PGOLID

Lake Management Plan

2016 Edition

Pelican Lake
Little Pelican Lake
Bass Lake
Fish Lake

Prepared by:
Moriya Rufer, current PGOLID Water Resource Coordinator

Past Lake Mangement Plans by:
(2006) Jordan Ornquist, former PGOLID Water Resource Coordinator
(2004) Steve McComas, Blue Water Science

Direction and Supervision by:
Pelican Group of Lakes Improvement District Board
RMB Environmental Laboratories, Inc.

Acknowledgements

Supervision and funding provided by:
Pelican Group of Lakes Improvement District Past and Present Board Members

Mike Ostbye
Jeff Peltier
Lisa Wheeler
Jonal Uglem
Denny Tollefson
Nick Valentine
Vance Stueness
Gary Hart
Doug Oksendahl
Bill Zimmerman
Doug Johnson
Larry Kohler
Ed Johnson
Suzanne Lervick
Bill Kelsven
Jay Elshaug
Bert McDonough
Melody Jensen
Paul Horstmann

Water quality data collection
Moriya Rufer, PGOLID Water Resource Coordinator (2006-present)
Emelia Hauck, RMB Environmental Laboratories (2014-present)
Jordan Ornquist, former PGOLID Water Resource Coordinator (2004-2006)

Report preparation and data analyses
Moriya Rufer, PGOLID Water Resource Coordinator (2009, 2013 & 2016 Lake Management Plan)
Emelia Hauck, RMB Environmental Laboratories (2016 Lake Management Plan)

Past report preparation and data analysis
Steve McComas, Blue Water Science (2004 Lake Management Plan)
Jordan Ornquist, former PGOLID Water Resource Coordinator (2006 Lake Management Plan)

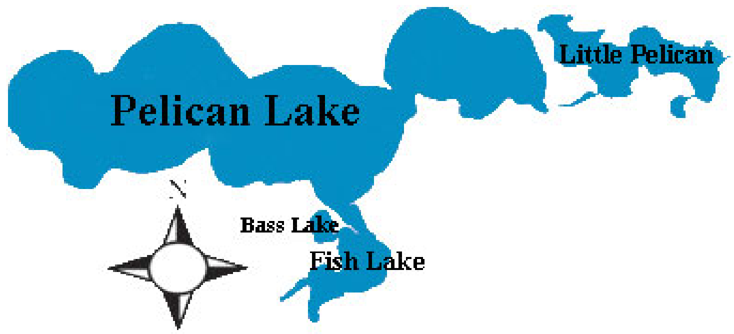
Organizational contacts and reference sites

Pelican Group of Lakes Improvement District (PGOLID)	http://www.pgolid.org
PGOLID Water Resource Coordinator	Moriya Rufer (2006-present) c/o RMB Environmental Laboratories, Inc 22796 County Highway 6 Detroit Lakes, MN 56501 (218) 846-1465 moriyar@rmbel.info
Pelican Lake Property Owners Association	PO Box 1782 Detroit Lakes, MN 56502 plpoa@pelicanlakemn.org http://www.pelicanlakemn.org/
West Otter Tail Soil and Water Conservation District	506 Western Ave N Fergus Falls, MN 56537 (218) 739-1308 ext.3 brad.mergens@mn.nacdnet.net http://www.eotswcd.fatcow.com/WOTSWCDORG/WOTHome.htm
Otter Tail County Land and Resource Department	Government Services Center 540 Fir Ave W Fergus Falls, MN 56537 (218) 998-8095 http://www.co.otter-tail.mn.us/land/default.php
DNR Fisheries Office	1509 1st Avenue North Fergus Falls, MN 56537 (218)-739-7576 FergusFalls.fisheries@dnr.state.mn.us http://www.dnr.state.mn.us/areas/fisheries/fergusfalls/index.html
Regional Minnesota Pollution Control Agency Office	714 Lake Ave., Suite 220 Detroit Lakes, MN 56501 218-847-1519 1-800-657-3864 www.pca.state.mn.us

Table of Contents

Chapter 1. Executive Summary

Introduction



The PGOLID Lake Management Plan is a comprehensive report from over a decade of data collection and effort from many organizations, including PGOLID, the Pelican Lake Property Owners Association, Blue Water Science and RMB Environmental Laboratories. This plan's purpose to address long range, ongoing concerns and issues related to water quality preservation and lake management. It is intended to be a working document that will provide direction and aid in cooperative decision making for the PGOLID Board, residents of PGOLID, county government, and the public at large with vested interests in establishing and maintaining high standards of water quality and sustainable use of these lakes as a natural resource for generations to come. It is a summary of water quality data, various lake projects, ongoing lake programs and recommendations for future projects. This report is also available online and gets updated yearly once the previous year's data is analyzed (http://www.pgolid.org/LMP/main.htm).

The Pelican Group of Lakes encompasses 4 lakes: Pelican, Little Pelican, Bass, and Fish. Although these lakes have somewhat different characteristics, they are all considered to have good water quality for northwest Minnesota.

Understanding What Impacts the Pelican Lakes

- Lake water quality results are within range compared to other lakes in the ecoregion.
- The water quality of the tributary streams is generally good and does not appear that stream inputs of nutrients are great enough to generate problems at this time.
- The lake basins upstream in the watershed act as sedimentation basins and help promote good water quality as streams make their way to the Pelican Lakes.
- Land cover analysis (pages 16-17) shows that impervious surface has increase significantly around PGOLID lakes. Impervious surface causes stormwater to run off into the lake instead of being soaked into the ground. To protect water quality, impervious surface should be minimized.
- Shoreline inventory and visual inspections show that about 60% of the shoreline around the PGOLID lakes is unnatural (manicured lawns) (page 121). In order to preserve water quality, manicured lawns should be converted back into natural vegetation, trees and shrubs.

PGOLID Lake Vitals

	Pelican	Little Pelican	Bass	Fish
Size (acres)	3,986	345	48	261
Mean depth (ft)	22	12	18	27
Littoral area (%)	41	74	50	48
Maximum depth (ft)	55	25	33	69
Volume (acre ft)	87,692	4,140	864	7,047
Watershed Area (acres)	164,092	96,538	138	162,190
Trophic State Index (TSI)	41	46	42	40
Total Phosphorus Mean (ug/L)	14	24	17	12
Chlorophyll *a* Mean (ug/L)	5	10	5	4
Chlorophyll *a* Maximum (ug/L)	17	31	17	9
Transparency (Secchi depth, ft)	12.6	8.3	12.0	12.4

PGOLID Goals

The Pelican Group of Lakes Improvement District (PGOLID) was formed to identify, quantify, study, and manage water resources as to preserve quality. Goals that have led to this report were outline by PGOLID early in 2002. The overall scope can be broken into tasks by subject.

1. Water Quality Evaluation
- Interpretation and analysis of existing lake data
- Identification of all potential sources of lake water pollution, e.g. septic, chemical, runoff, etc.
- Stream monitoring
- Collection of new lake water quality data
- Evaluation of wetlands for wildlife and water quality services
- Characterize lake sediments to evaluate potential for nuisance growth of aquatic invasive plants

2. Invasive Species Management
- Prevention of invasive species through education and DNR intern program
- Control of invasive plants with herbicide
- Promote re-establishment of native plants for quality habitat.

3. Pest Control
- Management of mosquitoes with pesticides to prevent the spread of mosquito-borne illnesses and promote enjoyment of the lake
- Annual spring monitoring for Tent caterpillars and funding available for pesticide treatment if necessary

4. Wildlife and Aesthetics
- Evaluate shoreland conditions
- Promote shoreline restoration
- Recommend ways to improve natural areas

5. On-Site Waste Treatment Systems
- Maintain septic system records of lake properties to monitor the age of systems and possible impacts to the lake
- Encourage residents to properly maintain septic systems and holding tanks

7. Lake Use and Recreation
- Monitor crowding potential
- Placement of buoys for boating safety

8. Lake Management Program
- List ongoing programs and projects
- List of new lake management recommendations
- Identify funding sources, e.g. grants

9. Information and Education
- Keep residents informed of PGOLID projects
- Stay abreast of new rules, regulations and legislation and pass any changes on to residents

PGOLID Programs

Mosquito Treatment

Category	Description	Person(s) Responsible
Mosquito Treatment	PGOLID hires an independent contractor to treat the perimeter of the lake for mosquitoes weekly throughout the summer.	Independent Contractor: Clarke
Recommendations	Continue Program as designed.	

Lake Monitoring

Category	Description	Person(s) Responsible
Baseline Water Quality Monitoring	1. Collect water samples at designated lake sites once a month from May to September and evaluate for total phosphorus, chlorophyll *a*. 2. Secchi disk monitoring once a month from May to September. 3. Dissolved oxygen and temperature profiles taken once a month from May to September.	PGOLID Water Resource Coordinator
Extra Water Quality Monitoring Projects	1. In 2008-2010, hypolimnion water samples collected twice a month from May to September to evaluate internal phosphorus loading from the lake sediment. 2. In 2009-2010, additional water quality parameters collected including ortho-phosphorus, total nitrogen, chloride, alkalinity, color, conductivity, and total suspended solids. 3. In 2007-2008, collected water samples in Echo Bay to evaluate conditions before a potential new development. 4. In 2015, additional water quality parameters collected to evaluate Zebra mussel suitability: calcium, alkalinity, chloride, magnesium, pH, total dissolved solids, potassium and bicarbonate. 5. In 2015-2016, collect water samples in Echo Bay to see if there are any changes since 2008.	PGOLID Water Resource Coordinator
Special Lake projects	1. Aquatic insect biomonitoring survey (2008). 2. Zooplankton community monitoring (2015).	PGOLID Water Resource Coordinator
Recommendations	1. Continue baseline monitoring, and add extra monitoring and special projects when necessary.	PGOLID Water Resource Coordinator

Watershed/Stream Monitoring

Category	Description	Person(s) Responsible
Baseline Water Quality Monitoring	1. Collect water samples at designated stream inlets monthly (total phosphorus, total suspended solids, water flow, dissolved oxygen, temperature, conductivity). 2. Collect water samples at designated stream inlets after storm events each season (>1 inch rain).	PGOLID Water Resource Coordinator
Extra Water Quality Monitoring Projects	1. Collect extra water samples during spring thaw to track the snow melt runoff into streams. 2. Collect E.coli samples at Bob Creek and Burton Lake Outlet during baseline monitoring and storm event monitoring to evaluate any health risks from upstream cattle operation. 3. Deploy a flow data logger to establish a rating curve for Pelican River (2015-2016).	PGOLID Water Resource Coordinator
Special Stream projects	1. Aquatic insect biomonitoring survey (2008).	PGOLID Water Resource Coordinator
Recommendations	2. Continue baseline monitoring, and add extra monitoring and special projects when necessary.	PGOLID Water Resource Coordinator

Aquatic Plant Projects

Categories	Description	Person(s) Responsible
Aquatic Plant Surveys	1. In 2003, Blue Water Science was hired to survey aquatic plants in the PGOLID lakes. This transect survey showed moderate aquatic plant diversity and the presence of invasive curly-leaf pondweed. 2. In 2010-2011, PGOLID completed a point intercept survey for all four lakes as a follow-up to the 2003 survey. 3. In 2015, completed a point intercept plant survey on Echo Bay to document the native plant community.	1. Blue Water Science 2. Independent Contractor 3. RMB Environmental Laboratories
Recommendations	Continue plant surveys every 10 years or so to monitor diversity and the presence of any new invasive species.	PGOLID Water Resource Coordinator

On-site Waste Treatment Systems

Project	Description	Person(s) Responsible
County Records Survey, 2004	Obtained county records for on-site waste treatment systems and evaluated the status and age of systems.	Blue Water Science
Waste Treatment System Screening Volunteer Survey, 2006	Invited lake residents to volunteer for a screening of their on-site waste treatment system.	PGOLID Water Resource Coordinator
County inspections of on-site waste treatment systems and abatements	In 2007-2009, Otter Tail County inspected on-site waste treatment systems that were 20 years old or older. They abated the properties that did not meet requirements.	Otter Tail County Land and Resource Department
County Records Survey, 2012	Obtained county records for on-site waste treatment systems and evaluated the status and age of systems. Compared to 2004 survey.	PGOLID Water Resource Coordinator
Outreach, 2013	Sent a letter to all residents with septic systems or holding tanks over 20 years old recommending they have it checked. Sent out an anonymous voluntary survey to home owners asking about how they maintain their system, while educating them on proper maintenance.	PGOLID Water Resource Coordinator
Recommendations	Maintain records from the county on the ages of septic systems and continue to education residents about waste treatment and water quality.	PGOLID Water Resource Coordinator

Invasive Species Projects

Categories	Description	Person(s) Responsible
Chemical Treatment of Aquatic Invasive Plants	1. PGOLID started a Curly-leaf pondweed (CLP) treatment program in 2005. This project has shown a great reduction in CLP and is an ongoing project.	Licensed chemical applicator
Surveys	1. From 2007-present, Eurasian flowering rush surveys are conducted from Buck's Mill to Little Pelican lake. Any flowering rush that is found is hand-removed. This project is ongoing and follows a flowering rush contingency plan. 2. From 2006-present, inspect areas around public accesses for Eurasian watermilfoil.	PGOLID Water Resource Coordinator
DNR Watercraft Inspection Program	1. From 2006-present, PGOLID has participated in the DNR Watercraft Inspection Program. This program hires DNR interns for the summer to inspect boats for invasive species and survey boaters entering and exiting the two Pelican Lake accesses.	Minnesota Department of Natural Resources (DNR)
Zebra Mussels	1. Educate PGOLID property owners about new regulations that apply to PGOLID lakes since zebra mussels were found in 2009.	PGOLID Water Resource Coordinator and PGOLID Board
Zebra Mussel Monitoring	1. Monitor Zebra mussel veliger density every two weeks throughout the summer, 2012-present. 2. Monitor Zebra mussel adult density and distribution, 2013- present.	PGOLID Water Resource Coordinator
Recommendations	Continue all programs as currently designed.	PGOLID Water Resource Coordinator and PGOLID Board

Shoreland Projects

Projects	Description	Person(s) Responsible
Shoreland Inventory	In 2004, Blue Water Science was hired to conduct a shoreland inventory on PGOLID lakes. This project evaluated how many parcels had 50% natural vegetation along the shoreline in a strip at least 15 feet deep. The results showed that 40% of properties met these criteria.	Blue Water Science
Shoreline Habitat Restoration Grant	PGOLID has been awarded 3 different grants from the DNR to restore shorelines. Through this program we have completed 15 projects since 2009.	PGOLID Water Resource Coordinator
Recommendations	In the next five years, complete a new shoreland inventory and compare results to 2004 to see if there is any improvement. Implement a voluntary tree and native wildflower seed planting program	PGOLID Water Resource Coordinator

Information and Education

Categories	Description	Person(s) Responsible
Educational Seminars and Presentations	1. Educational seminars for lake residents in the summer. 2. Educational presentations at PGOLID and PLPOA meetings.	PGOLID Water Resource Coordinator
Dissemination of Educational Information Via Electronic Sources	1. Articles in the Pelican Brief (Pelican Lake Property Owners Association [PLPOA] Newsletter). 2. PGOLID website. 3. Pelican Lake Property Owners Association Website (PLPOA).	PGOLID Water Resource Coordinator and PGOLID Board
New Regulations	1. Keep abreast of new state/county/local government lake regulations and disseminate the information in an understandable way to PGOLID residents.	PGOLID Water Resource Coordinator and PGOLID Board
Community	1. Work with upstream landowners, farmers, ranchers, and other lake associations to act in a proactive manner in the protection of the water quality that flows into the PGOLID.	PGOLID Water Resource Coordinator and PGOLID Board
Recommendations	Continue all programs as currently designed.	PGOLID Water Resource Coordinator and PGOLID Board

Recommendations Summary

These recommendations were provided by the PGOLID Water Resource Coordinator after evaluating the status of past and present projects and the resulting data. These recommendations were written in March of 2016.

1. **Monitoring**: Continue current baseline lake and stream monitoring programs and add extra monitoring and special projects when deemed necessary by the PGOLID Water Resource Coordinator and PGOLID Board.

2. **On-site Waste Treatment Systems**: Continue educating PGOLID residents through various means including surveys, the Pelican Brief and e-communications.

3. **Aquatic Plant Surveys**: Complete a new survey every 10 years or so to monitor plant diversity and the presence of any new invasive species.

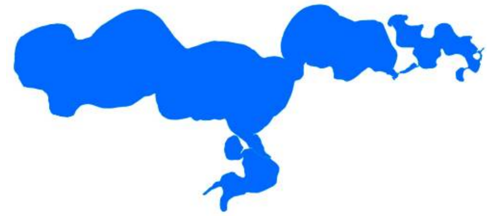
4. **Invasive Species**: Continue all current programs including Curly-leaf pondweed treatment, Eurasian flowering rush surveys and removal, zebra mussel monitoring, and DNR Watercraft Inspection Program.

5. **Shoreland Projects**: In the next five years, complete a new shoreland inventory project and compare results to 2004 to see if there is any improvement due to increased education and the DNR Shoreline Habitat Restoration Grants.

6. **Information and Education**: Continue current educational programs including articles for the website, educational seminars and presentations at meetings, communication with neighboring districts and land owners, and new regulation information.

7. **Land Conservation**: Promote the conservation of undeveloped shoreland parcels and smart responsible low-impact development practices. Protect land and limit the opportunities for future high-impact developments via conservation easements.

Chapter 2. Watershed Characteristics



The Pelican Lakes are glacial lakes formed during the last retreat of the Red River Lobe starting about 13,000 years ago. The soils deposited by the glacier are primarily sands and loamy sands.

The Pelican Lakes' watershed is approximately 162,000 acres (includes lake acres) and the watershed to lake ratio of the Pelican Lake is about 40 to 1. The watershed has the potential to have a huge impact on Pelican Lake; however, much of the watershed area drains through large lakes first before the water reaches the Pelican Lakes. The upstream lakes act as "treatment" ponds and help improve water quality of the Pelican River and Spring Creek, two of the major tributaries to the Pelican Lakes. Land use is primarily agriculture comprising 23% of the overall watershed, with forest accounting for about 22% of the total watershed area. Much of the watershed drains to the Pelican River and the Pelican River flows into Little Pelican Lake. The watershed is shown in Figures 2.2-2.3. To ensure good water quality for years to come conservation measures in the watershed and on the lakeshore of the Pelican Lakes are essential.

Lakesheds

Understanding a lakeshed requires the understanding of basic hydrology. A watershed is the area of land that drains into a surface water body such as a stream, river, or lake and contributes to the recharge of groundwater. There are three categories of watersheds: 1) basins, 2) major watersheds, and 3) minor watersheds.

Little Pelican, Pelican, Bass and Fish Lakes are located within the Red River of the North Basin, which includes the Otter Tail River Major Watershed as one of its twenty five major watersheds (Figure 2.1). The basin covers 45,000 square miles, while the Otter Tail River Watershed covers 1,982 square miles (approximately 1,268,480 acres).

The terrain of the Red River Basin in Minnesota is very diverse; from the flat, intensively farmed plain just east of the length of the Red River, to the rolling uplands full of trees and lakes in the east-central portion of the basin, to the extensive wetlands in the northeast.

Within this watershed hierarchy, lakesheds also exist. A lakeshed is defined simply as the land area that drains to a lake. While some lakes may have only one or two minor watersheds draining into them, others may be connected to a large number of minor watersheds, reflecting a larger drainage area via stream or river networks. Little Pelican Lake falls within the Pelican Lake – Pelican River (5600702) lakeshed, covering 1,899 acres (includes lake area) (Figure 2.2). Pelican, Bass and Fish Lakes Lake fall within the Pelican Lake – Pelican River (5600703) lakeshed, covering 15,783 acres (Figure 2.3).

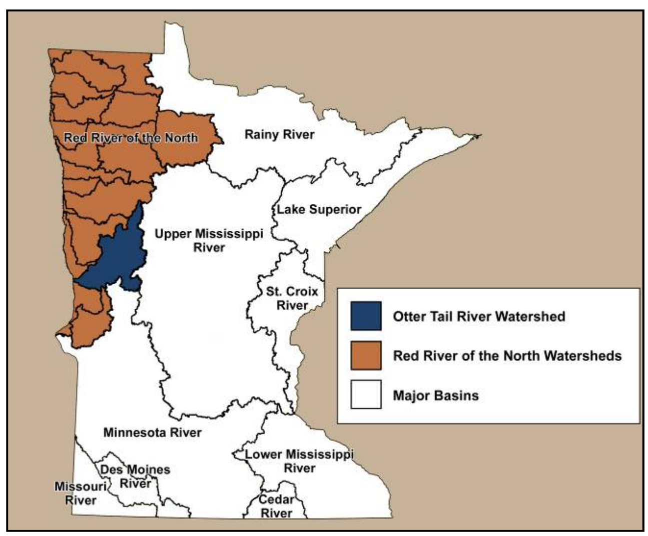


Figure 2.1. Red River of the North Basin and the Otter Tail River Watershed.

Little Pelican, Pelican, Bass and Fish Lakes fall within minor watershed 56007, one of the 108 minor watersheds that comprise the Otter Tail River Major Watershed (Figures 2.2-2.3).

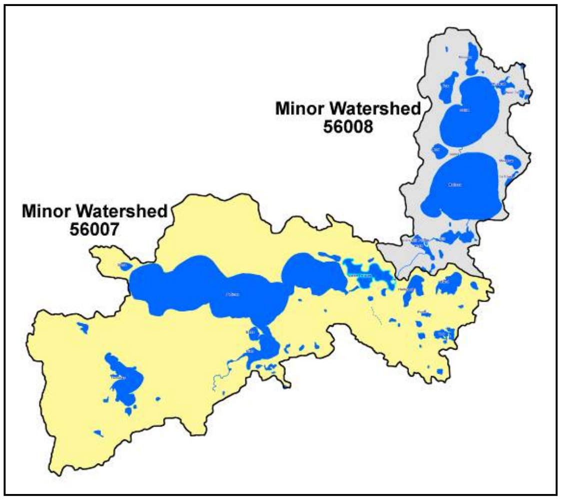


Figure 2.2. Minor Watersheds 56007 & 56008 contribute water directly to Little Pelican Lake.

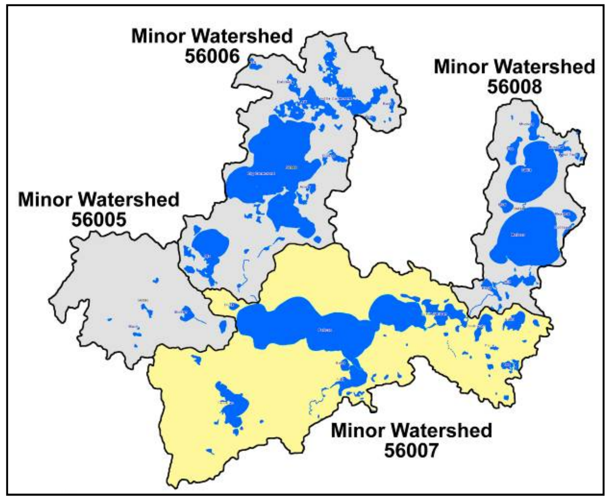


Figure 2.3. Minor Watersheds 56007, 56005, 56006, & 56008 contribute water directly to Pelican, Bass and Fish Lakes.

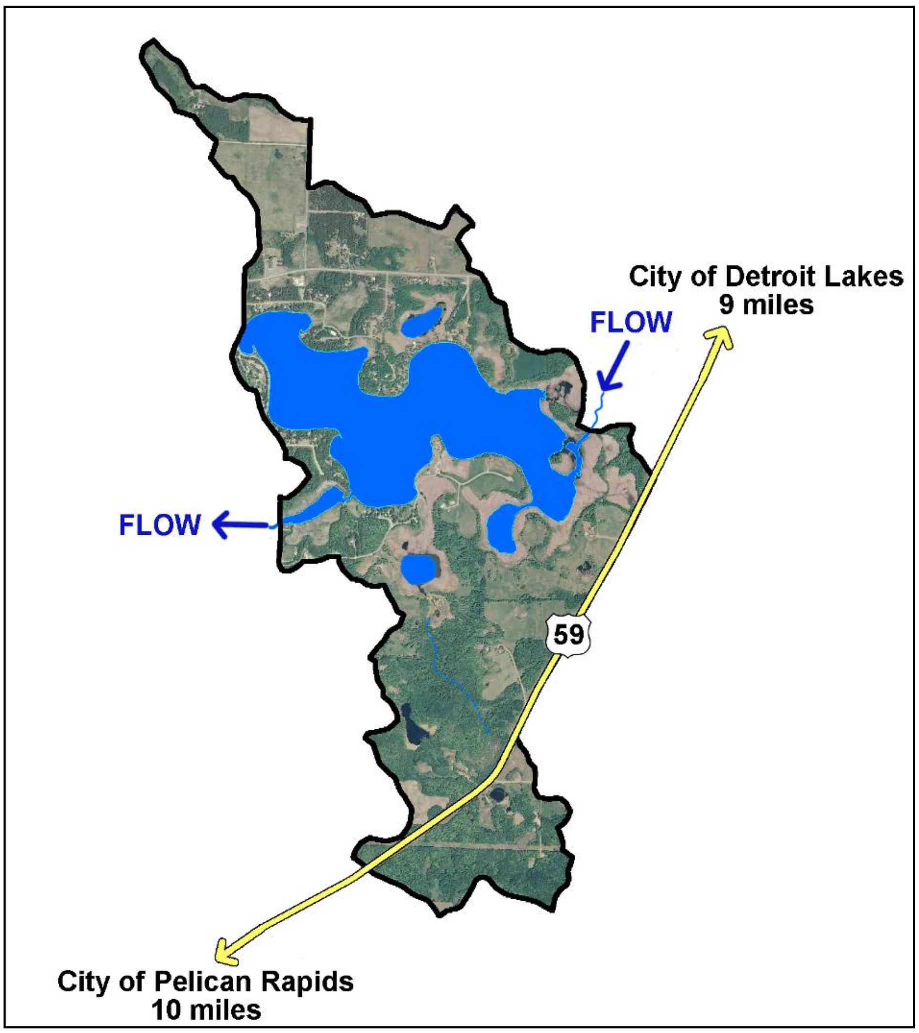


Figure 2.4. The Pelican Lake – Pelican River (5600702) lakeshed (Aerial imagery 2008).

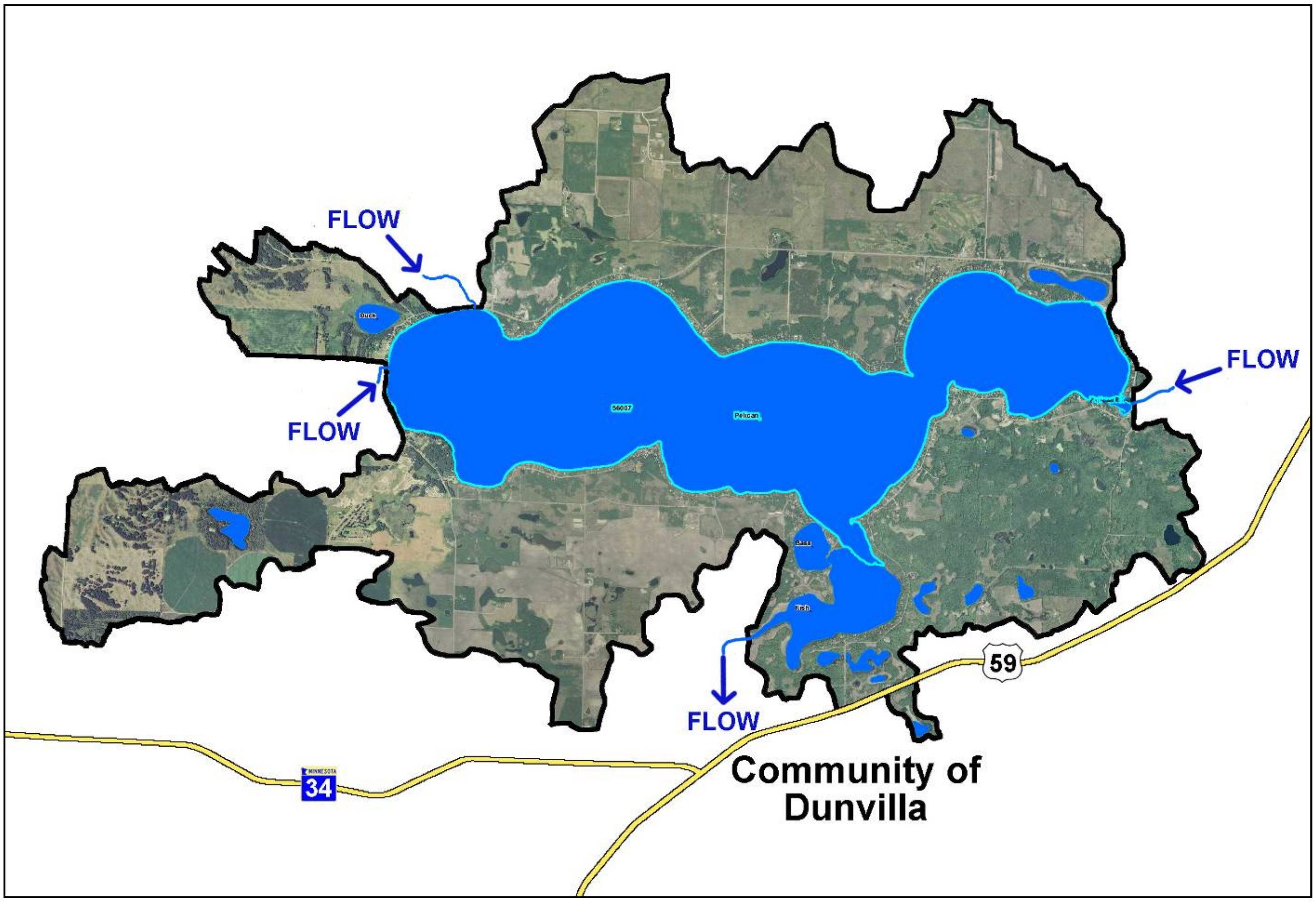


Figure 2.5. The Pelican Lake – Pelican River (5600703) lakeshed (Aerial imagery 2008).

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 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.

Table 2.1 describes Little Pelican Lake's lakeshed land cover statistics and percent change from 1990 to 2000. The reason this decade is shown is there was more change then than there has been more recently. 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 (Figure 2.6). The largest change in percentage is the increase in urban land cover (61.3%); however, in acreage, forest cover has increased the most (96 acres). In addition, the impervious intensity has increased, which has implications for storm water runoff into the lake. The increase in impervious intensity is consistent with the increase in urban acreage.

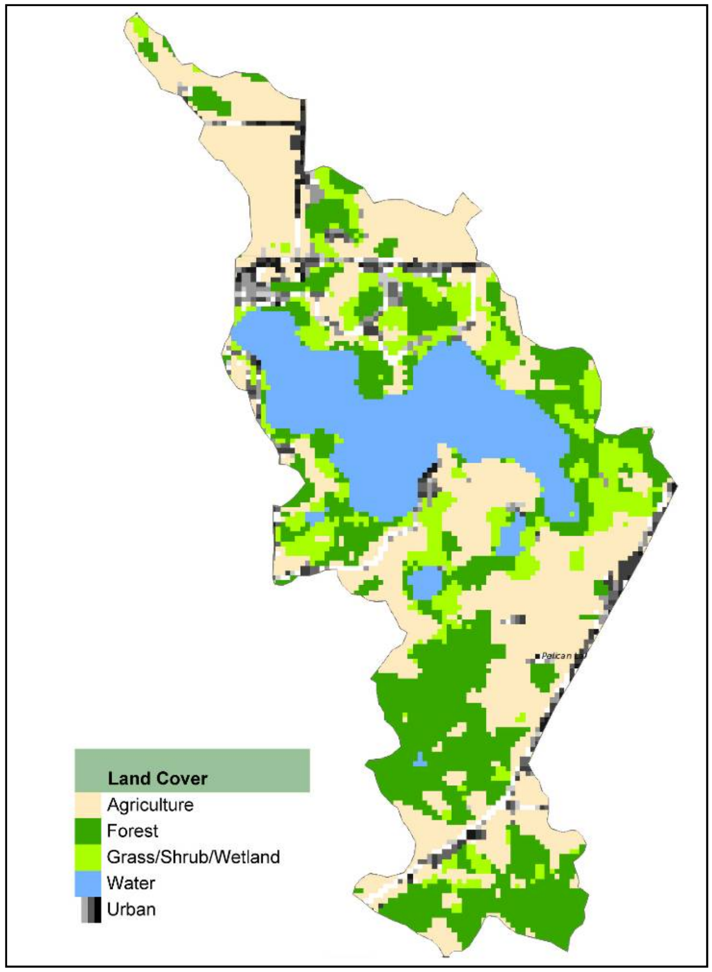


Figure 2.6. Little Pelican Lake Lakeshed showing land cover from 2000 (http://land.umn.edu)

Table 2.1. Little Pelican 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	699	36.81	654	34.44	45 acres decrease
Forest	420	22.12	516	27.17	96 acres increase
Grass/Shrub/Wetland	302	15.9	225	11.85	77 acres decrease
Water	367	19.33	325	17.11	42 acres decrease
Urban	111	5.85	179	9.43	68 acres increase
Total Area	1,899		1,899		
Total Impervious Area (Percent Impervious Area Excludes Water Area)	32	2.09	50	3.18	18 acres increase

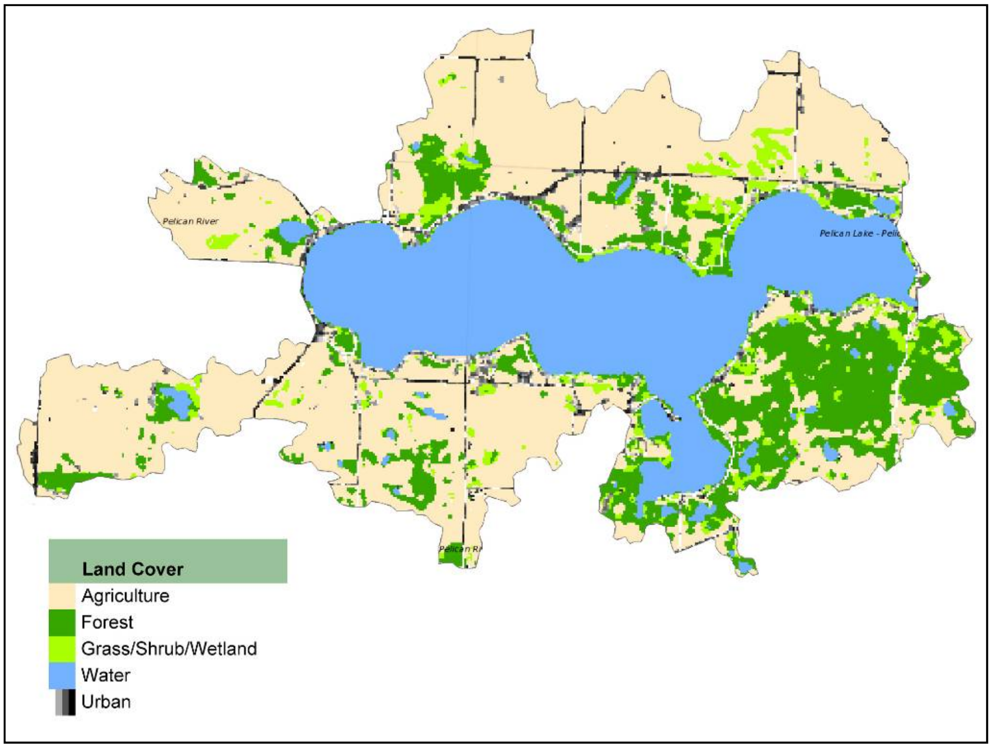


Figure 2.7. Pelican, Bass and Fish Lakes Lakeshed showing land cover from 2000 (http://land.umn.edu)

Table 2.2 describes Pelican 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 (Figure 2.7). The largest change in percentage is the increase in urban land cover (56.9%); however, in acreage, forest cover has increased the most (417 acres). In addition, the impervious intensity has increased, which has implications for storm water runoff into the lake. The increase in impervious intensity is consistent with the increase in urban acreage.

Table 2.2. Pelican 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	7,507	47.56	7,094	44.95	413 acres decrease
Forest	2,174	13.77	2,591	16.42	417 acres increase
Grass/Shrub/Wetland	1,031	6.53	706	4.47	325 acres decrease
Water	4,481	28.39	4,466	28.3	15 acres decrease
Urban	592	3.75	929	5.89	337 acres increase
Total Area	15,783		15,783		
Total Impervious Area **(Percent Impervious Area Excludes Water Area)**	136	1.2	246	2.17	110 acres increase

Figure 2.8 and Table 2.3 show more specifically the types of agriculture occurring in the PGOLID lakesheds. Much of the agricultural land to the north is pasture, which has a phosphorus runoff coefficient similar to grass land and prairie. The row crops are of greatest concern for runoff, and they mainly occur to the southwest of Pelican Lake. Since they are in the lakeshed, they do drain towards the lake.

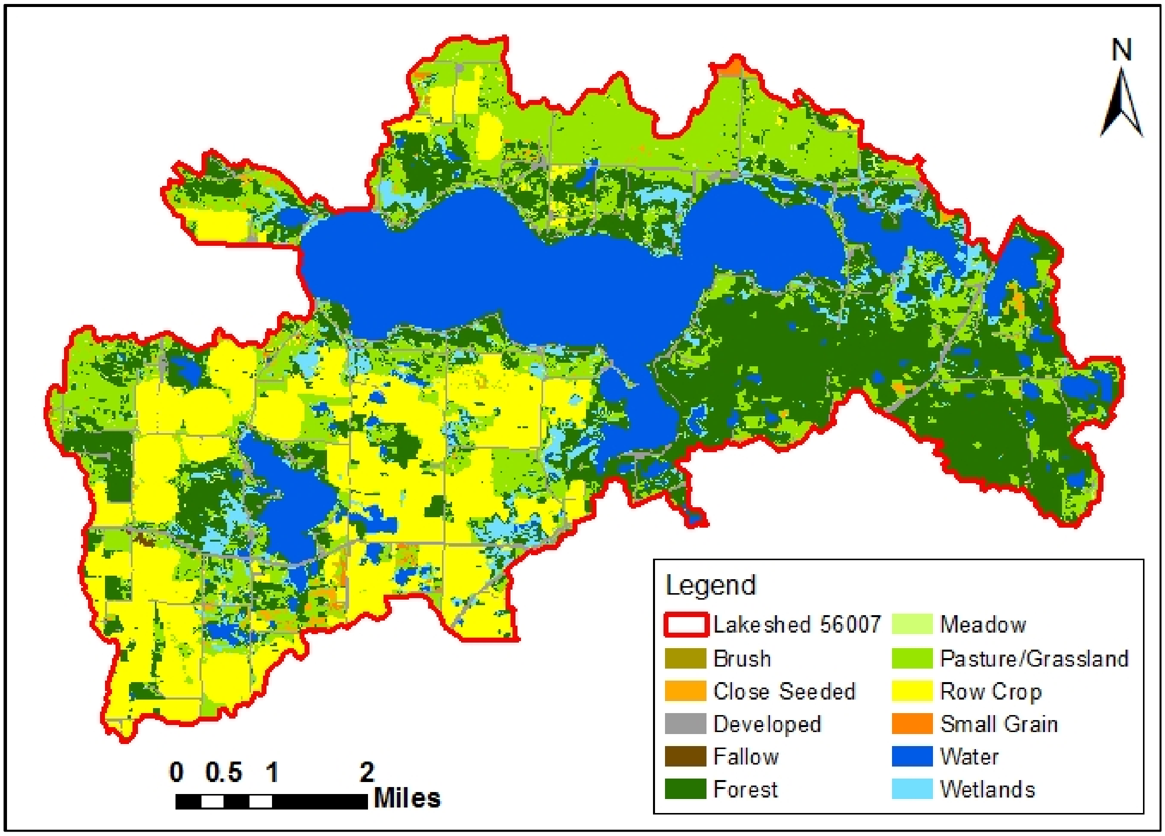


Figure 2.8. Land cover including crop types in the Pelican, Bass, Fish and Little Pelican lakesheds.

Table 2.3. Land cover acreage and percentage in the Pelican, Bass, Fish and Little Pelican lakesheds.

Landcover	Acres	Percent
Water	5,841	21.4%
Wetlands	1,236	4.5%
Forest	7,589	27.8%
Developed	1,248	4.6%
Brush	5	0.0%
Fallow	18	0.1%
Row Crop	5,239	19.2%
Small Grain	78	0.3%
Close Seeded	195	0.7%
Pasture/Grassland	5,635	20.6%
Meadow	216	0
Total	27,300	100%

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. For recommendations, see the next page.

Little Pelican Lake

	Private (82%)					18%	Public (0%)		
	Developed	Agriculture	Forested Uplands	Other	Wetlands	Open Water	County	State	Federal
Land Use (%)	8%	17%	36%	9%	12%	18%	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
Description	Focused on Shoreland	Cropland	Focus of develop-ment and protection efforts	Open, pasture, grass-land, shrub-land	Protected				
Potential Restoration and Protection Projects	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

Pelican, Bass and Fish Lakes

	Private (71%)					28%	Public (1%)		
	Developed	Agriculture	Forested Uplands	Other	Wetlands	Open Water	County	State	Federal
Land Use (%)	6%	32%	23%	6%	4%	28%	0%	0%	1%
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
Description	Focused on Shoreland	Cropland	Focus of develop-ment and protection efforts	Open, pasture, grass-land, shrub-land	Protected				
Potential Restoration and Protection Projects	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

Recommendations

Conservation Easements
The charts on the previous page show that the lakesheds of Little Pelican, Pelican, Bass and Fish lakes are mostly made up of private land. This means this land is not protected from future development. Any undeveloped lots with lakeshore and those considered "second ring" development should be considered for conservation easements. With conservation easements, these lands would be protected from future development.

Forestry
Property owners who own large forested lots should consider forest stewardship planning. This planning will allow proper protection and management of the forested land. The DNR forestry program is available for private forest landowners including corporations whose stocks are not publicly traded and own between 20 - 1,000 acres of land. At least 20 acres of the land must have or will have trees. For more information, visit:
http://www.dnr.state.mn.us/grants/forestmgmt/stewardship.html.

Developed Land
In the developed land around the lake, the most impact to the lake comes from runoff from grass lawns and impervious surface. To minimize this runoff, trees, shrubs and native vegetation should be planted along the shoreline. A secondary impact from developed land comes from improperly working septic systems. All septic systems should be properly maintained to protect the lake from excess nutrients.

Agriculture
Agricultural areas tend to have a high concentration of nutrients (fertilizers). Proper agricultural practices near lakes should minimize their impact to lakes. Conservation practices could include Conservation Reserve Program land and wetland restoration. The local Soil and Water Conservation District can help with both of these practices.

Lakeshed Vitals Table

In the table on the next page, potential impacts to the lakes are listed with descriptions of their impacts to the lakes. Pelican, Bass and Fish are combined because they are one large water system with one combined lakeshed.

Lakeshed Vitals	Pelican, Bass, Fish	Little Pelican	Comments
Miles of Shoreline	22.9	7.2	Miles of shoreline describes the distance around the lake shore. Lakes with more miles of shoreline have more area for potential shoreline impacts to occur.
Miles of Stream	0.4	1.0	Streams provide valuable habitat for aquatic and riparian organisms including fish, aquatic invertebrates (insects, crayfish, mussels), waterfowl, muskrats, and otters. Small streams are also highly productive systems, owing to their relationships with adjacent upland habitats. On the other hand, streams are also major sources of nutrients and suspended solids to lakes. It is important that lake residents keep riparian areas natural with vegetated buffers in order to protect the lake and the stream.
Miles of Road	39.3	7.0	Roads are considered impervious surface; they fragment the landscape for wildlife habitat and lead to increased development.
Water Residence Time	1.4 years	<1 year	For lakes having longer residence times (a year or more), long-term average pollutant loadings become more important to overall lake water quality. Lakes that have a residence time of more than 5 years have a capacity of retaining about 60% of the phosphorus loading that occurs and is not lost via outflow. This characteristic requires that the longer the water residence time, the longer the time frame needed for in-lake observations to detect any response to loading reduction.
Municipalities	None	None	Municipalities adjacent to a lake are areas of dense population and impervious surface. Stormwater runoff from streets, parking lots, roofs and storm gutters can contribute nutrient and pollutant loading to a lake. In addition, road salt used in the winter can increase the salinity and conductivity in a lake.
Sewage Management	Individual waste treatment systems (septic systems and holding tanks). County does lakewide inspections every 15-20 years		Properly maintained septic systems and holding tanks are effective in treating human waste. Education of property owners is the best way to get this message across in a positive fashion.
Public Drainage Ditches	None	None	Public drainage ditches can contribute nutrient enriched runoff to lakes during heavy rain events and spring thaw. Channelized streams or constructed ditches effectively increase the slope of the watershed and reduce the time it takes water to reach the lake.
Forestry Practices	None	None	Properly planned and managed forestry will have little impact on lake water quality; however, clear-cutting along a tributary or in the lakeshed can accelerate erosion and runoff.
Development Classification	General Development	Recreational Development	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. General Development Lakes usually have more than 225 acres of water per mile of shoreline and 25 dwellings per mile of shoreline, and are more than 15 feet deep. These different classifications have different setback requirements.

Lakeshed Vitals	Pelican, Bass, Fish	Little Pelican	Comments
Shoreline Development Index	2.5	2.7	The shoreline development index is the ratio of the length of shoreline to the circumference of a circle with an area equal to the lake area. As the index value increases from 1, it indicates a more irregularly shaped shoreline. An index value of 1 is the smallest possible value and indicates a lake that is perfectly circular. Lakes with an index value of approximately 2 are more elliptical in form, while elongated or dendritic-shaped lakes can have values greater than 4. The shoreline development index is an important morphological parameter to consider because it can give an idea of a lake's susceptibility to the impacts of shoreline development. Lakes with high index values are more susceptible to the impacts of development because there is more shoreline to be developed compared to a more regularly shaped (round) lake with a similar surface area. (Wetzel 2001)
Total Lakeshed to Lake Area Ratio (total lakeshed includes lake area)	3.7:1	5.2:1	The lakeshed to lake area ratio shows how much land area drains into the lake compared to the size of the lake. If this ratio is greater than 2, the land has more potential impact on the lake.
Public Land : Private Land	0.01:1	0:1	Public land is protected, and therefore additional development cannot occur in those areas. Private land that is undeveloped has the potential to be developed unless there are wetlands present that are protected by the Wetland Conservation Act.
Wetland Coverage	3%	5%	Wetland protection is a critical component for the long-term protection of water quality and recharge of groundwater. Historically, wetlands were drained for various land-use practices. Today, environmental awareness and increased stewardship has lead practices to restoration. All wetlands in the National Wetlands Inventory are protected by the Wetland Conservation Act and cannot be developed. The more land tied up in protected wetlands around a lake, the less development and impact there will be on the lake water quality. Wetlands in agricultural areas around the lake could be restored for better water storage in periods of high precipitation.
Exotic Species	Zebra mussels, Curly-leaf pondweed	Zebra mussels, Curly-leaf pondweed	Curly-leaf pondweed is under control in the Pelican Group of Lakes by chemical herbicide application. Zebra mussels are a problem with no solution for removal.

Demographics

Little Pelican 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.

Pelican Lake is classified as a general development lake. General development lakes usually have more than 225 acres of water per mile of shoreline 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. These projections are shown in Figure 2.10 below. Compared to Otter Tail County as a whole, Dunn Township population growth has higher extrapolated growth projections, while Scambler Township has lower extrapolated growth projections.

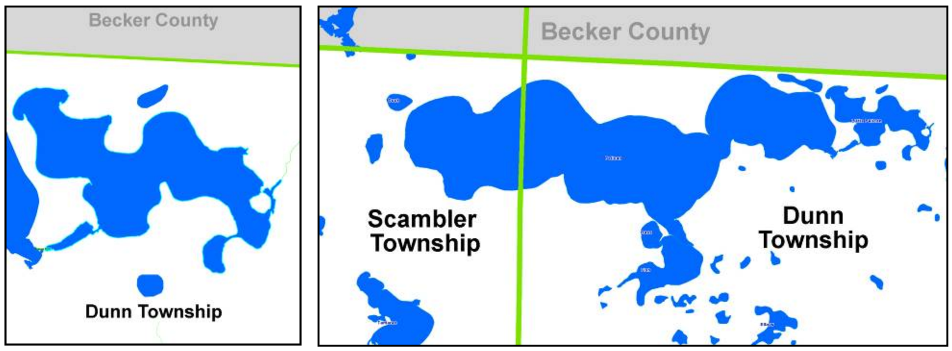


Figure 2.9. Little Pelican Lake showing Dunn Township and Pelican, Bass and Fish Lakes showing Dunn and Scambler Townships.

