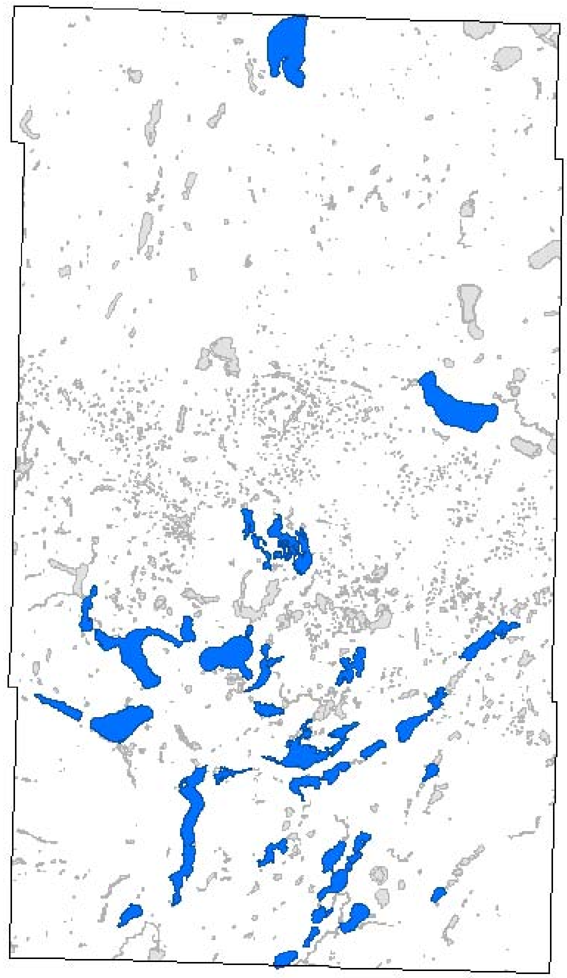
Hubbard County
Large Lakes Assessment



2012

Hubbard Soil and Water Conservation District
Minnesota Board of Soil and Water Resources

List of Abbreviations

BWSR: Board of Soil and Water Resources

CHLA: Chlorophyll *a*

CLMP: Citizens Lake Monitoring Program – transparency data collection

COLA: Coalition of Lake Associations

CSMP: Citizens Stream Monitoring Program

DNR: Minnesota Department of Natural Resources

MPCA: Minnesota Pollution Control Agency

SWCD: Soil and Water Conservation District

TMDL: Total Maximum Daily Load

TP: Total phosphorus

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Organizations contributing data and information
Minnesota Department of Natural Resources (DNR)
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Hubbard County Coalition of Lake Associations (COLA)

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Introduction

Hubbard County is located in the lakes country of northern Minnesota. Open water covers 7% of the surface area of Hubbard County - and an additional 12.5% of the county is covered by wetlands. These resources are valued for their excellent recreation opportunities and water quality.

Hubbard County has approximately 728 lakes, and thirty of these lakes have lake associations that are members of Hubbard County Coalition of Lake Associations (COLA). Most of the COLA lakes are located in the Crow Wing River Watershed (Figure 1).

For the purpose of future water planning, the Hubbard Soil and Water Conservation District (SWCD) and Hubbard COLA wanted an evaluation of current lake water quality. Lakes evaluated in this report are indicated in dark blue in Figure 1 and listed in Table 2.

Hubbard County lakes that are members of COLA have been monitored by volunteers from 1997-2011, and have an excellent data set for evaluation (Table 1).

The purpose of this report was to compile all available data for these lakes from all the different sources, evaluate the data quality, identify data gaps, assess the data, and look for water quality trends. This report contains a summary of the current state of Hubbard County COLA lakes and recommendations for future monitoring.

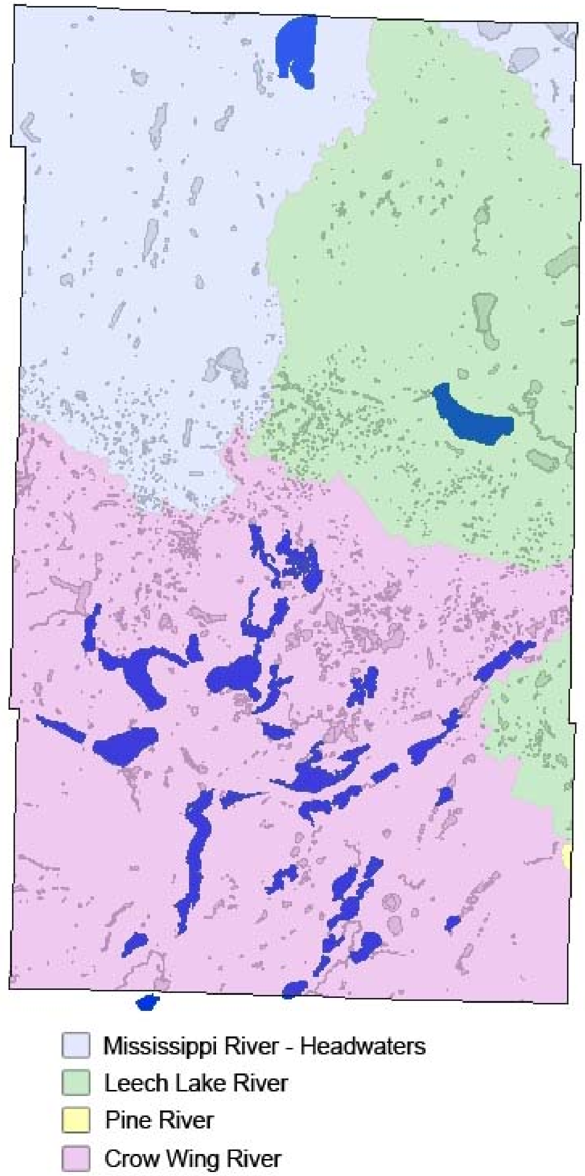


Figure 1. Major watersheds in Hubbard County.

