Spider Lake 29-0117-00 HUBBARD COUNTY

Lake Water Quality

Summary

Spider Lake is located two miles north of Nevis, Minnesota. It covers 597 acres and has an irregular shape with many bays.

Spider Lake has no major inlets or outlets, which classifies it as a groundwater seepage lake. There is a minor connection from a small lake to the north (Crow Wing Lake), and a minor outlet flowing to Shallow Lake to the south.

Water quality data have been collected on Spider Lake since 1977 (Table 3). These data show that the lake is at the oligotrophic, which is characterized by clear water throughout the summer and excellent recreational opportunities.

The Spider Lake Association is involved in many activities, including water quality monitoring. They are also a member of the Hubbard County Coalition of Lake Associations.

Table 1. Spider Lake location and key physical characteristics.

Location Data	
MN Lake ID:	29-0117-01
County:	Hubbard
Ecoregion:	Northern Lakes & Forests
Major Drainage Basin:	Upper Mississippi River
Latitude/Longitude:	46.99583333 / -94.85250000
Invasive Species:	Curly-leaf pondweed, 2011

Physical Characteristics	
Surface area (acres):	597
Littoral area (acres):	425
% Littoral area:	71%
Max depth (ft), (m):	96, 29.3
Inlets:	None
Outlets:	None
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	--	No monitoring is necessary because there are no major inlets or outlets.
Recommendations		**For recommendations refer to page 19.**

Lake Map

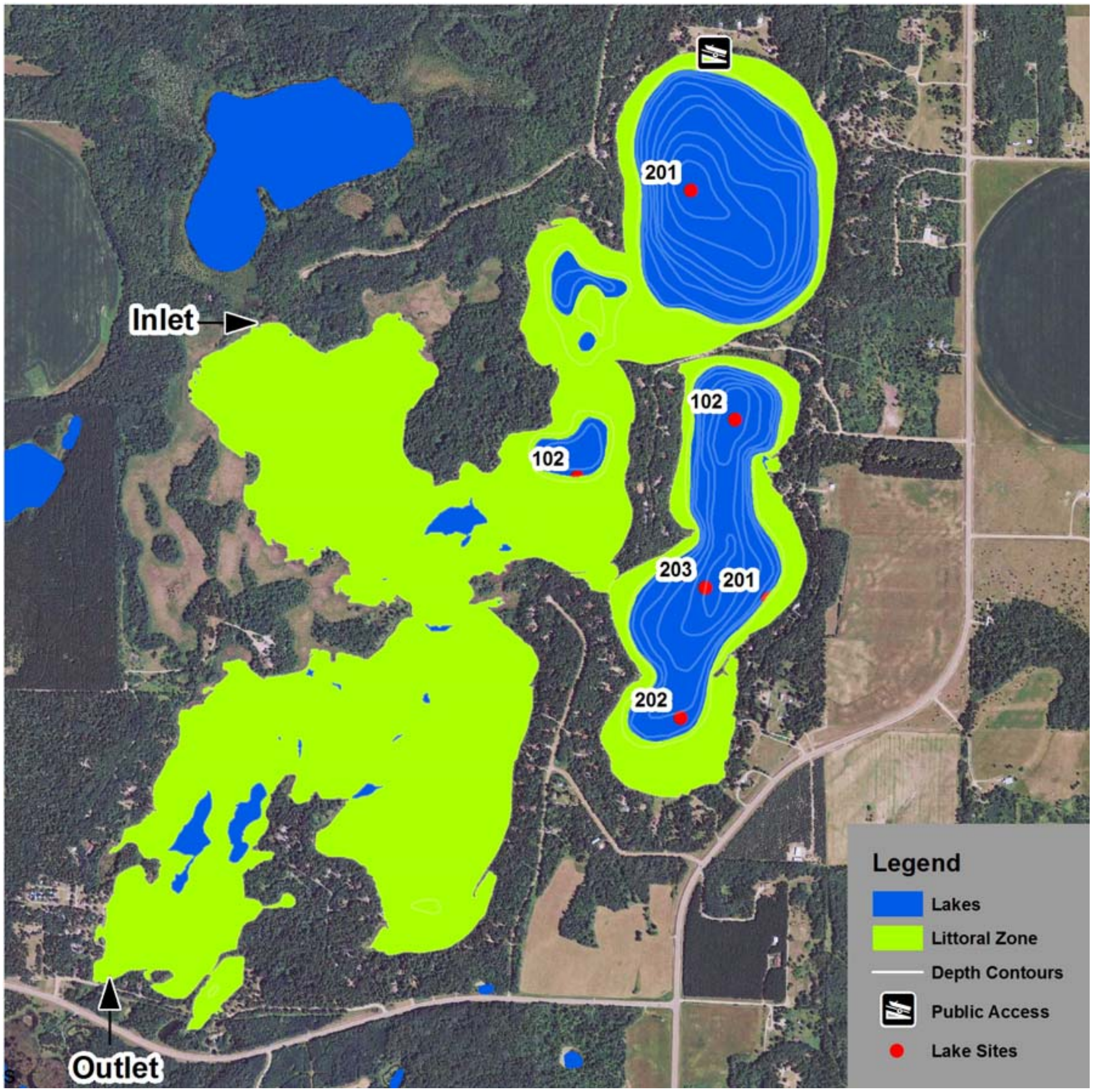


Figure 1. Map of Spider Lake with 2010 aerial imagery and illustrations of sample site locations, inlets and outlets, and public access points. The light green areas in the lake illustrate the littoral zone, where the sunlight can usually reach the lake bottom allowing aquatic plants to grow.

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).

Bay	Lake Site	Depth (ft)	Monitoring Programs
NE/SW Bay	102	22	MPCA: 1990
	201*primary site	96	MPCA: 1990; CLMP: 1994, 1997-2011 RMBEL: 1997-2011
East Bay	102	66	MPCA: 1990
	201	40	MPCA: 1979-1980; CLMP: 1977, 1979-1981, 1983-1985, 1989-1991, 1993, 1996-2004, 2006
	202	30	CLMP: 1992-1993, 2008-2009
	203	65	MPCA: 1990; CLMP: 2003, 2005-2007

Average Water Quality Statistics

The information below describes available chemical data for Spider 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 1990 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)	10	14 - 27	> 30	Results are better than the expected range for the ecoregion.
[3]Chlorophyll *a* (ug/L)	3	4 - 10	> 9	
Chlorophyll *a* max (ug/L)	7	<15		
Secchi depth (ft)	20	7.5 - 15	< 6.5	
Dissolved oxygen	Dimictic *See page 8*			Dissolved oxygen depth profiles show that the deep areas of the lake are anoxic in late summer.
Total Kjeldahl Nitrogen (mg/L)	0.63	0.40 - 0.75		Indicates insufficient nitrogen to support summer nitrogen-induced algae blooms.
Alkalinity (mg/L)	133	40 - 140		Indicates a low sensitivity to acid rain and a good buffering capacity.
Color (Pt-Co Units)	11	10 - 35		Indicates very clear water with little to no tannins (brown stain).
pH	8.8	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)	1.8	0.6 - 1.2		Slightly above the ecoregion average but still considered low level.
Total Suspended Solids (mg/L)	2.7	<1 - 2		Slightly above the ecoregion average but still considered low level.
Specific Conductance (umhos/cm)	220	50 - 250		Within the ecoregion average range.
Total Nitrogen :Total Phosphorus	63:1	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 NE/SW bay 201	East Bay Site 201	East Bay Site 202	East Bay Site 203
Total Phosphorus Mean (ug/L):	**10**	**38**		**7**
Total Phosphorus Min:	2	8		2
Total Phosphorus Max:	50	68		10
Number of Observations:	81	8		3
Chlorophyll *a* Mean (ug/L):	**3**			2
Chlorophyll-a Min:	1			1
Chlorophyll-a Max:	7			3
Number of Observations:	81			3
Secchi Depth Mean (ft):	**20.0**	**17.6**	**20.7**	**18.4**
Secchi Depth Min:	9.0	7.5	12.0	9.0
Secchi Depth Max:	36.0	36.0	30.0	30.5
Number of Observations:	159	251	31	56

