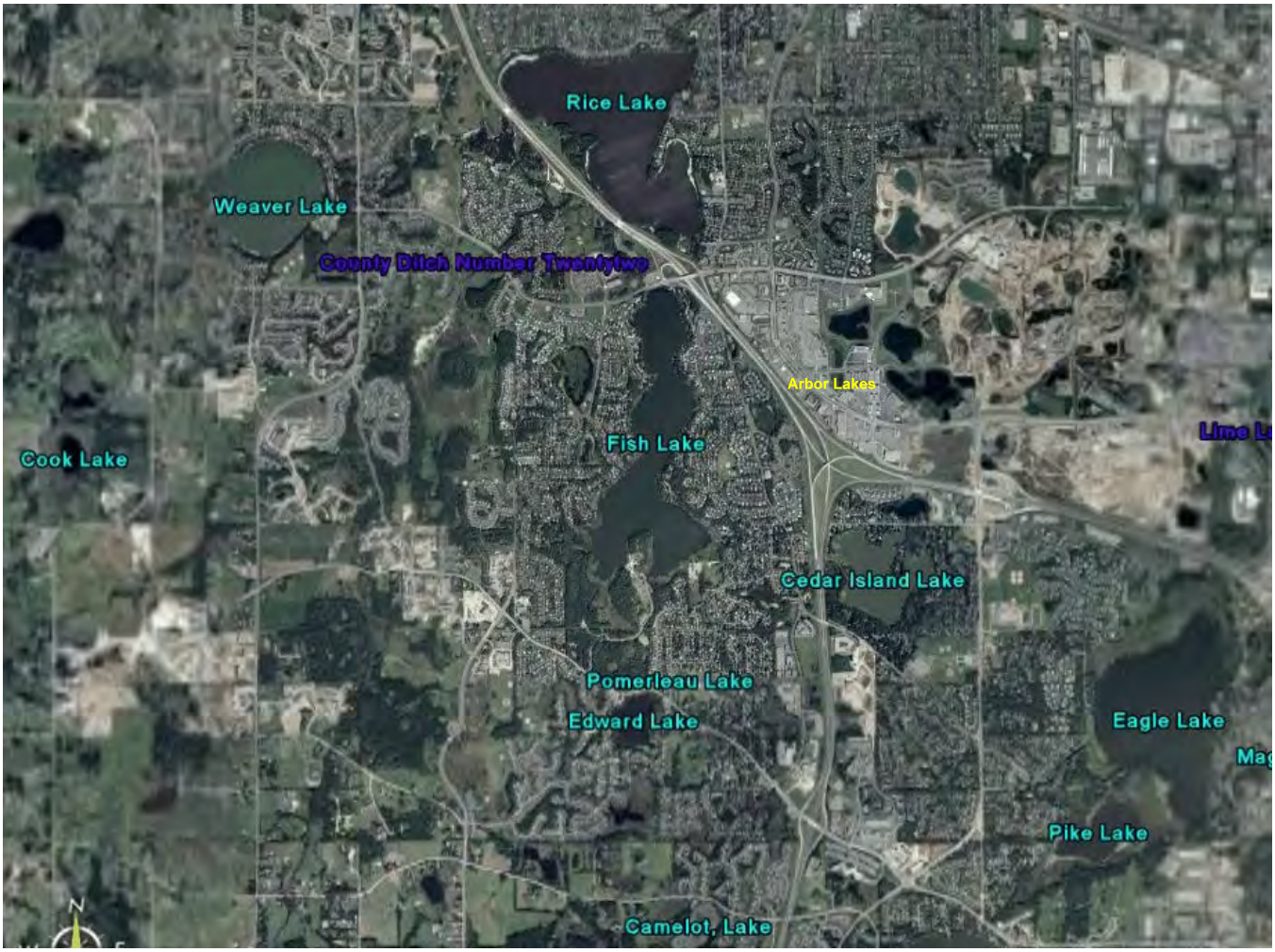

The Lakes of Maple Grove

Lake Water Quality Report for 2013

Maple Grove Lake Quality Commission

Prepared February 2014
by Steve McComas, Blue Water Science

The Lakes of Maple Grove
Status Report - 2013

Prepared for the Maple Grove Lake Quality Commission.

Commission Members - 2013

Karen Jaeger — Councilmember
Steve Lane — Cedar Island Lake
Larry McGough — Eagle Lake
Sharon Martin-Kotula — Edward Lake
Joe Randall — Fish Lake
Kurt Paulson — Pike Lake
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Ken Ashfeld, City Engineer, City of Maple Grove
Rick Lestina, Water Resources Engineer, City of Maple Grove
Mark Lahtinen, Water Resources, City of Maple Grove
Sue Rice, Minutes Secretary

Prepared by Steve McComas, Blue Water Science

February 2014

Introduction and Background

The City of Maple Grove has numerous lakes and smaller water bodies within the City limits. In 2013, Blue Water Science monitored a total of eight lakes over the summer months, including the three Arbor Lakes. Three Rivers Park District sampled Fish, Rice, and Weaver Lakes. Blue Water Science sampled Cedar Island, Cook, Eagle, Edward, Pike, and the three Arbor Lakes. This report summarizes the summer sampling data from May-September. A summary of general lake characteristics is shown in Table 1.

Table 1. General lake characteristics of Maple Grove Lakes. Watershed acreage is from the 1996 Stormwater Management Plan.

Lake	State ID Number	Watershed District	Size (acres)	Maximum Depth (feet)	Mean Depth (feet)	Total Watershed Size (ac)	Lake Classification (shallow or deep)	Lake Water Retention Time (years)
Fish	27-118	Elm Creek	239	48*	17.7	860	deep	9.1
Weaver	27-117	Elm Creek	165	57*	21*	320	deep	20
Rice	27-116	Elm Creek	333	11	6.6	13,400	shallow	0.3
Edward	27-121	Elm Creek	33	9.5	5.5	102	shallow	
Cook	27-0120	Elm Creek	16.5	20	8	196	shallow	2.3
Eagle	27-111	Shingle Creek	285	37	10.5	1,838	deep	3.1
Pike	27-111-02	Shingle Creek	75	25	4.9	746	shallow	1.0
Cedar Island	27-119	Shingle Creek	86	7.0*	4.3	389	shallow	1.8

* from Hennepin Conservation District
**from Met Council

Guide to Interpreting Water Quality Information

SD = Secchi disc - a black and white disc lowered into the water until it can't be seen from the surface. This is the Secchi disc transparency reading.
TP = Total phosphorus - the fertilizing nutrient most responsible for causing excess algae to grow.
Chl a = Chlorophyll a - the green pigment in algae that is analyzed in the laboratory. It is correlated to the amount of algae in a lake.
ppb = parts per billion - concentrations of phosphorus and chlorophyll are often reported in ppb.

Lake Goals (based on eutrophication criteria for North Central Hardwood Forest Ecoregion)

- Secchi disc: 5-7 feet of transparency as a summer average.
- Total phosphorus: try to keep phosphorus concentrations below 40 ppb as a summer average for deep lakes and less than 60 ppb for shallow lakes.
- Chlorophyll a: try to keep chlorophyll concentrations below 14 ppb as a summer average for deep lakes and less than 20 ppb for shallow lakes.

2013 Summer Sampling Results - Status Report

The objectives of the 2013 water quality sampling program were to check the health of the lakes in the City of Maple Grove and to see if they were improving, degrading, or staying the same. Water quality parameters monitored included Secchi disc (measure of water clarity), total phosphorus (measure of the primary nutrient that stimulates algal growth), and chlorophyll (measure of the amount of algae in the water).

Water quality was checked from May through September and results are shown in Table 2. North Arbor Lake had the best transparency and Cedar Island had the lowest transparency in 2013 (Tables 2 and 3).

Table 2. Water chemistry summer averages for Maple Grove Lakes in 2013 (source: Three Rivers Park District collected data for Fish, Rice, and Weaver Lakes. Other data collected by Blue Water Science).