Table 1. Data availability for Hubbard COLA lakes.

Data Availability

Transparency data		Secchi disk data have been collected extensively and should continue yearly since it is relatively easy and inexpensive.
Chemical data		Most large Hubbard County lakes have at least 10 years of water quality data.
Inlet/Outlet data		Inlet/outlet data are sparse, and could be collected on lakes with declining transparency trends to investigate the cause in water quality decline.

Table 2. Lakes assessed in the 2012 lakes assessment.

Lake Name	Lake ID	Lake Size (acres)
1st Crow Wing	29-0086-00	526
2nd Crow Wing	29-0085-00	181
3rd Crow Wing	29-0077-00	643
4th Crow Wing	29-0078-00	497
5th Crow Wing	29-0092-00	392
6th Crow Wing	29-0093-00	320
7th Crow Wing	29-0091-00	254
8th Crow Wing	29-0072-00	492
9th Crow Wing	29-0025-00	224
11th Crow Wing	29-0036-01	790
Bad Axe	29-0208-00	271
Belle Taine	29-0146-00	1185
Big Mantrap	29-0151-01	750
Big Sand	29-0185-00	1659
Blue	29-0184-00	324
Boulder	29-0162-00	360
Duck	29-0142-00	326
Eagle	29-0256-00	411
Emma	29-0186-00	77
Fishhook	29-0242-00	1632
Gilmore	29-0188-00	91
Ham	29-0017-00	178
Hinds	29-0249-00	294
South Island	29-0088-00	212
Kabekona	29-0075-00	2252
Little Sand	29-0150-00	386
Long	29-0161-00	1941
Lower Bottle	29-0180-00	652
Lower Twin	80-0030-00	391
Palmer	29-0087-00	142
Peysenske	29-0169-00	195
Plantagenet	29-0156-00	2529
Portage	29-0250-00	412
Potato	29-0243-00	2100
Spider	29-0117-01	569
Stocking	29-0172-00	88
Stony	29-0143-00	319
Tripp	29-0005-00	145
Upper Bottle	29-0148-00	465

=

Trophic State Index (TSI)

Trophic State Index (TSI) is a standard measure or means for calculating the trophic status, or productivity, of a lake. More specifically, it is the total weight of living biological material (*biomass*) in a waterbody at a specific location and time.

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

Trophic states are defined divisions of a continuum in water quality. The continuum is total phosphorus concentration, chlorophyll a concentration and Secchi depth. Scientists define certain ranges in the above lake measures as different trophic states so they can be easily referred to.

Most of the Hubbard County lakes fall into the oligotrophic and mesotrophic classifications (Table 3, Figure 2). The eutrophic lakes are shallow lakes.

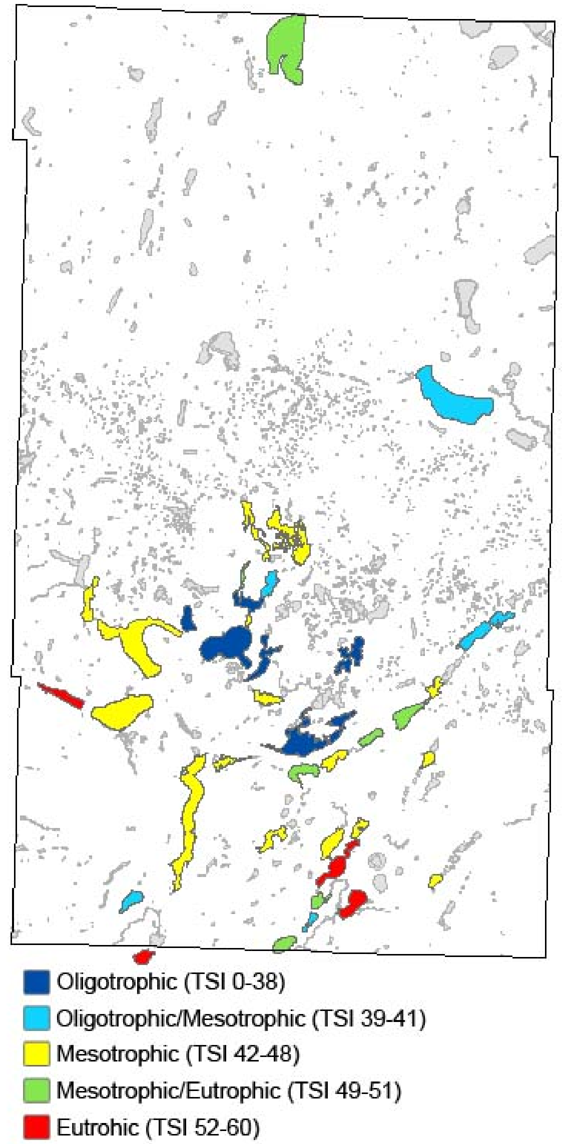


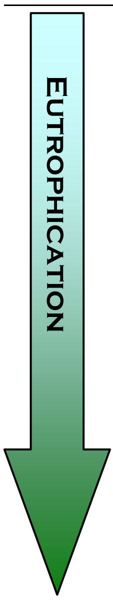
Figure 2. Hubbard County large lakes illustrating trophic states.