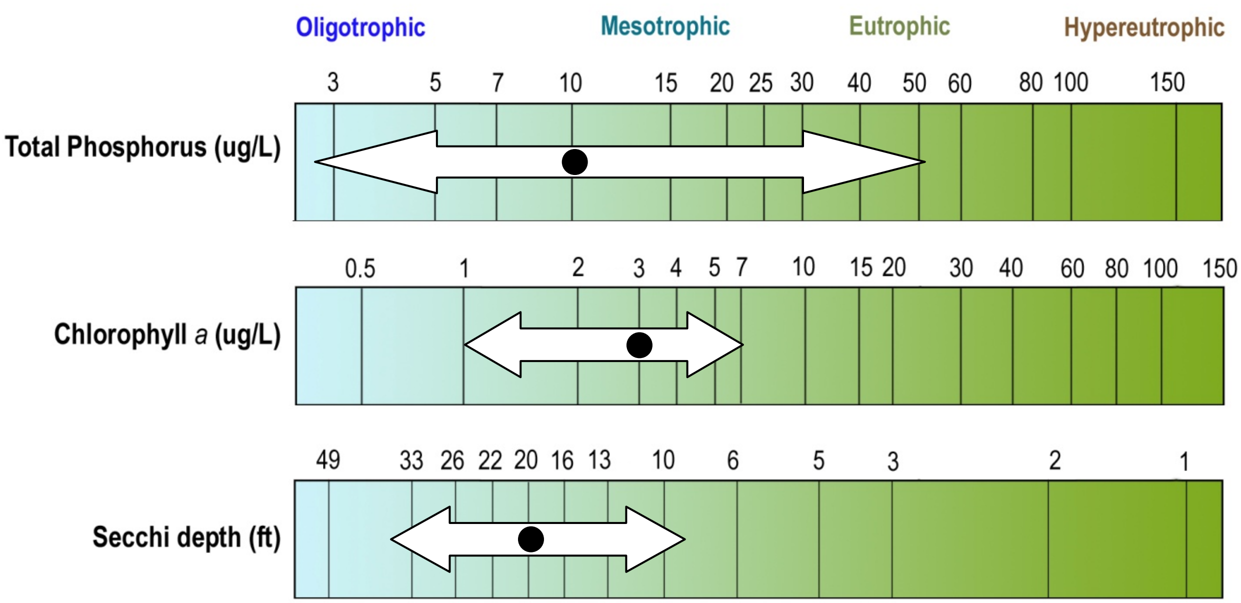


Figure 2. Spider Lake total phosphorus, chlorophyll *a* and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean (Primary Site, NE/SW Bay, 201). Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (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 Spider Lake range from 10.4 - 24.4 ft (Figure 3). Transparency is fairly consistent between site 201 in both bays and has hovered around the long-term mean since the late 1990s. Transparency monitoring should be continued at both sites to track water quality in Spider Lake.

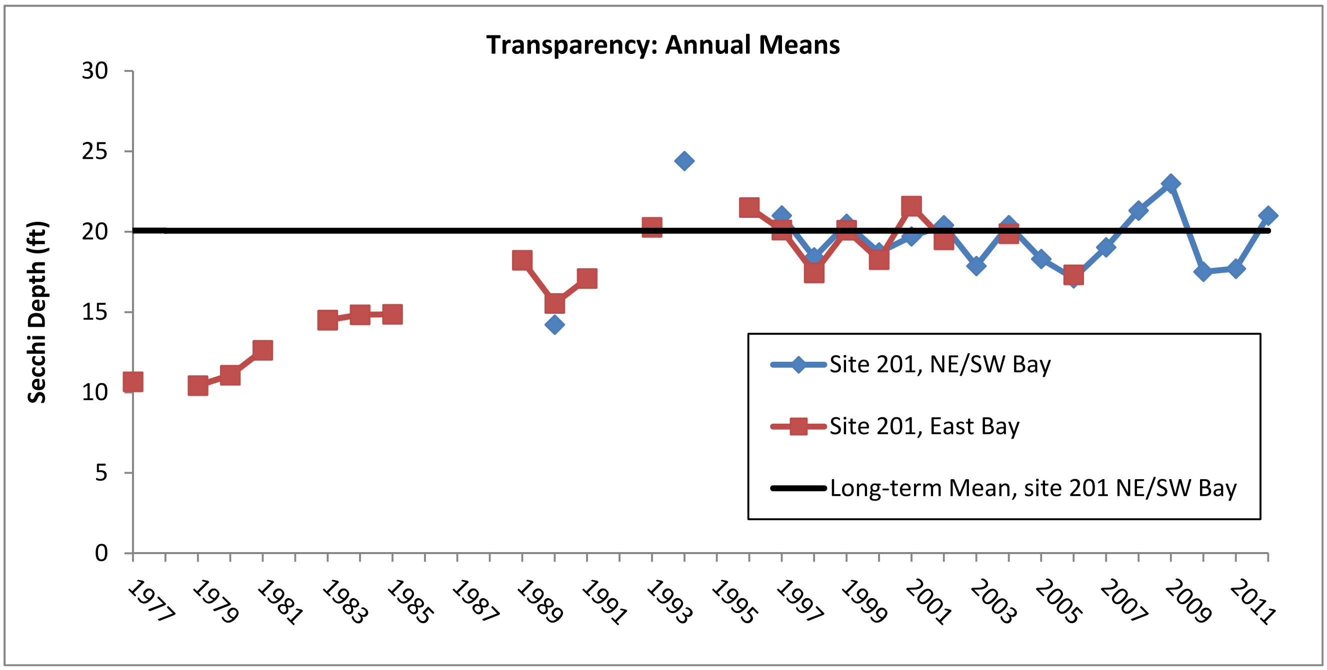


Figure 3. Annual mean transparency for sites 201 NE/SW Bay and 201 East Bay.

Spider Lake transparency ranges from 9 to 36 feet throughout the summer. Figure 4 shows the seasonal transparency dynamics. The maximum Secchi reading is usually obtained in early summer. Spider 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

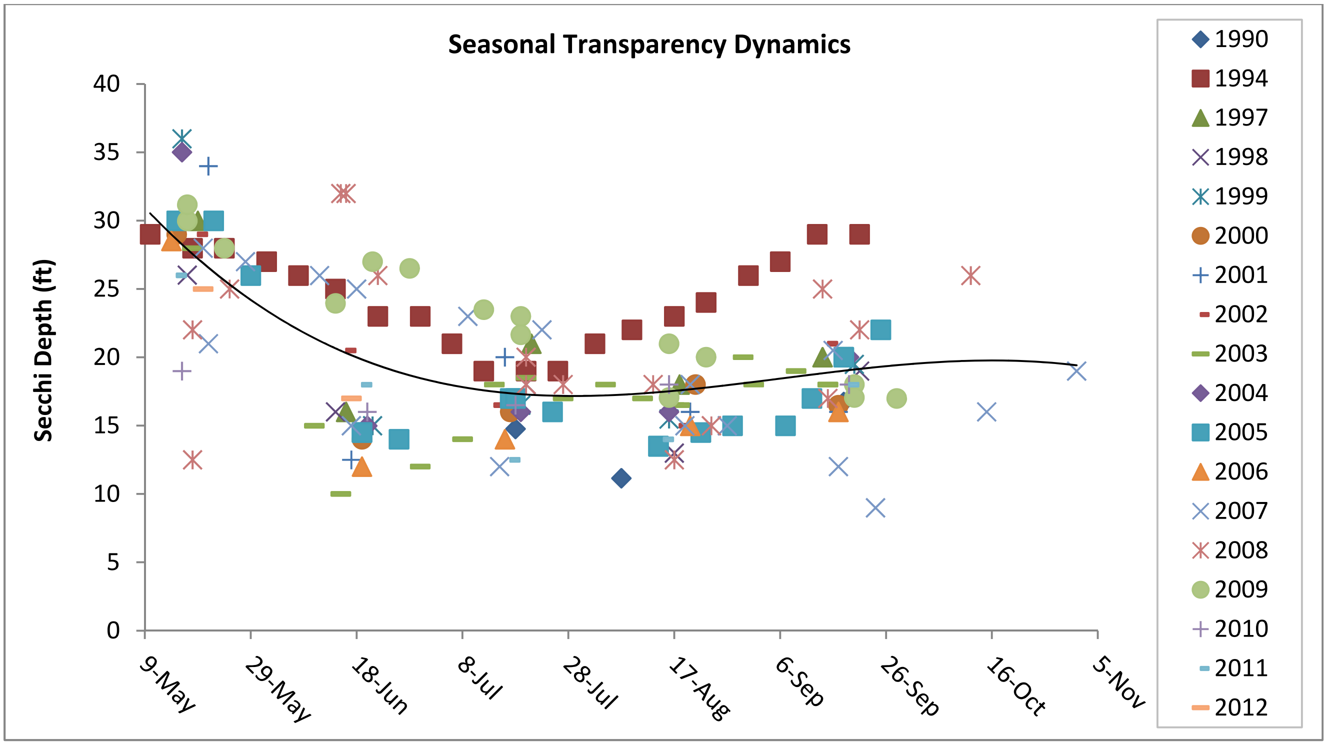


Figure 4. Seasonal transparency dynamics and year-to-year comparison (site 201). The black line represents the pattern in the data.

