Fish Hook 29-0242-00 HUBBARD COUNTY

Lake Water Quality

Summary

Fish Hook Lake is located just north of Park Rapids, Minnesota. It covers 1,643 acres and has an oblong shape.

Fish Hook Lake has three inlets and one outlet, which classifies it as a drainage lake. The Potato River enters Fish Hook Lake on the north side from Potato Lake. The Portage River enters Fish Hook Lake on the west side from Portage Lake. The Fish Hook River outlets Fish Hook Lake on the south and flows through Park Rapids. South of Park Rapids it joins the Shell River, which eventually joins the Crow Wing River.

Water quality data have been collected on Fish Hook Lake since 1988 (Table 3). These data show that the lake is mesotrophic, which is characterized by moderately clear water throughout the summer and excellent recreational opportunities.

The Fish Hook Lake and River Association has the following mission statement. “The Fish Hook Lake & River Association shall be an advocate of the environment of our lake/river systems. We shall be a partner with other lake associations and agencies which have an impact on water quality. We shall act as an educator in community understanding of the issues and goals of our association. The objectives of our efforts are better water quality and property values for everyone. As a group, we have a stronger voice than as separate individuals.” They are involved in many activities including water quality monitoring, aquatic invasive species education, newsletter distribution, and are a member of the Hubbard Coalition of Lake Associations (COLA).

Table 1. Fish Hook Lake location and key physical characteristics.

Location Data		Physical Characteristics	
MN Lake ID:	29-0242-00	Surface area (acres):	1643
County:	Hubbard	Littoral area (acres):	661
Ecoregion:	Northern Lakes & Forests	% Littoral area:	40%
Major Drainage Basin:	Upper Mississippi River	Max depth (ft), (m):	76, 23.2
Latitude/Longitude:	46.95777778 / -95.06222222	Inlets:	3
Invasive Species:	None	Outlets:	1
		Public Accesses:	1

Table 2: Availability of data and an observation of the quantity of sample points.

Data Availability

Transparency data		Excellent data set through the Citizens Lake Monitoring Program.
Chemical data		Excellent data set through the RMB Lab Lakes Program.
Inlet/Outlet data		Inlet data exists from the Portage River inlet from 2007-2008.

Recommendations **For recommendations refer to page 19.**

Lake Map

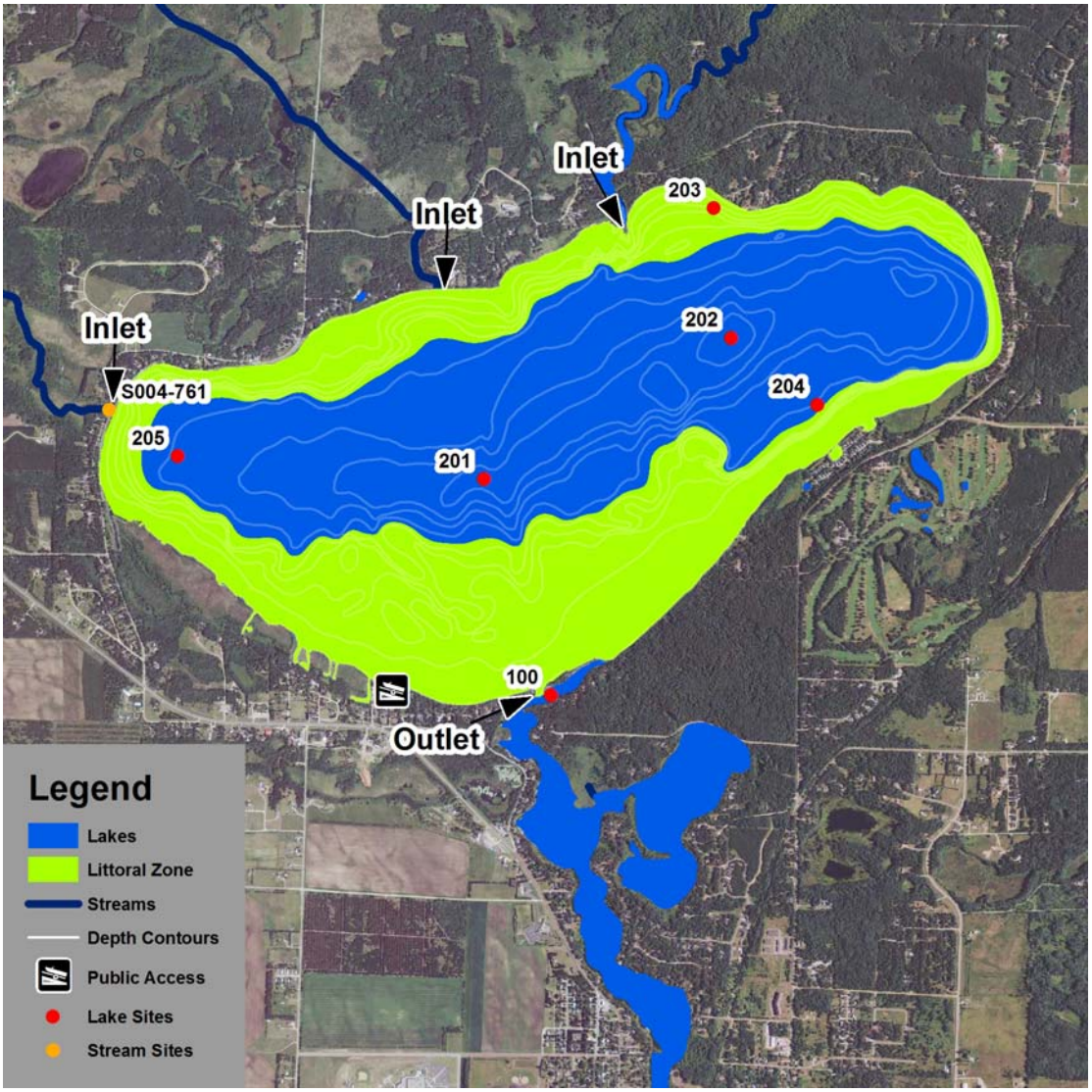


Figure 1. Map of Fish Hook Lake with 2010 aerial imagery and illustrations of sample site locations, inlets and outlets, and public access points. The light green areas in the lake illustrate the littoral zone, where the sunlight can usually reach the lake bottom allowing aquatic plants to grow.

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

Lake Site	Depth (ft)	Monitoring Programs
100	NA	MPCA: 1991
201*Primary site	60	CLMP: 1988-2011; RMBEL: 1999-2011
202	76	CLMP: 1988-2011
203	15	CLMP: 1988-2010
204	30	CLMP: 1988-2010
205	40	CLMP: 1989-2010

Average Water Quality Statistics

The information below describes available chemical data for Fish Hook Lake through 2011. The data set is limited, and all parameters, with the exception of total phosphorus, chlorophyll *a* and Secchi depth, are means for just 1991 MPCA data.

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

Table 4. Water quality means compared to ecoregion ranges and impaired waters standard.

Parameter	Mean	Ecoregion Range[1]	Impaired Waters Standard[2]	Interpretation
Total phosphorus (ug/L)	16	14 - 27	> 30	Results are within the expected range for the ecoregion.
[3]Chlorophyll *a* (ug/L)	5	4 - 10	> 9	
Chlorophyll *a* max (ug/L)	9	<15		
Secchi depth (ft)	11.2	7.5 - 15	< 6.5	
Dissolved oxygen	Dimitic *see page 8*			Dissolved oxygen depth profiles show that the deep areas of the lake are anoxic in late summer.
Total Kjeldahl Nitrogen (mg/L)	0.45	0.40 - 0.75		Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms.
Alkalinity (mg/L)	152	40 - 140		Indicates a low sensitivity to acid rain and a good buffering capacity.
Color (Pt-Co Units)	10	10 - 35		Indicates very clear water with little to no tannins (brown stain).
pH	8.5	7.2 - 8.3		Characteristic of a hard water lake. Lake water with pH less than 6.5 can affect fish spawning and the solubility of metals in the water.
Chloride (mg/L)	1.7	0.6 - 1.2		Slightly above the ecoregion average but still considered low level.
Total Suspended Solids (mg/L)	2.8	<1 - 2		Slightly above the ecoregion average but still considered low level.
Specific Conductance (umhos/cm)	275	50 - 250		Slightly above the ecoregion average.
Total Nitrogen :Total Phosphorus	28:1	25:1 – 35:1		Indicates the lake is phosphorus limited, which means that algae growth is limited by the amount of phosphorus in the lake.

[1]The ecoregion range is the 25th-75th percentile of summer means from ecoregion reference lakes
[2]For further information regarding the Impaired Waters Assessment program, refer to http://www.pca.state.mn.us/water/tmdl/index.html
[3]Chlorophyll *a* measurements have been corrected for pheophytin
Units: 1 mg/L (ppm) = 1,000 ug/L (ppb)

Water Quality Characteristics - Historical Means and Ranges

Table 5. Water quality means and ranges for primary sites.

