Leech Lake 11-0203-00 CASS COUNTY

Summary

Leech is located at Walker, MN in Cass County, and is the third largest lake in Minnesota (102,948 acres). The lake is geographically located in three glacial zones and has an irregular shape with many large and small bays.

The deepest area of the lake is Walker Bay, which reaches 150 feet deep. Approximately 80% of the lake is less than 35 feet deep. Leech Lake varies considerably from a morphological perspective. Some large bays, such as Steamboat and Boy, display eutrophic water characteristics whereas other large bays, such as Walker and Kabekona, have properties more congruent with oligotrophic lakes. The main basin of the lake, like most large Minnesota walleye lakes, is mesotrophic (Schultz 2008).

Leech Lake has numerous inlets, intermittent ditches and tributaries. The seven major inlets include Portage Creek, Sucker River, Whipholt Creek, Kabekona River, Steamboat River, Shingobee River, and Boy River. Leech Lake has one major outlet, the Leech Lake River, which has a controlled dam regulating water levels. The Leech Lake River drains eastward into the Mississippi River.

Water quality data have been collected for Leech Lake off and on since 1975. These data were collected by a number of organizations including the Minnesota Pollution Control Agency (MPCA), Department of Natural Resources (DNR), the Leech Lake Association, and the Leech Lake Band of Ojibwe.

The Leech Lake Association and the Leech Lake Area Watershed Foundation are involved in many aspects of the lake. The Association has participated in lake monitoring and stream inlet/outlet monitoring, shoreline restoration, and is a member of the Association of Cass County Lakes (ACCL). The Leech Lake Area Watershed Foundation is involved in conserving environmentally sensitive lands, promoting individual and community stewardship, and advocating for responsible land-use decisions.

Vitals

MN Lake ID:	11-0203-00
County:	Cass
Ecoregion:	Northern Lakes and Forest
Major Drainage Basin:	Upper Mississippi River
Latitude/Longitude:	47.16666667/-94.39194444
Water Body Type:	Public Waters
Invasive species present:	Eurasian watermilfoil, confirmed 2004.

Physical Characteristics

Surface area (acres):	102,948	
Littoral area (acres):	57,994	
% Littoral area:	56%	
Max depth (ft):	150	(m): 45.7
Lakeshed size (acres):	196,247	
Lakeshed:lake area ratio	1.9:1	
Inlets	Numerous	
Outlets	1 – Leech Lake River	
Accesses	8 public	

Data Availability

Transparency data		Transparency data were collected sporadically through the MPCA CLMP program from 1975-2008.
Chemical data		Chemical data exist from 2008 and from DNR Fisheries Surveys.
Inlet/Outlet data		No recent inlet/outlet data exist for Leech Lake.
Recommendations		For recommendations refer to page 16.

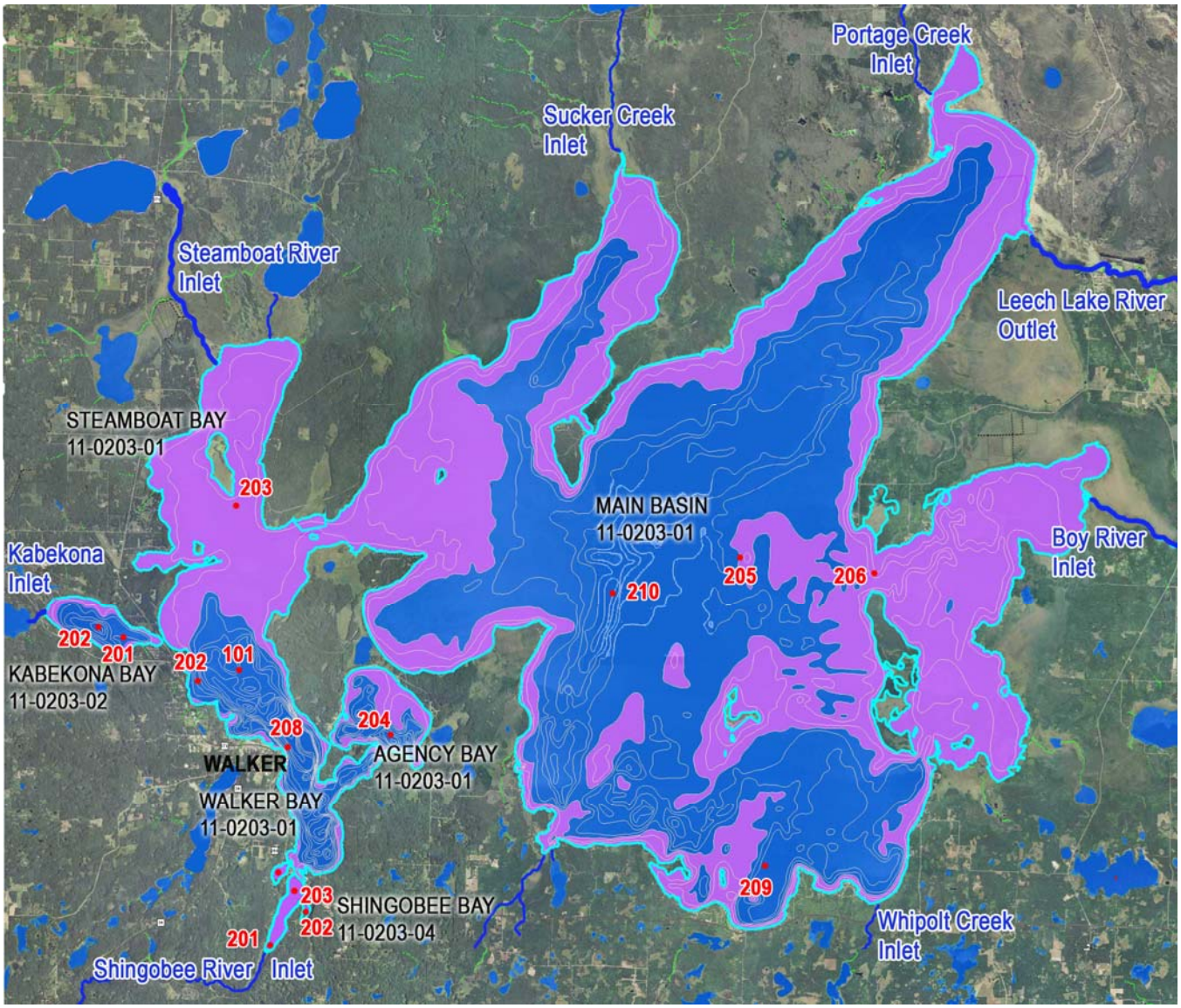


Figure 1. Map of Leech Lake illustrating basins, bathymetry, lake sample site locations, stream inlets and outlets and aerial land use. The pink shaded areas in the lake illustrate the littoral zone, where the sunlight can usually reach the lake bottom allowing aquatic plants to grow.

Basin	Lake Site	Depth (ft)	Monitoring Programs
Walker Bay	101 (WQ 7)	55	RMB Lab: 2008; DNR: 1984, 1986-1999, 2001-2003, 2006-2007
Walker Bay	202	40	CLMP:1990-1992, 1994
Walker Bay	208 (WQ 1)	80	CLMP: 2005
Agency Bay	204 (WQ 2)	65	CLMP: 1990-1991; RMB Lab: 2008
Shingobee Bay	201	20	CLMP: 1976-1981, 1986-1990
Shingobee Bay	202	30	CLMP: 1986-1990
Shingobee Bay	203	35	RMB Lab: 2008
Kabekona Bay	201	20	CLMP: 1990
Kabekona Bay	202	95	RMB Lab: 2008
Steamboat Bay	203	11	CLMP: 1990-2003
Main Basin	205	15	CLMP: 1990
Main Basin	209	30	CLMP: 2006-2007
Main Basin	210 (WQ 5)	40	RMB Lab: 2008; DNR: 1984, 1986-1999, 2001-2002

Site ID codes:
"100 & 200" series – MPCA Citizens Lake Monitoring Program (CLMP)
"WQ" series – Department of Natural Resources (DNR)

The information below describes available chemical data for Leech Lake through 2008 for all bays. The data set is limited, and all parameters with the exception of total phosphorus, chlorophyll *a* and secchi depth, are means from small data sets (1-20 data points).