	May - Sept Averages, 2013		
	Secchi Disc (ft)	Total Phosphorus (ppb)	Chl a (ppb)
Cedar Island	1.0	138	48.8
Cook	5.6	31	2.3
Eagle	5.7	30	6.4
Edward	3.2	97	50.2
Fish	4.9	53	32.6
Pike	3.9	66	13.5
Rice	2.5	326	114
Weaver	7.2	37	16.5
North Arbor	15.3	11	1.5
South Arbor	12.2	18	2.7
West Arbor	7.6	24	5.7

Table 3. Maple Grove water quality data 2013. Results for secchi disc (SD) are in feet, total phosphorus (TP) are in ppb, and chlorophyll a (chl) are in ppb. Data for Fish, Rice, and Weaver are from Three Rivers Park District.

Lakes	North Arbor			South Arbor			West Arbor			Cedar Island			Cook			Eagle			Edward			Fish			Pike			Rice			Weaver		
	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl
May																																	
week 1*																						3.6	125	66				3.4	87	55	4.8	30	17
week 2																																	
week 3	5.4	18	2.0	6.7	42	2.9	4.9	21	1.9	1.2	119	28.4	6.0	13	2.5	5.6	31	2.9	3.1	89	45.7	4.3	66	22	3.6	38	12.0	3.1	102	22	6.9	53	<5
week 4																																	
June																																	
week 1																						12.8	46	<5				4.4	73	18	23.1	35	<5
week 2																																	
week 3																						12.5	48	8				5.9	106	24	8.5	33	15
week 4	16.9	12	1.2	13.6	13	1.4	11.1	19	3.7	1.3	149	24.7	4.5	52	4.1	9.2	35	2.2	3.8	73	23.3				3.0	117	20.1						
July																																	
week 1																						3.8	46	34				2.3	247	110	3.0	49	51
week 2																																	
week 3	14.2	10	1.8	14.8	10	1.9	7.4	18	4.2	0.8	153	63.5	6.4	28	2.7	5.3	24	10.8	4.2	78	36.2	4.3	45	26	4.0	54	19.1	1.3	410	309	4.3	38	24
week 4																						4.9	50	28				1.7	344	179	6.1	41	11
August																																	
week 1																																	
week 2																						1.9	41	37				1.3	487	208	6.1	29	<10
week 3																																	
week 4	16.4	7	1.3	17.2	7	>1	5.4	25	6.1	0.7	160	75.3	5.4	44	<1	4.2	24	8.6	2.9	70	37.6	1.8	39	40	3.7	73	8.7	1.1	572	203	5.9	37	10
September																																	
week 1																																	
week 2																						1.7	35	50				1.3	572	79	5.8	30	16
week 3																																	
week 4	23.6	8	<1	8.9	17	6.1	9.2	36	12.7	0.9	108	52.2	5.5	20	<1	4.2	34	7.7	2.1	173	108	2.2	39	43	5.1	46	7.7	1.8	584	47	4.9	32	17
May-September Average																																	
	15.3	11	1.5	12.2	18	2.7	7.6	24	5.7	1.0	138	48.8	5.6	31	2.3	5.7	30	6.4	3.2	97	50.2	4.9	53	32.6	3.9	66	13.5	2.5	326	114	7.2	37	16.5

* Weeks: days 1-7 = week 1; days 8-14 = week 2; days 15-21 = week 3; days 22+ = week 4

Eurasian Watermilfoil (EWM) Monitoring Summary

Eurasian watermilfoil (EWM) has been found in eight lakes in Maple Grove -- Fish, Eagle, Pike, Rice, Weaver, and all three Arbor Lakes. EWM in all eight lakes is past the point of eradication, but typically nuisance growth is limited to several shoreline areas. Eagle Lake has a small infestation and little nuisance growth. Rice Lake had a new infestation in 1996 but milfoil was not found in 1997, 1998, or after 2007. Overall observations are summarized in Table 4.

Curlyleaf pondweed, also a non-native plant, is found in all lakes monitored in 2013 except for Cook Lake.

Table 4. Summary of Eurasian watermilfoil observations for Maple Grove Lakes in 2013.

	2013 Summer
Arbor - North	Eurasian watermilfoil found in 2003.
Arbor - South	Eurasian watermilfoil found in 2004.
Arbor - West	Eurasian watermilfoil found in 2002.
Cedar Island Lake	no Eurasian watermilfoil found
Cook	no Eurasian watermilfoil found.
Eagle Lake	scattered Eurasian watermilfoil, found in 1992.
Lake Edward	no Eurasian watermilfoil found
Fish Lake	scattered Eurasian watermilfoil, found in 1993.
Pike Lake	scattered Eurasian watermilfoil, found in 1992.
Rice Lake	scattered Eurasian watermilfoil, found in 1996.
Weaver Lake	Eurasian watermilfoil found in 2012

Water Quality Summaries

Secchi Disc, Phosphorus, and Chlorophyll a

A nineteen year summary of water quality results for Maple Grove Lakes is shown in Table 5. City lakes have been stable in regard to water quality except for Lake Edward and Rice Lake. Fluctuating clarity in Lake Edward may be influenced by fish kills that occurred in 1995 and 2000. Rice Lake may be impacted by the drawdown on 1997-1998. Rice and Cedar Island Lakes have the highest phosphorus concentrations in town and Cook and Eagle have the lowest.

Table 5. Growing season averages for the Maple Grove Lakes [SD = secchi disc (ft), TP = total phosphorus (ppb), Chl a = chlorophyll a (ppb)].

	Cedar Island			Cook			Eagle			Edward			Fish			Pike			Rice			Weaver		
	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl
1995	2.0	106	73	--	--	--	5.8	51	7	5.0	61	16	6.4	51	16	3.9	78	20	2.2	233	44	7.8	40	18
1996	1.8	--	--	--	--	--	5.9	33	9	8.1	104	2	7.0	55	9	3.4	66	23	2.9	453	37	6.5	35	6
1997	1.5	117	40	--	--	--	5.4	31	11	5.8	47	4	5.4	50	17	3.6	76	24	2.3	316	39	6.6	32	10
1998	1.4	102	44	--	--	--	5.9	29	11	4.1	46	11	5.9	46	13	3.3	70	31	3.3	469	20	6.6	40	14
1999	1.1	203	66	--	--	--	5.9	53	23	4.5	43	13	4.8	45	19	3.9	74	35	3.5	248	35	6.4	42	21
2000	--	--	--	--	--	--	9.5	36	5	5.5	45	6	4.6	53	19	4.3	65	30	5.2	175	23	6.6	43	15
2001	2.1	78	47	--	--	--	11	34	18	7.1	26	4	5.4	38	17	4.9	83	30	4.5	339	22	5.5	42	38
2002	1.8	90	55	--	--	--	3.3	42	67	6.7	48	13	3.6	51	26	--	--	--	4.2	152	18	8.3	43	20
2003	1.1	163	116	--	--	--	7.0	44	31	3.2	118	102	4.5	55	37	3.5	80	60	3.2	185	35	6.6	46	31
2004	1.0	147	133	6.2	26	4	6.8	45	28	2.2	77	47	7.9	47	29	3.5	97	65	3.9	207	36	8.9	51	40
2005	1.1	123	134	6.6	51	2	8.8	18	20	2.4	104	61	5.4	40	25	3.5	95	54	4.6	214	44	16.5	23	4
2006	0.7	161	173	7.5	22	33	5.8	47	36	1.9	95	55	3.9	49	29	4.3	89	47	3.0	187	50	14.4	25	7
2007	0.8	240	194	7.8	19	6	--	--	--	1.6	115	62	4.1	51	31	--	--	--	2.2	206	48	9.0	35	7
2008	0.7	455	226	8.0	20	2	--	--	--	3.2	105	67	2.7	47	17	--	--	--	2.6	436	51	8.0	30	8
2009	0.6	330	147	10.6	23	3	5.7	44	30	2.2	149	82	4.6	57.9	17	3.5	80.6	20	3.5	395	151	9.2	30.8	5
2010	0.7	143	67	7.4	18	3	5.9	50	21	3.6	88	58	4.9	48	14	3.9	89	29	3.4	227	57	13.1	31	5
2011	1.8	94	61	5.7	32	3	5.4	38	25	2.5	94	40	6.2	50	19	3.6	52	14	3.7	153	36	7.9	30	8
2012	0.9	130	58	5.0	34	3	5.7	42	25	3.4	72	41	5.5	42	26	3.5	34.8	15	2.5	256	53	7.6	31	11
2013	1.0	138	49	5.6	31	2	5.7	30	6	3.2	97	50	4.9	53	33	3.9	66	14	2.5	326	114	7.2	37	17

Cedar Island Lake data: Met Council - 1995; MPCA - 1996; and Blue Water Science - 1997 through 2013.
Eagle, Fish, Pike, and Weaver Lake data collected by Three Rivers Park District.
Rice Lake data: Met Council and by Three Rivers Park District

Report Card

Water quality data have been converted to grades based on a Met Council grading scale. Grades are shown in Table 6.