Parameters	Primary Site 201	Site 202	Site 203	Site 204	Site 205
Total Phosphorus Mean (ug/L):	**16**				
Total Phosphorus Min:	<5				
Total Phosphorus Max:	36				
Number of Observations:	55				
Chlorophyll *a* Mean (ug/L):	**5**				
Chlorophyll-a Min:	<1				
Chlorophyll-a Max:	9				
Number of Observations:	55				
Secchi Depth Mean (ft):	**11.2**	**11.3**	**11.3**	**11.2**	**10.9**
Secchi Depth Min:	6.5	6.0	6.0	6.0	6.5
Secchi Depth Max:	20.0	23.0	20.0	19.5	20.0
Number of Observations:	234	237	194	193	190

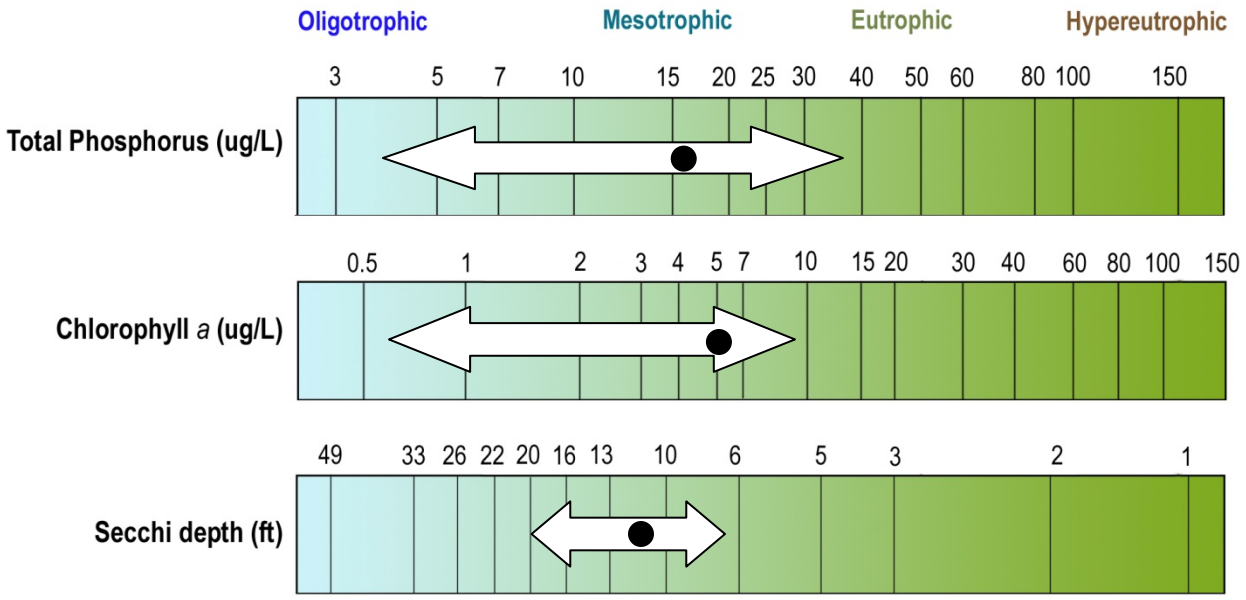


Figure 2. Fish Hook Lake total phosphorus, chlorophyll *a* and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Primary Site 201). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. 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.

The annual means for Fish Hook Lake range from 7.8 - 17.3 feet (Figure 3). Transparency is very consistent throughout the lake. This could be because the lake is fairly round with similar conditions throughout. Transparency monitoring should be continued, especially at sites 201 and 202, to track water quality in Fish Hook Lake.

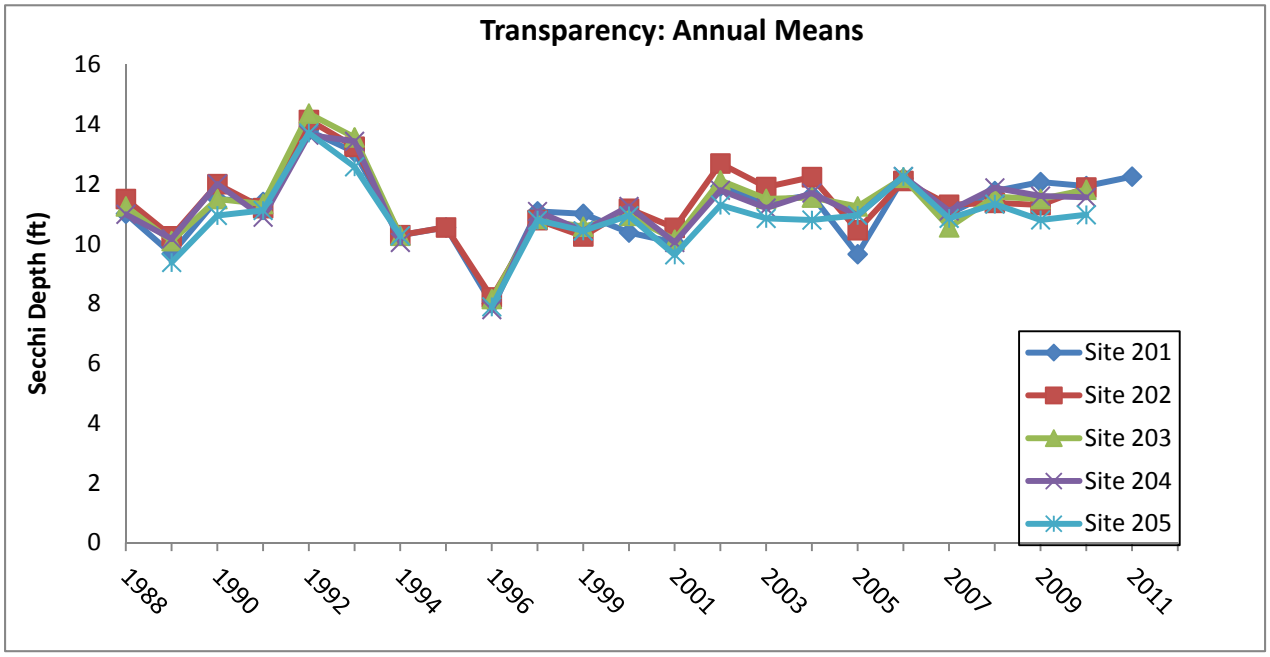


Figure 3. Annual mean transparency for sites 201, 202, 203, 204 and 205.

Fish Hook Lake transparency ranges from 6 to 23 feet throughout the summer. Figure 4 shows the seasonal transparency dynamics. The maximum Secchi reading is usually obtained in early summer. Fish Hook Lake transparency is high in May and June and declines slightly through August. The transparency then rebounds in October after fall turnover. The dynamics have to do with algae and zooplankton population dynamics, and lake turnover.

It is important for lake residents to understand the seasonal transparency dynamics in their lake so they are not worried about why their transparency is lower in August than it is in June. It is typical for a lake to vary in transparency throughout the summer

