Clearwater Lake 18-0038-00 CROW WING COUNTY

Lake Water Quality

Summary

Clearwater Lake is located 10 miles northeast of Brainerd, MN in Crow Wing County. It is a long lake covering 907 acres (Table 1).

Clearwater Lake has no inlets and one outlet, which classify it as a groundwater drainage lake (Figure 1). The Nokasippi River flows out of the north end of the lake at the Clearwater Lake Dam and flows to Eagle and Nokay Lakes. The Nokasippi River eventually joins the Mississippi at Fort Ripley.

Water quality data have been collected on Clearwater Lake since 1979 (Tables 2-3). These data show that the lake is mesotrophic, which is characteristic of moderately clear water throughout the summer and excellent recreational opportunities.

The Clearwater Lake Association has a Facebook page that describes their projects and contact information.

Table 1. Location data and physical characteristics for Clearwater Lake.

Location Data		Physical Characteristics	
MN Lake ID:	18-0038-00	Surface area (acres):	907
County:	Crow Wing	Littoral area (acres):	338
Ecoregion:	Northern Lakes and Forests	% Littoral area:	37%
Major Drainage Basin:	Upper Mississippi	Max depth (ft), (m):	54, 16.4
Latitude/Longitude:	46.39080048/-93.91419983	Inlets:	None
Invasive Species:	Eurasian watermilfoil	Outlets:	1
		Public Accesses:	1

Table 2. Data availability for Clearwater Lake.

Data Availability

Transparency data		Good data set through the Citizens Lake Monitoring Program.
Chemical data		Some phosphorus and chlorophyll a data exist, but not enough for a trend analysis.
Inlet/Outlet data		No inlet or outlet data exist for this lake.

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

Lake Map

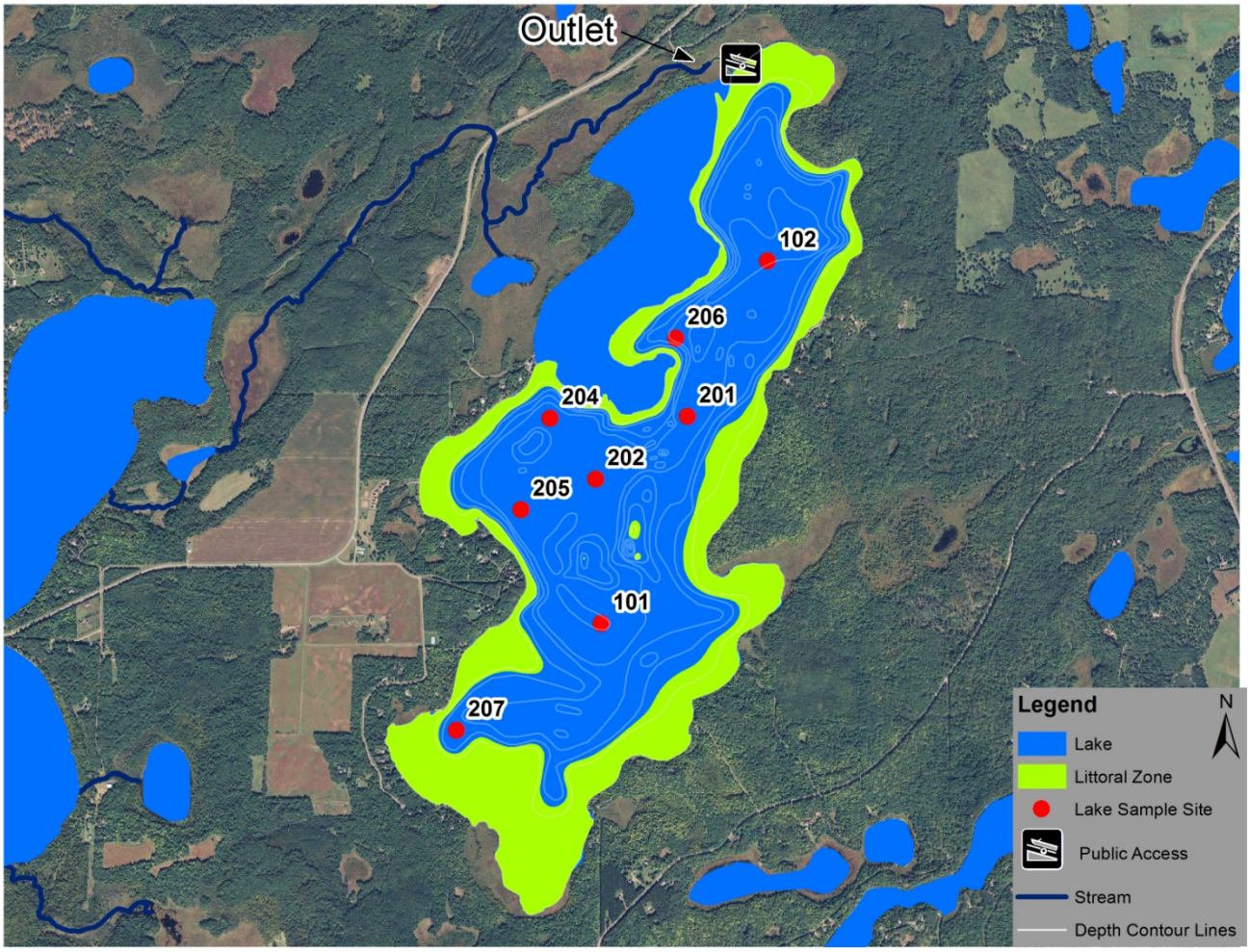


Figure 1. Map of Clearwater Lake with 2010 aerial imagery and illustrations of lake depth contour lines, sample site locations, inlets and outlets, and public access points. The light green areas in the lake illustrate the littoral zone, where the sunlight can usually reach the lake bottom allowing aquatic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

Table 3. Monitoring programs and associated monitoring sites. Monitoring programs include the Citizen Lake Monitoring Program (CLMP), the Minnesota Pollution Control Agency (MPCA), and the RMB Environmental Laboratories Lakes Monitoring Program (RMBEL).

Lake Site	Depth (ft)	Monitoring Programs
101	50	MPCA: 1990
102	50	MPCA: 1990
201	45	CLMP: 1979-1981
202	45	CLMP: 1982-1984, 2007-2008; RMBEL: 2007-2008
204	45	CLMP: 1986-1988
205*primary site	50	CLMP: 1985, 1989-2011
206	40	CLMP: 1991
207	25	CLMP: 2000-2011

Average Water Quality Statistics

Table 4 below describes available chemical data for site 202 of Clearwater Lake through 2008 (Table 4). The data set is limited, and all parameters with the exception of total phosphorus, chlorophyll *a* and secchi depth, are means for just 1990 data.

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.

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)	15	14 - 27	> 30	Results are within the expected range for the ecoregion.
[3]Chlorophyll *a* (ug/L)	5	4 - 10	> 9	
Chlorophyll *a* max (ug/L)	10	<15		
Secchi depth (ft)	13.9	7.5 - 15	< 6.5	
Dissolved oxygen	*Dimictic* *See page 8*			Dissolved oxygen depth profiles show that the deep areas of the lake are anoxic in late summer.
Total Kjeldahl Nitrogen (mg/L)	0.66	0.4 - 0.75		Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms.
Alkalinity (mg/L)	105	40 - 140		Indicates a low sensitivity to acid rain and a good buffering capacity.
Color (Pt-Co Units)	10	10 - 35		Indicates clear water with little to no tannins (brown stain).
pH	8.7	7.2 - 8.3		Indicates a hardwater 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	<1 - 2		Indicates low suspended solids and clear water.
Specific Conductance (umhos/cm)	181	50 - 250		Within the expected range for the ecoregion.
Total Nitrogen :Total Phosphorus	31:1	25:1 – 35:1		Indicates the lake is phosphorus limited, which means that algae growth is limited by the amount of phosphorus in the lake.