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. Spider Lake was rated as being "not quite crystal clear" 66% of the time between 1990-2011 (Figure 5).

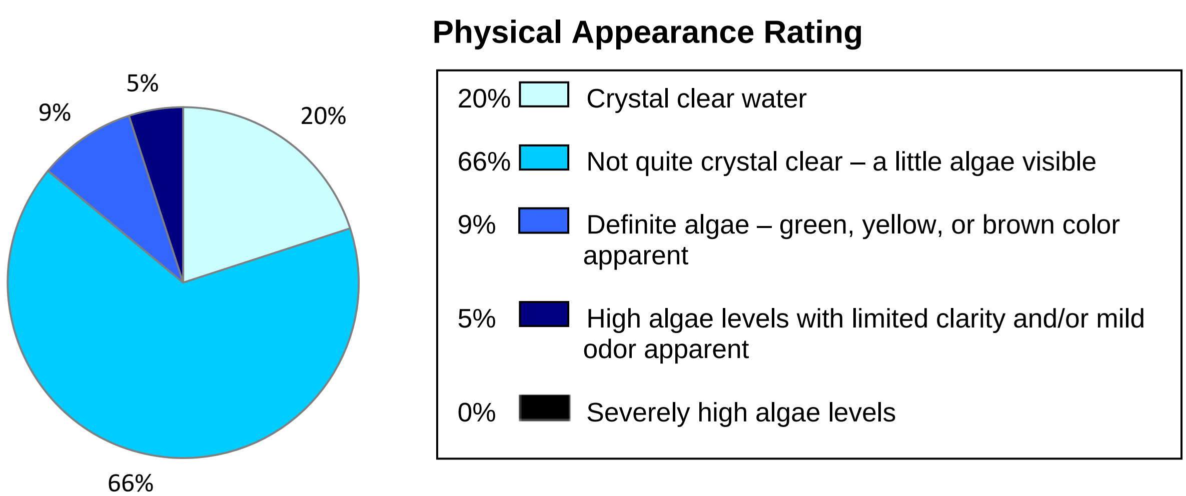
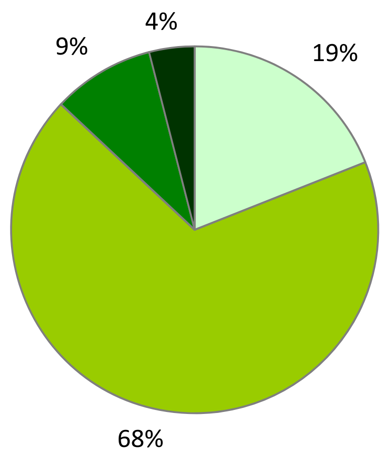


Figure 5. Physical appearance rating, as rated by the volunteer monitor.

As the secchi depth decreases, the perception of recreational suitability of the lake decreases. Spider Lake was rated as being "beautiful" 19% of the time from 1990-2011.



Recreational Suitability Rating

19%	Beautiful, could not be better
68%	Very minor aesthetic problems; excellent for swimming, boating
9%	Swimming and aesthetic enjoyment of the lake slightly impaired because of algae levels
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 6. Recreational suitability rating, as rated by the volunteer monitor.

Total Phosphorus

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

Total phosphorus was evaluated in Spider Lake in 1990 and 1997-2011. Most of the data points fall into the oligotrophic range (Figure 7). There is not much seasonal variation in phosphorus concentration for Spider lake.

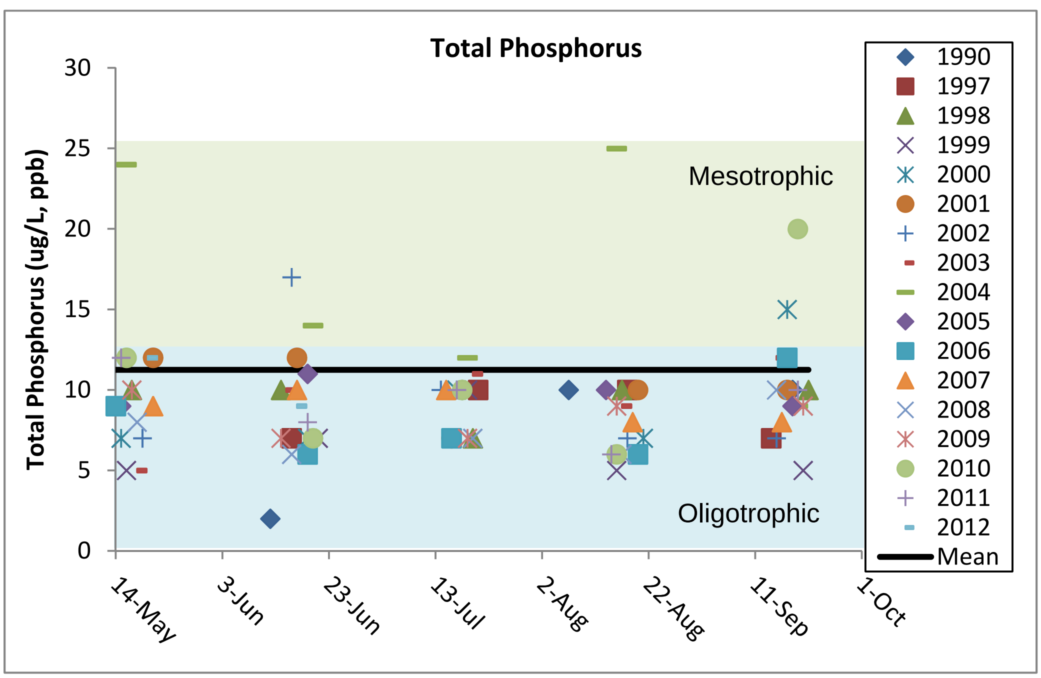


Figure 7. Historical total phosphorus concentrations (ug/L) at site 201 in the NE/SW bay for Spider Lake.

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

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.

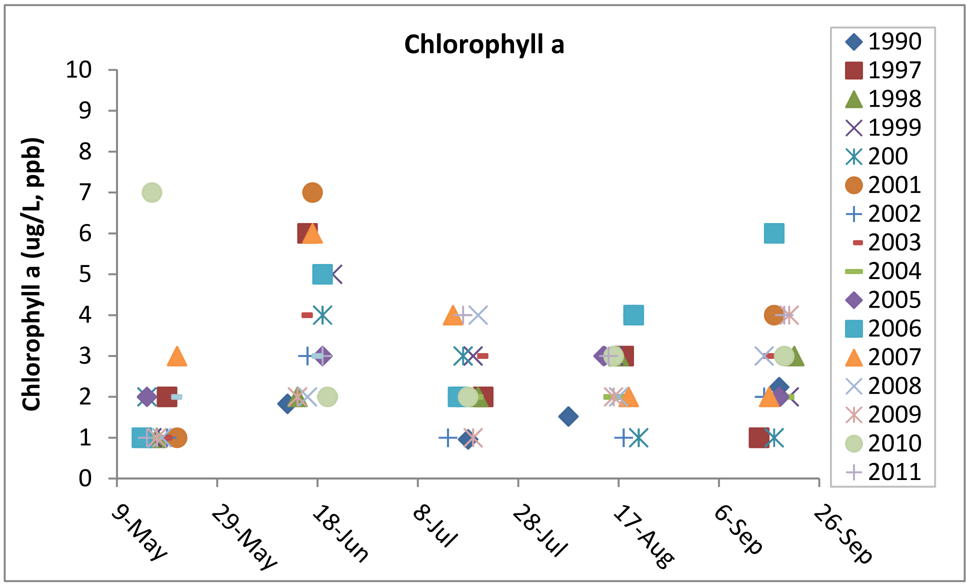


Figure 8. Chlorophyll *a* concentrations (ug/L) for Spider Lake.

Chlorophyll *a* was evaluated in Spider Lake in 1990 and 1997-2011 (Figure 8). Chlorophyll *a* concentrations remained well below 10 ug/L, indicating clear water all summer and no nuisance algae blooms.