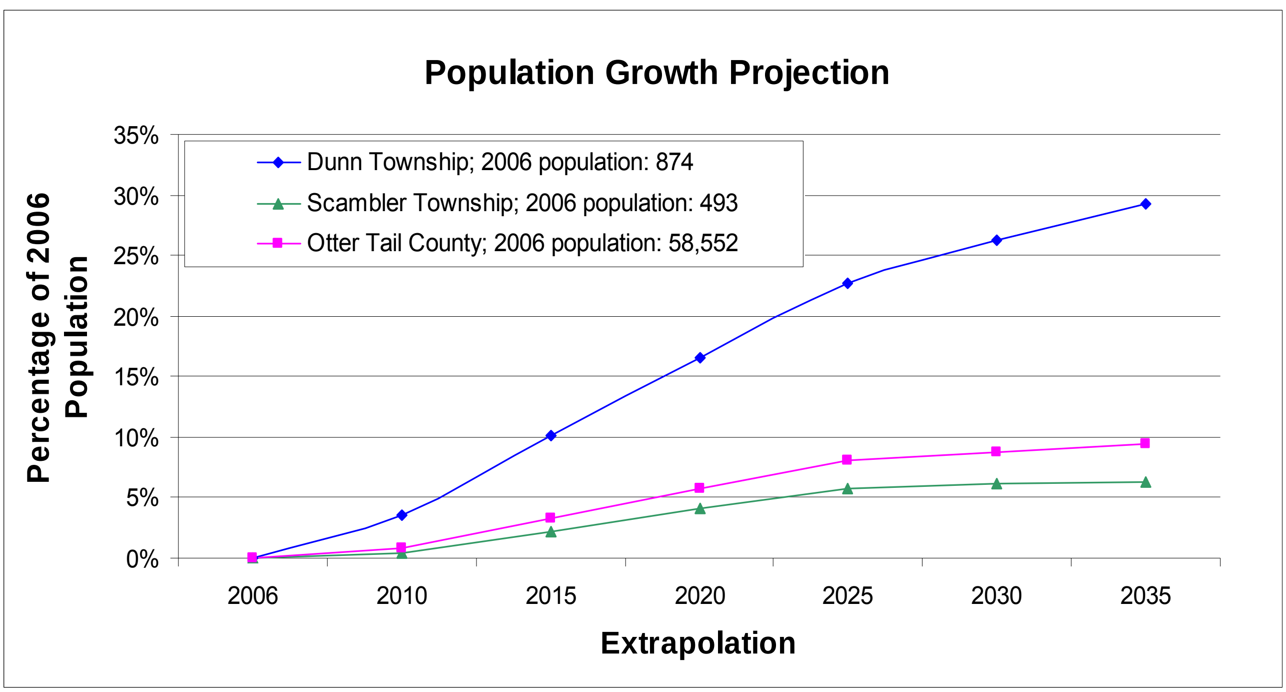


Figure 2.10. Population growth projection for Otter Tail County and the townships around the PGOLID Lakes (source: http://www.demography.state.mn.us/resource.html?Id=19332).

Lake Water Level Report

DNR: http://www.dnr.state.mn.us/lakefind/showlevel.html?id=56078600

Water Level Data
Period of record: 03/24/1938 to 10/14/2015
# of readings: 1657
Highest recorded: 1319.72 ft (08/25/1993)
Highest known: 1319.72 ft (08/25/93)
Lowest recorded: 1314.78 ft (03/24/1938)
Recorded range: 4.94 ft
Last reading: 1318.13 ft (10/14/2015)
Ordinary High Water Level (OHW) elevation: 1318 ft
Datum: MSL 1912 (ft)

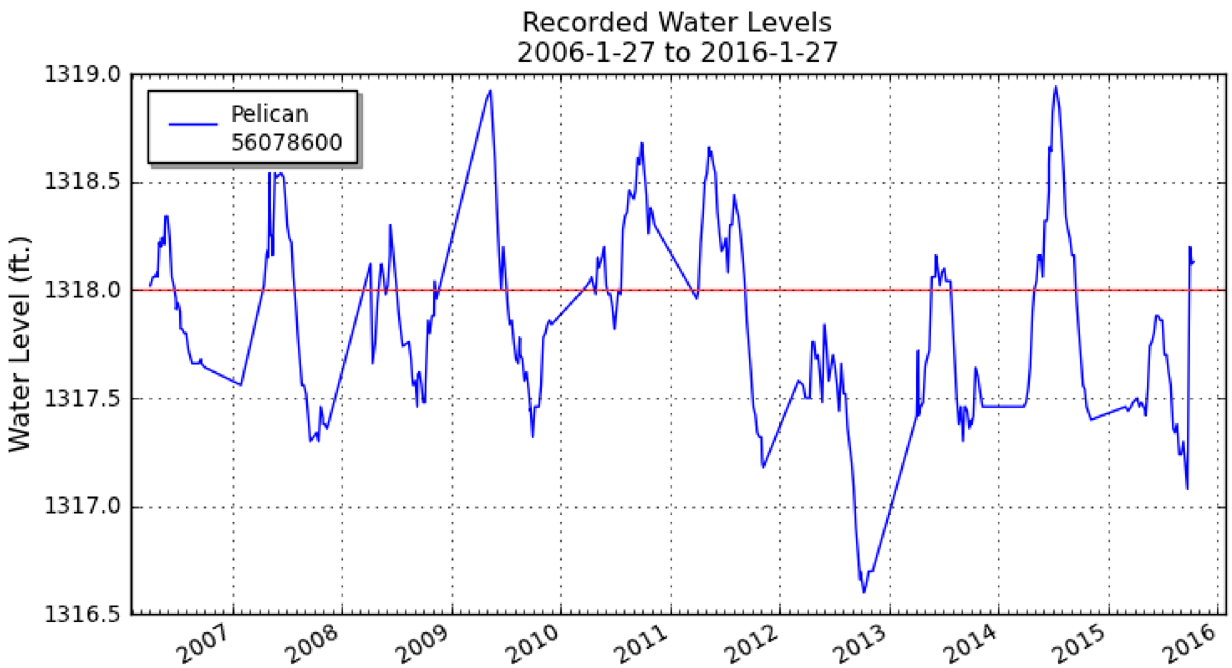


Figure 2.11. Water levels in Pelican Lake 2000-2015. Source: MN DNR

Benchmarks

Elevation: 1319.19 ft Datum: MSL 1912 (ft)	Date Set: 01/07/1998	**Benchmark Location** Township: 137 Range: 42 Section: 20
Description: Top left upstream corner of left abutment on "old dam" - also called "association dam" on Fish Lake (56-768).		
Elevation: 1323.19 ft Datum: MSL 1912 (ft)	Date Set: 09/23/2009	**Benchmark Location** Township: 137 Range: 42 Section: 20
Description: Set bent 3/8" x 8" spike 0.9' above ground in west side of 1.1' maple, 132' S-SE of dam, 28' SE of mowed trail to dam on Fish Lake (56-768).		
Elevation: 1322.25 ft Datum: MSL 1912 (ft)	Date Set: 07/28/1978	**Benchmark Location** Township: 137 Range: 42 Section: 20
Description: Bent 60d spk in notched NW root of a 12" maple, 95' SE of Pelican Lk dam.		
Elevation: 1327.76 ft Datum: MSL 1912 (ft)	Date Set: 03/24/1976	**Benchmark Location** Township: 137 Range: 42 Section: 2
Description: MHD disk in S end of E conc wheelguard of bridge for CSAH 31 crossing on narrows between Little Pelican and Pelican Lakes.		

Wetlands

"Wetlands" is the collective term for marshes, swamps, bogs, and similar areas. Wetlands are found in flat vegetated areas, in depressions on the landscape, and between water and dry land along the edges of streams, rivers, lakes, and coastlines.

Wetlands prevent flooding by holding water much like a sponge. By doing so, wetlands help keep river levels normal and filter and purify the surface water. Wetlands accept water during storms and whenever water levels are high. When water levels are low, wetlands slowly release water. Wetlands encompass many different habitats including ponds, marshes, swamps, and peatlands. They are areas where land and water meet and are wet for an ecologically significant part of the year. Wetlands may be temporally flooded by rain, or be filled seasonally with water from melting snow.

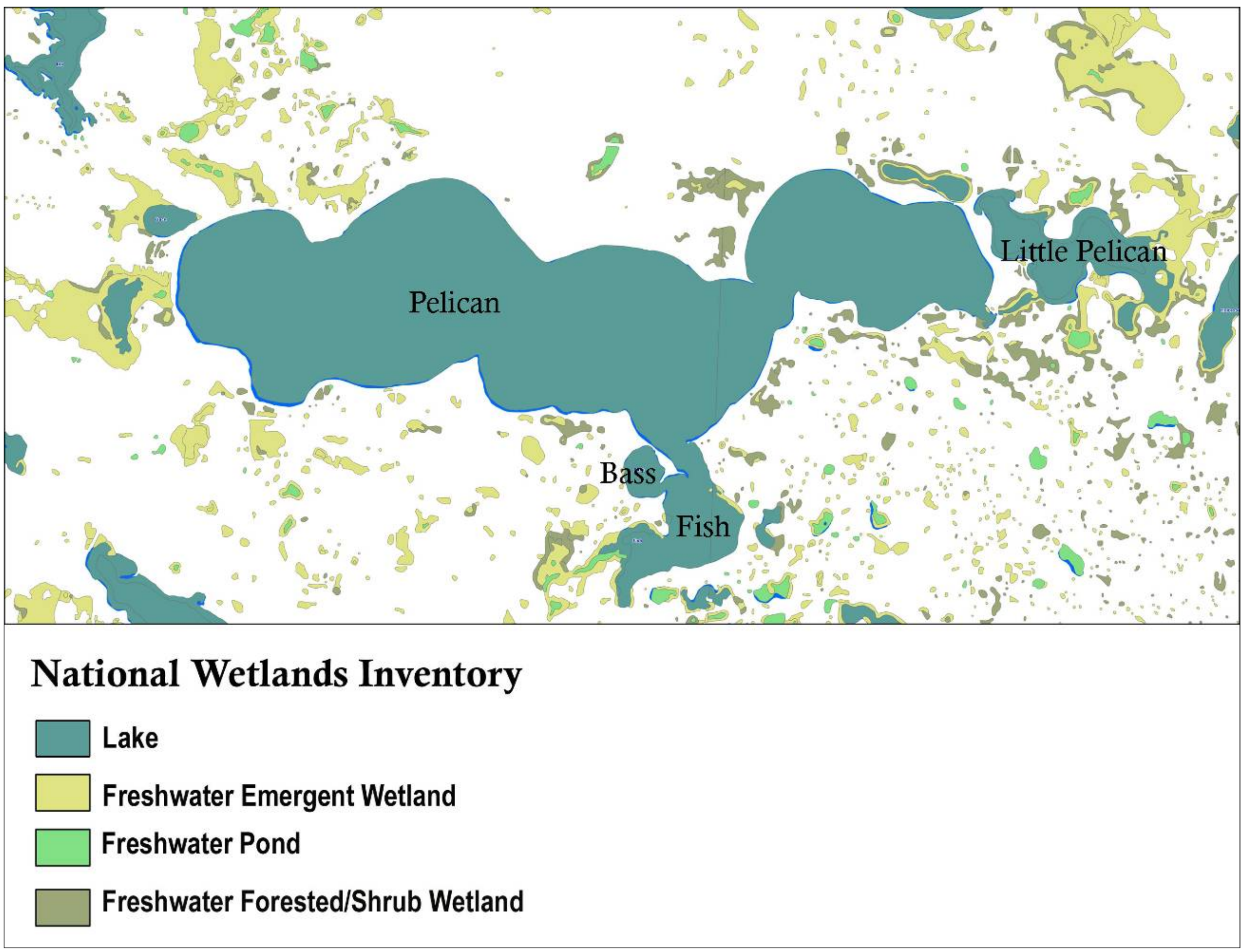


Figure 2.12. National Wetlands Inventory in the area around Little Pelican, Pelican, Bass and Fish Lakes.

Wetlands around PGOLID include emergent wetlands, which are usually colonized with cattails, ponds and forested/shrub wetlands (Figure 2.12).

If these areas are filled in, the water needs to go somewhere and could cause lake levels to rise. These areas are important for water storage and filtration and should be preserved to maintain water levels in the PGOLID lakes.

Stream Assessments

Streams and rivers are rated by the Minnesota Pollution Control Agency to have the most potential to impact lakes. After all, a lake can only be as healthy as the water that flows into it.

Pelican Lake has 4 impacting streams. All of which are tested in several places. By breaking up the sampling per stream we can better locate pollution sources. For example; points A, B, and C are sampled for pollutant X. A is upstream from B, and B is upstream from C. Pollutant X is found at C but not B or A. This means that the pollutant source must be in-between B and C. Say that pollutant X is found at B but not C. This means that (usually naturally) the pollutant is being "filtered" between B and C. Perhaps the most important sites are at where they enter the lake body. The rivers and streams that exit the lake are also sampled. This is for comparison purposes. For example the totals of a substance entering the lake can be found and compared with the totals exiting the lake. This is another way to distinguish if other pollutants are entering the lake by other means than streams.

PGOLID monitors 9 sites in 4 watersheds. The sites are numbered below and refer to the map below (Figure 2.13):

1. Highway 20 Culvert, Pelican River
2. Strom's Bridge, Pelican River
3. Pelican River Outlet
4. Bob Creek Inlet
5. Burton Lake Outlet
6. Spring Creek Inlet (Simenson)
7. 15823 Sherbrooke Road , Spring Creek
8. Lake Ida Outlet
9. Cormorant Lake Outlet

Samples are collected monthly year around. The PGOLID Water Resource Coordinator also periodically takes samples after "storm events" or after heavy precipitation (usually >1 inch). Sampling after a storm event can give us a relation as to how the watersheds runoff is impacting the water or the "worst case scenario". Storm event samples are included with other samples in statistics. This evens out to more accurately represent a true average. It also makes up for the other storm events that are not monitored, or recorded in the monthly samples.

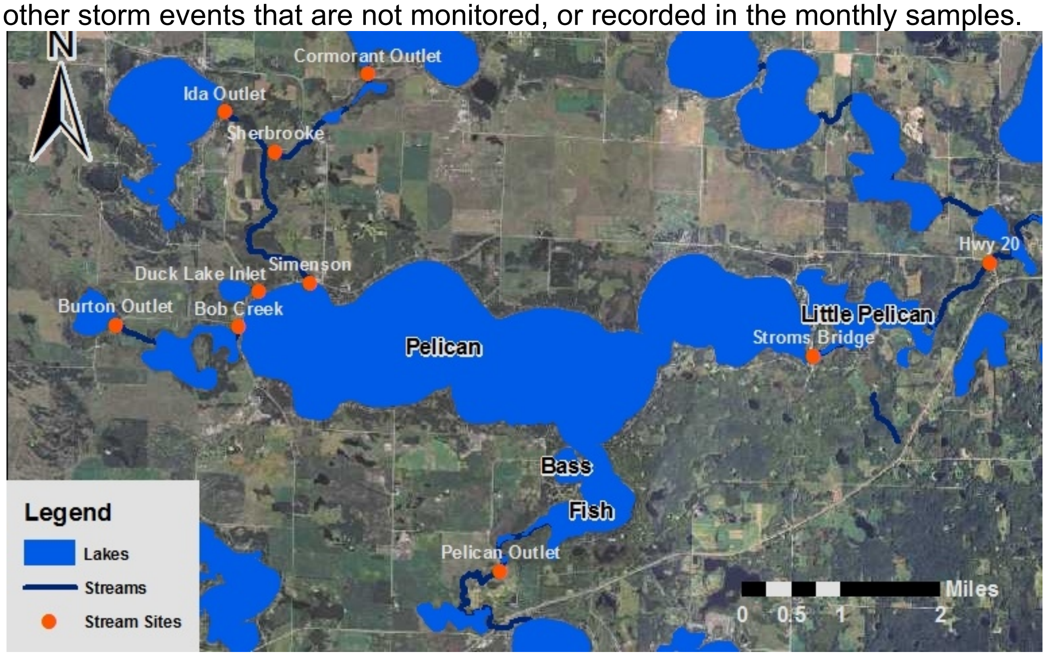


Figure 2.13. PGOLID stream monitoring sites.

Inlets and Outlet Loading Comparisons

Totals are approximated by averaging all the values. Storm events are included.

Average Totals Entering Pelican Lake	
3.03	Chlorophyll *a* (lbs / day)
1188	Total Suspended Solids (lbs / day)
48,615	Fecal Coliform Bacteria (Fecal Colonies / day)
13.63	Total Phosphorus (lbs / day)
9.80	Ortho Phosphorus (lbs / day)
63,644,236	Flow (GPD)

Average Totals Exiting Pelican Lake	
1.99	Chlorophyll *a* (lbs / day)
652	Total Suspended Solids (lbs / day)
50,234	Fecal Coliform Bacteria (Fecal Colonies / day)
8.81	Total Phosphorus (lbs / day)
7.91	Ortho Phosphorus (lbs / day)
66,628,510	Flow (GPD)

Flow

The combined flow from the inlets mirrors the outlet flow (Figure 2.14). This result is expected, and means that most of the water that is flowing into the PGOLID lakes is flowing back out. The peaks in flow correspond to spring thaw and usually occur in May-June.

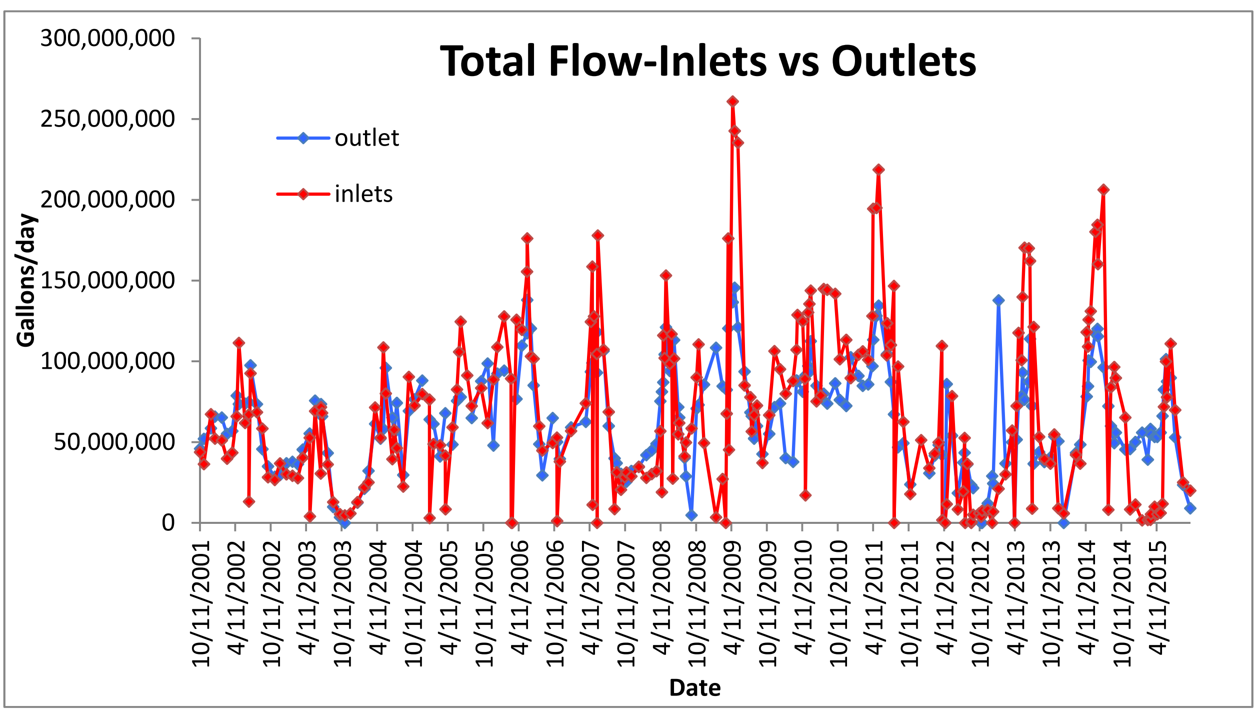


Figure 2.14 Combined inlets flow versus the outlet flow for the PGOLID lakes.

Total Phosphorus

The total phosphorus loading is calculated by taking into account both the phosphorus concentration in the water and the volume of flow passing through a certain area. In streams, phosphorus loading is a better indicator for water quality than phosphorus concentration. A stream with high phosphorus concentration that is just a trickle of water could be depositing less phosphorus into a lake than a stream with low phosphorus concentration and high flow.

The combined phosphorus loading from the inlets mirrors the phosphorus loading at the outlet. As pulses of phosphorus enter the PGOLID lakes, much of that phosphorus exits back out of the system. A portion of the phosphorus stays in the lake and gets taken up by plants and algae. If all the phosphorus was staying in the lake and not flowing back out, it would be a problem and would contribute to the lake getting greener with more plants and algae.

The peaks in phosphorus loading correspond with the peaks in flow (Figure 2.15). These peaks occur in the spring (April-June) as spring thaw and rains contribute to higher water levels.

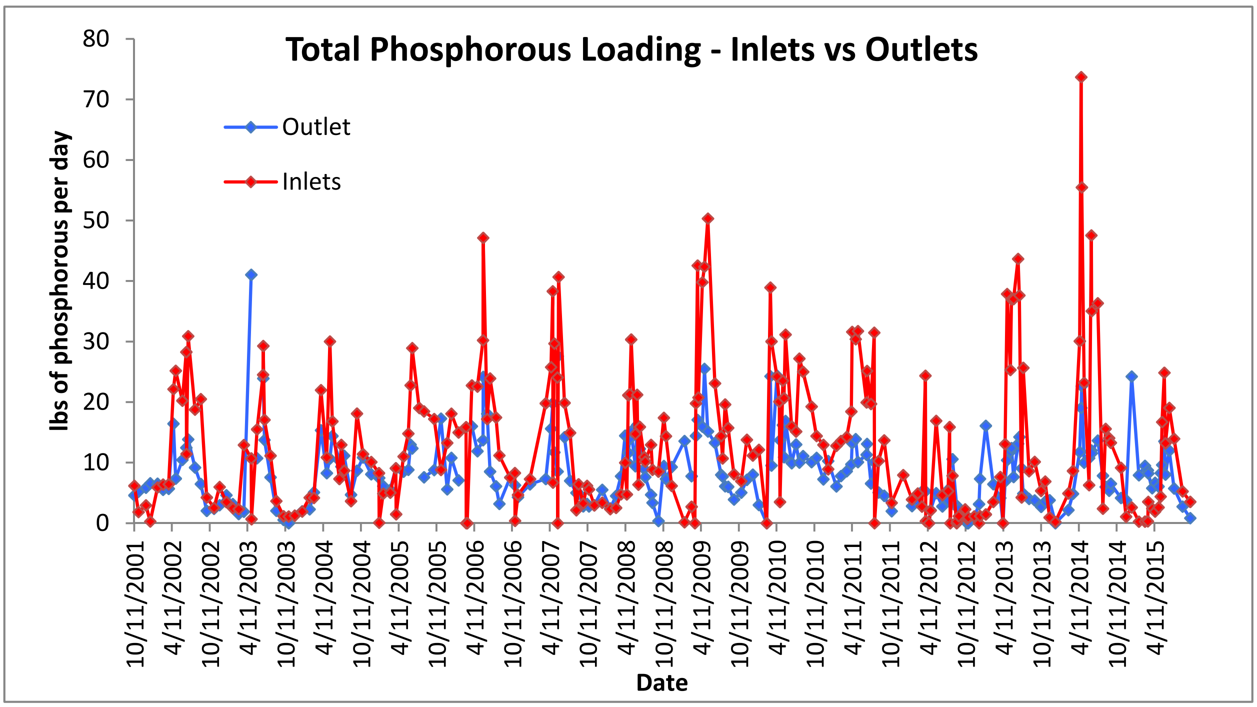


Figure 2.15. Combined inlets phosphorus loading versus the outlet phosphorus loading for the PGOLID lakes.

Totals and Average Loading by Watershed

Minor watersheds are grouped by the stream that discharges into Pelican Lake. These groups of watersheds are Bob Creek, Spring Creek, and the Pelican River (Figure 2.16).

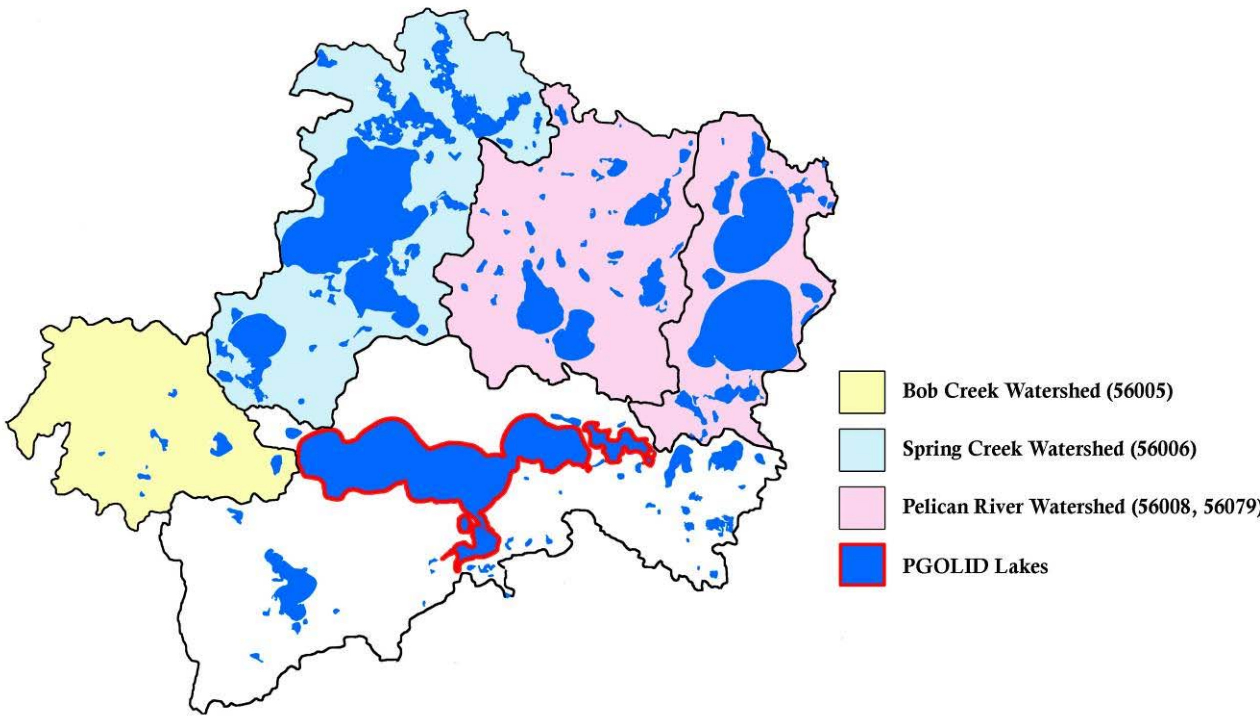


Figure 2.16 Minor watersheds draining directly into PGOLID Lakes.

Flow

In comparing the flow between the different inlets, the Pelican River accounts for the majority (81%) of the water flowing into the PGOLID lakes (Figure 2.17).

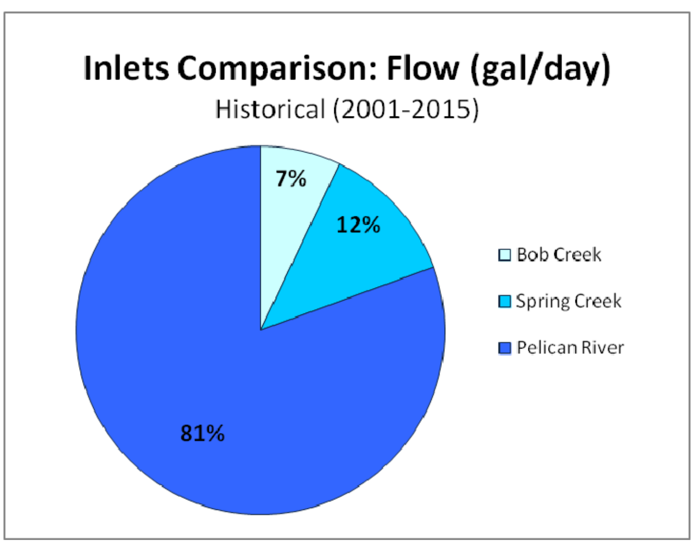


Figure 2.17 Comparison of water flow entering Pelican Lake between the different inlets.

Total Phosphorus
In comparing the total phosphorus between the different inlets, the Pelican River accounts for almost three quarters (71%) of the total phosphorus entering Pelican Lake (Figure 2.18). This would prioritize this stream for source identification; however, the phosphorus concentration in the Pelican River is average compared to the other sites, and is nearly half of other area streams. This would suggest that heavy loading is due to the sheer volume of water (Figure 2.17).

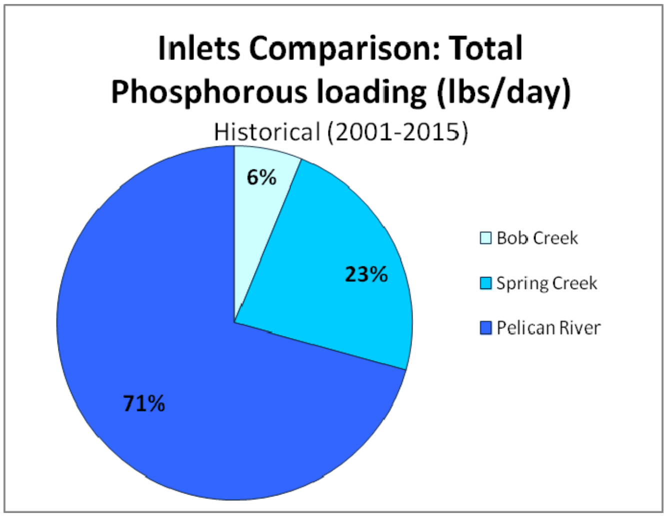


Figure 2.18 Total phosphorus loading proportions from each inlet to Pelican Lake.

Figure 2.19. shows the actual phosphorus loading for each inlet. Duck Lake is a small inlet that trickles in from a wetland on the west side of Pelican Lake. The flow and phosphorus loading from Duck Lake is negligible.

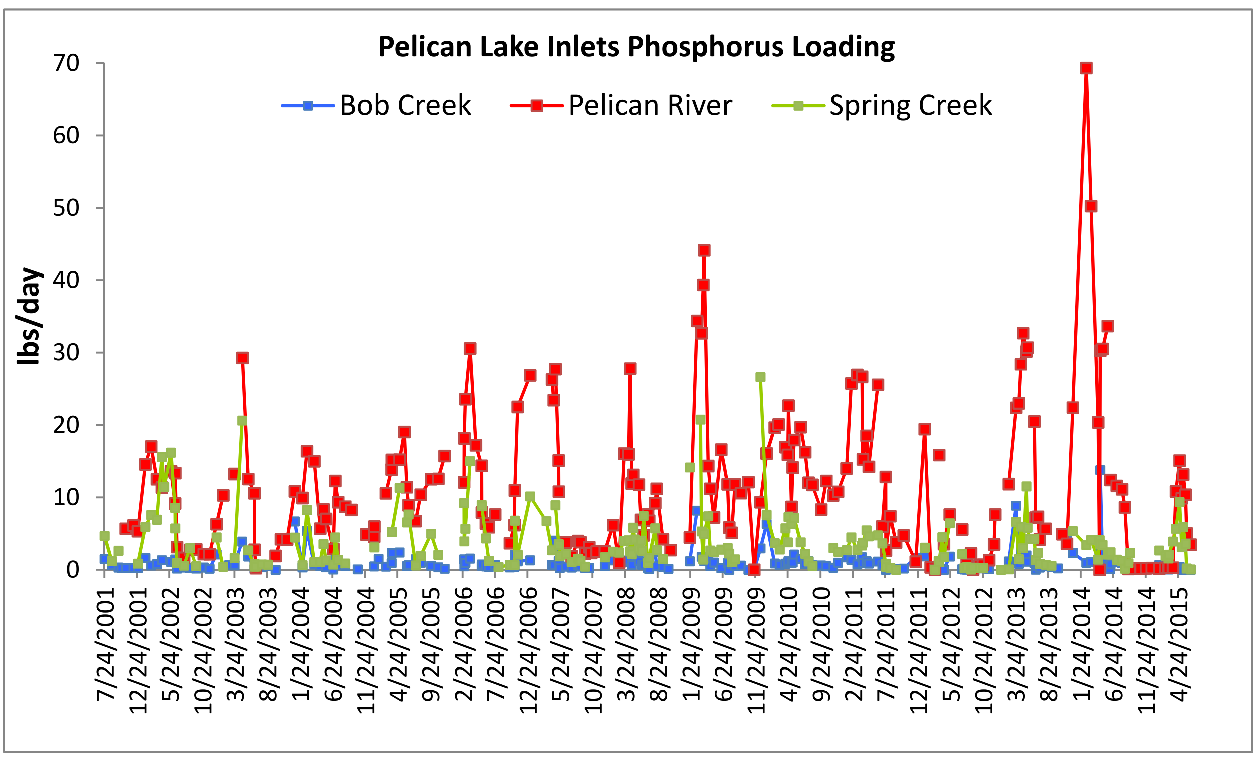


Figure 2.19 Comparison of total phosphorus loading from each inlet to Pelican Lake.

In looking at all the monitoring sites in each watershed, one can better pinpoint potential sources of phosphorus (Figure 2.20). In the Bob Creek watershed, both the Burton Lake Outlet (upstream) and the Bob Creek Inlet to Pelican Lake have similar phosphorus loading. This result means that not much phosphorus is picked by Bob Creek as it passes through a cattle farm and a large wetland.

In the Spring Creek Watershed, water exits Lake Ida and Big Cormorant Lake with very low phosphorus concentrations. The Sherbrooke Road site has higher phosphorus loading than the source at Big Cormorant Lake. As Spring Creek winds back and forth through the city of Cormorant, it has a rapids-like nature and picks up phosphorus from the stream banks as it flows. Further downstream, the branch from Lake Ida joins Spring Creek and then enters Pelican Lake at the Spring Creek Inlet. The phosphorus loading at the Spring Creek Inlet is slightly higher than at Sherbrooke Road, which could come from the Lake Ida branch or the wetlands.

The Pelican River has the highest phosphorus loading of all the watersheds. The Highway 20 site is just upstream from Little Pelican Lake and the Stroms Bridge site is between Little Pelican and Pelican Lakes. The results show that some phosphorus remains in Little Pelican Lake and most likely gets taken up by plants and algae for food.

The sum of the phosphorus loading from the inlets is higher than from the Pelican River Outlet, but this is common in lakes. The extra phosphorus gets utilized by plants and algae in the lake and also gets deposited at the bottom of the lake into the sediments.

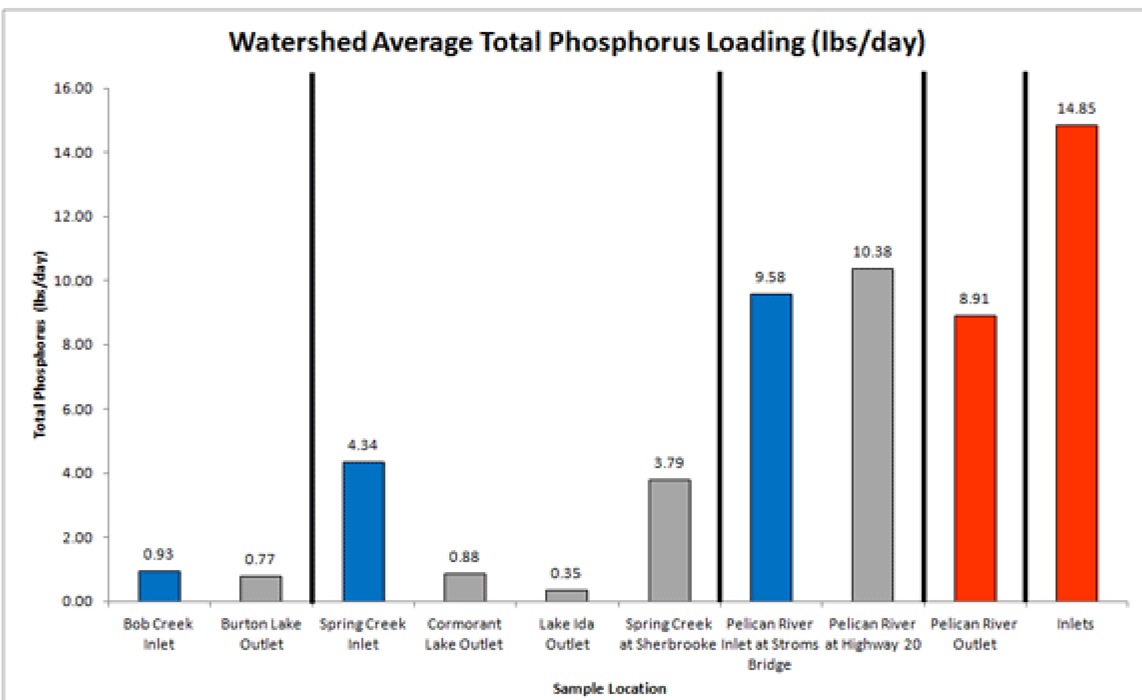
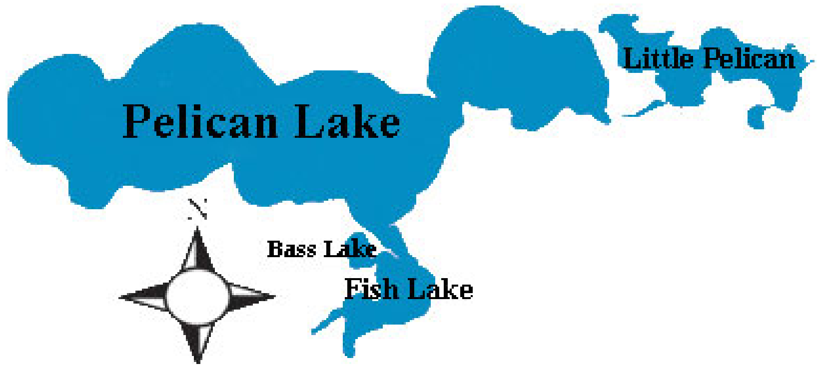


Figure 2.20 Comparison of total phosphorus loading from each watershed. The bars in blue are the actual inlets to Pelican Lake. The grey bars are monitoring sites upstream from the lake. For locations see Figure 2.13.

Chapter 3. Lake Assessments

Introduction



The Pelican Group of Lakes encompasses 4 lakes: Pelican, Little Pelican, Bass, and Fish. Although these lakes have somewhat different characteristics, they are all considered to have good water quality for northwest Minnesota.

Little Pelican Lake is the first of the PGOLID lakes when considering water flow. The Pelican River drains into Little Pelican Lake on the northeast side and provides the majority of the phosphorus entering the lake. Little Pelican Lake is considered a shallow lake because the majority of the area of the lake is 15 feet deep or less, and it is ringed with emergent vegetation (bulrush, cattails, wild rice, etc). Therefore, because Little Pelican Lake is a shallow lake and the Pelican River drains directly into it, it has the highest phosphorus and lowest clarity of the PGOLID lakes. It is still considered a very healthy shallow lake as the water quality and fishery characteristics are in the range of what is to be expected for a lake of this size and depth.

Pelican, Bass and Fish Lakes are all very similar in water quality and lake condition. In fact, they are all one large system of water. They are fairly deep (33-69 ft), have excellent fisheries, and are good for recreation. These characteristics make them a top tourist destination in northwest Minnesota. The Pelican River exits at the southwest end of Fish Lake.

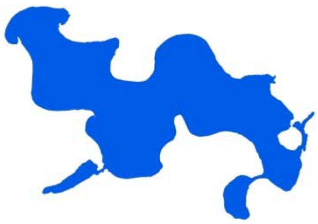
These four lakes must be protected by preserving aquatic habitat and plants, restoring natural shoreline conditions, minimizing impervious surface, working with neighbors upstream of the Pelican River for good watershed management practices, proper maintenance of waste water treatment systems, and education of lakeshore property owners.

PGOLID Lake Vitals

	Pelican	Little Pelican	Bass	Fish
Size (acres)	3,986	345	48	261
Mean depth (ft)	22	12	18	27
Littoral area (%)	41	74	50	48
Maximum depth (ft)	55	25	33	69
Volume (acre ft)	87,692	4,140	864	7,047
Watershed Area (acres)	164,092	96,538	138	162,190
Trophic State Index (TSI)	41	46	42	40
Total Phosphorus Mean (ug/L)	14	24	17	12
Chlorophyll *a* Mean (ug/L)	5	10	5	4
Chlorophyll *a* Maximum (ug/L)	17	31	17	9
Transparency (Secchi depth, ft)	12.6	8.3	12.0	12.4

Little Pelican Lake 56-0761-00 OTTER TAIL COUNTY

Summary



Little Pelican Lake is the first lake (water flow-wise) in the Pelican Group of Lakes. The Pelican River flows into Little Pelican Lake on the east side and exits on the south central side.

Little Pelican Lake is considered a shallow lake, meaning the majority of its area is less than 15 feet deep. Shallow lakes provide some of the most important wildlife habitat. Aquatic plants in and around the lake are home to nearly all aquatic animals such as waterfowl, muskrats, otters, fish, insects, frogs and turtles. These lakes are also important resting areas for migrating waterfowl. A healthy shallow lake has clear water and dense aquatic plant growth. Many shallow lakes, such as Little Pelican, have large stands of bulrush and/or wild rice. The plants in these shallow lakes lock up a lot of the nutrients in their tissues so that there is not as much algae growth, and they produce oxygen throughout the water as a byproduct of photosynthesis. These plants also keep the sediments stable at the bottom of the lake and not mixed up into the water column.

Currently, the main threats to Little Pelican Lake include the removal of aquatic plants, unnatural shorelines (manicured lawns by the lake), any new development that clears vegetation, and boats with large motors speeding around in the lake.

Water quality data have been collected in Little Pelican Lake since 1997. These data show that the lake is mesotrophic (TSI 48), which is characteristic of a dense aquatic plant population and clear water most of the summer.

Vitals

MN Lake ID:	56-0761-00
County:	Otter Tail
Ecoregion:	North Central Hardwood Forest
Major Drainage Basin:	Red River
Latitude/Longitude:	46.70833333 / -95.94950000
Water Body Type:	Public
Monitored Sites:	201, 202
Invasive species present: Zebra Mussels (confirmed September 2009), Curly-leaf pondweed	

Physical Characteristics

Surface area (acres):	345	
Littoral area (acres):	256	
% Littoral area:	74%	
Max depth (ft):	25	(m): 7.6
Mean depth (ft):	12	(m): 3.7
Lakeshed size (acres):	1,899	
Lakeshed : lake area ratio	5.5 : 1	
Inlets	Pelican River	
Outlets	Pelican River	
Public Accesses	1 shared with Pelican Lake	

Data Availability

Transparency data		Data exist from the MPCA CLMP program from 1997-2015, and RMB Labs from 2003-2015.
Chemical data		Data exist from RMB Labs from 2003-2015.
Inlet/Outlet data		The Pelican River has been monitored by RMB Lab from 2002-2015.

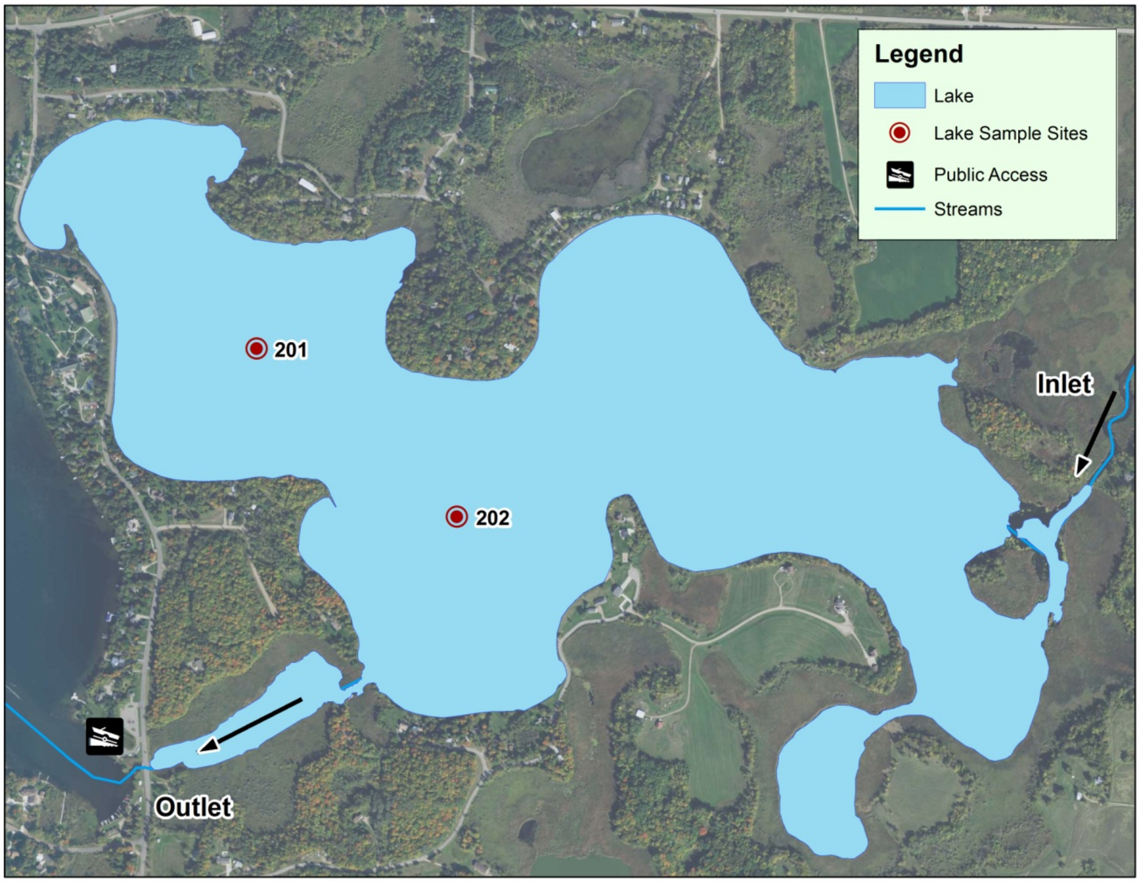


Figure 3.1 Map of Little Pelican Lake illustrating lake sample site locations, stream inlets and outlets and aerial land use. The pink shaded areas in the lake illustrate the littoral zone, where the sunlight can usually reach the lake bottom, allowing aquatic plants to grow.

Lake Site	Depth (ft)	Monitoring Programs
201	25	CLMP: 1997-2015
202	20	PGOLID: 2003-2015

KEY:
CLMP (MPCA Citizens Lake Monitoring Program)
PGOLID (Pelican Group of Lakes Improvement District)

The information below describes available chemical data for Little Pelican Lake through 2015. 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.

Below are typical measurements one might find for lakes in this ecoregion.

Parameter	Mean	Ecoregion Range[1]	Interpretation
Total phosphorus (ug/L)	23.9	23 – 50	Results are within the expected range for the ecoregion. See page 42 for more details.
Chlorophyll *a* (ug/L) [2]	9.5	5 – 22	
Chlorophyll *a* max (ug/L)	31	7 – 37	
Secchi depth (ft)	8.2	4.9 – 10.5	
Dissolved oxygen	*See page 41*		Dissolved oxygen depth profiles show that the lake mixes throughout most of the summer.
Total Kieldahl Nitrogen (mg/L)	0.6	0.62 – 1.2	Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms.
Ortho phosphorus (surface, ug/L)	5.7	NA	Indicates that all available ortho-phosphorus is taken up by plants and algae living in the lake.
Alkalinity (mg/L)	181	75 – 150	Indicates a low sensitivity to acid rain and a good buffering capacity.
Color (Pt-Co Units)	12.7	10-20	Indicates moderately clear water with little to no tannins (brown stain).
Total Suspended Solids (mg/L)	2.8	2 – 6	Within the ecoregion average range indicating mostly clear water with some algae.
Total Nitrogen : Total Phosphorus	25:1	25:1 – 35:1	The lake is most likely phosphorus limited, which means that algae growth is limited by the amount of phosphorus in the lake.
Calcium (mg/L)	34.9	NA	Indicates a hard water lake with sufficient calcium for Zebra mussel survival.
Magnesium (mg/L)	27.3	NA	Indicates a hard water lake.