[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 205	Site 202	Site 207
Total Phosphorus Mean (ug/L):		**15**	
Total Phosphorus Min:		11	
Total Phosphorus Max:		21	
Number of Observations:		12	
Chlorophyll *a* Mean (ug/L):		**5**	
Chlorophyll-a Min:		3	
Chlorophyll-a Max:		10	
Number of Observations:		12	
Secchi Depth Mean (ft):	**13.1**	**13.9**	**11.6**
Secchi Depth Min:	7.5	8.0	7.5
Secchi Depth Max:	18.5	23.0	19.4
Number of Observations:	215	59	176

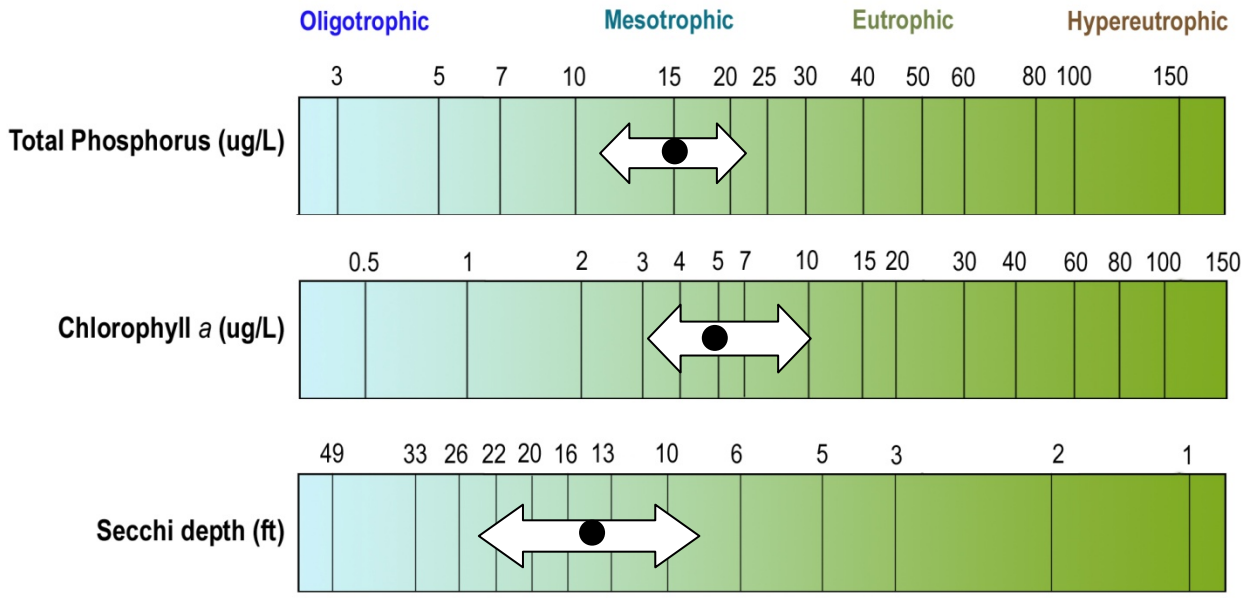


Figure 2. Clearwater Lake total phosphorus, chlorophyll *a* and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Site 202). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. No. EPA 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 mean transparency for Clearwater Lake ranges from 10.2 to 15.4 feet. The best transparency consistently occurred at deepest spot in the middle of the lake (site 205). Site 202 doesn't show up on the graph because the values are identical to site 207 for 2007-2008.

Transparency monitoring should be continued annually at sites 205 and 207 in order to track water quality changes.

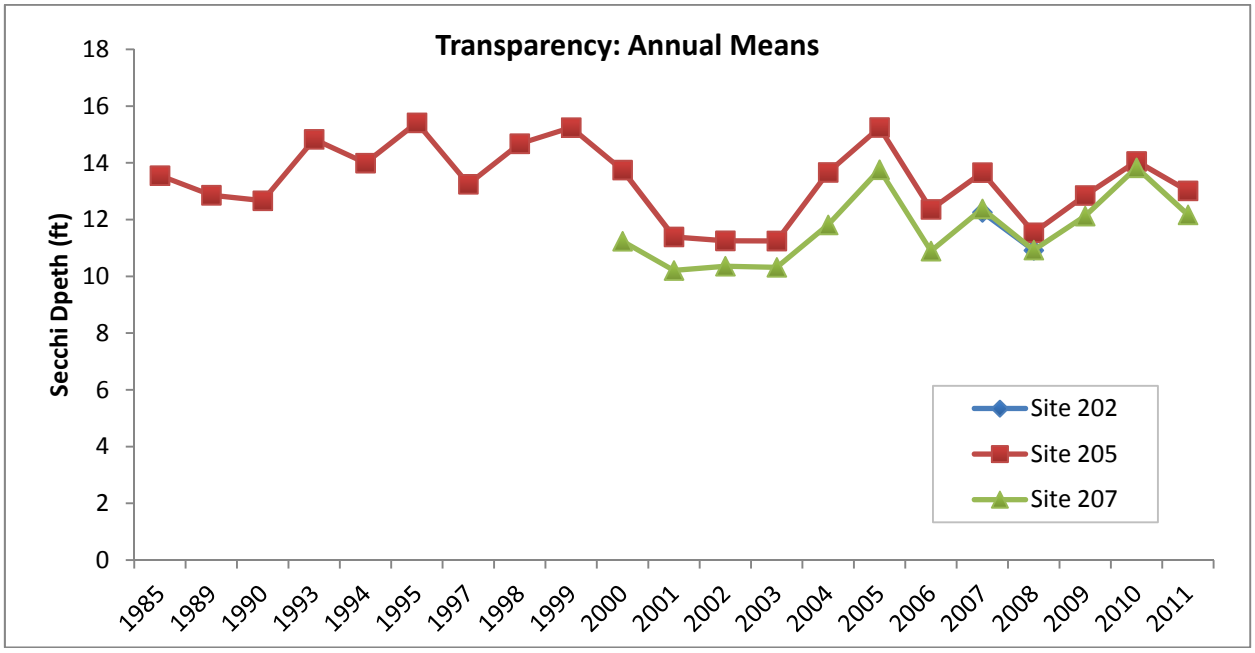


Figure 3. Annual mean transparency compared to long-term mean transparency, sites 205 and 203.

Clearwater Lake transparency ranges from 7.5 to 18.5 ft at the primary site (205). Figure 4 shows the seasonal transparency dynamics. The maximum Secchi reading is usually obtained in early summer. Clearwater Lake transparency is high in May and June, and then declines through August. If Secchi disk readings were taken in October, the transparency would most likely improve after lake turnover. This transparency dynamic is typical of a northern 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.