Dissolved Oxygen

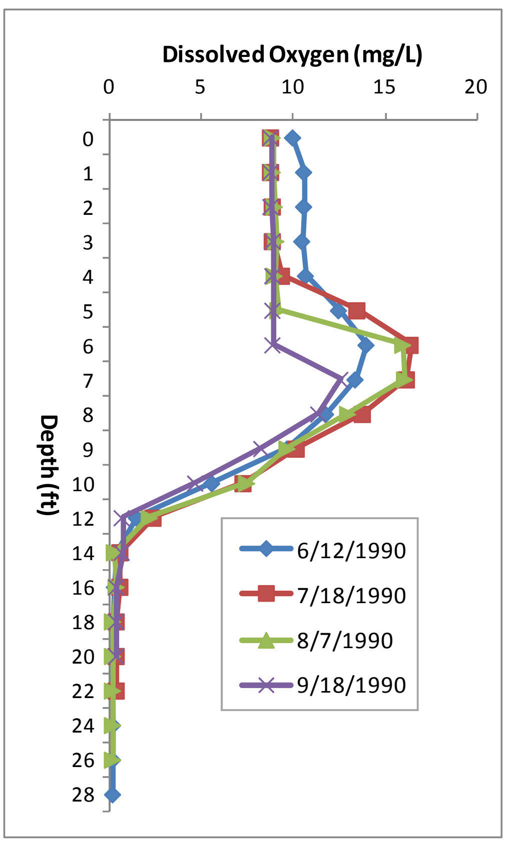


Figure 9. Dissolved oxygen profiles for Spider Lake in 1990.

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.

Spider Lake is a relatively deep lake, with a maximum depth of 96 ft. Dissolved oxygen profiles from 1990 indicate that the deep areas of Spider Lake stratify in the summer. In fact, the oxygen shows an interesting pattern in that it is highest from 5-8 meters (16.4 - 26.2 feet). This pattern is called a Metalimnetic Oxygen Maxima. It is caused by algae producing oxygen in that area of 5-8 meters deep. This pattern is usually only observed in lakes with good transparency and a very small closed deep basin, which applies to site 201 in the NE/SW bay of Spider Lake (Figure 1). This small deep hole stratifies very strongly as there is not much surface area for wind mixing.

There is no oxygen available below 12 meters (39.4 feet), which means that gamefish are most likely not present there in the summer.

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 Spider Lake falls into the oligotrophic range (Figure 10). There is good agreement between the TSI for phosphorus and chlorophyll *a*, indicating that these variables are strongly related (Table 6). The TSI for transparency is lower than the other parameters, which could be due to there being more data points, or large algae dominating the algal community, or selective grazing by zooplankton on smaller algal cells.

Oligotrophic lakes are characteristic of clear water throughout the summer and are excellent for recreation (Table 7). They have very low nutrient levels and sandy/rocky shores. If there is enough hypolimnetic oxygen, trout can survive.

Table 6. Trophic State Index.

Trophic State Index	Site 204
TSI Total Phosphorus	37
TSI Chlorophyll-a	41
TSI Secchi	34
TSI Mean	38
Trophic State:	Oligotrophic

Numbers represent the mean TSI for each parameter.

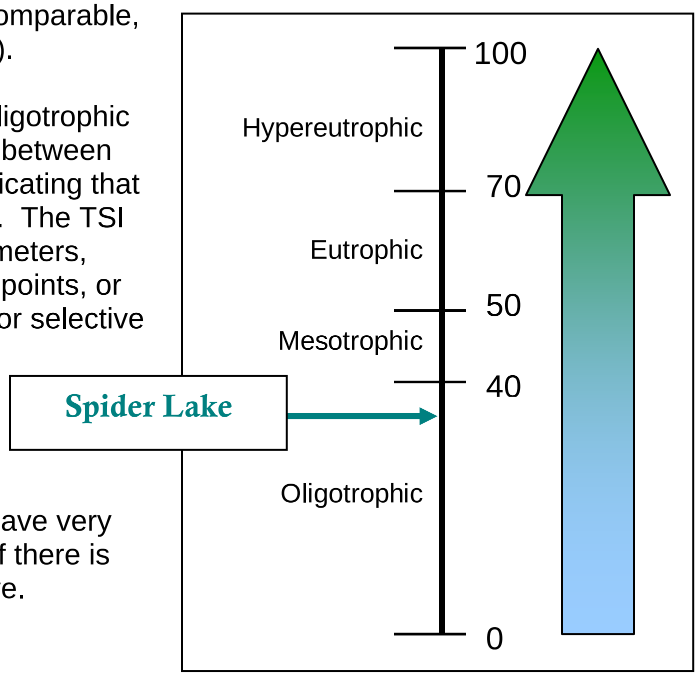


Figure 10. Trophic state index chart with corresponding trophic status.

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 Spider Lake (Table 8). The data was analyzed using the Mann Kendall Trend Analysis.

Table 8. Trend analysis for Spider Lake.

Lake Site	Parameter	Date Range	Trend
NE/SW Bay, 201	Transparency	1997-2011	No trend
NE/SW Bay, 201	Total Phosphorus	1997-2011	No trend
NE/SW Bay, 201	Chlorophyll a	1997-2011	No trend

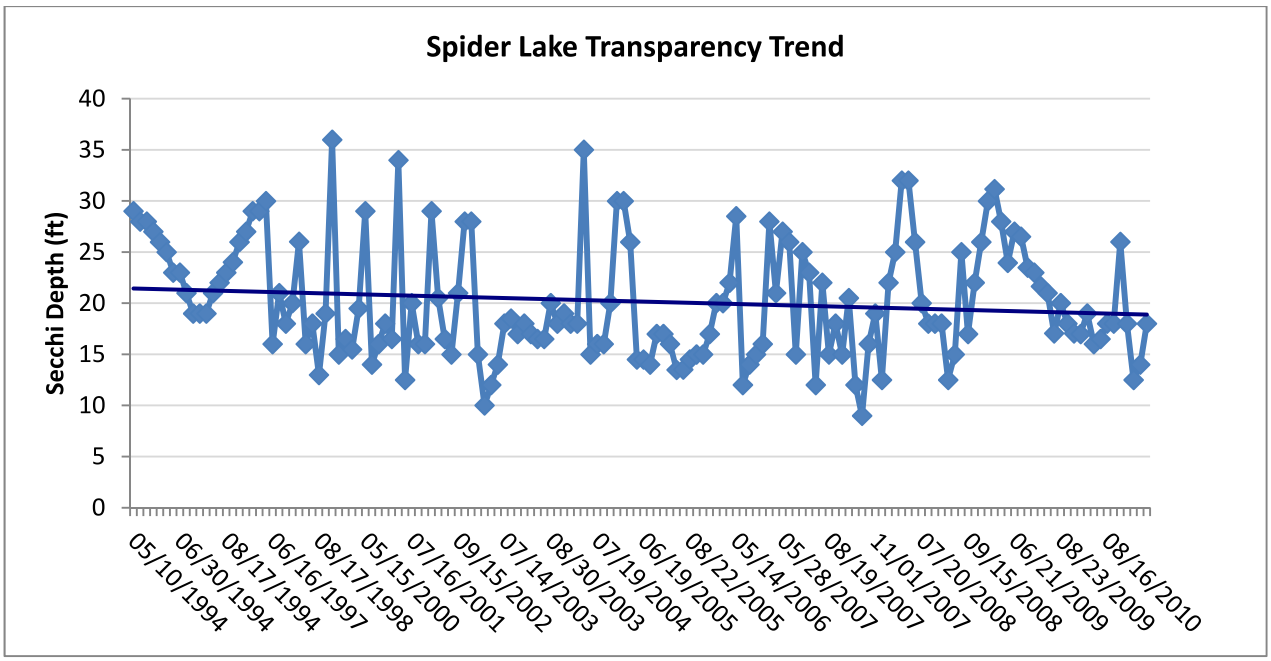


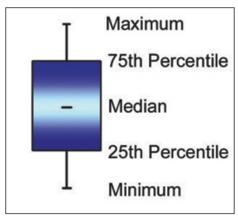
Figure 11. Long-term transparency trend for site 201 in Spider Lake.

There is no statistically significant trend in transparency for the NE/SW bay of Spider Lake (Figure 11). This means that water quality is staying the same. Monitoring should continue at site 201 so that this trend can be tracked in future years.