Minnesota is divided into seven 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 13.

Parameter	Main Basin	Walker Bay	Agency Bay	Steamboat Bay	Kabekona Bay	Shingobee Bay	Ecoregion Range[1]	Interpretation
Total phosphorus (ug/L)	23.1	13.5	16.3	-	12.6	18	14 - 27	Results for all bays are within the expected range for the ecoregion.
Chlorophyll *a* [2] (ug/L)	3.6	2.8	2.3	-	3.6	5.4	4 - 10	
Secchi depth (ft)	8.6	10.1	11.0	8.6	10.2	8.6	7.5 - 15	
Stratification and Dissolved oxygen	Poly-mictic	Dimictic	Dimictic	Does not stratify	Dimictic	Dimictic		Polymictic basins are large and shallow and mix every time there are heavy winds. Dimictic lakes are deep basins that only mix in spring and fall. To see implications for dissolved oxygen, see page 11.
Alkalinity (mg/L)	134	130	135	140	145	-	40 - 140	Indicates a low sensitivity to acid rain and a good buffering capacity.
Color (Pt-Co Units)	7	5	5	6	-	11	10 - 35	Indicates clear water with little to no tannins (brown stain).
pH	8.4	8.6	-	-	-	8.6	7.2 - 8.3	A pH of 8 or more is common in a hardwater lake. Lake water pH less than 6.5 can affect fish spawning and the solubility of metals in the water.
Total Dissolved Solids (mg/L)	169	181	162	147	-	-	-	Total dissolved solids (TDS) consists of inorganic salts, small amounts of organic material and dissolved materials. TDS in Leech Lake are typical for a Minnesota lake.
Conductivity (umhos/cm)	262	268	-	235	-	-	50 - 250	The Main Basin and Walker Bay are slightly above the expected range for the ecoregion.

Data Source: Minnesota Pollution Control Agency: 1991, 2005; Minnesota Department of Natural Resources: 1984-2008

[1]The ecoregion range is the 25th-75th percentile of summer means from ecoregion reference lakes

[2]Chlorophyll *a* measurements have been corrected for pheophytin

Units: 1 mg/L (ppm) = 1,000 ug/L (ppb)

Water Quality Characteristics - Historical Means

Years monitored: 1976-1981, 1986-2003, 2005-2008

Parameters	Main Basin	Walker Bay	*Agency Bay	Steamboat Bay	*Kabekona Bay	*Shingobee Bay
Phosphorus Mean (ug/L):	**23.1**	**13.5**	**16.3**	**-**	**12.6**	**18**
Total Phosphorus Min:	11	5	13	-	10	12
Total Phosphorus Max:	55	29	19	-	15	22
Number of Observations:	16	24	3	-	5	5
Chlorophyll *a* Mean (ug/L):	**3.6**	**2.8**	**2.3**	**-**	**3.6**	**5.4**
Chlorophyll-a Min:	3	1	1	-	2	3
Chlorophyll-a Max:	5	5	4	-	5	8
Number of Observations:	3	6	4	-	5	5
Secchi Depth Mean (ft):	**8.6**	**10.3**	**11.0**	**8.6**	**10.2**	**9.7**
Secchi Depth Min:	6.0	7.0	9.5	5.0	8.5	8.0
Secchi Depth Max:	11.4	15.0	21.0	10.5	11.0	11.0
Number of Observations:	9	43	25	165	14	4

**Phosphorus and chlorophyll-a data from 2008 only*

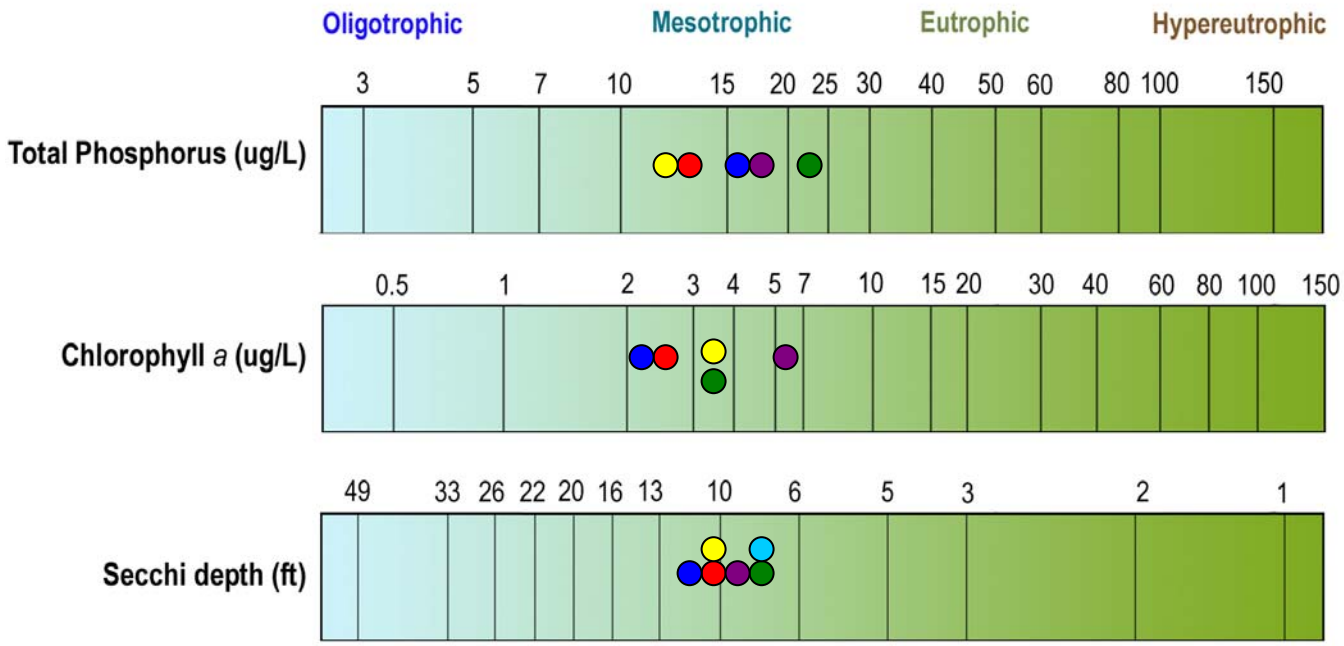


Figure 2. Leech Lake total phosphorus, chlorophyll *a* and transparency historical ranges. The different colored dots represent the historical mean for each basin. Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. No. EPA 440/5-88-002)

Transparency (Secchi Depth)

Transparency is how easily light can pass through a substance. In lakes it refers to 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.

Leech Lake is unique in that each bay behaves somewhat differently and can be thought of as a different lake. The mean transparency in Leech Lake ranges from 8.6 to 11.7 feet. The shallower bays such as the Main Basin, Shingobee Bay and Steamboat Bay have lower mean transparencies than the deeper bays such as Walker, Agency and Kabekona (Figure 3).

The transparency data for Leech Lake overall are extremely disjointed, and site 203 in Steamboat Bay is the only site that has over 5 consecutive years of data (1990-2003). It is recommended that the lake association begin collecting transparency data at the sites below again to compare to the previous data.

Since Leech Lake is so large, it is not feasible for one person to do all the transparency monitoring. A water quality task force could be formed, where each site has their own volunteer assigned to do weekly or bimonthly secchi disk readings. That way, at the end of each year all the data would go to the MPCA and comparisons can be made between sites and years of collection.