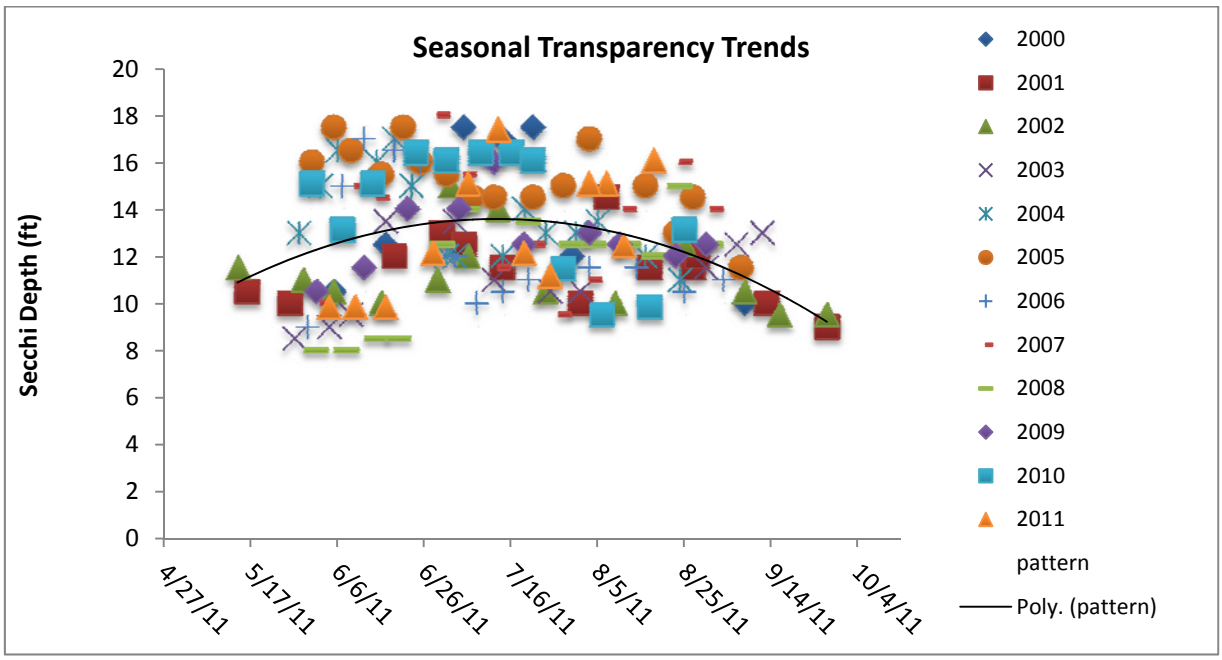
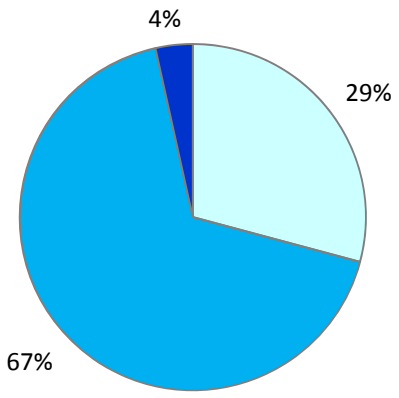


Figure 4. Seasonal transparency dynamics and year to year comparison (Primary Site 205). The black line represents the pattern in the data.

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. Clearwater Lake was rated as being "not quite crystal clear" 67% of the time from 1989-1990, 1993-1999, 2001-2002, 2005-2010 (Figure 5).

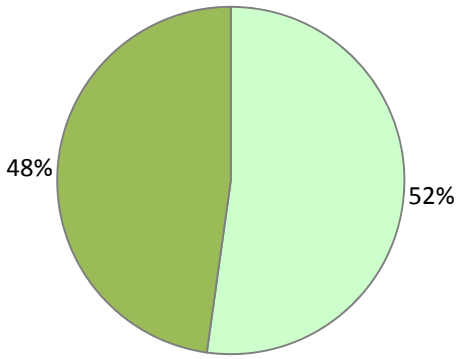


Physical Appearance Rating

29%	Crystal clear water
67%	Not quite crystal clear – a little algae visible
4%	Definite algae – green, yellow, or brown color apparent
0%	High algae levels with limited clarity and/or mild odor apparent
0%	Severely high algae levels

Figure 5. Physical appearance rating, as rated by the volunteer monitor (1989-1990, 1993-1999, 2001-2002, 2005-2010).

As the secchi depth decreases, the perception of recreational suitability of the lake decreases. Clearwater Lake was rated as being "beautiful" 52% of the time from 1989-1990, 1993-1999, 2001-2002, 2005-2010 (Figure 6).



Recreational Suitability Rating

89%	Beautiful, could not be better
10%	Very minor aesthetic problems; excellent for swimming, boating
1%	Swimming and aesthetic enjoyment of the lake slightly impaired because of algae levels
0%	Desire to swim and level of enjoyment of the lake substantially reduced because of algae levels
0%	Swimming and aesthetic enjoyment of the lake nearly impossible because of algae levels

Figure 6. Recreational suitability rating, as rated by the volunteer monitor (1989-1990, 1993-1999, 2001-2002, 2005-2010).

Total Phosphorus

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

Total phosphorus was evaluated in Clearwater Lake in 2007-2008. The data do not indicate much seasonal variability (Figure 7). The majority of the data points fall into the mesotrophic range.

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

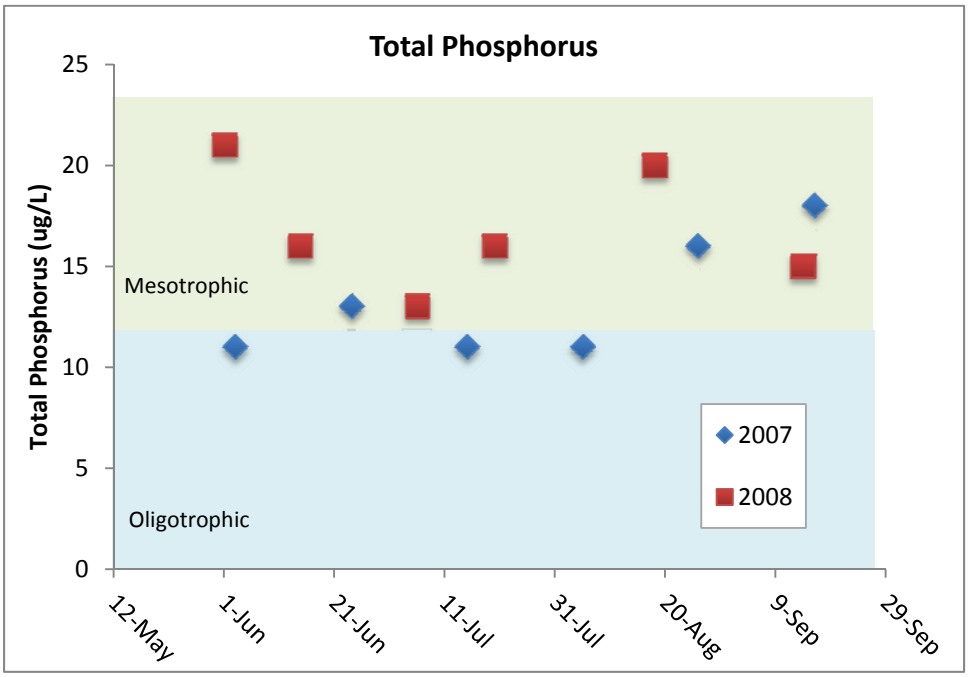


Figure 7. Historical total phosphorus concentrations (ug/L) for Clearwater Lake site 202.

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.