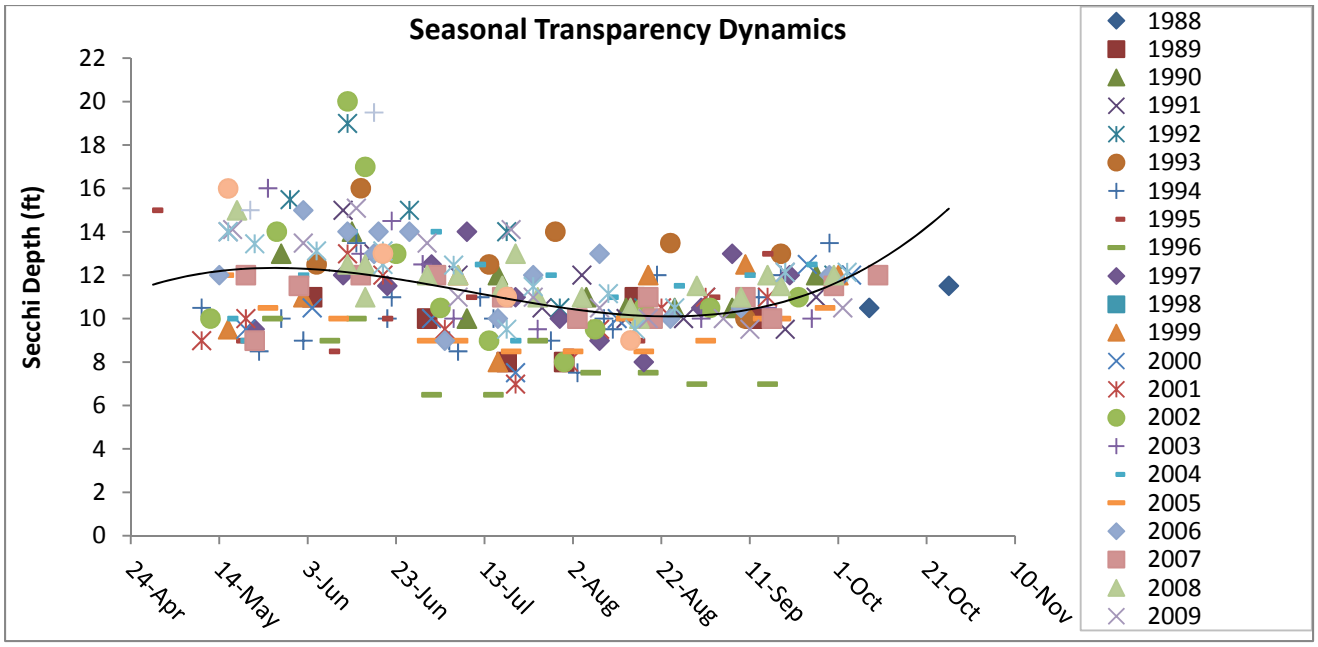


Figure 4. Seasonal transparency dynamics and year-to-year comparison (site 202). The black line represents the pattern in the data.

User Perceptions

When volunteers collect secchi depth readings, they record their perceptions of the water based on the physical appearance and the recreational suitability. These perceptions can be compared to water quality parameters to see how the lake "user" would experience the lake at that time. Looking at transparency data, as the secchi depth decreases the perception of the lake's physical appearance rating decreases. Fish Hook Lake was rated as being "not quite crystal clear" 86% of the time between 1989-2011 (Figure 5).

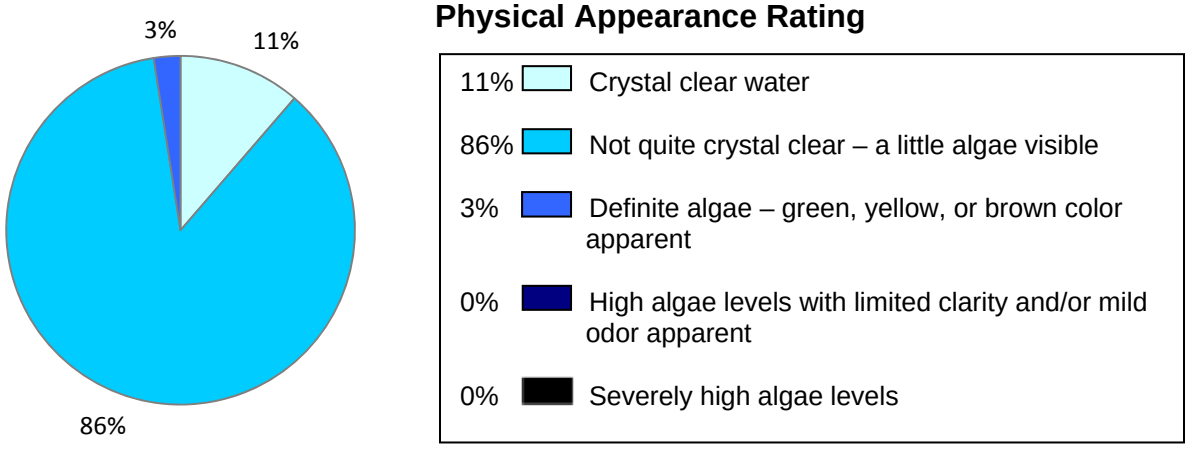


Figure 5. Physical appearance rating, as rated by the volunteer monitor.

As the secchi depth decreases, the perception of recreational suitability of the lake decreases. Fish Hook Lake was rated as being "beautiful" 28% of the time from 1989-2011.

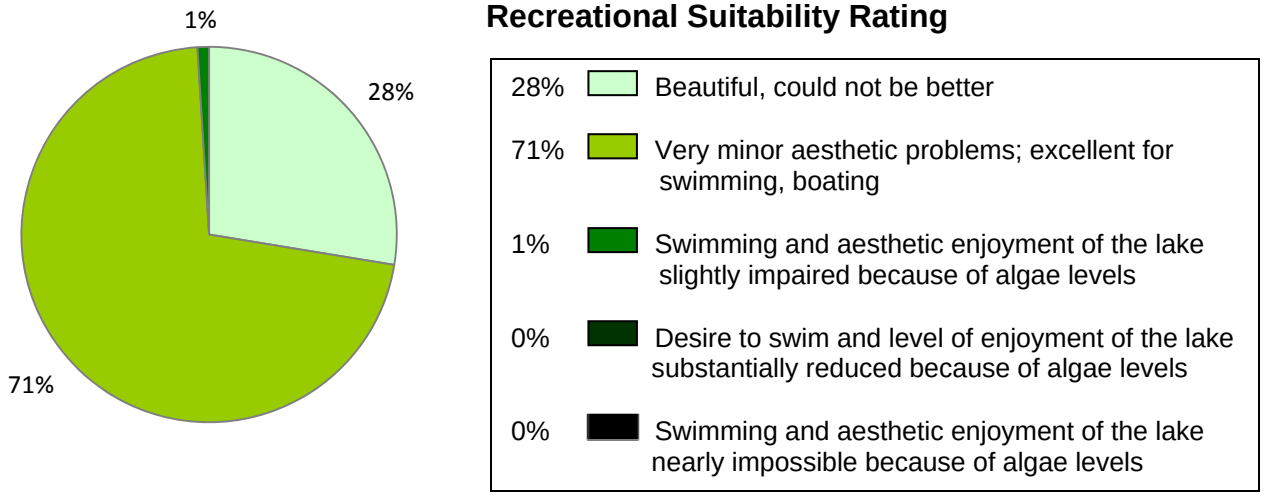


Figure 6. Recreational suitability rating, as rated by the volunteer monitor.

Total Phosphorus

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

Total phosphorus was evaluated in Fish Hook Lake in 1999-2011. Most of the data points fall into the mesotrophic range (Figure 7). The phosphorus concentrations increase somewhat as the summer progresses.

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

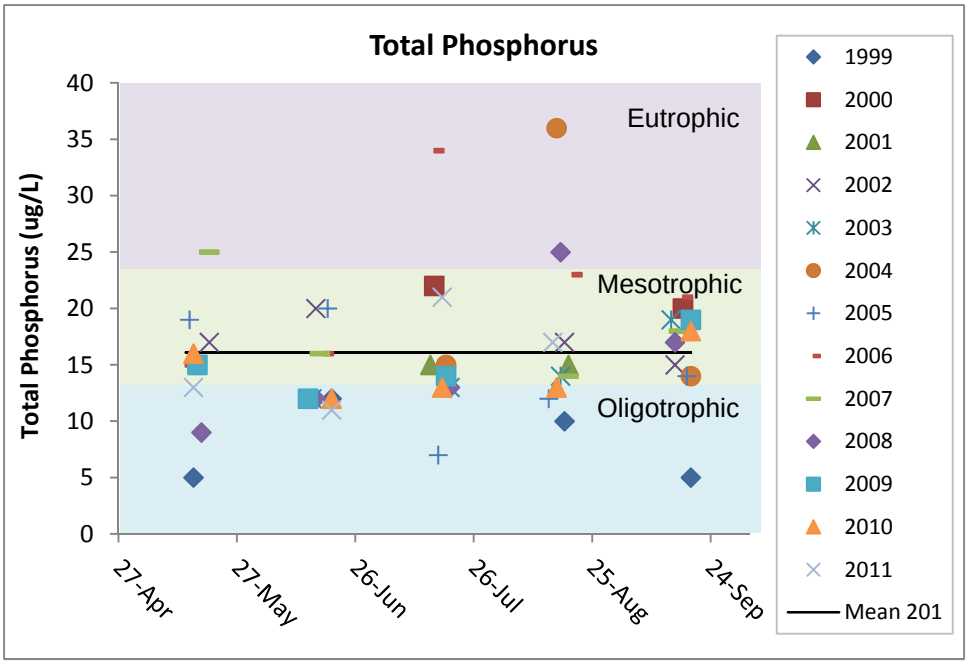


Figure 7. Historical total phosphorus concentrations (ug/L) at site 201 for Fish Hook Lake.

Chlorophyll *a*

Chlorophyll *a* is the pigment that makes plants and algae green. Chlorophyll *a* is tested in lakes to determine the algae concentration or how "green" the water is.

Chlorophyll *a* concentrations greater than 10 ug/L are perceived as a mild algae bloom, while concentrations greater than 20 ug/L are perceived as a nuisance.