Table 3. Trophic state and trophic state index for large lakes in Hubbard County.

Lake	Mean TSI	Trophic State	Mean TSI Secchi	Mean TSI phosphorus	Mean TSI chlorophyll *a*
Belle Taine	35	Oligotrophic	33	37	36
Little Sand	35	Oligotrophic	33	36	35
Big Sand	36	Oligotrophic	36	35	36
Spider	36	Oligotrophic	35	35	38
Lower Bottle	37	Oligotrophic	37	38	37
Blue	38	Oligotrophic	38	38	38
Gilmore	38	Oligotrophic	38	37	40
Kabekona	40	Oligotrophic/Mesotrophic	40	40	40
11th Crow Wing	41	Oligotrophic/Mesotrophic	40	40	44
Hinds	41	Oligotrophic/Mesotrophic	40	42	43
Palmer	41	Oligotrophic/Mesotrophic	40	39	42
Upper Bottle	41	Oligotrophic/Mesotrophic	39	42	41

Table 3. Continued…

Lake	Mean TSI	Trophic State	Mean TSI Secchi	Mean TSI phosphorus	Mean TSI chlorophyll *a*
Boulder	42	Mesotrophic	42	41	44
Emma	42	Mesotrophic	41	43	42
Ham	42	Mesotrophic	43	40	42
Peysenske	42	Mesotrophic	45	43	39
Bad Axe	43	Mesotrophic	39	44	45
Big Mantrap	43	Mesotrophic	40	44	46
Potato	43	Mesotrophic	43	39	46
Fishhook	44	Mesotrophic	43	44	46
Long	44	Mesotrophic	43	42	46
South Island	44	Mesotrophic	41	44	46
Stony	44	Mesotrophic	43	43	46
Tripp	44	Mesotrophic	43	44	45
9th Crow Wing	46	Mesotrophic	44	44	49
Eagle	46	Mesotrophic	44	46	48
4th Crow Wing	48	Mesotrophic	48	49	48
6th Crow Wing	48	Mesotrophic	46	48	49
5th Crow Wing	49	Mesotrophic/Eutrophic	46	48	52
Duck	49	Mesotrophic/Eutrophic	49	46	51
Stocking	49	Mesotrophic/Eutrophic	46	51	51
2nd Crow Wing	50	Mesotrophic/Eutrophic	50	47	54
7th Crow Wing	50	Mesotrophic/Eutrophic	49	50	52
8th Crow Wing	50	Mesotrophic/Eutrophic	47	52	52
Plantagenet	50	Mesotrophic/Eutrophic	47	52	51
3rd Crow Wing	52	Eutrophic	52	52	53
Lower Twin	54	Eutrophic	51	55	56
1st Crow Wing	58	Eutrophic	57	60	59
Portage	59	Eutrophic	58	59	59



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.

Water Quality Trends

For detecting trends, a minimum of 8-10 years of data with 4 or more readings per season are recommended. Minimum probabilty 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 a good amount of data available for Hubbard COLA lakes. Most lakes had enough data for trend analysis for total phosphorus (TP), chlorophyll a (CHLA) and Transparency (Tables 4-7). The data was analyzed using the Mann Kendall Trend Analysis.

Table 4. Hubbard COLA Lakes with improving water quality trends (TP=Total phosphorus, CHLA= Chlorophyll a, Secchi=Transparency).

Lake	Parameter	Date Range	Trend	Probability
Little Sand	Secchi	1987-2011	Improving	99.9%
	TP	1997-2011	Improving	99%
	CHLA	1997-2011	No trend	-
Big Sand	Secchi	1994-2011	Improving	99%
	TP	1998-2011	Improving	95%
	CHLA	1998-2011	No trend	
Emma	TP	1999-2011	Improving	90%
	CHLA	1999-2011	No trend	-
	Secchi	Insufficient data	-	-
Eagle	Secchi	1997-2011	Improving	95%
	TP, CHLA	1997-2011	No trend	
Hinds	Secchi	1994-2003, 2006-2011	Improving	95%
	TP, CHLA	1997-2000, 2002-2004, 2006-2011	No trend	
Kabekona	Secchi	2000-2011	Improving	95%
	Secchi	1995-2011	No trend	-
	TP, CHLA	1994,1997-2010	No trend	-
Potato	Secchi	1990-2011	Improving	95%
	TP, CHLA	1997-2011	No trend	-
Stocking	Secchi	1995-2011	Improving	99%
	TP, CHLA	1997-2011	No trend	-

Table 5. Hubbard COLA Lakes with no evidence of water quality trends (TP=Total phosphorus, CHLA= Chlorophyll a, Secchi=Transparency).