Data Source: 2003-2015 PGOLID Monitoring Program

[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: 1997-2015

Parameters	Site 201	Site *202
Total Phosphorus Mean (ug/L):		**23.9**
Total Phosphorus Min:		10
Total Phosphorus Max:		48
Number of Observations:		93
Chlorophyll *a* Mean (ug/L):		**9.5**
Chlorophyll *a* Min:		1
Chlorophyll *a* Max:		31
Number of Observations:		93
Secchi Depth Mean (ft):	**8.1**	**8.5**
Secchi Depth Min:	3.9	3.9
Secchi Depth Max:	18.0	19.0
Number of Observations:	208	93

*primary site

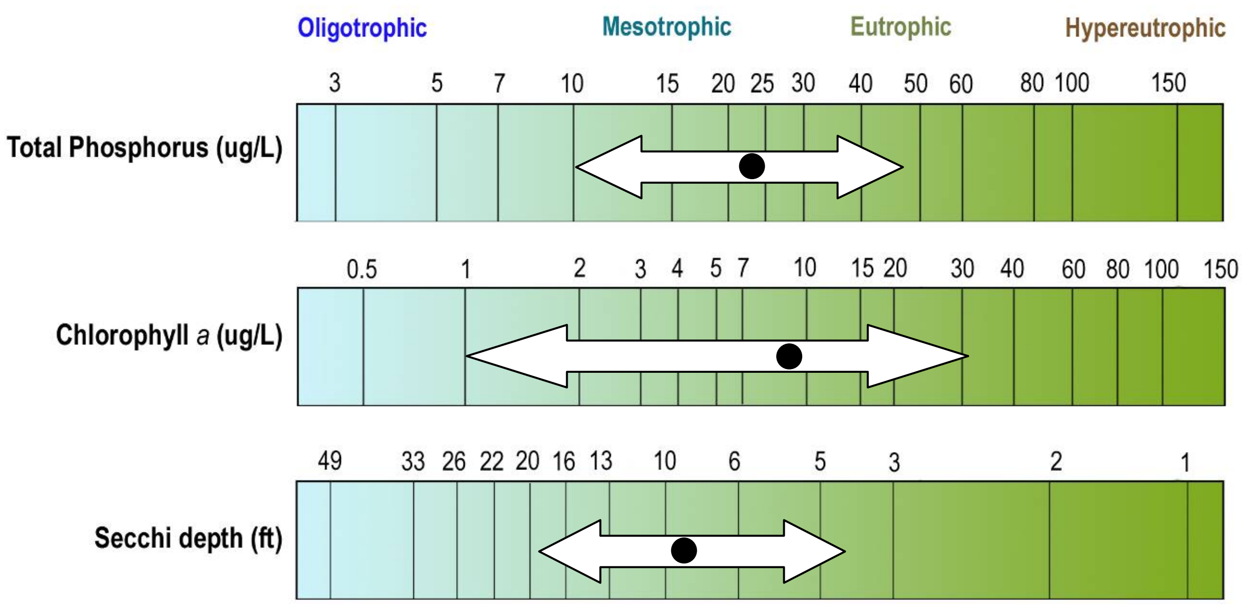


Figure 3.2 Little Pelican Lake total phosphorus, chlorophyll *a* and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Primary Site 202). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (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. Site 201 in Little Pelican Lake has been monitored from 1997-2015 by a volunteer living on the lake. The annual means for Little Pelican Lake range from 5.5-10.4 ft (Figure 3.3). The annual mean transparency hovers right around the historical mean with not much digression except for 2005. Transparency was highest in 2010 and lowest in 2005.

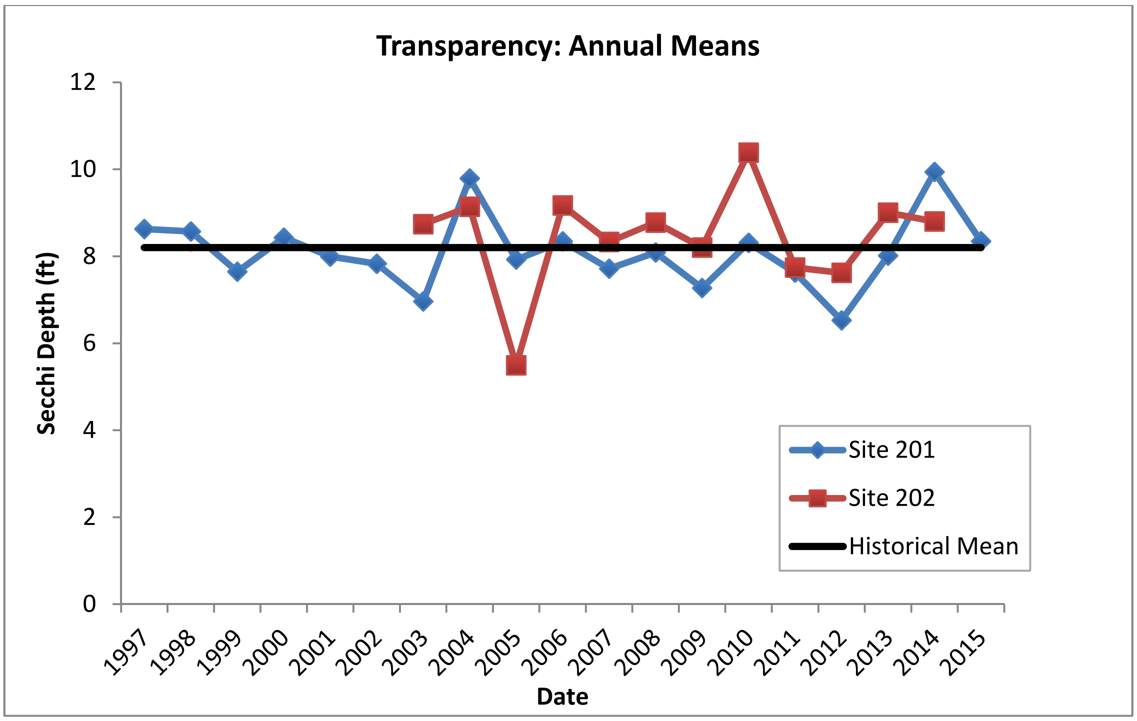


Figure 3.3 Little Pelican Lake annual mean transparency for site 201.

Little Pelican Lake transparency ranges from 4 to 18 feet throughout the summer. Figure 3.4 shows the seasonal transparency dynamics. Little Pelican Lake transparency is highest in May and early June and then declines throughout the summer. After the lake turns over in September the transparency improves in October. This pattern is typical for a lake of this depth in Minnesota. The transparency dynamics have to do with algae population dynamics and lake turnover.

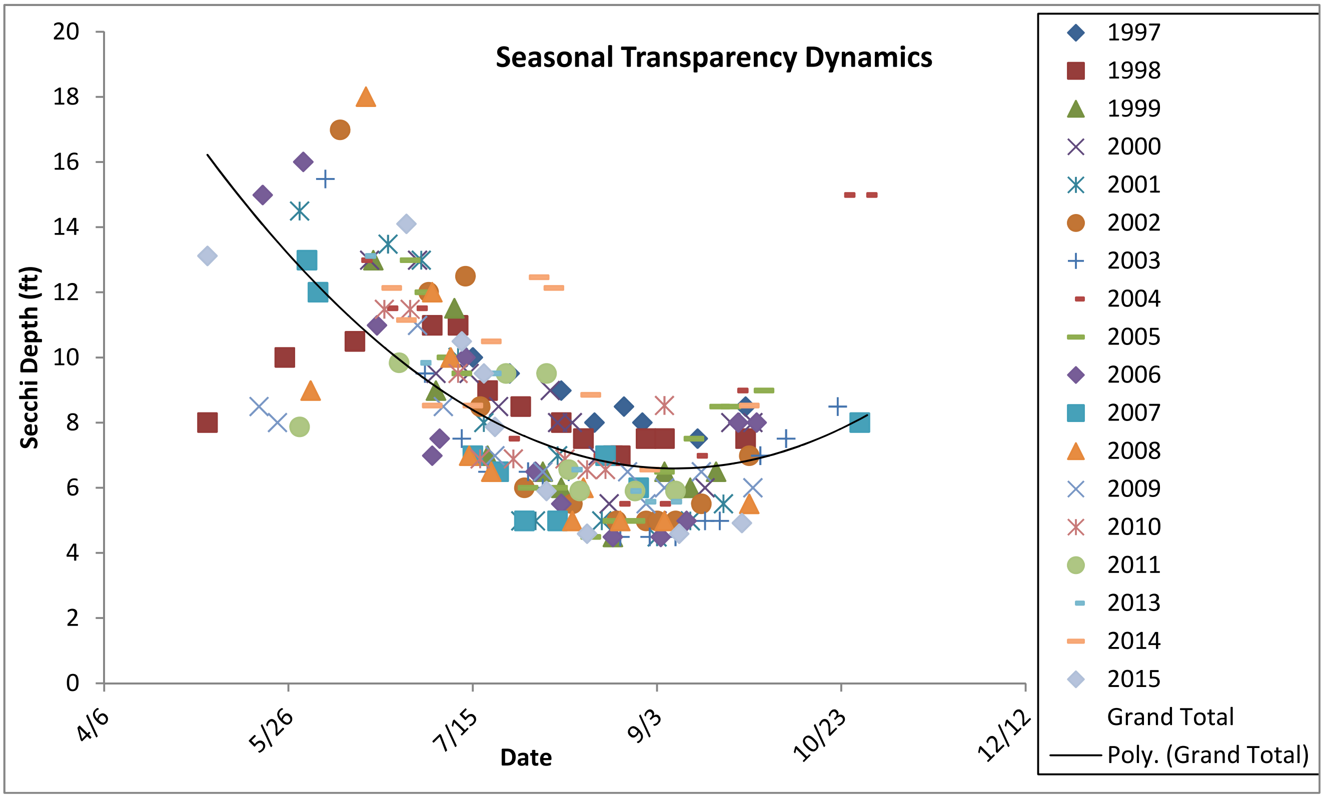


Figure 3.4 Seasonal transparency dynamics and year-to-year comparison.

User Perceptions

When Secchi depth readings are collected, the perceptions of the water based on the physical appearance and the recreational suitability is recorded. 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 Pelican Lake was rated as having "definite algae" 45% of the time between 1997-2015 (Figure 3.5).

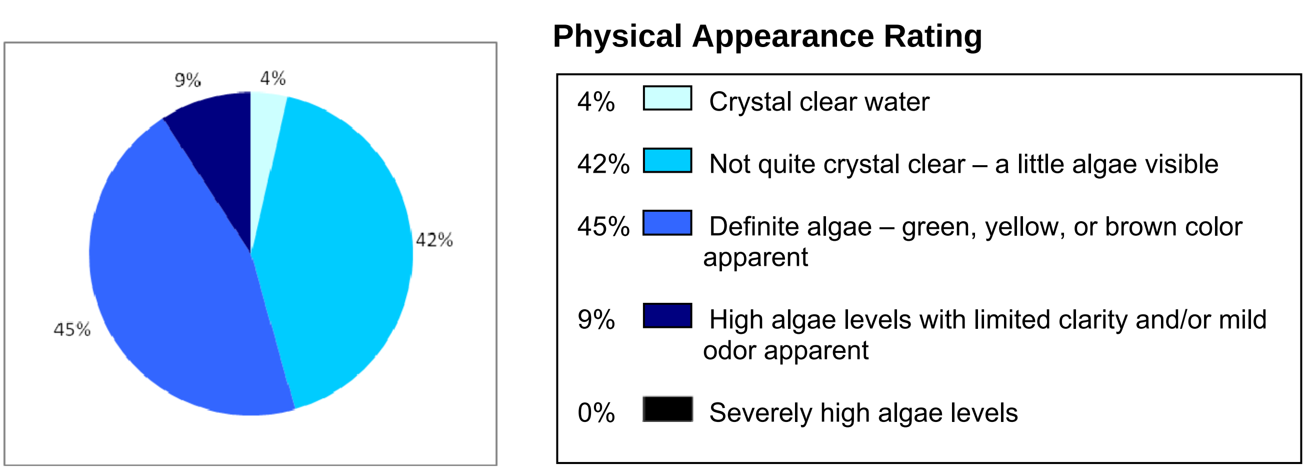
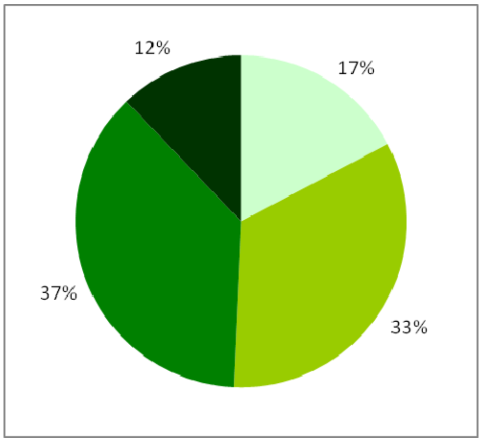


Figure 3.5. Physical appearance rating, as rated by the lake monitor (1997-2015).

As the Secchi depth decreases, the perception of recreational suitability of the lake decreases. Little Pelican Lake was rated as having "swimming and aesthetic enjoyment of the lake slightly impaired because of algae levels" 37% of the time from 1997-2015 (Figure 3.6). For 88% of the time, Little Pelican Lake was rated as being swimmable.



Recreational Suitability Rating

17% Beautiful, could not be better

33% Very minor aesthetic problems; excellent for swimming, boating

37% Swimming and aesthetic enjoyment of the lake slightly impaired because of algae levels

12% 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 3.6. Recreational suitability rating, as rated by the lake monitor (1997-2015).

Total Phosphorus

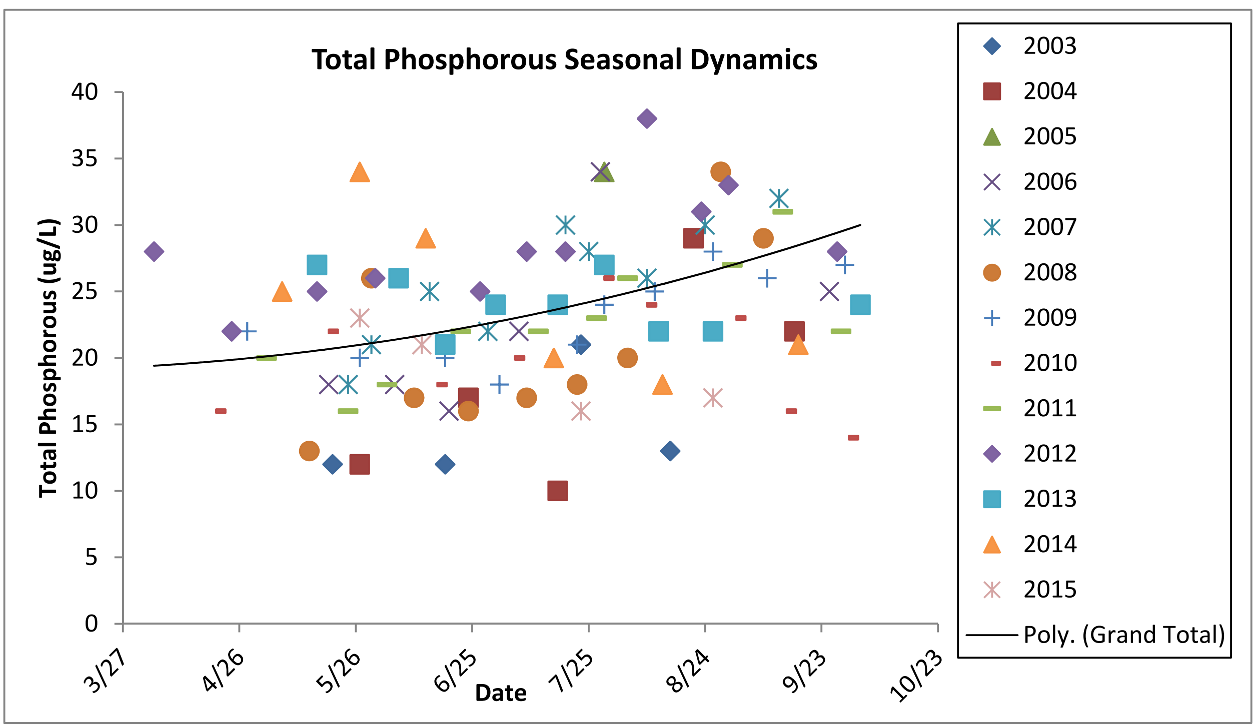


Figure 3.7 Historical total phosphorus concentrations (ug/L) for Little Pelican Lake site 202 (data set from 2003-2015). The black line is the best fit line to show the seasonal pattern.

Little Pelican Lake is phosphorus limited, which means that algae and aquatic plant growth is dependent upon available phosphorus. The total phosphorus concentration starts out low in the spring and gradually increases throughout the summer (Figure 3.7). There are two possible explanations to this pattern. One is that it follows the pattern in the Pelican River since that is a very large inlet to Little Pelican Lake. The other possible explanation is internal loading.

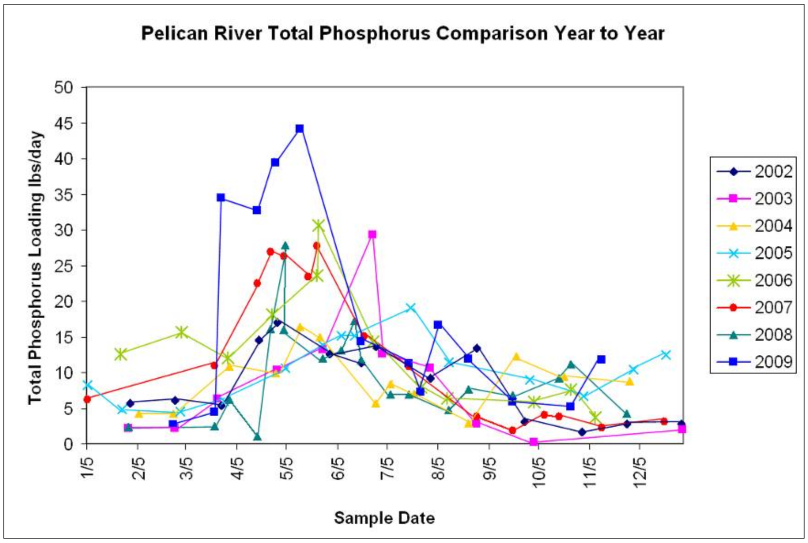


Figure 3.8 Pelican River total phosphorus loading pattern year to year.

Because data has been collected at the Pelican River inlet to Little Pelican Lake since 2002, we can compare those phosphorus concentrations to Little Pelican Lake.

Figure 3.8 shows that the phosphorus loading in Pelican River peaks in the spring and declines throughout the summer, so it is most likely not the cause of increasing phosphorus throughout the summer in Little Pelican Lake.

In 2009, water samples were collected just above the lake bottom to measure internal loading in Pelican Lake. Internal loading typically occurs in mid-summer when the oxygen at the bottom of the lake (hypolimnion) is depleted. When there is no oxygen in the hypolimnion, a chemical reaction occurs where phosphorus is released from the lake sediment back into the water. Then in the fall when the lake turns over this phosphorus comes up to the surface.

In shallow lakes (where the majority of the lake surface area is 15 feet deep or less) this pattern is somewhat different because the lake is not deep enough to strongly stratify. The lake may weakly stratify after a stretch of hot calm weather and then a day of strong wind will mix the lake up again. This means that the phosphorus in the lake sediment is constantly being replenished at the surface, which could explain the pattern seen in Figure 3.7.

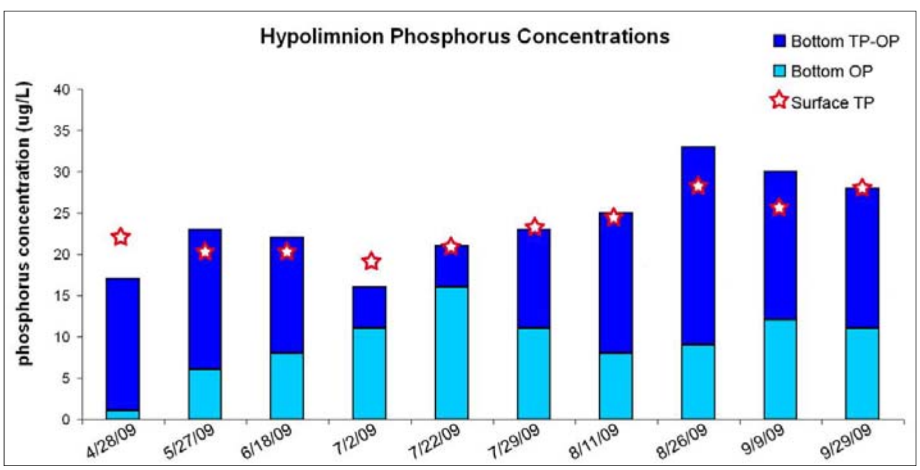


Figure 3.9. Hypolimnion phosphorus concentrations (ug/L) for Little Pelican Lake (data set from 2009).

Figure 3.9 shows that Little Pelican Lake follows a typical pattern shallow lake for internal loading. Most of the summer the hypolimnion phosphorus concentrations are similar to the surface water concentrations because the lake water column is fully mixed. On August 26th, the hypolimnion phosphorus concentration is higher than the surface, which could mean that the lake is weakly stratified and a windy day would mix phosphorus back up to the surface of the lake. The dissolved oxygen and temperature profiles on page 41 show that Little Pelican Lake was stratified on August 26, 2009.

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.

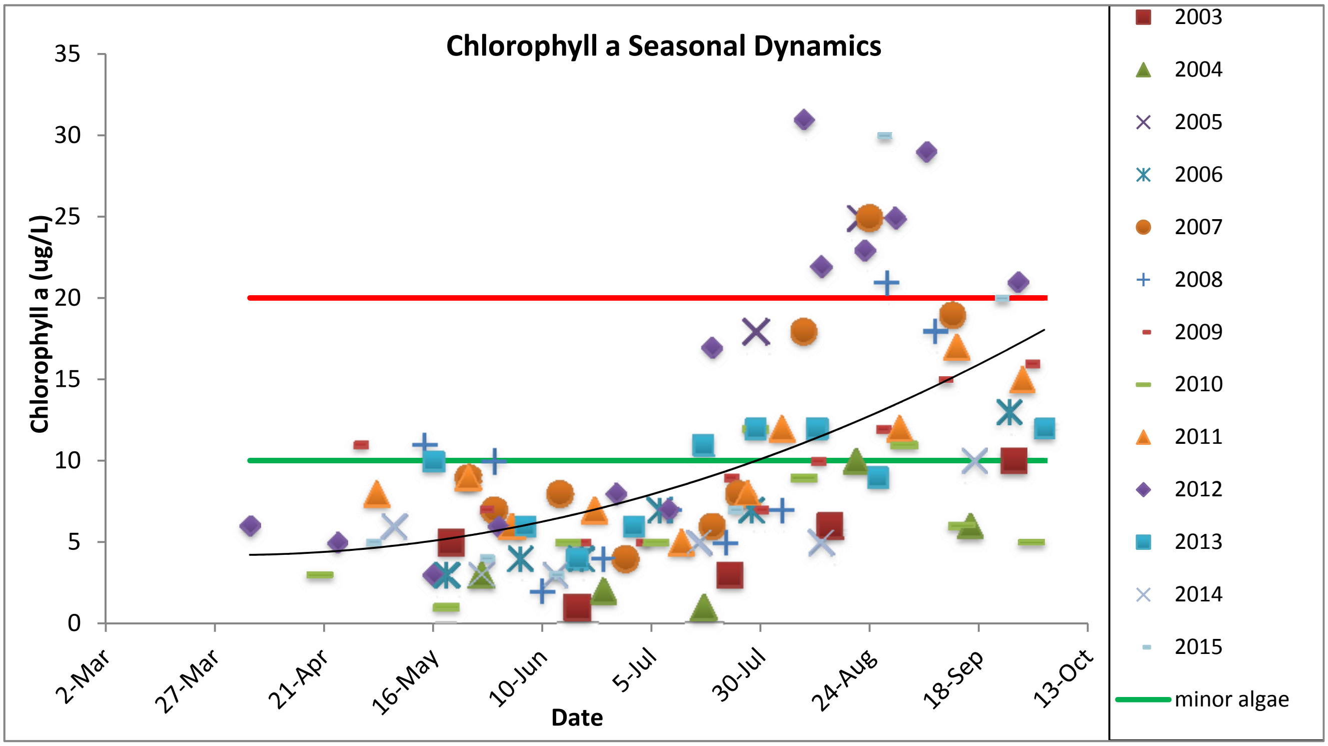


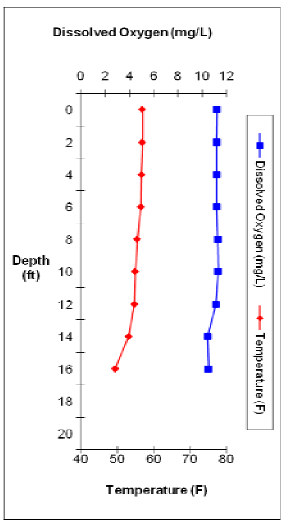
Figure 3.10 Chlorophyll a concentrations (ug/L) for Little Pelican Lake (data set from 2003-2015).

Chlorophyll *a* was evaluated in Little Pelican Lake in 2003-2015 (Figure 3.10). Chlorophyll *a* concentrations start out low in June and then increase to a peak in mid to late August. This pattern follows the phosphorus concentration because phosphorus is food for the algae (Figure 3.7). Chlorophyll *a* concentrations in Little Pelican Lake reached 10 ug/L every year indicating minor algae blooms toward the end of the summer. In 2005, 2007, 2008, 2012, and 2015 chlorophyll *a* concentrations reached 20 ug/L indicating nuisance algae blooms in late August. These chlorophyll *a* levels are typical for a shallow lake in northern Minnesota.

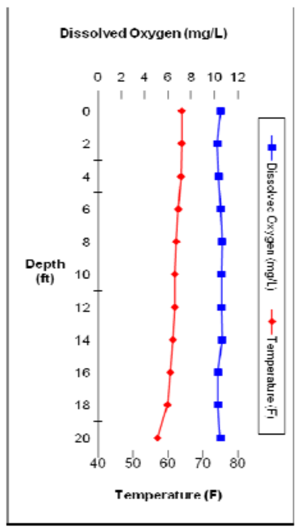
Dissolved Oxygen

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 oxygen that is dissolved in the water. Dissolved oxygen levels of <5 mg/L are typically avoided by game fish.

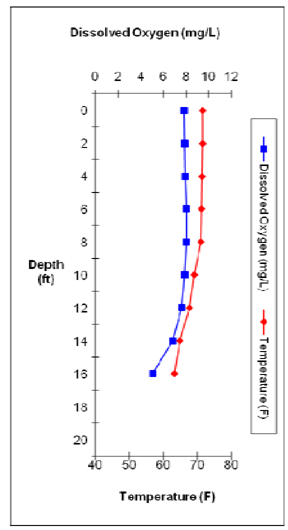
Little Pelican Lake is a shallow lake, with the majority of its depth less than 20 ft. Shallow lakes aren't deep enough to stratify throughout the whole summer. The dissolved oxygen/temperature profiles below show the dynamics in Little Pelican Lake in the summer of 2015. The graph shows that the temperature remains consistent from the surface of the lake to the bottom, which indicates no thermal stratification. On some dates in July and August the oxygen was depleted at the bottom of the lake. This usually occurs after a few warm calm days, and then a wind will mix the water column again.



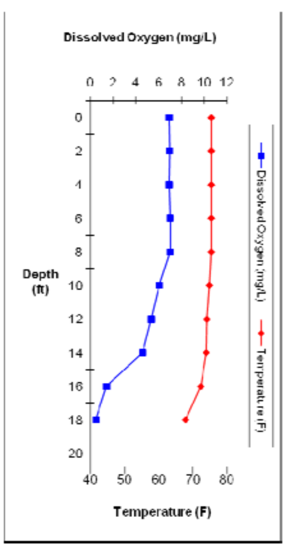
5/1/2015



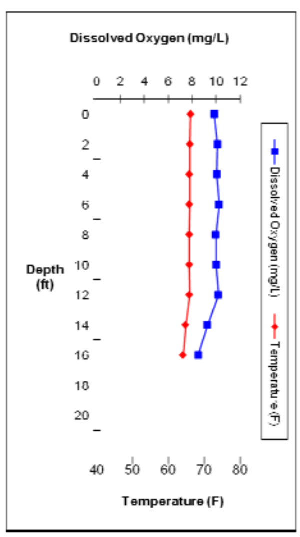
5/27/2015



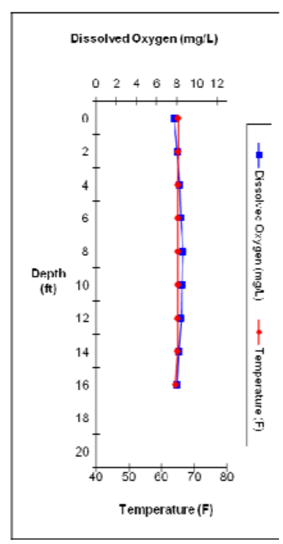
6/12/2015



7/23/2015



8/26/2015



9/22/2015

Trophic State Index

Trophic State Index	Site 202
TSI Total Phosphorus	50
TSI Chlorophyll-a	53
TSI Secchi	46
TSI Mean	50
Trophic State:	Mesotrophic/Eutrophic

Numbers represent the mean TSI for each parameter.

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 Little Pelican Lake falls in the mesotrophic/eutrophic border (Figure 3.11). There is good agreement between the TSI for phosphorus, chlorophyll *a* and transparency, indicating that these variables are strongly related.

Higher mesotrophic lakes (TSI=47-49) are characteristic of a dense aquatic plant population and algae blooms in mid to late summer. Fishing consists of panfish and bass.

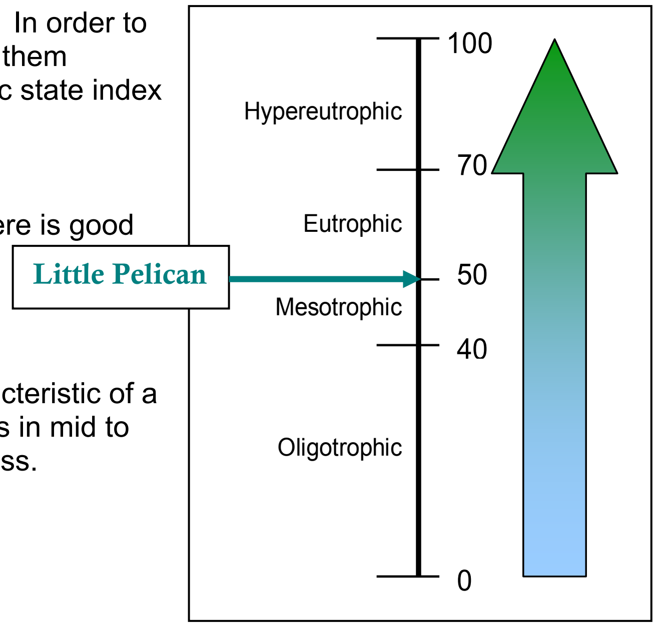


Figure 3.11 Trophic state index chart with corresponding trophic status.

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.

Little Pelican Lake has enough data to analyze long-term trends. The data was analyzed using the Mann Kendall Trend Analysis.

Lake Site	Parameter	Date Range	Trend
202	Total Phosphorus	2003-2015	No Trend
202	Chlorophyll *a*	2003-2015	No Trend
202	Transparency	2003-2015	No Trend
201	Long Term Transparency	1997-2011	No Trend

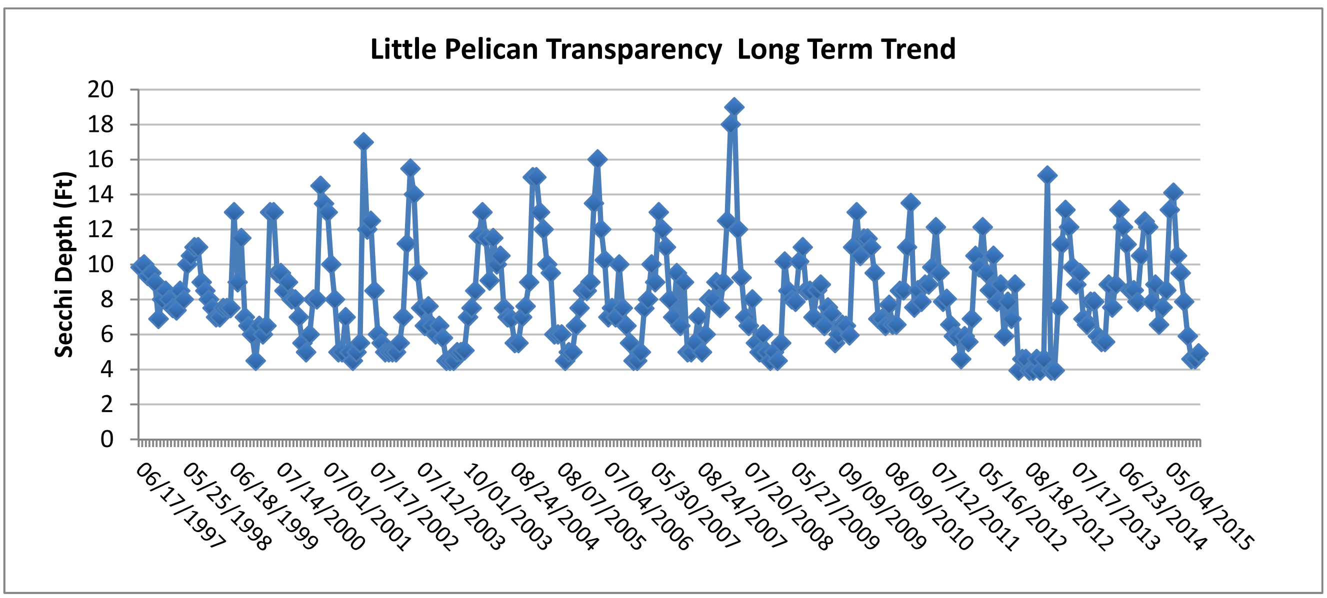
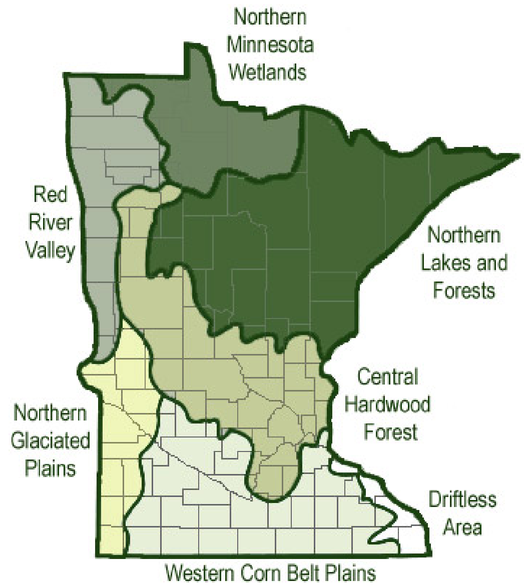


Figure 3.13 Little Pelican Lake long term transparency trend from 1997-2015.

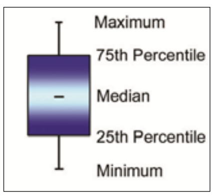
Little Pelican Lake shows no current trends in water quality. The majority of phosphorus loading into Little Pelican Lake comes from the Pelican River (89%), while 8% comes from runoff, 2% from precipitation and 1% from septic systems (see page 94 for lake loading models).

Little Pelican Lake has a very dense native plant population along with emergent plants such as bulrush and cattails. This vegetation has been increasingly removed over the past decade, which could contribute to higher phosphorus levels. The aquatic plants take up a lot of the phosphorus in the water and stabilize the lake sediments. When aquatic plants are removed, the phosphorus is available for more algae growth. In order to maintain the water quality in Little Pelican Lake, aquatic plants should be protected and not removed by homeowners.

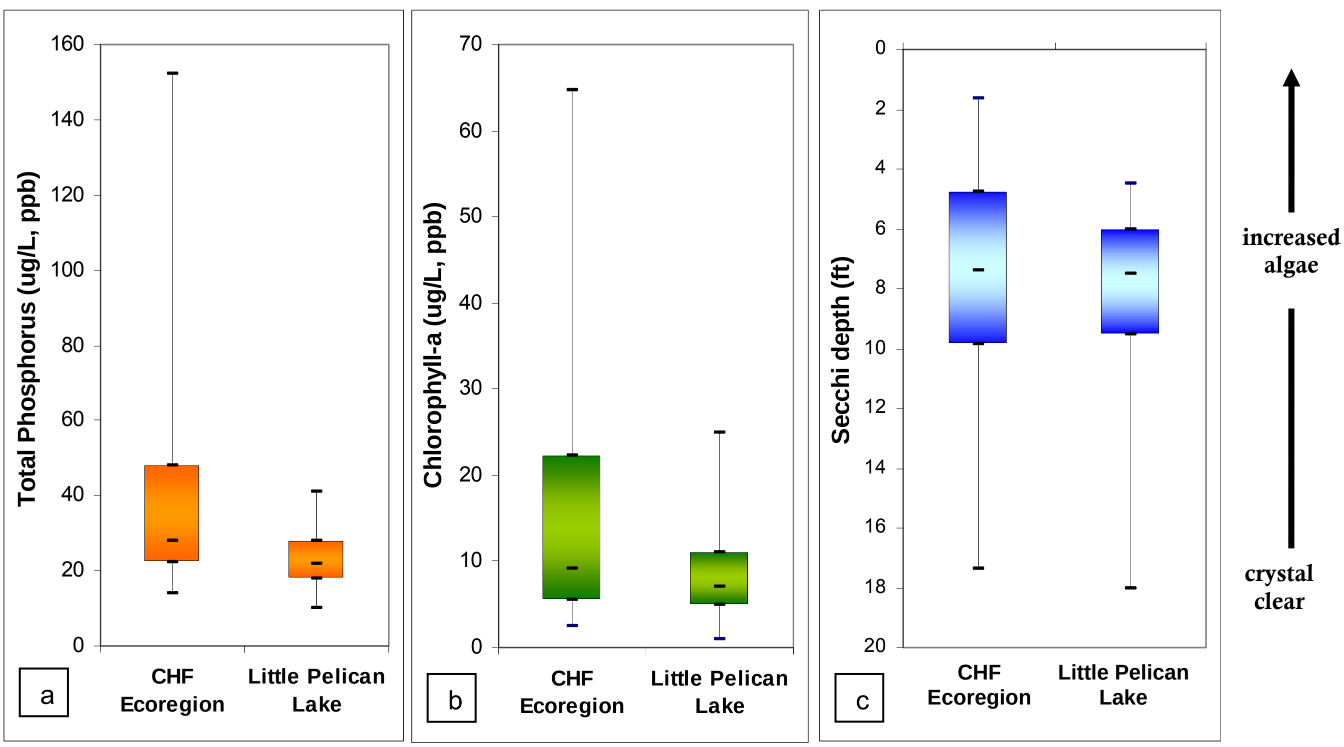
Ecoregion Comparisons



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.



Little Pelican Lake is in the Central Hardwood Forest Ecoregion. The mean total phosphorus, chlorophyll *a* and transparency (Secchi depth) for Little Pelican Lake are all within the expected ecoregion ranges (Figures 3.14a-c).



Figures 3.14a-c. Little Pelican Lake ranges compared to North Central Hardwood Forest Ecoregion ranges (data from 2003-2009).

State Assessments (Minnesota Pollution Control Agency)

Impaired Waters Assessment 303(d) List
There are two main types of Impaired Waters Assessment for lakes: eutrophication (excess phosphorus) for aquatic recreation and mercury in fish tissue for aquatic consumption. Little Pelican Lake is not listed as impaired for mercury in fish tissue; however, Pelican Lake is listed and is connected to Little Pelican Lake. Therefore, the fish in Little Pelican Lake should be considered impaired for mercury as well. See page 111 for fish consumption guidelines. Little Pelican Lake is not listed as impaired for eutrophication.

Aquatic Recreational Use Assessment 305(b)
In the 2008 MPCA Aquatic Use Assessment (305(b)), Little Pelican Lake was classified as being fully supporting for Aquatic Recreational Use.

Shallow Lakes and plants vs. algae (*article by Moriya Rufer*)

Have you ever wondered why shallow lakes have such dense aquatic plant growth? Having aquatic plants established in a shallow lake is a good thing, because the alternative is not so desirable. This article explains the natural state and importance of shallow lakes and what happens if this natural state is not protected.

Before we go any further, let's define "shallow". Shallow lakes are lakes where the sunlight can reach the bottom. Generally, this corresponds to 15 feet deep or less. Since the sunlight can reach the bottom, plants are able to grow there. Examples of shallow lakes in the Detroit Lakes area include Little Pelican, Rock, Rice, Rossman, Marshall, and Shell Lakes.

Shallow lakes provide some of the most important wildlife habitat. Aquatic plants in and around the lake are home to nearly all aquatic animals such as waterfowl, muskrats, otters, fish, insects, frogs and turtles. These lakes are also important resting areas for migrating waterfowl. There are over 5,000 shallow lakes in Minnesota that are over 50 acres in size.

Shallow lakes behave differently and have different dynamics than deep lakes. Deep lakes only mix in spring and fall, and the bottom of deep lakes stays cold and dark because light cannot reach the bottom. Shallow lakes, in contrast, mix all summer because light reaches the bottom of the lake and warms the whole water column.

A healthy shallow lake has clear water and dense aquatic plant growth. Many shallow lakes have large stands of bulrush and/or wild rice. The plants in these shallow lakes lock up a lot of the nutrients in their tissues so that there is not as much algae growth, and they produce oxygen throughout the water as a byproduct of photosynthesis. These plants also keep the sediments stable at the bottom of the lake and not mixed up into the water column. Tiny invertebrates called zooplankton eat algae and use plants as a hiding place from their predators (perch, sunfish and crappies).

Unfortunately, if a shallow lake isn't taken care of, it can turn into pea soup. If large areas of plants are removed by pulling them out, cutting them with a weed roller or with a boat motor, the sediments can get churned up and nutrients are released. If there are fewer plants to use the nutrients, the algae will use them and multiply. In addition, bulrushes and wild rice are protected by the DNR, and a DNR permit is necessary to remove them.

Once the water is "green" with dense algae, these lakes have mostly muck on the bottom instead of plants because the sunlight can't get through the dense algae to the bottom of the lake. Algae-dominated shallow lakes are also not as high of quality habitat for fish and wildlife. If the plants are gone there is no place for aquatic animals to hide. In addition, the oxygen at the bottom of these shallow lakes is usually depleted because of all the decomposition of dead algae that sinks to the bottom.

If there are fewer plants, the zooplankton have nowhere to hide and are eaten up by small fish. With the zooplankton gone, there is nothing to eat the algae and keep it in check. The lake just continues to support more algae.

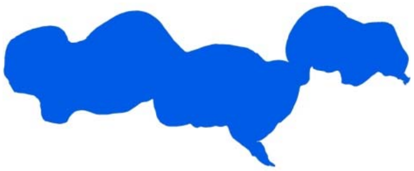
All these factors are like a positive feed back loop that just keeps pushing the lake towards more and more algae, cloudier (turbid) water, and less plants and wildlife.

If you live on a shallow lake, keep in mind that the natural state of the lake is to have abundant aquatic vegetation. Enjoy the excellent bird and wildlife viewing available on these lakes.

To learn more about shallow lakes, visit:
http://www.dnr.state.mn.us/wildlife/shallowlakes/index.html.

Pelican Lake 56-0786-00 OTTER TAIL COUNTY

Summary



Pelican Lake is the largest lake in the Pelican Group of Lakes. The Pelican River enters Pelican Lake on the east end, and Spring Creek and Bob Creek enter Pelican Lake on the west end. The Pelican River exits Pelican Lake to the south, flowing through Fish Lake until finally exiting the Pelican Group of Lakes.

Due to its size, good fishing and good recreational opportunities, Pelican Lake is one of the most popular tourism lakes in northwest Minnesota. Approximately half of the Pelican Lake visitors come from North Dakota.

In 2009, Zebra mussels were found in Pelican Lake. Due to the size of the mussels and their distribution, it was concluded that they have probably been established in the lake for over a year. Unfortunately, at this time there is no treatment or fix for zebra mussels.

Currently, the main threats to Pelican Lake include land use changes upstream from the inlets, removal of aquatic plants, unnatural shorelines (manicured lawns by the lake), any new development that clears vegetation, and boats with large motors speeding around in the lake in areas less than 10 feet deep. The west end of Pelican Lake is most susceptible to boat motor stirring because it is shallow.

Water quality data have been collected in Pelican Lake since 1997. These data show that the lake is mesotrophic, which is characteristic of moderately clear water all summer.

Vitals

MN Lake ID:	56-0786-00
County:	Otter Tail
Ecoregion:	North Central Hardwood Forest
Major Drainage Basin:	Red River
Latitude/Longitude:	46.70138889 / -96.02805556
Water Body Type:	Public
Monitored Sites:	206 (primary), 201, 205
Invasive species present:	Zebra Mussels (confirmed September 2009), Curly-leaf pondweed

Physical Characteristics

Surface area (acres):	3,986	
Littoral area (acres):	1,625	
% Littoral area:	40%	
Max depth (ft):	55	(m): 16.8
Mean depth (ft):	22	(m): 6.7
Lakeshed size (acres):	15,783	
Lakeshed : lake area ratio	4 : 1	
Inlets	Pelican River, Bob Creek, Spring Creek	
Outlets	Pelican River to Fish Lake	
Public Accesses	2	

Data Availability

Transparency data	Data exist from the MPCA CLMP program from 1996-2002, and RMB Labs from 2003-2015.
Chemical data	Data exist from RMB Labs from 2003-2015.
Inlet/Outlet data	The inlets and outlets been monitored by RMB Lab from 2002-2015.

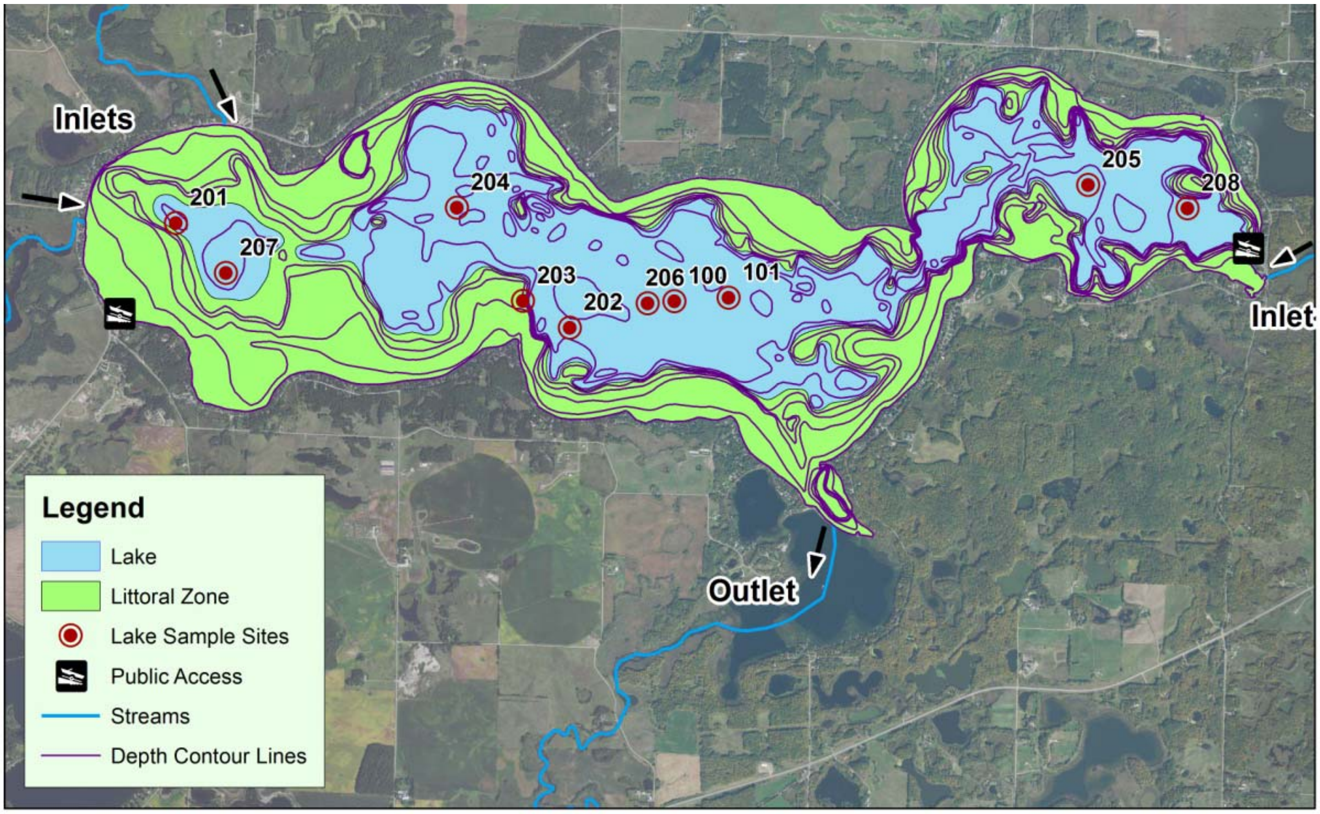


Figure 3.15. Map of Pelican Lake illustrating bathymetry, lake sample site locations, stream inlets and outlets and aerial land use. The pink shaded areas in the lake illustrate the littoral zone, where the sunlight can usually reach the lake bottom allowing aquatic plants to grow.

Lake Site	Depth (ft)	Monitoring Programs
201	30	CLMP: 1982, 1995-1996; PGOLID: 2007-2015
202	40	CLMP: 1982-1985, 1995
203	20	CLMP: 1988
204 (103)	50	CLMP: 1995-2008
205	52	CLMP: 1995-2012; PGOLID: 2007-2015
206 (19406, 101) *Primary Site	50	MPCA: 1980, 1986, 1997, 2005 CLMP: 1996-2009 PGOLID: 2003-2015
207	30	CLMP: 1997-2007
208 (102)	40	CLMP: 2006-2012

KEY:
CLMP (MPCA Citizens Lake Monitoring Program)
PGOLID (Pelican Group of Lakes Improvement District), monitoring done by Lake Resource Coordinator (RMB Lab)
MPCA (Minnesota Pollution Control Agency)

The information below describes available chemical data for Pelican Lake through 2009. 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

Parameter	Mean	Ecoregion Range[1]	Interpretation
Total phosphorus (ug/L)	15.2	23 - 50	Results are better than the expected range for the ecoregion. For more details, see page 60.
Chlorophyll *a* (ug/L) [2]	4.8	5 – 22	
Chlorophyll *a* max (ug/L)	17	7 – 37	
Secchi depth (ft)	12.7	4.9 – 10.5	
Dissolved oxygen	Dimictic *See page 58*		Dissolved oxygen depth profiles show that the deep areas of the lake are anoxic in late summer.
Chloride (mg/L)	17.8	4 - 10	Slightly higher than the Ecoregion range, which could be due to winter road salt.
Total Kieldahl Nitrogen (mg/L)	0.3	0.62 – 1.2	Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms.
Ortho phosphorus (surface, ug/L)	5.3	NA	Indicates that all available ortho-phosphorus is taken up by plants and algae living in the lake.
Alkalinity (mg/L)	179.3	75 – 150	Indicates a low sensitivity to acid rain and a good buffering capacity.
Color (Pt-Co Units)	6.5	10-20	Indicates very clear water with little to no tannins (brown stain).
Total Suspended Solids (mg/L)	1.6	2 – 6	Below the ecoregion average range indicating clear water.
Specific Conductance	404.7	300-400	Within the ecoregion average range.
Total Nitrogen : Total Phosphorus	20:1	25:1 – 35:1	The lake is phosphorus limited, which means that algae growth is limited by the amount of phosphorus in the lake.
Calcium (mg/L)	33.6		Indicates a hard water lake with sufficient calcium for Zebra mussel survival.
Magnesium (mg/L)	27.8		Indicates a hard water lake.

