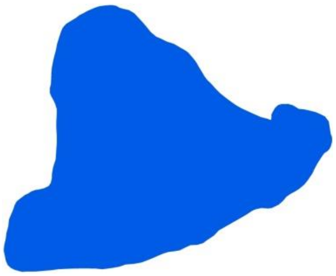
Little Wabana Lake **31-0399-00 ITASCA COUNTY**

Lake Water Quality

Summary



Little Wabana Lake is located 13.8 miles north of Grand Rapids, MN in Itasca County. It is a triangular lake covering 116 acres (Table 1).

Little Wabana Lake has no inlets or outlets, which classify it as a groundwater seepage lake. Groundwater lakes can have periodic swings in water level due to precipitation and the water table.

Water quality data have been collected on Little Wabana Lake from 1999-2015 (Tables 2 & 3). These data show that the lake is mesotrophic (TSI = 40) with moderately clear water conditions most of the summer and excellent recreational opportunities.

Little Wabana 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 Wabana Lake location and key physical characteristics.

Location Data		Physical Characteristics	
MN Lake ID:	31-0399-00	Surface area (acres):	116
County:	Itasca	Littoral area (acres):	37
Ecoregion:	Northern Lakes and Forests	% Littoral area:	32
Major Drainage Basin:	Mississippi R. -Grand Rapids	Max depth (ft), (m):	57, 17
Latitude/Longitude:	47.400037/ -93.492265	Inlets:	0
Invasive Species:	None	Outlets:	0
		Public Accesses:	0

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

Data Availability		
Transparency data		Good data set from 1999-2015 through the CLMP.
Chemical data		Data from 1991,1999-2000, 2003, 2005, 2010-2011. Not enough data for a trend analysis.
Inlet/Outlet data	--	Not necessary
Recommendations		**For recommendations refer to page 19.**

Lake Map

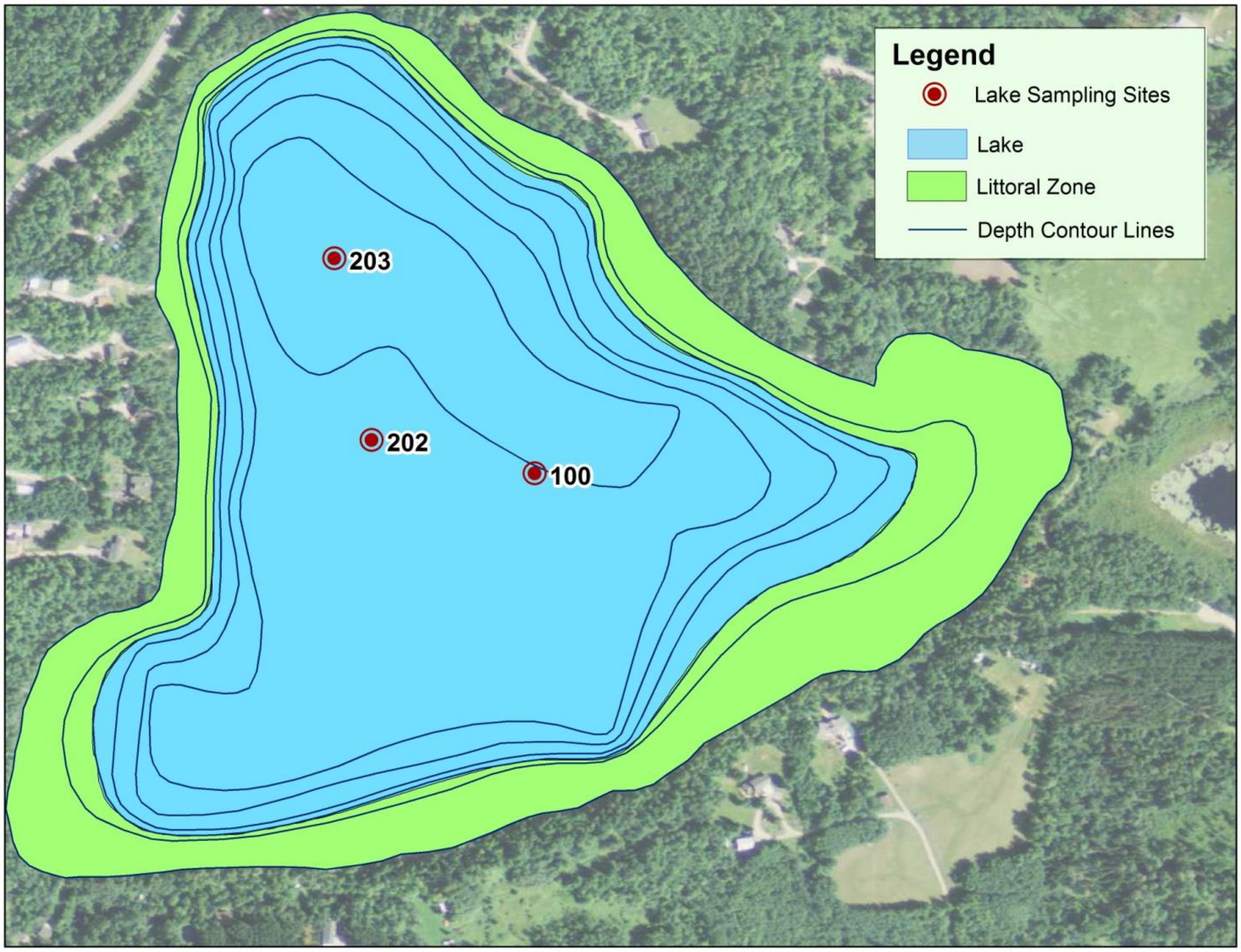


Figure 1. Map of Little Wabana Lake with 2010 aerial imagery and illustrations of lake depth contour lines, sample site locations, inlets and outlets, and public access points. The light green areas in the lake illustrate the littoral zone, where the sunlight can usually reach the lake bottom, allowing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

Table 3. Monitoring programs and associated monitoring sites. Monitoring programs include the Citizen Lake Monitoring Program (CLMP), Wabana Chain of Lakes (WCOLA).

Lake Site	Depth (ft)	Monitoring Programs
202	40	CLMP: 1999-2015
203 *Primary	57	WCOLA: 1991, 1999-2000, 2003, 2005, 2010-2011

Average Water Quality Statistics

The information below describes available chemical data for Little Wabana Lake through 2015 (Table 4). Data for total phosphorus, chlorophyll *a*, and Secchi depth are from the primary site 203.