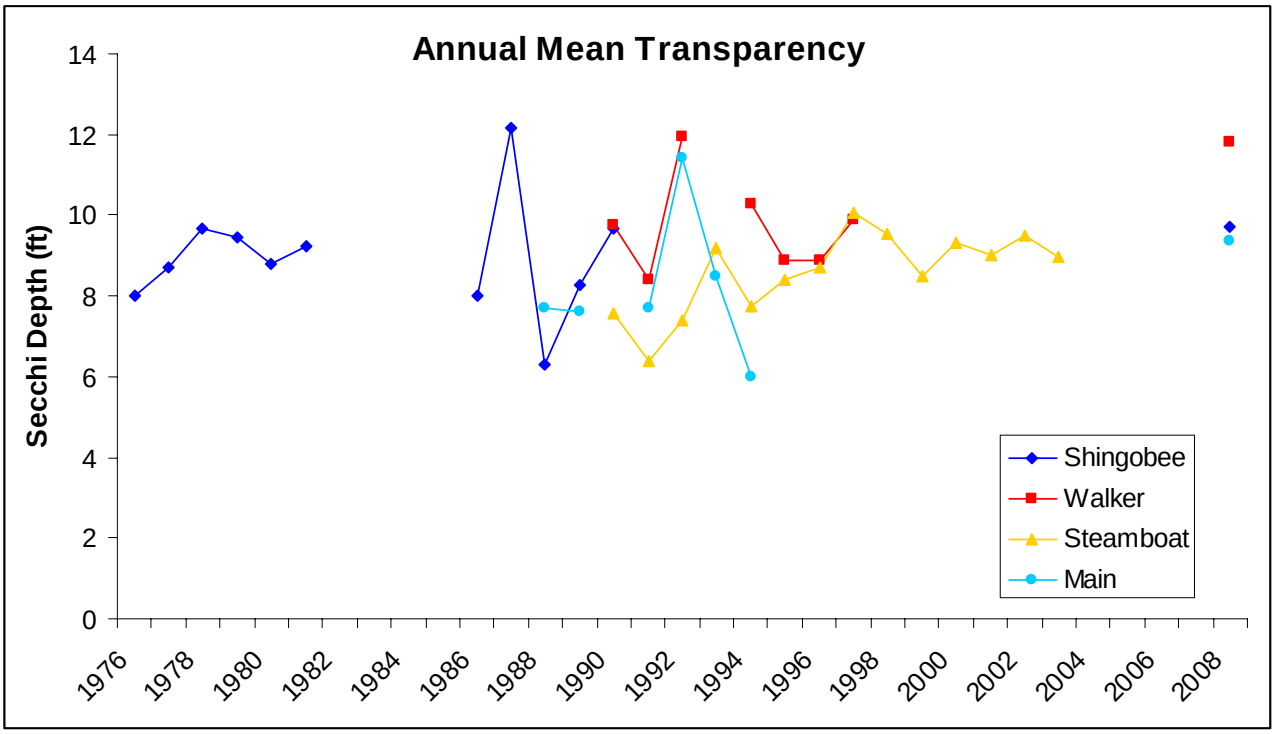


Figure 3. Annual mean transparency for each bay that had more than 3 years of data.

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.

Physical Appearance Rating

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

This rating varies somewhat between different volunteers, but overall, the MPCA has determined that 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. From the physical appearance ratings below, most of the bays were rated similarly (Figure 4). Shingobee Bay was the only bay to have more than 5% of the ratings with "definite algae".

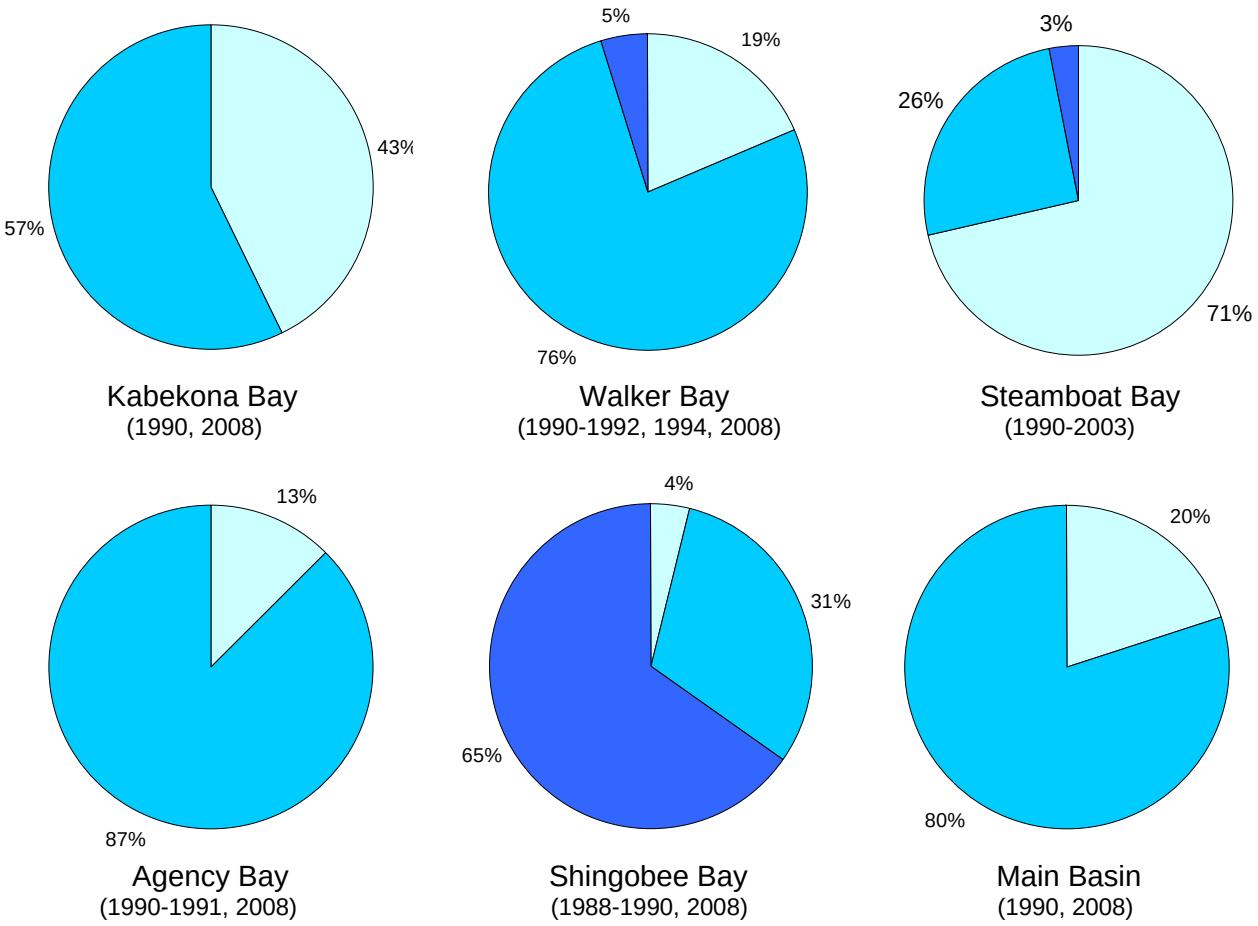


Figure 4. Physical appearance rating for each bay as rated by the volunteer monitor.

As the secchi depth decreases, the perception of recreational suitability of the lake decreases.

Leech Lake was rated as being "beautiful" for recreation or having "very minor aesthetic problems" for most sites (Figure 5). Steamboat bay was rated as "swimming and aesthetic enjoyment of the lake slightly impaired because of algae levels" 21% of the time between 1988-1990, 2008.