Data Source: 1997 MPCA LAP, 2003-2015 PGOLID Monitoring Program

[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: 1997-2015

Parameters	Site 206*	Site 201	Site 205	Site 204	Site 207
Total Phosphorus Mean (ug/L):	**14.6**	**12.8**	**15.6**	**13.4**	
Total Phosphorus Min:	5	6	5	10	
Total Phosphorus Max:	45	24	39	17	
Number of Observations:	122	73	75	5	
Chlorophyll *a* Mean (ug/L):	**4.7**	**4.3**	**5.6**	**5.1**	
Chlorophyll *a* Min:	1	1	1	2.8	
Chlorophyll *a* Max:	12	12	17	8.2	
Number of Observations:	122	73	75	5	
Secchi Depth Mean (ft):	**13.0**	**13.1**	**12.1**	**15.9**	**11.7**
Secchi Depth Min:	6.5	3.9	5.5	8.5	2.0
Secchi Depth Max:	35.0	32.1	27.9	29.0	19.3
Number of Observations:	198	126	251	99	84

*primary site

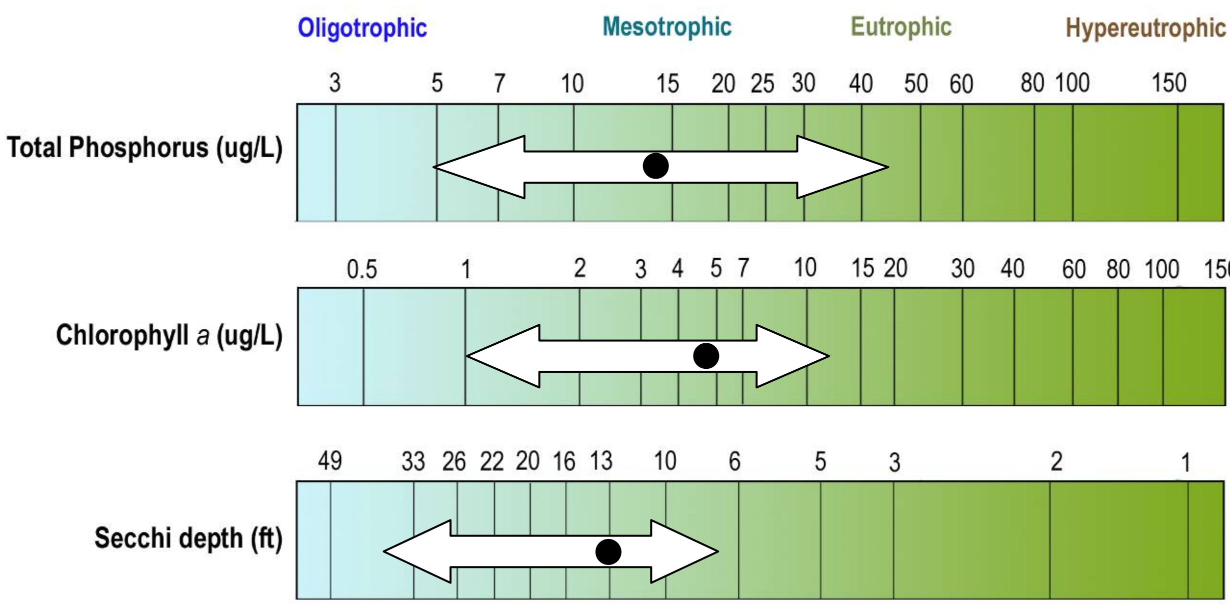


Figure 3.16. Pelican Lake total phosphorus, chlorophyll *a* and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Primary Site 206). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. 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. Sites 205 and 206 in Pelican Lake have been monitored from 1996-2015, and Site 201 has been monitored from 2007-2015. The annual means for Pelican Lake range from 9.1-22.3 ft. Figure 3.17 shows that Site 206 in the middle of the lake consistently has the best transparency in the lake. Site 205 on the east end of the lake consistency has the lowest transparency, which makes sense because the Pelican River is the largest contributor of phosphorus to Pelican Lake. The Pelican River enters Pelican Lake on the east end. Transparency has been higher since 2011, which is likely due to Zebra mussels filtering the water.

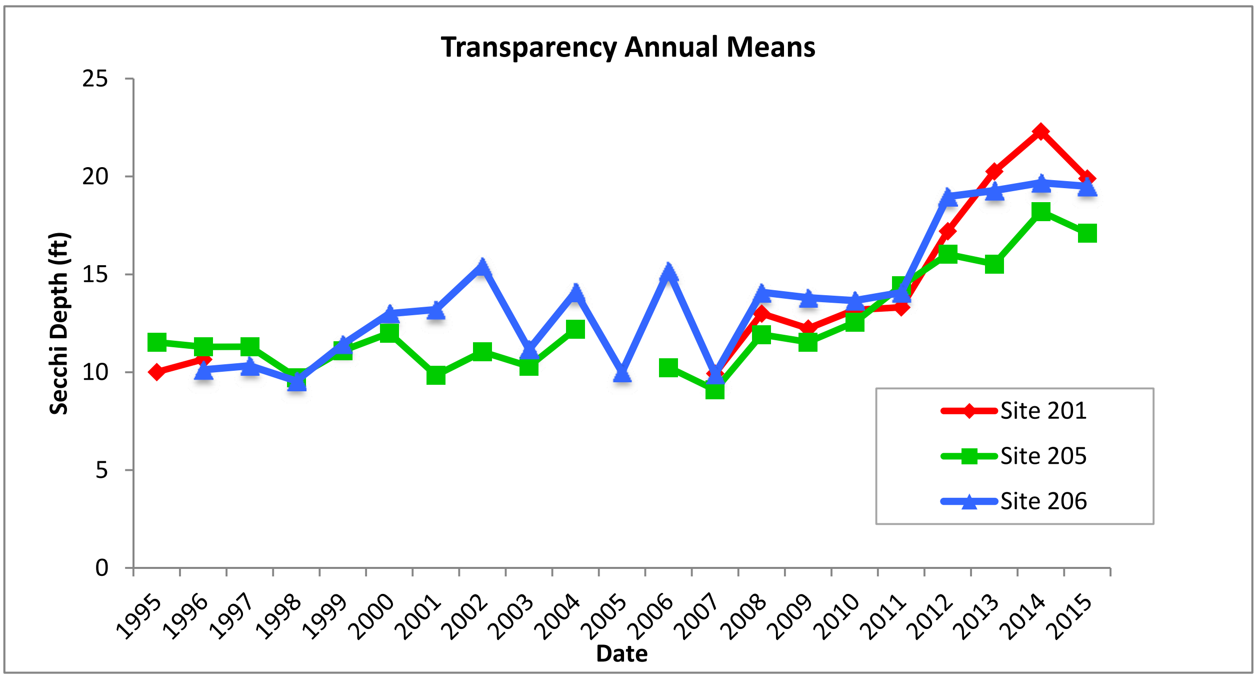


Figure 3.17 Pelican Lake annual mean transparency for sites 201, 205 and 206.

Pelican Lake transparency ranges from 6.5 to 30 feet throughout the summer. Figure 3.18 shows the seasonal transparency dynamics. Pelican Lake transparency is highest in May and early June and then declines throughout the summer. After the lake turns over in September the transparency improves in late September - October. This pattern is typical for a lake of this depth in Minnesota. The transparency dynamics have to do with algae population dynamics and lake turnover.

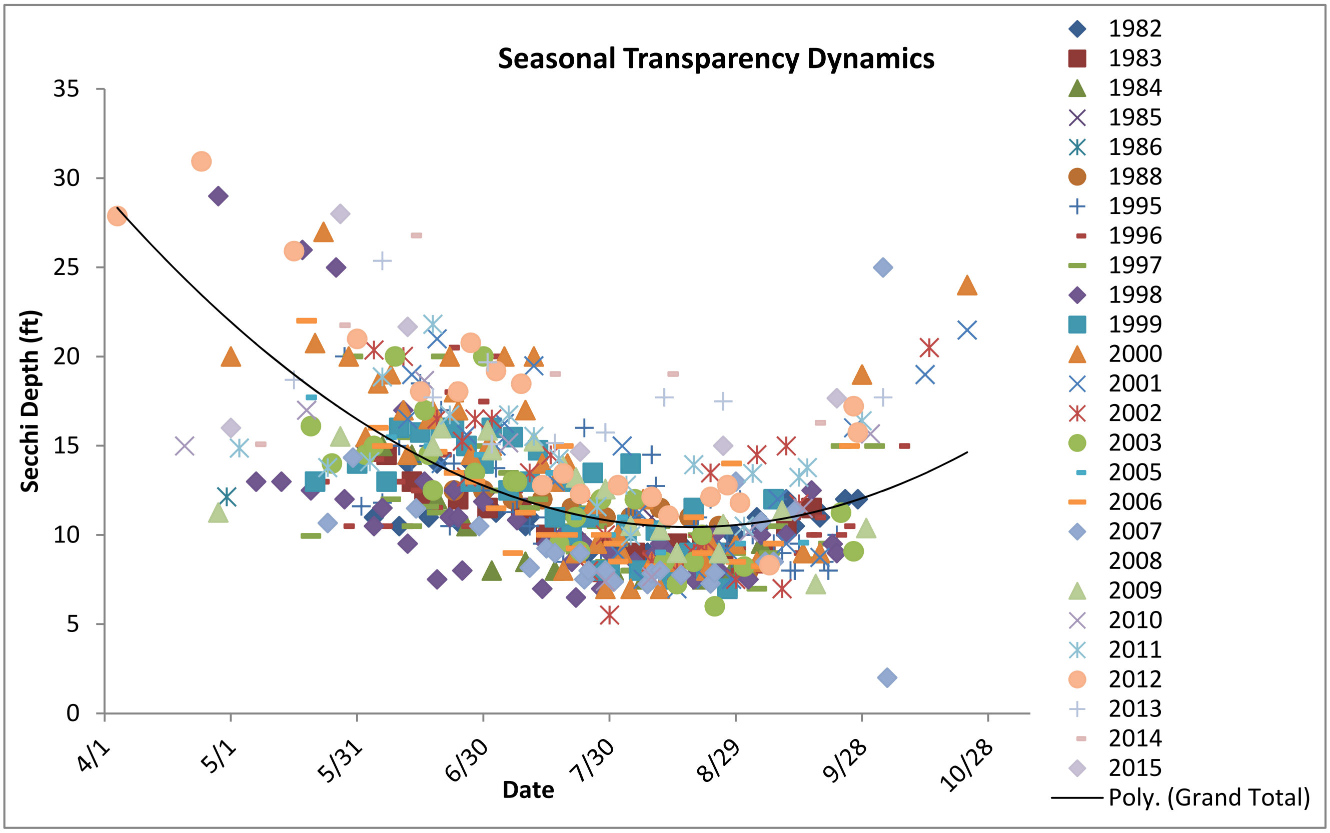


Figure 3.18 Seasonal transparency dynamics and year-to-year comparison.

User Perceptions

When Secchi depth readings are collected, the perceptions of the water based on the physical appearance and the recreational suitability is recorded. 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. Pelican Lake was rated as being "not quite crystal clear" 48% of the time between 1997-2015 (Figure 3.19).

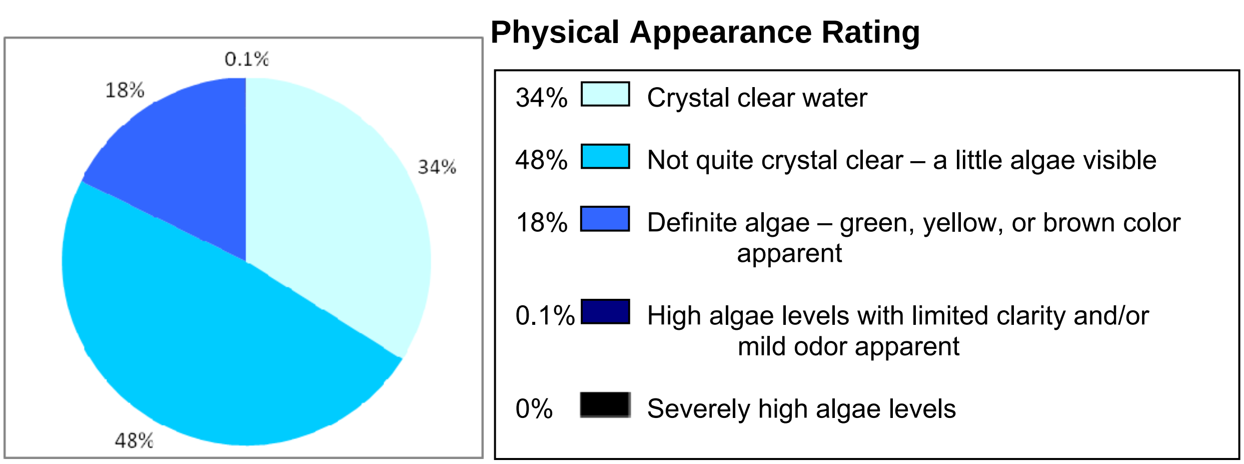
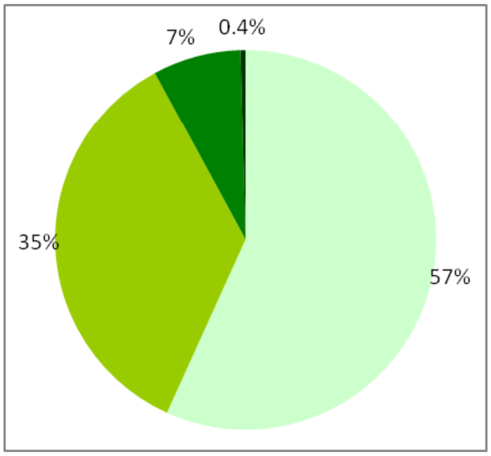


Figure 3.19. Physical appearance rating, as rated by the lake monitor (1997-2015).

As the Secchi depth decreases, the perception of recreational suitability of the lake decreases. Pelican Lake was rated as being "beautiful" 57% of the time from 1997-2015 (Figure 3.20). For 99% of the time, Pelican Lake was rated as being swimmable.

Recreational Suitability Rating



57% Beautiful, could not be better

35% Very minor aesthetic problems; excellent for swimming, boating

7% Swimming and aesthetic enjoyment of the lake slightly impaired because of algae levels

0.4% 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 3.20 Recreational suitability rating, as rated by the lake monitor (1997-2015).

Total Phosphorus

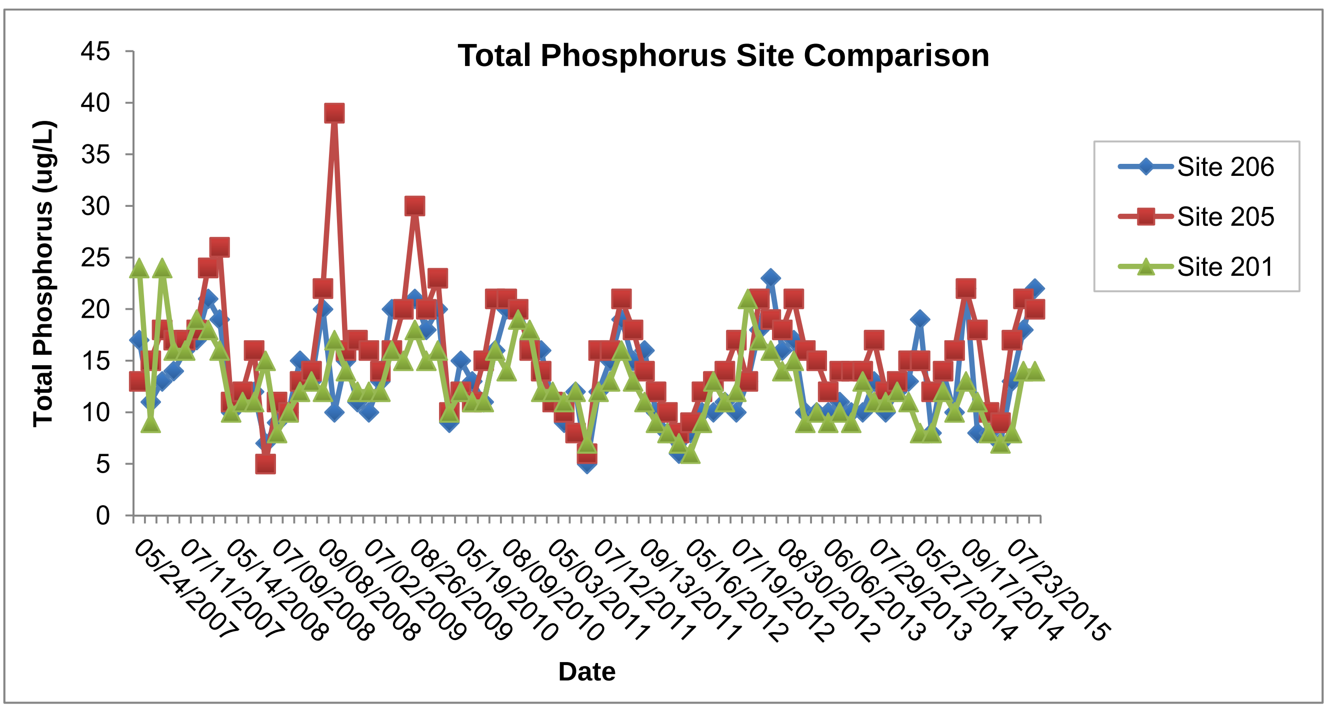


Figure 3.21 2007-2015 total phosphorus concentrations (ug/L) for Pelican Lake comparing sites 206, 205 and 201.

Pelican Lake is phosphorus limited, which means that algae and aquatic plant growth is dependent upon available phosphorus. Generally, the less phosphorus in the lake, the better the water quality for recreation.

From 2007-2015, all three Pelican Lake sites were monitored for total phosphorus. The lowest phosphorus concentration was consistently at Site 206 in the middle of the lake (Figure 3.21). This makes sense because this site is the furthest from any inlets to the lake, and lake inlets are usually the highest source of phosphorus. Site 205 had the highest phosphorus concentration, which makes sense because the Pelican River is the largest contributor of phosphorus to Pelican Lake. The Pelican River enters Pelican Lake on the east end. Site 201 was higher than the middle of the lake due to the Spring Creek and Bob Creek inlets which carry phosphorus into the lake from the west side.

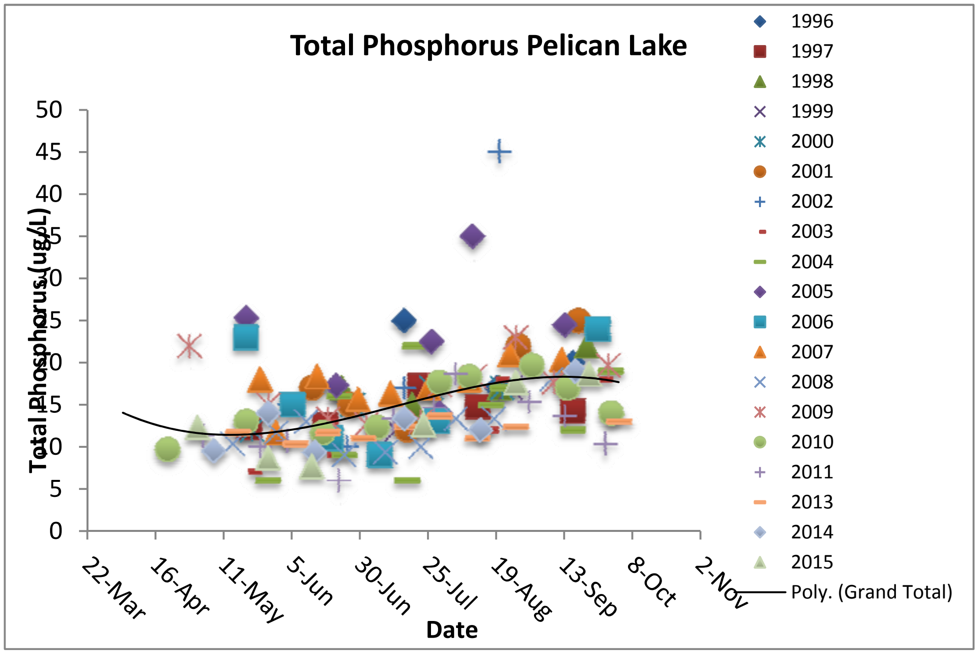


Figure 3.22. 1996-2015 total phosphorus concentrations (ug/L) for Pelican Lake. The Black line is the best fit trend line.

In Pelican Lake, the total phosphorus concentration starts out low in the spring and gradually increases throughout the summer (Figure 3.22). There are two possible explanations to this pattern. One is that it follows the pattern in the Pelican River since that is a very large inlet to Pelican Lake. The other possible explanation is internal loading.

Because data has been collected at the Pelican River inlet to Pelican Lake (Strom's Bridge) since 2002, we can compare those phosphorus concentrations to Pelican Lake.

Figure 3.23 shows that the phosphorus loading in Pelican River peaks in the spring and declines throughout the summer, so it is most likely not the cause of increasing phosphorus throughout the summer in Pelican Lake.

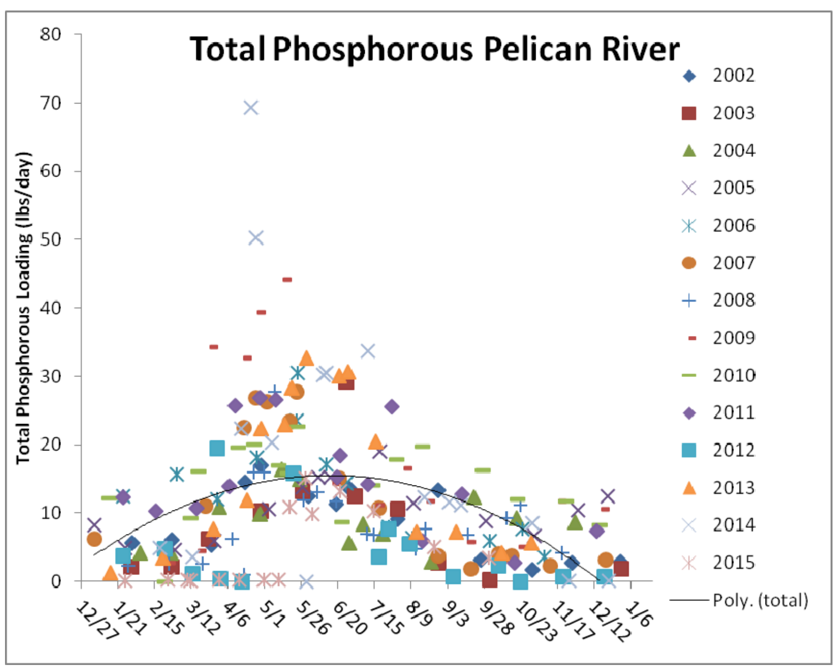


Figure 3.23. 2001-2015 total phosphorus loading (lbs/day) for Pelican River. The black line represents the pattern.

In 2009, water samples were collected just above the lake bottom to measure internal loading in Pelican Lake. Internal loading typically occurs in mid-summer when the oxygen at the bottom of the lake (hypolimnion) is depleted. When there is no oxygen in the hypolimnion, a chemical reaction occurs where phosphorus is released from the lake sediment back into the water. Then in the fall when the lake turns over this phosphorus comes up to the surface.

Pelican Lake follows a typical pattern for internal loading in a lake of its depth and geographical placement in Minnesota (Figures 3.24-3.27). The different lake sites vary in the degree of stratification and internal loading that occurs. Both sites 206 (middle of lake) and 205 (east end of lake) stratify in the summer (pages 58-59); however, site 205 shows high internal loading and site 206 does not (Figure 3.26). A possible explanation for this result is that the Pelican River carries a large load of phosphorus into the lake on the east side and this phosphorus settles at the bottom of the east end of the lake. Site 206 is far from any inlets to the lake, which is why there could be less phosphorus at the bottom to re-circulate into the water column.

Most of the summer the hypolimnion phosphorus concentrations at site 201 are similar or less than the surface water concentrations because the lake water column is fully mixed.

Site 201 (west end of the lake) behaves like a shallow lake site since it is only 30 feet deep. In shallow lakes the pattern is somewhat different because the lake is not deep enough to strongly stratify. The west end of Pelican Lake may weakly stratify after a stretch of hot

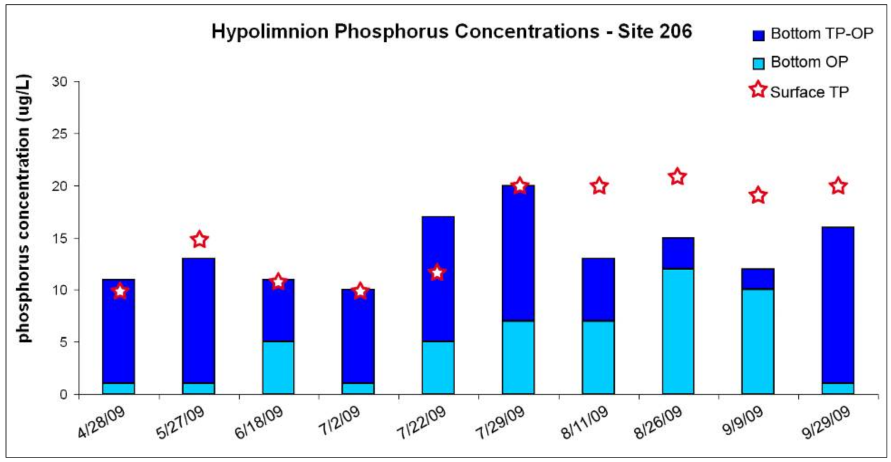


Figure 3.24 Site 206 internal loading data from 2009. These data show that hypolimnion phosphorus is only higher than surface phosphorus on 7/22/09.

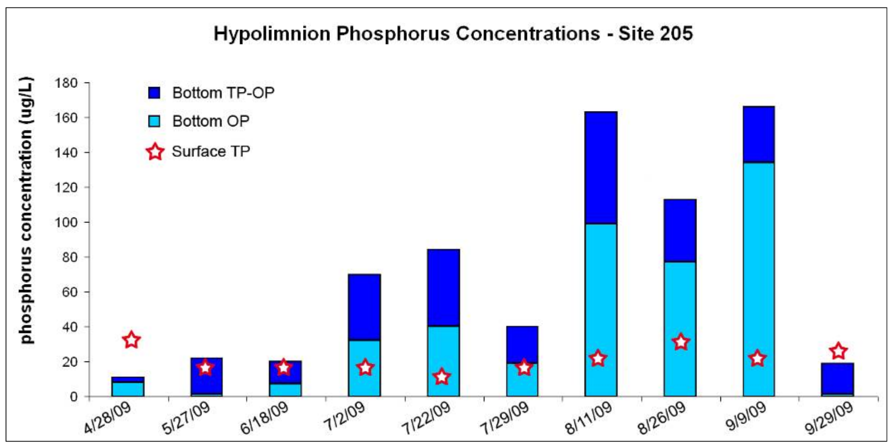


Figure 3.25 Site 206 internal loading data from 2009. These data show that hypolimnion phosphorus is only higher than surface phosphorus on 7/22/09.

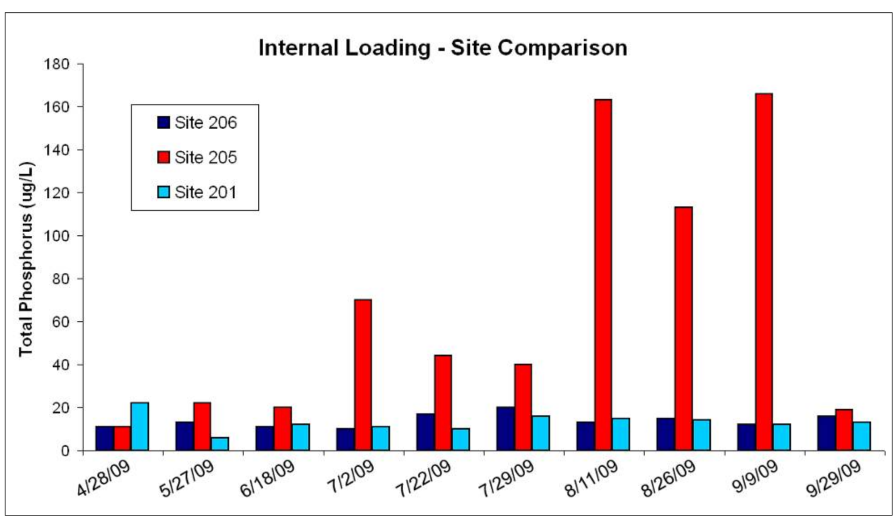


Figure 3.26 Internal loading comparison between sites in Pelican Lake. Site 205 shows much higher hypolimnion phosphorus levels than sites 201 and 206.

calm weather and then a day of strong wind will mix the lake up again.

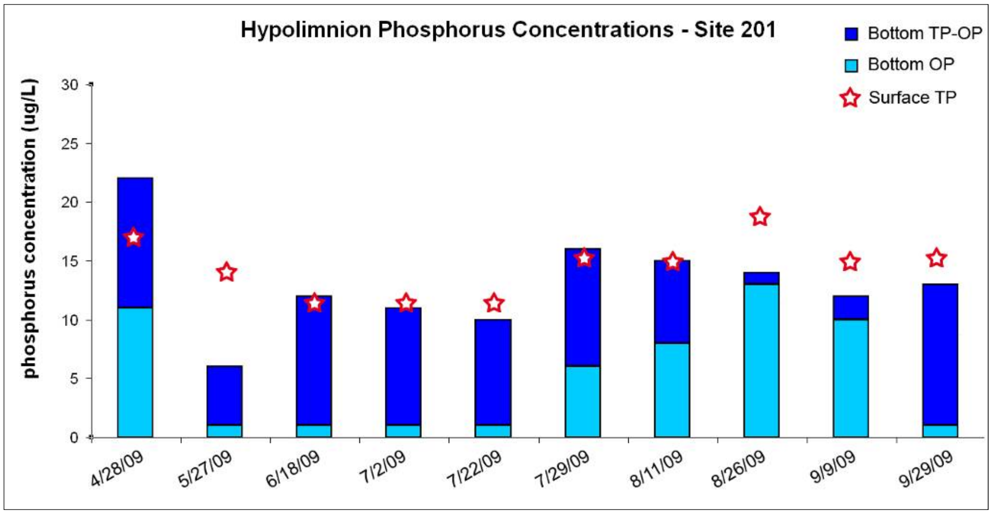


Figure 3.27 Site 201 internal loading data from 2009. These data show that hypolimnion phosphorus is only higher than surface phosphorus on 4/28/09 and 7/29/09.

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 algae bloom.

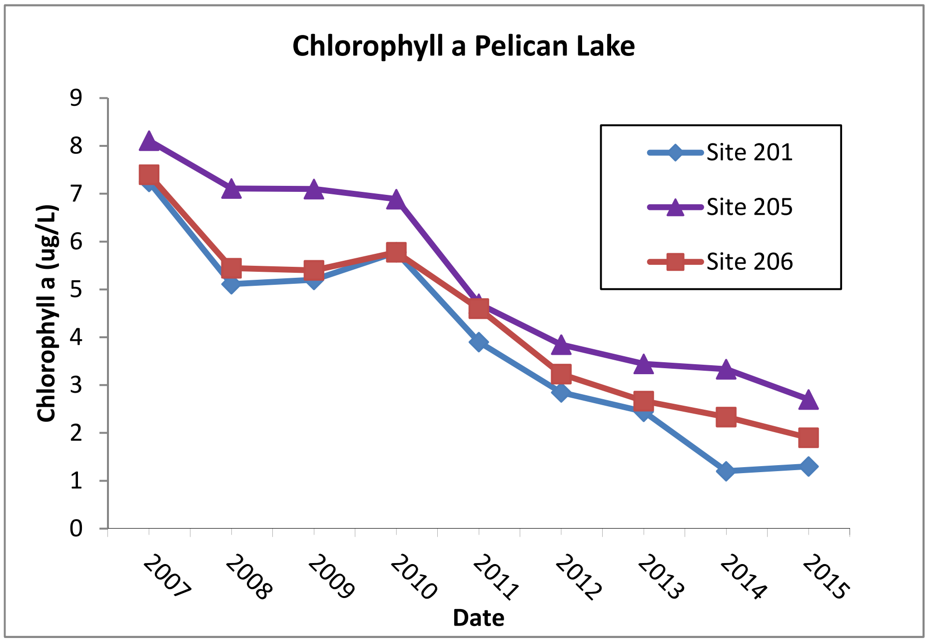


Figure 3.28. 2007-2015 chlorophyll a annual mean concentrations (ug/L) for Pelican Lake comparing sites 201, 205 and 206. .

Chlorophyll *a* concentrations are highest at site 205 and lowest at site 206, which matches the total phosphorus results (Figures 3.21 and 3.28). Since phosphorus is food for algae, this result makes sense. Chlorophyll a concentrations at site 205 exceed 10 ug/L, indicating minor algae blooms in late summer (Figure 3.29). Sites 201 and 206 barely ever make it to 10 ug/L, indicating clear water most of the summer.

Chlorophyll a concentrations in Pelican Lake have decreased dramatically since Zebra mussels were established in 2009 (Figure 3.28).

Chlorophyll *a* was evaluated at site 206 in Pelican Lake from 2002-2013 (Figure 3.29). Chlorophyll *a* concentrations start out low in June and then increase to a peak in mid to late August. This pattern follows the phosphorus concentration because phosphorus is food for the algae (Figures 3.22 and 3.29).

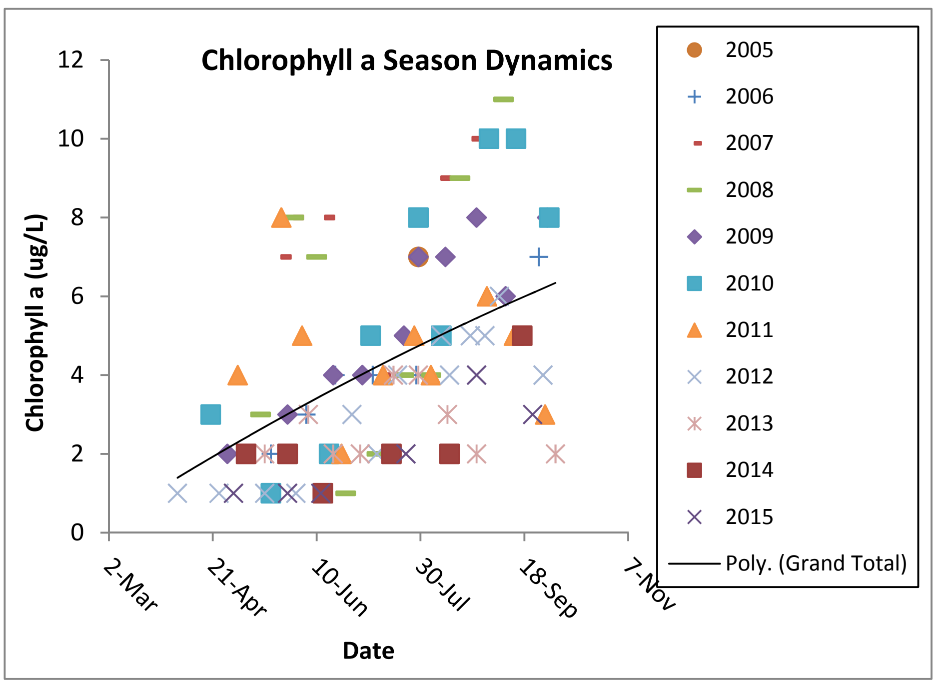


Figure 3.29. Chlorophyll a seasonal dynamics at site 206 for Pelican Lake 2002-2015.

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 oxygen that is dissolved in the water. Dissolved oxygen levels of <5 mg/L are typically avoided by game fish. Dissolved oxygen profiles Lake have been collected in Pelican Lake by the Lake Resource Coordinator from 2007-2009.

Site 205 (east end of the lake) has a maximum depth of 52 ft. The profiles indicate that site 205 in Pelican Lake stratifies in mid summer (Figure 3.30). In 2015, the lake began stratifying in June and turned over in September. In the summer the thermocline was at approximately 24 feet, which means that game fish were most likely absent below 24 feet.

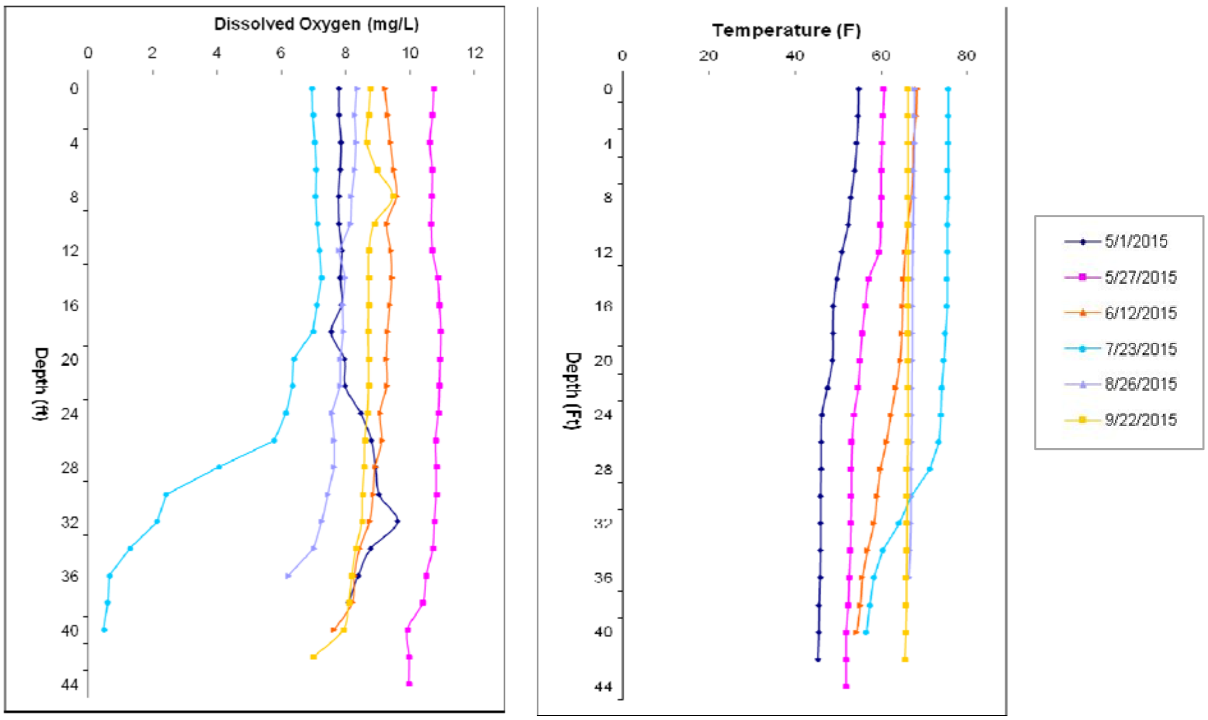


Figure 3.30. Site 205 dissolved oxygen and temperature profiles, 2015.

Site 206 (middle of the lake) has a maximum depth of 50 ft. The profiles indicate that site 206 in Pelican Lake stratifies in mid summer, but not as strongly as site 205 (Figure 3.31). Because Pelican Lake has such a long fetch (area for wind to whip up the water) site 206 is subject to more wind mixing. In 2015, the lake began stratifying in early June and turned over in early September. In the summer the thermocline was at approximately 28 feet, which means that game fish were most likely absent below 28 feet.

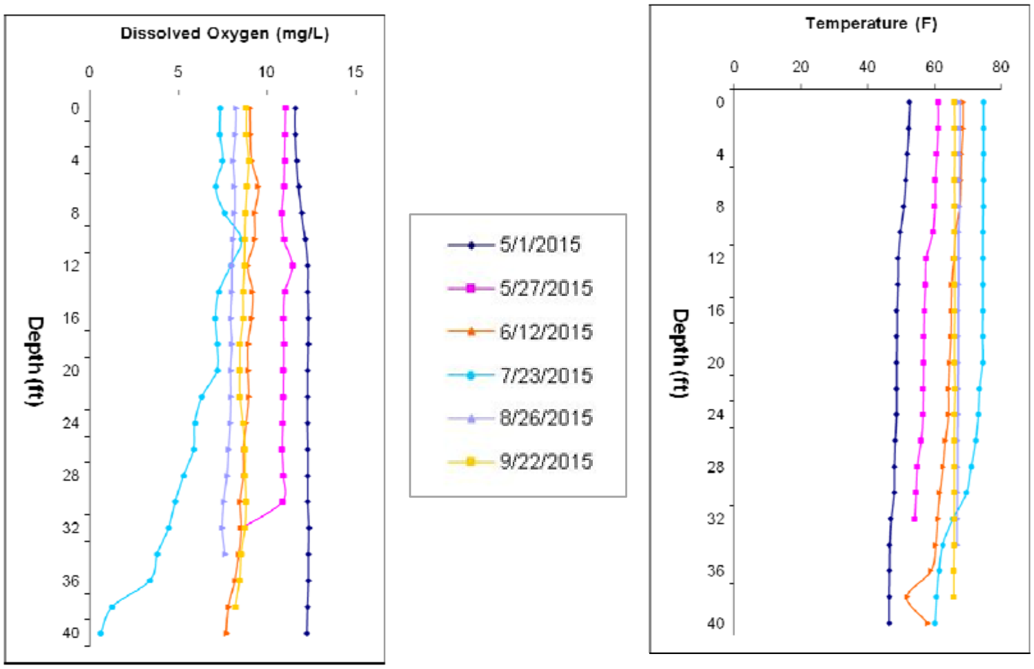


Figure 3.31 Site 206 dissolved oxygen and temperature profiles, 2015.

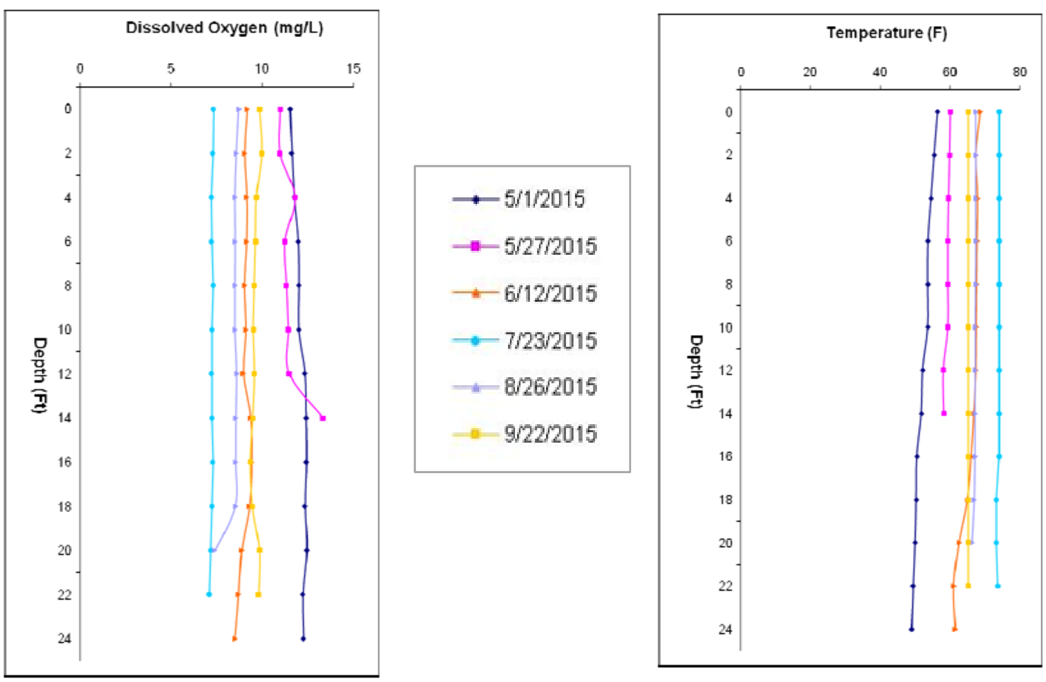


Figure 3.32 Site 201 dissolved oxygen and temperature profiles, 2015.

The west end of Pelican Lake is relatively shallow, with the majority of its depth less than 30 ft. This area of Pelican Lake isn't deep enough to stratify throughout the whole summer. The dissolved oxygen/temperature profiles (Figure 3.32) show the dynamics at site 201 in Pelican Lake in the summer of 2015. The graph shows that the temperature remains consistent from the surface of the lake to the bottom, which indicates no thermal stratification. On some dates in July and August the oxygen was depleted at the bottom of the lake. This usually occurs after a few warm calm days, and then a wind will mix the water column again.

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.

Trophic State Index	Site 206	Site 205	Site 201
TSI Total Phosphorus	43	44	42
TSI Chlorophyll-a	46	50	46
TSI Secchi	36	42	36
TSI Mean	42	45	41
Trophic State:	Mesotrophic	Mesotrophic	Mesotrophic

Numbers represent the mean TSI for each parameter.

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 Pelican Lake falls in the mesotrophic range (Figure 3.33). There is good agreement between the TSI for phosphorus, chlorophyll *a* and transparency, indicating that these variables are related. In comparing sites, these results match the phosphorus, chlorophyll *a* and secchi results. Site 205 has the highest TSI, while site 206 has the lowest.

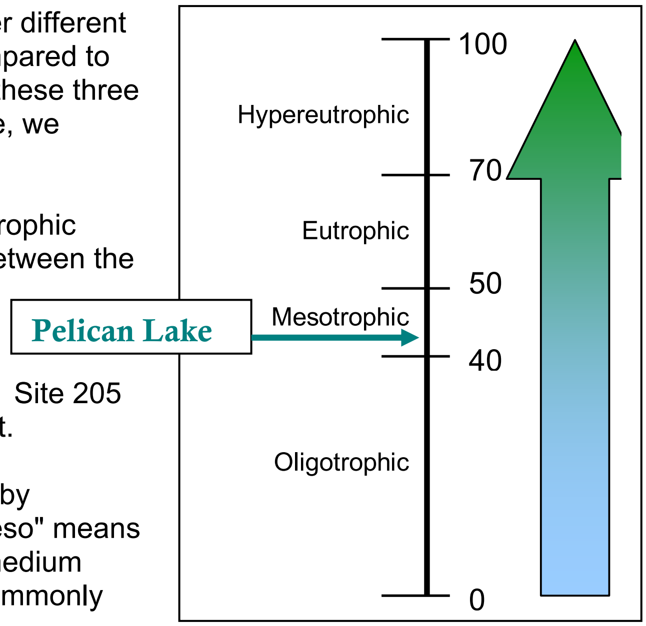


Figure 3.33 Trophic state index chart with corresponding trophic status.

Mesotrophic lakes (TSI 40-50) 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 some algal blooms in late summer. Mesotrophic lakes can also be good walleye lakes.

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.

Pelican Lake has data for site 206 from 1996 to 2015. The data was analyzed using the Mann Kendall Trend Analysis.