Lake	Parameter	Date Range	Trend	Probability
2nd Crow Wing	Secchi, TP, CHLA	2003-2011	No trend	-
4th Crow Wing	Secchi, TP, CHLA	2003-2011	No trend	-
5th Crow Wing	Secchi, TP, CHLA	1998-2006, 2009-2011	No trend	-
6th Crow Wing	Secchi, TP, CHLA	1998-2011	No trend	-
7th Crow Wing	Secchi, TP, CHLA	2004-2011	No trend	-
8th Crow Wing	Secchi	1997-2011	No trend	-
	TP, CHLA	Insufficient data		-
Bad Axe	Secchi	1996-2011	No trend	-
	TP, CHLA	Insufficient data		-
Belle Taine	Secchi, TP, CHLA	1994-2007, 2009-2011	No trend	-
Big Mantrap (all bays)	Secchi, TP, CHLA	1997-2011	No trend	-
Blue	Secchi, TP, CHLA	1989-1996, 2002-2011	No trend	-
Boulder	Secchi, TP, CHLA	2002-2004, 2007-2011	No trend	-
Duck	Secchi, TP, CHLA	2005-2011	No trend	-
Fishhook	Secchi	1988-2011	No trend	-
	TP, CHLA	Insufficient data	-	-
Lower Twin	Secchi, TP, CHLA	1997-2011	No trend	-
Peysenske	Secchi, TP, CHLA	1997-1998, 2000, 2004-2011	No trend	-
Portage	Secchi, TP, CHLA	1997-2011	No trend	-
South Island	Secchi, TP, CHLA	1997-2011	No trend	-
Spider	Secchi, TP, CHLA	1997-2011	No trend	-
Stony	Secchi, TP, CHLA	1997-2011	No trend	-
Upper Bottle	Secchi, TP, CHLA	1998-2011	No trend	-

Table 6. Hubbard COLA Lakes with declining water quality trends. For chlorophyll a and phosphorus parameters, a declining trend means that their concentrations are increasing. For transparency, a declining trend means that the clarity is decreasing (TP=Total phosphorus, CHLA= Chlorophyll a, Secchi=Transparency).

Lake	Parameter	Date Range	Trend	Probability
1st Crow Wing	Secchi	1997-2011	Declining	90%
	TP, CHLA	1997-1999,2001-2011	No trend	-
9th Crow Wing	Secchi	1999-2001, 2004-2011	Declining	95%
	TP, CHLA	Insufficient data		-
Gilmore	Secchi	1991-2011	Declining	90%
	TP, CHLA	1997-2011	No trend	-
Long	Secchi	1990-2011	Declining	95%
	TP, CHLA	1997-2011	No trend	-
Lower Bottle	Secchi	2000-2011	Declining	90%
	CHLA	2000-2011	Declining	90%
	TP	2000-2011	No trend	-
Palmer	Secchi	1997-2011	Declining	95%
	CHLA	1997-2011	Declining	90%
Plantagenet	Secchi	2003-2011	Declining	90%
	TP, CHLA	2003-2011	No trend	-

Table 7. Hubbard COLA Lakes with insufficient data for analyzing water quality trends (TP=Total phosphorus, CHLA= Chlorophyll a, Secchi=Transparency).

Lake	Parameter	Date Range	Trend	Probability
11th Crow Wing	Secchi, TP, CHLA	Insufficient data	-	-
3rd Crow Wing	Secchi, TP, CHLA	Insufficient data	-	-
Ham	Secchi, TP, CHLA	Insufficient data	-	-
Tripp	Secchi, TP, CHLA	Insufficient data	-	-

Ecoregion Comparisons

Minnesota is divided into 7 ecoregions based on land use, vegetation, precipitation and geology. The MPCA has developed a way to determine the "average range" of water quality expected for lakes in each ecoregion. 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.

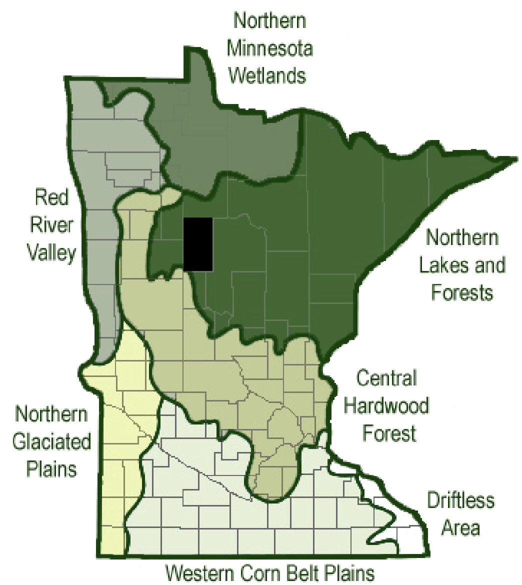


Figure 3. Minnesota Ecoregions. Hubbard County is shown in black.

All of Hubbard County is in the Northern Lakes and Forests (NLF) Ecoregion (Figure 3). This heavily forested ecoregion is made up of steep, rolling hills interspersed with pockets of wetlands, bogs, lakes and ponds. Lakes are typically deep and clear, with good gamefish populations. These lakes are very sensitive to damage from atmospheric deposition of pollutants (mercury), storm water runoff from logging operations, urban and shoreland development, mining, inadequate wastewater treatment, and failing septic systems. Agriculture is somewhat limited by the hilly terrain and lack of nutrients in the soil, though there are some beef and dairy cattle farms.

Most of the lakes evaluated in this report fall within the expected ecoregion ranges. The Crow Wing Chain of Lakes, Lower Twin, Portage, and Stocking Lakes are not typical lakes for the NLF Ecoregion. They are shallow, which may be why they are poorer than the Ecoregion ranges (Table 8).

Table 7. Northern Lakes and Forest Ecoregion ranges.