Ecoregion Comparisons

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

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



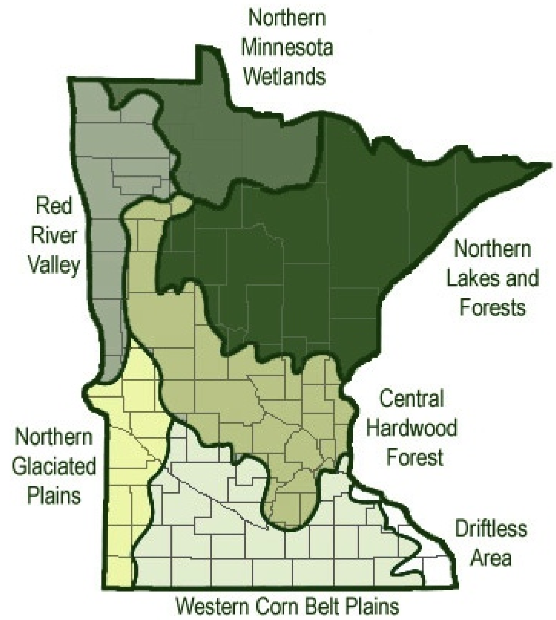
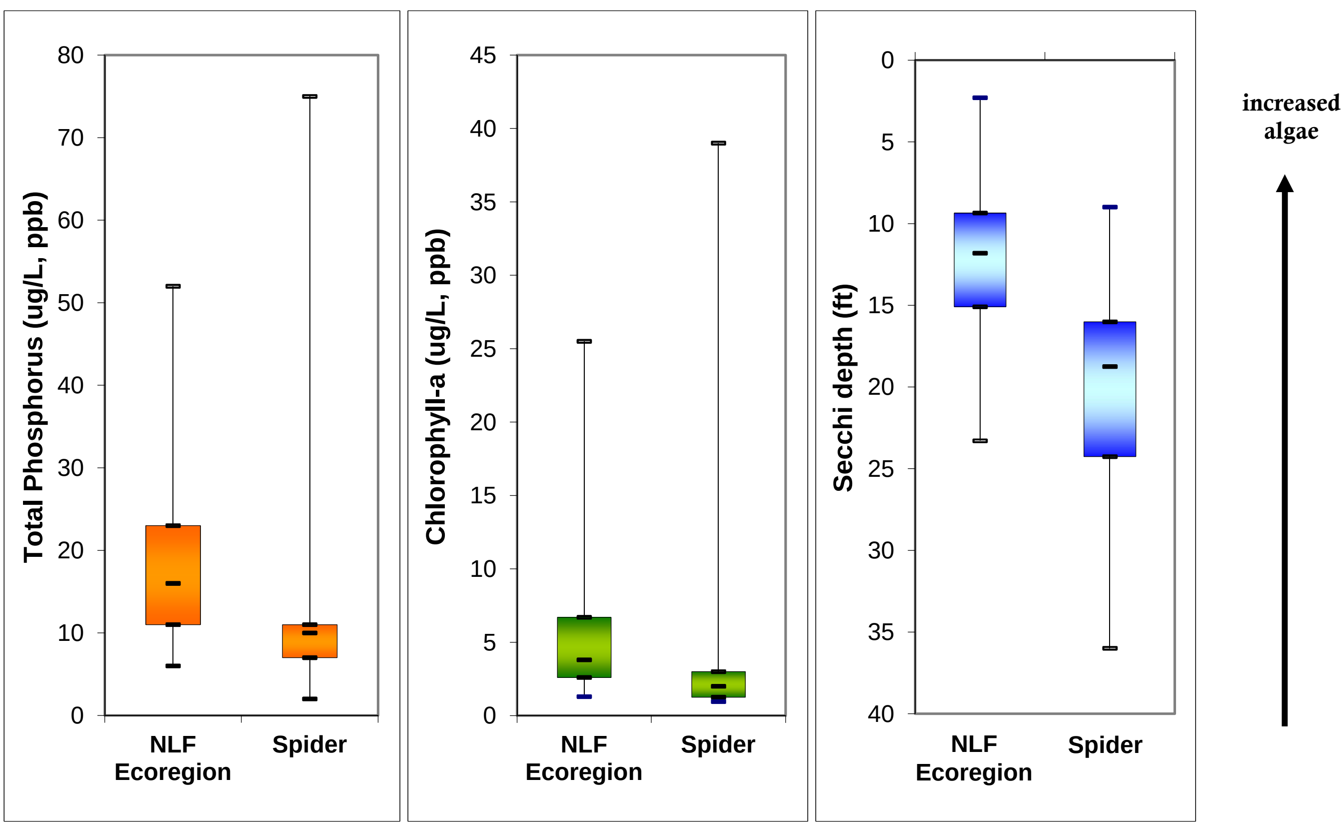


Figure 12. Map of Minnesota with the seven ecoregions.



Figures 13a-c. Spider Lake ranges compared to Northern Lakes and Forest Ecoregion ranges. The Spider Lake total phosphorus and chlorophyll *a* ranges are from 81 data points collected in May-September of 1997-2011. The Spider Lake Secchi depth range is from 159 data points collected in May-September from 1994-2011.

Lakeshed Data and Interpretations

Lakeshed

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.

The **Crow Wing River Major Watershed** is one of the watersheds that make up the Upper Mississippi River Basin, which begins at Itasca State Park and drains south towards the Gulf of Mexico (Figure 14). This major watershed is made up of 136 minor watersheds. Spider Lake is located in **minor watershed 12142** (Figure 15).

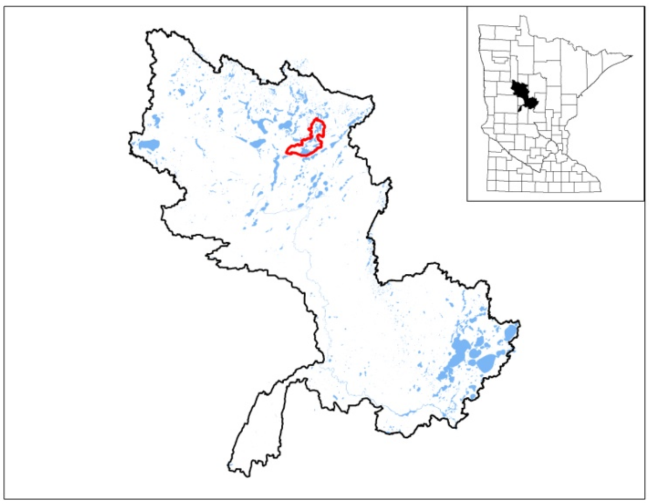


Figure 14. Crow Wing River Major

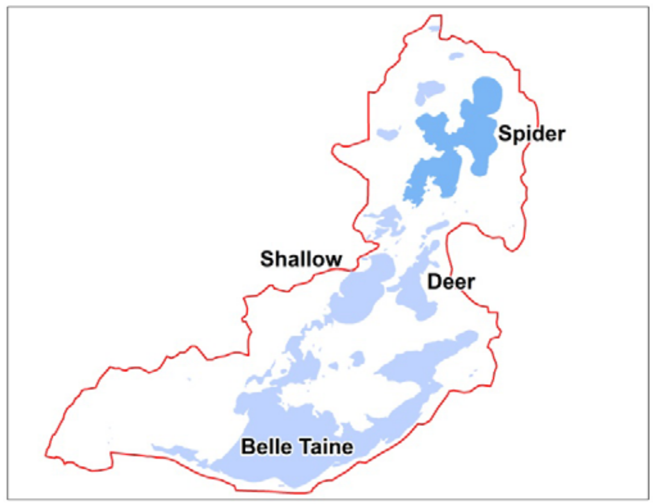


Figure 15. Minor Watershed 12142

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. Spider Lake falls within lakeshed number **1214201** (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 Spider Lake's full watershed, containing all the lakesheds upstream of Spider Lake lakeshed, see page 17. The data interpretation of the

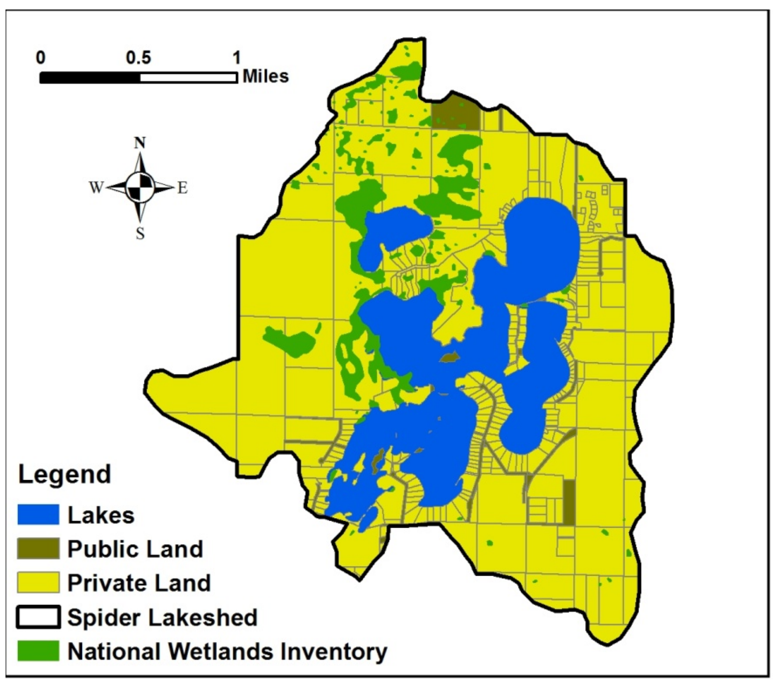


Figure 16. Spider Lake Lakeshed (1214201) with land ownership, lakes, wetlands, and rivers illustrated.