Table 6. Lake grades for Maple Grove Lakes.

	Cedar Island			Cook			Eagle			Edward			Fish			Pike			Rice			Weaver		
	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl
1995	F	D	D	--	--	--	C	C	A	C	C	B	C	C	B	C	D	B	F	F	C	B	C	B
1996	F	--	--	--	--	--	C	B	A	B	D	A	C	C	A	D	D	C	D	F	C	C	C	A
1997	F	D	C	--	--	--	C	B	B	C	C	A	C	C	B	D	D	C	D	F	C	C	B	B
1998	F	D	D	--	--	--	C	B	B	C	C	B	C	C	B	D	D	C	D	F	D	C	C	B
1999	F	F	D	--	--	--	C	C	C	C	C	B	C	C	B	C	D	C	D	F	C	C	C	C
2000	--	--	--	--	--	--	B	C	A	C	C	A	C	C	B	C	C	C	C	F	C	C	C	B
2001	F	D	C	--	--	--	A	C	B	C	B	A	C	C	B	C	D	C	C	F	C	C	C	C
2002	F	D	D	--	--	--	D	C	D	C	C	B	D	C	C	--	--	--	C	D	B	B	C	B
2003	F	F	F	--	--	--	C	C	C	D	D	F	C	C	C	D	D	D	D	F	C	C	C	C
2004	F	D	F	C	B	A	B	C	C	F	D	C	B	C	C	D	D	D	D	F	C	B	C	C
2005	F	D	F	C	C	A	B	A	B	D	D	D	C	C	C	D	D	D	C	F	C	A	B	A
2006	F	F	F	B	A	C	C	C	C	F	D	D	C	C	C	C	D	C	D	F	D	A	B	A
2007	F	F	F	B	A	A	--	--	--	F	D	D	C	C	C	--	--	--	F	F	C	B	C	A
2008	F	F	F	B	A	A	--	--	--	D	D	D	D	C	B	--	--	--	D	F	D	B	B	A
2009	F	F	F	A	A	A	C	C	C	F	D	F	C	C	B	D	D	C	D	F	F	B	B	A
2010	F	D	D	B	A	A	C	C	C	D	D	C	C	C	B	C	D	C	D	F	D	A	B	A
2011	F	D	D	C	B	A	A	C	C	D	D	C	C	C	B	D	C	B	D	F	C	B	B	A
2012	F	D	D	C	C	A	C	C	C	D	D	C	C	C	C	D	C	B	D	F	D	B	B	B
2013	F	F	D	C	B	A	C	B	A	D	D	D	C	C	C	D	C	B	D	F	F	B	C	B

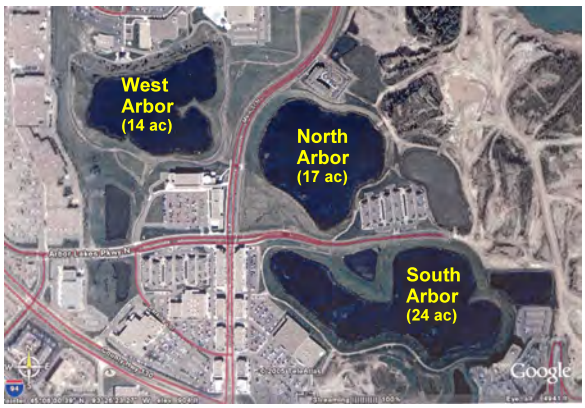
Arbor Lakes: Results of Arbor Lake sampling are summarized in Tables 7 and 8 and Figure 1. All three have good water quality and relatively low phosphorus concentrations.

Table 7. Growing season averages for the Arbor Lakes.

	West			North			South		
	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl
May-September Average									
1999 (1 date - Aug)	3.1	18	11	6.7	20	<1	5.4	13	<1
2001 (1 date - Sept)	5.3	--	--	16.0	--	--	8.2	--	--
2002 (3 dates)	9.0	16	1	8.9	11	2	13.0	12	1
2003 (5 dates)	7.0	19	4	12.3	9	3	11.7	10	3
2004 (5 dates)	9.6	18	5	11.5	12	2	12.4	12	2
2005 (5 dates)	10.7	28	2.4	13.2	17	3	10.7	17	2
2006 (5 dates)	9.7	23	2	13.8	13	2	7.9	29	17
2007 (5 dates)	9.4	19	2.6	12.1	9	2.2	11.3	15	5
2008 (5 dates)	8.4	24	7.0	14.3	12	3.7	10.2	16	4.4
2009 (5 dates)	9.6	28	5.3	13.9	14	1.1	13.9	17	2.0
2010 (5 dates)	7.9	36	11	13.8	9	1.7	13.4	14	1.7
2011 (5 dates)	7.1	27	12	12.7	12	4.4	12.4	14	2.6
2012 (5 dates)	6.6	28	12	14.5	11	6.1	13.0	15	5.3
2013 (5 dates)	7.6	24	5.7	15.3	11	1.5	12.2	18	2.7

Table 8. Lake grades for the Arbor Lakes.

	West			North			South		
	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl
1999	D	A	B	C	A	A	C	A	A
2001	C	--	--	A	--	--	B	--	--
2002	B	A	A	B	A	A	A	A	A
2003	C	A	A	A	A	A	A	A	A
2004	A	A	A	A	A	A	A	A	A
2005	A	B	A	A	A	A	A	A	A
2006	B	B	A	A	A	A	B	B	B
2007	B	A	A	A	A	A	A	A	A
2008	B	B	A	A	A	A	A	A	A
2009	B	B	A	A	A	A	A	A	A
2010	B	C	B	A	A	A	A	A	A
2011	B	B	B	A	A	A	A	A	A
2012	C	B	B	A	A	A	A	A	A
2013	B	B	A	A	A	A	A	A	A