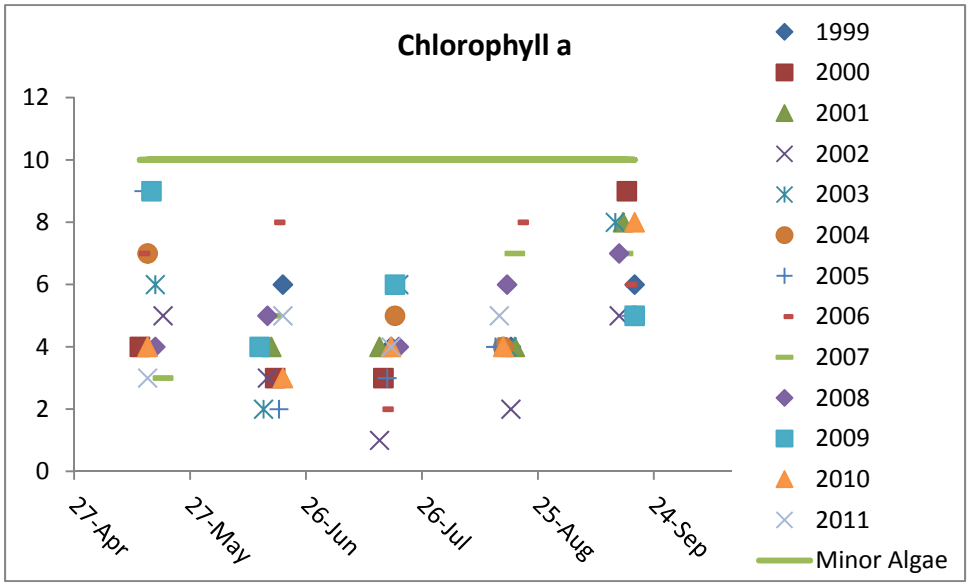
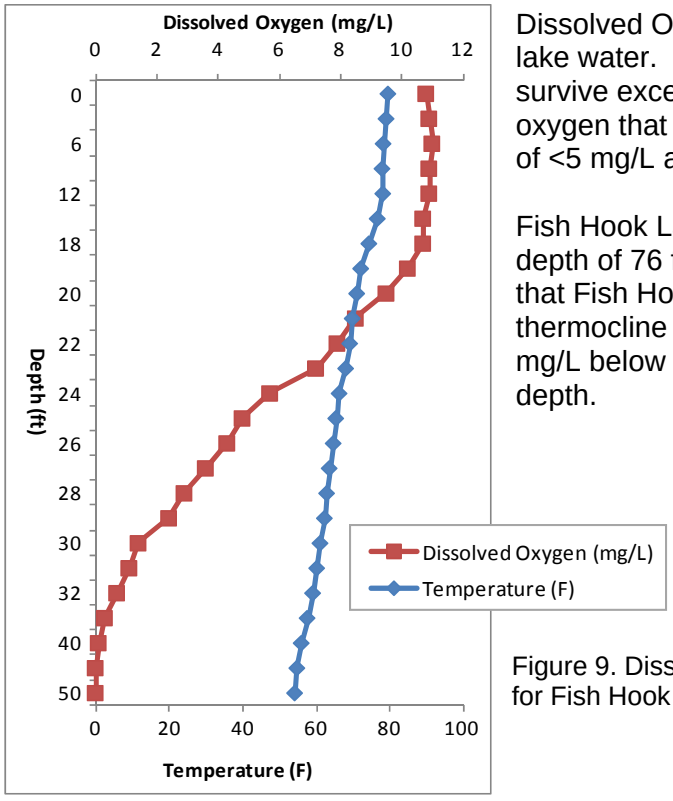


Figure 8. Chlorophyll *a* concentrations (ug/L) for Fish Hook Lake.

Chlorophyll *a* was evaluated in Fish Hook Lake in 1999-2011 (Figure 8). Chlorophyll *a* concentrations remained below 10 ug/L, indicating clear water all summer and no nuisance algae blooms.

Dissolved Oxygen



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

Fish Hook Lake is a moderately deep lake, with a maximum depth of 76 feet. Dissolved oxygen profiles from 2012 indicate that Fish Hook Lake stratifies in the summer (Figure 9). The thermocline occurs around 24 feet, and oxygen drops below 5 mg/L below the thermocline. This is typical for a lake of this depth.

Figure 9. Dissolved oxygen and temperature profile for Fish Hook Lake on 7/12/2012.

Trophic State Index

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

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

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

Mesotrophic lakes (TSI 40-50) are characterized by moderately clear water most of the summer (Table 7). "Meso" means middle or mid; therefore, mesotrophic means a medium amount of productivity. Mesotrophic lakes are commonly found in central Minnesota and have clear water with algal blooms in late summer. They are also good for walleye fishing.

Table 6. Trophic State Index.

Trophic State Index	Site 204
TSI Total Phosphorus	44
TSI Chlorophyll-a	46
TSI Secchi	42
TSI Mean	44
Trophic State:	Mesotrophic

Numbers represent the mean TSI for each parameter.

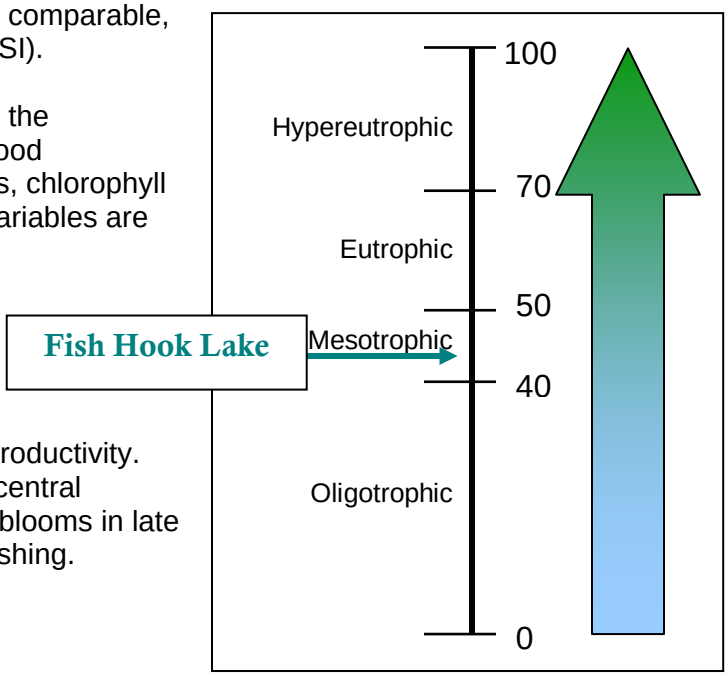


Figure 10. Trophic state index chart with corresponding trophic status.

Table 7. Trophic states and corresponding lake and fishery conditions.

TSI	Attributes	Fisheries & Recreation
<30	**Oligotrophy:** Clear water, oxygen throughout the year at the bottom of the lake, very deep cold water.	Trout fisheries dominate
30-40	Bottom of shallower lakes may become anoxic (no oxygen).	Trout fisheries in deep lakes only. Walleye, Cisco present.
40-50	**Mesotrophy:** Water moderately clear most of the summer. May be "greener" in late summer.	No oxygen at the bottom of the lake results in loss of trout. Walleye may predominate.
50-60	**Eutrophy:** Algae and aquatic plant problems possible. "Green" water most of the year.	Warm-water fisheries only. Bass may dominate.
60-70	Blue-green algae dominate, algal scums and aquatic plant problems.	Dense algae and aquatic plants. Low water clarity may discourage swimming and boating.
70-80	**Hypereutrophy:** Dense algae and aquatic plants.	Water is not suitable for recreation.
>80	Algal scums, few aquatic plants	Rough fish (carp) dominate; summer fish kills possible

Source: Carlson, R.E. 1997. A trophic state index for lakes. *Limnology and Oceanography*. 22:361-369.

Trend Analysis

For detecting trends, a minimum of 8-10 years of data with 4 or more readings per season are recommended. Minimum confidence accepted by the MPCA is 90%. This means that there is a 90% chance that the data are showing a true trend and a 10% chance that the trend is a random result of the data. Only short-term trends can be determined with just a few years of data, because there can be different wet years and dry years, water levels, weather, etc, that affect the water quality naturally.

There is enough historical data to perform trend analysis for total phosphorus, chlorophyll *a,* and transparency on Fish Hook Lake (Table 8). The data was analyzed using the Mann Kendall Trend Analysis.

Table 8. Trend analysis for Fish Hook Lake.