Spider Lake lakeshed includes only the immediate lakeshed, as this area is the land surface that flows directly into Spider 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 Big Sand Lake.

Lakeshed Vitals		Rating
Lake Area	467 acres (NE/SW Bay); 103 acres (East Bay)	descriptive
Littoral Zone Area	381 acres (NE/SW Bay); 44 acres (East Bay)	descriptive
Lake Max Depth	96 ft. (NE/SW Bay); 66 ft. (East Bay)	descriptive
Lake Mean Depth	10.7 ft (NE/SW Bay); 24.6 ft (East Bay)	Warrants attention
Water Residence Time	NA	NA
Miles of Stream	None	descriptive
Inlets	None	Warrants attention
Outlets	None	Warrants attention
Major Watershed	12 - Crow Wing River	descriptive
Minor Watershed	12142	descriptive
Lakeshed	1214201	descriptive
Ecoregion	Northern Lakes and Forest	descriptive
Total Lakeshed to Lake Area Ratio (total lakeshed includes lake area)	5:1	Warrants attention
Standard Watershed to Lake Basin Ratio (standard watershed includes lake areas)	5:1	Beneficial to the lake
Wetland Coverage	7%	Beneficial to the lake
Aquatic Invasive Species	None	Beneficial to the lake
Public Drainage Ditches	None	Beneficial to the lake
Public Lake Accesses	1	Warrants attention
Miles of Shoreline	11.9	descriptive
Shoreline Development Index	3.13 (NE/SW Bay); 1.62 (East Bay)	Warrants attention
Public Land : Private Land (excludes water)	0.04:1	Warrants attention
Development Classification	Recreational Development	Warrants attention
Miles of Road	11.6	descriptive
Municipalities in lakeshed	None	Beneficial to the lake
Forestry Practices	2002 Hubbard County Forest Resources Management Plan	Beneficial to the lake
Feedlots	None	Beneficial to the lake
Sewage Management	Individual waste treatment systems (last lake-wide county inspection - 1995)	Beneficial to the lake
Lake Management Plan	Healthy Lakes & Rivers Partnership, 2010	Beneficial to the lake
Lake Vegetation Survey/Plan	None	Warrants attention

Land Cover / Land Use

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

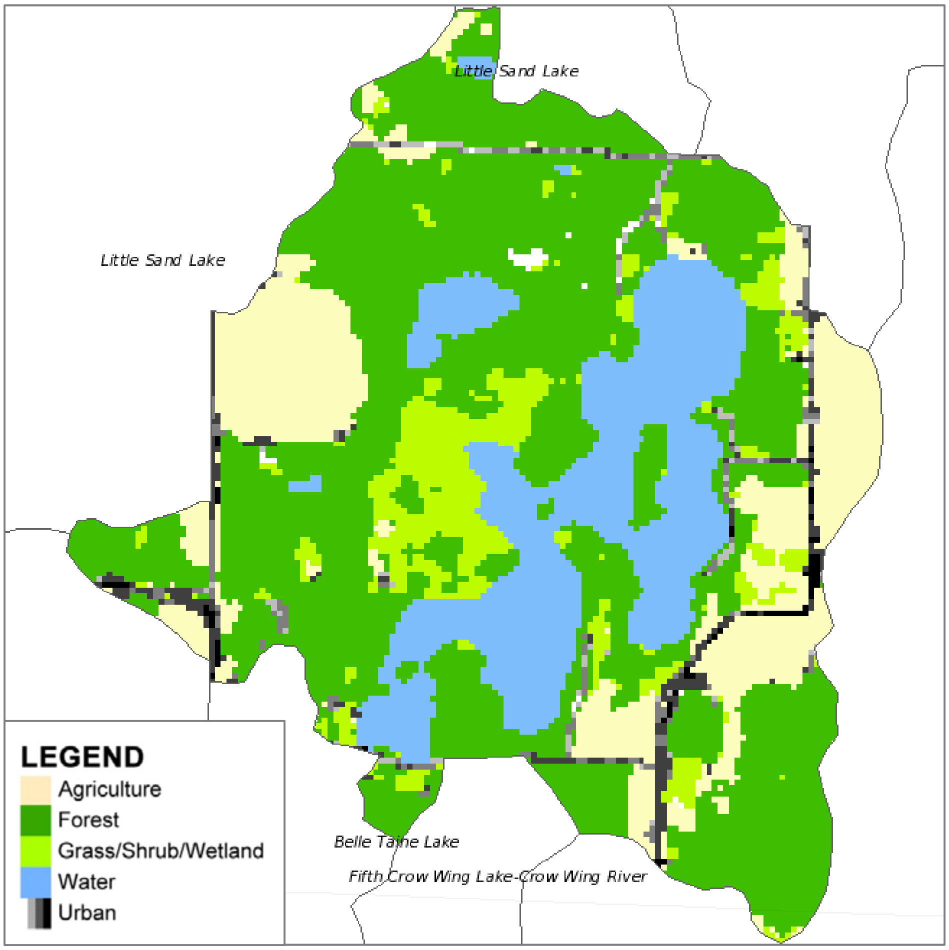


Figure 17. Land use/land cover for Spider Lake lakeshed (http://land.umn.edu).

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 Spider Lake's lakeshed.

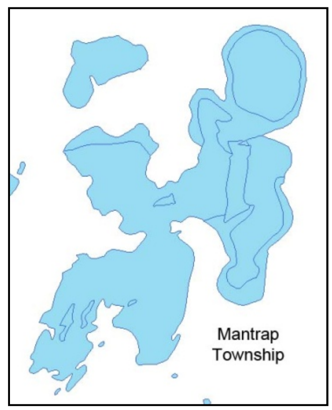
The University of Minnesota has online records of land cover statistics from years 1990 and 2000 (http://land.umn.edu). This data is somewhat outdated, but it is the most recent comparable data available. Table 10 describes Spider Lake's lakeshed land cover statistics and percent change from 1990 to 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 acreages to forest and urban acreages. The largest change in percentage is the increase in grass/shrub/wetland cover (48.2%); however, in acreage, agriculture cover has decreased the most (126 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 10. Spider 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	615	20.76	489	16.5	20.5% Decrease
Forest	1423	48.03	1535	51.81	7.9% Increase
Grass/Shrub/Wetland	170	5.74	252	8.5	48.2% Increase
Water	651	21.97	540	18.22	17.1% Decrease
Urban	107	3.61	151	5.1	41.1% Increase
Impervious Intensity %					
0	2860	96.72	2813	95.13	1.6% Decrease
1-10	24	0.81	26	0.88	8.3% Increase
11-25	30	1.01	44	1.49	46.7% Increase
26-40	17	0.57	29	0.98	70.6% Increase
41-60	19	0.64	30	1.01	57.9% Increase
61-80	7	0.24	15	0.51	114.3% Increase
81-100	0	0	0	0	No Change
Total Area	2963		2963		
Total Impervious Area (Percent Impervious Area Excludes Water Area)	26	1.12	43	1.77	65.4% Increase

Demographics

Spider 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, Mantrap Township has a higher extrapolated growth projection (Figure 18).