Recreational Suitability Rating

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

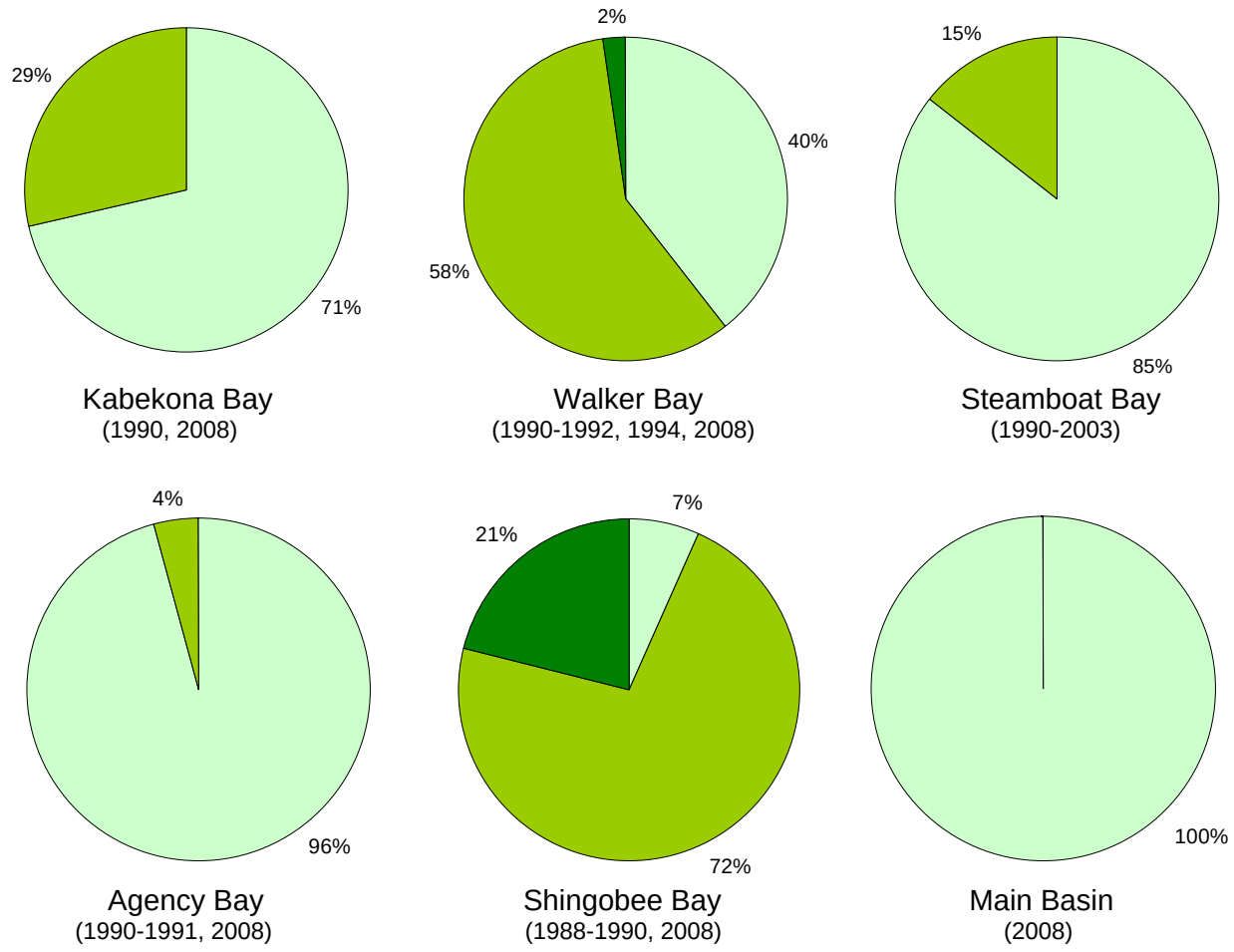


Figure 5. Recreational suitability rating for each bay as rated by the volunteer monitor.

Total Phosphorus

Leech Lake is most likely phosphorus limited, which means that algae and aquatic plant growth is dependent upon available phosphorus and reducing phosphorus sources to the lake will decrease algae concentrations.

Total phosphorus was evaluated in Leech Lake in 2008 through an MPCA Surface Water Assessment Grant (Figure 6). This grant will cover data collection in 2009 as well. The 2008 results are similar to what one would expect in comparing the 5 bays. Walker Bay consistently had the lowest phosphorus concentrations, and Kabekona Bay had the next lowest phosphorus concentrations.

Shingobee Bay and the Main Basin had the highest phosphorus concentrations.

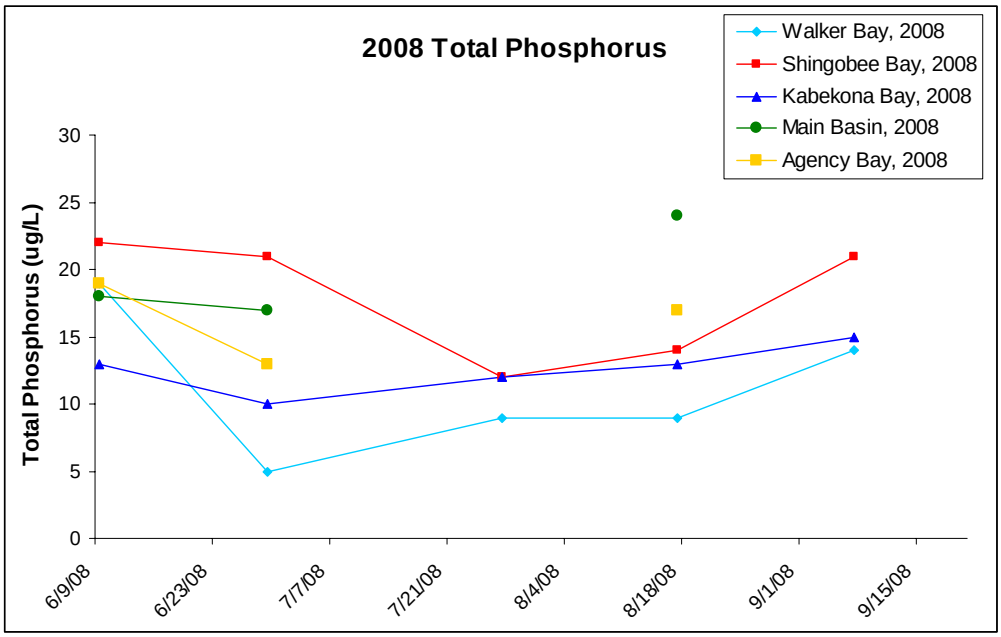


Figure 6. 2008 total phosphorus concentrations (ug/L) for Leech Lake.

The DNR has collected total phosphorus data in Walker Bay and the Main Basin of Leech Lake each year between July 21 and August 20. The results are shown in Figure 7. Walker Bay had consistently lower phosphorus concentrations than the Main Basin.

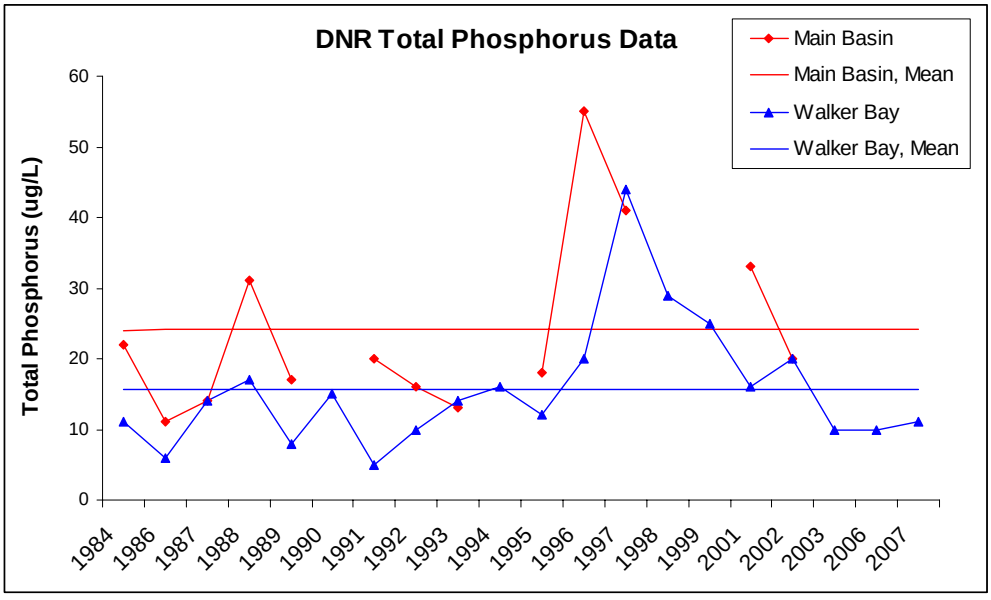


Figure 7. Total phosphorus concentrations (ug/L) for Leech Lake collected between July 21 and August 20 for each year.

In 1996 and 1997 phosphorus concentrations were much higher than average. Historical records could be checked to see if there was some large impact to Leech Lake over those two years.

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.