Lake Site	Parameter	Date Range	Trend	Probability
Site 206	Transparency	1997-2015	Improving	99.9%
Site 206	Chlorophyll a	1997-2015	Improving	99.9%
Site 206	Total Phosphorus	1997-2015	Improving	99.9%

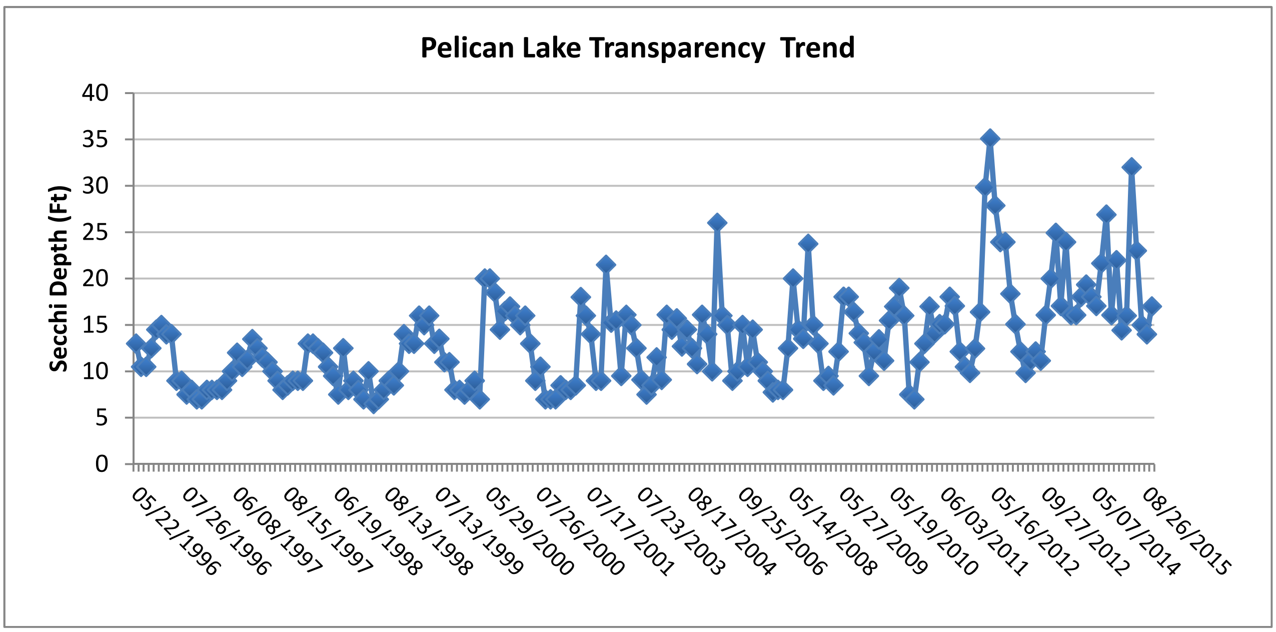
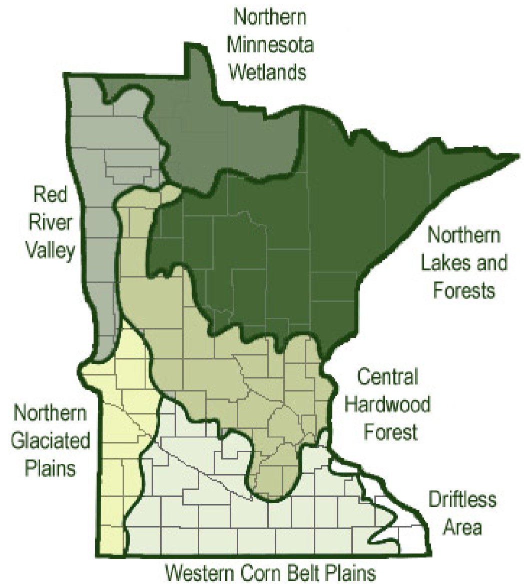


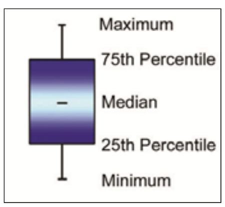
Figure 3.34 Pelican Lake transparency trends from 1997-2015 at primary site 206.

Pelican Lake shows an improving trend in transparency at site 206 from 1996-2015 (Figure 3.34). There is also an improving trend in phosphorus and chlorophyll a, which means that those concentrations are decreasing. The improving trends are likely due to Zebra mussels. They were found in 2009, and in 2011 were noticed throughout the whole lake. In 2011 was when the clarity started drastically improving.

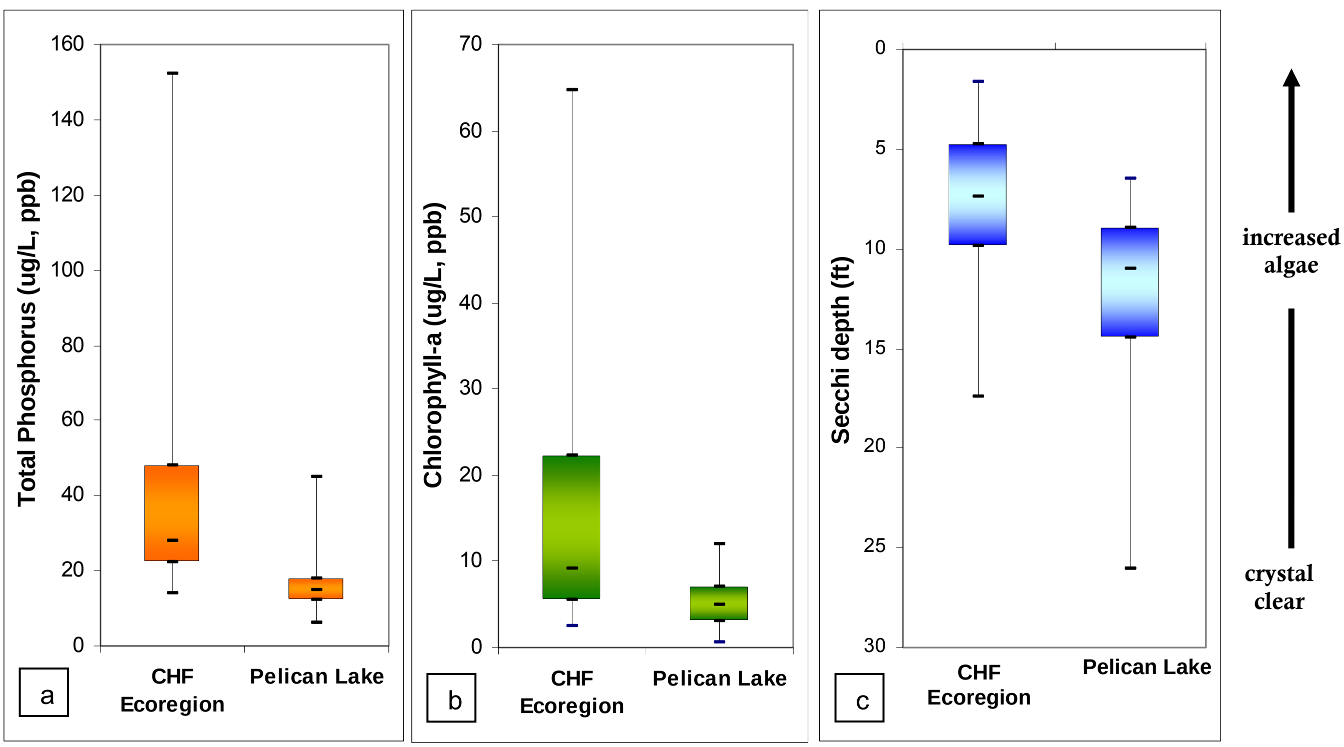
Ecoregion Comparisons



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 25^{th} - 75^{th} percentile range for data within each ecoregion. For the purpose of this graphical representation, the means of the reference lake data sets were used.



Pelican Lake is in the Central Hardwood Forest Ecoregion. The mean total phosphorus, chlorophyll *a* and transparency (Secchi depth) for Pelican Lake are all better than the expected ecoregion ranges (Figures 3.35a-c).



Figures 3.35a-c. Pelican Lake ranges compared to Central Hardwood Forest Ecoregion ranges (data from 2003-2009).

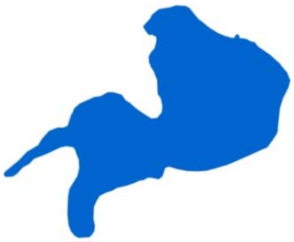
State Assessments (Minnesota Pollution Control Agency)

Impaired Waters Assessment 303(d) List
There are two main types of Impaired Waters Assessment for lakes: eutrophication (excess phosphorus) for aquatic recreation and mercury in fish tissue for aquatic consumption. Pelican Lake is listed as impaired for mercury in fish tissue. See page 111 for fish consumption guidelines. Pelican Lake is not listed as impaired for eutrophication.

Aquatic Recreational Use Assessment 305(b)
In the 2008 MPCA Aquatic Use Assessment (305(b)), Pelican Lake was classified as being fully supporting for Aquatic Recreational Use.

Fish Lake 56-0768-00 OTTER TAIL COUNTY

Summary



Fish Lake is attached to Pelican Lake at its north end. Water flows from Pelican Lake through Fish Lake and the Pelican River exits at the southwest end of the lake. Fish Lake has the best water quality of the Pelican Group of Lakes. This is most likely due to the fact that it doesn't have any stream inlets, it is fairly deep, and has a good population of emergent vegetation around its shoreline (cattails and bulrushes).

Currently, the main threat to Fish Lake is the removal of bulrush around the shoreline. Historically, the lake was most likely ringed entirely with bulrush. Since human development on the lake, bulrush has been removed to create swimming areas. Aquatic plants such as bulrush filter pollutants and take up a lot of the phosphorus in the water and stabilize the lake sediments. In order to maintain the excellent water quality in Fish Lake, aquatic plants should be protected and not removed by homeowners.

Water quality data have been collected in Fish Lake since 1995. These data show that the lake is on the oligotrophic/mesotrophic border (TSI 39-41), which is characteristic of clear water throughout the summer and excellent recreational opportunities.

Vitals

MN Lake ID:	56-0768-00
County:	Otter Tail
Ecoregion:	North Central Hardwood Forest
Major Drainage Basin:	Red River
Latitude/Longitude:	46.67805556 / -96.00061111
Water Body Type:	Public
Monitored Sites:	201, 202, 203
Invasive species present:	Zebra Mussels *(confirmed in 2009)*, Curly-leaf pondweed

Physical Characteristics

Surface area (acres):	261	
Littoral area (acres):	127	
% Littoral area:	48%	
Max depth (ft):	69	(m): 21
Mean depth (ft):	27	(m): 8.2
Lakeshed size (acres):	15,783	
Lakeshed : lake area ratio	60 : 1	
Inlets	Connection to Pelican Lake	
Outlets	Connection to Pelican Lake	
Public Accesses	0	

Data Availability

Transparency data	Data exist from the MPCA CLMP program from 1995-2002, and RMB Labs from 2003-2015.
Chemical data	Data exist from RMB Labs from 2003-2015.
Inlet/Outlet data	The Fish Lake outlet has been monitored by RMB Lab from 2003-2015.

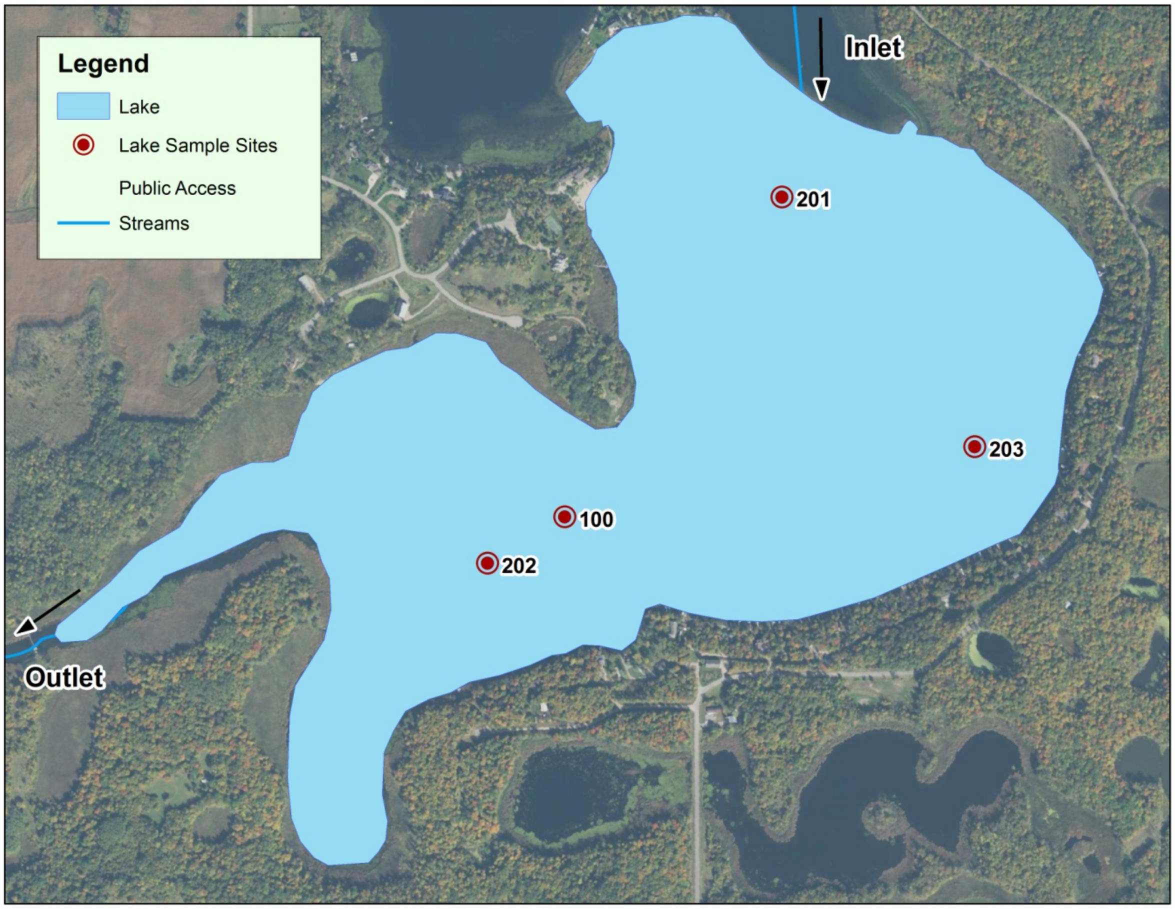


Figure 3.36 Map of Fish Lake illustrating lake sample site locations, stream inlets and outlets and aerial land use.

Lake Site	Depth (ft)	Monitoring Programs
201	45	PGOLID: 2003-2015; CLMP: 1995-2012; MPCA: 1997
202	40	PGOLID: 2007-2008, 2015
203	40	CLMP: 2008

KEY:
MPCA (Minnesota Pollution Control Agency);
CLMP (MPCA Citizens Lake Monitoring Program)
PGOLID (Pelican Group of Lakes Improvement District)

The information below describes available chemical data for Fish Lake through 2015. 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.

Below are typical measurements one might find for lakes in this ecoregion.

Parameter	Mean	Ecoregion Range[1]	Interpretation
Total phosphorus (ug/L)	11.8	23 - 50	Results are below the expected range for the ecoregion. For more information, see page 75.
Chlorophyll *a* (ug/L) [2]	3.9	5 – 22	
Chlorophyll *a* max (ug/L)	9	7 – 37	
Secchi depth (ft)	13.6	4.9 – 10.5	
Dissolved oxygen	Dimictic *See page 73*		Dissolved oxygen depth profiles show that the deep areas of the lake are anoxic in late summer.
Total Kieldahl Nitrogen (mg/L)	0.43	0.62 – 1.2	Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms.
Ortho phosphorus (surface, ug/L)	4.4		Indicates that all available ortho-phosphorus is taken up by plants and algae living in the lake.
Alkalinity (mg/L)	176.1	75 – 150	Indicates a low sensitivity to acid rain and a good buffering capacity.
Color (Pt-Co Units)	7.1	10-20	Indicates very clear water with little to no tannins (brown stain).
Total Suspended Solids (mg/L)	1.7	2 – 6	Below the ecoregion average range indicating clear water.
Total Nitrogen :Total Phosphorus	36:1	25:1 – 35:1	The lake is most likely phosphorus limited, which means that algae growth is limited by the amount of phosphorus in the lake.
Calcium (mg/L)	32.3		Indicates a hard water lake sufficient for Zebra mussel survival.
Magnesium (mg/L)	27.7		Indicates a hard water lake.

Data Source: 2003-2015 PGOLID Monitoring Program

[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: 1997-2015

Parameters	Site *201	Site 202	Site 203
Total Phosphorus Mean (ug/L):	**11.7**	**12.6**	
Total Phosphorus Min:	6	5	
Total Phosphorus Max:	21	34	
Number of Observations:	94	17	
Chlorophyll *a* Mean (ug/L):	**3.7**	**5.1**	
Chlorophyll *a* Min:	1	3	
Chlorophyll *a* Max:	9	8	
Number of Observations:	94	17	
Secchi Depth Mean (ft):	**12.4**	**11.5**	**16.7**
Secchi Depth Min:	6.0	9.0	7.9
Secchi Depth Max:	26.6	16.0	25.9
Number of Observations:	275	17	117

*primary site

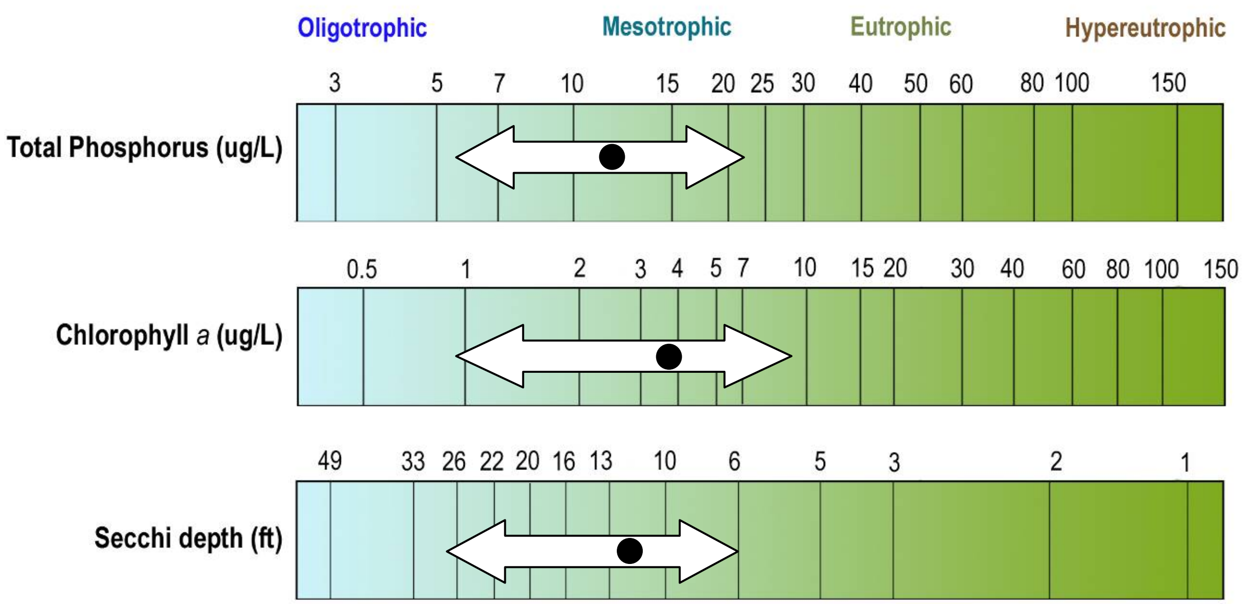


Figure 3.37. Fish Lake total phosphorus, chlorophyll *a* and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Primary Site 201). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. No. EPA 440/5-88-002)

Transparency (Secchi Depth)

Transparency is how easily light can pass through a substance. In lakes, it is how deep sunlight penetrates through the water. Plants and algae need sunlight to grow, so they are only able to grow in areas of lakes where the sun penetrates. Water transparency depends on the 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. Site 201 in Fish Lake has been monitored from 1995-2015. The annual means for Fish Lake range from 9.5-20 ft (Figure 3.38). The annual mean transparency has been above the historical average since 2011. Zebra mussels were found in Pelican Lake in 2009 and residents noticed them everywhere in 2011. It is likely that the Zebra mussels have caused the increase in water clarity since 2011.

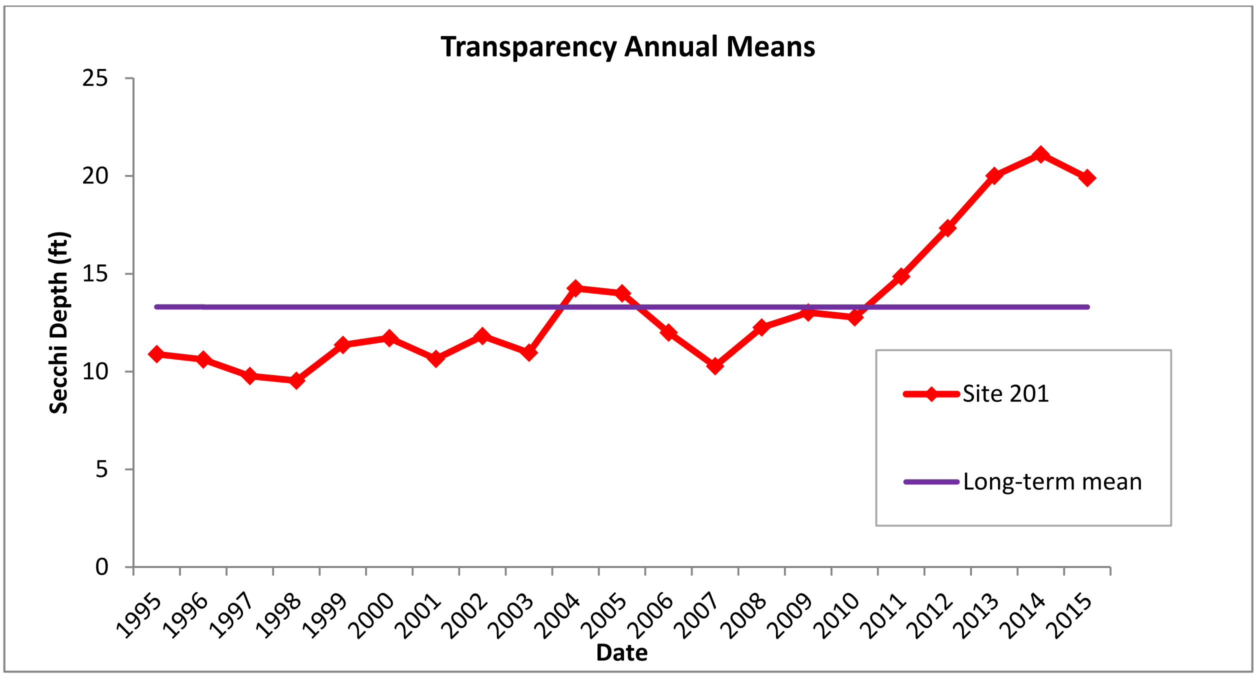


Figure 3.38. Fish Lake annual mean transparency for sites 201.

Fish Lake transparency ranges from 6 to 20 feet throughout the summer. Figure 3.39 shows the seasonal transparency dynamics. Fish Lake transparency varies greatly year to year, but shows an overall slight decline throughout the summer. After fall turnover the transparency most likely recovers to near spring levels, but there are not much data past mid-September for Fish Lake, so this pattern is not shown. This pattern is typical for a lake of this depth in Minnesota. The transparency dynamics have to do with algae population dynamics and lake turnover.

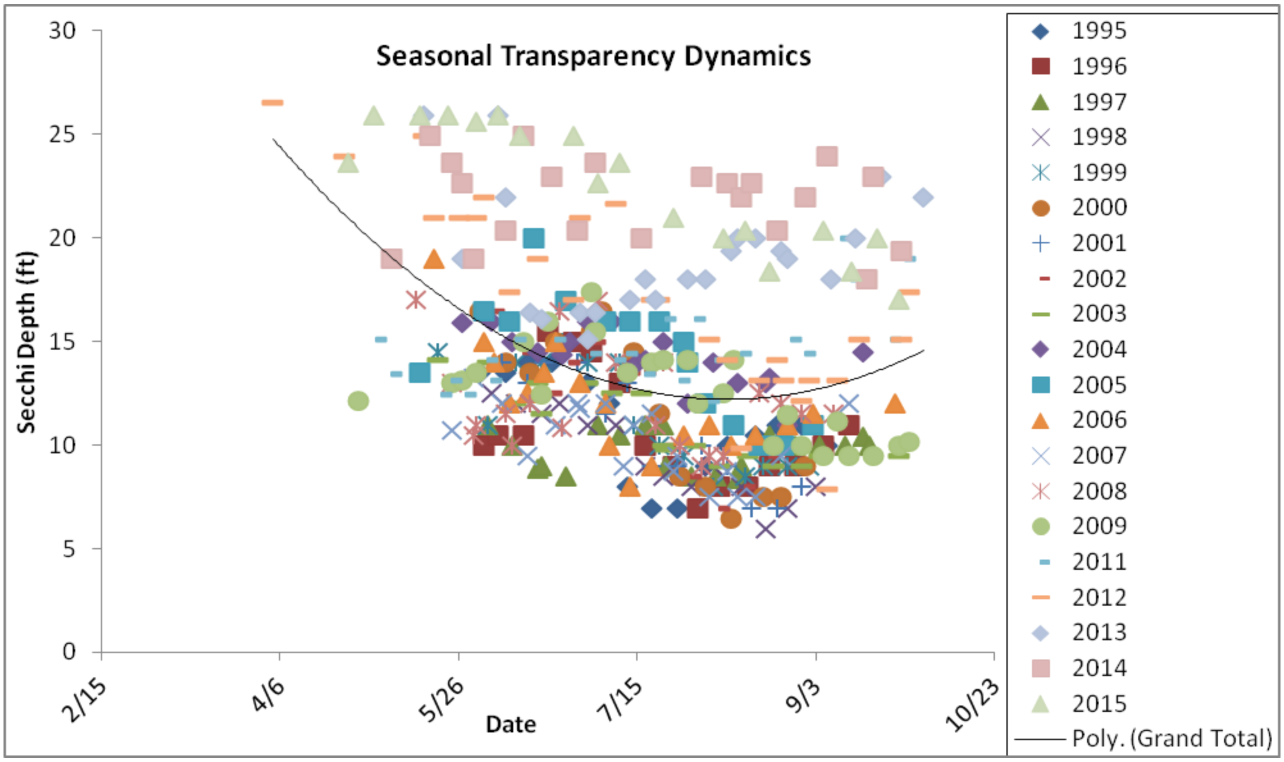
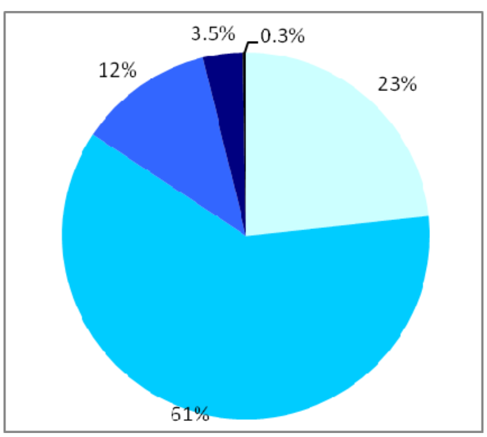


Figure 3.39. Seasonal transparency dynamics and year-to-year comparison. The light yellow line represents the best fit line to show the pattern in the data.

User Perceptions

When Secchi depth readings are collected, the perceptions of the water based on the physical appearance and the recreational suitability is recorded. 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. Fish Lake was rated as being "not quite crystal clear" 61% of the time between 1995-2015 (Figure 3.40).



Physical Appearance Rating

23% Crystal clear water

61% Not quite crystal clear – a little algae visible

12% Definite algae – green, yellow, or brown color apparent

3.5% High algae levels with limited clarity and/or mild odor apparent

0% Severely high algae levels

Figure 3.40. Physical appearance rating, as rated by the lake monitor (1995-2015).

As the Secchi depth decreases, the perception of recreational suitability of the lake decreases. Fish Lake was rated as having "very minor aesthetic problems" 51% of the time from 1995-2015 (Figure 3.41). For 95% of the time, Fish Lake was rated as being swimmable.

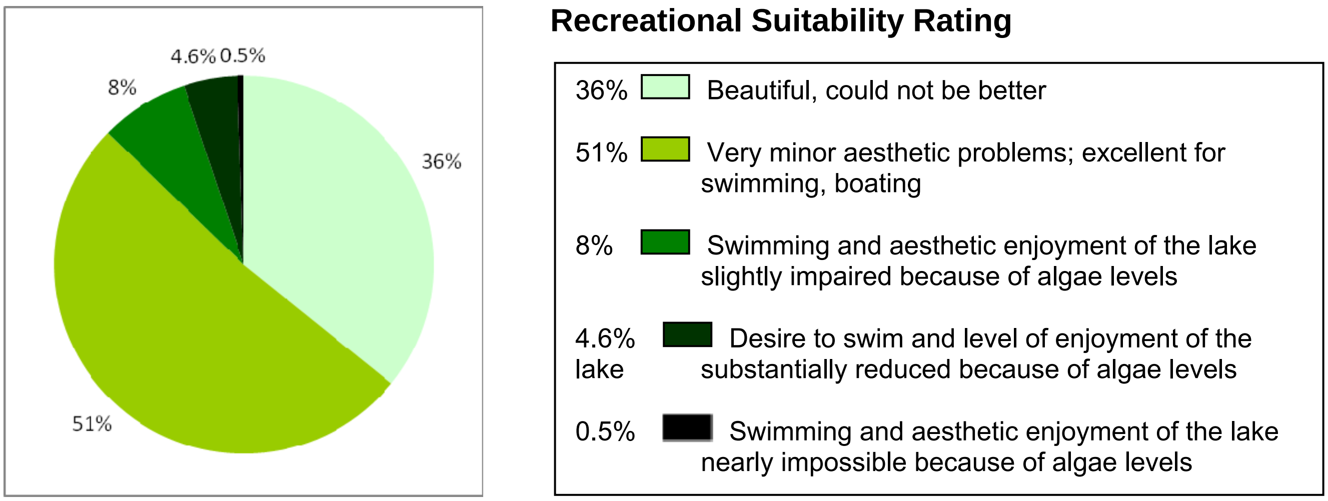


Figure 3.41. Recreational suitability rating, as rated by the lake monitor (1995-2015).

Total Phosphorus

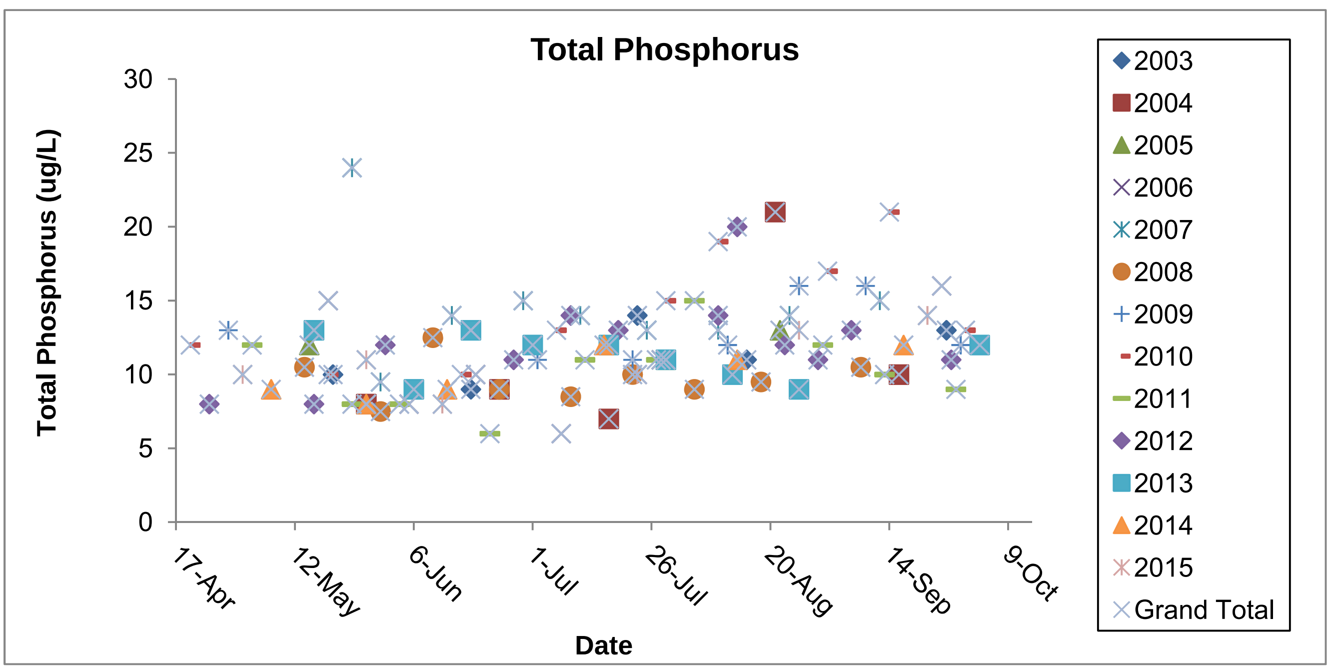


Figure 3.42. Historical total phosphorus concentrations (ug/L) for Fish Lake site 201 from 2003-2015.

Fish Lake is phosphorus limited, which means that algae and aquatic plant growth is dependent upon available phosphorus. The total phosphorus concentrations remain fairly consistent all season long. This could be due to the lack of any stream inlets into Fish Lake.

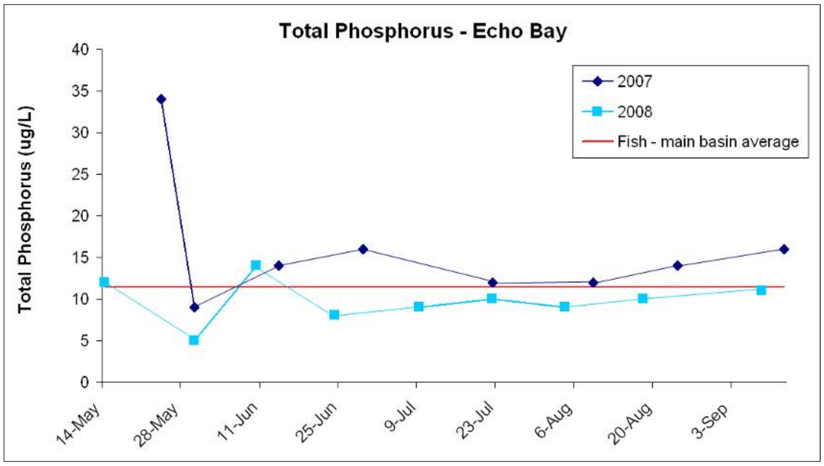


Figure 3.43. Historical total phosphorus concentrations (ug/L) for Echo Bay site 202 (data set from 2007-2008).

The south bay of Fish Lake (Echo Bay) is some of the only shoreline in the Pelican group of lakes that is still undeveloped. It is not sandy, but is lined with reeds and cattails, which make excellent habitat for aquatic animals and fish. Due to a proposed development project in this area in 2006, site 202 was monitored in 2007-2008 to get a good picture of baseline water quality. Since then, this development has fallen through, but now we have baseline conditions to compare in case this area ever gets developed in the future. The results from 2007-2008 show that Echo Bay has some of the best water quality in the Pelican Group of Lakes (Figure 3.43).

In 2009, water samples were collected just above the lake bottom to measure internal loading in Fish Lake. Internal loading typically occurs in mid-summer when the oxygen at the bottom of the lake (hypolimnion) is depleted. When there is no oxygen in the hypolimnion, a chemical reaction occurs where phosphorus is released from the lake sediment back into the water. Then in the fall when the lake turns over this phosphorus comes up to the surface.

Figure 3.44 shows that Fish Lake follows a typical pattern for internal loading. Internal loading is usually highest in July through mid-August when the surface water is warm. In spring, the hypolimnion phosphorus concentrations are similar to the surface water concentrations because the lake water column is fully mixed. In late fall, the lake turns over again. In 2009, September was very warm, so the lake may have turned over later than normal, which is why there is still internal loading occurring on 9/29/09.

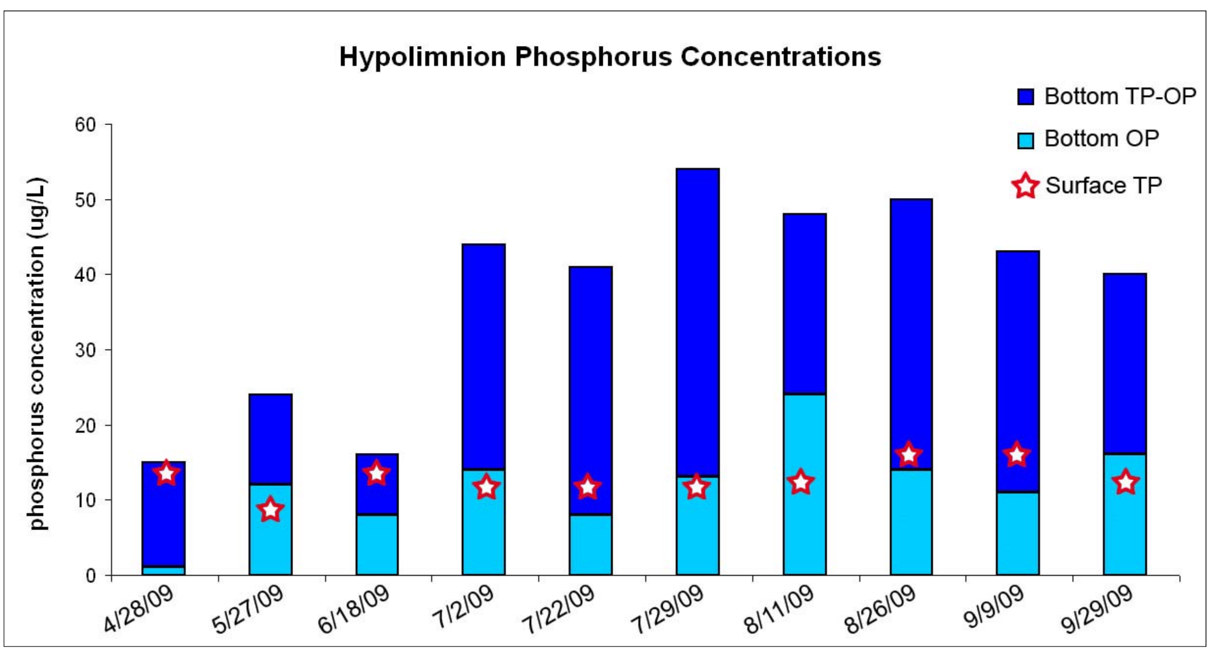


Figure 3.44. Hypolimnion phosphorus concentrations (ug/L) for Fish Lake (data set from 2009).

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.

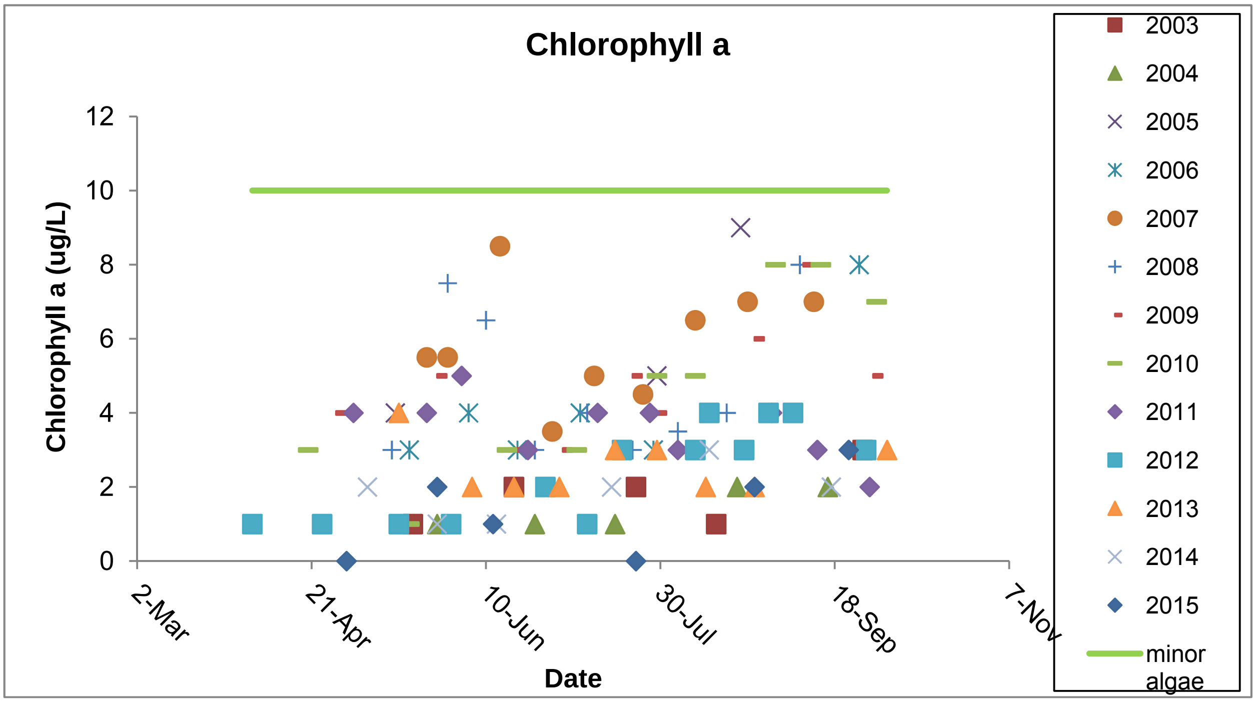


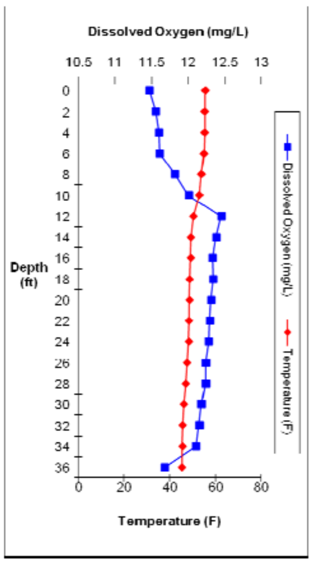
Figure 3.45. Chlorophyll *a* concentrations (ug/L) for Fish Lake (data set from 2003-2015).

Chlorophyll *a* was evaluated in Fish Lake in 2003-2011 (Figure 3.45). Chlorophyll *a* concentrations don't follow much of a pattern in Fish Lake. Chlorophyll *a* concentrations in Fish Lake remained below 10 ug/L during all years from 2003-2011, indicating clear water all summer.

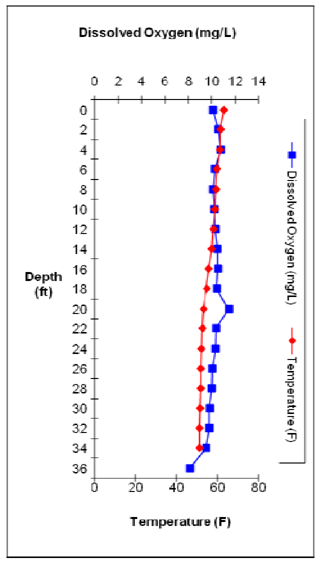
Dissolved Oxygen

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

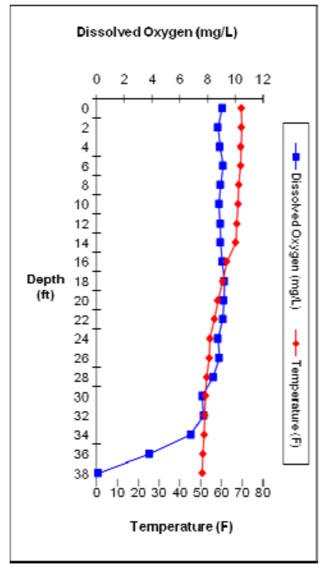
Fish Lake is its own distinct basin with a maximum depth of 69 ft. Dissolved oxygen profiles for Fish Lake have been collected by the Lake Resource Coordinator from 2007-present. The profiles indicate that Fish Lake stratifies in mid summer. In 2015, the lake began stratifying in early June and turned over in late September. In the summer the thermocline was at approximately 28 feet, which means that game fish were most likely absent below 28 feet.



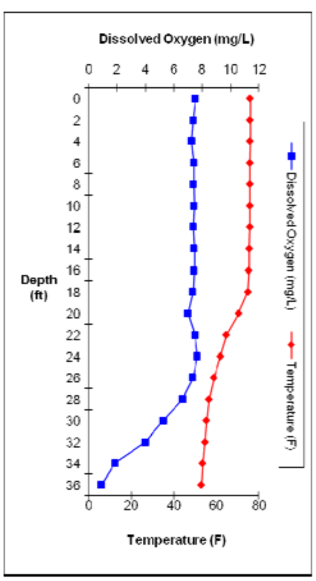
5/1/2015



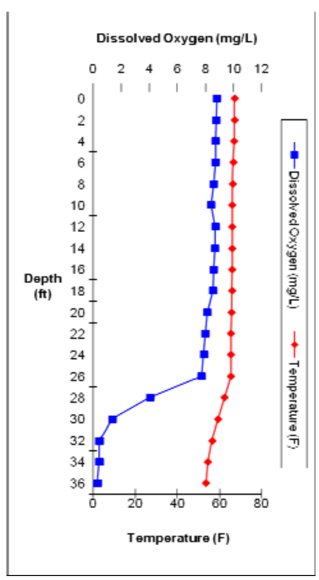
5/27/2015



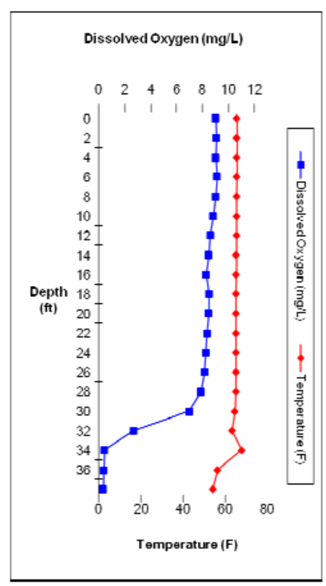
6/12/2015



7/23/2015



8/26/2015



9/22/2015

Trophic State Index

Trophic State Index	Site 201
TSI Total Phosphorus	40
TSI Chlorophyll-a	43
TSI Secchi	36
TSI Mean	40
Trophic State:	Oligotrophic/ Mesotrophic

Numbers represent the mean TSI for each

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 Fish Lake falls in the lower mesotrophic range, close to the oligotrophic/mesotrophic border (Figure 3.46). There is good agreement between the TSI for phosphorus, chlorophyll *a* and transparency, indicating that these variables are strongly related.

Lakes on the oligotrophic/mesotrophic border (TSI 39-41) are characteristic of clear water throughout the summer and are excellent for recreation.

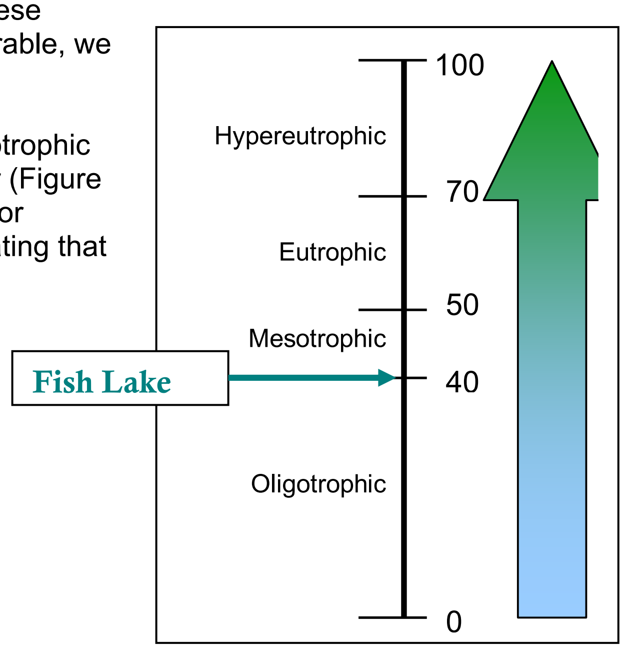


Figure 3.46. Trophic state index chart with corresponding trophic status.

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.

Bass Lake has data from 2003-2009, which covers seven consecutive years. Because there is not ten years of data, the trends below would be considered short-term trends. The data was analyzed using the Mann Kendall Trend Analysis.

Lake Site	Parameter	Date Range	Trend	Probability
201	Transparency	1995-2015	Improving	99.9%
201	Phosphorus	2003-2015	No trend	--
201	Chlorophyll *a*	2003-2015	Improving	99.9%

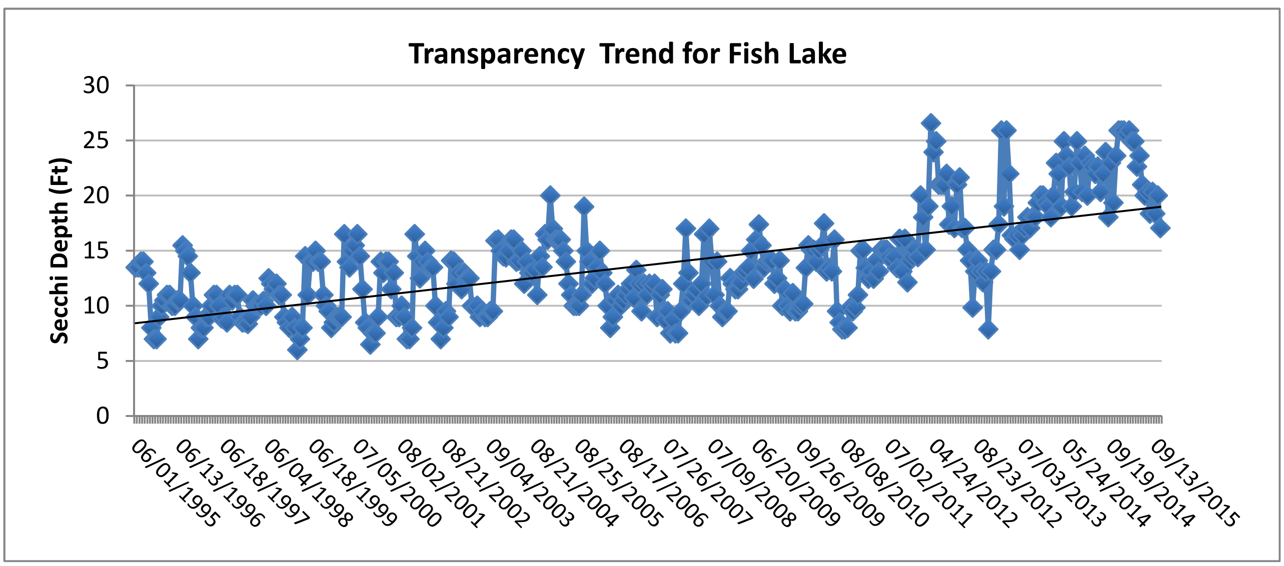
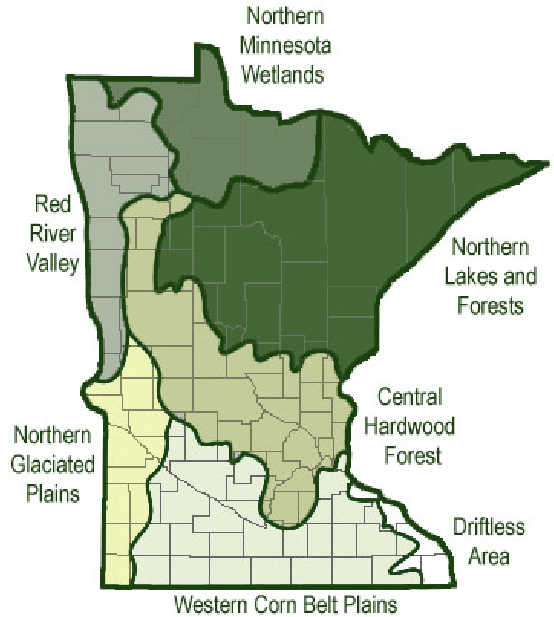


Figure 3.47 Fish Lake chlorophyll *a* trend from 2003-2015.