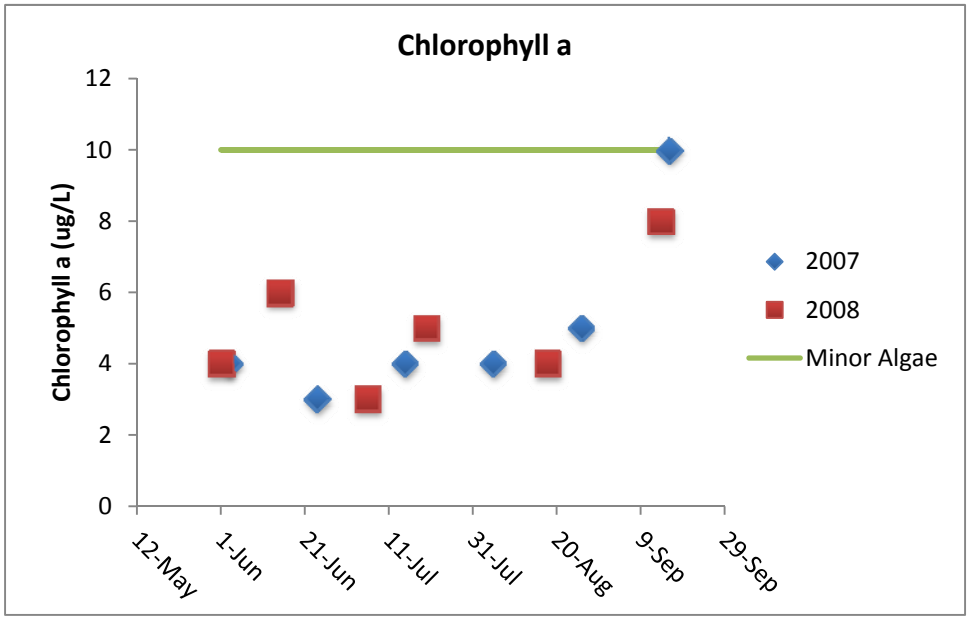
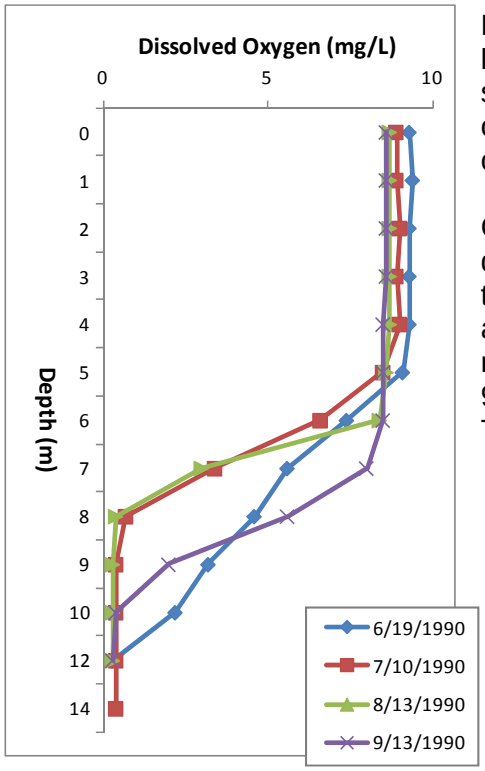


Figure 8. Chlorophyll *a* concentrations (ug/L) for Clearwater Lake site 202.

Chlorophyll *a* was evaluated in Clearwater Lake in 2007-2008. Chlorophyll *a* concentrations for all dates except one remained below 10 ug/L, indicating clear water most of the summer (Figure 8). The chlorophyll a was highest at the end of the summer with corresponds with the low transparency at this time (Figure 4).

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.

Clearwater Lake is a relatively deep lake, with a maximum depth of 54 ft. Dissolved oxygen profiles from 1990 indicate that the lake stratifies in the summer. The thermocline appears to reside at approximately 6-7 meters (19.5-23 feet), meaning that gamefish will be scarce below that depth. Figure 9 illustrates stratification in the summer of 1990 at site 101. This is a representative DO profile for Clearwater Lake.

Figure 9. Dissolved oxygen profile for Clearwater Lake in 2002 at site 205.

Trophic State Index

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.

The results from these three measurements cover different units and ranges and thus cannot be directly compared to each other or averaged. In order to standardize these three measurements to make them directly comparable, we convert them to a trophic state index (TSI).

The mean TSI for Clearwater Lake falls in the mesotrophic range (Figure 10). There is good agreement between the TSI for phosphorus, chlorophyll *a* and transparency, indicating that these variables are strongly related (Table 6).

Mesotrophic lakes (TSI 40-50) are characterized by moderately clear water most of the summer (Table 7). "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. They are also good for walleye fishing.

Table 6. Trophic State Index for site 202

Trophic State Index	Site 202
TSI Total Phosphorus	43
TSI Chlorophyll-a	46
TSI Secchi	39
TSI Mean	43
Trophic State:	Mesotrophic

Numbers represent the mean TSI for each parameter.

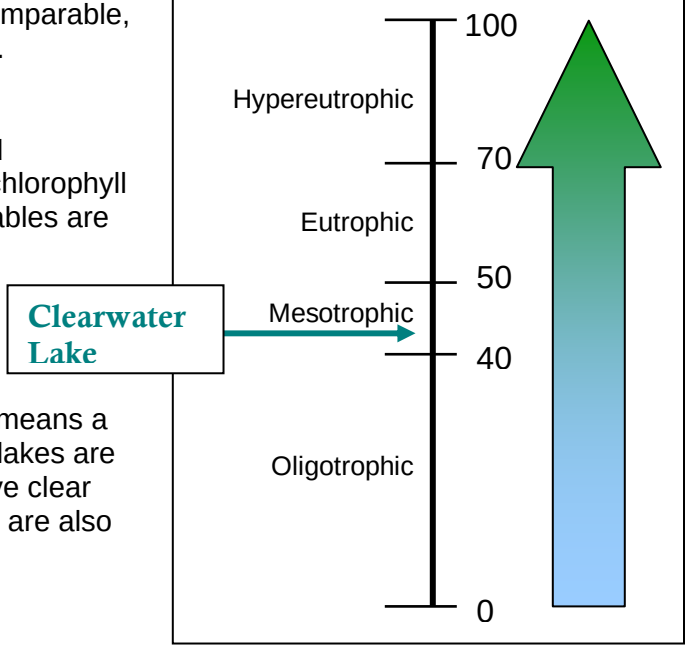


Figure 10. Trophic state index chart with corresponding trophic status.

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.

There is not enough historical data to perform trend analysis for total phosphorus or chlorophyll *a* on Clearwater Lake. Site 205 had over 8 years of transparency data, which was enough data to perform a long-term trend analysis (Table 8). The data was analyzed using the Mann Kendall Trend Analysis.

Table 8. Trend analysis for Clearwater Lake.

