



Lake Nokomis Water Quality Improvement Project: Implementation of Biomanipulation Project – 2014 Update

Introduction

Lake Nokomis is a 201-acre lake located in Minneapolis, Minnesota. Water quality in Lake Nokomis is impaired for nutrients, algal abundance and water transparency. Lake analyses and lake modeling scenarios suggest phosphorus from internal sources may be keeping Lake Nokomis reaching acceptable nutrient goals. One of the many internal sources that may be contributing to the nutrient impairment is the omnivorous, bottom feeding fish populations – black bullheads and bluegill sunfish. An estimated reduction of 126 kg of phosphorus in Lake Nokomis via fish community manipulation would bring the water quality of the lake closer to Minnesota Pollution Control Agency's (MPCA) nutrient criteria.

Project Objectives: 2010-2013

The biomanipulation project will attempt to re-balance the fish community over a 4-year period. By re-balancing the fish community in Lake Nokomis, the following should occur:

1. Increase walleye population
2. Reduced black bullhead and blue gill populations
3. Observe an increase in native aquatic plants
4. Reduce an estimated 126 kg of phosphorus
5. Water quality parameters meet the MPCA's nutrient criteria

Project Summary: 2010-2013

At the end of 2013, the biomanipulation project only achieved the first three objectives.

1. The walleye population is elevated due to stocking efforts through biomanipulation project and by the Department of Natural Resources.
2. The walleyes, along with yellow perch, have successfully managed the bluegill and remaining black bullheads*. The length frequency of the blue gills in Lake Nokomis improved throughout the project indicating a change in feeding habitats. Larger blue gills are more suited to feeding in the water column than rooting in the sediments.
3. The plant community in Lake Nokomis responded to the change in the fish community. In 2010, Lake Nokomis only had two species of aquatic plants colonizing 13 acres of the

lake. By 2013, eight species of aquatic plants had colonized a total of 22 acres of the lake.

4. Unfortunately, the water quality in Lake Nokomis did not respond as quickly. Less than 61 kg/year of phosphorus was removed through the black bullhead removal efforts, which is below the goal of 126 kg/year of phosphorus.
5. Water quality of Lake Nokomis did not consistently meet the MPCA's nutrient criteria throughout the duration of the project.

*4,410 lbs of black bullheads were removed from Lake Nokomis through trap-netting removal efforts from 2010-2011.

Post-Project Objectives: 2014

The post-biomanipulation project objectives were to monitor the progress of the fish, aquatic plants, plankton communities as well as water quality in Lake Nokomis throughout 2014 open-water season. There was no fish removal or stocking in Lake Nokomis during the post-project phase.

Post-Project Summary: 2014

- August 20, 2014: Steve McComas, Blue Water Science, conducted a point-intercept aquatic plant survey of Lake Nokomis (Attachment 1).
 - 10 species of aquatic plants were identified; 8 of the 10 were native plants
 - Aquatic plants grew out to depths of 10 feet
 - Estimated aquatic plant coverage was up to 32 acres; double the coverage observed in 2010

- October 1-3, 2014: Steve McComas, Blue Water Science, conducted a fish survey of Lake Nokomis (Attachment 2).
 - 13 fish species were sampled
 - Bluegill sunfish was the dominate catch; however, the bluegill densities have remained lower than densities at the start of the project
 - Walleyes abundance is high; if the numbers remain high, the walleyes will continue to manage the bluegill and black bullhead populations

- Water Quality of Lake Nokomis in 2014 (collected by Minneapolis Parks and Recreation Board (MPRB)): The first year since the biomanipulation project was implemented that all three parameters (Secchi depth, chlorophyll-*a*, and total phosphorus) met the MPCA’s eutrophication standards (See table below).