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 Wabana 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)	12.1	14 – 27	> 30	Results are better than the expected range for the Northern Lakes and Forests Ecoregion.
[3]Chlorophyll *a* (ug/L)	3.3	4 – 10	> 9	
Chlorophyll *a* max (ug/L)	7.2	< 15		
Secchi depth (ft)	18.3	8 – 15	< 6.5	
Dissolved oxygen	*See page 8*			Dissolved oxygen depth profiles show that the lake mixes in spring and fall (dimictic).
Total Kjeldahl Nitrogen (mg/L)	0.6	<0.4 – 0.75		Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms.
Alkalinity (mg/L)	73.9	40 – 140		Indicates a low sensitivity to acid rain and a good buffering capacity.
Color (Pt-Co Units)	9.7	10 – 35		Indicates clear water with little to no tannins (brown stain).
pH	8.4	7.2 – 8.3		Indicates a hard water lake. Lake water pH less than 6.5 can affect fish spawning and the solubility of metals in the water.
Chloride (mg/L)	1.1	0.6 – 1.2		Within the expected range for the ecoregion.
Total Suspended Solids (mg/L)	2.0	<1 – 2		Indicates low suspended solids and clear water.
Specific Conductance (umhos/cm)	134.7	50 – 250		Within the expected range for the ecoregion.
TN:TP Ratio	49.2	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 203	Site 202
Total Phosphorus Mean (ug/L):	**12.1**	NA
Total Phosphorus Min:	6	NA
Total Phosphorus Max:	19	NA
Number of Observations:	24	NA
Chlorophyll *a* Mean (ug/L):	**3.3**	NA
Chlorophyll-a Min:	<1	NA
Chlorophyll-a Max:	7.2	NA
Number of Observations:	31	NA
Secchi Depth Mean (ft):	**18.3**	**19.2**
Secchi Depth Min:	12.1	7.5
Secchi Depth Max:	29.5	35.1
Number of Observations:	16	230

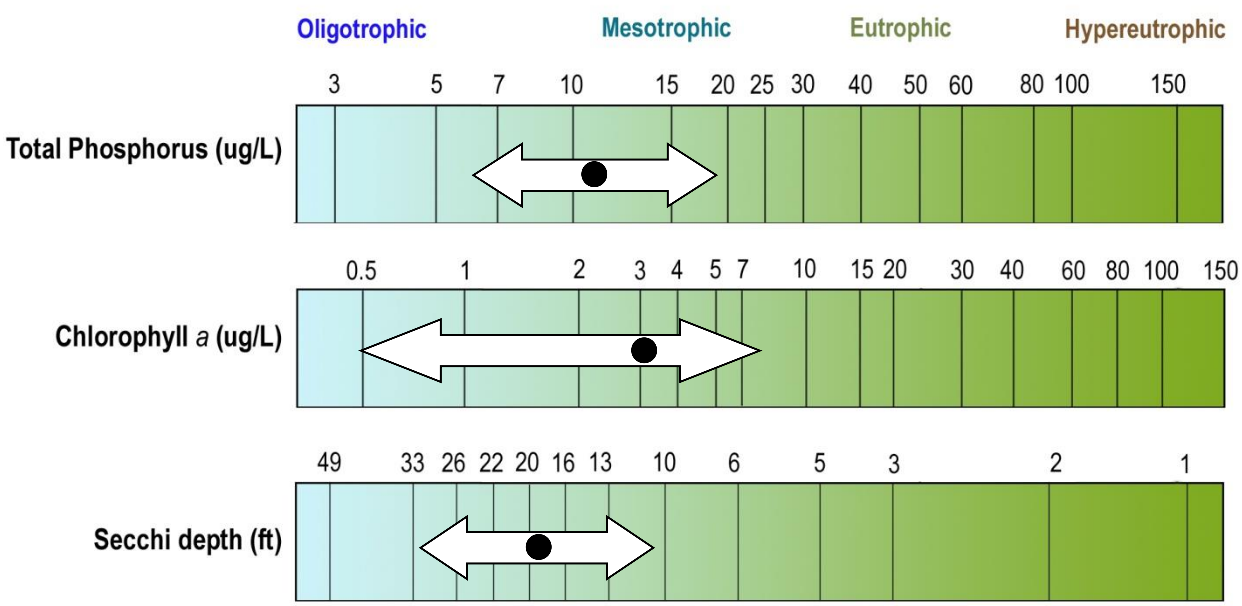


Figure 2. Little Wabana Lake total phosphorus, chlorophyll a and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Primary Site 203). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. 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 Wabana Lake ranges from 14.3 to 25.2 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.

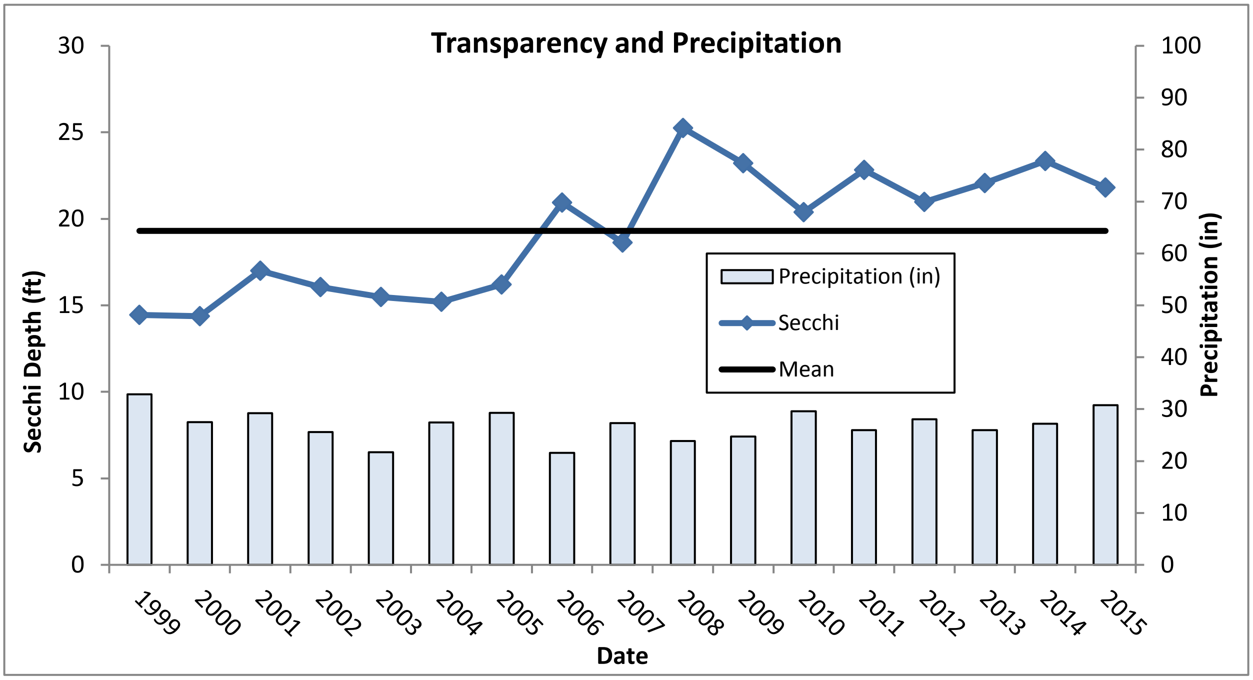


Figure 3. Annual mean transparency compared to long-term mean transparency.

Little Wabana Lake transparency ranges from 7.5 to 35.1 feet at site 202. Figure 4 shows the seasonal transparency dynamics. The maximum Secchi reading is usually obtained in early summer. Little Wabana Lake transparency is high in May and June, and then declines through August. The transparency then rebounds in October after fall turnover. This transparency dynamic is typical of a Minnesota lake. 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.