Lake Site	Parameter	Date Range	Trend
205*primary	Transparency	1989-2011	No trend
205*primary	Transparency	2000-2011	No trend
202	Total Phosphorus	2007-2008	Insufficient data
202	Chlorophyll a	2007-2008	Insufficient data

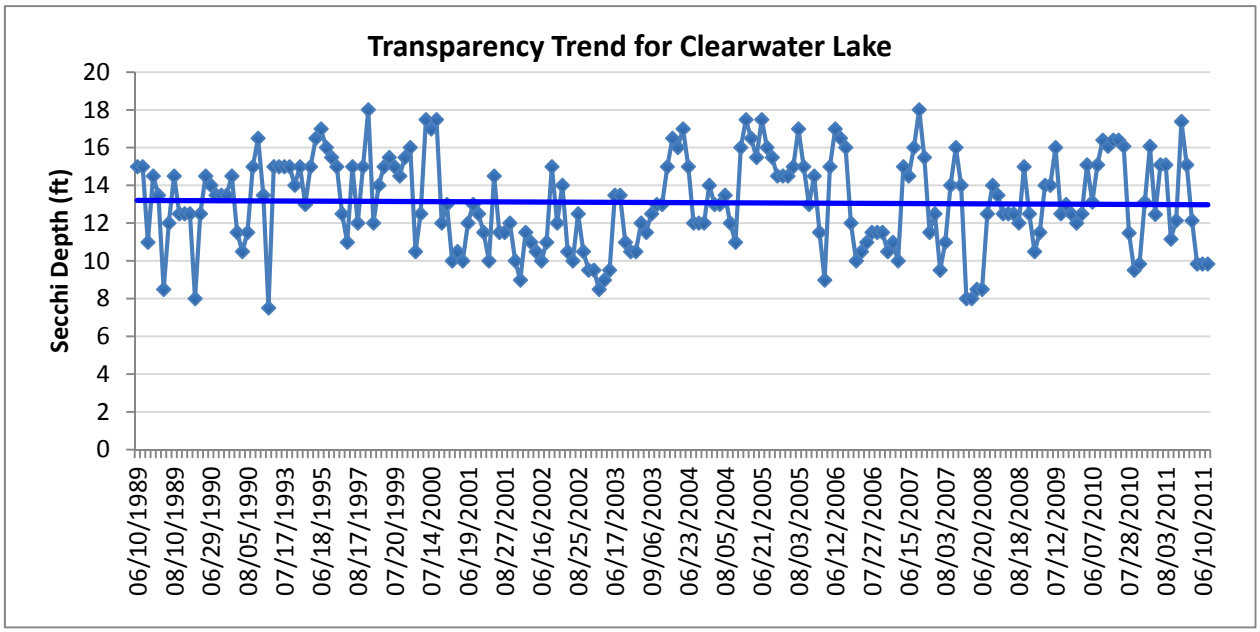


Figure 11. Transparency (ft) trend for site 205.

Clearwater Lake has no detectable trend in transparency over the long-term or short-term. This means the transparency is stable (Figure 11). 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.

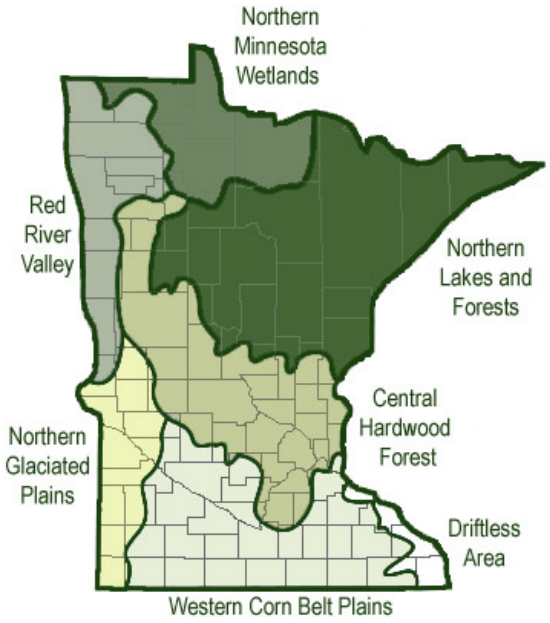
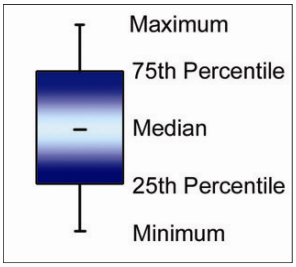
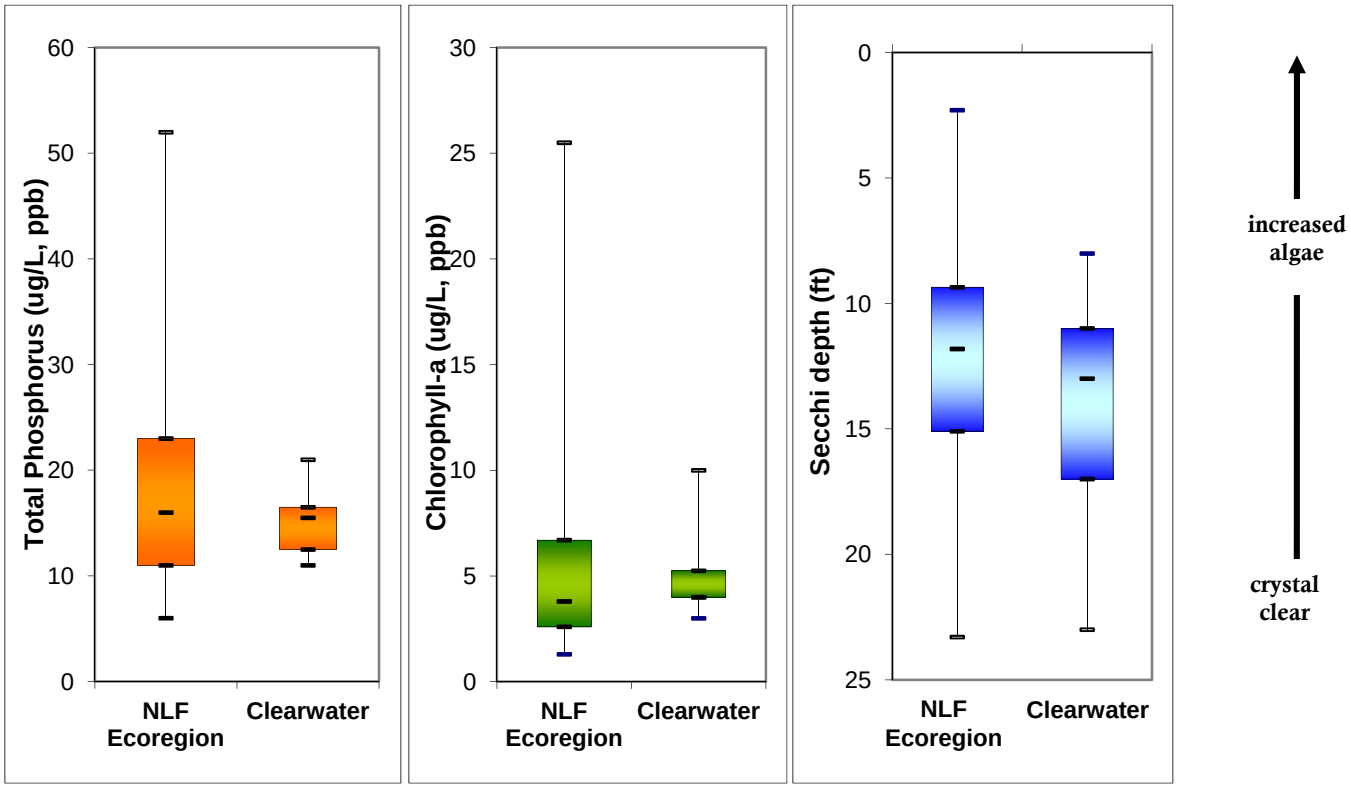


Figure 12. Minnesota Ecoregions.

Clearwater Lake is in the Northern Lakes and Forests Ecoregion. The mean total phosphorus, chlorophyll a and transparency (secchi depth) for Clearwater are all within the expected ecoregion ranges (Figure 13).