Lake Nokomis Water Quality (June-Sept Averages)

Year	Secchi Depth (m)	Surface Chlorophyll- <i>a</i> (µg/L)	Surface Total Phosphorus (µg/L)
Standard Limits:	> 1.4 m	< 20 µg/L	< 50 µg/L
2009	0.78	28.90	61
2010*	0.99	26.43	47
2011	1.28	14.56	35
2012	0.91	22.49	48
2013	1.33	18.18	53
2014	1.76	10.21	34

* Start of the Biomanipulation Project

- Under Review: Analysis of the plankton data. MPRB collects and analyzes the plankton data in Lake Nokomis.
- In-progress: Steve McComas (Blue Water Science), Rachael Crabb (MPRB), and Kelly Dooley submitted the paper for review in June 2014. We are currently addressing comments from the peer-review committee of the Lake and Reservoir Management Journal.

Additional Monitoring:

- May-September 2014: Steve McComas, Blue Water Science, monitored total phosphorus once a month in the three settling ponds adjacent to Lake Nokomis (Attachment 3). The average total phosphorus concentrations for the three ponds was 171 µg/L to 331 µg/L.
- August 2014: Justine Kock, Research Fellow for the Six Mile Creek Subwatershed Carp Assessment, conducted a carp survey on Lake Nokomis.
 - The survey estimated that the carp population size to be about 8,421 carp with a biomass of ~298 kg/ha
 - Carp biomass above ~100 kg/ha has been found to cause ecological damage in shallow lakes (Bajer et al. 2009)

Lessard-Sams Outdoor Heritage Grant:

- May 2014: MPRB submitted a proposal to improve fish and wildlife habitat in Lake Nokomis. One part of the proposal was to initiate a 10-year walleye-stocking program to maintain the positive results from the biomanipulation project. MCWD Board of Managers provided a letter of support.

- October 2014: The Council will recommend to the legislature to grant the Lake Nokomis habitat project \$440,000. The grant funds are only to be spent on shoreline restoration work. The walleye-stocking program and plant propagation work of the proposal were not funded.

Partners Meeting:

- November 18, 2014: MCWD staff met with Daryl Ellison (DNR), Steve McComas (Blue Water Science), and Rachael Crabb (MRPB) to discuss future plans for improving the water quality in Lake Nokomis. MCWD staff will be bringing recommendations to the Board in 2015.



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Aquatic Plants Sampled in Lake Nokomis, Minneapolis, on August 20, 2014

Aquatic Plant Survey for Lake Nokomis, Minneapolis, Minnesota, 2014

Survey conducted on: June 20 and August 20, 2014

Prepared for:
Minnehaha Creek
Watershed District



Prepared by:
Steve McComas
Blue Water Science
St. Paul, MN 55116

December 3, 2014

Aquatic Plant Surveys for Lake Nokomis, Minneapolis, Minnesota, 2014

Summary

Lake Nokomis (MnDNR ID: 27-0019) is a 201 acre lake located in Minneapolis, Minnesota. The coverage of aquatic plants in 2014 was evaluated by conducting an early season and late season point-intercept aquatic plant surveys with 50 meter spacing between points.

In the early summer point-intercept survey on June 20, 2014, native plants were scarce. Six species of submerged aquatic plants were found in June, 2014. The most abundant was Eurasian watermilfoil followed by coontail. The non-native Eurasian watermilfoil was observed at 15 sites (Table S1). Plants grew out to a water depth of 13 feet and estimated plant coverage was 14 acres out of 201 acre lake (7% coverage)(Figure S2).

In the late summer point-intercept survey on August 20, 2014, native plants increased. Ten species of submerged aquatic plants were found in August, 2014. The most abundant was Eurasian watermilfoil followed by coontail. The non-native Eurasian watermilfoil was observed at 43 sites (Table S1). Plants grew out to a water depth of 10 feet and estimated plant coverage was 32 acres out of 201 acre lake (15% coverage)(Figure S2).

The distribution of aquatic plants in Lake Nokomis appears to be increasing (Table S2 and Figure S3). Aquatic plant coverage has more than doubled since 2010 (Table S2). The number of aquatic plant species has also increased (Table S2).



Figure S1. Aquatic plants from June 20 (left) and August 20, 2104 (right).