Arbor Lakes Secchi Disc and Total Phosphorus Data

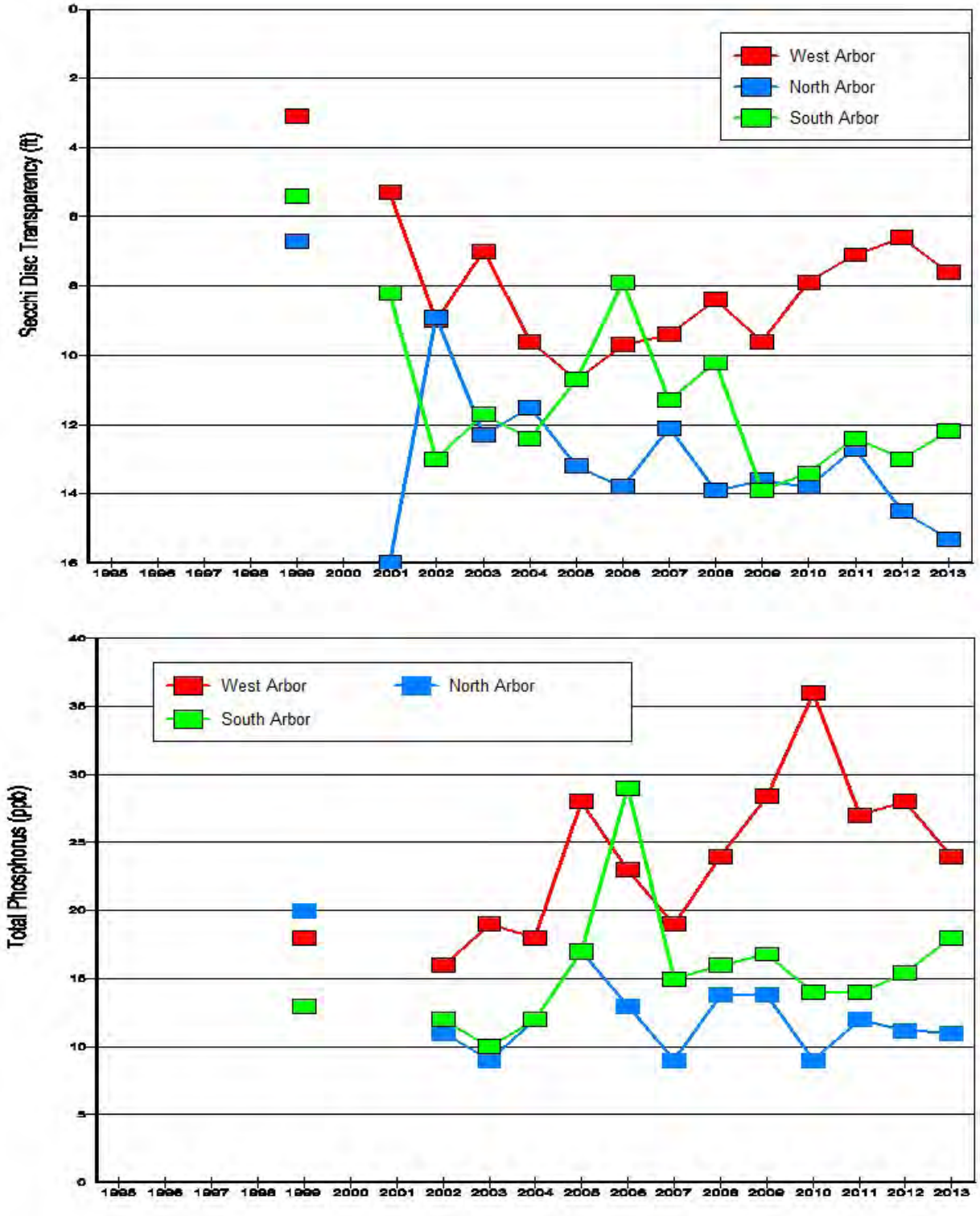


Figure 1. Secchi disc transparency (top) and total phosphorus concentrations (bottom) for the Arbor Lakes from 1999 - 2013.

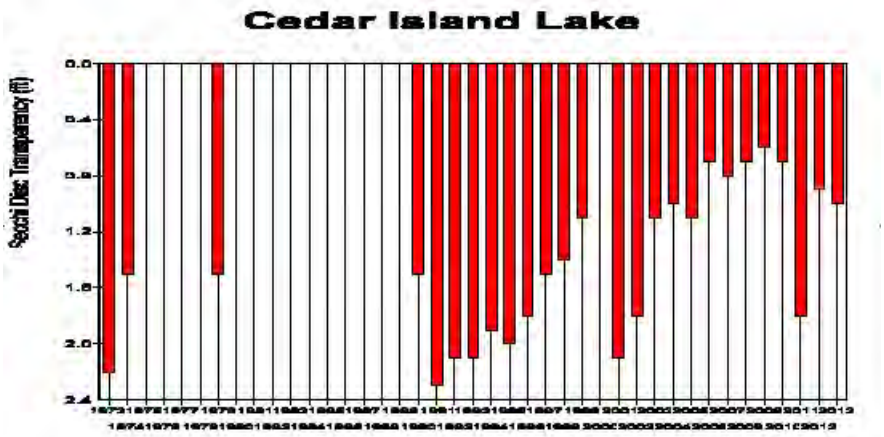
Secchi Disc Transparency Graphs for Maple Grove Lakes

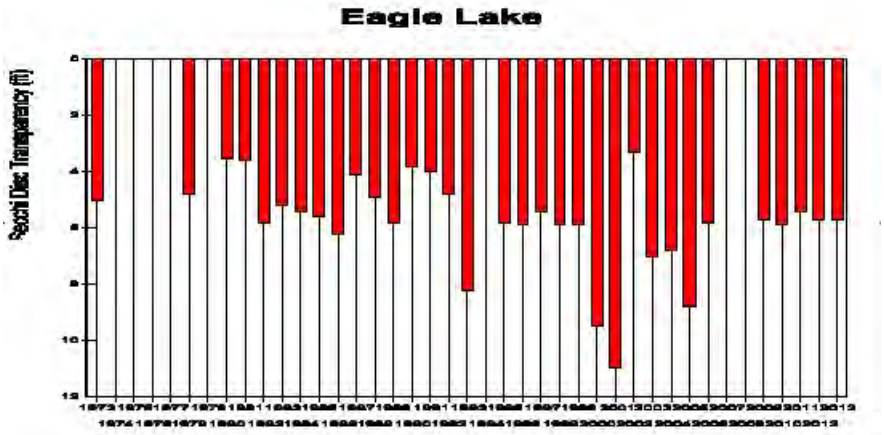
Graphs of average summer water transparency over the years for each of the major Maple Grove lakes are displayed on the next two pages. Eagle, Fish, and Weaver Lakes have summer water clarity averages generally over five feet. Cedar Island Lake generally has a summer average less than two feet. Pike and Rice Lakes averages are right around 3 to 5 feet. Transparency goals for all lakes should average 5 to 7 feet over the summer.

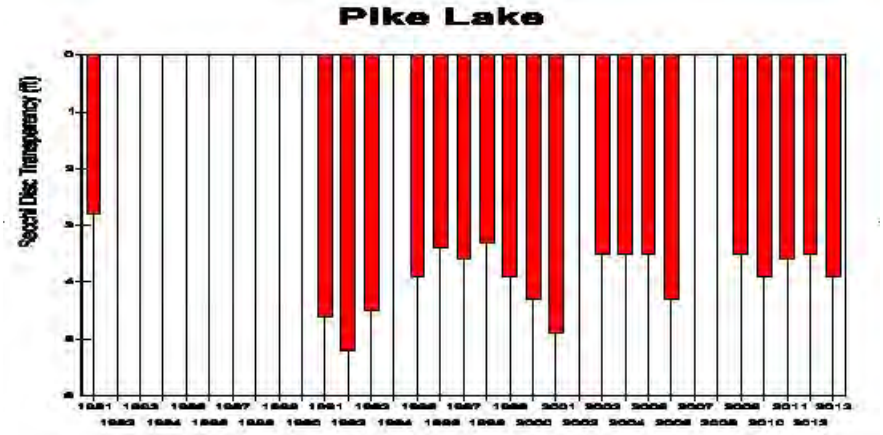
Total Phosphorus Graphs for Maple Grove Lakes

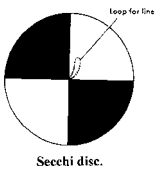
Graphs of average summer water total phosphorus for the major Maple Grove Lakes (not including the Arbor Lakes) are shown after the Secchi disc graphs. Cook Lake had the lowest summer phosphorus concentration of the lakes (although the Arbor Lakes also have low phosphorus concentrations). Rice Lake and Cedar Island Lake had the highest total phosphorus in 2013.