Figures 13a-c. Clearwater Lake ranges compared to Northern Lakes and Forest Ecoregion ranges. The Clearwater Lake total phosphorus and chlorophyll *a* ranges are from 12 data points collected in May-September of 2007-2008. The Clearwater Lake secchi depth range is from 215 data points collected in May-September from 1989-2011.

Lakeshed Data and Interpretations

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-Brainerd Major Watershed** is one of the watersheds that make up the Upper Mississippi River Basin, which drains south to the Gulf of Mexico (Figure 14). This major watershed is made up of 128 minor watersheds. Clearwater Lake is located in **minor watershed 10108** (Figure 15).

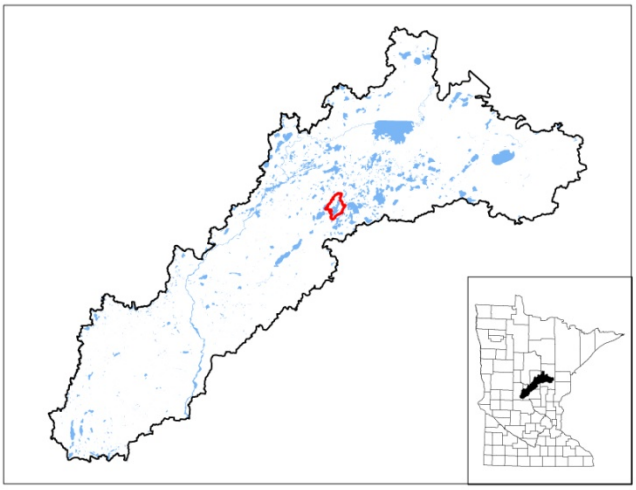


Figure 14. Mississippi River-Brainerd Major Watershed.

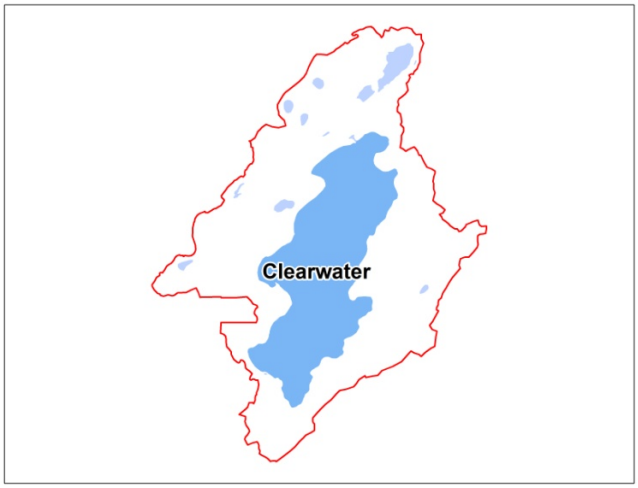


Figure 15. Minor Watershed 10108.

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. Clearwater Lake falls within **lakeshed 1010801** (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 Clearwater Lake's full watershed, containing all the upstream lakesheds, see page 17. The data interpretation of the Clearwater Lake lakeshed includes only the immediate

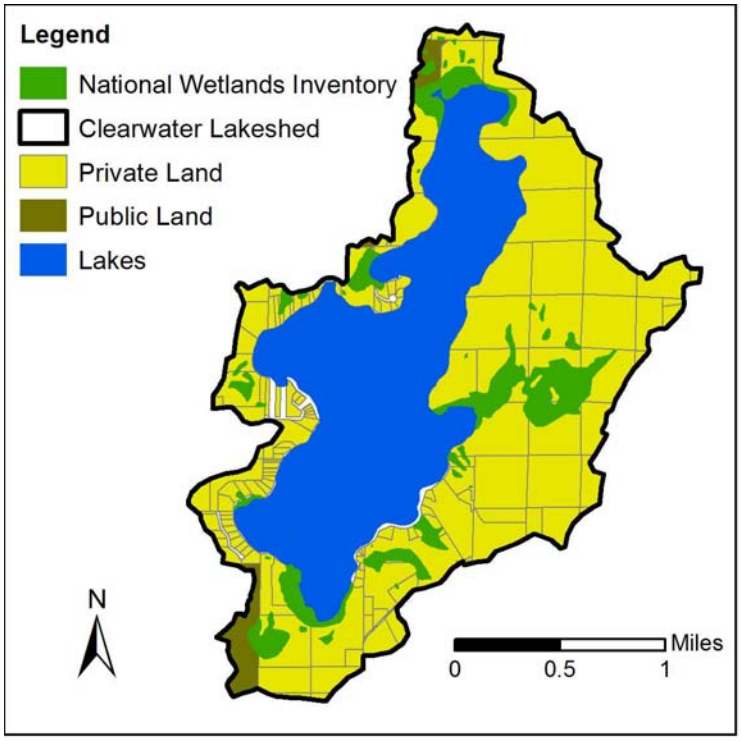


Figure 16. The Clearwater Lake Lakeshed (1010801).

lakeshed as this area is the land surface that flows directly into Clearwater Lake.

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. Clearwater Lake lakeshed vitals table.

Lakeshed Vitals		Rating
Lake Area	907 acres	descriptive
Littoral Zone Area	338 acres	descriptive
Lake Max Depth	54 ft.	descriptive
Lake Mean Depth	24 ft.	
Water Residence Time	NA	NA
Miles of Stream	0.2	descriptive
Inlets	None	
Outlets	1	
Major Watershed	10 – Mississippi River-Brainerd	descriptive
Minor Watershed	10108	descriptive
Lakeshed	1010801	descriptive
Ecoregion	Northern Lakes and Forest	descriptive
Total Lakeshed to Lake Area Ratio (total lakeshed includes lake area)	3:1	
Standard Watershed to Lake Basin Ratio (standard watershed includes lake areas)	3:1	
Wetland Coverage	8.5%	
Aquatic Invasive Species	Eurasian watermilfoil	
Public Drainage Ditches	None	
Public Lake Accesses	1	
Miles of Shoreline	8.6	descriptive
Shoreline Development Index	2.04	
Public Land to Private Land Ratio	0.04:1	
Development Classification	Recreational Development	
Miles of Road	7	descriptive
Municipalities in lakeshed	None	
Forestry Practices	County Forest Management: http://www.co.crow-wing.mn.us/index.aspx?NID=261	
Feedlots	None	
Sewage Management	Individual Subsurface Sewage Treatment Systems (Inspection and assessment required for all permits and property transfers within the Shoreland Protection Zone)	
Lake Management Plan	None	
Lake Vegetation Survey/Plan	None	

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.