Aquatic Plant Coverage in Lake Nokomis in 2014

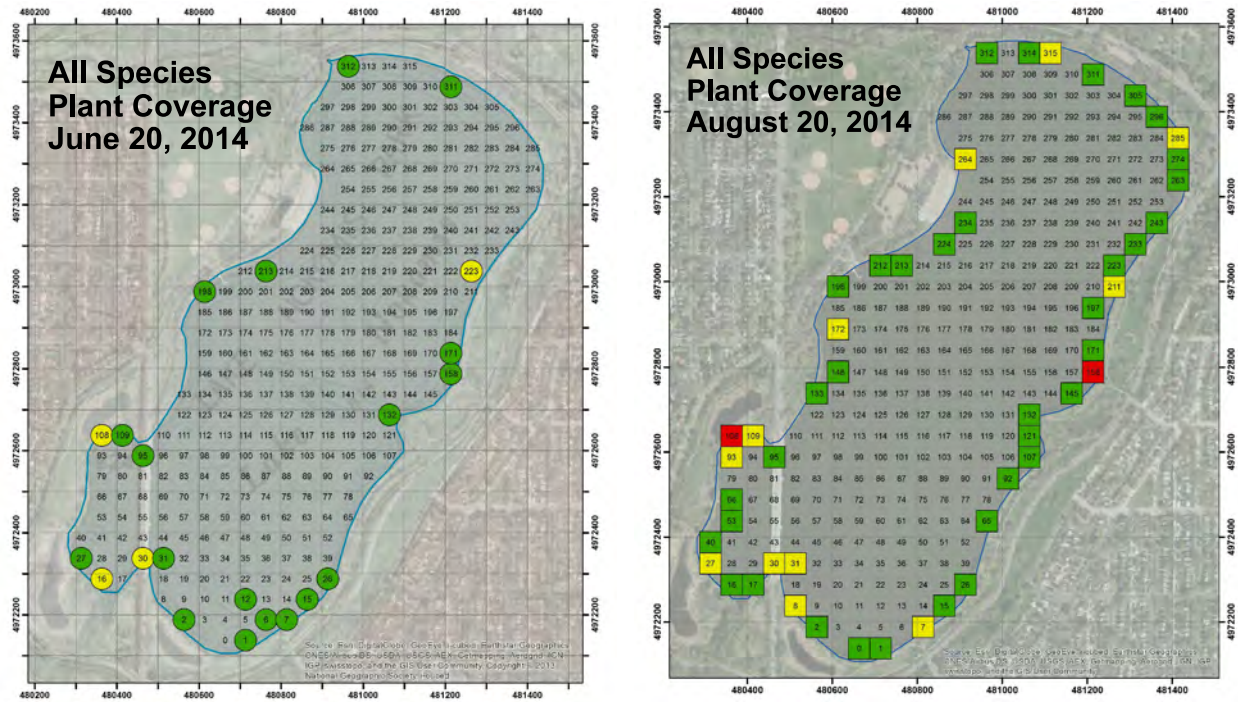


Figure S2. [left] Submerged aquatic plant coverage in Lake Nokomis on June 20, 2014. [right] Submerged aquatic plant coverage in Lake Nokomis on August 20, 2014. Key: Green = light growth, yellow = moderate growth, and red = heavy growth.

Table S1. Comparison of early season to late season aquatic plant occurrences.

	June 20, 2014 173 sites	August 20, 2014 173 sites
Chara	--	1
Coontail	11	21
Elodea	3	9
Eurasian watermilfoil	15	43
Naiads	--	3
Cabbage	--	1
Curlyleaf pondweed	1	4
Floatingleaf pondweed	1	2
Stringy pondweed	1	16
Sago pondweed	--	5
Number of Species	6	10