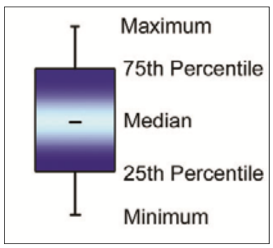
Fish Lake shows a significant improving long-term trend in transparency from 1995-2015. Over this time period, the transparency has improved an average of five feet. This trend is likely due to zebra mussels establishing in the lake in 2009. The phosphorus and concentration shows no trend from 2003 to 2015, which means it is not getting significantly better or worse, it is maintaining at the same level (Figure 3.47).

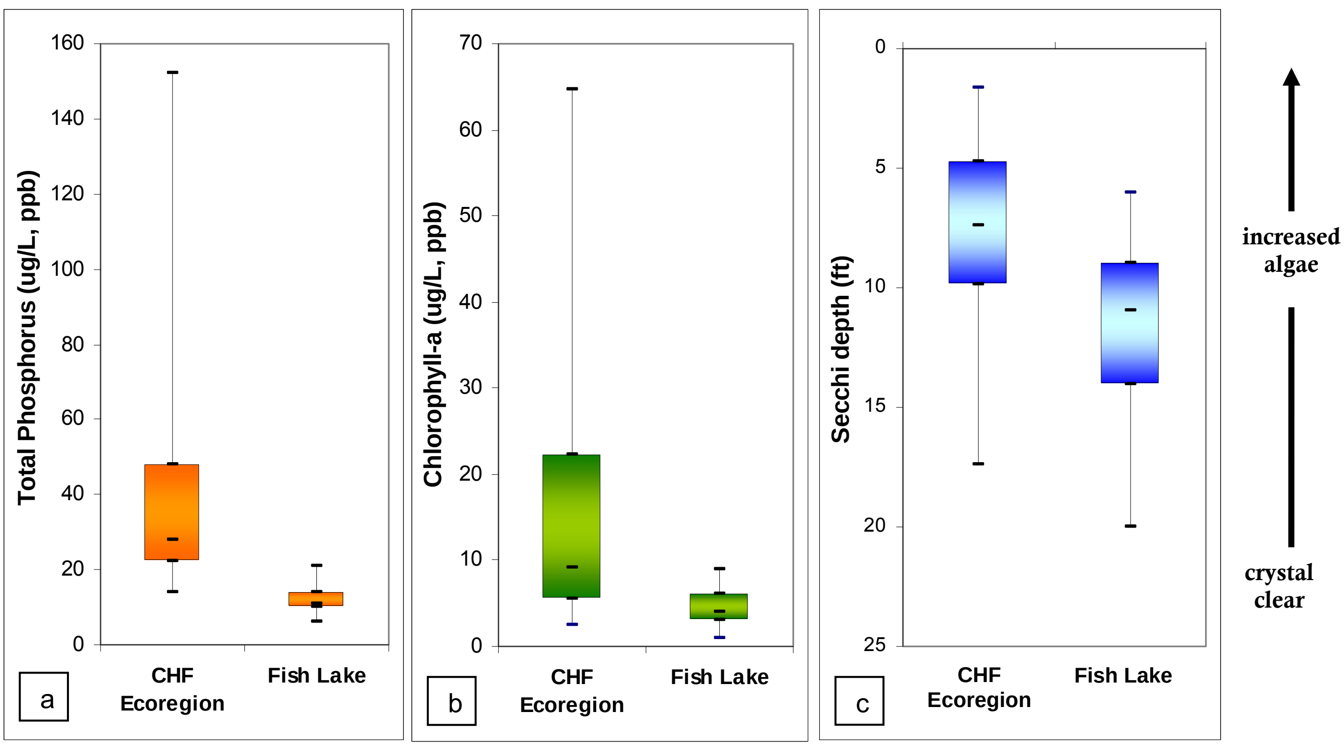
Ecoregion Comparisons

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.



Fish Lake is in the Central Hardwood Forest Ecoregion. The mean total phosphorus, chlorophyll *a* and transparency (Secchi depth) for Fish Lake are all better than the expected ecoregion ranges (Figures 3.48a-c).





Figures 3.48a-c. Fish Lake ranges compared to Central Hardwood Forest Ecoregion ranges (data from 2003-2009).

State Assessments (Minnesota Pollution Control Agency)

Impaired Waters Assessment 303(d) List

There are two main types of Impaired Waters Assessment for lakes: eutrophication (excess phosphorus) for aquatic recreation and mercury in fish tissue for aquatic consumption. Fish Lake is not listed as impaired for mercury in fish tissue; however, Pelican Lake is listed and is connected to Fish Lake. Therefore, the fish in Fish Lake should be considered impaired for mercury as well. See page 111 for fish consumption guidelines. Fish Lake is not listed as impaired for eutrophication.

Aquatic Recreational Use Assessment 305(b)

In the 2008 MPCA Aquatic Use Assessment (305(b)), Fish Lake was classified as being fully supporting for Aquatic Recreational Use.

Bass Lake 56-0770-00 OTTER TAIL COUNTY

Summary

Bass Lake is a very small basin (48 acres) attached to Fish and Pelican Lakes. Bass Lake has no direct inlets and outlets, just a connection with Fish Lake that doesn't show much flow of water either direction. Because of its isolation and small surface area, Bass Lake is more susceptible to impacts occurring on the shoreline of the lake such as adding impervious surface, adding artificial sand beaches, and removing aquatic plants.

Currently, the main threat to Bass Lake is the removal of aquatic plants. Trend analyses of water quality data show that there is a significant increasing trend in algae over the past seven years. Bass Lake has a very dense native plant population along with emergent plants such as bulrush and cattails. This vegetation has been increasingly removed over the past decade, which could contribute to higher algae levels. The aquatic plants take up a lot of the phosphorus in the water and stabilize the lake sediments. When aquatic plants are removed, the phosphorus is available for more algae growth. In order to maintain the water quality in Bass Lake, aquatic plants should be protected and not removed by homeowners.

Water quality data have been collected on Bass Lake since 1997. These data show that the lake is mesotrophic (TSI 40-50). Mesotrophic lakes are commonly found in north-central Minnesota and have clear water with occasional algal blooms in late summer.

Vitals

MN Lake ID:	56-0770-00
County:	Otter Tail
Ecoregion:	North Central Hardwood Forest
Major Drainage Basin:	Red River
Latitude/Longitude:	46.68441667 / -96.01061111
Water Body Type:	Public
Monitored Sites:	201
Invasive species present:	Zebra Mussels (confirmed in 2009), Curly-leaf pondweed

Physical Characteristics

Surface area (acres):	48	
Littoral area (acres):	24	
% Littoral area:	50%	
Max depth (ft):	33	(m): 10.1
Mean depth (ft):	18	(m): 5.5
Inlets	Connection to Fish Lake	
Outlets	Connection to Fish Lake	
Public Accesses	0	

Data Availability

Transparency data	Data exist from the MPCA CLMP program from 1997-2002, and RMB Labs from 2003-2012.
Chemical data	Data exist from RMB Labs from 2003-2012.
Inlet/Outlet data	Bass Lake has no inlet or outlet

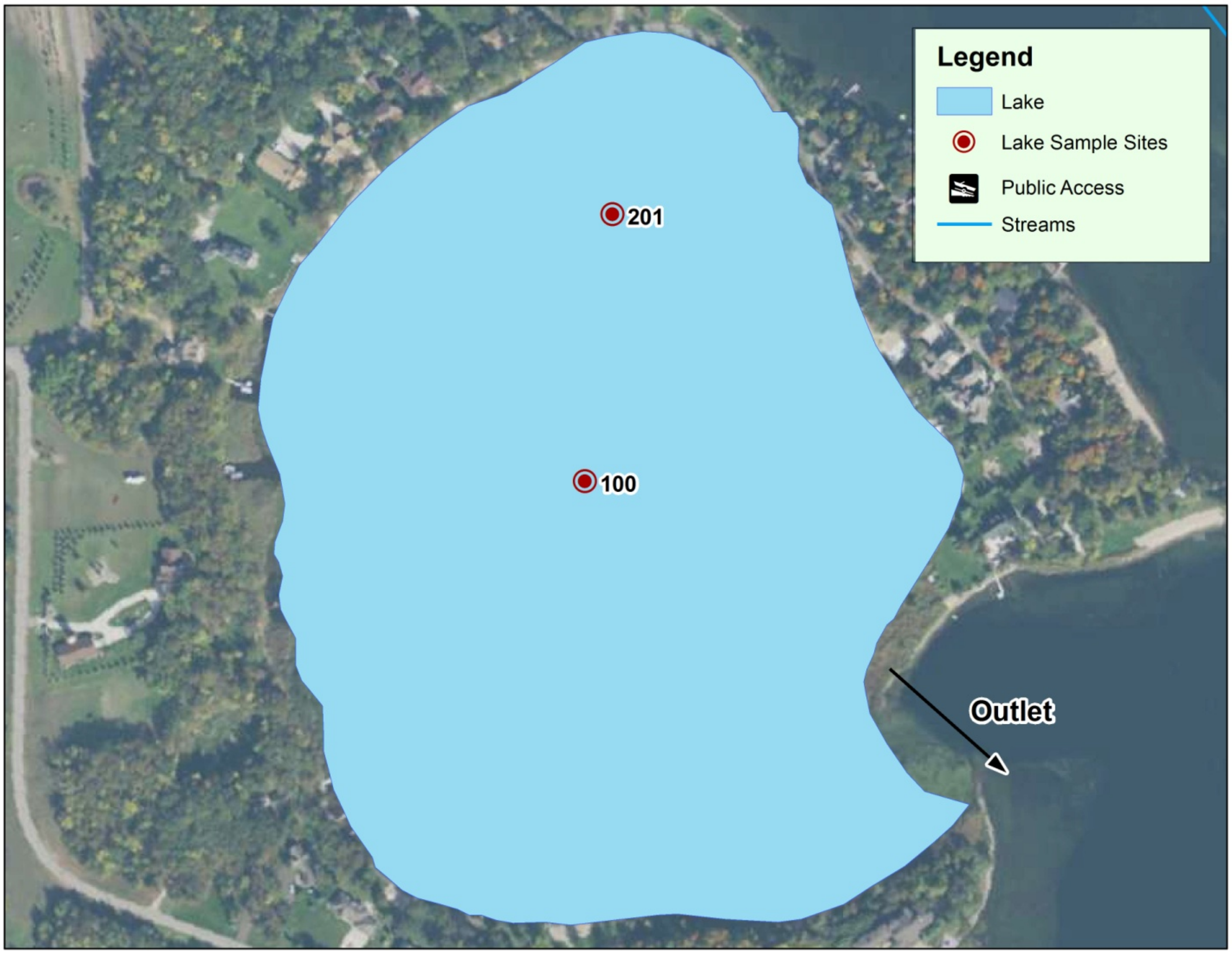


Figure 3.49 Map of Bass Lake lake sample site locations, stream inlets and outlets and aerial land use. The pink shaded areas in the lake illustrate the littoral zone, where the sunlight can usually reach the lake bottom, allowing aquatic plants to grow.

Lake Site	Depth (ft)	Monitoring Programs
201	33	PGOLID 2003-2012; CLMP: 1997-2003; MPCA: 1997

KEY:
MPCA (Minnesota Pollution Control Agency);
CLMP (MPCA Citizens Lake Monitoring Program)
PGOLID (Pelican Group of Lakes Improvement District)

The information below describes available chemical data for Bass Lake through 2009. 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.

This ecoregion is an area of transition between the forested areas to the north and east and the agricultural areas to the south and west. The terrain varies from rolling hills to smaller plains. Upland areas are forested by hardwoods and conifers. Plains include livestock pastures, hay fields and row crops such as potatoes, beans, peas and corn.

The ecoregion contains many lakes, and water clarity and nutrient levels are moderate. Land surrounding many of these lakes has been developed for housing and recreation, and the densely populated metropolitan area dominates the eastern portion of this region. Water quality problems that face many of the water bodies in this area are associated with contaminated runoff from paved surfaces and lawns.

Below are typical measurements one might find for lakes in this ecoregion.

Parameter	Mean	Ecoregion Range[1]	Interpretation
Total phosphorus (ug/L)	11.8	23-50	Results are better than the expected range for the ecoregion. For more details, see page 89.
Chlorophyll *a* (ug/L) [2]	3.9	5 – 22	
Chlorophyll *a* max (ug/L)	9	7 – 37	
Secchi depth (ft)	13.6	4.9 – 10.5	
Dissolved oxygen	*See page 87*		Dissolved oxygen depth profiles show that the deep areas of the lake are anoxic in late summer.
Total Kieldahl Nitrogen (mg/L)	0.7	0.62 – 1.2	Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms.
Ortho phosphorus (surface, ug/L)	5.2		Indicates that most available ortho-phosphorus is taken up by plants and algae living in the lake.
Alkalinity (mg/L)	181.4	75 – 150	Indicates a low sensitivity to acid rain and a good buffering capacity.
Color (Pt-Co Units)	8.2	10-20	Indicates very clear water with little to no tannins (brown stain).
Total Suspended Solids (mg/L)	1.3	2 – 6	Better than the ecoregion average range, which indicates clear water.
Total Nitrogen :Total Phosphorus	59:1	25:1 – 35:1	The lake is phosphorus limited, which means that algae growth is limited by the amount of phosphorus in the lake.
Calcium (mg/L)	33.5	NA	Indicates a hard water lake with sufficient calcium for Zebra mussel survival.
Magnesium (mg/L)	28.2	NA	Indicates a hard water lake.

Data Source: 2003-2012 PGOLID Monitoring Program

[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: 1997-2015

Parameters	Site *201
Total Phosphorus Mean (ug/L):	**16.7**
Total Phosphorus Min:	5
Total Phosphorus Max:	47
Number of Observations:	93
Chlorophyll *a* Mean (ug/L):	**5.2**
Chlorophyll *a* Min:	1
Chlorophyll *a* Max:	17
Number of Observations:	93
Secchi Depth Mean (ft):	**12.0**
Secchi Depth Min:	7.5
Secchi Depth Max:	21.6
Number of Observations:	189

*primary site

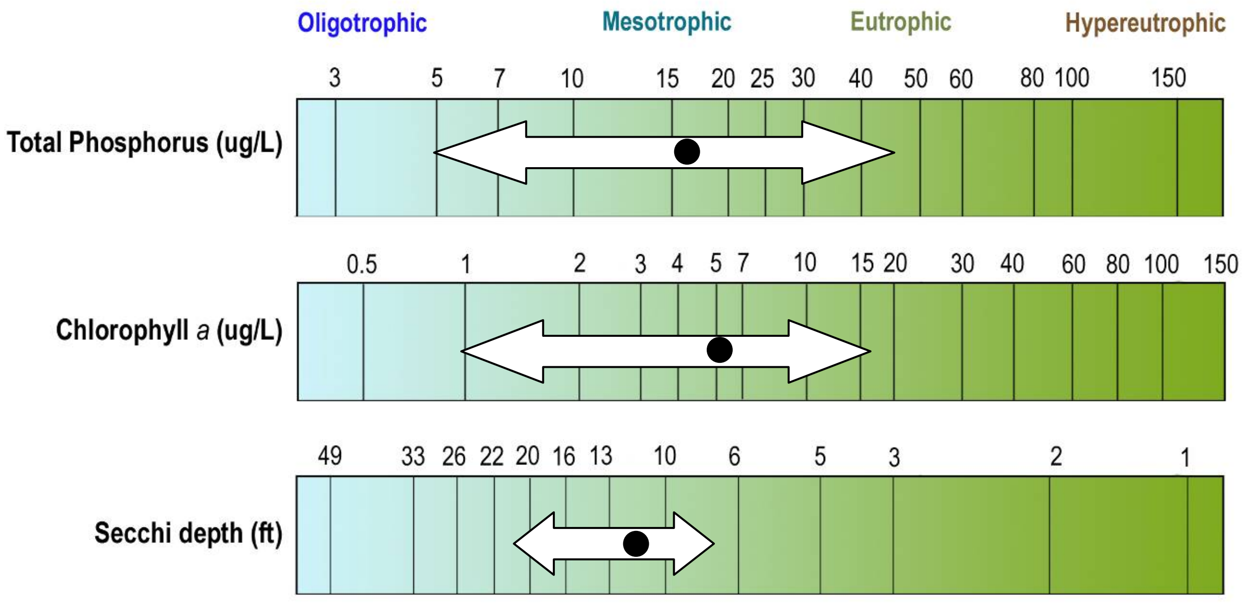


Figure 3.50. Bass Lake total phosphorus, chlorophyll *a* and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Primary Site 201). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. No. EPA 440/5-88-002)

Transparency (Secchi Depth)

Transparency is how easily light can pass through a substance. In lakes, it is how deep sunlight penetrates through the water. Plants and algae need sunlight to grow, so they are only able to grow in areas of lakes where the sun penetrates. Water transparency depends on the 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. Site 201 in Bass Lake has been monitored from 1997-2015. The annual means for Bass Lake range from 9.8-21 ft (Figure 3.51). The annual mean transparency stays right around the historical mean for most years until 2011 when Zebra mussels were found all over the lake. Since then, transparency has been higher.

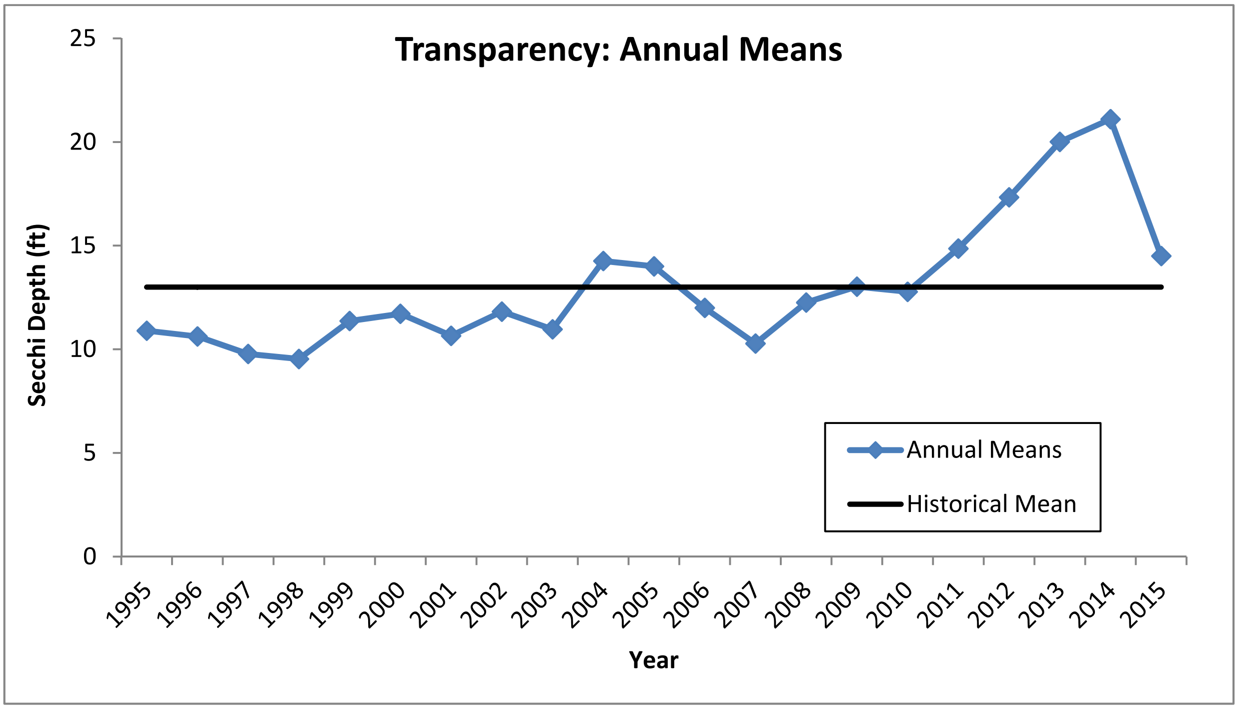


Figure 3.51 Annual mean transparency for site 201.

Bass Lake transparency ranges from 7.5 to 20 feet throughout the summer. Figure 3.52 shows the seasonal transparency dynamics. Bass Lake transparency varies greatly in May and early June and then declines slightly throughout the summer. This pattern is typical for a lake of this depth in Minnesota. The transparency dynamics have to do with algae population dynamics and lake turnover.

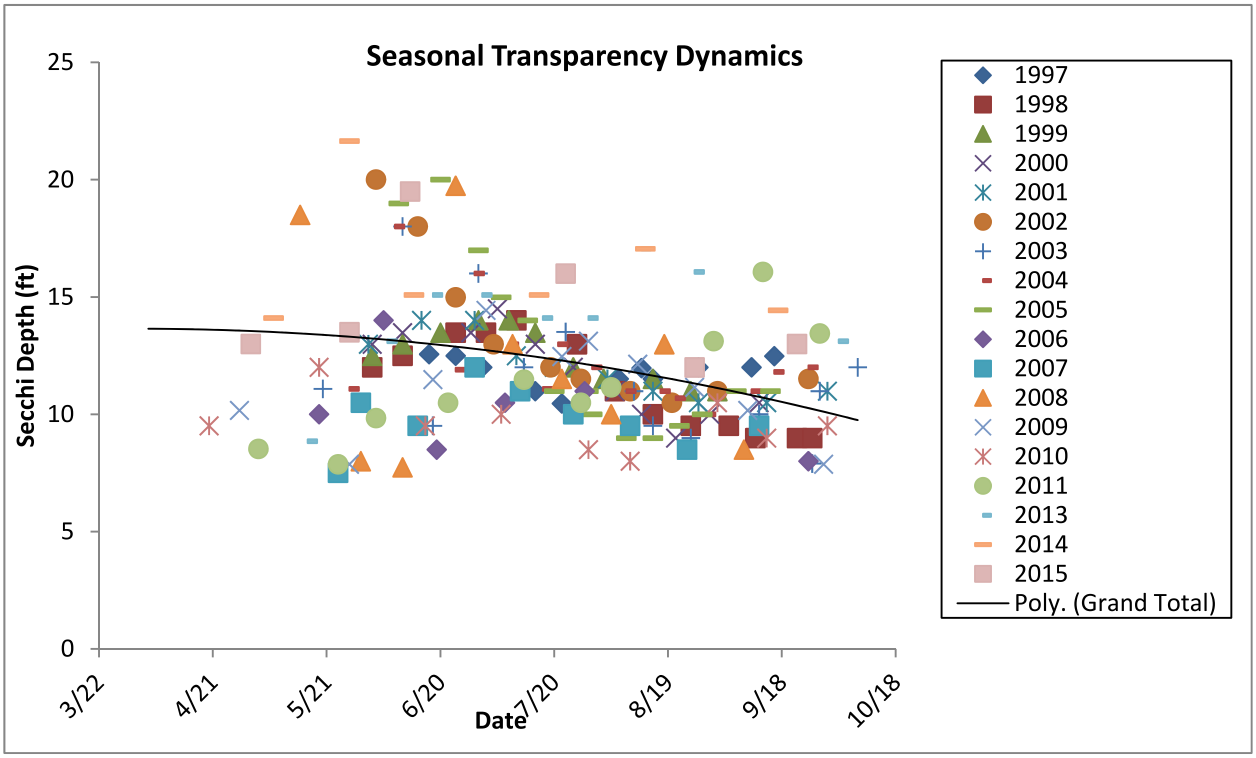


Figure 3.52 Seasonal transparency dynamics and year-to-year comparison.

User Perceptions

When Secchi depth readings are collected, the perceptions of the water based on the physical appearance and the recreational suitability is recorded. 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. Bass Lake was rated as being "not quite crystal clear" 81% of the time between 1997-2015 (Figure 3.53).

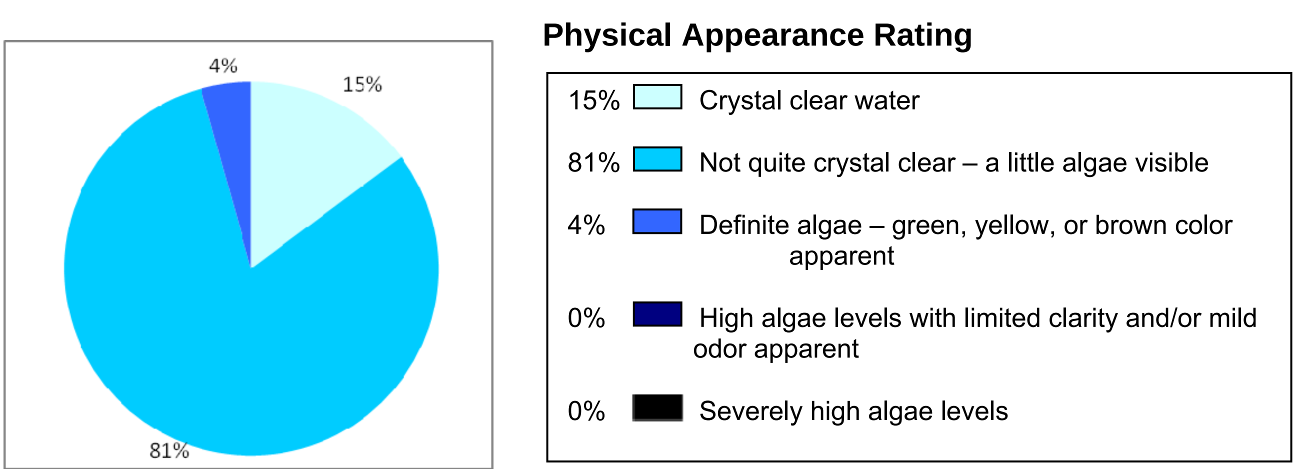


Figure 3.53 Physical appearance rating, as rated by the lake monitor (1997-2015).

As the Secchi depth decreases, the perception of recreational suitability of the lake decreases. Bass Lake was rated as having "very minor aesthetic problems" 62% of the time from 1997-2015 (Figure 3.54). For 99% of the time, Bass Lake was rated as being swimmable.

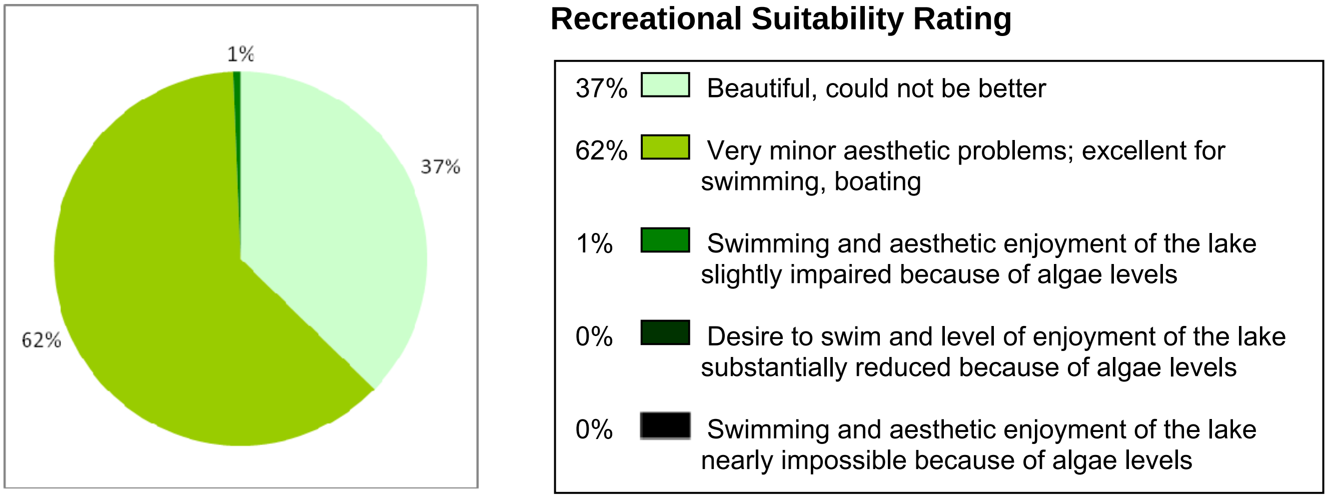


Figure 3.54 Recreational suitability rating, as rated by the lake monitor (1997-2015).

Total Phosphorus

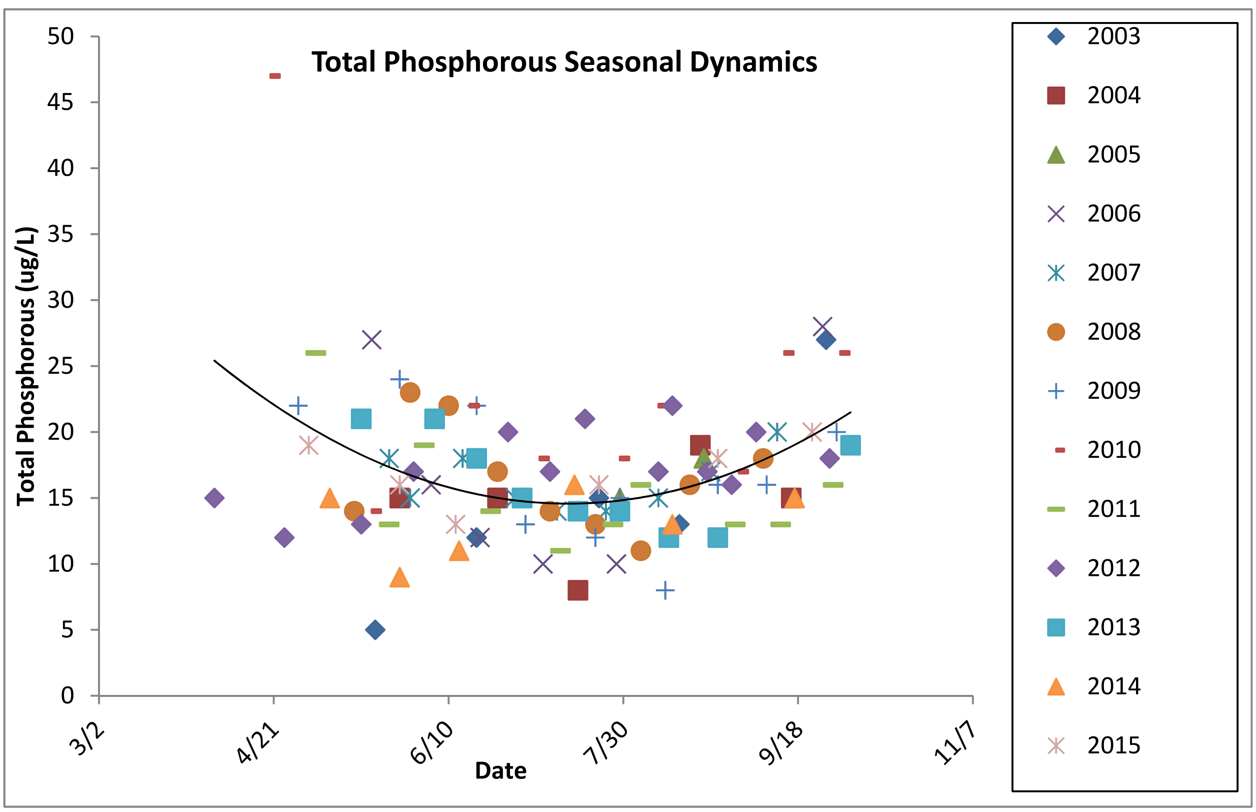


Figure 3.55 Historical total phosphorus concentrations (ug/L) for Bass Lake (2003-2015).

Bass Lake is phosphorus limited, which means that algae and aquatic plant growth is dependent upon available phosphorus. The total phosphorus concentrations follow a pattern in Bass Lake. Concentrations are high in May, when the lake is turning over, low in June through mid-August when the lake is stratified, and high again in September when the lake turns over again (Figure 3.55). This pattern is typical for dimictic lakes that have a distinct bowl-shaped basin and no stream inlets like Bass Lake does.

In 2009, water samples were collected just above the lake bottom to measure internal loading. Internal loading typically occurs in mid-summer when the oxygen at the bottom of the lake (hypolimnion) is depleted. When there is no oxygen in the hypolimnion, a chemical reaction occurs where phosphorus is released from the lake sediment back into the water. Then in the fall when the lake turns over this phosphorus comes up to the surface.

Figure 3.56 shows that Bass Lake follows a typical pattern for internal loading. Internal loading is usually highest in July through mid-August. In spring and fall, the hypolimnion phosphorus concentrations are similar to the surface water concentrations because the lake water column is fully mixed.

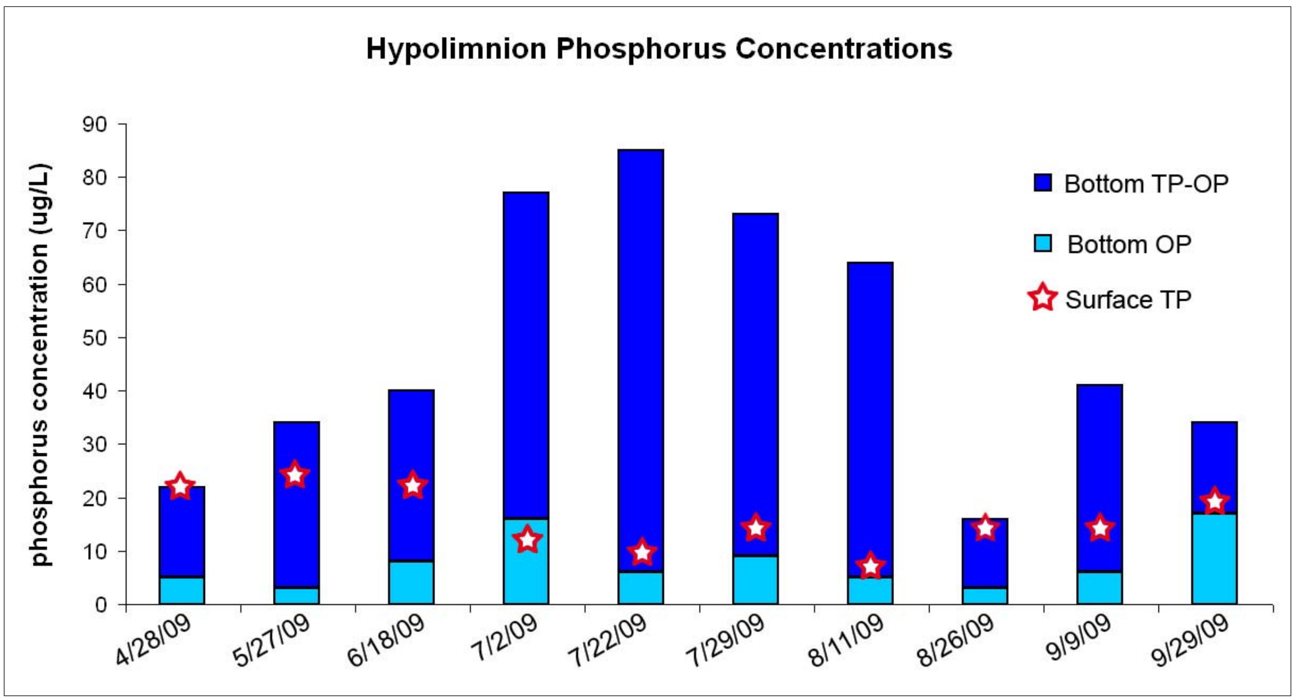


Figure 3.56 Hypolimnion phosphorus concentrations (ug/L) for Bass Lake (data set from 2009).

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.

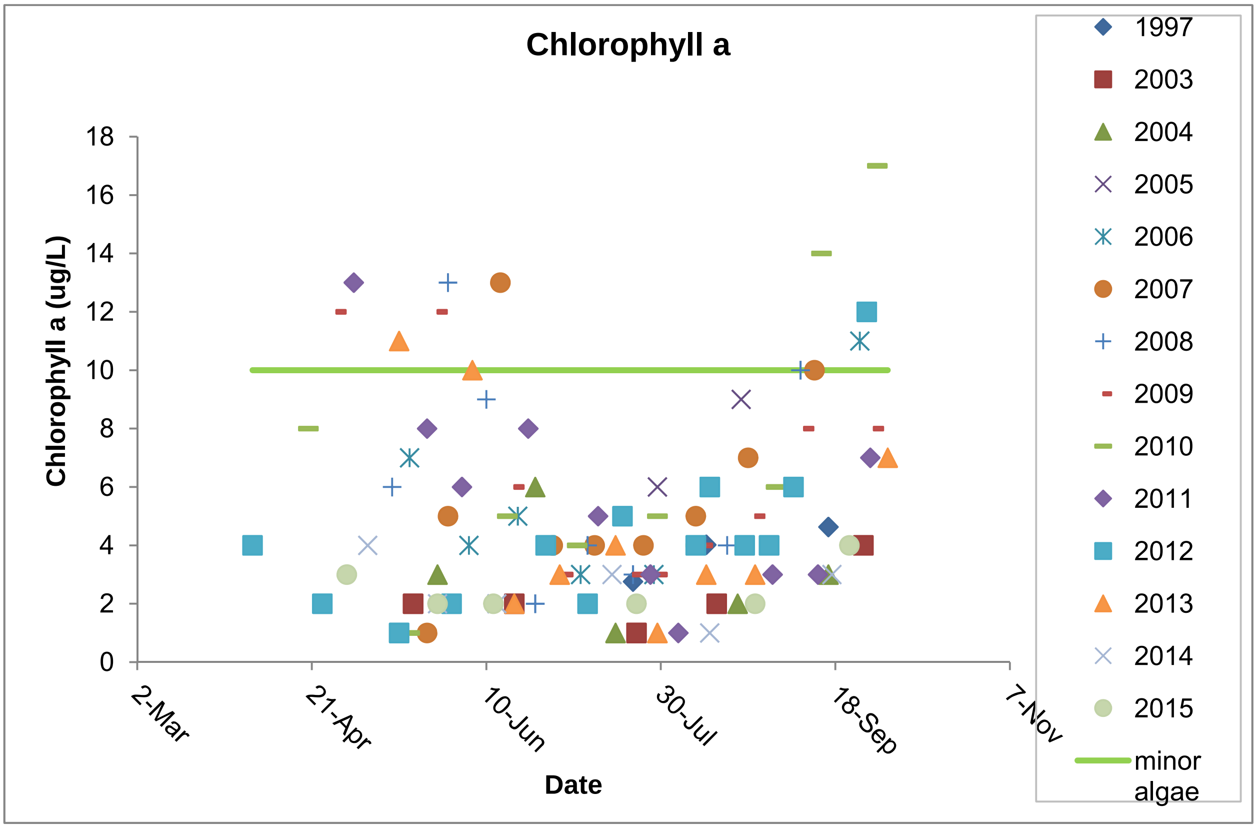


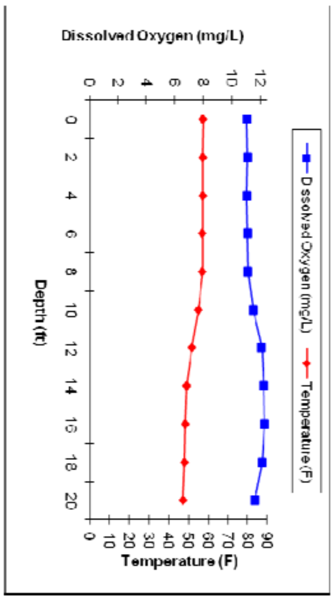
Figure 3.57 Chlorophyll *a* concentrations (ug/L) for Bass Lake (data set from 2003-2015).

Chlorophyll *a* was evaluated in Bass Lake in 2003-2015 (Figure 3.57). Chlorophyll *a* concentrations follow the phosphorus concentrations because phosphorus is food for the algae (Figures 3.55 and 3.57). Chlorophyll *a* concentrations are highest in spring and fall and lowest in the summer. Chlorophyll *a* concentrations in Bass Lake remained below 10 ug/L except for some dates in spring and fall, indicating clear water most of the summer. Chlorophyll *a* concentrations did not reach levels that are considered a nuisance algae bloom on any of the sample dates from 2003-2015.

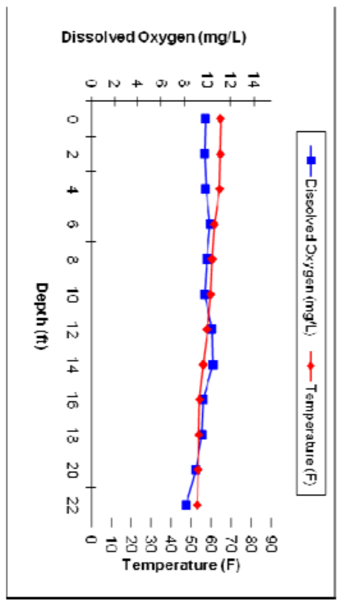
Dissolved Oxygen

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 oxygen that is dissolved in the water. Dissolved oxygen levels of <5 mg/L are typically avoided by game fish.

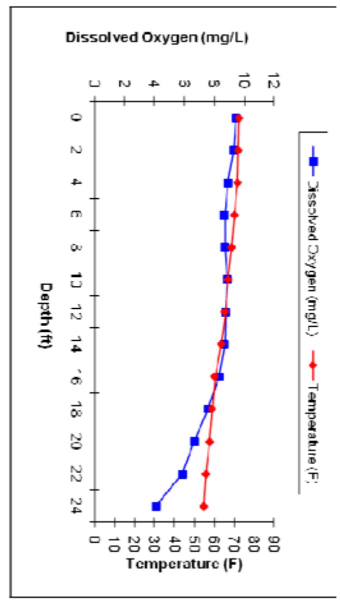
Bass Lake is its own distinct basin with a maximum depth of 33 ft. Dissolved oxygen profiles for Bass Lake have been collected by the PGOLID Water Resource Coordinator from 2007-2015. The profiles indicate that Bass Lake stratifies in mid summer. In 2015, the lake began stratifying in mid June and turned over in late August. In the summer the thermocline was at approximately 17 feet, which means that game fish were most likely absent below 17 feet.



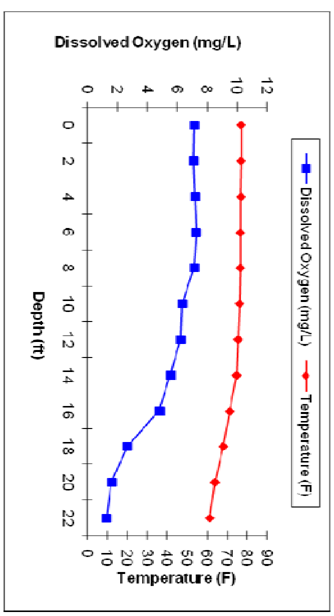
5/1/2015



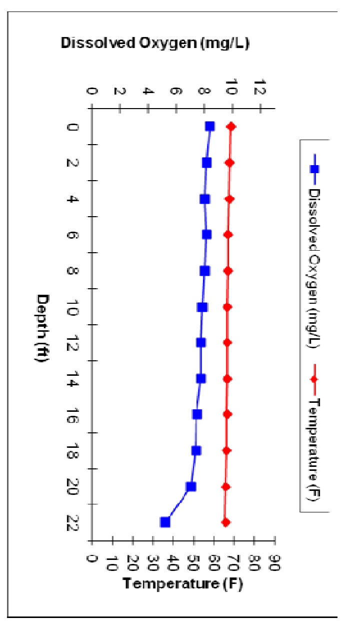
5/27/2015



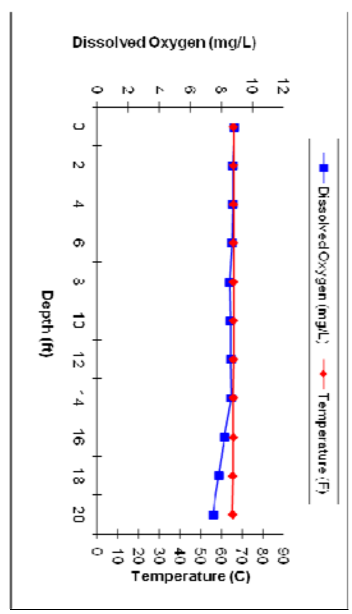
6/12/2015



7/23/2015



8/26/2015



9/22/2015

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.

Trophic State Index	Site 201
TSI Total Phosphorus	45
TSI Chlorophyll-a	47
TSI Secchi	41
TSI Mean	44
Trophic State:	Mesotrophic

Numbers represent the mean TSI for each parameter.

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 Bass Lake falls in the mesotrophic range (Figure 3.58). There is good agreement between the TSI for phosphorus, chlorophyll *a* and transparency, indicating that these variables are strongly related.

Mesotrophic lakes (TSI 40-50) 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 some algal blooms in late summer. Mesotrophic lakes can also be good walleye lakes.

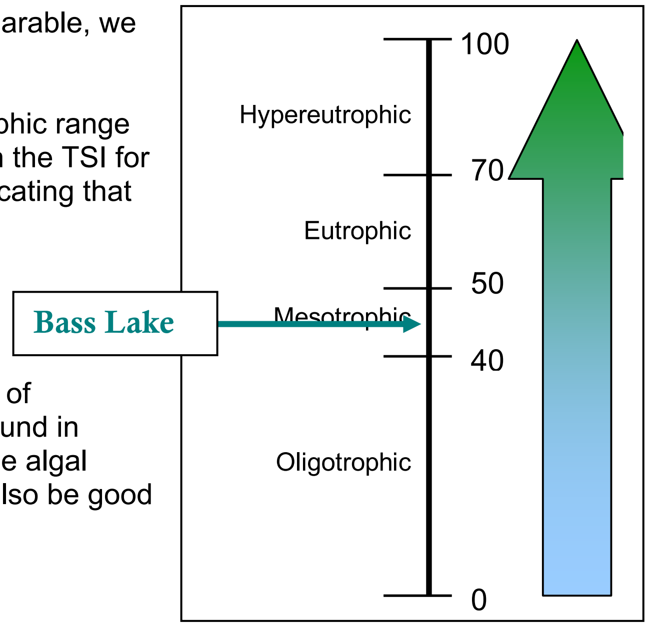


Figure 3.58 Trophic state index chart with corresponding trophic status.

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.

Bass Lake has data from 2003-2015. The data was analyzed using the Mann Kendall Trend Analysis.

Lake Site	Parameter	Date Range	Trend	Probability
201	Total Phosphorus	2003-2015	No Trend	--
201	Chlorophyll *a*	2003-2015	No Trend	--
201	Transparency	1997-2015	No Trend	--

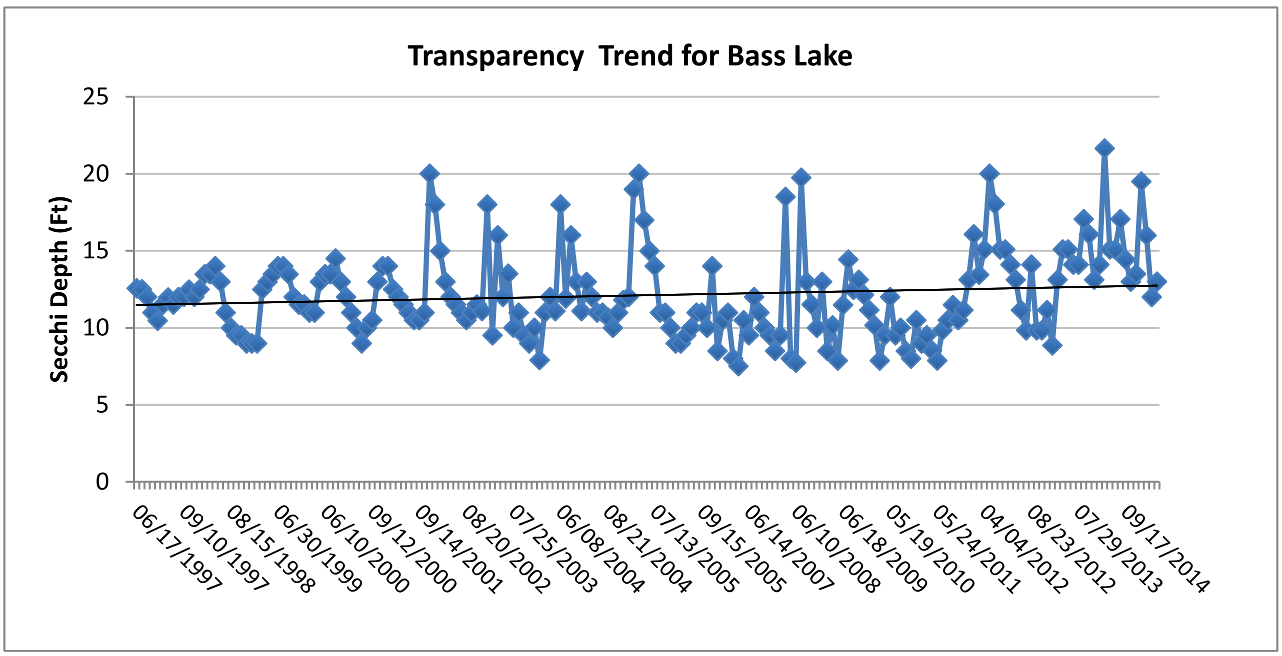


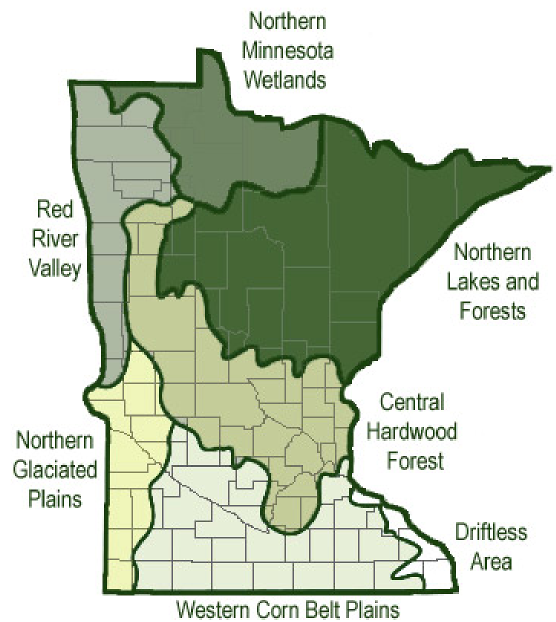
Figure 3.59 Bass Lake transparency trend from 2003-2015.