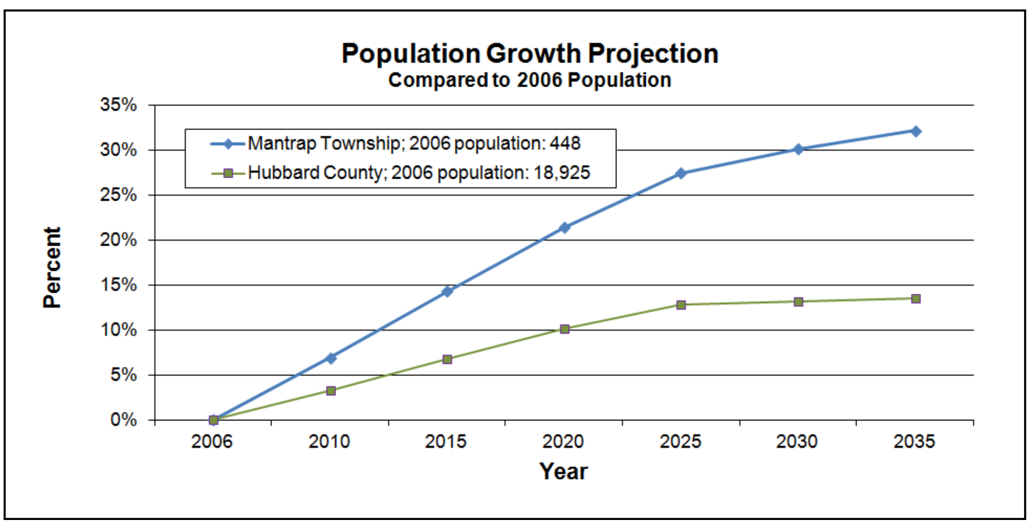


Figure 18. Population growth projection for Mantrap Township and Hubbard County. (source: http://www.demography.state.mn.us/resource.html?Id=19332)

Spider 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 Spider 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. Almost all the county-owned land consists of roads, which would have a developed runoff coefficient.

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 (75%)					22%	Public (3%)		
	Developed	**Agriculture**	**Forested Uplands**	**Other**	**Wetlands**	**Open Water**	**County**	**State**	**Federal**
Land Use (%)	3.2%	15.2%	47.7%	2.5%	6.4%	22%	1.7%	1.2%	0%
Runoff Coefficient Lbs of phosphorus/acre/year	0.45 – 1.5	0.26 – 0.9	0.09		0.09				
Estimated Phosphorus Loading Acreage x runoff coefficient	42 – 139	117 – 405	127		17				
Description	Focused on Shoreland	Cropland	Focus of develop-ment and protection efforts	Open, pasture, grass-land, shrub-land	Protected				
Potential Phase 3 Discussion Items	Shoreline restoration	Restore wetlands; CRP	Forest stewardship planning, 3rd party certification, SFIA, local woodland cooperatives		Protected by Wetland Conservation Act		County Tax Forfeit Lands	State Forest	National Forest

DNR Fisheries approach for lake protection and restoration

Credit: Peter Jacobson and Michael Duval, Minnesota DNR Fisheries

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

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

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

The next step was to prioritize lakes within each of these management categories. DNR Fisheries identified high value fishery lakes, such as cisco refuge lakes. Ciscos (*Coregonus artedi)* can be an early indicator of eutrophication in a lake because they require cold hypolimnetic temperatures and high dissolved oxygen levels. These watersheds with low disturbance and high value fishery lakes are excellent candidates for priority protection measures, especially those that are related to forestry and minimizing the effects of landscape disturbance. Forest stewardship planning, harvest coordination to reduce hydrology impacts and forest conservation easements are some potential tools that can protect these high value resources for the long term.

Spider Lake was classified with having 25.4% of the watershed protected and 20.1% of the watershed disturbed (Figure 19). Therefore, Spider Lake should have a protection focus. This lake is almost at the 25% disturbed threshold, so it is almost ranked in the yellow (full restoration) category. Goals for the lake should be to limit any increase in disturbed land use. Spider Lake is in its own watershed with no inlet or outlet.

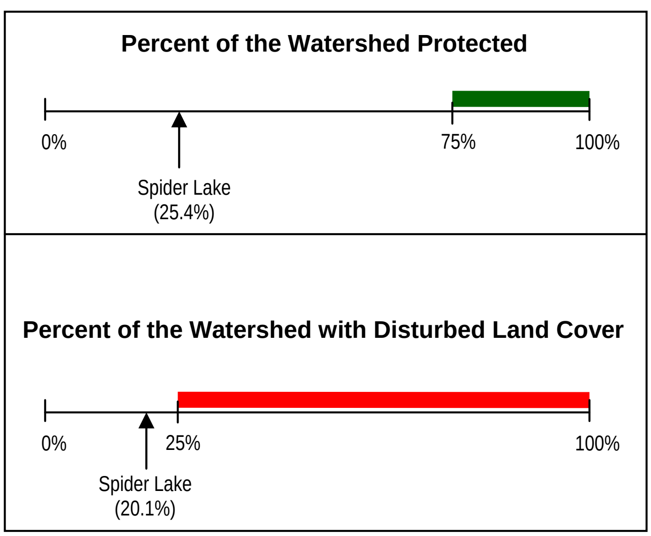


Figure 19. Spider Lake lakeshed's percentage of watershed protected and disturbed.

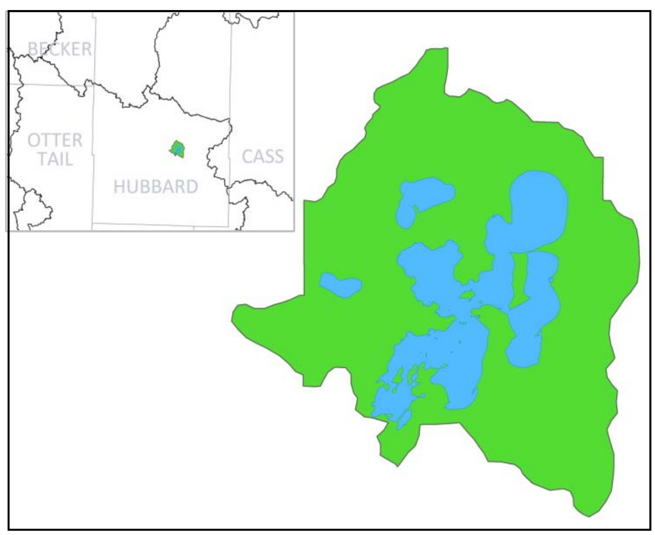


Figure 20. Upstream lakesheds that contribute water to the Spider Lake lakeshed. Color-coded based on management focus (Table 3).

Spider, Status of the Fishery (as of 06/17/2009)

Spider Lake is located three miles north of Nevis in Hubbard County. Like its name, Spider Lake is irregularly shaped with two deep basins and several shallow bays. Spider has a surface area of 544 acres and a maximum depth of 96 feet. However, there is lots of shallower water with 75% of the lake area 15 feet or less in depth. There is abundant aquatic vegetation growth in these shallow areas. Numerous hardstem bulrush stands and water lily beds are found providing excellent habitat for such species as black crappie, bluegill, and largemouth bass. The west bay can become almost solid with water lilies and water shield during the summer months. There is a public access located on the north end of the lake. Spider provides angling opportunities for panfish, largemouth bass, and northern pike.

The Minnesota Department of Natural Resources (DNR) has classified Minnesota's lakes into 43 different types based on physical, chemical, and other characteristics. Spider Lake is in class 25. Other area lakes in this same classification include West Crooked, Big Mantrap, Little Mantrap, and Ojibway.

Panfish are a popular choice for anglers on Spider. Black crappie were sampled in moderate numbers, within the range "typical" for this lake class and similar to past surveys. Anglers should be aware that all black crappie less than 10.0 inches in length must be returned to the water (10.0 inch minimum length limit). Present and past surveys have shown the bluegill population to fluctuate from low to moderate numbers. Anglers will find bluegill and pumpkinseed in the 6-8 inch size range.

Spider Lake supports a good largemouth bass fishery, probably known more for size than numbers of bass. Largemouth bass were sampled in moderate numbers (68 bass/hour) during the spring electrofishing survey, similar to past surveys.

Northern pike abundance (6.2 pike/gillnet) was within the range "typical" for this lake class and similar to past surveys. While larger northern pike are present in Spider, small, "hammer handle" pike dominate the population. Sampled northern pike had an average length and weight of 20.2 inches and 1.8 inches, with pike measured up to 34.8 inches. The northern pike in Spider have slow growth rates. Silver pike, a color phase of northern pike, have been sampled in past surveys.

Walleye are found in low numbers in Spider. Walleye abundance (0.1 walleye/gillnet) was well below the range "typical" for this lake class. Walleye have not been stocked into Spider since 1991. The walleye population in Spider is being maintained by limited and sporadic natural reproduction.

Other species sampled included moderate numbers of white sucker, yellow bullhead, and rock bass. Brown bullhead, black bullhead, and tullibee (cisco) were sampled in low numbers.

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=29011700

Key Findings / Recommendations

Monitoring Recommendations
Transparency monitoring at site 201 in both bays should be continued annually (Figure 1). 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, as the budget allows, to track future water quality trends.