Shingle Creek Watershed District - Secchi Disc Data





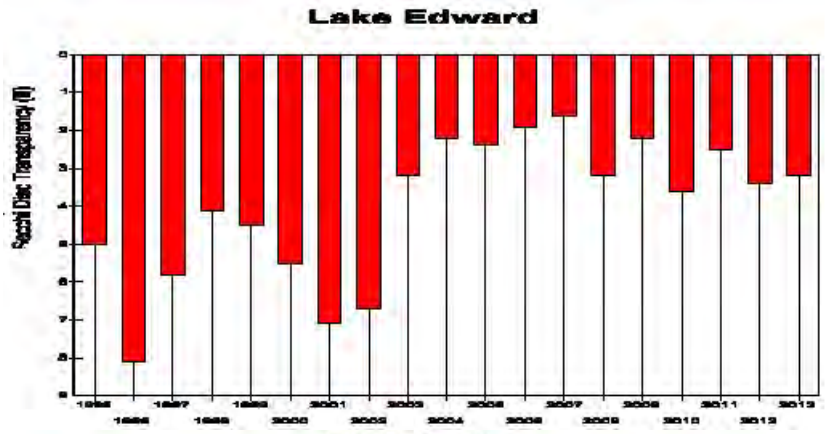


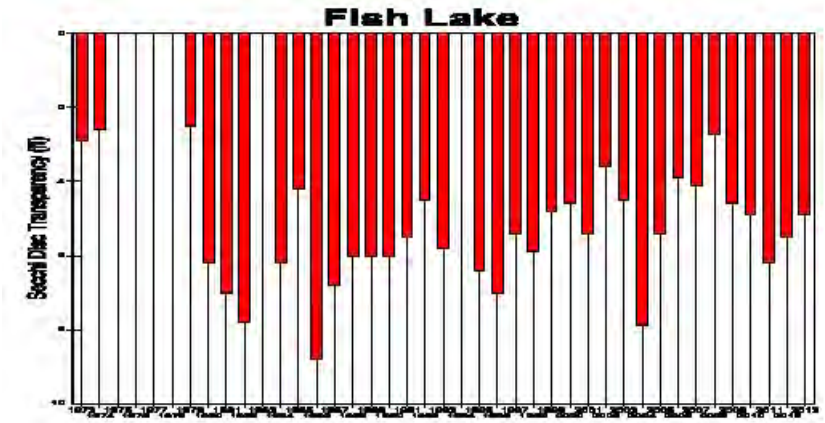


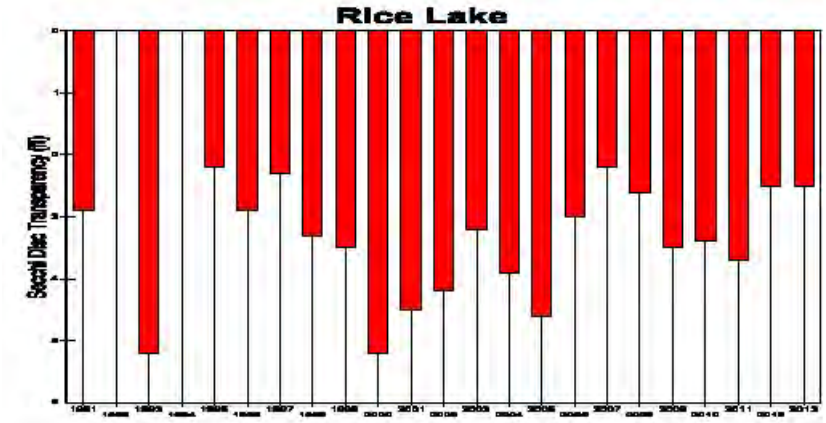
Secchi Disc Results

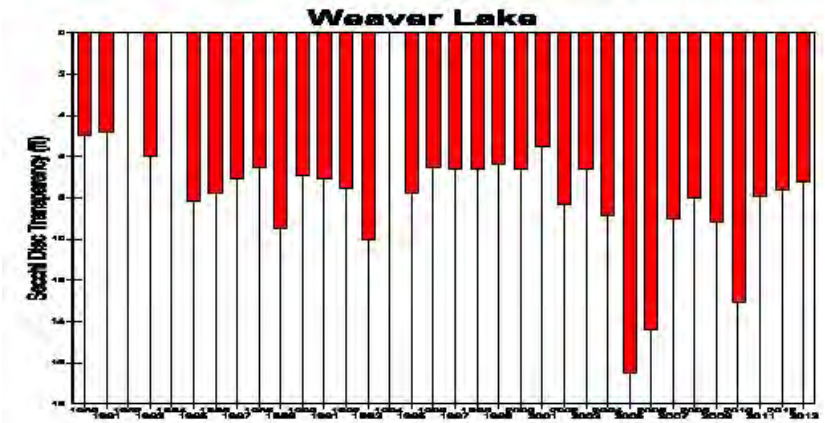
Cedar Island Lake has the lowest Secchi disc transparency in Maple Grove. Transparency fluctuates in the remaining Maple Grove lakes. Aquatic plants could grow to twice the average seasonal secchi disc transparency. Aquatic plants are beneficial for lakes and help to maintain or improve water clarity.