Total Phosphorus (ug/L)	Chlorophyll *a* (ug/L)	Secchi Depth (ft)
14-27	<10	8 - 15

Table 8. Hubbard COLA lakes compared to the NLF Ecoregion Ranges.

Better than Ecoregion averages	Within Ecoregion Averages	Poorer Than Ecoregion Averages
Belle Taine	4th Crow Wing	1st Crow Wing
Big Sand	5th Crow Wing	2nd Crow Wing
Blue	6th Crow Wing	3rd Crow Wing
Gilmore	7th Crow Wing	8th Crow Wing
Hinds	9th Crow Wing	Lower Twin
Kabekona	11th Crow Wing	Portage
Little Sand	Bad Axe	Stocking
Lower Bottle	Big Mantrap	
Spider	Boulder	
	Duck	
	Eagle	
	Emma	
	Fishhook	
	Ham	
	South Island	
	Long	
	Palmer	
	Peysenske	
	Plantagenet	
	Potato	
	Stony	
	Tripp	
	Upper Bottle	

* The "average range" refers to the 25th - 75th percentile range for data within each ecoregion. For more information visit: http://www.pca.state.mn.us/index.php/topics/environmental-data/eda-environmental-data-access/eda-surface-water-searches/eda-guide-to-typical-minnesota-water-quality-conditions.html

Statewide Assessments

Lake monitoring should be designed and accomplished for achieving specific goals. There are two main purposes for lake monitoring in Minnesota. The first is the MPCA statewide 303(d) and 305(b) assessments that occur every two years. Statewide MPCA Assessments are performed with a minimum data set of 8 data points each of total phosphorus, chlorophyll *a*, and secchi depth over a two-year period in the past 10 years. This assessment can be considered the first step to understanding a lake.

The second purpose for lake monitoring is ongoing education, awareness and lake condition. After the lake's current condition is determined, associations can monitor water quality each year to learn about seasonal variability, year-to-year variability, and if the water quality is improving, declining or staying the same (trend analysis). Condition monitoring involves collecting at least 5 samples during the growing season (the typical program involves monitoring once a month May-September) each year.

Impaired Waters Assessment 303(d) List
There are two main types of Impaired Waters Assessment for lakes: eutrophication (phosphorus) for aquatic recreation and mercury in fish tissue for aquatic consumption.

Numerous Hubbard County lakes were listed as impaired for aquatic consumption on the Impaired Waters List; however, many of them are part of the statewide mercury TMDL (Figure 4). The remaining lakes in the county most likely are not listed due to lack of fish tissue data. There are statewide fish consumption guidelines available from the Minnesota Department of Health: http://www.health.state.mn.us/divs/eh/fish/index.html.

Most Mercury comes from the air. Mercury gets into the air through emissions from coal-burning plants and taconite processing and moves long distances in the wind currents. From there, it settles into our lakes and streams and bacteria convert it to a toxic form, methyl mercury. The problem is that 90% of the mercury in our waters comes from other states and countries, which is why it is so hard to regulate. In turn, 90% of the mercury emitted in Minnesota goes to other states and countries.

The mercury that settles into our lakes and streams gets filtered by zooplankton, the tiny animals that get eaten by small fish. The larger the small fish gets, the more mercury builds up in its tissue from all the zooplankton eaten. Mercury bioaccumulates, which means that at each step in the food chain the mercury builds to higher levels, especially in large predatory fish such as walleye, northern pike and muskies.

Ten lakes in Hubbard County are currently listed as impaired for eutrophication as of the 2010 Impaired Waters List: First Crow Wing, Eighth Crow Wing, Lower Twin, Portage, and Upper Twin (Figure 4).

