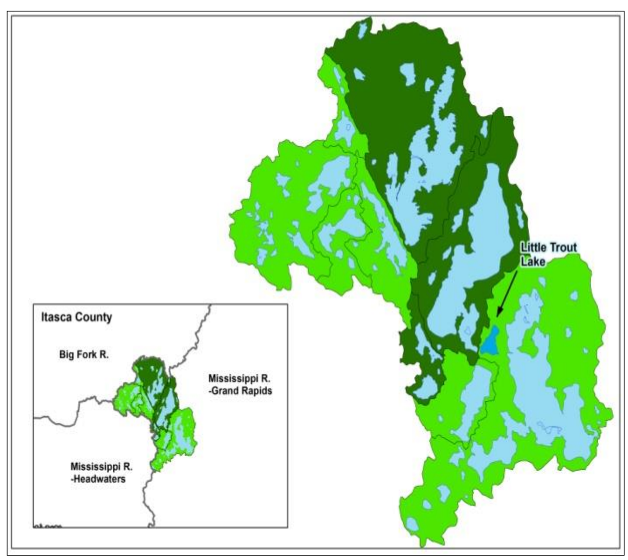


Figure 20. Lakesheds that contribute water to the Little Trout Lake lakeshed. Color-coded based on management focus (Table 13).

Status of the Fishery (DNR, as of 06/22/2009)

Little Trout Lake is a 74 acre lake located 15 miles north of Grand Rapids. The lake is part of the Wabana chain of lakes and is in ecological lake class 28. Lakes in this class are small, deep and clear with relatively hard water. Other area lakes in this class include Nashwauk, Napoleon and Gale Lakes.

Tullibee were the most abundant species sampled in the gill nets in the 2009 assessment, at a catch rate of 11.5/net. This catch rate is down from the previous survey but still near the lake class third quartile. Sampled tullibee ranged from 8.9 to 17.9 inches with a mean length of 13.6 inches. Tullibee are an important prey species for large walleye and northern pike.

The walleye gill-net catch was within the expected range for this lake class at 1.0/net. No walleye are stocked in Little Trout Lake, but a modest population exists as a result of natural reproduction and/or migration from other lakes in the chain. Anecdotal reports suggest that some large walleye are caught from the lake, particularly in spring.

The northern pike gill-net catch in 2009 was 0.5/net, below the expected range but similar to the previous survey. One large (36.8 inch) northern pike was also captured in a trap net. The low-density pike population and an abundant tullibee prey base create good potential for trophy size fish.

Bluegill were the most abundant species in the trap nets, with a catch rate of 24.7/net. This is down from the previous survey but still above the lake class median. Bluegill size structure was poor; fish ranged from 3.6 to 8.3 inches with a mean length of 6.6 inches. Recruitment appeared fairly consistent, with ages 3-10, 12 and 13 represented in the sample. Growth rates were below the lake class average for all ages.

Largemouth bass were caught at a rate of 3.5/trap net. This is above the expected range and higher than the previous survey. Sampled bass ranged from 5.6 to 13.3 inches with a mean length of 9.0 inches.

Other species sampled included black crappie, green sunfish, hybrid sunfish, pumpkinseed, rock bass and yellow perch. The 1981 survey reported sampling one lake trout and one splake. A special deep-water gill net was set as part of this assessment in an attempt to sample trout, but none were captured.

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=31039400

Key Findings / Recommendations

Monitoring Recommendations
Transparency monitoring at site 202 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. Total Phosphorus and chlorophyll *a* monitoring should continue, as the budget allows, to track trends in water quality.

Overall Summary
Little Trout Lake is an oligotrophic lake (TSI = 37) with no evidence of a long-term trend in water clarity. The total phosphorus, chlorophyll *a* and transparency ranges are better than the ecoregion ranges.

Three percent (3%) of the Little Trout Lake lakeshed is disturbed by development (Figure 19). The threshold of disturbance where water quality tends to decline is 25%. Little Trout Lake is well under this threshold. Thirty two percent (32%) of the lakeshed is the lake itself, 16.9% is forested uplands, and 2.9% is wetlands, which is generally good for water quality (Table 12).

The dissolved oxygen profile in Little Trout Lake shows an interesting pattern in that it is highest from 8-10 meters (27 - 33 feet) (Figure 9). This pattern is called a Metalimnetic Oxygen Maxima. It is caused by algae producing oxygen in that area of 8-10 meters deep. This pattern is usually only observed in lakes with good transparency and a very small closed deep basin, which applies Little Trout Lake (Figure 1). This small deep hole stratifies very strongly as there is not much surface area for wind mixing.

Ciscos (*Coregonus artedi),* also called Tullibee, can be an early indicator of eutrophication in a lake because they require cold hypolimnetic temperatures and high dissolved oxygen levels. The 2009 DNR Fisheries survey showed a very healthy population of ciscos in Little Trout Lake (page 18).

Priority Impacts to the Lake
Almost half of the Little Trout Lake lakeshore is federally owned, which protects it from development (Figure 16). Most of the development appears to be along the southwest shore. The priority impact to Little Trout Lake would be the expansion of residential housing development in the lakeshed and second tier development along the southwest lakeshore. The conversion of small lake cabins to year-round family homes increases the impervious surface and runoff from the lake lots.

Best Management Practices Recommendations
The management focus for Little Trout Lake should be to protect the current water quality and lakeshed. Efforts should be focused on managing and/or decreasing the impact caused by additional development, and impervious surface area on existing lots (conversion of seasonal cabins to year-round homes).

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). Forested uplands can be managed with Forest Stewardship Planning. In addition, filter strips or native vegetative buffers could be installed to decrease or slow the runoff reaching the water's edge. Septic systems should be pumped and inspected regularly.

The lakeshed still has large undeveloped shoreline parcels (Figure 16). 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.

Project Implementation
The best management practices above can be implemented by a variety of entities. Some possibilities are listed below.

Individual property owners

- Shoreline restoration
- Rain gardens
- Aquatic plant bed protection (only remove a small area for swimming)
- Conservation easements

Lake Associations

- Lake condition monitoring
- Ground truthing – visual inspection upstream on stream inlets
- Watershed runoff mapping by a consultant
- Shoreline inventory study by a consultant
- Conservation easements

Soil and Water Conservation District (SWCD) and Natural Resources Conservation Service (NRCS)

- Shoreline restoration
- Stream buffers
- Wetland restoration
- Forest stewardship planning

Organizational contacts and reference sites

Lake Association	Wabana Chain of Lakes http://www.wcola.org
Itasca County Environmental Services Department	124 NE 4th St., Grand Rapids, MN 55744 (218) 327-2857 https://www.co.itasca.mn.us
Itasca Soil and Water Conservation District	1889 East Highway 2, Grand Rapids, MN 55744 (218) 326-0017 http://www.itascaswcd.org
DNR Fisheries Office	1201 East Highway 2, Grand Rapids, MN 55744 (218) 327-4430 http://www.dnr.state.mn.us/areas/fisheries/grandrapids/index.html
Regional Minnesota Pollution Control Agency Office	525 Lake Avenue South, Duluth, MN 55802 (218) 723-4660 http://www.pca.state.mn.us
Regional Board of Soil and Water Resources Office	1601 Minnesota Drive, Brainerd, MN 56401 (218) 828-2383 http://www.bwsr.state.mn.us