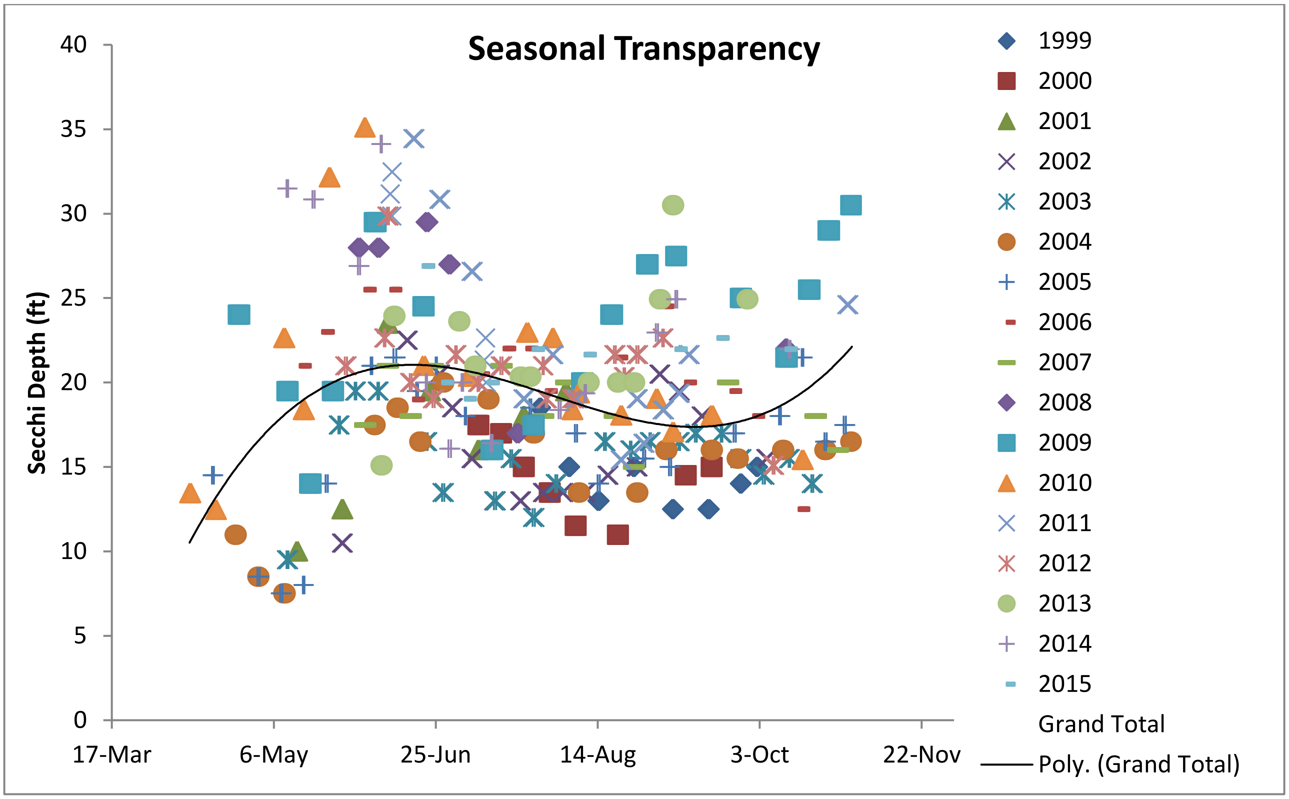


Figure 4. Seasonal transparency dynamics and year to year comparison (Primary Site 202). The black line represents the pattern in the data.

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 Wabana Lake was rated as being "crystal clear" 79% of the time by samplers at site 202 between 1999 and 2015 (Figure 5).

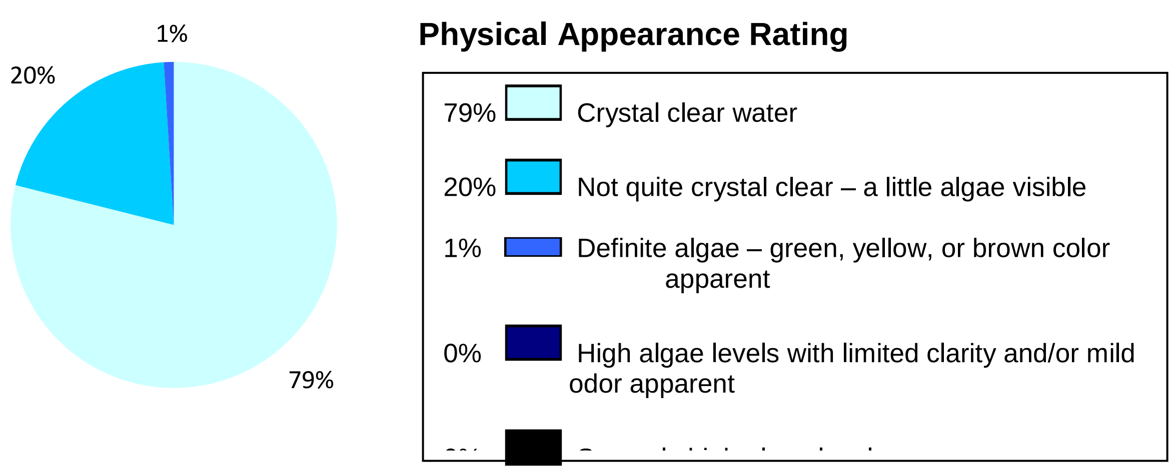


Figure 5. Little Wabana Lake physical appearance ratings by samplers.

As the Secchi depth decreases, the perception of recreational suitability of the lake decreases. Little Wabana Lake was rated as being "beautiful" 86% of the time from 1999 to 2015 (Figure 6).

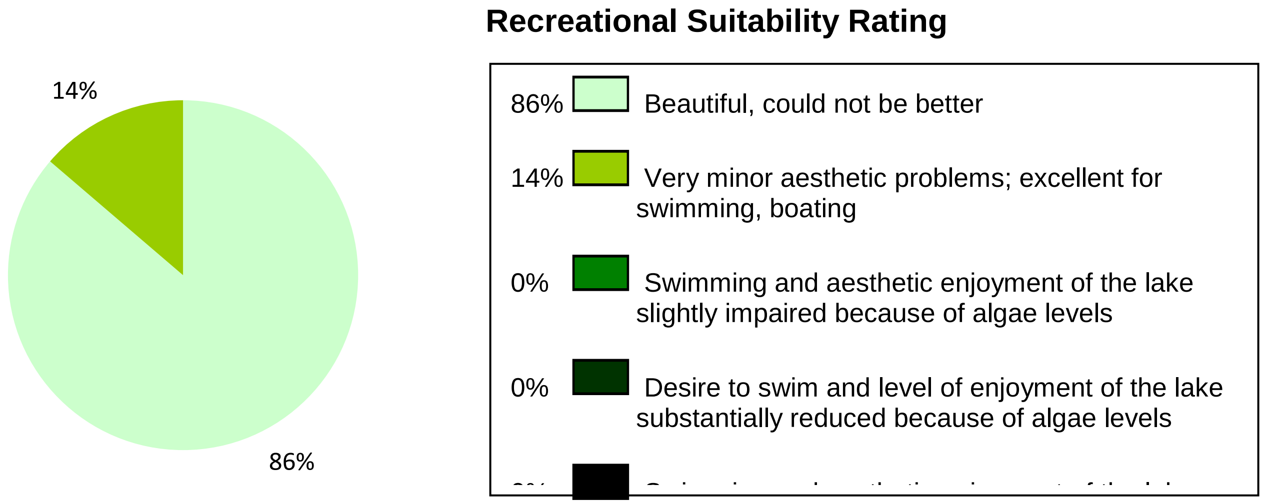


Figure 6. Recreational suitability rating, as rated by the volunteer monitor.

Total Phosphorus

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

Total phosphorus was evaluated in Little Wabana Lake in 1991, 1999-2000, 2003, 2005, 2010-2011. The data do not indicate much seasonal variability. The majority of the data points fall into the oligotrophic/mesotrophic border (Figure 7).