Bass Lake shows no water quality trends, which means that the water quality is stable (Figure 3.59).

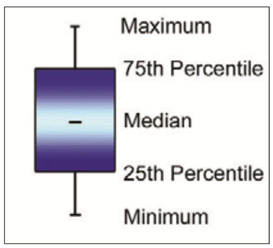
Bass Lake has a very dense native plant population along with emergent plants such as bulrush and cattails. This vegetation has been increasingly removed over the past decade, which could contribute to higher algae levels. The aquatic plants take up a lot of the phosphorus in the water and stabilize the lake sediments. When aquatic plants are removed, the phosphorus is available for more algae growth. In order to maintain the water quality in Bass Lake, aquatic plants should be protected and not removed by homeowners.

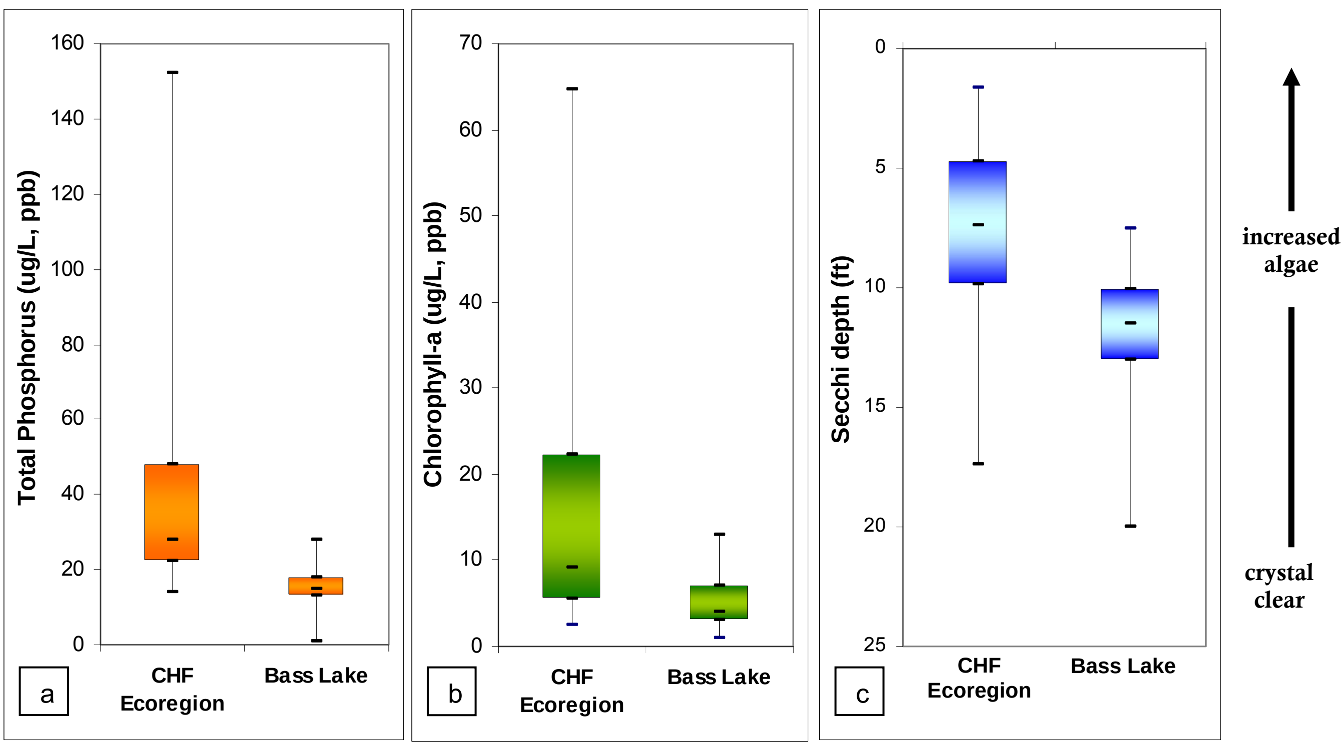
Ecoregion Comparisons

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.



Bass Lake is in the Central Hardwood Forest Ecoregion. The mean total phosphorus, chlorophyll *a* and transparency (Secchi depth) for Bass Lake are all better than the expected ecoregion ranges (Figures 3.60a-c).





Figures 3.60a-c. Bass Lake ranges compared to Central Hardwood Forest Ecoregion ranges (data from 2003-2009).

State Assessments (Minnesota Pollution Control Agency)

Impaired Waters Assessment 303(d) List
There are two main types of Impaired Waters Assessment for lakes: eutrophication (excess phosphorus) for aquatic recreation and mercury in fish tissue for aquatic consumption. Bass Lake is not listed as impaired for mercury in fish tissue; however, Pelican Lake is listed and is connected to Bass Lake. Therefore, the fish in Bass Lake should be considered impaired for mercury as well. See page 111 for fish consumption guidelines. Bass Lake is not listed as impaired for eutrophication.

Aquatic Recreational Use Assessment 305(b)
In the 2008 MPCA Aquatic Use Assessment (305(b)), Bass Lake was classified as being fully supporting for Aquatic Recreational Use.

Phosphorus Loading Models

Introduction

Introduction
PGOLID has an extensive data set from its monitoring programs. The lake monitoring program was started in 1996, and has resulted in consistent data from 1996 to 2014. The stream monitoring program was started in 2001 and has resulted in consistent data from 2001 to 2014. This data was inputted to a BATHTUB computer model (US Army Corps of Engineers) to determine the proportion of phosphorus loading from different sources to the lake. These results can be used to implement programs to improve or maintain the water quality by addressing the phosphorus sources. Potential phosphorus sources include septic systems, shoreline runoff, precipitation, internal loading and inlet loading.

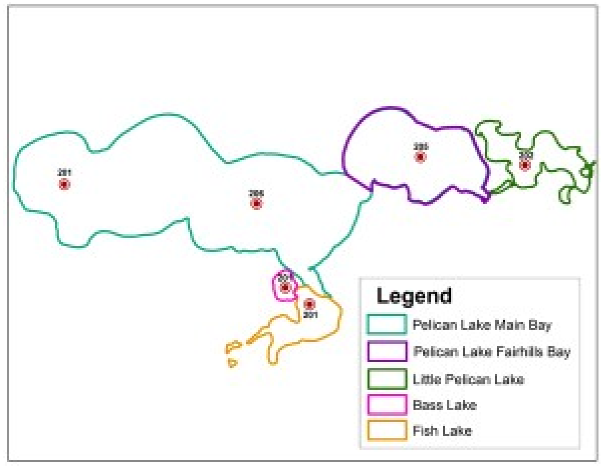


Figure 3.61. Watersheds contributing water and phosphorus to PGOLID.

Results
The model output for each lake shows the percentage of phosphorus loading from each of the different sources (Figure 3.62). Little Pelican, Pelican, and Fish Lakes look somewhat similar because they have major inflows from the Pelican River. Overall, the largest source of phosphorus loading to the lakes is the inlets, especially the Pelican River. Septic systems and shoreline runoff are minimal in comparison to the inlets.

Bass Lake looks different from the other lakes because it is fairly isolated, with no major inlets. The connection between Bass and Fish Lakes does not appear to move much water back and forth, but there is undoubtedly some exchange (~11%). Therefore, the septic systems and shoreline runoff have a larger proportional impact in Bass Lake than the other PGOLID lakes (Figure 3.62).

	Little Pelican Lake	Pelican Fairhills Bay	Pelican Main Bay	Fish Lake	Bass Lake
Inlet Loading	94.1%	76.8%	77.0%	96.2%	10.5%
Internal Loading	2.4%	16.6%	7.0%	1.0%	11.1%
Precipitation	1.9%	4.5%	11.5%	1.6%	30.4%
Shoreline Runoff	1.1%	0.9%	2.2%	0.7%	31.0%
Septic Systems	0.6%	1.1%	2.3%	0.5%	17.0%

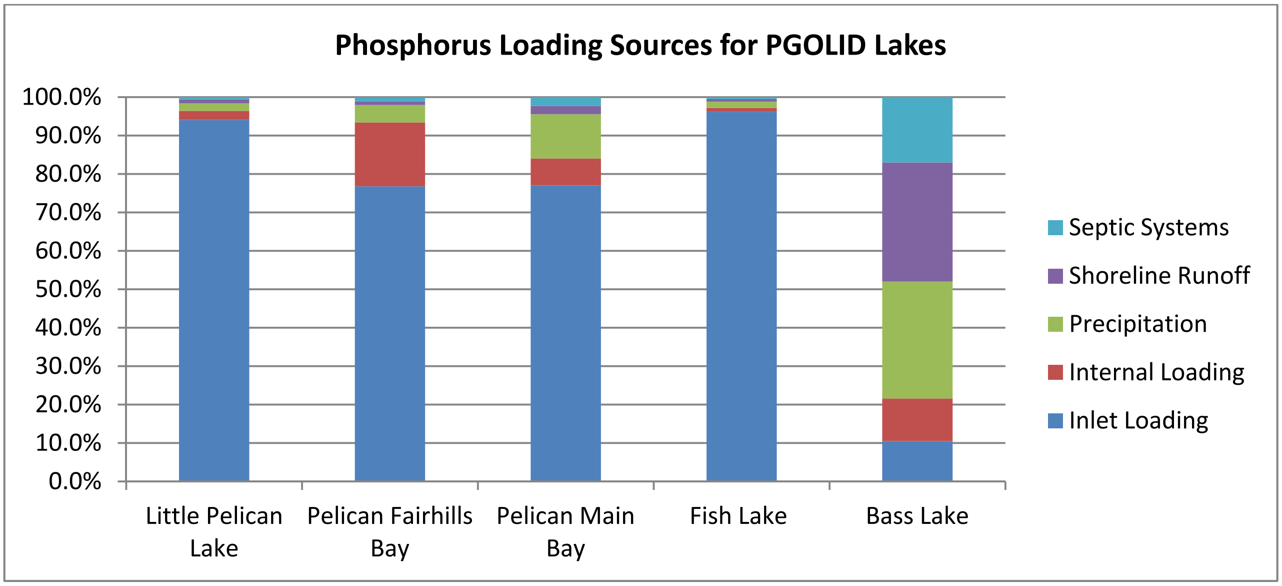


Figure 3.62. Phosphorus loading sources for PGOLID Lakes.

Implications
Because the Pelican Group of Lakes has so much water flowing through them, they are continually flushed out. This is good, because much of the nutrients coming into the lake go back out of the lake. The nutrients that stay in the lake are taken up by plants and algae and settle down into the sediments.

Septic Systems
Septic systems are a phosphorus source to the lake that can be controlled. Because of the Pelican River flow through the lakes, septic systems do not have much impact on the lake. Bass Lake, however, is different. Because there is not the water exchange occurring in Bass Lake, the septic system nutrients stay in the lake. It is still important to make sure the septic systems in the lake remain in good working order.

Shoreline Runoff
Shoreline runoff is a phosphorus source to the lake that can be controlled. Because of the Pelican River flow through the lakes, shoreline runoff is not a major source of phosphorus to the lake, but it does still affect it, especially in localized areas. When looking at the shoreline area from the water's edge to 250 feet back from the lake, 58-85% of the phosphorus loading from that land area comes from developed lots (impervious surface and turf grass). Shoreline runoff can fuel plant growth in swimming areas near shore. PGOLID has been implementing a Shoreline Restoration Program with a DNR Shoreline Habitat Restoration Grant since 2009. Restoring turf lawns to native grasses, wildflowers, trees and shrubs, and limiting the impervious surface in new development will limit future shoreline runoff. Having a natural shoreline is especially important in Bass Lake because it does not have a major inlet flushing it out.

Precipitation
Precipitation is a phosphorus source to the lake that cannot be controlled. The amount of phosphorus loading from precipitation is determined by the surface area of the lake. The more surface area the lake has, the more rain it receives directly from rainfall. Bass Lake had the highest loading from precipitation, but this is because it has very little inlet loading. Of the other segments, the Main Bay of Pelican Lake had the most phosphorus loading from precipitation because it has the largest surface area. There is nothing that can be done to limit phosphorus loading from precipitation.

Internal Loading

Internal loading is a phosphorus source to the lake that can be somewhat controlled. It is based on the morphometry (size and depth), and biology of the lake, but it is also based on the amount of phosphorus in the lake. Limiting external phosphorus inputs to the lake can help reduce the amount of internal loading in a lake. Internal loading is most prevalent in Fairhills Bay of Pelican Lake. This is because this bay is deep enough to stratify (separate into a warm top layer and cold bottom layer) and it receives nutrients and sediment from the Pelican River. Little Pelican Lake has the highest in-lake phosphorus of all the PGOLID lakes, but because it is shallow it does not fully stratify in the summer. The water column remains fairly mixed, and so the bottom of the lake has oxygen present, which keeps the phosphorus in the sediments from releasing in to the water.

Inlet Loading

Inlet loading is a phosphorus source to the lake that can be somewhat controlled. The best way to manage inlet loading is to maintain good relationships with upstream neighbors, and to monitor for any problems that could arise. If problems are detected they can hopefully be fixed before the impact to the lake is large. PGOLID has been implementing a stream monitoring program since 2001.

The largest source of phosphorus to the PGOLID Lakes is the Pelican River (Figure 3.62). This means much of the phosphorus comes from upstream in the watershed such as Detroit Lakes.

It is difficult to control phosphorous inputs upstream in the watershed. PGOLID maintains good working relationships with upstream entities such as the Pelican River Watershed District and the City of Detroit Lakes.

MINLEAP model *(run by MPCA, 1997)*

Summary

In 1997, the Minnesota Pollution Control Agency (MPCA) conducted their Lake Assessment Program on Pelican Lake. The summary report showed that Pelican Lake phosphorus levels are better than one would predict taking into account the watershed. In short, this means that the lake water quality is better than expected for the area. For Pelican Lake, it would be desirable to maintain the currently low in-lake phosphorus (P) concentration. An in-lake P goal on the order of 15 – 22 µg/L may be appropriate based on historical data. Should in-lake P concentrations increase, it is likely that the frequency of nuisance algal blooms would increase and transparency would decrease. One indication of a declining trend in water quality would be if summer-mean transparency remained consistently below the current long-term mean of 11.3 feet (3.4 m) or if summer-mean TP increased above 25 µg/L.

Details

Numerous complex mathematical models are available for estimating nutrient and water budgets for lakes. These models can be used to relate the flow of water and nutrients from a lake's watershed to observed conditions in the lake. Alternatively, they may be used for estimating changes in the quality of the lake as a result of altering nutrient inputs to the lake (e.g., changing land uses in the watershed) or altering the flow of amount of water that enters the lake.

To analyze the in-lake water quality of Pelican Lake, the model, MINLEAP (Wilson and Walker, 1989), was used. The "Minnesota Lake Eutrophication Analysis Procedures" (MINLEAP), was developed by MPCA staff based on an analysis of data collected from the ecoregion reference lakes. It is intended to be used as a screening tool for estimating lake conditions with minimal input data and is described in greater detail in Wilson and Walker (1989). The model, Vighi and Chiaudani (1985), was also used estimated a background phosphorus (P) concentration for Pelican Lake. This model is built into the MINLEAP model and is run concurrently with MINLEAP.

MINLEAP uses the total watershed area of the lake (minus lake surface area) combined with ecoregion-based typical runoff and stream total phosphorus (TP) as a basis for predicting TP loading to the lake.

In our first model run for Pelican MINLEAP predicted an in-lake TP of 27 (± 11) µg/L. This value is higher than the historical observed mean of 15.7 µg/L (1996-2009). Since the initial MINLEAP model run predicted a TP value that was higher than anticipated, we decided a closer review was in order. Upon closer examination of the watershed map and model inputs for Pelican Lake, it was thought that the southwestern portion of the watershed (area containing Tamarac Lake) may, in fact, not even drain to Pelican Lake – as it appears to be a closed basin. In addition, the model does not consider the "processing" of the watershed TP loading that takes place in Little Pelican Lake; which leads to a much lower P-loading to Pelican from that portion of the watershed. Both of these factors would contribute to a higher predicted P-loading, to the lake than what actually occurs. Thus, in an attempt to generate a more "realistic" loading, we calibrated the model by reducing the inflow stream TP concentration. This resulted in a predicted in-lake TP of 22 µg/L. This value, while higher, is not significantly different than the historical observed TP (Table 3.1) nor the long-term mean (Table 3.2). In turn, predicted chlorophyll *a* and Secchi values were quite similar to observed.

A second mathematical model developed by Vighi and Chiaudani (1985) estimated a background phosphorus (P) concentration for Pelican Lake at 22.3 µg/L. This prediction is based on the morphoedaphic index routinely used in fishery science and predicts background (~ natural) P based on the lake's alkalinity and mean depth. Because of its large size and volume the lake retains a very high percentage of the P which enters the lake (about 83 percent). The model estimates water residence time (time it would take to fill the lake if it was completely empty) at about 8-9 years.

Table 3.1. MINLEAP Model Results for Pelican Lake.

Parameter	**Observed** Historical (1996-2009)	**MINLEAP** Predicted	**MINLEAP** Calibrated
TP (µg/L)	15.7 ± 5.7	27 ± 11	22 ± 9
chl-*a* (µg/L)	5.3 ± 2.8	8.1 ± 5.5	6.2 ± 4.2
% chl-*a* >20 µg/L	0	2	11
% chl-*a* >30 µg/L	0	0	0
Secchi (ft)	11.8 ± 3.8	7.5 ± 3.3	8.9 ± 3.9
P loading rate (kg/yr)		2,368	1,754
P retention (%)		85	83
P inflow conc. (µg/L)		177	131
water load (m/yr)		0.84	0.84
outflow volume (hm3/yr)		13.41	13.41
"background P" (µg/L)		22.3	22.3
residence time (yrs)		8.6	8.6

Table 3.2. Pelican Lake Summer-Mean TP Concentrations & Model Estimates.

2009 Mean	**Long-Term Mean**	**MINLEAP**	**Vighi – P**
15.8 ± 4.5 µg/L	15.7 ± 5.7	22 – 27 µg/L	22.3 µg/L

Goal Setting

The phosphorus criteria value for lakes in the North Central Hardwoods Forest ecoregion, for support of swimmable use, is less than 40 µg/L (Heiskary and Wilson, 1990). At or below 40 µg P/L, "nuisance algal blooms" (chlorophyll *a* > 20 µg/L) should occur less than 20% of the summer and transparency should remain above 1m over 90% of the summer. Pelican Lake, with a summer-mean P of 15.7 µg/L and a summer-mean chlorophyll *a* of 5.3 µg/L, does not experience nuisance blooms during the summer (MINLEAP model, Table 3.1). For Pelican Lake, it would be desirable to maintain the currently low in-lake P concentration. An in-lake P goal on the order of 15 – 22 µg/L may be appropriate based on data from 1997, and model results (Table 3.2). The summer-mean P concentration in 1997 was below the background concentrations as estimated by Vighi and Chiaudani regression – 22.3 µg/L. Should in-lake P concentrations increase, it is likely that the frequency of nuisance algal blooms would increase and transparency would decrease.

Based on historical user perception information, perceptions of “impaired swimming” and “algal green” never occurred. Maintaining a summer-mean P concentration of about 15 - 22 µg/L or lower over the long term, may ultimately require that P-loading to the lake be reduced. Important considerations include implementation of BMP’s in the shoreland area and ultimately through the watershed with a particular emphasis on the direct drainage area. A more comprehensive review of land use practices in the watershed may reveal opportunities for implementing BMPs in the watershed and reducing P-loading to the lake. Proper maintenance of buffers areas between lawns and the lakeshore, minimizing use of fertilizers, and minimizing the introduction of new significant sources of P loading, e.g., stormwater from nearshore development activities in the watershed, will serve to minimize loading to the lake. These and other considerations will be important if the good water quality of Pelican Lake is to be maintained over the long term.

Reference: Klang, Jennifer. 2004. Lake Assessment Program, 1997. Minnesota Pollution Control Agency Report, St. Paul, MN. http://www.pca.state.mn.us/publications/reports/lar-56-0786.pdf

Chapter 4. Invasive Species

Introduction and Current Status

Introduction
Since 2004, PGOLID has been very vigilant in working to prevent invasive species in their lakes and educating lake residents. These activities have included chemical treatment of invasive plants, the DNR Watercraft Inspection Program, and Educational Seminars conducted by the PGOLID Water Resource Coordinator.

In 2003, Curly-leaf pondweed was found in Pelican, Little Pelican and Bass Lakes during the lakewide plant survey (Blue Water Science). In 2005, PGOLID started a curly-leaf pondweed chemical treatment program and the results have been successful. From 2005 to 2009, there was a 95% reduction in curly-leaf pondweed in the PGOLID lakes. Eradication of this exotic species is not likely within any body of water the size of Pelican Lake, but continued management practices can keep detrimental effects of this plant to a minimum.

In 2006, PGOLID started the DNR Invasive Species Watercraft Inspection Program. In this program, PGOLID applies for DNR grant funding to have a DNR summer intern posted at their public accesses. This intern interviews boaters and inspects all boats entering and leaving Pelican Lake about invasive species. In 2008-2012, the DNR intern was present at public accesses from Thursday to Sunday every weekend from Opening Fishing to Labor Day. This program both protects Pelican Lake from invasive species and educates boaters about invasive species in Minnesota lakes. PGOLID plans to continue this program every summer in the future.

Current Status
Currently, the only invasive species present in the PGOLID lakes are curly-leaf pondweed and zebra mussels. The curly-leaf pondweed is under control by chemical treatment, and unfortunately there is no treatment for zebra mussels.

The largest threat for new invasive species establishment is Eurasian flowering rush. This invasive aquatic plant is established upstream in the Pelican River in Detroit, Sallie, Melissa and Mill Lakes. Flowering rush has been found in Buck Lake the past two summers, but the PGOLID Water Resource Coordinator and PGOLID boardmembers have dug it out. The next lake down the Pelican River is Little Pelican. PGOLID has a Flowering rush Contingency Plan to deal with the threat of this plant in the future.

Zebra Mussels

Zebra mussels were found in Pelican Lake in September of 2009 by a lake resident. The resident called the PGOLID Water Resource Coordinator, and the sample was confirmed as a zebra mussel. That same afternoon, the PGOLID Water Resource Coordinator and the DNR searched for zebra mussels and confirmed that they were established in Pelican Lake. Some mussels were over an inch long, indicating that they have been established for over a year. Later in the fall of 2009, zebra mussels were also found in Fish Lake.

Zebra mussels are ¼ to 1 ½ inches long and are D-shaped with alternating black and brown stripes. Zebra mussels are tricky to find when they are larvae (veligers), because they are not visible to the naked eye. Zebra mussel veligers can live anywhere water is present including bilge pumps, live wells, and trailers and are easily spread into other lakes if proper decontamination processes aren't followed. This could be how they entered Pelican Lake. Zebra mussels can attach to hard surfaces such as boat lifts and docks and clog water intake pipes causing problems for property owners, cities, and businesses alike.

Curly-leaf pondweed

History

Curly-leaf pondweed is an invasive plant that can form large mats early in the summer and interfere with recreational activities. When curly-leaf pondweed dies off in early June, these large mats wash up on shore and create a nuisance.

A curly-leaf pondweed survey was performed within Pelican and Little Pelican Lakes during June 2005 for the identification and mapping of curly-leaf pondweed area perimeters. The areas that were mapped as containing curly-leaf pondweed during 2005 received herbicidal treatment during May 2006. The herbicidal treatment program was very successful. The curly-leaf pondweed program was continued during 2007 and 2008 adding Fish and Bass Lakes, and a total of approximately 31 acres were treated each year (Figure 4.1).

Program Goals

Goals of the curly-leaf pondweed herbicide control efforts include:

1. Minimization of floating and drifting cut and fragmented curly-leaf pondweed plants which will inevitably be spread throughout the lakes and transported to non-infested lakes
2. Prevention of the development and maturity of turions (nodules that propagate the plant)
3. Prevention of matting curly-leaf pondweed on the water's surface. This prevention will improve recreational activities and increase lake-user safety
4. Allowance of the native plant community to become reestablished in places where they are currently being displaced by curly-leaf pondweed to improve fish habitat

Treatment Process

A Minnesota Department of Natural Resources (MN DNR) *permit to destroy aquatic vegetation* must be obtained yearly before the application of herbicide is allowed. All property owners that are adjacent to the treatment areas must provide written herbicide application authorization before the MN DNR will issue a permit.

Summary/Discussion

Curly-leaf pondweed is now surveyed every spring, and dense areas are treated with herbicide. The largest areas of curly-leaf pondweed are now sufficiently thinned-out, and PGOLID is in maintenance-mode with annual treatments in small areas.

Participation by property owners, Lake Improvement District supporters, Lake Improvement District Board Persons, Minnesota Department of Natural Resources personnel and others have all contributed successfully to this program. Continued surveying and herbicidal treatments are recommended in order to keep this exotic aquatic plant managed within Bass, Little Pelican and Pelican Lakes. Eradication of this exotic species is not likely within any body of water but continued management practices can keep detrimental effects of this plant to a minimum.

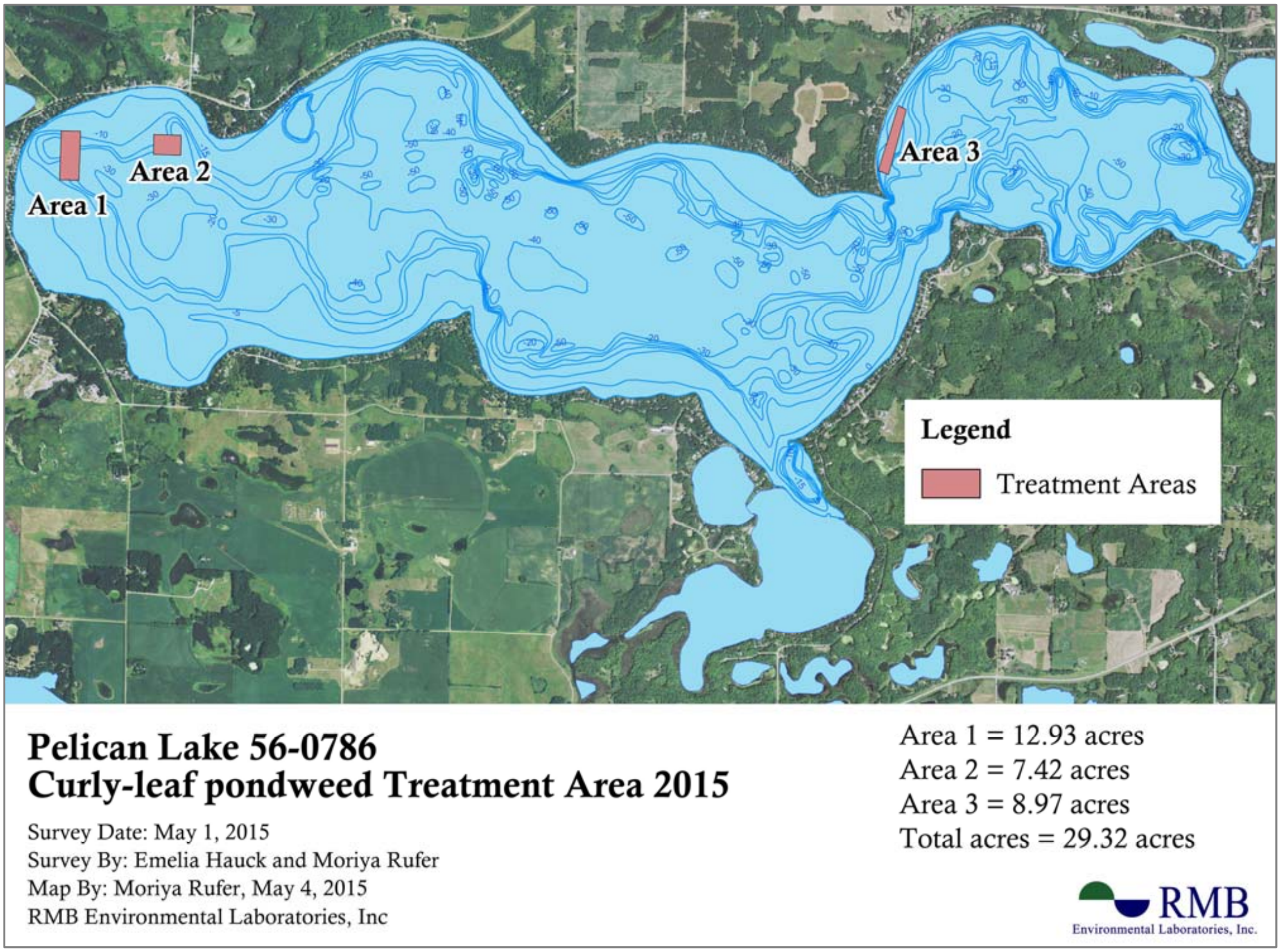


Figure 4.1 Curly leaf pondweed treatment areas, 2015.

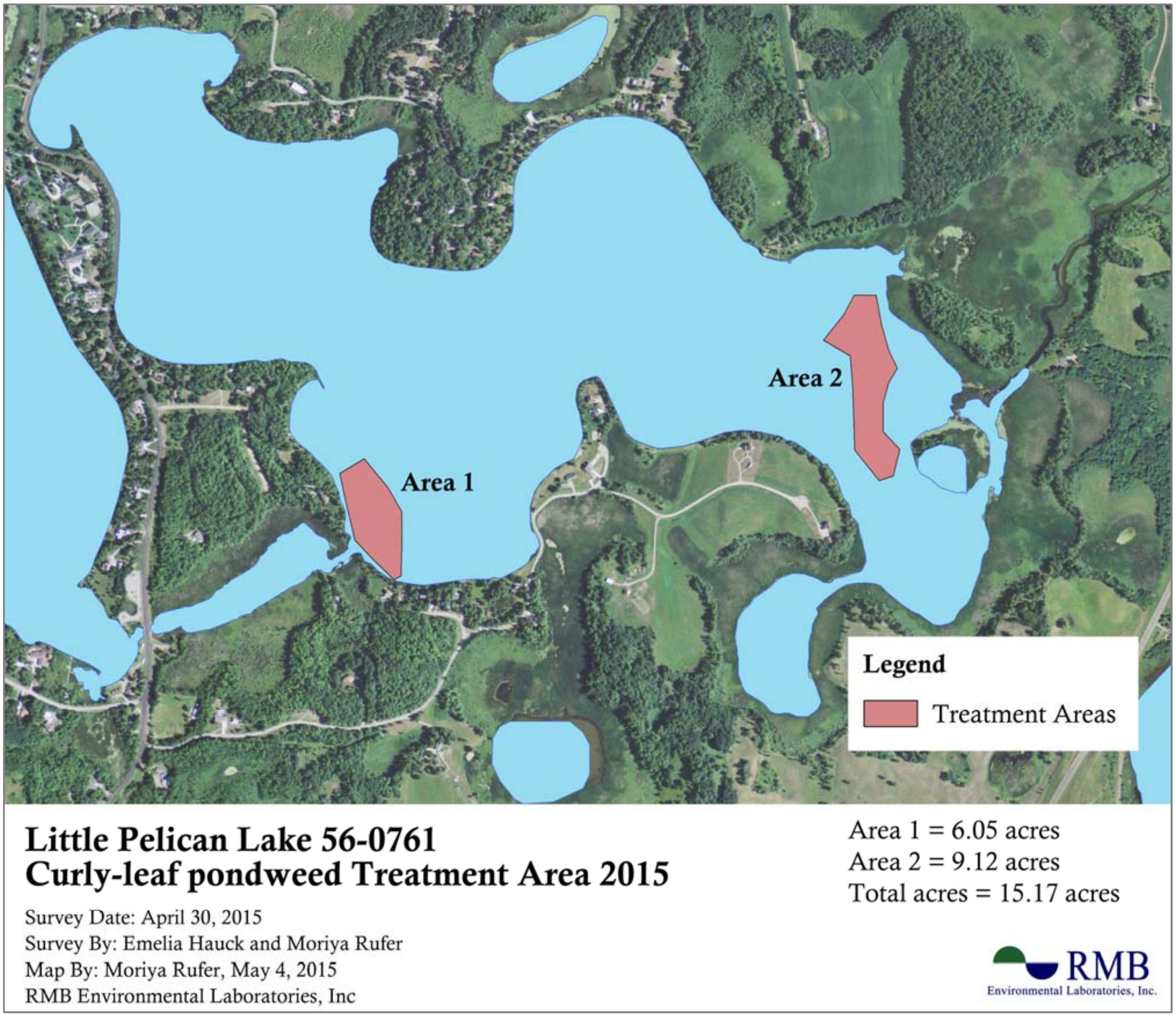


Figure 4.2 Curly leaf pondweed treatment areas, 2015.

Eurasian Flowering Rush

Figure 4.2 Flowering rush on Detroit Lake's public beach

Origin in the Watershed

FR was introduced into North America as an ornamental garden plant from Eurasia. It was first identified in Deadshot Bay in the mid-1970s, and spread into the Big Detroit by the end of that decade (Figure 4.2). By the early 1980s it was found in many places around Big and Little Detroit; and moved down the Pelican River to Muskrat, Sallie and Melissa Lakes (Figure 4.3). In 2007, it was found in Mill Lake, and 2008 it was found in Buck Lake. The next lake down the chain is Little Pelican. As of July 2009, the furthest FR population documented is Buck Lake (Figure 4.4).

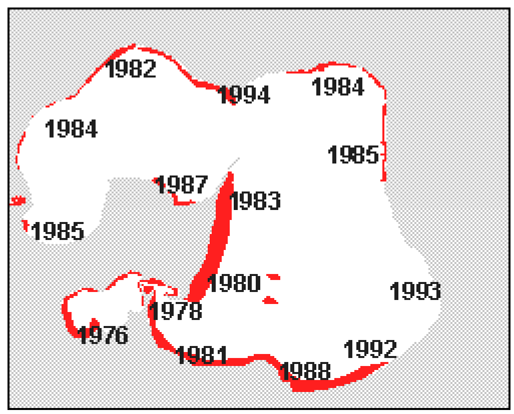


Figure 4.3 Detroit Lake Flowering Rush spread.
Source:http://www.prwd.org/?D=45&PHPSESSID=4653d36f2da9717664047bf2925d2649

Affects of Introduction

FR is an extremely invasive aquatic plant. It displaces native riparian vegetation, and easily invades areas not occupied by other plants. It grows in dense clusters up to 10 feet deep. Depending on water levels it can become emergent.

FR makes aesthetics difficult. It can prevent boating, swimming, and can limit fishing. Shoreline access becomes difficult. As a result property values decrease.

Virtually all of Pelican Lake up to 10 feet of water is vulnerable to FR invasion. Most of Pelican Lake's beaches contain a limited density of native aquatic plants, thus making it more vulnerable.

PGOLID Contingency Control Plan

The Water Resource Coordinator shall monitor the district and upstream of the district for the introduction of FR, as well as the success of the treatment and methods of control used by the PRWD and DNR. The FR Contingency Control Plan will be updated accordingly.

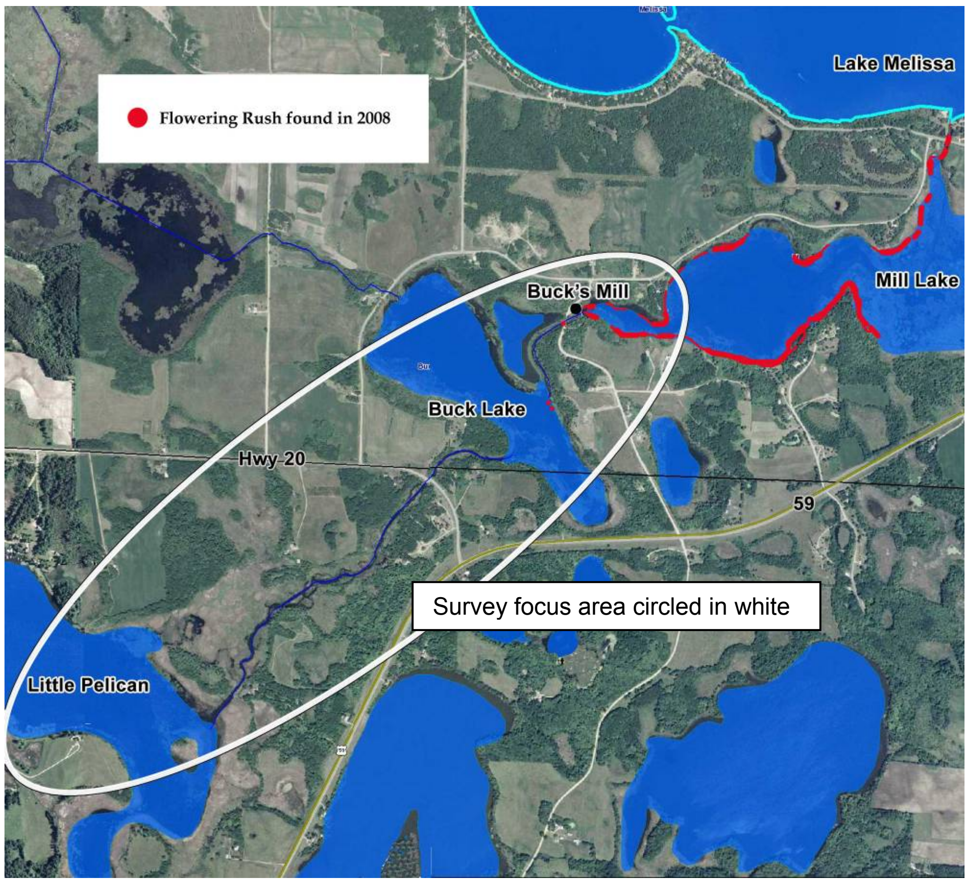


Figure 4.7 Eurasian flowering rush survey area showing known locations of flowering rush.

Annually, numerous surveys will be conducted by the Water Resource Coordinator. Canoeing down the Pelican River is the best method, since many survey areas are too shallow and too dense with aquatic vegetation for a motorized boat. The survey focus will be just north of the Bucks Mill Dam in Mill Lake, the Pelican River south to Buck Lake, and the Pelican River into Little Pelican Lake (Figure 4.7). PGOLID has requested DNR surveys in Little Pelican Lake as well.

If small stands of FR are discovered south of Bucks Mill, the Water Resource Coordinator will acquire a DNR permit for hand removal. The Water Resource Coordinator with an accompanying PGOLID board member will remove the plant(s) with a shovel. All discovered stands of FR will be documented by a GPS location so the sites can be monitored in following years.

In the future, if larger areas of FR are discovered that are unable to be removed by hand, chemical treatment will need to be implemented. The Water Resource Coordinator will seek permission from all landowners within 150 feet of the proposed treatment area, and the PGOLID board will acquire a DNR permit and hire a chemical applicator to treat the infested areas. The chemical imazapyr under the label *Habitat* would be applied annually over several years for control. Residents near the infected area would be educated on the spread and treatment of FR to encouraging best management practices of this exotic plant.

The PGOLID board has set aside funding for chemical treatment of FR if the need arises. This flexibility in the budget allows for swift mitigation of any new problem areas. In addition, the DNR has a new grant program for Early Detection/Rapid Response to invasive species. Under this grant, PGOLID could apply for funding to chemically treat FR if it is ever found in a large area south of Mill Pond.

Chapter 5. Fisheries Status and Consumption Guidelines

Status of the Fisheries

Pelican Lake *(DNR Report, as of 8/2/2011)*

Pelican Lake is located in northwestern Otter Tail County approximately seven miles north of Pelican Rapids, MN. Pelican Lake is a 3,986-acre mesotrophic (moderately fertile) lake that is located within the Otter Tail River Watershed. The southern portion of the lake (309 acres) is referred to as Fish Lake. Pelican Lake is connected to Little Pelican Lake and Lake Lizzie via the Pelican River. The Pelican River inlet is located along the east shoreline of the lake while the outlet is located along the south shoreline of Fish Lake. The Pelican River is navigable by boat upstream to Little Pelican Lake. A dam at the outlet impedes navigability downstream to Lake Lizzie. The maximum depth of Pelican Lake is 55 feet; however, 41% of the lake is less than 15 feet in depth. The secchi disk reading during the 2011 lake survey was 10.0 feet. Previous secchi disk readings have ranged from 5.4 to 13.0 feet.

The shoreline of Pelican Lake has been extensively developed. Homes, cottages, and resorts compose the majority of the development. DNR owned concrete public water accesses are located along the east and southwest shorelines of the lake. Remnant stands of hardstem bulrush and wild rice are scattered along various shorelines of the lake. A large stand of hardstem bulrush is located along the north shoreline of the entrance into Fish Lake. Emergent aquatic plants such as bulrush and wild rice provide valuable fish and wildlife habitat, and are critical for maintaining good water quality. Emergent plants provide spawning areas for fish such as northern pike, largemouth bass, and panfish. They also serve as important nursery areas for all species of fish. Because of their ecological value, emergent plants may not be removed without a DNR permit. To maintain the excellent water quality and angling that this lake has to offer, it is imperative to preserve the quality of the aquatic habitat.

Pelican Lake is a popular angling lake during both the open water and ice fishing seasons. The lake is best known for its excellent walleye, northern pike, and bluegill fishing. Data from the population assessment indicate that these species are abundant. Pelican Lake is also becoming renowned as a trophy muskellunge lake. Walleye is a primary management specie in this lake. The test-net catch rate of walleye was the third highest recorded in any survey on this lake. Walleye ranged in length from 7.9 to 26.1 inches with an average length and weight of 13.4 inches and 1.0 pound. The 2008 and 2009 year classes appear to be strong and should provide consistently good walleye angling for several years. Walleyes attain an average length of 14.2 inches at four years of age.

Northern pike population characteristics have demonstrated stability over the recent series of assessments. The pike population has remained at a moderate density since the 1983 survey and natural reproduction has continued to be consistently good. Northern pike ranged in length from 11.3 to 30.3 inches with an average length and weight of 20.5 inches and 1.6 pounds. Pike exhibit moderate growth rates with an average length of 22.6 inches at four years of age.

The muskellunge population can be characterized as a trophy fishery; a low-density population with fish of quality size. Muskellunge up to 46.0 inches in length have been sampled in recent assessments. The DNR will continue to manage Pelican Lake as a trophy muskellunge fishery.

Bluegill test-net catch rates have fluctuated over the recent series of assessments with the general trend being a decline in the catch rate. The decline in bluegill abundance has led to a corresponding increase in bluegill size distribution. Fifty-three percent of the bluegills were 7.0 inches or greater in length. Bluegills attain an average length of 6.7 inches at six years of age. A low-density smallmouth bass population exists in Pelican Lake.

Smallmouth bass test-net catch rates have historically been low. Suitable spawning habitat and/or juvenile nursery areas may be factors limiting smallmouth bass abundance. Anglers can maintain the quality of fishing by practicing selective harvest. Selective harvest encourages the release of medium to large-size fish while allowing the harvest of the more abundant smaller fish for table fare. Releasing the medium to large fish will ensure that the lake will have enough spawning age fish on an annual basis and will provide anglers with more opportunities to catch large fish in the future.
See the link below for specific information on gillnet surveys and stocking information:
http://www.dnr.state.mn.us/lakefind/showreport.html?downum=56078600

Little Pelican Lake *(DNR Report, as of 06/14/1999)*

Little Pelican Lake is a 345 acre mesotrophic (moderately fertile) lake located in the Otter Tail River Watershed. It has a maximum depth of 25 feet and 74% of the lake is 15 feet or less in depth. Shoreline substrates consist primarily of sand and muck. Access is gained through a navigable channel from Big Pelican Lake. Development is located on the north and south shorelines. The east end of the lake contains marshy areas. Emergent vegetation (bulrush, cattail, wild rice) is located in areas throughout the basin. Emergent plants are important because they provide valuable fish and wildlife habitat and are critical for maintaining good water quality. They protect shorelines from erosion and can even absorb and break down pollutants from the water. Emergent plants provide spawning areas for fish species such as northern pike, largemouth bass and panfish. They also are important nursery areas all species of fish. Because of their ecological importance, emergent plants may not be removed without a DNR permit.

Little Pelican Lake contains good populations of bluegill, largemouth bass, northern pike and black crappie. The bluegill size structure is good with 42% of the bluegill sampled in 1999 over 7.0 inches in length.

Largemouth bass and black crappie are likely present in good numbers. Spring assessments in the future will provide better information on these species. Spawning habitat exists throughout the basin for these species to thrive on their own.

Walleye are not stocked in Little Pelican Lake. The walleye population is likely maintained by immigrants entering from Big Pelican Lake. The population is currently good and well balanced with fish ranging in length from 10.0 to 24.5 inches.

See the link below for specific information on gillnet surveys and stocking information:
http://www.dnr.state.mn.us/lakefind/showreport.html?downum=56076100

Fish Lake *(DNR Report, as of 07/14/2008)*

Fish Lake is a 267-acre mesotrophic (moderately fertile) lake located in the Otter Tail River Watershed. A portion of Fish Lake is also referred to as Bass Lake. Fish Lake is connected to

Pelican Lake by a navigable channel. The immediate watershed is composed of mixed hardwood forest.

Shoalwater substrates consist primarily of sand and gravel. Hardstem bulrush and common cattail are prevalent along the shorelines of the lake. These emergent plants provide valuable fish and wildlife habitat and are critical in maintaining good water quality. Emergent plants also provide critical spawning habitat for several species of fish including northern pike, largemouth bass, and panfish. They also serve as important nursery areas for many species of fish. Because of their ecological value, emergent plants cannot be removed without a DNR permit.

Since Fish Lake is connected to Pelican Lake, population dynamics of the fish community tend to reflect those in Pelican Lake. The northern pike test-net catch rate exceeded the normal range for this class of lake. Age data indicate that pike reproduction is consistently good. Pike ranged in length from 10.9 to 33.7 inches with an average length and weight of 19.6 inches and 1.8 pounds. Seventeen percent of the northern pike were 24.0 inches or greater in length. Pike attain an average length of 21.9 inches at five years of age.

The walleye test-net catch rate was within the normal range for this class of lake. The 2002 and 2006 year classes are strong. These year classes are also strong in Pelican Lake. Walleyes ranged in length from 10.0 to 22.6 inches with an average length and weight of 15.3 inches and 1.3 pounds. Walleye attain an average length of 14.1 inches at four years of age.

The bluegill test-net catch rate was within the normal range for this class of lake. Bluegill size structure is very good. The average length of bluegill was 6.9 inches. Sixty-five percent of the bluegills were 7.0 inches or greater in length. Bluegills attain an average length of 7.5 inches at five years of age.

Anglers can maintain the quality of angling by practicing selective harvest. Selective harvest encourages the release of medium to large size fish while allowing the harvest of more abundant smaller fish for table fare. Releasing the medium to large fish will ensure that the lake will have enough spawning age fish on an annual basis and will provide anglers with more opportunities to catch large fish in the future.

Bass Lake

Bass Lake is considered an extension of Fish Lake, therefore it doesn't have its own DNR fisheries status report.

Fish Consumption Guidelines

These fish consumption guidelines help people make choices about which fish to eat and how often. Following the guidelines enables people to reduce their exposure to contaminants while still enjoying the many benefits from fish.

The guidelines below are specific to Pelican Lake, but since Little Pelican, Bass and Fish Lakes are attached to Pelican, we can assume that they should have the same guidelines.

General Population

LAKE NAME County, DOWID	Species	Meal Advice				Contaminants
		Unrestricted	1 meal/week	1 meal/month	Do not eat	
PELICAN Otter Tail Co., 56078600	Bluegill Sunfish	All sizes				
	Cisco	All sizes				
	Crappie	All sizes				
	Largemouth Bass			All sizes		Mercury
	Northern Pike		All sizes			Mercury
	Walleye		All sizes			Mercury

Pregnant Women, Women who may become pregnant and Children under age 15

LAKE NAME County, DOWID	Species	Meal Advice				Contaminants
		Unrestricted	1 meal/week	1 meal/month	Do not eat	
PELICAN Otter Tail Co., 56078600	Bluegill Sunfish		All sizes			Mercury
	Cisco		All sizes			Mercury
	Crappie		All sizes			Mercury
	Largemouth Bass			All sizes		Mercury
	Northern Pike			All sizes		Mercury
	Walleye			All sizes		Mercury

DOWID - MN DNR, Division of Waters' lake ID number.