Aquatic Plant Coverage (all species): 2008 - 2014

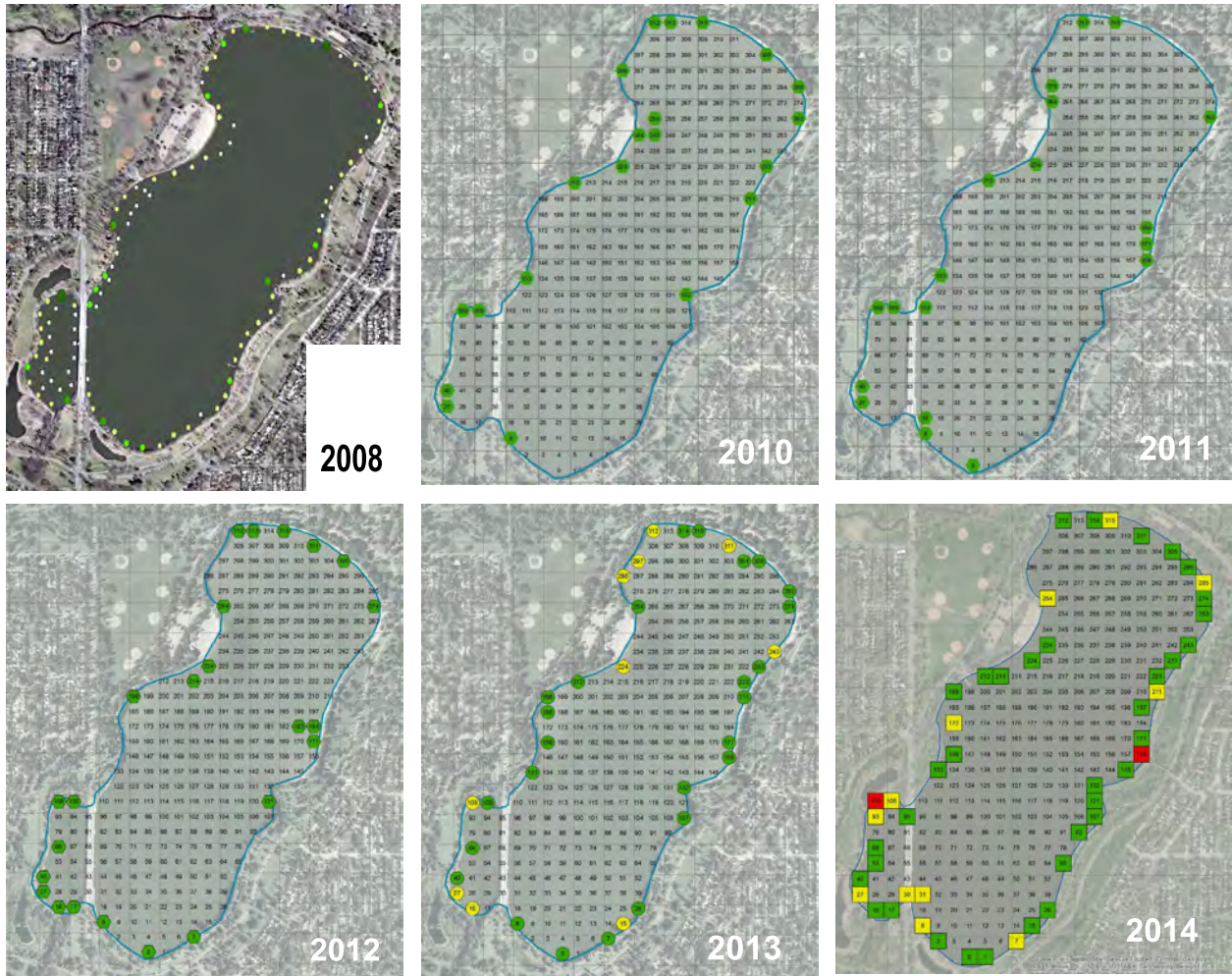


Figure S3. Aquatic plant distribution in Lake Nokomis in 2008 and 2010-2014.

Table S2. Summary of aquatic plant surveys in 2008, 2010 through 2014. Sample sites within the littoral zone were 173 sites.