Lake Site	Parameter	Date Range	Trend
201	Transparency	1988-2011	No trend
201	Total Phosphorus	1999-2011	No trend
201	Chlorophyll a	1999-2011	No trend

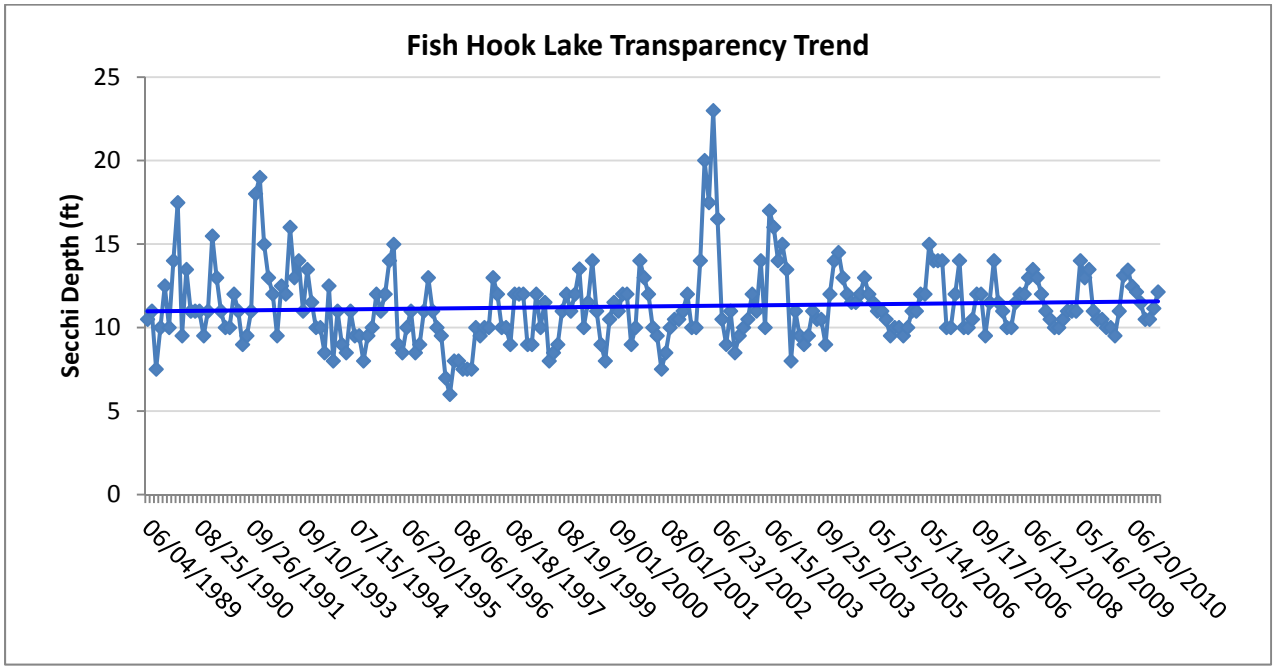


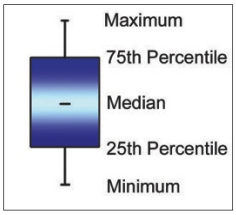
Figure 11. Long-term transparency trends for Fish Hook Lake.

Fish Hook Lake has no detectable trends in water quality. This means the water quality is most likely stable. Monitoring should continue so that trends can be tracked in future years.

Ecoregion Comparisons

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

Fish Hook Lake is in the Northern Lakes and Forests Ecoregion. The means for phosphorus, chlorophyll a and transparency are within the ecoregion ranges (Fig 13).



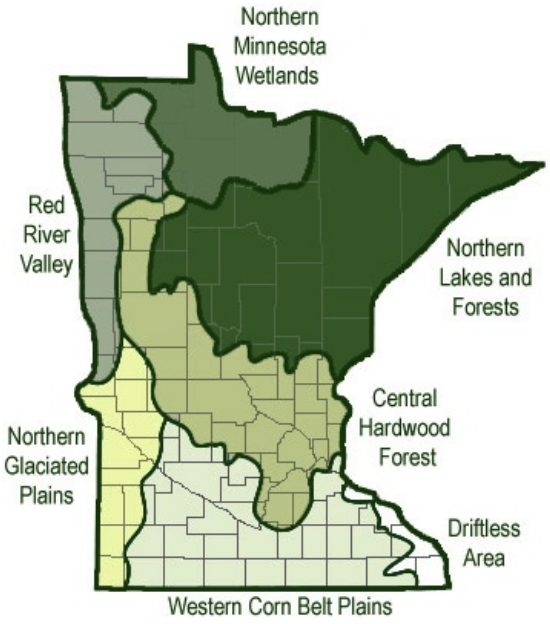
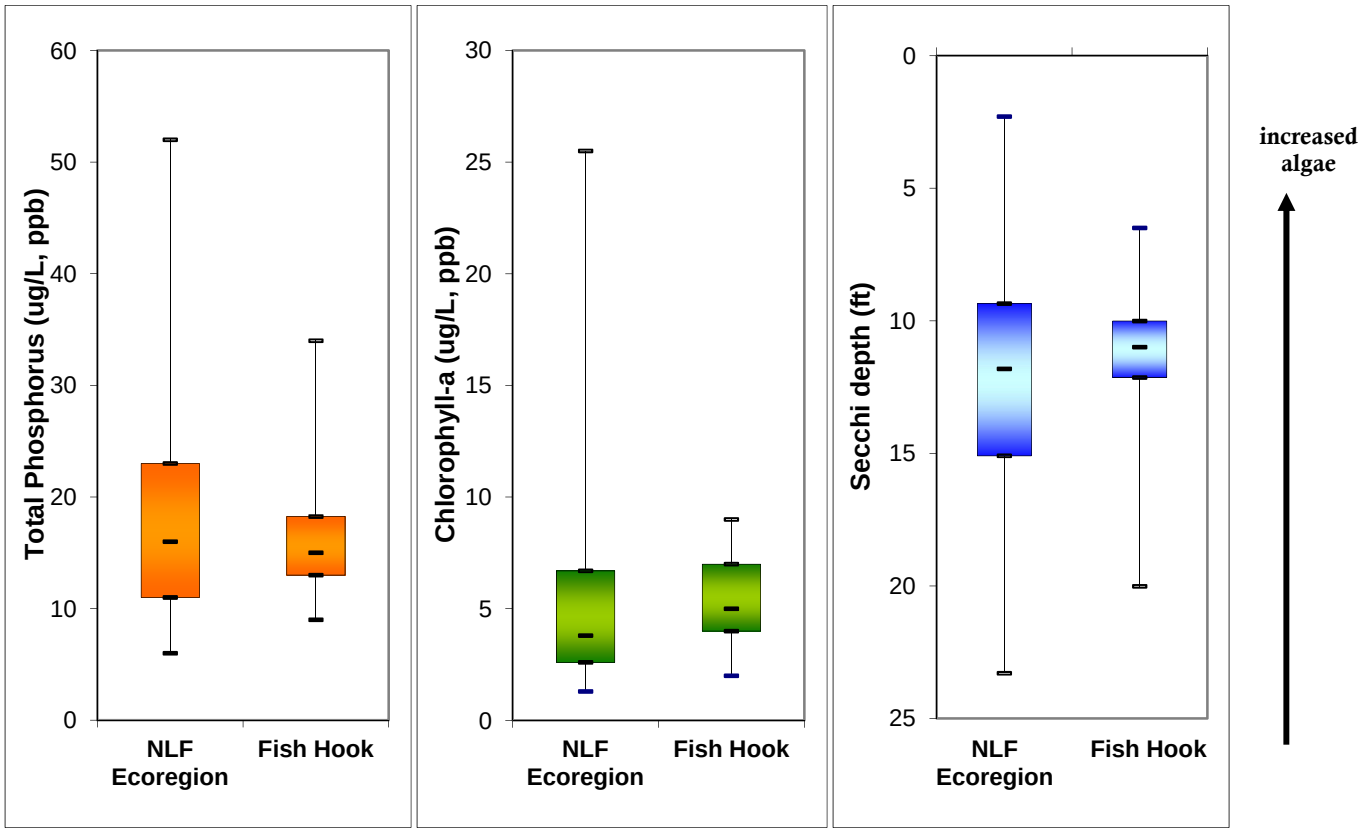


Figure 12. Map of Minnesota with the seven ecoregions.



Figures 13a-c. Fish Hook Lake ranges compared to Northern Lakes and Forest Ecoregion ranges. The Fish Hook Lake total phosphorus and chlorophyll *a* ranges are from 55 data points collected in May-September of 1999-2011. The Fish Hook Lake Secchi depth range is from 237 data points collected in May-September from 1988-2011.

Lakeshed Data and Interpretations

Lakeshed

Understanding a lakeshed requires an understanding of basic hydrology. A watershed is defined as all land and water surface area that contribute excess water to a defined point. The MN DNR has delineated three basic scales of watersheds (from large to small): 1) basins, 2) major watersheds, and 3) minor watersheds.

The **Crow Wing River Major Watershed** is one of the watersheds that make up the Upper Mississippi River Basin, which drains south to the Gulf of Mexico (Figure 14). This major watershed is made up of 136 minor watersheds. Fish Hook Lake is located in **minor watershed** 12024 (Figure 15).