Elm Creek Watershed District - Secchi Disc Data

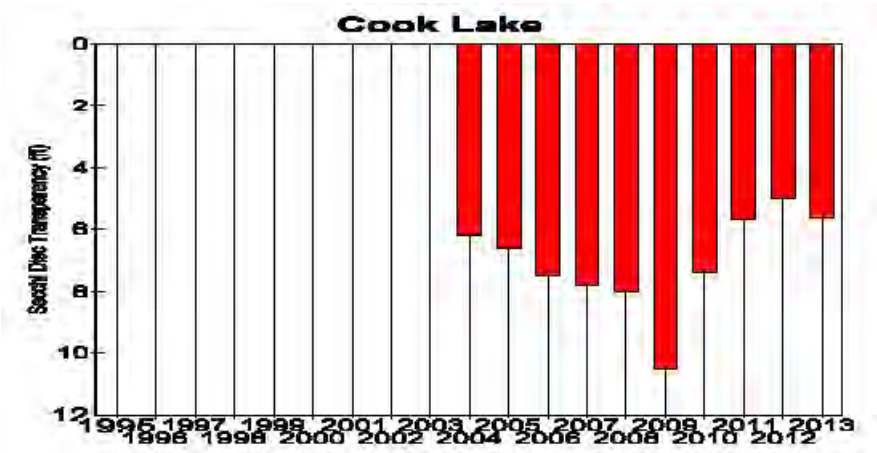


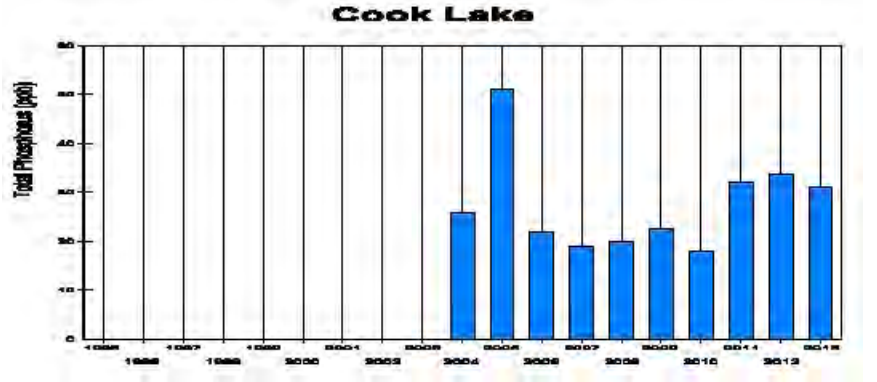




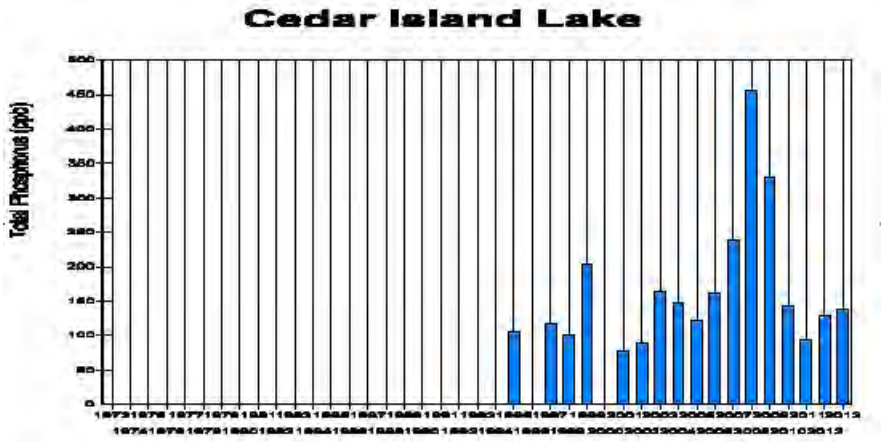


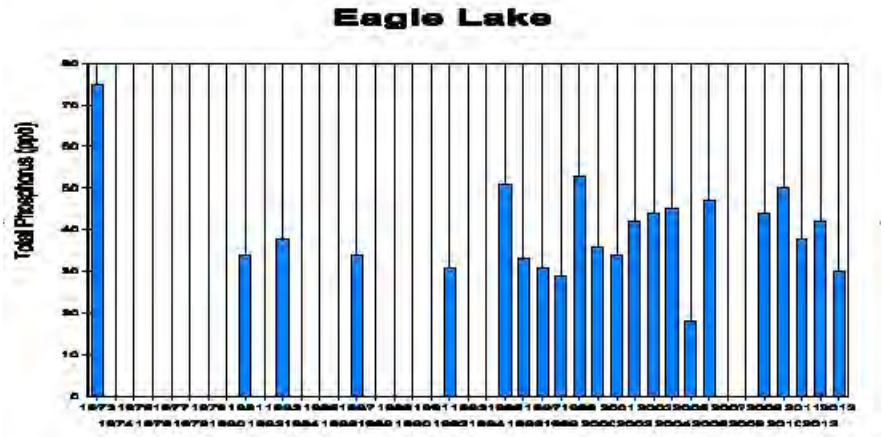
Cook Lake Data

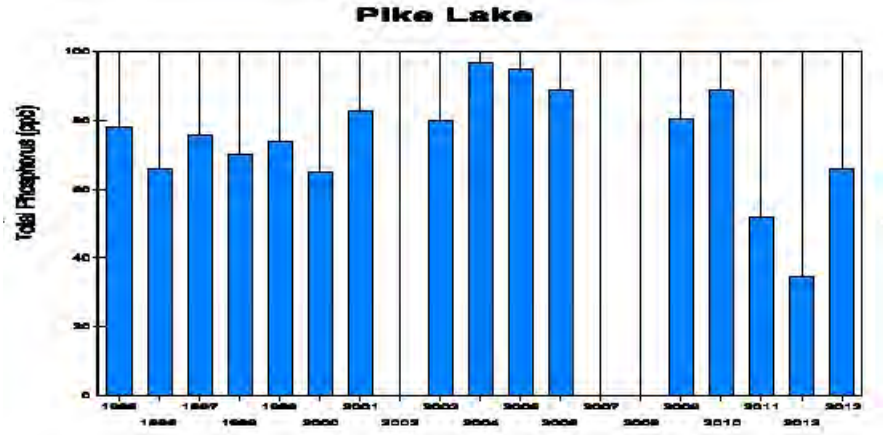




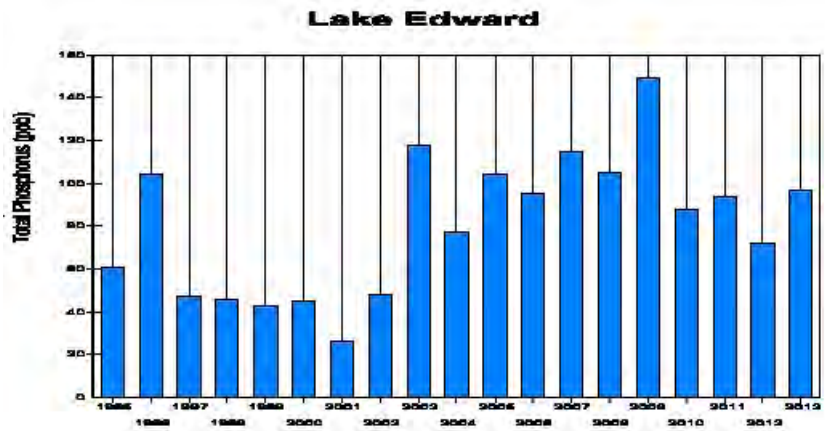
Shingle Creek Watershed District - Total Phosphorus Data

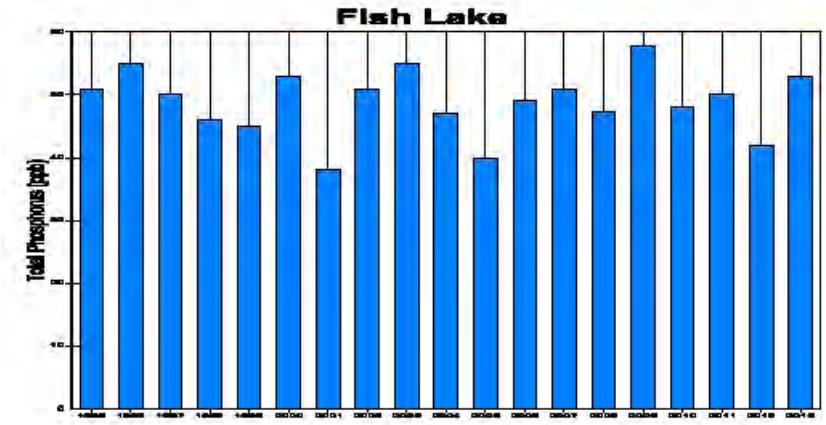


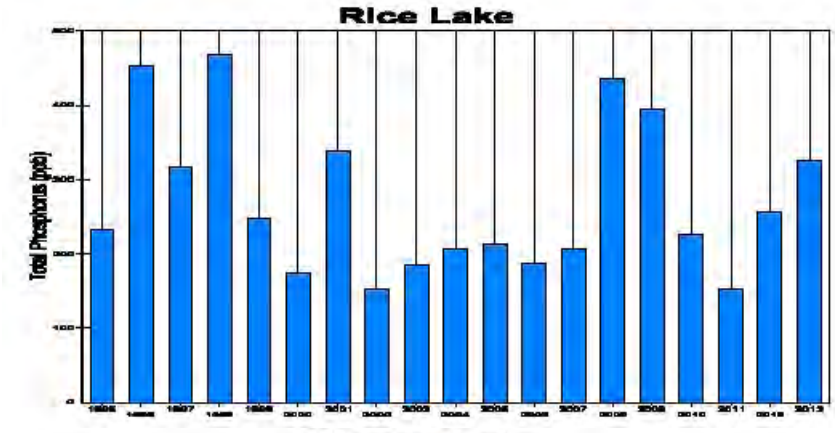


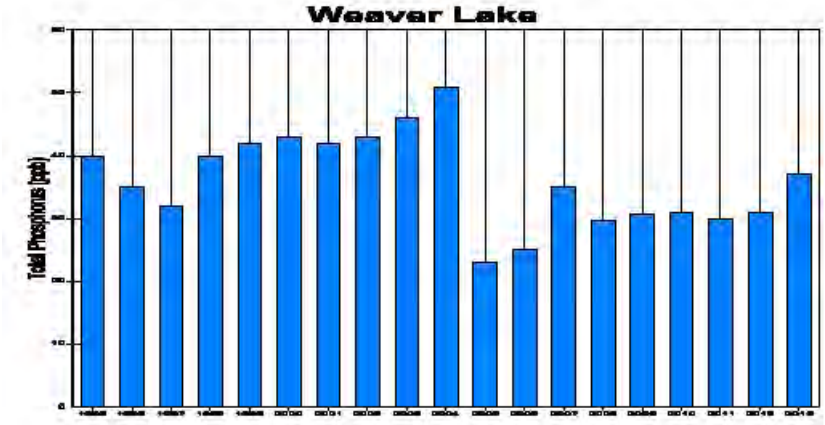


Elm Creek Watershed District - Total Phosphorus Data









Appendix

Table A1. 2009 data.