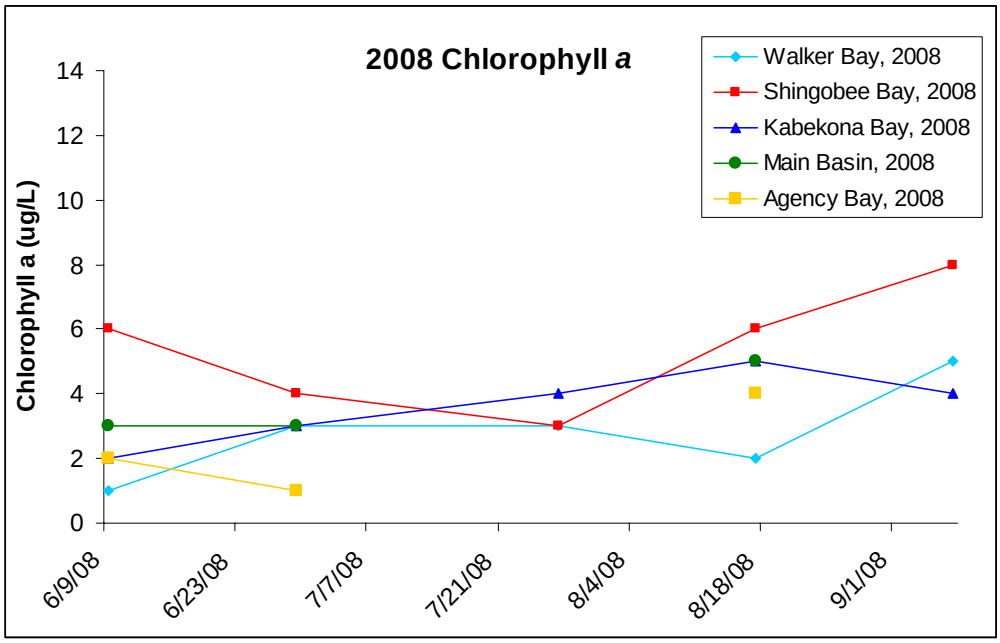


Figure 8. 2008 chlorophyll *a* concentrations (ug/L) for Leech Lake.

Chlorophyll *a* was evaluated in Leech Lake in 2008 through an MPCA Surface Water Assessment Grant. This grant will cover data collection in 2009 as well.

The 2008 results (Figure 8) show that chlorophyll *a* concentrations remained below 10 ug/L for all bays. Shingobee Bay consistently had the highest chlorophyll *a* concentration of all the bays. Walker and Agency Bays had the lowest chlorophyll *a* concentration.

The DNR has collected chlorophyll *a* data in Walker Bay and the Main Basin of Leech Lake each year between July 21 and August 20. The results are shown in Figure 9. Walker Bay had consistently lower chlorophyll *a* concentrations than the Main Basin.

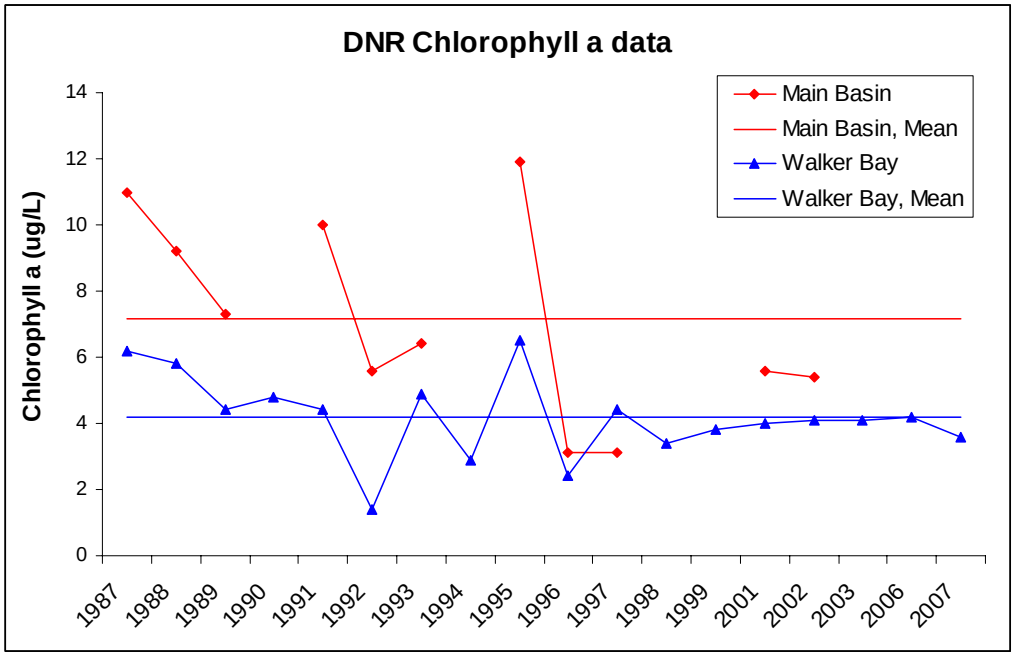


Figure 9. Total phosphorus concentrations (ug/L) for Leech Lake collected between July 21 and August 20 for each year.

Since these DNR results only represent July and August, they don't capture the entire growing season. The means are most likely on the high end since chlorophyll a concentrations are usually lower in May and September and higher in July and August.

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 fish.

Leech Lake is made up of many bays, and each behaves somewhat differently due to its size, shape and depth. The main basin is very large and relatively shallow (approximately 30 feet deep). The main basin stratifies only after numerous consecutive calm days. Any time the wind picks up the basin mixes, which mixes oxygen throughout the water column (Figure 10).

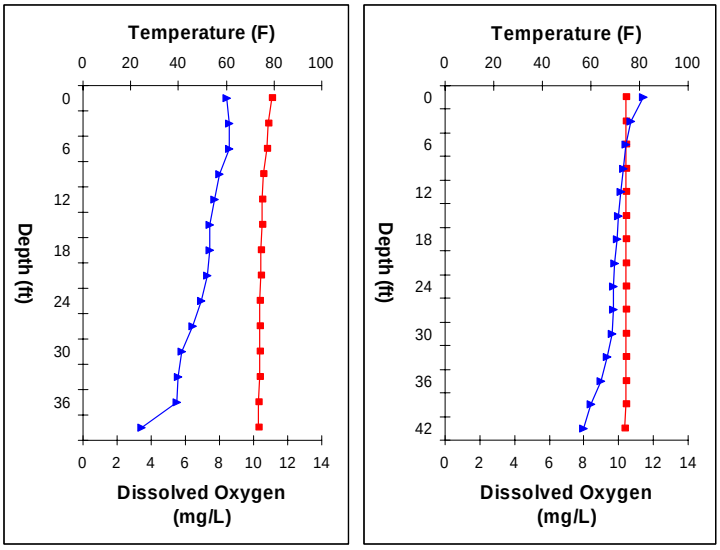
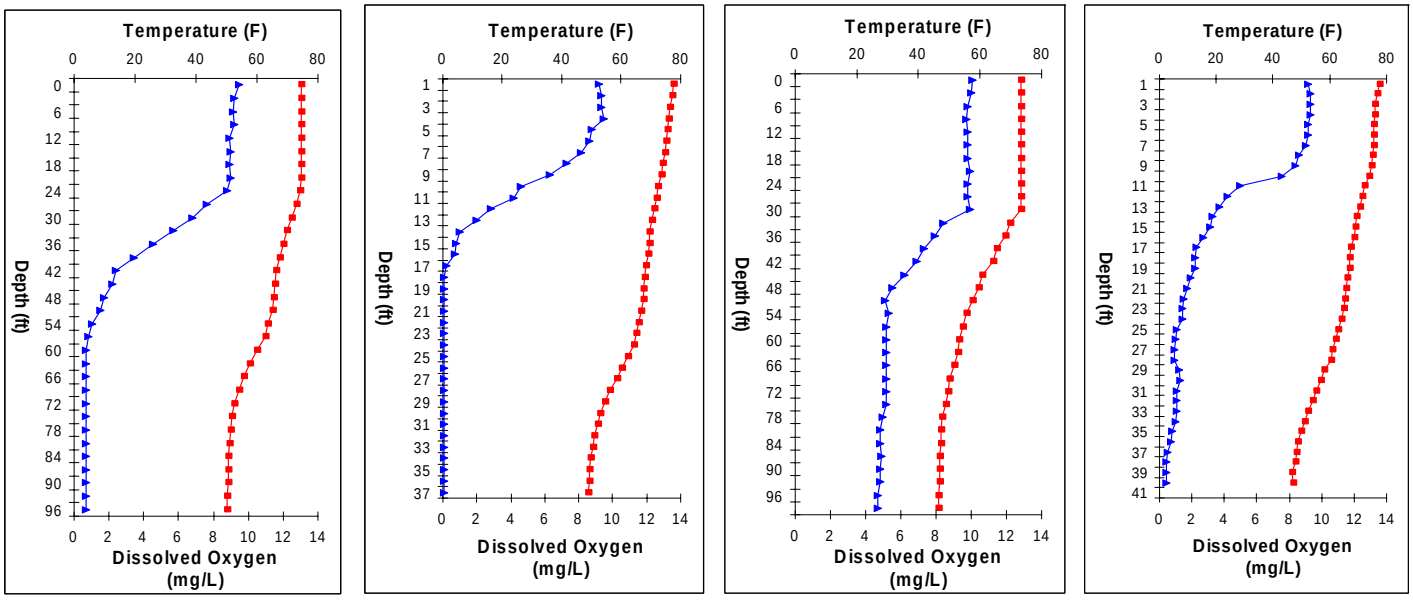


Figure 10. Temperature and dissolved oxygen profiles for the Main Basin, 10 August 2007 and 2008 (source: Schultz 2007, Schultz 2008).