Contaminants listed were measured at levels high enough to warrant a recommendation to limit consumption.

Chapter 6. Waste Treatment History and Status

Introduction and Summary

PGOLID has been vigilant in monitoring septic system records for the lakes. In 2004 as part of the original Lake Management Plan, Blue Water Science conducted an Otter Tail County Individual Waste Treatment System record survey for the PGOLID lakes. In 2006, PGOLID conducted a voluntary survey and waste treatment screening project. In addition, over the past 3 years, Otter Tail County has conducted mandatory waste treatment system inspections for systems over 20 years old.

These studies have shown that although the majority of PGOLID individual waste treatment systems are working properly, property owners are not always maintaining them correctly. After the 2006 survey, an educational campaign was launched for PGOLID property owners to try and improve their waste treatment system maintenance.

In 2012, a follow-up Otter Tail County Individual Waste Treatment System record survey was conducted and compared with the 2004 survey. The status of PGOLID waste treatment systems has improved overall since the 2003 records survey. Many of the systems from the 1970s have been updated in the last few years. In 2003, there were 209 systems in the PGOLID lakes that were installed in the 1970s. In 2012, there are 90 systems that were installed in the 1970s, and 290 systems that were installed since 2000.

Otter Tail County Abatements, 2007-2009

In 2007-2009, Otter Tail County conducted mandatory inspections on individual waste treatment systems that were 20 years old or older. The statistics for these inspections are summarized below (Table 6.1).

Table 6.1. Abatement summary for Pelican Lake, 2007-2009.

Number	Description
23	Illegal cesspools
1	Illegal cesspool in the groundwater table
1	Illegal cesspool with an open end pipe discharging sewage to the ground surface
4	Holding tanks with broken bottoms
1	Holding tank with an apparent illegal outlet installed
1	Illegal wooden crib tank
3	Block tanks
2	Tanks too close to a well
1	Illegal steel tank with the drainfield under the driveway
7	Paved over drainfields or drainfield with no vegetative cover
10	Illegal sink drains
1	Illegal washing machine drain
3	Illegal outhouses
3	Systems not brought into compliance as required by issued site or septic permits
1	Illegal dump station in ground not connected into a septic system
1	Illegal outdoor shower
Totals:	
86	Abatements
329	Properties Inspected
26.1%	Of properties abated

Waste Treatment Records Survey, 2004

In 2004, Blue Water Science conducted a soil suitability study for waste treatment systems and an Otter Tail County waste treatment system record survey.

Soil Suitability for On-site Systems

Soil survey data on an aerial base map of the Pelican Lakes area, from Otter Tail County, was used to evaluate the suitability of soils for septic systems. The soil suitability area was evaluated from the shoreline to ¼ mile back from the shoreline. All shoreland soils for Pelican, Little Pelican, Bass, and Fish Lakes were reviewed. The shoreland area encompassed roughly 3,300 acres which represents a 1/4 mile deep band around the Pelican Lakes shoreline.

A total of 71 soil types were found in the 1/4 mile zone around the lake shorelines. Each of the 71 soils and their soil sub-types in the Pelican Lakes area were examined for slope, permeability, and depth of the water table. These factors determine septic system drainfield suitability. The five categories of septic soil limitations created by these parameters are: 1) severe soil with a poor filter, 2) severe soil because of slope or depth of groundwater, 3) moderate soil, 4) slight soil, and 5) sand or gravel pits with little to no soil present.

Moderate soils are able to properly treat septic tank effluent and have few constraints in regard to slope and percolation. Of the 71 present soils in the area, 13 soil types are considered moderate. These soils are shown in yellow areas on the soils map and represent 656 acres or 20% of the 1/4 mile zone.

Severe soils with a poor filter include those soils which are very permeable and filter water too quickly with the potential for inadequate nutrient removal. Of the 71 present soils, 23 soil types are considered severe with a poor filter. These soils are shown in orange areas on the soils map and include 812 acres or 25% of the 1/4 mile zone.

The majority of soils in the area are considered severe with the following constraints which prevent them from being suitable for septic systems: slope, wetness, slow percolation, subsiding, or ponding. Of the 71 present soils, 58 soil types are considered severe. These severe soils are shown in red areas on the soils map and include 1,786 acres or 55% of the 1/4 mile zone.

The final type of soil with minimal presence in the Pelican Lakes area is considered slight. This type only comprises 2 of the 71 soils. (Note: for each soil series, there may be more that one soil type which accounts for the totals of each type of septic suitability to be greater than the 71 total soils).

All other areas shown on the soils map are considered sand or gravel pits and represent a small acreage. A summary of soil limitations is shown in Table 6.2 and a map of septic drainfield soil suitability is shown in Figure 6.1.

Table 6.2. Summary of the acres associated with various types of soil limitations for septic tank system drainfields (source: Otter Tail County Soil Survey)

	Red "Severe limitation" based on distance to groundwater		Orange "Severe limitation" based on being a poor filter		Yellow "Moderate limitation" few constraints		Other Sand or gravel pits		**Total**
	Acres	%	Acres	%	Acres	%	Acres	%	**Acres**
Pelican	1,052	52%	726	36%	248	12%	11	1%	**2037**
Little Pelican	459	74%	64	10%	95	15%	1	0%	**619**
Bass	47	40%	22	19%	48	41%	1	1%	**118**
Fish	228	51%	0	0%	265	48%	6	1%	**499**
Total	**1,786**	**55%**	**812**	**25%**	**656**	**20%**	**19**	**0.5%**	**3273**

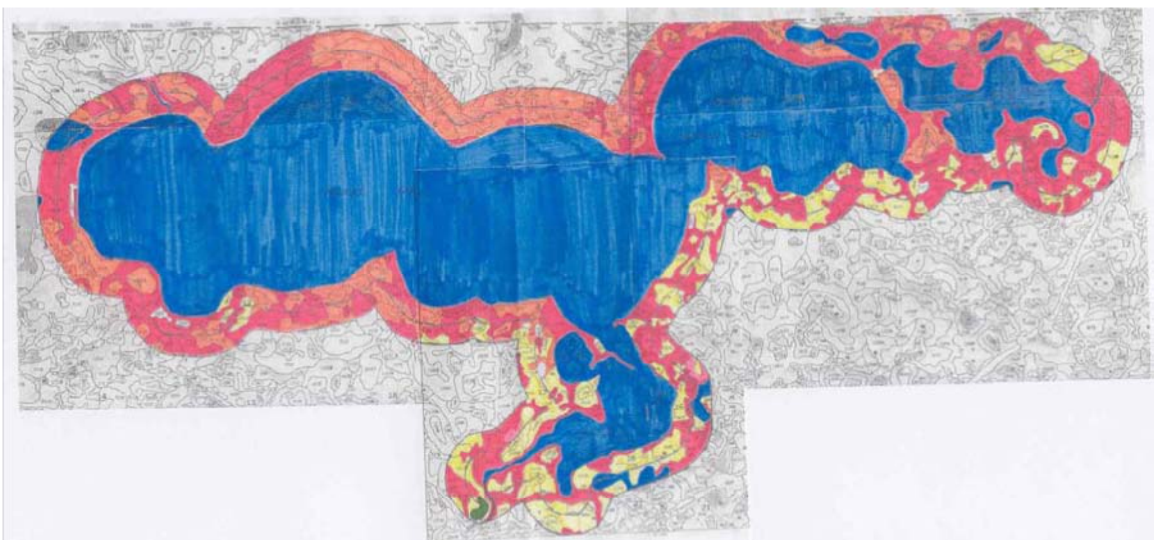


Figure 6.1 Septic tank drainfield soil suitability map for soils around the Pelican Lakes (source of soils data: Otter Tail County Soil Survey. Soil suitability map produced by Blue Water Science). Red = severe limitations; orange = severe limitations; yellow = moderate limitations. Blue represents the lake area.

On-site Waste Treatment System Record Review

In July of 2003, a group of interns from Blue Water Science and one intern from the Pelican River Watershed District went to the Otter Tail County Courthouse in Fergus Falls, MN to locate and examine all property files for property owners on Pelican Lake, Little Pelican Lake, Fish Lake, and Bass Lake. Approximately 1,000 files were reviewed for the following parameters:
- property identification number
- name of property owner/s
- legal description including section number, township name and number, and range
- year of installation of onsite wastewater treatment system
- property parcel number
- lake address or addition of the property
- lot size in square feet
- impervious surface size in square feet
- lake frontage in feet
- system type

- tank size
- drainfield size
- tank and drainfield setback from the lake front
- tank and drainfield depth to groundwater
- percolation test
- tank and drainfield distance from a well on the property

These data were then transferred into spreadsheet format where they were evaluated, and averaged for several of the parameters. These results give some insight about the state of the Pelican Lakes area with regards to its current onsite wastewater treatment conditions (Figure 6.2).

Table 6.3. Summary of septic tank and holding tanks recorded for the Pelican Lakes, based on Otter Tail County records in 2003.

	Septic Tanks		Holding Tanks		Other		**Total**
	number	percent	number	percent	number	percent	
Pelican	598	72%	236	28%	0	0%	**834**
Little Pelican	26	66%	12	31%	1	3%	**39**
Bass	10	100%	0	0%	0	0%	**10**
Fish	27	39%	41	59%	1	2%	**69**
Total	**661**	**69%**	**289**	**30%**	**2**	**--**	**952**

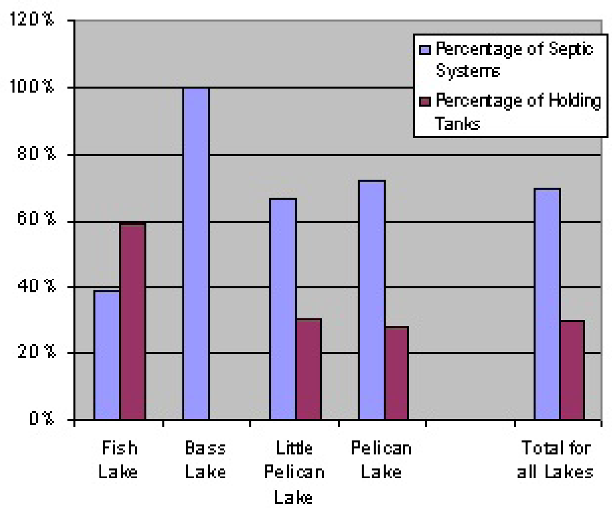


Figure 6.2 Percentage of septic tanks and holding tanks for each lake.

To see individual statistics, please refer to the 2004 PGOLID Lake Management Plan. The 2004 results are summarized below.

Year of septic system installation.

- Nearly all of the on-site wastewater treatment systems around the Pelican Lakes are 35 years old or newer.
- The majority of the systems are from 1981 or more recent.
- A well maintained on-site wastewater treatment system has a life expectancy of 30 to 50 years.

Drainfield setbacks from the lake

- The minimum set back of a septic tank drainfield is 50 feet from the lake.
- Records show that 99% of the drainfields are at least 50 feet from the lake.

Distance of Drainfield to groundwater table

- The minimum separation of the bottom of the septic tank drainfield from the groundwater table is 3 feet.
- County records indicate that all existing drainfields have at least a 3-foot separation.

Conclusions

- County records indicate that the septic tank/drainfield systems are in good shape and should function properly if maintained.
- The existing onsite wastewater treatment systems do not appear to be adversely impacting the water quality of the Pelican Lakes.
- However, there are a high number of holding tanks (30% of the onsite systems) in the shoreland area. In the future offsite treatment employing cluster systems or centralized sewers could be considered.

Waste Treatment Screening Special Project, 2006

The current status of the septic systems on the Pelican Group of Lakes is unknown. In order to acquire a better understanding of the status of septic systems within the improvement district, PGOLID approved funding of a special project in 2006. Funding was approved for the screening of 150 properties. Jordan Ornquist, PGOLID Lake Resource Coordinator at that time, designed, implemented and managed the project.

A letter requesting voluntary participation was sent to all lakeshore property owners within the improvement district in June of 2006. Nearly 300 property owners responded, requesting that they be considered for the special project. 152 sites were chosen, based upon the project's goals and available funding, and property owners were notified in July. Twenty-five percent of the volunteered sites were chosen from the oldest holding tanks, 50% were chosen from the oldest septic tanks with drain fields, and 25% were chosen by a random selection of newer (10 years or less) septic tanks with drain fields.

As stated within the design of the program, each participant was given a unique ID number in order to keep personal identities and property information strictly confidential. Access to such information was limited to RMB Environmental Laboratories, Jordan Ornquist and A1 Septic. PGOLID Board members were excluded from access to the confidential property information. As initially designed, PGOLID was to receive the facts and findings of the project.

A1 Septic, a Minnesota state-certified and licensed septic inspection company, was awarded the service contract to complete the septic compliance screening. On-site screening began in August and was completed on November 28th. Results were tallied and statistical analysis was completed to identify the current status of the district's septic systems that were surveyed and their effects on Pelican, Little Pelican, Fish, and Bass lakes.

It must be stated that the inspections completed by A1 Septic were for screening purposes alone, and must not be construed as being a complete certified inspection. The septic system screenings included, but were not limited to: tank inspection and probing, soil boring (when applicable), drainfield inspection (yard seepage and drainfield ponding), proper sizing, and potential impact to the water table. General information surveys were submitted by the participants and were used to identify usage and maintenance practices.

Thorough and accurately balanced studies such as this one will begin to assist PGOLID in understanding the potential impact on the Improvement District's water resources and assist the district in making better decisions to preserve the quality of its lakes and rivers.

Summary

In this study, 137 holding tanks and septic systems were inspected out of approximately 1,000 waste treatment systems in the Pelican Group of Lakes Improvement District. These inspections were voluntary and were for screening purposes alone, and must not be interpreted as being a complete certified inspection. Thirty-one (23%) holding tanks and septic systems were found to be Potentially Incompliant and 21 (15%) were potentially impacting the Pelican Group of Lakes water quality. While most of the systems were not potentially impacting water quality, over half were improperly maintained. When your septic system is properly designed, installed, operated and maintained it will provide economical and effective sewage treatment. If you properly treat sewage today, future generations will not incur the costs of cleaning up the health or environmental problems that may have otherwise been created. Please see the PGOLID website (www.pgolid.org) for worksheets for properly maintaining your septic system or holding tank.

The overall Facts and Findings of the study are summarized in the following tables.

Number of systems chosen for this study	**152**
Number of systems inspected	**137**
Number of systems not found	**15**
Number of systems replaced since last county inspection	**6**
Number of systems never pumped/cleaned	**5**

Survey Participants

Resident Status	
11%	Year-round
59%	Seasonal
30%	Weekend

System Types

Qty	% of Total	
40	29 %	Holding Tanks from 1972-1997
65	48 %	Septic Systems from 1971-1986
32	23 %	Septic Systems from 1992-2006

Estimated Total Systems

	Qty	% of Total
Potentially Incompliant	31	23 %
Potentially Impacting Pelican Waters	21	15 %

Insufficient Maintenance	100	73	%
Good Condition	38	26	%

Some systems had more than one reason for incompliance and/or insufficient maintenance and are listed separately under these statistics, which is why they do not add up to 100%.

Estimated Holding Tanks			
	Qty	% of Total	
Potentially Incompliant	7	18	%
Potentially Impacting Pelican Waters	3	8	%
Insufficient Maintenance	28	70	%
Good Condition	13	33	%

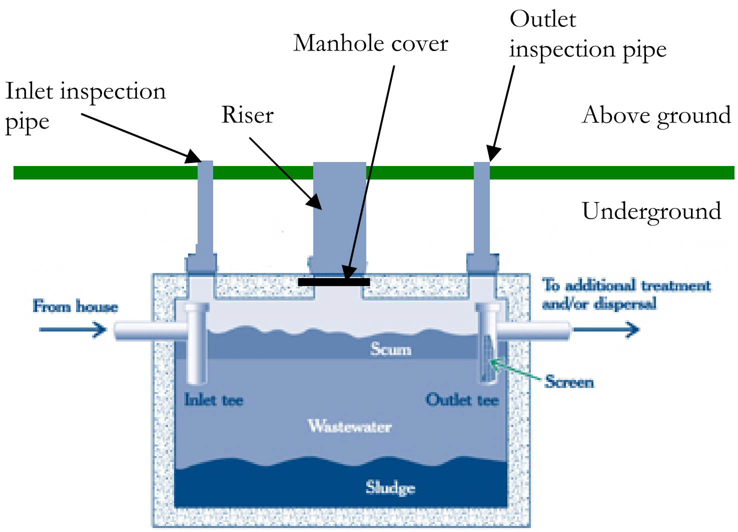
Some tanks had more than one reason for incompliance and/or insufficient maintenance and are listed separately under these statistics, which is why they do not add up to 100%.

Estimated Septic Systems <1986			
	Qty	% of Total	
Potentially Incompliant	19	29	%
Potentially Impacting Pelican Waters	14	22	%
Insufficient Maintenance	55	85	%
Good Condition	10	15	%

Some systems had more than one reason for incompliance and/or insufficient maintenance and are listed separately under these statistics, which is why they do not add up to 100%.

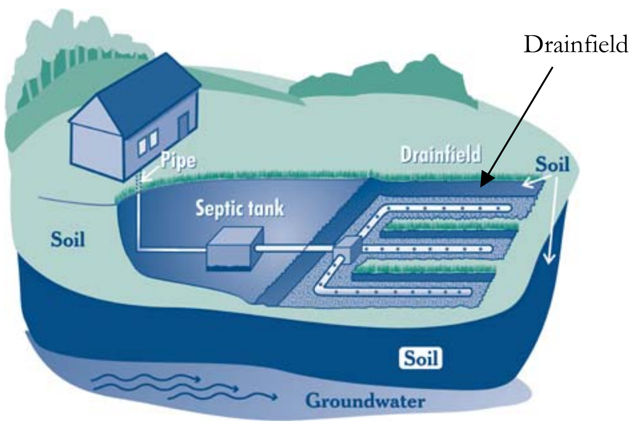
Estimated Septic Systems >1992			
	Qty	% of Total	
Potentially Incompliant	5	16	%
Potentially Impacting Pelican Waters	4	13	%
Insufficient Maintenance	17	53	%
Good Condition	15	41	%

Some systems had more than one reason for incompliance and/or insufficient maintenance and are listed separately under these statistics, which is why they do not add up to 100%.



Septic and Holding Tank Best Management Practices

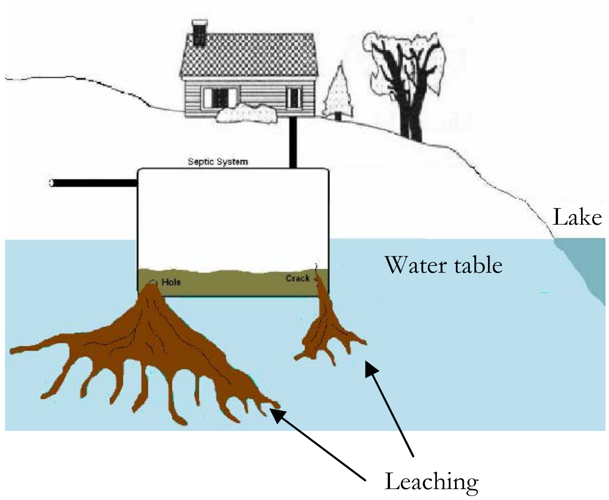
- Make sure the riser is exposed so the tank can be inspected and pumped properly through the manhole
- Make sure your tank has an alarm to warn you when it is so full that it could cause backup
- Pump your holding tank every few weeks and your septic tank every few years
- Be conservative with your water usage



Septic System Drainfield Best Management Practices

(not applicable to holding tank)

- Make sure you have a drainfield that is not clogged and filtering correctly
- Do not irrigate your drainfield
- Do not drive on your drainfield or compact the soil, decreasing its filtering ability
- Make sure your drainfield is set back from the lake at least 50 feet
- Make sure no chemicals are killing the bacteria that recycle your waste in the drainfield (pesticides, bleaches, ammonias, paint, fuels and herbicides)



Lake Proximity Best Management Practices

- Make sure your septic or holding tank is set back at least 50 feet from the lake
- Regularly have your tank inspected for cracks or leaks that could be leaching sewage into the lake
- Make sure your tank is properly sized for your house

PGOLID On-site Waste Treatment System Status 2012

Introduction and History

The Pelican Group of Lakes Improvement District (PGOLID) has been vigilant in monitoring septic system records for the lakes. In 2003, as part of the original Lake Management Plan, Blue Water Science conducted an Otter Tail County Individual Waste Treatment System record survey for the PGOLID lakes. In 2006, PGOLID conducted a voluntary survey and waste treatment screening project. In addition, in 2007-2009, Otter Tail County conducted mandatory waste treatment system inspections for systems over 20 years old.

These studies showed that although the majority of PGOLID individual waste treatment systems are working properly, property owners are not always maintaining them correctly. After the 2006 survey, an educational campaign was launched for PGOLID property owners to try and improve their waste treatment system maintenance.

In the summer of 2012, the PGOLID Water Resource Coordinator went to the Otter Tail County Land and Resource Department in Fergus Falls, MN to re-examine the property files for PGOLID residents. These files were reviewed for the following parameters:

- Property identification number
- Name of property owner(s)
- Address of property
- System type (septic system or holding tank)
- Year of last inspection

The 2012 data was then compared to the 2003 data to see if there have been improvements in the overall status of the septic systems in PGOLID in the past 10 years.

Summary

System Type

A septic system treats waste in a drainfield, while a holding tank just holds the waste until it is pumped out. Septic systems are a very good way to treat waste when properly maintained. Holding tanks are common in areas where there is not sufficient surface area or distance from the water table to install a drainfield.

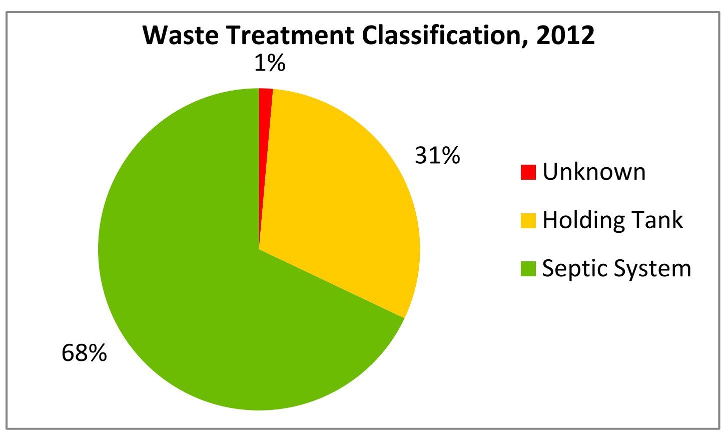


Figure 6.3. Waste treatment systems in PGOLID, 2012.

In 2012, 68% of PGOLID waste treatment systems were septic systems, while 31% were holding tanks (Figure 6.3, Table 6.4). In 2003, 69% of waste treatment systems were septic systems and 30% were holding tanks (Table 6.4). Therefore, the type of systems in PGOLID have not changed much over the last 10 years. This can be expected since the areas that have holding tanks will never be suitable for a septic system and drainfield.

Table 6.4. Comparison of system types between 2003 and 2012 surveys.

	2003 Count	2003 Percent	2012 Count	2012 Percent
Septic Systems	661	69%	738	68%
Holding Tanks	289	30%	333	31%
Other	2	1%	15	1%

Each lake varies in the number of septic systems versus holding tanks (Figure 6.4). Bass Lake has only septic systems. Fish Lake has the highest percentage of holding tanks, while Pelican Lake has the highest number of holding tanks.

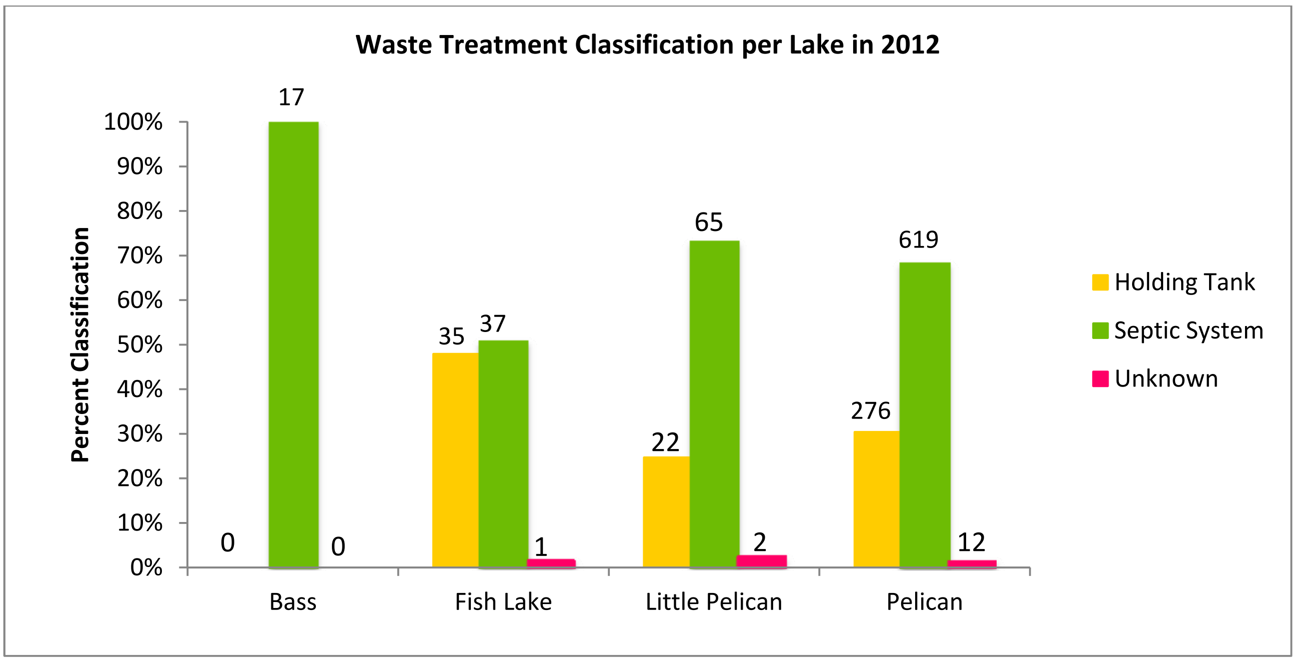


Figure 6.4. Waste treatment classification per lake in 2012.

System Age

Septic systems can last 30 years or more when properly maintained. For all the lakes, the majority of the systems are newer than 30 years old (Table 6.5, Figure 5). All of Bass Lake's systems are newer than 1991, which is most likely because development on Bass Lake has occurred since then (Figure 6.5).

Most of the systems in Pelican Lake are older than 20 years (62%) (Table 6.6). This is most likely because the development on Pelican Lake occurred more than 20 years ago, and many properties have stayed within families and not been sold.

Table 6.5. Waste treatment systems in PGOLID lakes that are over 30 years old.

Lake	% systems less than 30 yrs old	% systems over 30 yrs old
Pelican	92%	8%
Little Pelican	91%	9%
Bass	100%	0%
Fish	93%	7%

Table 6.6. Waste treatment systems in PGOLID lakes that are over 20 years old.

Lake	% systems less than 20 yrs old	% systems over 20 yrs old
Pelican	38%	62%
Little Pelican	72%	28%
Bass	100%	0%
Fish	51%	49%

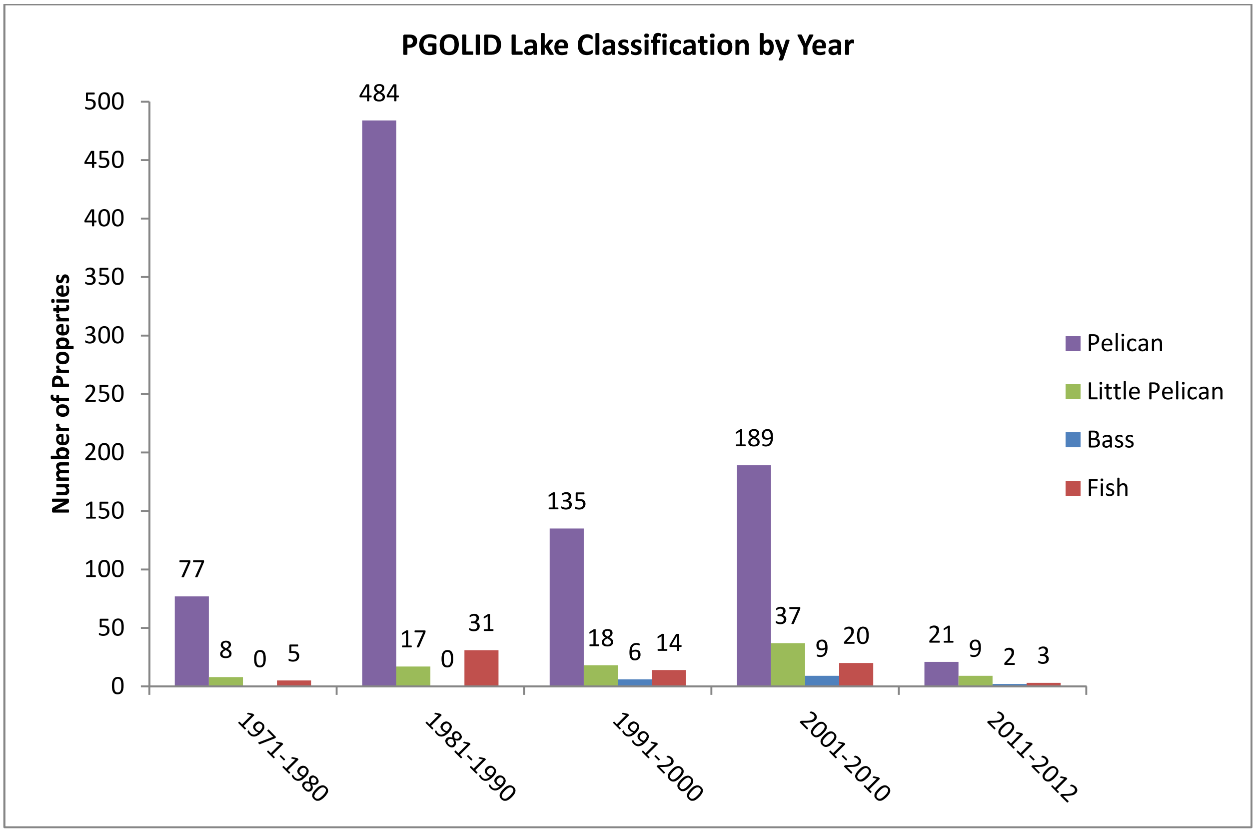


Figure 6.5. PGOLID waste treatment system ages.

Next Steps

Even though a septic system can last 30 years, most people do not properly maintain them, which decreases the life expectancy of the system. A properly maintained septic system should be pumped at least every three years, and a holding tank should be pumped whenever it is full (numerous times per year). If property owners are not pumping their systems, then the waste could be leaching into the ground. In addition, septic system drainfields need to be kept clear and porous to be able to treat the waste. When drainfields are driven over and built upon, they cannot work properly anymore.

PGOLID next sent a letter to everyone with systems older than 20 years (622 property owners) informing them of their system's age, and recommending they conduct an inspection.

Chapter 7. Shoreline Projects

Introduction and Summary

The shoreland area is valuable for promoting a natural lake environment and a natural lake experience for lake users. Shoreline buffers of native plants not only filter and absorb overland runoff, they also prevent shoreline erosion, attract songbirds and butterflies and deter nuisance geese. The shoreland is defined as the upland area about 300 to 1,000 feet back from the shoreline, and out into the lake about the end of your dock.

The PGOLID Lakes encompass approximately 1,117 parcels in total. In 2004, Blue Water Science conducted a shoreline inventory survey for PGOLID. In this survey, a photograph was taken of each parcel and the parcel was rated as to its vegetative cover. In all, approximately 40% of the parcels in PGOLID meet the natural ranking criteria for shorelines and upland areas. This is about average compared to other lakes found in northern Minnesota; however, these results show a great potential for improvement.

PGOLID took this shoreline inventory information and applied for a DNR Shoreline Habitat Restoration Grant to restore natural conditions to participating properties. PGOLID has now received three consecutive DNR grants and completed 15 restoration projects since 2009. These projects will act as demonstration sites for other property owners to see the benefits of a natural shoreline.

In the next few years, it is recommended to repeat the 2004 shoreline inventory project and see if there is improvement in the percentage of parcels that have over 50% natural vegetation.

2004 Shoreline Inventory (Blue Water Science)

The shoreland area encompasses three components: the upland fringe, the shoreline, and shallow water area by the shore. A photographic inventory of Pelican Lake shoreline was conducted on July 17, August 21, and September 16, 2004 by Blue Water Science. The objectives of the survey were to characterize existing shoreland conditions which will serve as a benchmark for future comparisons.

For each photograph the shoreline and the upland condition were looked at and evaluated. The criteria for natural conditions were the presence of 50% native vegetation in the understory and at least 50% natural vegetation along the shoreline in a strip at least 15 feet deep (Figure 7.1). Shorelines and uplands at the 75% natural level were evaluated as well.

A summary of the inventory results is shown in Table 7.1. Based on the subjective criteria over 40% of the parcels in Pelican Lake shoreland area meet the natural ranking criteria for shorelines and upland areas. This is about average compared to other lakes found in the Northern Minnesota data set. In comparing the lakes, Pelican had the least amount of natural shoreline condition and Little Pelican Lake had the most.

In the next five to ten years proactive volunteer native landscaping could improve the natural aspects of some of parcels. Improving the percentage of naturally landscaped parcels will improve water quality and fish and wildlife habitat in the Pelican Group of Lakes.

Table 7.1. Summary of shoreline buffer and upland conditions in the shoreland area of Pelican Lake. Approximately 1,117 parcels were examined.

	Natural Shoreline Condition		Natural Upland Condition		Undevel. Photo Parcels	Shoreline Structure Present	
	>50%	>75%	>50%	>75%		Riprap	Wall
PELICAN LAKE TOTALS (no. of parcels = 881)	21% (181)	16% (142)	21% (183)	14% (123)	14% (2)	68% (596)	18% (158)
LITTLE PELICAN LAKE TOTALS (no. of parcels = 119)	66% (79)	61% (73)	55% (65)	61% (51)	33% (39)	23% (27)	0% (0)
BASS LAKE TOTALS (no. of parcels = 22)	41% (9)	41% (9)	6% (27)	3% (14)	0% (0)	27% (6)	5% (1)
FISH LAKE TOTALS (no. of parcels = 95)	43% (41)	36% (38)	38% (36)	36% (34)	21% (20)	48% (46)	2% (2)
PGOLID TOTAL (no. of parcels = 1,117)	28% (310)	23% (262)	28% (311)	20% (222)	5% (61)	60% (675)	14% (161)

Figure 7.1 Both of the pictures are from Pelican Lake.
[bottom] This parcel would rate as having a shoreline with a buffer greater than 50% of the lot width and an understory with greater than 50%natural cover.
[top] These parcels would not qualify as having a natural shoreline buffer greater than 50% of the lot width. Also the understory in the upland area would be rated as having less than 50% natural cover.

2009-2015 DNR Shoreline Habitat Restoration Grants

In 2009, the PGOLID Water Resource Coordinator applied for a Shoreline Habitat Restoration Grant. This grant program is funded by the Minnesota Department of Natural Resources (DNR) and being implemented to protect the Pelican Group of Lakes water quality through shoreline buffers.

The purpose of this project was to educate PGOLID property owners about shoreline restoration and show them that it is not very hard to do. In order to improve the shoreline conditions in PGOLID lakes, people's attitudes need to be changed as to what is beautiful near the lake. The goal is to have property owners appreciate natural conditions over manicured lawns.

The restoration requirements to qualify for this grant funding are as follows. Projects require that at least 75% of the frontage is restored with an adjacent native plant buffer zone that is at least 25 ft deep/wide. The focus of these restoration projects must be on reestablishing native vegetation. Funds cannot be used for rock riprap stabilization or permanent wave breaks. In addition, funds cannot be used for new structures such as stairs.

Funds can be used for materials needed to reestablish native vegetation along shorelines. This may include: native trees, shrubs, plants and seeds; temporary biodegradable toe protection and erosion control fabric, mulch; herbicide to treat invasive species; controlled burns to prep or maintain the restoration site, labor to design, install and maintain the restoration project, temporary biodegradable wave breaks and fencing to keep out foot traffic or herbivores (geese/muskrats) from the site.

Projects should not destroy existing, desirable habitat or native vegetation. Only local, native species may be included within the project area. No exotic species or nursery-derived cultivars of natives may be used. Plants included in the project should be native to the county and grow in natural, reference sites along the lake or similar nearby ecosystems.

Since 2009, 15 properties have participated in this program.

- In 2009, PGOLID was awarded a $25,000 grant for restoring shoreline properties back to their natural conditions. 6 properties were planted.
- In 2011, PGOLID was awarded a $21,500 grant for restoring shoreline properties. 7 projects were completed with this funding.
- In 2013, PGOLID was awarded a $20,000 grant for restoring shoreline properties. 2 projects were completed with this funding.

One of the participant's before and after photos are shown on the next page. On this property, railroad ties were removed and the area was filled in with soil, covered with landscape fabric, and planted with shrubs.

Shoreline project
“BEFORE”

Shoreline Project
“DURING”

Shoreline project
“AFTER”

Chapter 8. Aquatic Plant Surveys

Summary

Aquatic plants are very important to lakes. Unfortunately, most people see aquatic plants as problems. They perceive lakes or lakeshores with lots of so-called "weeds" as messy and in need of cleaning. But what a cabin owner sees as a weedy mess is an essential part of a lake's or river's ecosystem. Without aquatic plants, lakes would have fewer aquatic insects, minnows, and other wildlife. If too many aquatic plants are removed from lakeshores, fish and wildlife populations and water clarity may suffer. Aquatic plants are an essential part of the natural community in most lakes.

Aquatic plants serve many important functions:
- Provide fish food
- Offer fish shelter
- Improve water clarity and quality
- Protect shorelines and lake bottoms
- Provide food and shelter for waterfowl
- Improve aesthetics
- Provide economic value

In 2003, Blue Water Science was hired by PGOLID to conduct a plant survey. They completed a transect survey that concluded that the Pelican Lakes have a moderate diversity of aquatic plants. In addition, this survey identified the presence of Curly-leaf pondweed, an invasive aquatic plant. Unfortunately, transect surveys aren't recognized by the Minnesota Department of Natural Resources (DNR).

In 2010-2011, PGOLID conducted another plant survey in Little Pelican, Bass, Fish and Pelican Lake. These surveys used the point intercept method, which is recognized by the DNR. The goals of this survey were to update plant data on the lake and compare it to the 2003 results and identify any new areas of invasive aquatic plants.

In 2015, PGOLID conducted a plant survey of Echo Bay to document the native plants present there. Echo Bay was found to have a very diverse and healthy plant community.

Comparison of 2003 to 2010-2011

Overall Conclusions
The Pelican Group of Lakes Improvement District (PGOLID) hired a contractor to conduct a survey in 2003 to determine the plant diversity in Pelican, Little Pelican, Bass and Fish Lakes. During this survey, the invasive plant, Curly-leaf pondweed was found for the first time. The Curly-leaf pondweed treatment program began in 2005 and has greatly reduced the density of the invasive plant in the lakes.

In 2010-2011, a follow up survey was conducted by a different contractor. The standard methods used for these surveys (point-intercept method) is different than the 2003 survey, which makes it hard to directly compare them.

Overall, the plant density was higher in the 2003 survey than the 2010-2011 survey. This could be due to the fact that two different survey methods were used. Either some plants were missed at the survey points in 2010-2011, some rare plants were found in 2003, or plant diversity has decreased over time. The latter is the least likely explanation, as the PGOLID native plant populations appear to be healthy and sustaining.

Wild Rice was found in Pelican and Fish Lakes in the 2010-2011 survey. It is an excellent food source for wildlife and waterfowl. This plant is protected by the state, and a license is necessary to harvest wild rice. Wild rice destruction and removal is against the law.

Pelican Lake
The plant diversity was higher in 2003 than 2010-2011; however, the most abundant plant was the same. Chara is common in lakes with good clarity, and is a beneficial plant for the lake.

	Pelican Lake					
Date Data taken	5/20/2003	8/14/2003	*4/28/2011	*8/10/2011	5/10/2010	8/3/2010
Number of Aquatic Plants found	13	21	10	8	10	10
Most Abundant Plant	Chara	Chara	Clasping Leaf Pondweed	Chara	Chara	Chara

*Data from the western bay of Pelican Lake

Little Pelican Lake
The plant diversity was higher in 2003 than 2010; however, the most abundant plant was curly-leaf pondweed in 2003. Due to the curly-leaf pondweed treatment program, it is no longer the most abundant plant in 2010. Coontail is a common native plant that is found in healthy shallow lakes. Little Pelican Lake has a healthy native plant population, which is good for shallow lake habitat and fishing.

	Little Pelican Lake			
Date Data taken	5/20/2003	7/23/2003	4/10/2010	8/10/2010
Number of Aquatic Plants found	15	19	10	10
Most Abundant Plant	Curly Leaf Pondweed	Flatstem Pondweed	Coontail	Coontail

Bass Lake
Overall, the plant diversity was only slightly higher in 2003 than 2010. The most abundant plant changed; however, there doesn't actually appear to be much change between surveys. In the early season surveys, Bulrush was most abundant 2010, and third most abundant in 2003. An increase in Bulrush from 2003 to 2010 would be good for the lake, as Bulrush is an excellent water filterer. In the late season surveys, Chara was the most abundant plant in 2003, and the second most abundant plant in 2010.

	Bass Lake			
Date Data taken	5/20/2003	7/23/2003	4/28/2010	8/10/2010
Number of Aquatic Plants found	4	10	7	9
Most Abundant Plant	Chara	Chara	Bulrush	Coontail

Fish Lake
The plant diversity in Fish Lake was higher in 2010 than 2003. The most abundant plant, Chara, was the same for all surveys except the late season 2010 survey. In the late season 2010 survey, however, Chara was the second most abundant plan. Chara is common in lakes with good clarity, and is a beneficial plant for the lake.

	Fish Lake			
Date Data taken	5/20/2003	7/23/2003	4/28/2010	8/10/2010
Number of Aquatic Plants found	3	7	13	12
Most Abundant Plant	Chara	Chara	Chara	Coontail

Echo Bay, 2015

The overall results of this plant show that Echo Bay has a very healthy native plant community. No aquatic invasive plants were found in Echo Bay. Aquatic plant communities are important to a body of water because of their ability to maintain water clarity and good fish habitat.

In addition, some plants are found more often in lakes with good water clarity, such as Muskgrass (*Chara*). It is a great bottom stabilizer and slows the suspension of sediments. This plant is also wonderful habitat for fish and is a favorite food for waterfowl.

Coontail is also a great native plant and is common in Echo Bay. It has a unique ability to draw a great abundance of nutrients from the water, which increases water clarity

Bulrush is very important to a lake for many reasons. It provides spawning habitat for crappies, filters the water, and helps to prevent shoreline erosion by acting as a wave break.

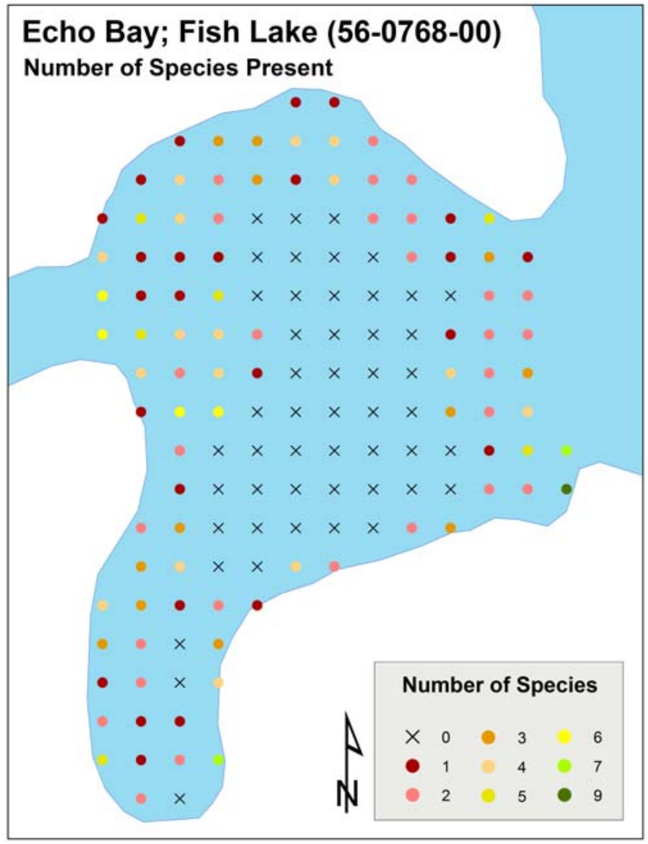


Figure 8.1. Map of number of aquatic plant species found in Echo Bay of Fish Lake, 2015.

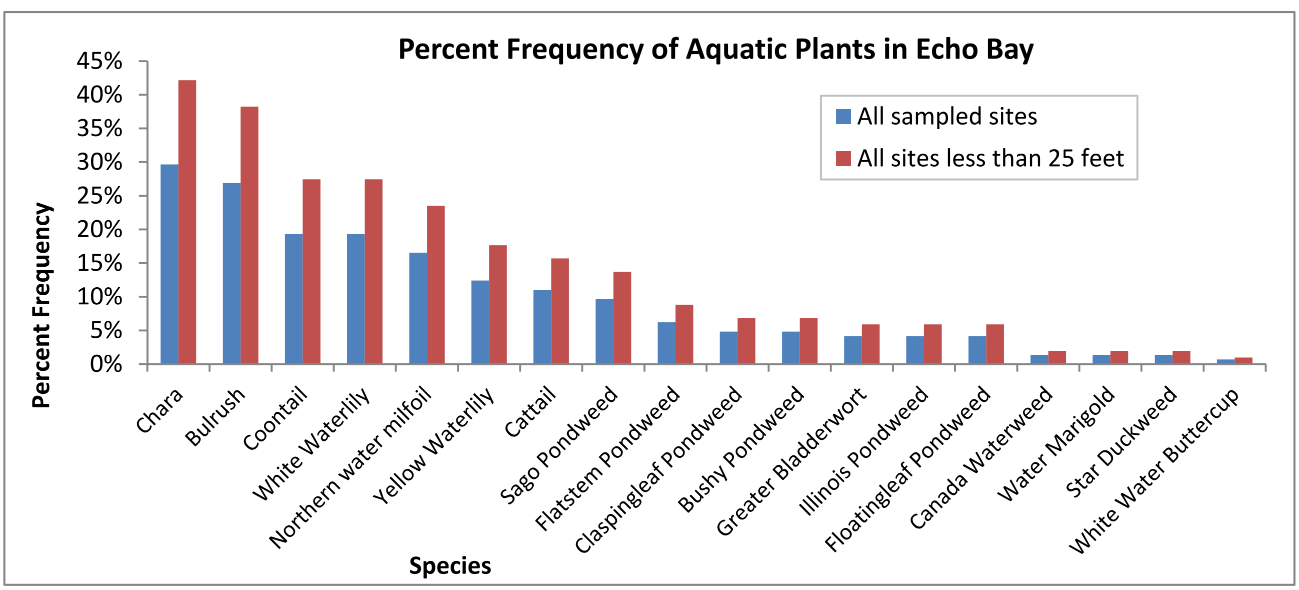


Figure 8.2. Aquatic plant species found in Echo Bay of Fish Lake, 2015.

Chapter 9. Ongoing Educational Programs

Summary

As a recommendation from the 2004 PGOLID Lake Management Plan, prepared by Blue Water Science, PGOLID hired a Water Resource Coordinator in 2005. This position started out as a full-time seasonal position covering just the summer months. Jordan Ornquist served as the PGOLID Water Resource Coordinator for the summers of 2005-2006. In 2006, the position changed to a part-time, year-round position. In December of 2006, Moriya Rufer was hired and has been the PGOLID Water Resource Coordinator from December 2006 to present (March 2016).

The PGOLID Water Resource Coordinator's responsibilities include water quality monitoring and planning, data assessment and interpretation, problem identification and mitigation, grant writing for new lake projects and educational programs.

These educational programs have included:

- Educational seminars for lake residents in the summer.
- Articles in the Pelican Brief (Pelican Lake Property Owners Association [PLPOA] Newsletter).
- Educational presentations at PGOLID and PLPOA meetings.
- Maintenance of the PGOLID website.
- Act as a contact and resource for community education and outreach and availability to PGOLID residents for any questions (calls, emails, visits).
- Keep abreast of new state/county/local government lake regulations and disseminate the information in an understandable way to PGOLID residents.
- Work with upstream landowners, farmers, ranchers, and other lake associations to act in a proactive manner in the protection of the water quality that flows into the PGOLID.

Education has focused on the following topics:

- Water quality
- Invasive species
- Shoreline restoration
- Septic system and holding tank maintenance
- Aquatic plants and algae
- The importance of maintaining native aquatic plants such as bulrush
- Boater stewardship
- DNR regulations

These educational programs have been deemed successful, and it is important to continue them into the future.