Lakes	North Arbor			South Arbor			West Arbor			Cedar Island			Cook			Eagle			Edward			Fish			Pike			Rice			Weaver		
	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl
May																																	
week 1*																						3.6	61.7	32.0				2.5	102	19	9.3	46.5	8.49
week 2																																	
week 3																						9.3	55.9	9.61				2.5	164	110	14.8	35.6	4.85
week 4	11.0	17	<1	15.5	17	1.3	10.0	18	1.3	0.8	171	14.1	10.8	21	5.0	10.7	26	5.0	2.6	56	8.7				4.9	56	6.2	4.0 2.5	138	98			
June																																	
week 1																						7.0	70.1	17.9							9.4	37.6	6.74
week 2																												2.0					
week 3																						4.3	59.1	21.8				6.5			8.8	32.3	6.8
week 4	8.3	15	<1	11.8	14	<1	12.8	19	1.5	0.5	314	121	8.3	25	<1	7.0	33	2.9	4.1	80	7.7	3.7	54.6	14.7	3.5	103	3.7	2.5			7.1	24	4.25
July																																	
week 1																												3.0 2.5	338	91			
week 2																						3.4	65.7	13.7							8.5	19.5	2.44
week 3																												1.0	632	500			
week 4	15.9	12	<1	14.5	17	1.6	12.2	24	3.1	0.6	506	235	9.0	30	<1	4.5	50	19.9	1.2	183	186	3.6	87	10.2	1.8	102	56.1	2.0			7.7	31.6	3.52
August																																	
week 1																												1.5					
week 2																						5.2	46.9	15.0				1.5	750	370	8.0	33	3.31
week 3																																	
week 4	15.7	13	<1	15.9	14	1.7	9.8	24	7.1	0.4	351	189	12.1	16	<1	3.1	62	95.3	1.2	223	86.0	3.0	48.4	24.9	4.2	70	9.8	5.0 3.5	529	78	9.6	26.3	3.6
September																																	
week 1																												5.5	333	56			
week 2																						3.8	47	21.4				8.5			9.1	24	2.46
week 3	17.1	12	1.3	11.8	22	4.3	3.1	57	13.7	0.6	306	177	12.2	21	5.0	3.1	50	24.6	2.1	203	123				2.9	72	23.7	6.0	566	34	8.6	28.3	3.67
week 4																						3.7	40.9	20.1									
May-September Average																																	
	13.6	13.8	1.1	13.9	16.8	2.0	9.6	28.4	5.3	0.6	330	147	10.5	22.6	2.6	5.7	44.2	29.5	2.2	149	81.7	4.6	57.9	16.5	3.5	80.6	19.9	3.5	395	151	9.2	30.8	4.6

Table A2. 2010 data

Lakes	North Arbor			South Arbor			West Arbor			Cedar Island			Cook			Eagle			Edward			Fish			Pike			Rice			Weaver		
	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl
May																																	
week 1*																7.0	45	13.5				5.4	61	14.3							23.6	40	1.5
week 2																												5.9	76	6.1			
week 3	9.25	18		7	17		6.7	53		0.67	159	32	7.3	19		13.3	37	3.3	6.7	65		5.7	61	9.7	5.6	64	11.1	5.2	103	15	22.7	29	1.4
week 4																												7.2	116	22			
June																																	
week 1																11.3	48	4.1				9.6	39	4.7	4.8	65	19.2	2.3	92	140	16.6	21	2.9
week 2																																	
week 3																5.1	49	18.0				59	45	12.2	4.1	121	40.2	2.6	130	62	13.6	50	4.8
week 4	10.7	6	1.8	16.8	11	1.2	6.7	20	12.4	0.58	161	74.3	7.4	22	6.2	6.0	46	13.6	3.8	90	41.3	5.0	40	12.7	3.8	75	25.8				14.9	31	3.1
July																																	
week 1																																	
week 2																3.9	47	22.7				3.2	38	15.1	2.1	85	38.1	3.3	448	94	16.5	27	2.1
week 3																																	
week 4	14.4	5	1.2	16.5	7	2.4	9.6	16	4.8	0.9	161	87.8	8.2	12	3.6	3.2	51	35.3	1.9	94	41.3	3.5	34	12.9	3.4	68	20.6	3.3	480	86	9.5	28	4.5
August																												1.6	233	110			
week 1																																	
week 2																3.0	47	36.8				3.3	39	19.1	3.4	54	26.3				9.4	24	4.2
week 3																																	
week 4	17.2	7	1.31	14.7	13	3.7	7.6	47	6.8	0.67	154	70.3	7.4	23	2.4	3.0	53	24.3	2.2	114	77	3.7	51	20.8	3.0	98	35.6	1.6	354	21	6.1	27	8.9
September																																	
week 1																3.2	68	42.7							2.3	164	73.3	1.6	287	38	5.3	27	11.4
week 2																																	
week 3																												2.3	174	36			
week 4	17.5	11	2.4	12.4	22	10.4	4.8	45	18.2	0.7	81	72.1	6.8	15	1.2	4.2	58	16.0	3.7	80	70.5	3.3	74	18.8	7.6	93	9.3				5.9	42	14.1
May-September Average																																	
	13.8	9.4	1.7	13.5	14	4.4	7.9	36	10.5	0.7	143	67.3	7.4	18	3.4	5.9	50	20.9	3.65	88	57.5	4.9	48	14.0	3.9	89	28.8	3.4	227	57.3	13.1	31	5.4

Table A3. 2011 Data

Lakes	North Arbor			South Arbor			West Arbor			Cedar Island			Cook			Eagle			Edward			Fish			Pike			Rice			Weaver		
	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl
May																																	
week 1*																												3.3	52	5.9			
week 2	7.5	19	3.6	7.2	23	3.6	8.9	15	5.9	4.1	37	18	6.0	29	1.2	5.8	42	<1	4.2	64	19.7	5.3	78	26.6	2.9	61	4.5				6.2	33	8.9
week 3																												3.6	62	14			
week 4																						9.4	50	2.9							9.3	33	2.1
June																																	
week 1																						15.6	44	3.2				5.9	68	7.8	14.1	28	6.1
week 2																												4.3	113	40			
week 3										1.3	130	61.2				6.6	42	1.6				8.7	30	7.7	3.0	70	13.5				8.4	32	9.5
week 4	9.5	12	1.2	13.3	9	1.2	11.5	17	1.8										3.1	59	13.4												
July																																	
week 1																						6.5	43	12.0				4.3	106	6.6	4.9	32	6.9
week 2																																	
week 3																						4.7	49	20.2							7.3	30	6.5
week 4	15.8			14.2			5.5			1.7			6.3			6.0			2.3						3.8			4.3	184	29			
August																																	
week 1		11	<1		11	1.1		20	8.7		48	42.2		18	1.8		25	7.4		63	36.8	4.3	45	25.3		36	6.0				7.4	34	9.5
week 2																												4.3	176	35			
week 3																						1.9	49	44.5							5.2	26	11.7
week 4	17.5	12	15.3	18.1	16	1.2	5.5	34	11.6	1.0	111	65	5.1	58	3.1	4.6	30	14.5	1.5	115	66.5	3.1	61	17.7	4.9	51	28.9	1.3	311	110	5.1	27.6	8.6
September																																	
week 1																												3.3	261	53			
week 2																						3.0	49	21.9							9.3	24.3	<5
week 3																																	
week 4	13.1	7	<1	9.2	12	5.8	4.1	47	31.8	0.9	142	120	5.3	24	5.8	3.8	52	102	1.4	170	60.9	5.4	55	21.9	3.6	42	27.6	2.6	194	56	9.8	33.3	8.2
May-September Average																																	
	12.7	12	4.4	12.4	14	2.6	7.1	27	12	1.8	94	61.3	5.7	32	3	5.4	38	25.3	2.5	94	39.5	6.2	50	19	3.6	52	14.1	3.7	153	35.7	7.9	30	7.6