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

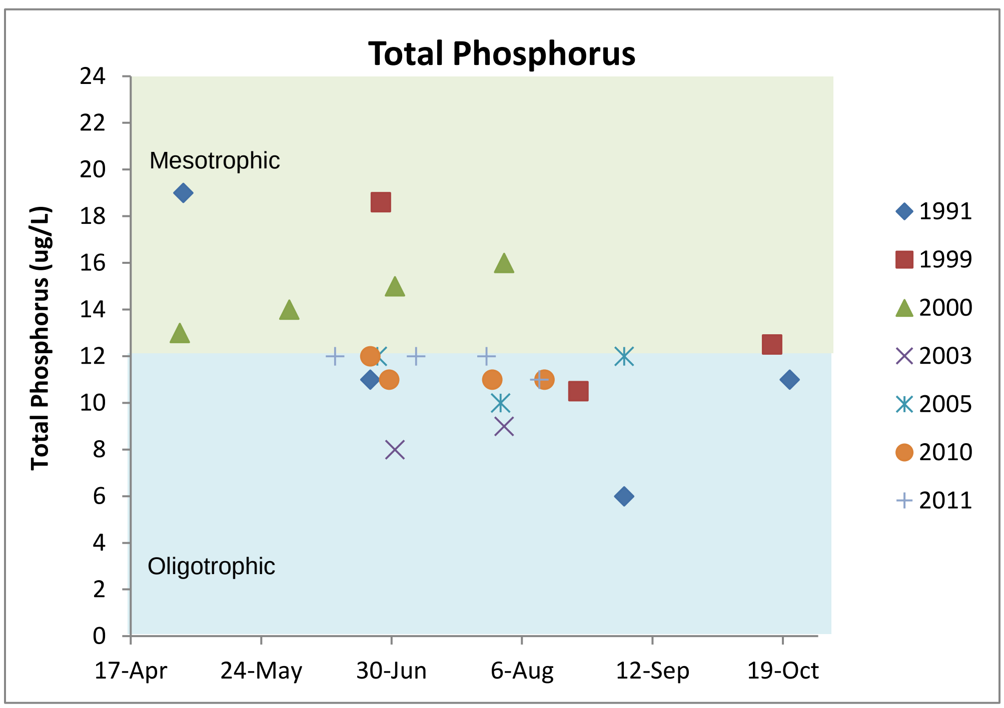


Figure 7. Historical total phosphorus concentrations (ug/L) for Little Wabana Lake.

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.

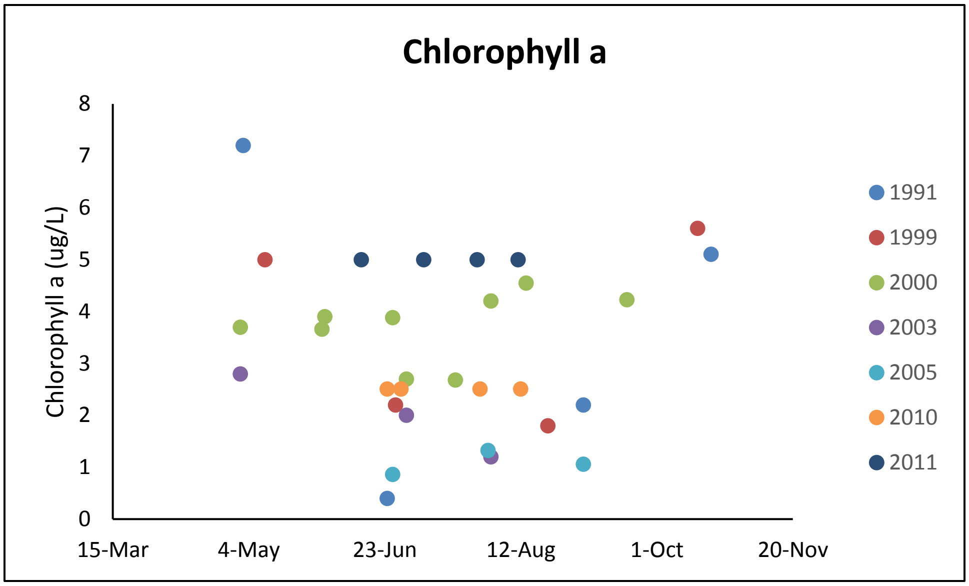


Figure 8. Chlorophyll *a* concentrations (ug/L) for Little Wabana Lake at sites 202 & 203.

Chlorophyll *a* was evaluated in Little Wabana Lake in 1991, 1999, 2000, 2003, 2005, 2010-2011 (Figure 8). Chlorophyll *a* concentrations stayed below 10 ug/L in all three 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

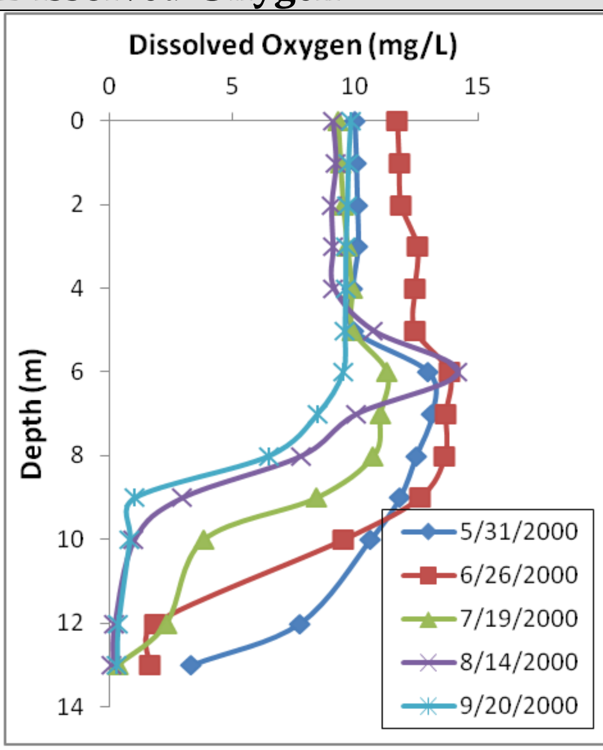


Figure 9. Dissolved oxygen profile for Little Wabana

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 Wabana Lake is a deep lake, with a maximum depth of 57 feet. Dissolved oxygen profiles from data collected in 2000 at site 100 show stratification developing mid-summer (Figure 9). The thermocline occurs at approximately 6 meters, and dissolved oxygen levels below that depth remain high for cold water fish such as ciscos. Little Wabana is designated by the DNR as a cisco refuge lake. Figure 9 is a representative DO profile for Little Wabana Lake and it illustrates stratification in the summer of 2000 at site 100.

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 Wabana Lake falls into the mesotrophic range (Figure 10). There is good agreement between the TSI for phosphorus and chlorophyll *a* indicating that these variables are strongly related (Table 6). The TSI for Secchi is lower, but this could be due to the fact that there are a lot more Secchi data than nutrient data for the lake.

Mesotrophic lakes (TSI 40-49) are characterized by moderately clear water most of the summer. "Meso" means middle or mid; therefore, mesotrophic means a medium amount of productivity. Mesotrophic lakes are commonly found in central Minnesota and have clear water with algal blooms in late summer (Table 7).