Steamboat Bay is very shallow (15 feet deep), and it continually mixes throughout the summer. The sunlight can reach the bottom of Steamboat Bay, causing aquatic plants to grow. These plants produce oxygen as a by-product of photosynthesis, which keeps the water column fully oxygenated.

The deep bays (Walker, Agency and Kabekona) stratify in the summer and only mix in the spring and fall (dimictic) (Figure 11). In these bays, dissolved oxygen gets used up at the bottom of the lake by decomposition, and the oxygen doesn't replenish until the lake mixes in the fall.



Agency Bay, 2008 Agency Bay, 2007 Walker Bay, 2008 Walker Bay, 2007

Figure 11. Temperature and dissolved oxygen profiles for Agency Bay and Walker Bay in August of 2007 and 2008 (Schultz 2007, Schultz 2008).

Trophic State Index

Trophic State Index	Main Basin	Walker Bay	Agency Bay	Steamboat Bay	Kabekona Bay	Shingobee Bay
TSI Total Phosphorus	48	38	44	-	41	45
TSI Chlorophyll-a	43	40	38	-	43	47
TSI Secchi	46	42	43	46	44	44
TSI Mean	46	40	42*	-	43	45
Trophic State:	Mesotrophic	Oligotrophic	Low Mesotrophic	Mesotrophic	Low Mesotrophic	Mesotrophic

Numbers represent the mean TSI for each parameter.
**Because the TSI for phosphorus and chlorophyll a are not within 5 points of each other, it is not appropriate to average them to determine an overall TSI mean.*

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 biological material (*biomass*) in a waterbody at a specific location and time.

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.

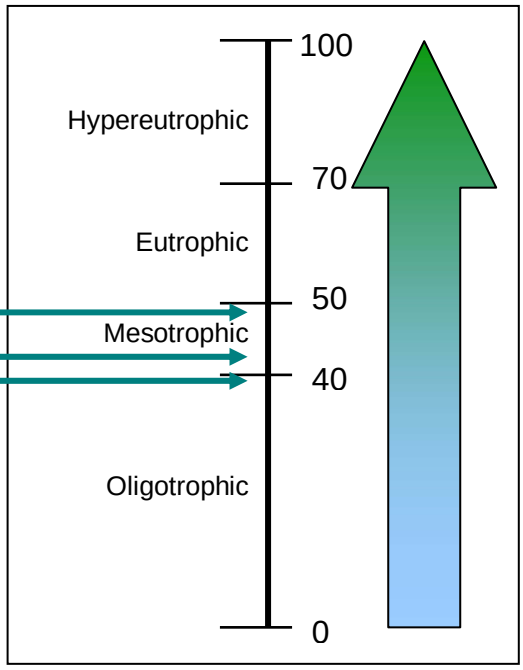


Figure 12. Trophic state index chart with corresponding trophic status.

The data sets for calculating the total phosphorus and chlorophyll *a* TSI are very limited for all sites (see table on page 4). The results indicate that Walker Bay is oligotrophic, Agency and Kabekona Bays are on the low end of the mesotrophic range, and the Main Basin, Steamboat Bay and Shingobee bay are mesotrophic. Collecting more data would better explain the pattern and the relationship between phosphorus, chlorophyll *a* and transparency in Leech Lake.

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, Tullibee 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 Leech Lake. Only site 203 in Steamboat Bay had enough transparency data to perform a long-term trend analysis (14 years). The data were analyzed using the Mann Kendall Trend Analysis.

Basin	Lake Site	Parameter	Date Range	Trend	Probability
Steamboat	203	Transparency	1990-2003	Improving	99.9%

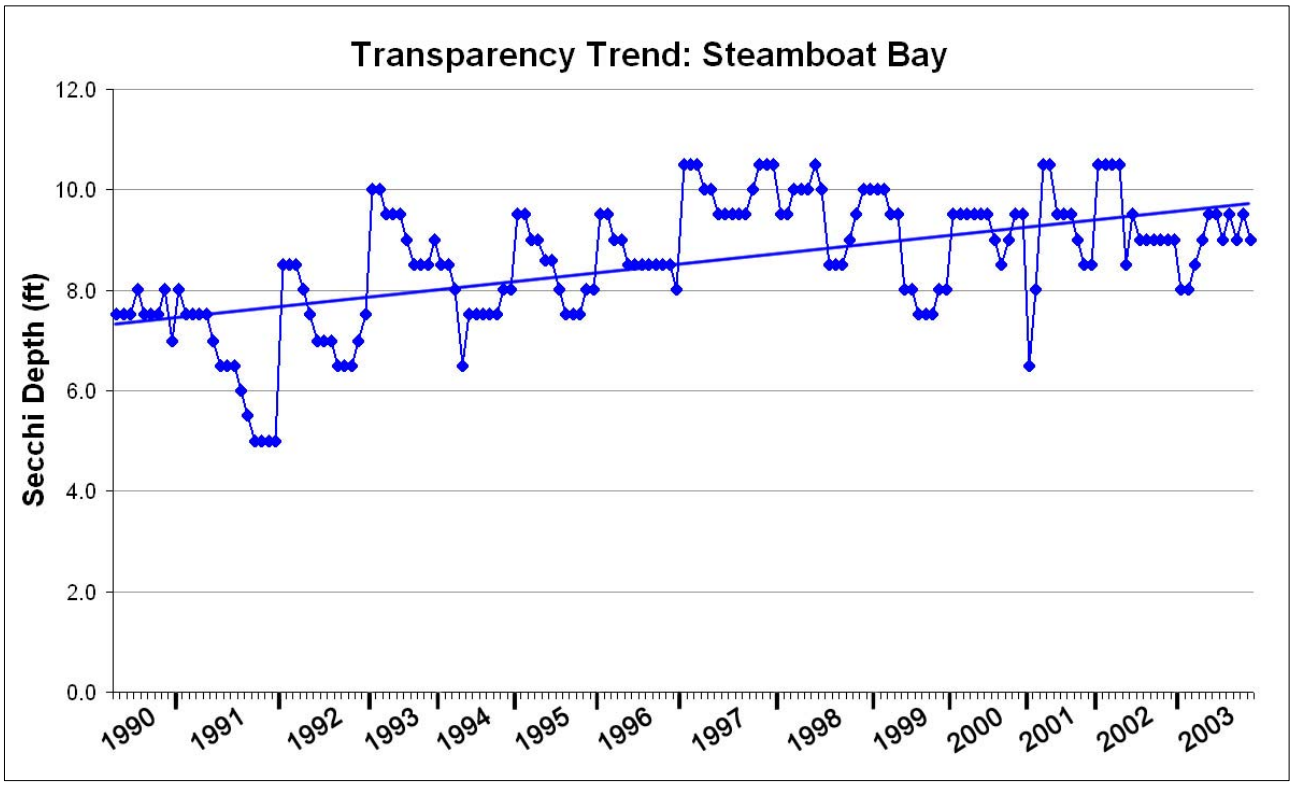


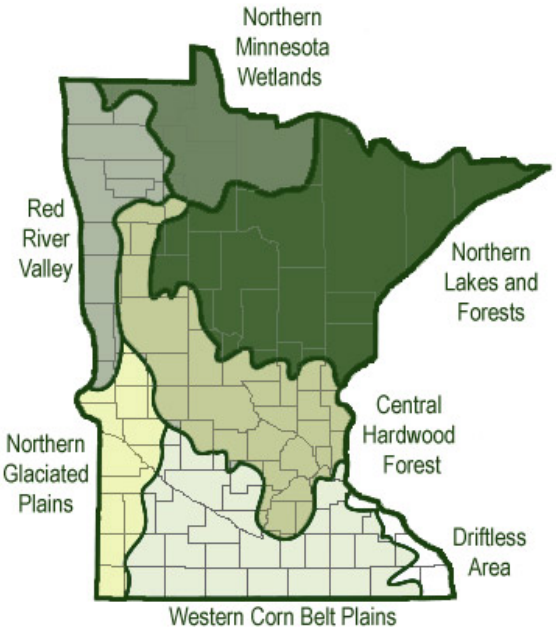
Figure 13. Transparency trend for Steamboat Bay, 1990-2003.