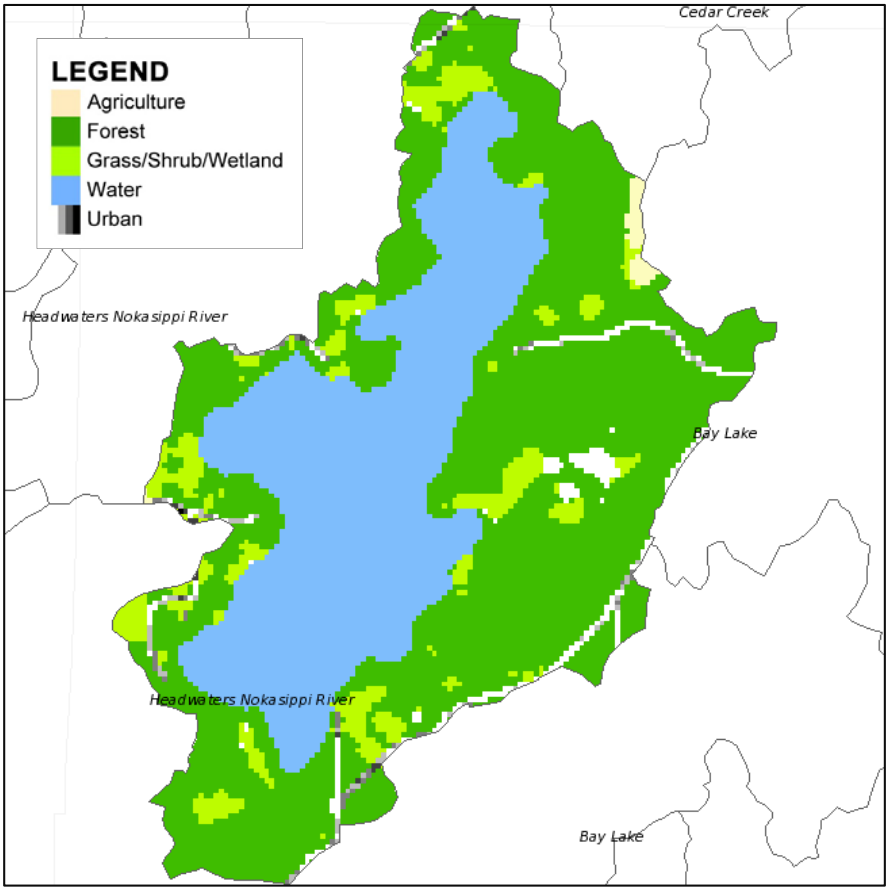


Figure 17. The Clearwater (1010801) lakeshed land cover (http://land.umn.edu).

Changes in land use, and ultimately land cover, impact the hydrology of a lakeshed. Land cover is also directly related to the lands 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 lands 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.

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 Clearwater Lake's lakeshed.

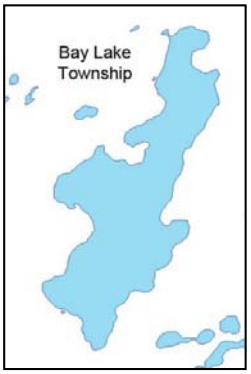
The University of Minnesota has online records of land cover statistics from years 1990 and 2000 (http://land.umn.edu). Although this data is 12 years old, it is the only data available that is able to compare over a decade's time. Table 10 describes Clearwater Lake's lakeshed land cover statistics and percent change from 1990 to 2000. Due to the many factors that influence demographics, one cannot determine with certainty the projected statistics over the next 10, 20, 30+ years, but one can see the transition within the lakeshed from agriculture, grass/shrub/wetland, and water acreages to forest and urban acreages. The largest change in percentage is the decrease in agriculture cover (78%); however, in acreage, forest cover has increased the most (100 acres). In addition, the impervious intensity has increased, which has implications for storm water runoff into the lake.

Table 10. Clearwater Lake's lakeshed land cover statistics and % change from 1990 to 2000 (http://land.umn.edu).

	1990		2000		% Change
Land Cover	**Acres**	**Percent**	**Acres**	**Percent**	**1990 to 2000**
Agriculture	63	2.52	14	0.56	77.8% Decrease
Grass/Shrub/Wetland	170	6.81	198	7.93	16.5% Increase
Forest	1272	50.94	1372	54.95	7.9% Increase
Water	918	36.76	837	33.52	8.8% Decrease
Urban	78	3.12	78	3.12	No Change
Impervious Intensity %					
0	2472	99.08	2466	98.84	0.2% Decrease
1-10	11	0.44	16	0.64	45.5% Increase
11-25	9	0.36	10	0.4	11.1% Increase
26-40	2	0.08	2	0.08	No Change
41-60	0	0	1	0.04	100% Increase
61-80	0	0	0	0	No Change
81-100	0	0	0	0	No Change
Total Area	2497		2497		
Total Impervious Area (Percent Impervious Area Excludes Water Area)	3	0.19	4	0.24	33.3% Increase

Demographics

Clearwater 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 Crow Wing County as a whole, Bay Township has a slightly higher extrapolated growth projection (Figure 18).

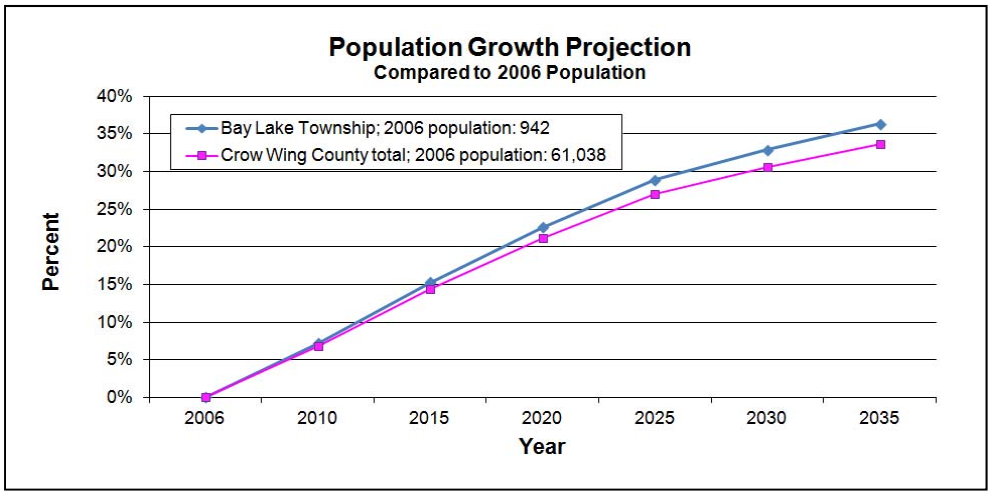


Figure 18. Population growth projection for Bay Township and Crow Wing County. (source: http://www.demography.state.mn.us/resource.html?Id=19332)

Clearwater Lake 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 land within Clearwater Lake's lakeshed is made up of private forested uplands (Table 11). This land can be the focus of development and protection efforts in the lakeshed.

Table 11. Land ownership, land use/land cover, estimated phosphorus loading, and ideas for protection and restoration in Clearwater Lake lakeshed (Sources: Crow Wing County parcel data, National Wetlands Inventory, and the 2006 National Land Cover Dataset).

	Private (61.7%)					**35.6%**	**Public (2.7%)**		
	Developed	**Agriculture**	**Forested Uplands**	**Other**	**Wetlands**	**Open Water**	**County**	**State**	**Federal**
Land Use (%)	2%	1.2%	46.5%	4%	8.0%	37%	2.65%	0.02%	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	22–72	8–27	104		18		6	0.04	0
Description	Focused on Shoreland	Cropland	Focus of develop-ment and protection efforts	Open, pasture, grass-land, shrub-land	Protected				
Potential Phase 3 Discussion Items	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 12). Watershed disturbance was defined as having urban, agricultural and mining land uses. Watershed protection is defined as publicly owned land or conservation easement.

Table 12. 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.

Clearwater Lake is classified with having 43.7% of the watershed protected and 3.9% of the watershed disturbed (Figure 19). Therefore, Clearwater Lake should have a protection focus. Goals for the lake should be to limit any increase in disturbed land use.

Figure 20 displays the upstream lakesheds that contribute water to the lakeshed of interest. All of the land and water area in this figure has the potential to contribute water to Clearwater Lake, whether through direct overland flow or through a creek or river. Clearwater lakeshed is a headwaters catchment, which means no additional water flows into this area from upstream lakesheds.