Table 6. Trophic State Index for Little Wabana

Trophic State Index	Site 202
TSI Total Phosphorus	40
TSI Chlorophyll-a	42
TSI Secchi	35
TSI Mean	40
Trophic State:	Mesotrophic

Numbers represent the mean TSI for each parameter.

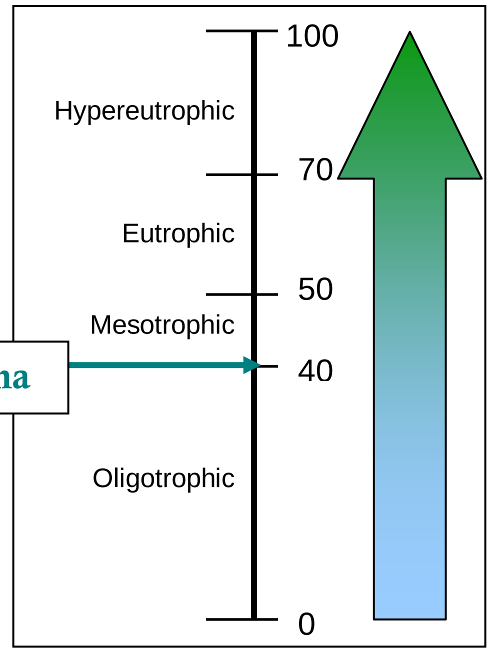


Figure 10. Trophic state index chart with corresponding trophic status.

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 Wabana 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 Wabana Lake.

Lake Site	Parameter	Date Range	Trend	Probability
203	Total Phosphorus	1991, 1999-2000, 2003, 2005, 2010-2011	Insufficient data	-
203	Chlorophyll *a*	1991, 1999-2000, 2003, 2005, 2010-2011	Insufficient data	-
202	Transparency	1999-2015	Improving	99.9%

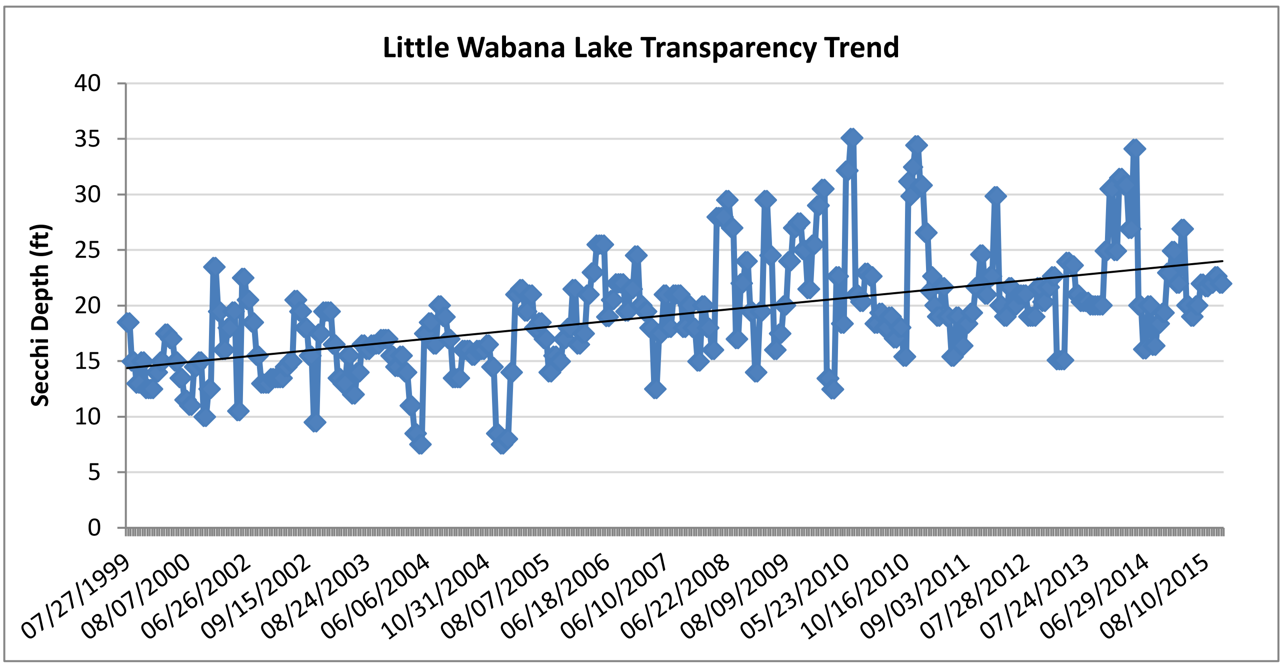


Figure 11. Transparency (feet) trend for site 202 from 1999-2015.

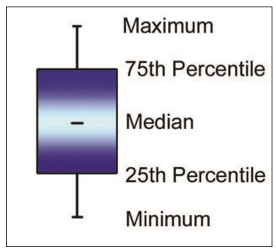
Little Wabana Lake shows evidence of an increasing transparency trend (Figure 11). Since 2007, the clarity minimums and maxiumus are higher than before 2007, showing clearer water. Transparency monitoring should continue so that this trend can be tracked in future years.