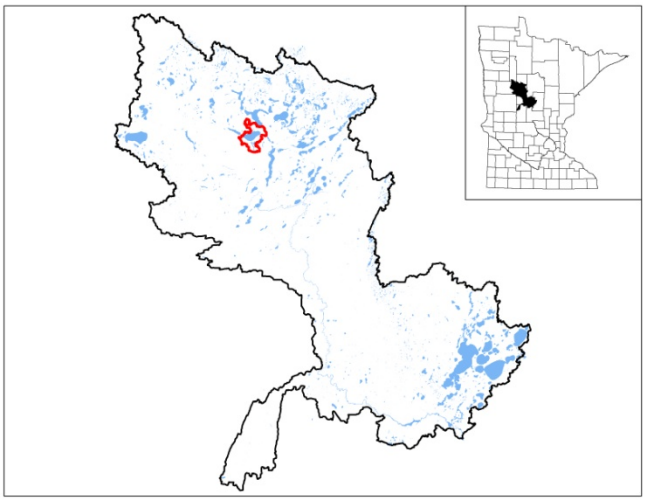


Figure 14. Crow Wing River Watershed.

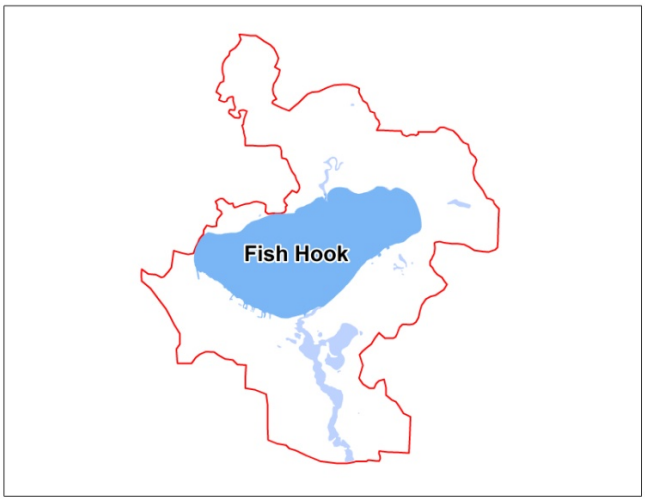


Figure 15. Minor Watershed 12024

The MN DNR also has evaluated catchments for each individual lake with greater than 100 acres surface area. These lakesheds (catchments) are the "building blocks" for the larger scale watersheds. Fish Hook Lake falls within the **Fish Hook (1202400) lakeshed** (Figure 16). Though very useful for displaying the land and water that contribute directly to a lake, lakesheds are not always true watersheds because they may not show the water flowing into a lake from upstream streams or rivers. While some lakes may have only one or two upstream lakesheds draining into them, others may be connected to a large number of lakesheds, reflecting a larger drainage area via stream or river networks. For further discussion of Fish Hook Lake's full watershed, containing all the lakesheds upstream of Fish Hook Lake lakeshed, see page 17. The data interpretation of the Fish Hook Lake lakeshed includes only the immediate

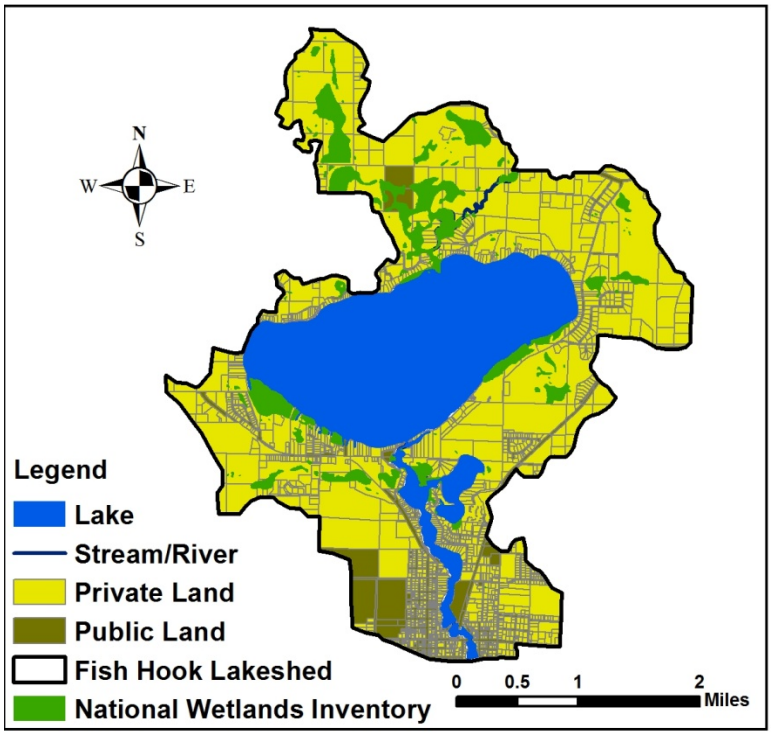


Figure 16. The Fish Hook (1202400) Lakeshed with land ownership, lakes, wetlands, and rivers illustrated.

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

The lakeshed vitals table identifies where to focus organizational and management efforts for each lake (Table 9). Criteria were developed using limnological concepts to determine the effect to lake water quality.

KEY
Possibly detrimental to the lake
Warrants attention
Beneficial to the lake

Table 9. Lakeshed vitals for Fish Hook Lake.

Lakeshed Vitals		Rating
Lake Area	1643 acres	descriptive
Littoral Zone Area	661 acres	descriptive
Lake Max Depth	76 ft.	descriptive
Lake Mean Depth	26.7 ft.	
Water Residence Time	0.4 years	
Miles of Stream	4.1	descriptive
Inlets	3	
Outlets	1	
Major Watershed	12 - Crow Wing River	descriptive
Minor Watershed	12024	descriptive
Lakeshed	1202400	descriptive
Ecoregion	Northern Lakes and Forest	descriptive
Total Lakeshed to Lake Area Ratio (total lakeshed includes lake area)	4:1	
Standard Watershed to Lake Basin Ratio (standard watershed includes lake areas)	74:1	
Wetland Coverage	7.7%	
Aquatic Invasive Species	None	
Public Drainage Ditches	None	
Public Lake Accesses	1	
Miles of Shoreline	9.1	descriptive
Shoreline Development Index	1.6	
Public Land : Private Land (excludes water)	0.1:1	
Development Classification	Recreational Development	
Miles of Road	44.3	descriptive
Municipalities in lakeshed	Park Rapids	
Forestry Practices	2002 Hubbard County Forest Resources Management Plan	
Feedlots	None	
Sewage Management	Properties in the city limits of Park Rapids are on the city sewer. The rest have individual waste treatment systems (last lake-wide county inspection - 1994)	
Lake Management Plan	Healthy Lakes & Rivers Partnership program, 2003	
Lake Vegetation Survey/Plan	None	

Land Cover / Land Use

The activities that occur on the land within the lakeshed can greatly impact a lake. Land use planning helps ensure the use of land resources in an organized fashion so that the needs of the present and future generations can be best addressed. The basic purpose of land use planning is to ensure that each area of land will be used in a manner that provides maximum social benefits without degradation of the land resource.