	2008 105 nearshore sites - Sept (conducted by the MPRB)		2010 173 sites 0-15 ft deep Sept 9		2011 173 sites 0-15 ft deep July 15		2012 173 sites 0-15 ft deep August 29		2013 173 sites 0-15 ft deep July 18		2014 173 sites 0-15 ft deep June 20		2014 173 sites 0-15 ft deep August 20	
	Sites	% Occur	Sites	% Occur	Sites	% Occur	Sites	% Occur	Sites	% Occur	Sites	% Occur	Sites	% Occur
Chara	0	0	0	0	0	0	0	0	1	1%	0	0	1	1%
Coontail	21	20%	3	1%	3	1%	10	5%	11	6%	11	6%	21	12%
Elodea	0	0	0	0	0	0	0	0	1	1%	3	2%	9	5%
Eurasian watermilfoil	64	61%	21	12%	18	10%	18	10%	33	19%	15	9%	43	25%
Naiads	0	0	0	0	0	0	0	0	0	0	0	0	3	2%
Cabbage	0	0	0	0	0	0	0	0	0	0	0	0	1	1%
Curlyleaf pondweed	1	1%	0	0	0	0	0	0	2	1%	1	1%	4	2%
Floatingleaf pondweed	0	0	0	0	0	0	0	0	0	0	1	1%	2	1%
Stringy pondweed	0	0	0	0	1	1%	0	0	7	4%	1	1%	16	9%
Sago pondweed	0	0	0	0	0	0	2	1%	6	4%	0	0	5	3%
Whitstem pondweed	0	0	0	0	0	0	0	0	1	1%	0	0	0	0
Number of Species	3	--	2	--	3	--	3	--	8	--	6	--	10	--
Plant Coverage (ac)	--		13		12		15		22		--		31	



Four Walleyes from Lake Nokomis, October 2014

Fish Survey for Lake Nokomis (ID #27-0019), Hennepin County, Minnesota in 2014

Trapnet Fish Survey Dates: October 1-3, 2014

MnDNR Fish Permit Number: 19901

Prepared for:
Minnehaha Creek
Watershed District and
MnDNR



Prepared by:
Steve McComas and
Jo Stuckert
Blue Water Science
St. Paul, MN 55116

December 2, 2014

Fish Survey for Lake Nokomis (ID #27-0019), Hennepin County, Minnesota in 2014

Summary

Lake Nokomis is a 201 acre lake located in Hennepin County, Minnesota. On October 1-3, 2014, a fish survey using trapnets was conducted on Lake Nokomis. The objectives of the fish survey were to characterize existing fish conditions and to determine if fish densities were high enough to be contributing to the observed poor water quality in Lake Nokomis.

Results of the 2014 fish survey along with other trapnet surveys going back to 1948 are shown in Table S1. A total of 13 species were sampled in 2014. The fish catch was dominated by bluegill sunfish and the abundance of other fish species were within or close to normal range for fish of similar lakes (based on MnDNR statistics).

Bluegill sunfish densities appear to be coming to an equilibrium and their contribution to poor water quality in Lake Nokomis should be decreasing. It is recommended that a bluegill control program should continue using stocked walleyes as the primary predator. Walleyes have the potential to keep both bluegill sunfish and black bullheads under control if walleye abundance remains high.

Table S1. Lake Nokomis trapnet results for fish surveys conducted from 1948 - 2005 and 2010 - 2014. The 2008, 2011 through 2014 surveys were conducted by Blue Water Science, all other surveys were conducted by the MnDNR.