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



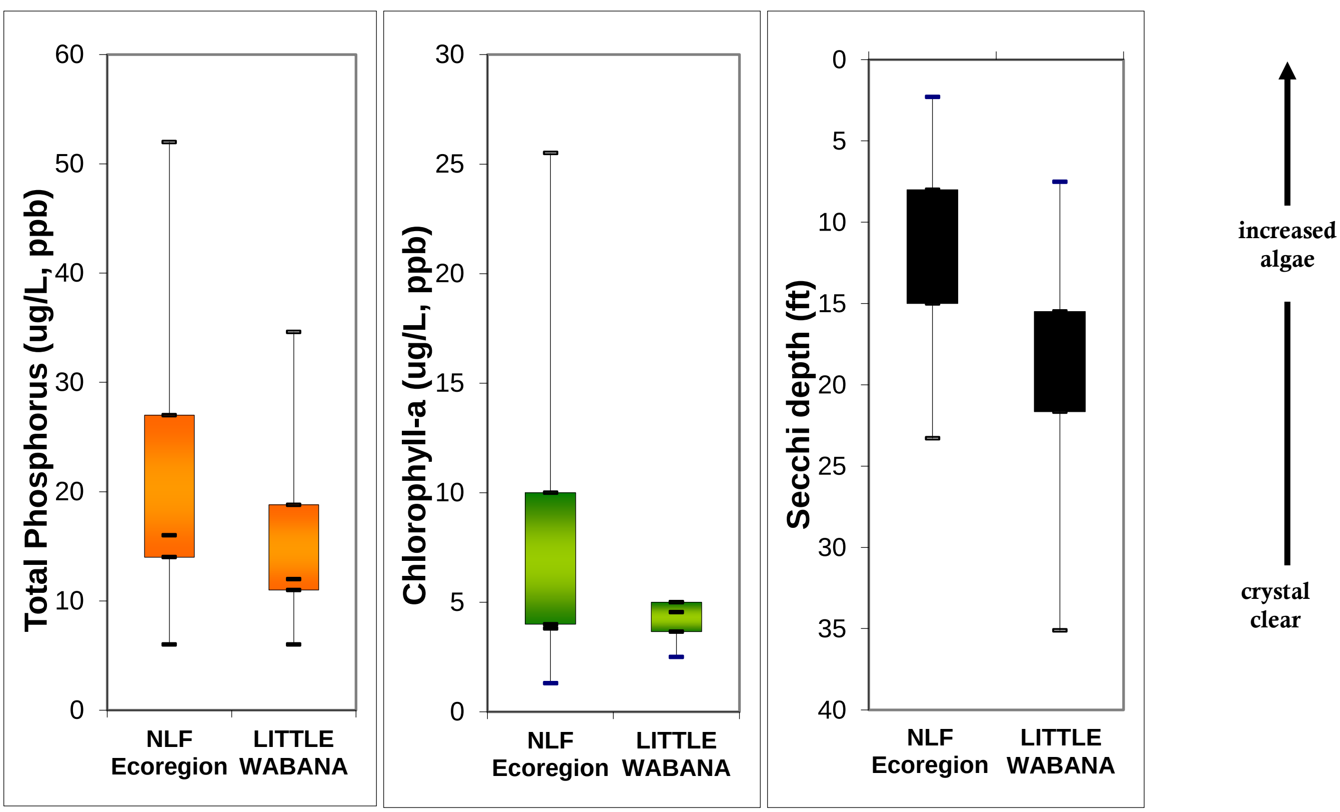


Figure 13. Little Wabana Lake ranges compared to Northern Lakes and Forest Ecoregion ranges. The Little Wabana Lake total phosphorus and chlorophyll *a* ranges are from 43 and 26 data points, respectively, collected in May-September of 1991,1999-2000,2003,2005,2010-2011,2014. The Little Wabana Lake Secchi depth range is from 484 data points collected in May-September of 1999-2015.

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 Wabana Lake is located in minor watershed 09047 (Figure 15).

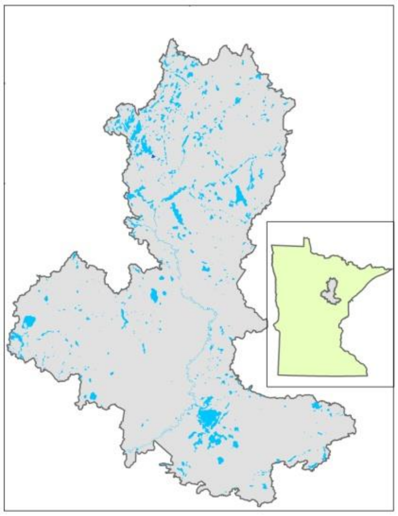


Figure 14. Major Watershed.

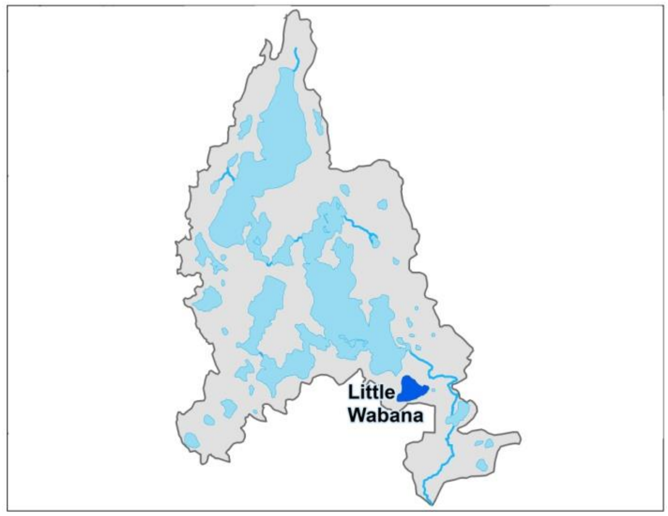


Figure 15. Minor Watershed.

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 Wabana Lake falls within lakeshed 0904705 (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 Wabana Lake ’s watershed, containing all the lakesheds upstream of the Little Wabana Lake lakeshed, see page 17. The data interpretation of the Little Wabana Lake lakeshed includes only the immediate lakeshed as this area is the land surface that flows directly into Little Wabana Lake.

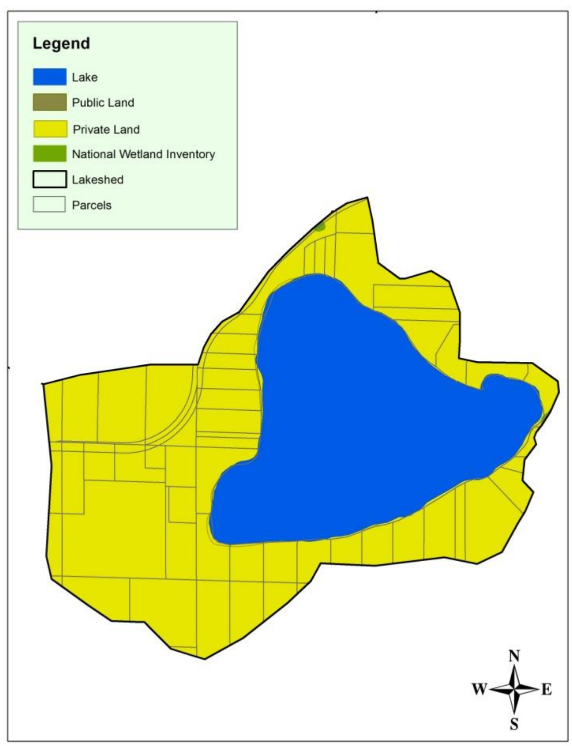


Figure 16. Little Wabana Lake lakeshed (0904705) with land ownership, lakes, wetlands, and rivers illustrated.

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

- (dark oval) Possibly detrimental to the lake
- (medium oval) Warrants attention
- (light oval) Beneficial to the lake

Table 9. Little Wabana Lake lakeshed vitals table.

Lakeshed Vitals		**Rating**
Lake Area (acres)	116	descriptive
Littoral Zone Area (acres)	37	descriptive
Lake Max Depth (feet)	57	descriptive
Lake Mean Depth (feet)	29.0	(light oval) Beneficial to the lake
Water Residence Time	NA	NA
Miles of Stream	0	descriptive
Inlets	0	(light oval) Beneficial to the lake
Outlets	0	(light oval) Beneficial to the lake
Major Watershed	Mississippi R. –Grand Rapids	descriptive
Minor Watershed	09047	descriptive
Lakeshed	0904705	descriptive
Ecoregion	Northern Lakes and Forests	descriptive
Total Lakeshed to Lake Area Ratio (total lakeshed includes lake area)	3	(medium oval) Warrants attention
Standard Watershed to Lake Basin Ratio (standard watershed includes lake areas)	3	(light oval) Beneficial to the lake
Wetland Coverage (NWI) (acres)	0.2	(medium oval) Warrants attention
Aquatic Invasive Species	None	(light oval) Beneficial to the lake
Public Drainage Ditches	0	(light oval) Beneficial to the lake
Public Lake Accesses	0	(light oval) Beneficial to the lake
Miles of Shoreline	1.9	descriptive
Shoreline Development Index	1.24	(light oval) Beneficial to the lake
Public Land to Private Land Ratio	0:1	(medium oval) Warrants attention
Development Classification	Natural Environment	(light oval) Beneficial to the lake
Miles of Road	1.5	descriptive
Municipalities in lakeshed	None	(light oval) Beneficial to the lake
Forestry Practices	None	(light oval) Beneficial to the lake
Feedlots	0	(light oval) Beneficial to the lake
Sewage Management	Individual Waste Treatment Systems (septic systems and holding tanks)	(medium oval) Warrants attention
Lake Management Plan	WCOLA, 2016	(light oval) Beneficial to the lake
Lake Vegetation Survey/Plan	None	(medium oval) 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.