Overall Conclusions
Spider Lake is an excellent water resource. It is an oligotrophic lake (TSI=38) with no detectable water quality trends. Three percent (3%) of the lakeshed is in public ownership, and 25.4% of the watershed is protected, while 20.1% of the watershed is disturbed (Figure 6).

For a small, mostly shallow lake, Spider Lake has very low productivity (phosphorus and chlorophyll). This could be due to the fact that it has a very small watershed, with no inlets or outlets (5:1 watershed to lake area ratio). This means that land practices around the lake are the main impact to the lake. It also means that any improvements to land management in the lakeshed should have a direct positive effect on the lake's water quality.

Spider Lake is unique limnologically because of its size, shape and depth. Most of the lake is very shallow, but there is a very small deep (96 ft) hole on the north end of the NE/SW Bay. This small deep hole stratifies very strongly in the summer as there is not much surface area for wind mixing. It also shows interesting oxygen dynamics, as the oxygen is highest in the middle of the water column (Figure 9).

The DNR is in the process of acquiring an Aquatic Management Area (AMA) on Spider Lake. See the pages 21-22 for details.

Priority Impacts to the Lake
The main disturbances to Spider Lake include agriculture on the eastern shoreline and development pressure. The northwestern shoreline is largely undeveloped; however, land parcel subdivision along a new road extension in 2007 signal future shoreline development. From 1990-2000, urban land cover in the Spider Lake lakeshed increased by 44 acres (Table 2). The population in the Mantrap Township is projected to grow another 25% in the next 10 years.

Best Management Practices Recommendations
The management focus for Spider Lake should be to protect the current water quality. Protection efforts should be focused on improving lake protection from agriculture and development, including second tier development, through wetland restoration, shoreline buffers (especially on the eastern side from agriculture), rain gardens, and septic system maintenance. In addition, land could be protected from future disturbance by conservation easements.

Targeted placement of best management practices can increase their cost effectiveness. Individual parcel assessment of percent impervious cover and proximity to 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. Placement of BMPs near the shoreline on a path where water flow accumulates would be ideal placement.

Organizational contacts and reference sites

Spider Lake Association	No contact information available.
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/

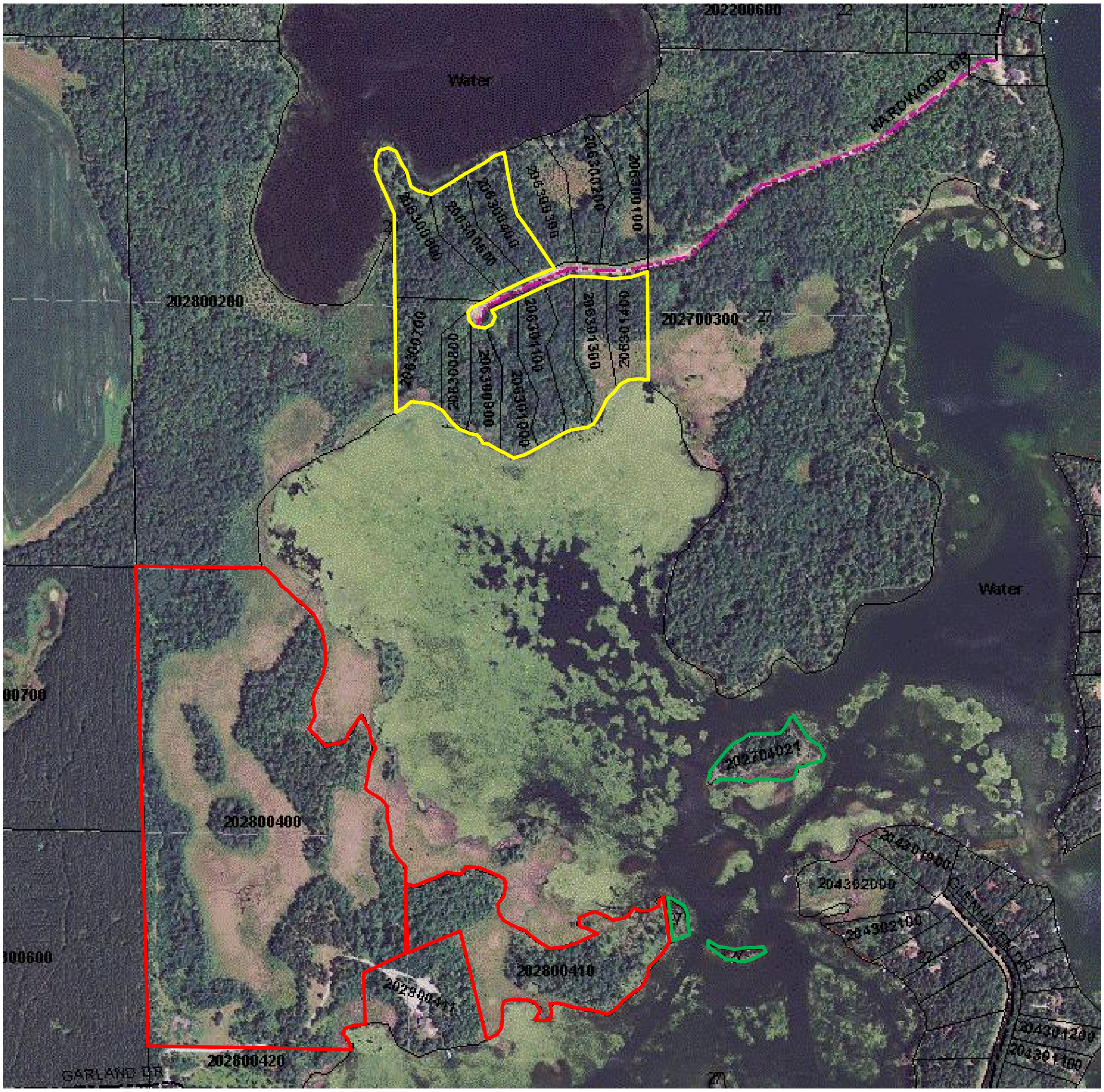
Spider Lake
Aquatic Management Area (AMA)

What: A cooperative project between Minnesota Department of Natural Resources (MN DNR) Fisheries, Spider Lake Association and private landowners to purchase approximately 96 acres on Spider and Crow Wing Lakes in Hubbard County. The two proposed tracts together contain about 7,360 feet of shoreline on Spider Lake, about 1,300 feet of shoreline on Crow Wing Lake, and about 34 acres of riparian wetlands. The project would provide access for shore fishing on both Spider and Crow Wing Lakes.

Why: Acquisition of this property would:

- Protect high quality riparian wetlands in and along a very shallow back bay of Spider Lake
  - Public ownership of these properties would reduce boat traffic, limiting destruction of aquatic vegetation and re-suspension of nutrient rich substrates.
- Protect critical fisheries habitat
  - Spider Lake is managed primarily for crappie, largemouth bass and bluegill, but also supports good populations of northern pike, yellow perch and a variety of nongame fish
  - The 7,360 feet of Spider Lake shoreline provides important habitat for spawning, nursery, feeding, resting, and cover for these fish
- Protect water quality of Spider and Crow Wing Lakes
  - Maintaining natural land cover will allow greater infiltration of rainwater, resulting in less runoff, less sediments and fewer nutrients (Phosphorus) entering the lakes.
  - Maintaining native aquatic vegetation will help add dissolved oxygen to the water, filter nutrients, stabilize substrates and reduce erosion.
  - Less boat traffic in shallow areas will reduce the re-suspension of nutrient rich substrates, reducing potential algae blooms or oxygen depletion.
- Protect wildlife resources
  - Wildlife likely to breed, nest or use the area include deer, bear, beaver, otter, mink, other furbearers, loons, ruffed grouse, and a variety of birds, migratory waterfowl, reptiles and amphibians.
- Protect this area from development
  - Recent studies by DNR and others have found that as shoreland areas are developed, fish habitat decreases and water quality is negatively impacted.
- The Fisheries Management Plan for Spider Lake identifies development, removal of vegetation, and water quality degradation as limiting factors to fish management.
- The Fisheries Management Plan specifically recommends acquiring property to protect identified spawning areas or other critical habitat.
- Provide public access to Crow Wing Lake for shore fishing and fisheries management activities, additional shore fishing access on Spider Lake, and potential opportunities for recreation trails for hiking or nature observation.

Spider Lake
Aquatic Management Area (AMA)



Legend

- Existing State Lands
- Proposed Spider L AMA – Tract 1
- Proposed Spider L AMA – Tract 2