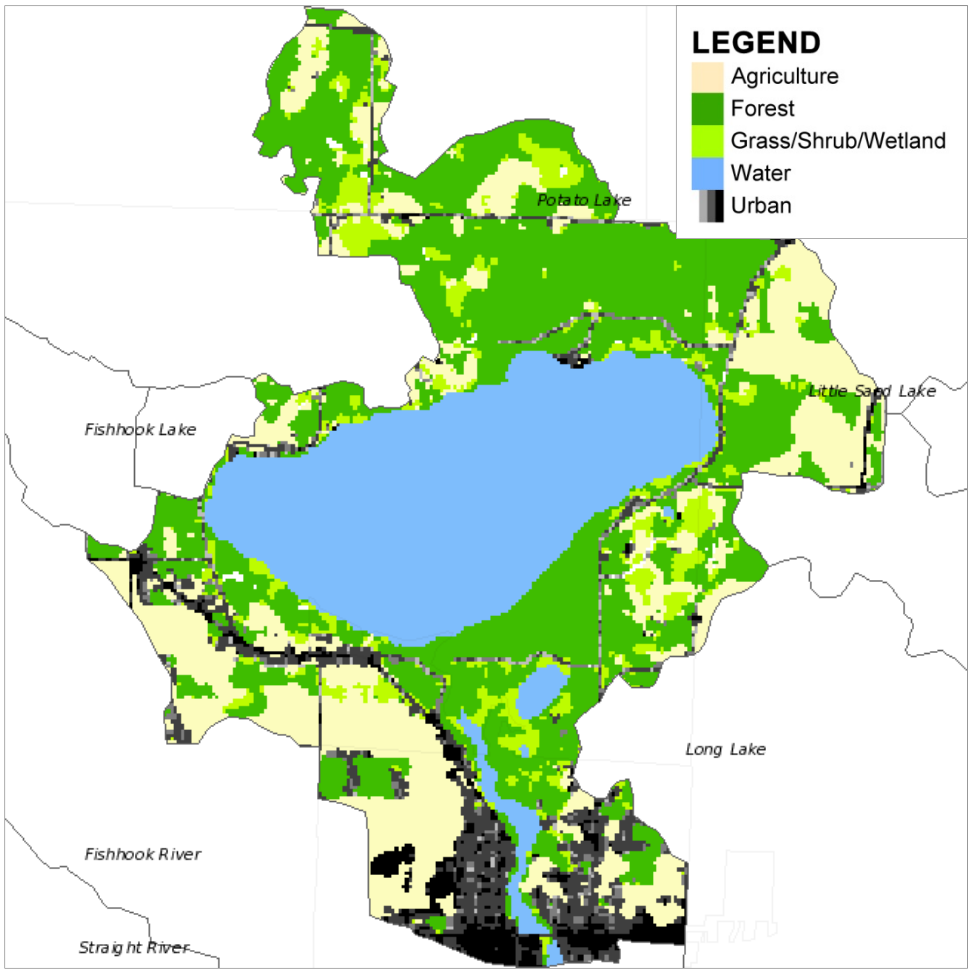


Figure 17. The Fish Hook (1202400) lakeshed land cover (http://land.umn.edu).

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

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

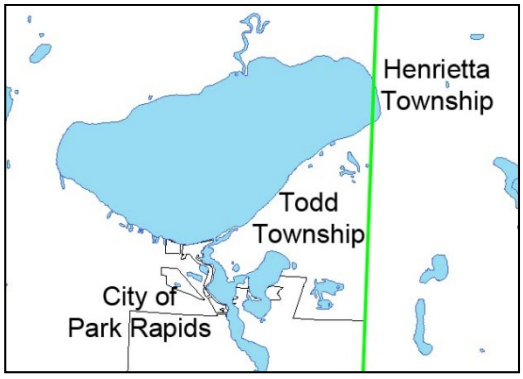
The University of Minnesota has online records of land cover statistics from years 1990 and 2000 (http://land.umn.edu). This data is somewhat outdated, but it is the most recent comparable data available. Table 10 describes Fish Hook Lake's lakeshed land cover statistics and percent change from 1990 to 2000. Due to the many factors that influence demographics, one cannot determine with certainty the projected statistics over the next 10, 20, 30+ years, but one can see the transition within the lakeshed from agriculture, grass/shrub/wetland, and water acreages to forest and urban acreages. The largest change in percentage is the increase in urban cover (40%) which has implications for storm water runoff into the lake. The increase in impervious intensity is consistent with the increase in urban acreage.

Table 10. Fish Hook 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	1763	25.22	1394	19.94	20.9% Decrease
Grass/Shrub/Wetland	601	8.6	478	6.84	20.5% Decrease
Forest	2125	30.4	2474	35.39	16.4% Increase
Water	1852	26.49	1733	24.79	6.4% Decrease
Urban	652	9.33	914	13.08	40.2% Increase
Impervious Intensity %					
0	6352	0	6081	0	4.3% Decrease
1-10	64	0.04	64	0.04	No Change
11-25	136	0.34	142	0.37	4.4% Increase
26-40	140	0.67	223	1.04	59.3% Increase
41-60	155	1.13	245	1.74	58.1% Increase
61-80	75	0.73	112	1.12	49.3% Increase
81-100	73	1	128	1.74	75.3% Increase
Total Area	6990		6990		
Total Impervious Area (Percent Impervious Area Excludes Water Area)	272	5.29	424	8.07	55.9% Increase

Demographics

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



The Minnesota Department of Administration Geographic and Demographic Analysis Division extrapolated future population in 5-year increments out to 2035. Compared to Hubbard County as a whole, Todd Township and the City of Park Rapids have a lower extrapolated growth projection (Figure 18).

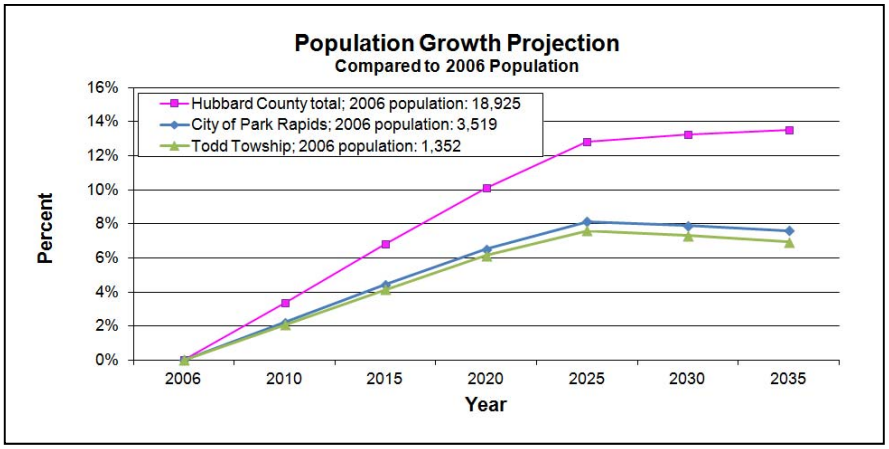


Figure 18. Population growth projection for Todd Township, City of Park Rapids and Hubbard County. (source: http://www.demography.state.mn.us/resource.html?Id=19332)

Fish Hook Lake Lakeshed Water Quality Protection Strategy

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

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

Table 11. Percent land use in private versus publicly owned land with corresponding phosphorus loading and protection/restoration ideas (Sources: Minnesota DNR GAP Stewardship data, National Wetlands Inventory, and the 2006 National Land Cover Dataset).

	Private (66%)					26 %	Public (8%)		
	Developed	**Agriculture**	**Forested Uplands**	**Other**	**Wetlands**	**Open Water**	**County**	**State**	**Federal**
Land Use (%)	11.1%	10.5%	32.5%	4.9%	7%	26%	7.3%	0.7%	0.002%
Runoff Coefficient Lbs of phosphorus/acre/ year	0.45 – 1.5	0.26 – 0.9	0.09		0.09		0.09	0.09	0.09
Estimated Phosphorus Loading Acreage x runoff coefficient	347 – 1157	190 – 658	205		44		46	4	0.01
Description	Focused on Shoreland	Cropland	Focus of develop-ment and protection efforts	Open, pasture, grass-land, shrub-land	Protected				
Potential Phase 3 Discussion Items	Shoreline restoration	Restore wetlands; CRP	Forest stewardship planning, 3rd party certification, SFIA, local woodland cooperatives		Protected by Wetland Conservation Act		County Tax Forfeit Lands	State Forest	National Forest

DNR Fisheries approach for lake protection and restoration

Credit: Peter Jacobson and Michael Duval, Minnesota DNR Fisheries

In an effort to prioritize protection and restoration efforts of fishery lakes, the MN DNR has developed a ranking system by separating lakes into two categories, those needing protection and those needing restoration. Modeling by the DNR Fisheries Research Unit suggests that total phosphorus concentrations increase significantly over natural concentrations in lakes that have watershed with disturbance greater than 25%. Therefore, lakes with watersheds that have less than 25% disturbance need protection and lakes with more than 25% disturbance need restoration (Table 12). Watershed disturbance was defined as having urban, agricultural and mining land uses. Watershed protection is defined as publicly owned land or conservation easement.

Table 12. Suggested approaches for watershed protection and restoration of DNR-managed fish lakes in Minnesota.

Watershed Disturbance (%)	Watershed Protected (%)	Management Type	Comments
< 25%	> 75%	Vigilance	Sufficiently protected -- Water quality supports healthy and diverse native fish communities. Keep public lands protected.
	< 75%	Protection	Excellent candidates for protection -- Water quality can be maintained in a range that supports healthy and diverse native fish communities. Disturbed lands should be limited to less than 25%.
25-60%	n/a	Full Restoration	Realistic chance for full restoration of water quality and improve quality of fish communities. Disturbed land percentage should be reduced and BMPs implemented.
> 60%	n/a	Partial Restoration	Restoration will be very expensive and probably will not achieve water quality conditions necessary to sustain healthy fish communities. Restoration opportunities must be critically evaluated to assure feasible positive outcomes.

The next step was to prioritize lakes within each of these management categories. DNR Fisheries identified high value fishery lakes, such as cisco refuge lakes. Ciscos (*Coregonus artedi)* can be an early indicator of eutrophication in a lake because they require cold hypolimnetic temperatures and high dissolved oxygen levels. These watersheds with low disturbance and high value fishery lakes are excellent candidates for priority protection measures, especially those that are related to forestry and minimizing the effects of landscape disturbance.