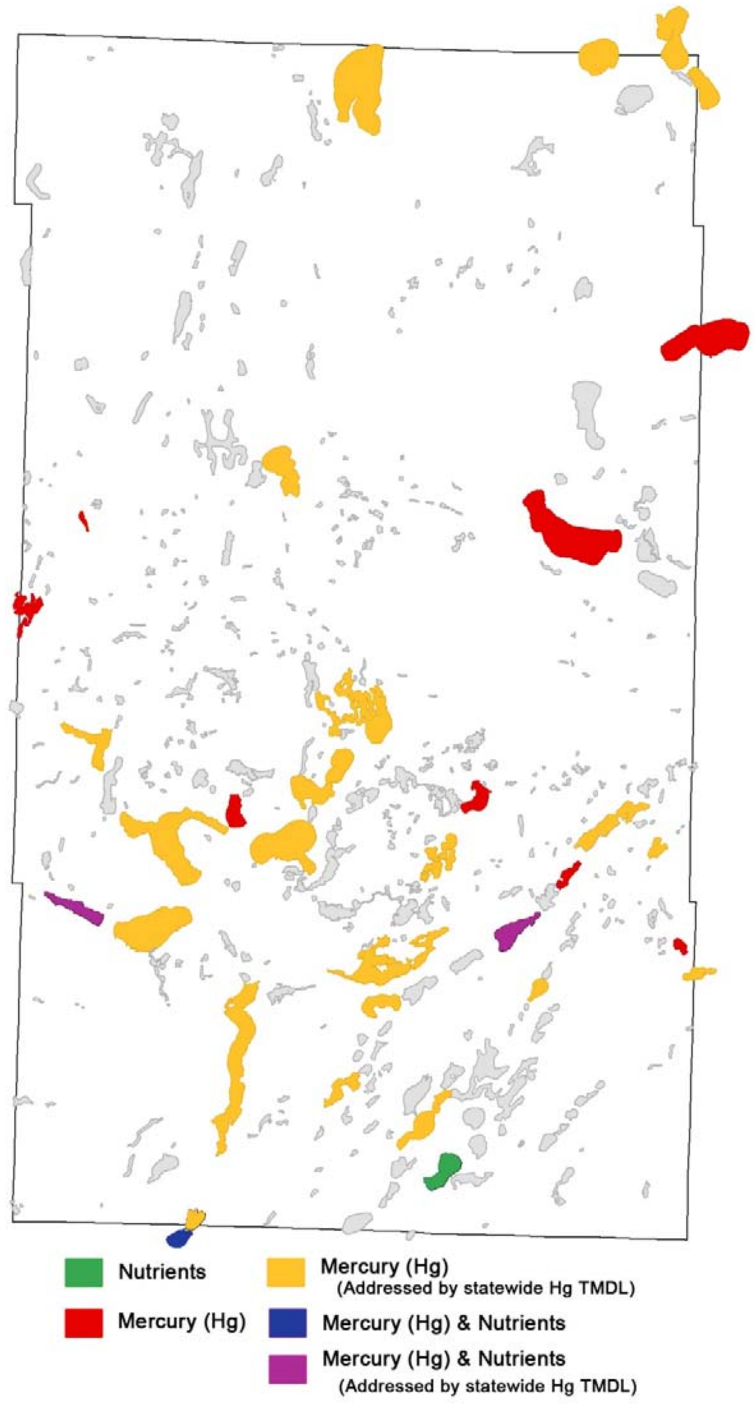


Figure 4. Hubbard County lakes illustrating impaired waters status.

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 9). Watershed disturbance was defined as having urban, agricultural and mining land uses. Watershed protection is defined as publicly owned land or conservation easement.

Table 9. 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.

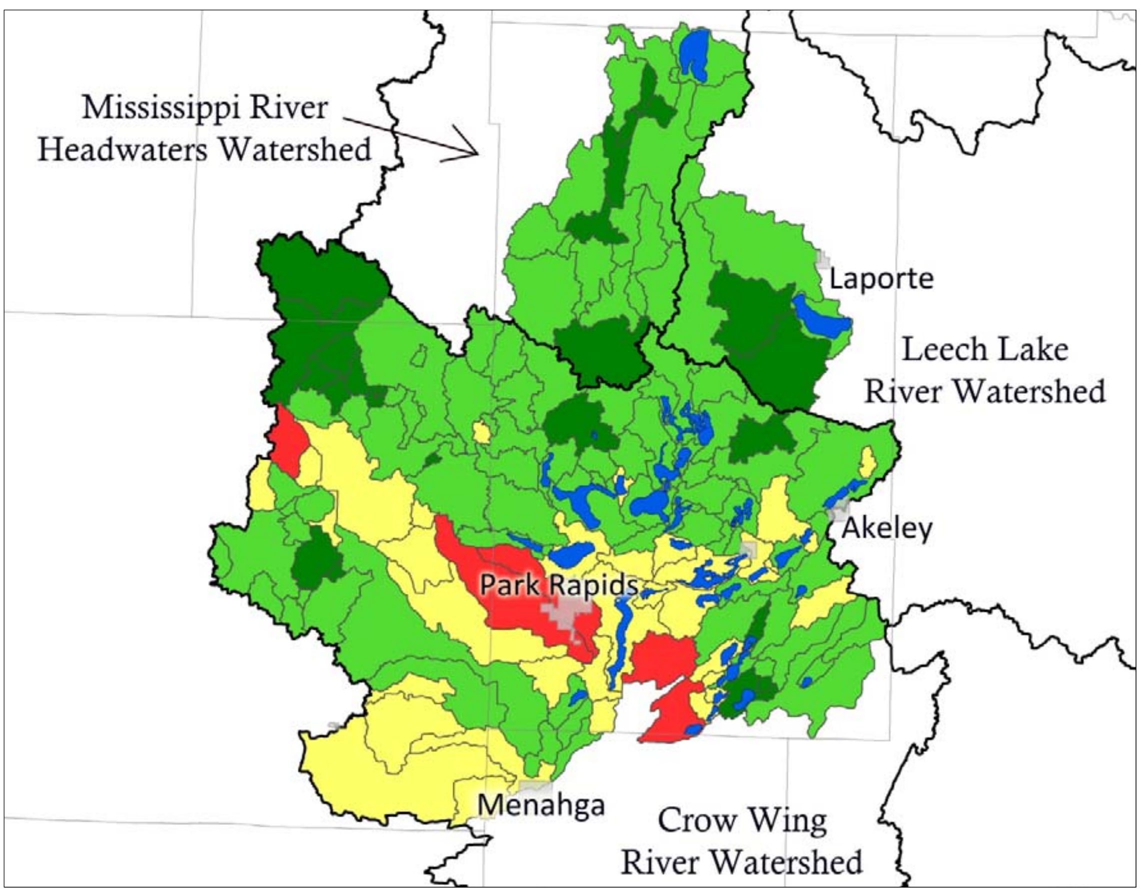


Figure 5. Suggested approaches for watershed protection and restoration of lakesheds that drain to or contain the lakes of interest.

Over half of the Hubbard County lakes have a protection focus, with several more being fully restorable (Figure 5, Table 10). Only Duck Lake was evaluated as having just a partial restoration focus.

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.