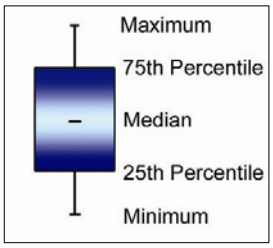
Site 203 in Steamboat Bay shows an improving transparency trend from 1990-2003 (Figure 13). The transparency improved an average of approximately 2 feet over that time period. Possible reasons for improvement could be tied to the Steamboat River inlet and any improvements in land management in the watershed.

Transparency data should be collected continuously at this site and in the other bays to determine if trends continue.

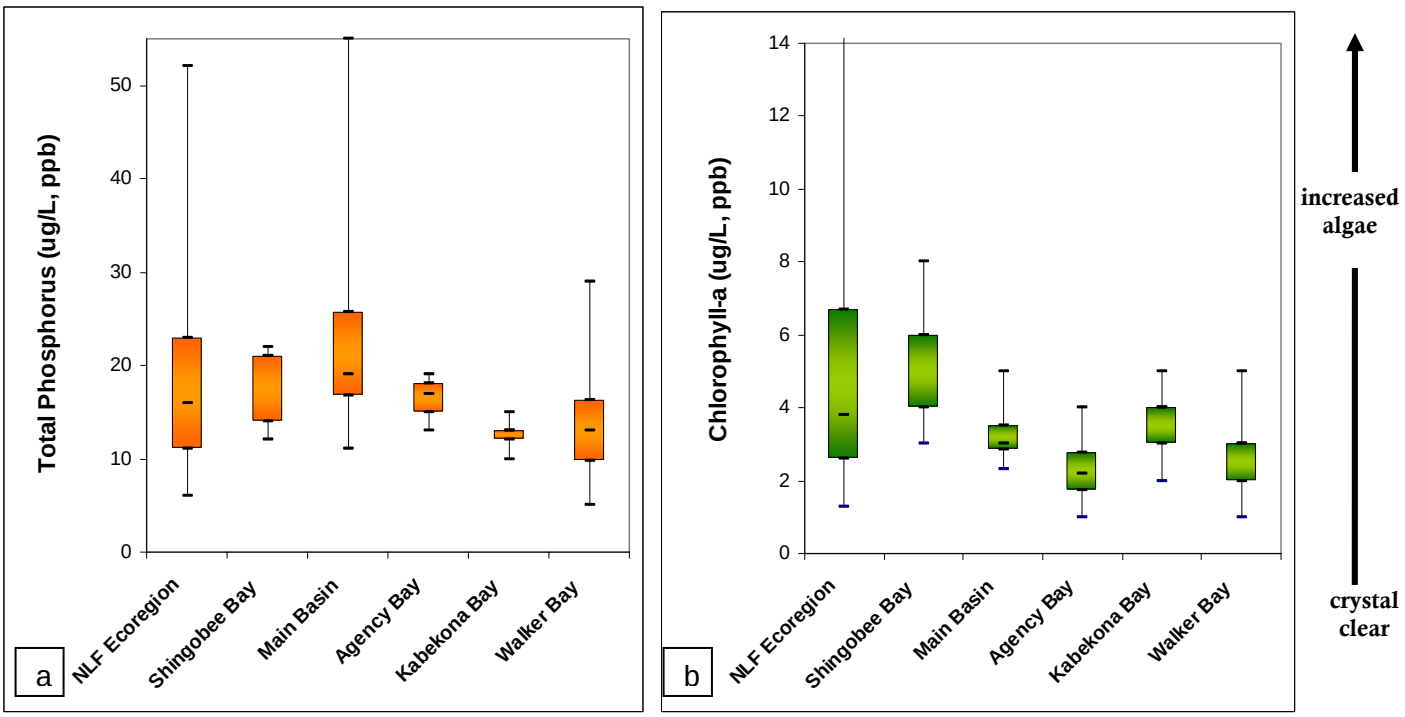
Ecoregion Comparisons

Minnesota is divided into seven 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. 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.





Leech Lake is in the Northern Lakes and Forests (NLF) Ecoregion. The total phosphorus, chlorophyll *a* and transparency (secchi depth) for all bays are within the expected ecoregion ranges (Figures 14a-b).



Figures 14a-b. Leech Lake ranges compared to Northern Lakes and Forest Ecoregion ranges. The Leech Lake total phosphorus and chlorophyll *a* ranges for all bays with the exception of the Main Basin and Walker Bay are from data collected in 2008. Walker Bay and the Main Basin ranges included data from the DNR that covers 1984, 1986-1999, 2001-2002.

Shingobee Bay, Steamboat Bay and the Main Basin are at the lower end of the ecoregion range. These basins are relatively shallow and more productive, causing lower transparency. Agency, Kabekona and Walker Bay are well within the expected ecoregion range (Figure 14c).

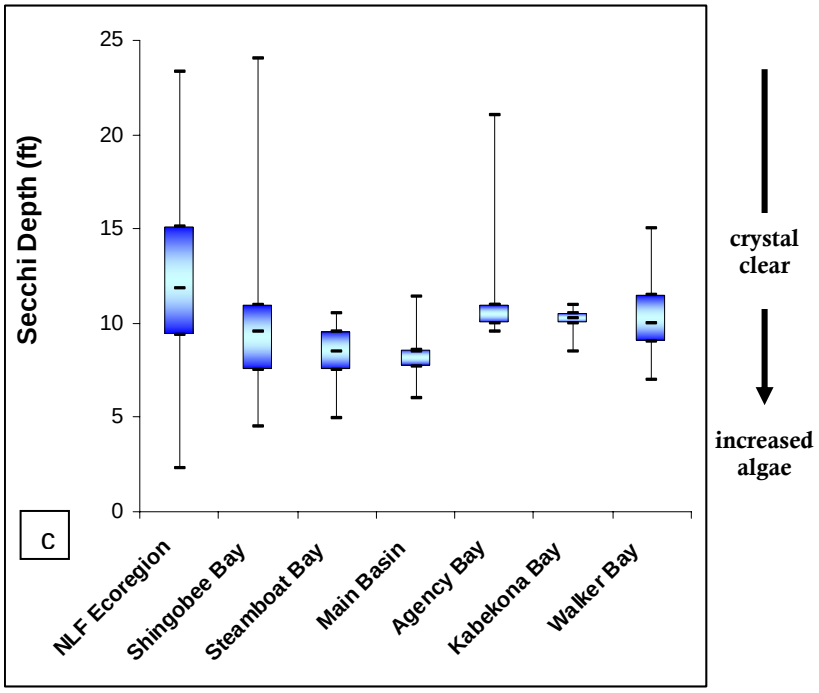


Figure 14c. Leech Lake secchi depth ranges compared to Northern Lakes and Forest Ecoregion ranges. See the table on page 4 for the number of data points contained in each range.

Inlet/Outlet Assessment

There is no inlet or outlet data for Leech Lake within the past decade. Some limited data exist from the USGS and USFWS from 1975 and 1993; however it mainly consists of field data such as dissolved oxygen, pH and temperature.