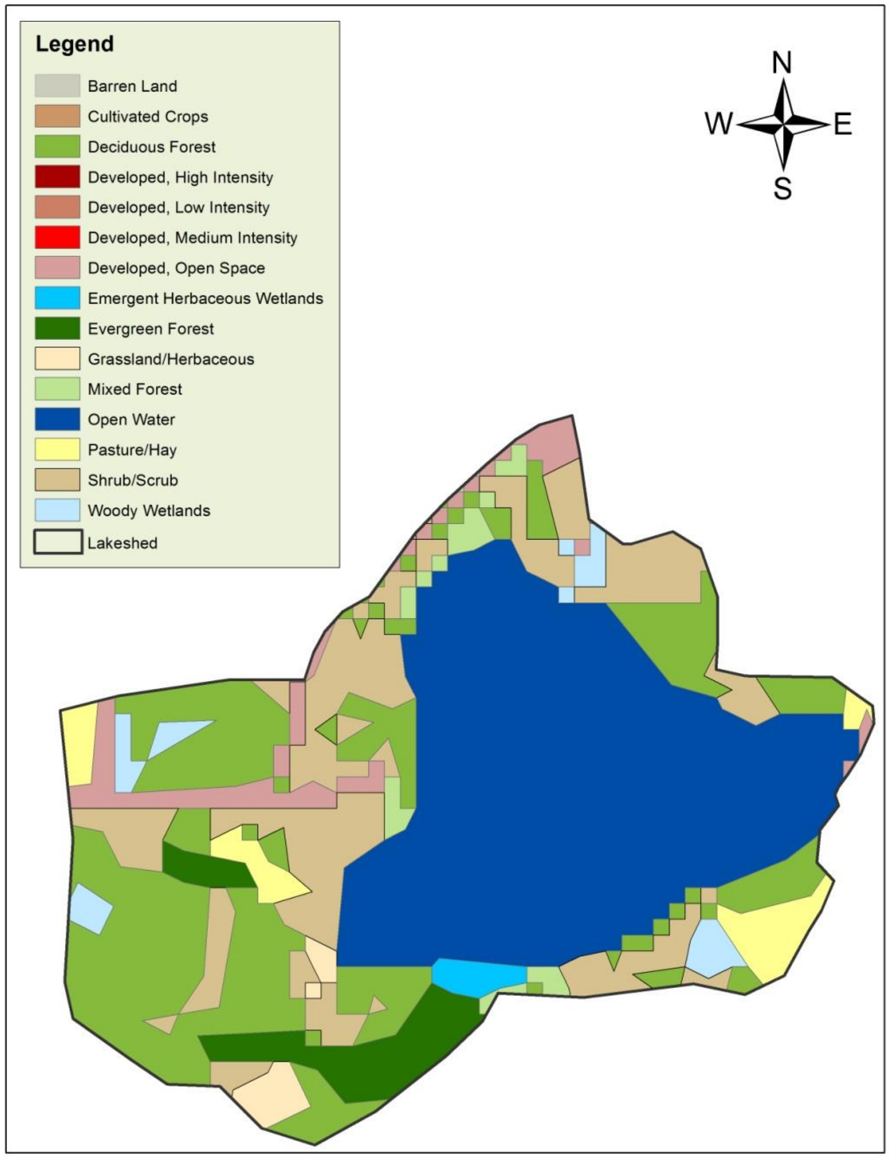


Figure 17. Little Wabana Lake lakeshed (0904705) land cover (NLCD 2011).

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 Wabana Lake's lakeshed.

The National Land Cover Dataset (NLCD) has records from 2001 and 2011. Table 10 describes Little Wabana 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)

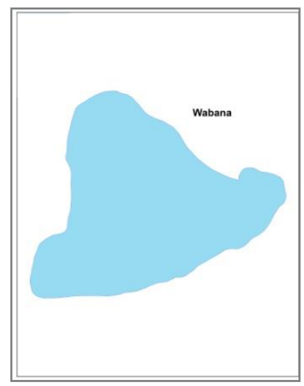
Table 10. Little Wabana Lake's lakeshed land cover statistics and % change from 2001 to 2011 (Data Source: NLCD).

Land Cover	2001 Acres	Percent	2011 Acres	Percent	% Change 2001 to 2011
Deciduous Forest	74.66	24.70	77.64	25.68	0.98
Developed, Open Space	13.17	4.36	13.22	4.37	0.01
Emergent Herbaceous Wetlands	2.44	0.81	2.36	0.78	-0.03
Evergreen Forest	13.69	4.53	13.58	4.49	-0.04
Grassland/Herbaceous	4.31	1.43	3.86	1.28	-0.15
Mixed Forest	5.43	1.79	5.41	1.79	0
Pasture/Hay	12.01	3.97	10.50	3.47	-0.5
Shrub/Scrub	53.93	17.84	52.72	17.44	-0.4
Woody Wetlands	7.20	2.38	7.30	2.41	0.03
Open Water	115.48	38.20	115.70	38.27	0.07
Total Area	302.31		302.31		

Table 11. Little Wabana 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	1	0.55	1	0.51	-0.04
Urban Acreage	6	1.99	6	1.99	0

Demographics



Little Wabana Lake is classified as a Natural Environment lake. Natural environment lakes usually have less than 150 total acres, less than 60 acres per mile of shoreline, and less than three dwellings per mile of shoreline. They may have some winter kill of fish; may have shallow, swampy shoreline; and are less 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)

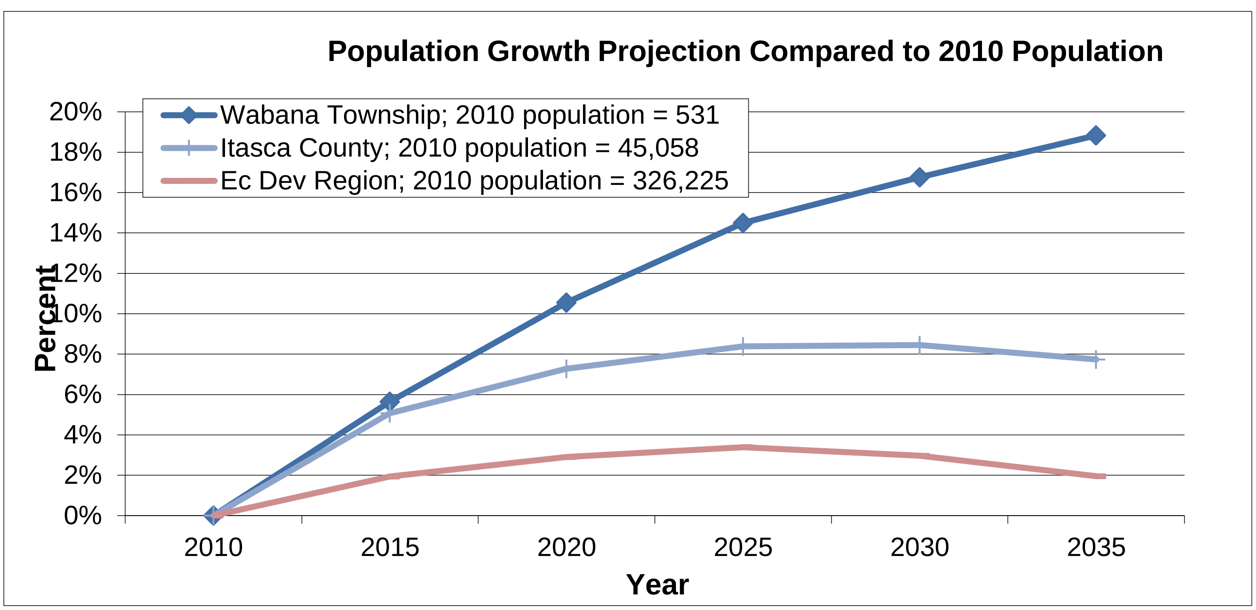


Figure 18. Population growth projection for adjacent townships and Itasca County.