Table A4. 2012 Data

Lakes	North Arbor			South Arbor			West Arbor			Cedar Island			Cook			Eagle			Edward			Fish			Pike			Rice			Weaver		
	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl	SD	TP	Chl
May																																	
week 1*																10.8	32	8.8				12.7	32	8.4									
week 2																13.5	25	6.5													13.6	30.5	6.4
week 3																						10.9	31	6.9									
week 4	7.3	10.8	23	14.8	11	1	7.1	28	12.4	0.8	58	34.4	4.8	30	3.8	9.2	29	13.5	5.4	67	19.2	8.7	31	15.3	4.7	32	6.1	3.6	75	23.5	8.5	44	17.1
June																																	
week 1																																	
week 2																5.3	37	16.6				5.3	35	18.2							6.4	33	14.9
week 3																																	
week 4	14.4	13	1.8	18.1	16	1.4	7.7	20	3.8	0.9	124	59.8	6.1	38	2.7	5.9	37	15.3	4.2	56	12.7	4.9	58	16.5	4.1	28	4.8	3.1	246	87.5	8.5	29	7.2
July																																	
week 1																																	
week 2																3.8	35	31.6				6.1	34	15							6.9	25	8
week 3																																	
week 4	14.2	10	2.1	16.1	10	2.9	3.7	26	14.4	0.9	122	70.1	4.3	48	5.3	3.0	42	35	2.9	57	36.9	1.6	42	62	3.2	32	19.2	2.4	511	74.4	4.4	29	17.3
August																																	
week 1																2.5	50	41				2.1	41	41							6.4	32	13
week 2																																	
week 3																2.6	53	41				2.1	48	35							6.0	32	11.8
week 4	18.4	10	2.2	7.1	16	12.5	6.7	27	8.9	0.9	123	37.6	4.6	36	2.2				1.7	77	65.7				2.6	33	25.8	1.5	302	40.4			
September																																	
week 1																3.1	65	29.2				3.1	50	23.6							7.7	35	6.8
week 2																																	
week 3																3.0	58	32				3.1	59	39							8.2	29	8.3
week 4	18.2	12	1.6	8.8	24	8.7	7.9	29	7.7	0.9	221	90.3	5.4	16	1.6				2.6	104	68.5				3.1	49	19.2	1.9	148	38.3			
May-September Average																																	
	14.5	11.2	6.1	13.0	15.4	9.4	6.6	26	9.4	0.88	130	58.4	5.0	33.6	3.1	5.7	42	25	3.4	72.2	40.6	5.5	42	26	3.54	34.8	15.0	2.5	256	52.8	7.6	31	10.6

Table A5. Arbor Lakes profile data for temperature, dissolved oxygen, pH, conductivity, oxidation/reduction potential (ORP) for 2013.

South Arbor Lake

Depth (m)	June 24					July 18					August 29					September 24				
	Temp (C)	DO (mg/l)	pH	Cond (µs)	ORP (mV)	Temp (C)	DO (mg/l)	pH	Cond (µs)	ORP (mV)	Temp (C)	DO (mg/l)	pH	Cond (µs)	ORP (mV)	Temp (C)	DO (mg/l)	pH	Cond (µs)	ORP (mV)
0	24.4	9.6	8.7	0.99	366	27.5	9.2	9.5	0.92	341	27.1	8.3	9.6	0.95	309	18.6	8.6	9.3	1.03	349
1	23.7	9.1	8.8	0.99	365	27.4	9.2	9.5	0.92	338	27	8.2	9.7	0.95	307	18.5	8.6	9.3	1.03	354
2	23.4	8.9	8.8	0.99	364	26.3	9.5	9.5	0.92	339	27	8.1	9.7	0.95	306	18.4	8.6	9.3	1.03	358
3	21.5	9	8.8	1.06	366	25.2	8.5	9.3	0.93	341	25	8.3	9.7	0.95	304	18.2	8.6	9.3	1.03	362
4	16.45	9	8.5	1.13	377	21.4	8.5	87	1.12	355	23.6	7	8.9	1.01	289	18.1	8.6	9.3	1.04	368
5	12.3	6.2	8.2	1.22	388	15.4	8.2	8.4	1.21	369	22.1	5.1	8.6	1.09	226	18	7.8	9.1	1.04	375
6	9.5	5	8	1.29	393	11.8	5.8	8.1	1.29	376	20.3	4.2	8.5	1.1	208	16.8	3.1	8.5	1.28	398
7	7.9	2.2	7.9	1.35	352	10.2	4.6	8.1	1.33	365						13.9	0.8	8.3	1.36	177

North Arbor Lake

Depth (m)	June 24					July 18					August 29					September 24				
	Temp (C)	DO (mg/l)	pH	Cond (µs)	ORP (mV)	Temp (C)	DO (mg/l)	pH	Cond (µs)	ORP (mV)	Temp (C)	DO (mg/l)	pH	Cond (µs)	ORP (mV)	Temp (C)	DO (mg/l)	pH	Cond (µs)	ORP (mV)
0	23.8	9	8.7	1.035	372	27.1	8.2	9.1	0.989	380	26.9	8.1	9.2	1.03	290	18.7	8.9	9.3	1.1	284
1	23.5	8.7	8.8	1.048	371	27	8.1	9	0.99	374	26.7	8.1	9.2	1.03	291	18.5	9	9.3	1.1	291
2	234	8.5	8.77	1.05	370	26.2	8.2	9.1	0.995	372	26.7	8	9.2	1.02	291	18.4	9	9.3	1.1	299
3	22	8.6	8.7	1.086	372	25.3	8.5	9.1	1	369	25.8	8.3	9.2	1.04	292	18.4	9	9.3	1.1	305
4	18.4	8.8	8.6	1.165	375	23.9	8.5	9	1.05	369	25	8.6	9.2	1.04	294	18.4	9	9.3	1.1	309
5	13.89	10.7	8.5	1.2	381	18.6	12.6	8.9	1.178	376	22.5	9.8	9	1.12	302	18.3	8.9	9.3	1.1	314
6	10.2	12.43	8.4	1.256	385	12.8	15.9	8.8	1.26	382	16.8	15	8.8	1.275	313	18.3	9	9.3	1.1	316
7	7.72	12.7	8.3	1.29	391	9.4	14.2	8.5	1.3	389	12.4	12.5	8.6	1.31	323	14.8	9.5	8.7	1.3	335
8	6.3	8.2	8.1	1.317	396	7.4	9	8.3	1.32	396	9.5	6.5	8.5	1.35	308	11.3	5.9	8.5	1.35	342
9	5.6	4	7.9	1.343	399	6.4	5.2	8.1	1.35	399	8.3	3.6	8.3	1.35	289	9.6	3.2	8.4	1.35	344
10	5.4	1	7.9	1.368	298	6	1.4	8	1.35	389						8.4	1.8	8.4	1.34	345
11																7.3	0.7	8.3	1.35	95

West Arbor Lake

Depth (m)	June 24					July 18					August 29					September 24				
	Temp (C)	DO (mg/l)	pH	Cond (µs)	ORP (mV)	Temp (C)	DO (mg/l)	pH	Cond (µs)	ORP (mV)	Temp (C)	DO (mg/l)	pH	Cond (µs)	ORP (mV)	Temp (C)	DO (mg/l)	pH	Cond (µs)	ORP (mV)
0	24.8	9.3	9.1	0.347	377	28	8.7	9.5	0.334	354	28	9	9.6	0.367	312	19.7	8.8	9.4	0.39	261
1	24	9.1	9.2	0.347	374	27.9	8.6	9.5	0.334	351	27.7	8.3	9.6	0.367	310	19.6	8	9.4	0.39	268
2	23.4	8.8	9.1	0.347	373	26.4	8.8	9.5	0.334	350	26.9	8.2	9.6	0.362	309	19.2	8	9.4	0.39	272
3	19.5	8.5	8.8	0.408	381	25.5	8.7	9.5	0.337	351	25.8	6.3	9.4	0.38	313	19	7.7	9.3	0.39	276
4	16	8.3	8.6	0.434	390	21.7	8.6	8.9	0.458	365	24.9	3.2	8.8	0.94	324	18.9	7.6	9.3	0.39	279
5	13.8	4.3	8.3	0.492	399	19	5.3	8.5	0.495	376	23.7	1	8.5	0.413	101	18.8	7.3	9.3	0.39	281
6	12.7	2	8.1	0.51	357	16.3	1.3	8.3	0.499	338	21.6	0.3	8.2	0.475	26	18.8	7.3	9.3	0.39	284
7						12.5	0.4	8	0.55	64						18.7	7	9.2	0.39	176