Table 10. Hubbard County Lakes evaluation of watershed protection and disturbance.

Lake Name	Management Focus	MN DNR cisco refuge lake
1st Crow Wing	Vigilance	
South Island	Vigilance	
Stony	Vigilance	
3rd Crow Wing	Protection	
6th Crow Wing	Protection	
8th Crow Wing	Protection	
11th Crow Wing	Protection	X
Bad Axe	Protection	
Big Mantrap	Protection	
Big Sand	Protection	X
Eagle	Protection	
Emma	Protection	
Gilmore	Protection	
Ham	Protection	
Hinds	Protection	
Kabekona	Protection	X
Little Sand	Protection	
Lower Bottle	Protection	
Lower Twin	Protection	
Plantagenet	Protection	
Portage	Protection	
Potato	Protection	
Spider	Protection	
Stocking	Protection	
Tripp	Protection	
Upper Bottle	Protection	
2nd Crow Wing	Full Restoration	
4th Crow Wing	Full Restoration	
5th Crow Wing	Full Restoration	
7th Crow Wing	Full Restoration	
9th Crow Wing	Full Restoration	X
Belle Taine	Full Restoration	
Blue	Full Restoration	X
Boulder	Full Restoration	
Fishhook	Full Restoration	
Long	Full Restoration	X
Palmer	Full Restoration	
Peysenske	Full Restoration	
Duck	Partial Restoration	

Aquatic Invasive Species

Invasive species are a large threat to Minnesota's lakes. Invasive species can get out of control because there is nothing in the ecosystem naturally to keep the population in check. They can also replace native beneficial species and change the lake's ecosystem.

As of 2011, Hubbard County only has a few aquatic invasive species. Curly-leaf pondweed is found in Upper Twin, Hinds, and Portage Lakes. This invasive plant is a nuisance because it can form dense mats in early spring that interfere with recreation. When it dies off in June, it washes up in thick piles on the shoreline. Curly-leaf pondweed can be successfully controlled with herbicidal treatments.

Faucet snails are established in First and Second Crow Wing Lakes, and Upper Twin Lake. The faucet snail is an aquatic snail native to Europe and was introduced to the Great Lakes in the 1870s. It is an intermediate host for three intestinal trematodes, or flukes, that cause mortality in ducks and coots.