	1948 May 5	1958 May 19	1972 July 1	1975 Aug 5	1977 Jun 29	1982 Jun 25	1987 Jun 24	1991 May 2	1992 Jun 22	1996 Jun 24	2001 July 19	2005 July 18	2007 July 16	2008 July 10 (BWS)	2010 July 17	2011 Oct 11 (BWS)	2012 Oct 11 (BWS)	2013 Jun 29 (BWS)	2014 Oct 1 (BWS)	% occur for all surveys
Bluegill	0.9	20	1	0.4	21	23	75	0.4	115	94	54	27	183	474	188	158	21	46	64	100%
Black Bullhead	1	6.7	2	0.6	3.4	13	12	26	6	7.8	1.6	1.3	2.6	5.7	0.8	0.1		0.5	0.2	95%
Black Crappie	1.6	83	12	11	16	98	28	5	133	293	23	2	5.8	14	4.9	14	5.5	26	24	100%
Bowfin						0.3	0.3					0.2	0.1				0.1		0.1	31%
Brown Bullhead				0.1		0.3														11%
Carp	0.08	0.2		0.3	0.6	2			0.4	0.2			0.1				0.2	0.1	0.1	58%
Golden Shiner		0.5			0.4	0.1	0.3	0.1	5.1	4.3	0.9	0.2		0.08				0.1	0.3	63%
Goldfish											0.1									5%
Green Sunfish		0.3					1.8	0.1		1.4	2.4	0.1								33%
Hybrid Sunfish		0.3		0.3	0.6	1.9	2.3		1.1	0.2	4.4	0.9	0.6	0.2	1.0				0.2	68%
Largemouth Bass	0.3	0.3					1.3			0.1	0.1							0.1	0.2	37%
Northern Pike			0.1	0.1	0.3	0.3														21%
Pumpkin-seed		16			0.7	4	7	0.7	13	2.2	3.8	0.6	4.5	3.3	0.4	1.3	1.2	0.7	5.2	84%
Tiger Muskie										0.2	0.1	0.1								16%
Walleye						0.9	0.3	3	3.1	2	0.4	1.2	0.3	0.5	0.7	3.8	2.8	0.4	3.3	74%
White Crappie			8.9							1.6					0.4		0.1			21%
White Sucker	0.08	0.1	0.6	0.2	1	4.5		1.3	2.3	1.3	0.4	2.1		0.5	0.1	1.0	0.4	0.4	0.3	89%
Yellow Bullhead	0.08					0.5	0.8	0.6	0.3	0.3	0.1		0.1						0.2	42%
Yellow Perch	0.08	1.7	12	2	2.7	4.3	15	5	15	21	6.8	3.8	0.4	0.5	1.0	1.5	2.3	0.3	23	100%
Number of fish species	8	11	7	9	10	14	12	10	11	15	14	12	10	9	9	7	9	10	13	

Although fish are suspected as being a water quality factor, many variables are involved. There is basically no correlation to the number of bluegills per trapnet and Secchi disc summer averages ($r^2 = 0.07$)(based on data in Table S2). However, there is also no correlation to rainfall, which is a surrogate for watershed loading as well ($r^2= 0.02$). The role of fish impacts on water quality is an evolving issue in Lake Nokomis.

Table S2. Lake Nokomis fish survey results for bluegill sunfish, carp, and black bullheads for surveys conducted from 1948 through 2014. Water quality parameters in the green boxes represent unimpaired water quality conditions.

	Average Annual Rainfall (inches)	Water Quality (May-Sept)			Fish Survey Results for Benthivores and Planktivores						Zooplankton (May-Sept)	
		Secchi (m)	TP (ppb)	Chl a (ppb)	Bluegill fish/net (trapnet)	Black Crappies fish/net (trapnet)	Carp fish/net (gillnet)	Carp fish/net (trapnet)	Black Bullhead fish/net (gillnet)	Black Bullhead fish/net (trapnet)	Copepods + Cladocerans (#/l)	Cladocerans (#/l)
1948	17				1	2	0	0.1	0.4	1.0		
1958	16				20	83	0.5	0.2	8.0	6.7		
1972	24	1.2			1	12	0	0	1.0	2.0		
1973	21											
1974	19											
1975	35				1	11	2.0	0.3	1.3	0.6		
1976	17											
1977	35	0.9 (6.29)			21	16	2.7	0.6	10	3.4		
1978	30											
1979	31											
1980	22	0.9										
1981	28	1.0 (6.23)										
1982	30				23	98	0.3	2	1.7	13		
1983	39											
1984	37	0.9										
1985	32											
1986	37											
1987	32	1.8 (6.24)			75	28	0.3	0	14	12		
1988	19	0.8										
1989	23	0.9										
1990	33	0.7										
1991	37	0.6			1	5		0		26		
1992	30	0.9			115	133	0.5	0.4	14	6.0		
1993	32	1.5										
1994	30	1.2										
1995	26	1.4										
1996	26	1.1			94	293	0.2	0.2	2.8	7.8		
1997	34	1.6										
1998	33	1.4	59	26								
1999	31	1.5	64	47								
2000	32	1.3	59	33								
2001	34	1.3	76	39	54	23	0	0	5.5	1.6		
2002	38	1.7										
2003	23	1.7	43	20							330	151
2004	27	1.1	83	28							263	51
2005	33	1.2	57		27	2	1.0	0	56	1.3	372	77
2006	28	1.0	67	36							148	53
2007	24	1.1	56	29	183	6	0.3	0.1	28	2.6	171	49
2008	22	1.1	44	12	474	14		0		5.7	123	52
2009	25	1.0	60	25							271	44
2010	33	1.2	47	22	188		0.5	0	2.3	0.8	89	18
2011	28	1.4	36	14	158	14		0		0.1	191	41
2012	30	1.2	46	21	21	6		0.2		0	219	69
2013	34	1.3	53	18	46	26		0.1		0.5	214	58
2014	34*	1.8**	34**	10**	64	24		0.1		0.2		