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 Wabana 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 (61.17)						Public (0)		
	Developed	Agriculture	Forested Uplands	Other	Wetlands	Open Water	County	State	Federal
Land Use (%)	4.51	3.58	31.83	18.04	3.23	38.83	0	0	0
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	6 - 20	3 - 9	8.4		0.85		0	0	0
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 Wabana Lake's lakeshed is classified with having 38% of the watershed protected and 8% 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 Wabana Lake is a headwaters lakeshed, which means that no other lakesheds flow into it (Figure 20).

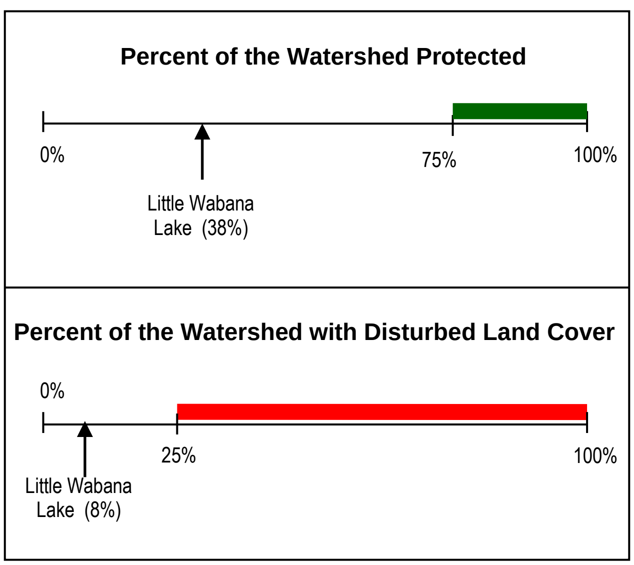


Figure 19. Little Wabana Lake's lakeshed percentage of watershed protected and disturbed.

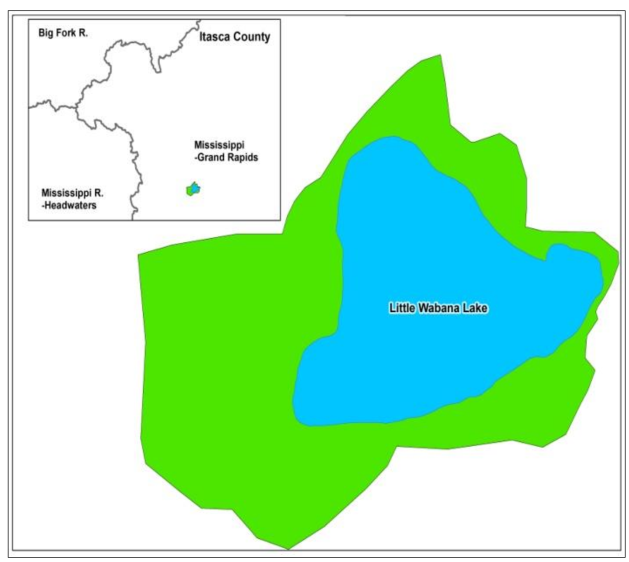


Figure 20. Lakesheds that contribute water to the Little Wabana Lake lakeshed. Color-coded based on management focus (Table 13).

Status of the Fishery (DNR, as of 08/29/2005)

Little Wabana Lake is a 104 acre lake located 11 miles north of Grand Rapids, MN in the Mississippi River watershed. The lake has a maximum depth of 57 feet and clear water (18 ft Secchi transparency). There is a privately owned boat access on the north end of the lake off County Road #49.

As in the two previous surveys, the gill-net catch rate for northern pike (3.0/net) was below the lake class average (5.0/net). Gill-net sampled pike had a good quality size structure; they ranged in length from 18.1 to 40.2 inches, with an average length of 27.0 inches. Two fish over 38 inches were sampled. Northern pike growth rates were well above the statewide average.

The gill-net catch rate for walleye (4.3/net) in the 2005 assessment was above the lake class average and the highest recorded in any of the three assessments on Little Wabana. Sampled walleye ranged from 15.6 to 25.3 inches, with an average length of 19.4 inches. No walleye have been stocked in Little Wabana since the 1950's. Ages 3-8 were represented in the sample, indicating fairly consistent natural reproduction. Growth rates were similar to the statewide average.

The trap-net catch rate for bluegill was near the lake class average at 16.3/net. This is down substantially from the catch of 53.2/net in the 1990 survey. Bluegill size structure was fairly poor in 2005. Fish in the trap nets varied from 3.4 to 8.1 inches, with only one fish over 8 inches in the sample.

The gill-net catch rate for black crappie was above the normal range at 2.0/net. Sampled black crappie ranged from 8.3 to 11.8 inches, with an average length of 9.8 inches. Ages 3-5 were represented in the sample and growth rates were similar to the statewide average.

Gill-net and trap-net catch rates for largemouth bass were within the normal range in 2005. Similar catch rates were observed for both gears for in the 1990 survey, while substantially higher catches were recorded in the 1978 survey. Smallmouth bass were sampled in both gears in the 1978 survey, but have not been captured in test nets since that time. A spring electrofishing assessment would likely provide better information on the bass population.

The yellow perch gill-net catch was slightly above the normal range at 14.7/net. Similar catch rates were reported in the two previous surveys. The gill-net catch rate for tullibee was within the normal range at 6.3/net. Test-net catches of tullibee are typically quite variable due to the pelagic and schooling nature of this species. The tullibee catch was substantially higher in 1990 at 14.5/net, while no tullibee were sampled in the 1978 survey.

Other species sampled included: green sunfish, rock bass, and white sucker.

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=31039900

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 Wabana Lake is a Mesotrophic lake (TSI = 40) with evidence of an improving long-term trend in water clarity. The total phosphorus, chlorophyll *a* and transparency ranges are within the ecoregion ranges.

Eight percent (8%) of the Little Wabana Lake lakeshed is disturbed by development and agriculture/pasture (Figure 19). Thirty nine percent (39%) of the lakeshed is the lake itself, 32% is forested uplands, and 3% is wetlands, which is generally good for water quality (Table 12).

Little Wabana Lake has the advantage of a very small watershed. The lake does not have any major inlets, which means that it is probably groundwater fed. This means that the main potential impacts to the lake are from land practices directly around the shoreline.

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. Little Wabana Lake is classified by the DNR as a Cisco Refuge Lake because it has deep, cold water, and a well-protected lakeshed. The 2005 DNR Fisheries survey did show Ciscoes present in the lake, which is an indicator that the lake has good water quality. In addition, the dissolved oxygen profiles for the lake show sufficient oxygen for cisco survival (Figure 9).

Priority Impacts to the Lake
The first tier around the lake appears to be mostly developed (Figure 16). The priority impact to Little Wabana Lake would be the expansion of residential housing development in the lakeshed and second tier development along the 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 Wabana 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
- Work with farmers to

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