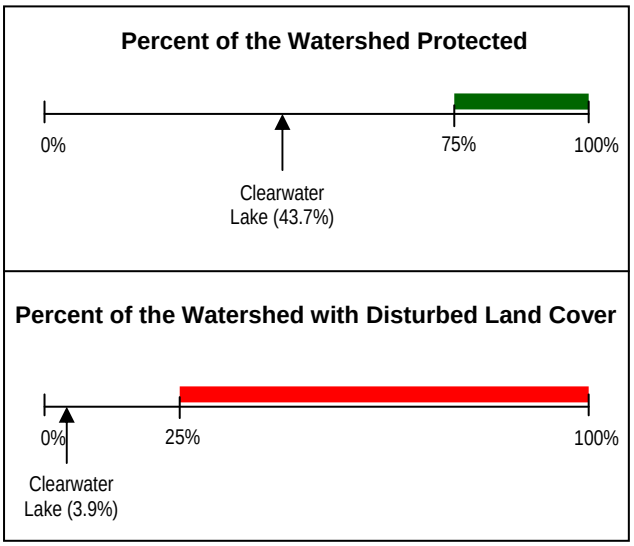


Figure 19. Clearwater Lake lakeshed's percentage of watershed protected and disturbed.

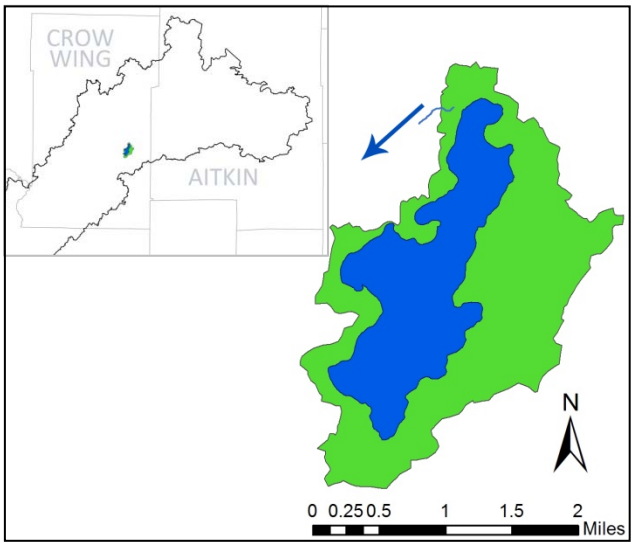


Figure 20. Upstream lakesheds that contribute water to the Clearwater lakeshed. Color-coded based on management focus (Table 12).

Clearwater, Status of the Fishery (as of 08/06/2007)

Clearwater Lake is 880 acres and is located about four miles south of Deerwood in Crow Wing County. Maximum depth is 54 feet and 29 % of the lake is 15 feet deep or less. Bottom substrate varies from rubble- boulder areas, to sandy areas stretching lake ward. The aquatic plant community is relatively diverse with a minimum of 29 species present. Emergent plants like bulrush, and wild rice and floating leaf plants such as water lilies are abundant in areas of little or no shoreline development. The large areas of undeveloped shoreline and diverse aquatic habitat make this lake unique for the Brainerd area and these qualities have helped maintain water quality, and provide essential spawning, and cover habitat for northern pike, largemouth and smallmouth bass, and panfish species.

The walleye management plan calls for fingerling stocking every third year and has been completed since 1989, except for the year 2004 when the rotation was moved back one year and stocking took place in 2004. The 2007 walleye catch of 3.8/gill net is down from the previous two surveys, but comparable to the average catch rate for this lake. Sizes ranged from 15.0 to 23.5 inches and averaged 19.8 inches. The majority of the fish captured were from years of stocking, and 66% were from the age six-year class and from the 2001 stocking.

Northern pike numbers of 3.92/gillnet is comparable to past surveys on this lake. Fish varied in size from 12.9 to 32.2 inches and averaged 21.8 inches in the gillnets. The size structure is similar to past surveys. Largemouth and smallmouth bass were observed in moderate numbers in spring electro fishing and in summer net catches. As in past surveys largemouth bass numbers were very good and size structure usually composed of fish less than 16.0 inches. Smallmouth numbers were good with all sizes present. Special consideration should be taken when fishing smallmouth bass in this lake because of the fact so few lakes in the Brainerd area have smallmouth bass fishing populations large enough to maintain a quality fishery for this species. Hopefully anglers will use discretion and practice voluntary catch and release. Black crappie catch rates were good and comparable to past nettings on this lake. Critical to the crappies future is to maintain the bulrush stands. Angling pressure has increased substantially on this lake in recent years and maintaining a quality fishery will depend on protecting the undeveloped shoreline habitat and lakeshore homeowners will have to show restraint when developing lake frontage.

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=18003800

Key Findings / Recommendations

Monitoring Recommendations
Transparency monitoring at sites 202, 205 and 207 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 at site 202, as the budget allows, to track water quality.

Overall Conclusions
Overall, Clearwater Lake is in good shape for water quality and lakeshed protection. It is a mesotrophic lake (TSI=43) with no detectable trends in water quality. Three percent (3%) of the lakeshed is in public ownership, and 44% of the watershed is protected, while only 4% of the watershed is disturbed (Figure 19).

Clearwater Lake is at an advantage in that it is a headwaters catchment. This means no other lakes or lakesheds flow into it, and the land practices around the lake are the main impact to the lake. The entire watershed is approximately 2,497 acres.

Priority Impacts to the Lake
Clearwater Lake is not heavily developed, and had no change in urban or impervious land cover from 1990-2000. The western shore is lightly developed in the first tier, while the northern half of the lake remains in large un-subdivided parcels (Figure 16). Some of this land is also tax forfeited property. There doesn't seem to be much development pressure currently on the lake, but if that changes in the future, it would be the priority impact to Clearwater Lake.

The protection of the water quality in Clearwater Lake certainly benefits from the enrollment of over a mile of the shoreline into permanent conservation easement near the outlet, which will limit the development along that section.

Best Management Practices Recommendations
The management focus for Clearwater 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 additional development, including second tier development, and impervious surface area. Project ideas include protecting land with conservation easements, enforcing county shoreline ordinances, smart development, shoreline restoration, rain gardens, and septic system maintenance.

County-wide Recommendation
In order to better manage the impact of septic systems on lake water quality, it is recommended that the county implement a lake-wide septic inspection program. In a program such as this, the county would focus on one to three lakes a year, pull septic system records on those lakes, and require old systems to be inspected. This program can rotate through the county doing a few lakes each year.

Organizational contacts and reference sites

Clearwater Lake Association	Visit on Facebook
DNR Fisheries Office	1601 Minnesota Drive, Brainerd, MN 56401 218-828-2550 brainerd.fisheries@state.mn.us
Regional Minnesota Pollution Control Agency Office	7678 College Road, Suite 105, Baxter, MN 56425 218-828-2492, 800-657-3864 http://www.pca.state.mn.us/pyri3df
Crow Wing Soil and Water Conservation District	Crow Wing County Land Services Building 322 Laurel St. Suite 13, Brainerd, MN 56401 218-828-6197 http://www.co.crow-wing.mn.us/swcd/
Crow Wing County Environmental Services Department	Crow Wing County Land Services Building 322 Laurel St. Suite 14, Brainerd, MN 56401 218-824-1125 http://www.co.crow-wing.mn.us/index.aspx?nid=211

Funding

This project was funded in part by the Board of Water & Soil Resources and the Initiative Foundation, a regional foundation.