*Precipitation through October for Hennepin County.

** June-September average

Conclusions and Recommendations

The walleye abundance (based on fish per trapnet) fluctuates in Lake Nokomis. In 2014, walleye abundance was the second highest (at 3.3 walleyes/trapnet) since 1948. In addition, the abundance of bluegill sunfish and black bullheads are lower in number compared to 2008 which was one of the lake management objectives. With a less dense population maybe bluegill food habits will change from a benthic (bottom) feeding mode to a more open water mode. This could benefit water quality. The carp population in Lake Nokomis appears to be at a moderate level based on an electrofishing survey conducted by the University of Minnesota in the summer of 2014. The combined effects of external loading, carp activities, and the relative abundance of bluegill sunfish could play a role in the producing moderately poor water transparency, which in turn, could limit plant distribution.

In the last few years, plant growth is documented out to about 10 feet of water depth. It is estimated that the lake area from 0 - 10 feet is only about 20 acres (BWS estimate), but the lake area from 0 - 15 feet covers an area of 100 acres (MnDNR). If a summer average clarity increases to 7 or 8 feet, than plant growth could become established out to 15 feet of water depth and the lake could sustain long-term good water quality with the help of the aquatic plant community. Currently, the average Secchi disc transparency is about 5-feet. To sustain good water quality in Lake Nokomis (1.4 m transparency, 50 ppb of TP, and 14 ppb of chlorophyll), continuing predation pressure by walleyes on black bullheads and bluegill sunfish would be beneficial.

It is theorized that maintaining a broad distribution of aquatic plant growth coupled with a balanced fish population could produce unimpaired water quality conditions for the long term in Lake Nokomis.

Ongoing Recommended Lake Projects

1. Evaluate the performance of key stormwater wetlands and ponds that are tributary to Lake Nokomis.
2. Conduct annual aquatic plant surveys to track distribution, diversity, and depth of colonization of plants.
3. Conduct an annual fish survey in Lake Nokomis to track the fish community, especially for walleye and bluegill abundance.
4. Conduct trapnet surveys in tributary ponds and lakes to characterize carp status as well as other fish species.
5. The connection between Mother Lake (lake to the south of Lake Nokomis) and Lake Nokomis as a source of carp to Lake Nokomis should be investigated.
6. If water quality does not consistently meet unimpaired status, a potential project is a carp removal option. Electrofishing in 2014, conducted by the University of Minnesota, found carp at an estimated 200 pounds or more per acre. In the next couple of years winter seining for carp removal should be considered. Annual seining should be continued annually until less than 10,000 pounds/winter are netted.

Lake Nokomis Pond Sampling Results for 2014

prepared by Steve McComas, Blue Water Science

Table 1. Lake Nokomis Ponds sampled for total phosphorus. Total phosphorus results are shown as ppb.

Date	Southeast Pond	Southwest Pond	North Pond
May 2, 2014	77	92	--
June 24, 2014	111	110	181
July 20, 2014	211 (open water)	263 (open water) 66 (in cattails)	531
August 20, 2014	280	85	178
October 2, 2014	314	306	434
Average (May - October)	199	171	331



Figure 1. Pond locations for 2014 sampling program.



High water conditions in Lake Nokomis, June 22, 2014



Southwest Pond, June 22, 2014



Southeast Pond, June 22, 2014



North Pond Outlet, August 20, 2014