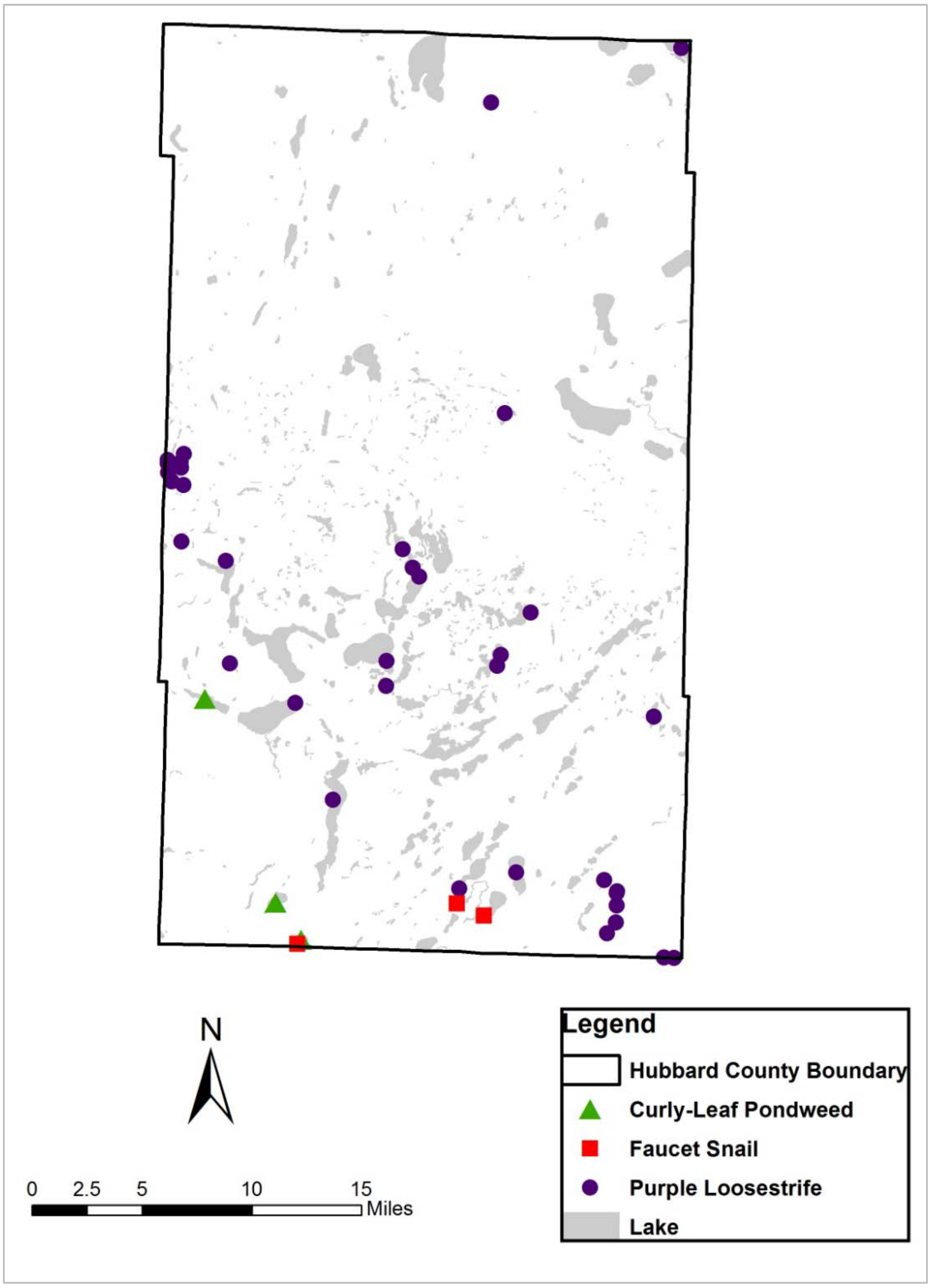


Figure 6. Aquatic invasive species in Hubbard County as of 2011.

At boat landings, there are usually DNR signs telling which invasive species are present in the waterbody and how to prevent their spread. Boaters should be educated about how to check for invasive species before moving from lake to lake. Care should be taken to protect Hubbard County's excellent water resources from future aquatic invasive species infestations.

For a current list of the infested waters in Minnesota, visit the DNR's website: http://www.dnr.state.mn.us/invasives/index_aquatic.html.

Specific Recommendations

Overall
The lakes area in Hubbard County is at an advantage because it is at the headwaters of three major watersheds: Crow Wing Watershed, Leech Lake Watershed and the Mississippi River Headwaters. Therefore, most of the lakes evaluated in this report are in excellent condition; they have no declining trend and a well protected watershed.

Some lakes are an exceptional water resource including Big Sand, Little Sand and Kabekona Lakes. They have improving water quality trends, protected watersheds, and Big Sand and Kabekona are cisco refuge lakes. It's imperative to maintain the current water quality in these lakes.

Second tier development seems to be the largest risk to the lakes in Hubbard County. Once the second tier is developed, the drainage in the lakeshed changes and more runoff reaches the lake from impervious surface and lawns.

Aquatic Invasive Species
As of 2011, there are only a very small number of invasive species infestations in Hubbard County Lakes. Great care should be taken to protect Hubbard County's excellent water resources from any future infestations. Protection projects could include lake access boat inspections and educational campaigns.

Lakes of Concern
The lakes that are the greatest cause for concern are those that have a declining trend in water quality and a high level of disturbance in the watershed. Those lakes include 9th Crow Wing, Long and Palmer. The disturbance in this area includes agriculture, shoreline development, and the city of Park Rapids. Stormwater management in Park Rapids, best management practices by area farmers, and shoreline protection projects (shoreline restorations, rain gardens and septic system maintenance) are suggested projects for improving these lakes.

The lakes that have a full restoration focus (page 13), but no trend in water quality include 2nd Crow Wing, 4th Crow Wing, 5th Crow Wing, 7th Crow Wing, Belle Taine, Blue, Boulder, Fishhook, and Peysenske. Duck Lake has a partial restoration focus, but no water quality trend. Restoration projects for these lakes could include stormwater management in Park Rapids, Nevis and Akeley, best management practices by area farmers, protecting land with conservation easements, and shoreline restoration.

The lakes that have a declining water quality trend and a protection focus (page 13) include 1st Crow Wing, Gilmore, Lower Bottle, and Plantagenet. These lakes should be further investigated for the cause of their declining water quality.

1st Crow Wing Lake is on the Impaired Waters List, and will be part of a future TMDL study. Gilmore and Lower Bottle Lakes are adjacent to Big and Little Sand, which have improving in water quality. The shoreline around Lower Bottle and Gilmore Lake should be inspected for erosion, lack of buffer strips and septic system status. A shoreline inventory study would be helpful in better understanding the shoreline impacts to these lakes. Lake Plantagenet is near Bemidji. Further investigation such as inlet monitoring, watershed ground-truthing and a shoreline inventory study could help determine the impacts to Plantagenet.

General Recommendations

- Monitor transparency weekly or bi-monthly through the MPCA Citizen Lakes Monitoring Program (CLMP) every year. Continual annual transparency data is a great way to monitor lake water quality and track trends. Avoid missing years of monitoring, which leads to gaps in data. For example, if a lake is showing a significant decline in water quality but there are gaps in their data, it is hard to determine when the impact occurred and whether it was acute or chronic.

- Monitor phosphorus and chlorophyll *a* concentrations. If annual monitoring is not feasible, consider monitoring on a 3-5 year rotation.

- Continue to follow BMPs (Best Management Practices) in the lakeshed:
  - Plant natural vegetation along the shoreline
  - Protect and extend low phosphorus land covers wherever possible (forest/wetland)
  - Properly maintain septic systems and their drainfields
  - Limit the use of phosphorus fertilizer on lawns
  - Surface water onsite management (rain gardens, drainage, etc)

- Complete a ground truthing study of the watersheds that contain lakes showing significant declines in water quality over the past 10 years:
  - Visually inspect the shoreline of each parcel and look for erosion, lack of a vegetation buffer and other harmful management practices.
  - Visually inspect ditch and stream networks leading into the lake to look for sources of phosphorus and erosion.

- For lakes located near a town, investigate where storm water drains so that it is not impacting the lake. Rain gardens and wetlands can be good areas for storm water storage and infiltration.

- Begin stream inlet monitoring and storm event monitoring for the lakes showing significant declines in water quality over the past 10 years to determine where the phosphorus is coming from.