Fish Hook Lake was classified with having 28.5% of the watershed protected and 28.4% of the watershed disturbed (Figure 19). Therefore, Fish Hook Lake should have a full restoration focus. The percent of watershed disturbed is just over the threshold of 25%. The City of Park Rapids is most likely the main cause of disturbance in the Fish Hook Lake lakeshed. By reducing the disturbed land percentage and implementing BMPs, this lake has a realistic chance for full restoration of water quality and improving the quality of fish communities.

Figure 20 displays the upstream lakesheds that contribute water to the Fish Hook Lake lakeshed. All of the land and water area in this figure has the potential to contribute water to Fish Hook Lake, whether through direct overland flow or through a creek or river. The majority of the upstream lakesheds have a protection focus.

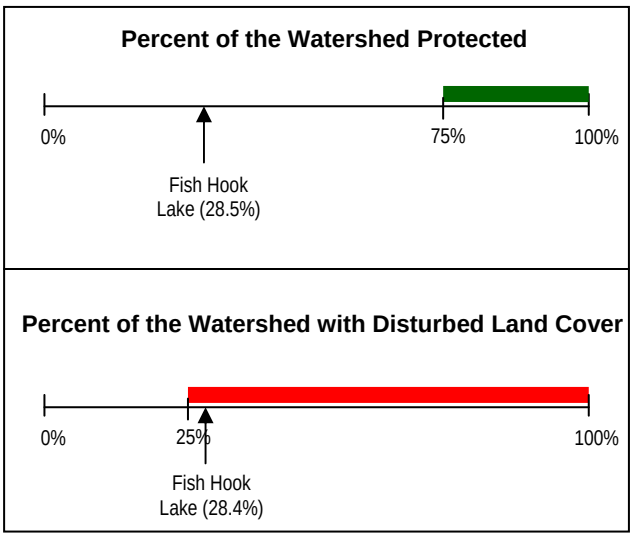


Figure 19. Fish Hook Lake lakeshed's percentage of watershed protected and disturbed.

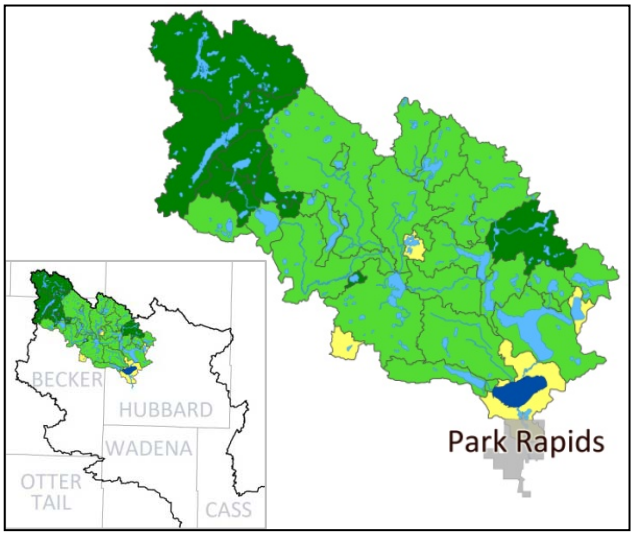


Figure 20. Upstream lakesheds that contribute water to the Fish Hook lakeshed. Color-coded based on management focus (Table 3).

Fish Hook Lake, Status of the Fishery (as of 07/09/2007)

Fish Hook Lake is located just north of Park Rapids in Hubbard County. Fish Hook has a surface area of 1,632 acres and a maximum depth of 76 feet. There are county-owned public accesses located on the southwest shore of the lake and on the Fish Hook River south of the lake in Heartland Park. Fish Hook is a popular lake and receives a fair amount of fishing and recreational activity year around. The Minnesota Dept. of Natural Resources (DNR) has classified Minnesota's lakes into 43 different types based on physical and chemical characteristics. Fish Hook is in lake class 27. Other area lakes in this same classification are Upper Bottle, Garfield, and Lake George.

Fish Hook is an excellent fishing lake and is known as one of the best "multi-species" lakes around, providing good fishing opportunities for walleye, northern pike, largemouth bass, and panfish. Fish Hook has good water quality, bottom substrate, and aquatic vegetation that provides excellent habitat for a variety of gamefish species. Important emergent aquatic vegetation such as hardstem bulrush are found along the southwest and north shores. Good beds of submerged aquatic vegetation such as claspingleaf and whitestem pondweed ("cabbage"), coontail, and northern milfoil are common and found out to 20 foot depths.

Walleye abundance (7.0 walleye/gillnet) was up from past surveys and above the current management goal of 5 walleye/gillnet. Anglers can expect to find good numbers of 16-20 inch walleye as well as larger fish up to 30 inches. Fish Hook Lake is known as one of the better lakes in this area for the opportunity of catching a trophy walleye (30 inch plus). Fish Hook Lake is currently stocked with walleye fingerlings during odd numbered years.

Northern pike were sampled in high numbers (10.2 pike/gillnet), above the range "typical" for this lake class. Northern pike abundance in past surveys has fluctuated from moderate to high numbers. Sampled northern pike had an average length and weight of 21.1 inches and 2.2 pounds with pike measured up to 36.2 inches.

Fish Hook has an excellent population of largemouth bass and panfish. Largemouth bass in the 14-16 inch size range are common as well as bass up to 20 inches. Smallmouth bass are present in low numbers. Anglers will find good numbers of bluegill in the 7-8 inch range. The black crappie population in Fish Hook fluctuates from low to moderate numbers. Anglers will find black crappie in the 10-12 inch size range

See the link below for specific information on gillnet surveys, stocking information, and fish consumption guidelines. http://www.dnr.state.mn.us/lakefind/showreport.html?downum=29024200

Key Findings / Recommendations

Monitoring Recommendations
Transparency monitoring at sites 201 should be continued annually. It is important to continue transparency monitoring weekly or at least bimonthly every year to enable year-to-year comparisons and trend analyses. Phosphorus and chlorophyll a monitoring should continue at site 201, as the budget allows, to track future water quality trends.

Overall Conclusions
Fish Hook Lake is a mesotrophic lake (TSI=44) with no detectable water quality trends and an excellent fishery. Eight percent (8%) of the lakeshed is public land (Table 3), and 28.5% of the watershed protected, while 28.4% of the watershed disturbed (Figure 6). From 1990-2000, the impervious surface around the lake increased by 56% (152 acres) (Table 2).

Priority Impacts to the lake
The main sources of disturbance for Fish Hook Lake is most likely 2nd tier development around the lake, agriculture, and the City of Park Rapids. There are 44 miles of roads in the Fish Hook Lakeshed (Table 9), which is a lot of impervious surface. Stormwater runoff from impervious surface in 1st and 2nd tier development, and the city and nearby roads can contribute nutrients and sediment to the lake.

The slightly higher chloride and specific conductance (Table 4) could be from the runoff from impervious surfaces in the lakeshed.

There is also a golf course on the southeast side of the lake. The golf course is within the lakeshed, which means its land area drains towards the lake. This area could be visually inspected for any streams or ditches that run through the golf course into the lake. To protect the lake, all runoff should be contained on the golf course property in ponds or rain gardens.

Best Management Practices Recommendations
The management focus for Fish Hook Lake should be to restore the lakeshed by decreasing the impact of the impervious surface in the lakeshed. Although it may not be possible to decrease the impervious area in the lakeshed, it is possible to reduce the impact of the impervious surface by retaining stormwater instead of allowing it to runoff into the lake. Project ideas include shoreline restorations on lakeshore property, rain gardens in the city and around the lake, and enforcement of county shoreline ordinances that limit impervious surface.

Targeted placement of best management practices can increase their cost effectiveness. Individual parcel assessment of percent impervious cover and proximity to a river or the shoreline is one way to rank priority. Flow analysis using GIS software could also pinpoint locations where water accumulates into a swale or depression.

Organizational contacts and reference sites

Fish Hook Lake and River Association	http://www.minnesotawaters.org/group/fhlara/welcome
DNR Fisheries Office	301 South Grove Avenue, Park Rapids, MN 56470 218-732-4153 parkrapids.fisheries@state.mn.us http://www.dnr.state.mn.us/areas/fisheries/parkrapids/index.html
Regional Minnesota Pollution Control Agency Office	714 Lake Ave., Suite 220, Detroit Lakes, MN 56501 218-847-1519, 1-800-657-3864 http://www.pca.state.mn.us/yhiz3e0
Hubbard County Soil and Water Conservation District	212 1/2 2nd St W, Park Rapids MN 56470 218-732-0121, http://www.hubbardswcd.org/