In 1997, the Minnesota Chippewa Tribe Laboratory and the Leech Lake Division of Resource Management of the Leech Lake Band of Ojibwe completed a Leech Lake Watershed Assessment. This assessment included monitoring the inlets and outlet of Leech Lake (Figure 15). The results can be found in Table 1 below.

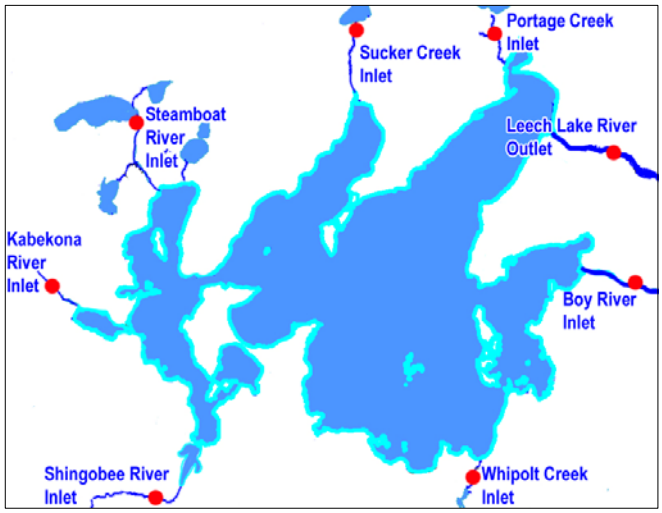


Figure 15. Leech Lake tributary monitoring sites (Persell, 1997).

The Boy River contributes the most phosphorus loading of all the inlets to Leech Lake while Whipolt Creek contributes the least. Loading takes into account both phosphorus concentration and stream volume.

Table 1. Stream volumes and loading data for Leech Lake inlets and outlet (Persell, 1997). The data is calculated from 8 data points collected in 1995-1997. The table is sorted by phosphorus loading from low to high.

Stream Name	Average Volume (cfs)	Total Phosphorus Concentration mean (ug/L)	Phosphorus Loading (lbs/year)
Whipolt Creek	5.8	18	216
Portage Creek	22.0	22	920
Sucker River	19.2	33	1,266
Steamboat River	74.1	19	2,620
Kabekona River	154.5	13	4,128
Shingobee River	98.3	36	6,730
Boy River	313.5	15	8,779
Leech Lake River (Outlet)	906.1	14	23,806

The 1997 assessment included analyses for the lake taking the phosphorus loading data into account. The results showed that the majority of phosphorus loading to Leech Lake comes from precipitation and tributaries (Figure 16). Because of the large surface area of Leech Lake, precipitation and atmospheric deposition are significant contributors of phosphorus. Just 5% of the phosphorus loading to Leech Lake comes from septic systems.

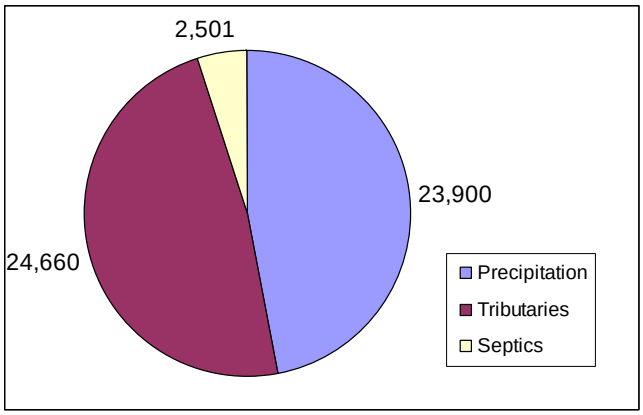


Figure 16. Annual phosphorus inputs to Leech Lake in lbs.

Table 2. Leech Lake Phosphorus Budget Analysis (Persell, 1997).

Total Annual Phosphorus Input	51,061 lbs
Total Annual Phosphorus Output	23,806 lbs
Annual Phosphorus Storage APS = input-output	27,255 lbs
Lake Phosphorus Mass LMP = (Lake [TP] x Lake volume)	69,562 lbs
Phosphorus Loading Ratio (APS/LMP) x 100	39%

In conclusion, based upon the data collected during the 1997 study, it appears that erosion and nutrient abatement practices in the Leech Lake watershed are effective management tools. Continued efforts to implement these resource conservation practices may reduce the direct watershed phosphorus load by 10%-15%, a substantial quantity for this relatively clean ecosystem (Persell, 1997).

Assessment/Findings Recommendations

Transparency

Transparency data is extremely sparse and disjointed for Leech Lake. Monitoring at the sites in Table 3 should be continued each year. It is important to continue transparency monitoring weekly or at least bimonthly every year to enable year-to-year comparisons and trend analyses.

Table 3. Recommended Monitoring Sites.

Bay	Site
Walker	101
Agency	204
Steamboat	203
Shingobee	203
Main Basin	210
Kabekona	202

Since Leech Lake is so large, it is not feasible for one person to do all the transparency monitoring. A water quality task force could be formed, where each site has their own volunteer assigned to do weekly or bimonthly secchi disk readings. That way, at the end of each year all the data would go to the MPCA and comparisons can be made between sites and years of collection.

Impaired Waters Assessment 303(d) List

There are two main types of Impaired Waters Assessment for lakes: eutrophication (phosphorus) for aquatic recreation and mercury in fish tissue for aquatic consumption. Leech Lake was listed as impaired for aquatic consumption on the 2006 Impaired Waters List; however it is part of the statewide mercury TMDL and therefore was not on the 2008 Impaired Waters List.

As of 2008, the Leech Lake data set is insufficient for Impaired Waters Assessment for eutrophication. A data set of 10 data points each of total phosphorus, chlorophyll *a*, and secchi depth over a two-year period in the past 10 years is required for eutrophication assessment. The 2008 and 2009 data will suffice for the 2010 Impaired Waters Assessment.

In addition, there are currently no impaired streams inletting to Leech Lake; however, most of the stream inlets have not been assessed for impaired conditions. For further information regarding the Impaired Waters Assessment program, refer to http://www.pca.state.mn.us/water/tmdl/index.html

Aquatic Recreational Use Assessment 305(b)
In the 2008 MPCA Aquatic Use Assessment (305(b)), Leech Lake did not have enough data to be included this assessment. The 2008 and 2009 data will count towards the next assessment in 2010.

Inlet/Outlet Assessment
It may be beneficial to do a full assessment of all main inlets and outlets to see if there are any problem areas. Since tributary contributions to the lake can change throughout the years, it is important to periodically re-check these sites to determine if any changes in loading have occurred.

Organizational contacts and reference sites

Leech Lake Association	P.O. Box 1613, Walker MN 56484 http://www.minnesotawaters.org/index.php?uberKey=1295 leechlake@mnlakes.org
Leech Lake Area Watershed Foundation	P.O. Box 455, Hackensack, MN 56452 218-675-5773, http://www.leechlakewatershed.org/ info@leechlakewatershed.org
Leech Lake Band of Ojibwe Division of Resource Management	15756 State 371 NW, Cass Lake, MN 56633 (218) 335-7400 http://www.lldrm.org/index.html
Cass County Environmental Services Department	303 Minnesota Avenue W, P.O. Box 3000, Walker, MN 56484-3000 (218) 547-7241 http://www.co.cass.mn.us/esd/home_esd.html
DNR Fisheries Office	7316 State Hwy 371 NW, Walker, MN 56484 (218) 547-1683 http://www.dnr.state.mn.us/lakefind/index.html
Regional Minnesota Pollution Control Agency Office	7678 College Road, Suite 105, Baxter, MN 56425 (218) 828-2492, 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

References:

Persell, John. 1997. A Water Quality Assessment of the Leech Lake Watershed. Leech Lake Division of Resource Management, Minnesota Chippewa Tribe. Cass Lake, MN.

Schultz, Doug. 2007. Large Lake Sampling Program Assessment Report for Leech Lake. Minnesota Department of Natural Resources, Division of Fisheries and Wildlife, Completion Report, F-29-R(P)-27, Study 2.

Schultz, Doug. 2008. Large Lake Sampling Program Assessment Report for Leech Lake. Minnesota Department of Natural Resources, Division of Fisheries and Wildlife, Completion Report, F-29-R(P)-28, Study 2.