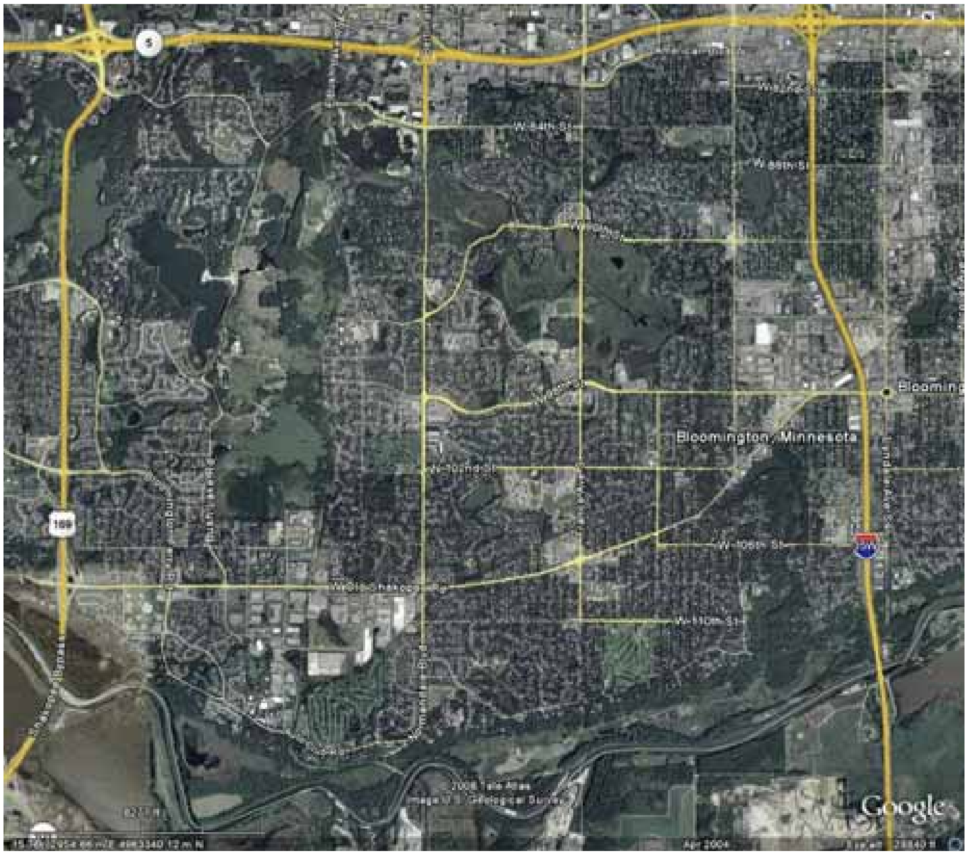

Bloomington Pond Study Area (Google Earth Map)

Water Quality and Aquatic Plant Conditions in 28 Lakes and Ponds in Bloomington, Minnesota

Lakes: Normandale, NW Anderson, Bush Lake Beach

Ponds: River Bluff, Nesbitt, Timberglade, Berkshire, Canterbury Oaks, Hyalnd Courts, Round, Smith Park, Adelmann, Skriebakken, Forest Crest, Wanda Miller, Oxmore, Pauly's, Vitoria, Forest Haven, Wood Cliff, Tierney's Woods, Bogen, Pickfair, Marce Woods North, Marce Woods South, South Bay, Sunrise, Xylon

Prepared for:
City of Bloomington

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

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Introduction

A survey of 25 Bloomington ponds and three lakes was conducted over the summer of 2009 and was sponsored by the City of Bloomington. The location of the ponds in the study is shown in Figure 1.

The objective of the survey included the following:

- Characterize water quality conditions in the selected ponds in June, July, and August.
- Evaluate how ponds were performing in regard to reducing nutrients in stormwater runoff.
- Evaluate aquatic plant and algal treatments on treated ponds.
- Suggest future management options for the Bloomington pond group.

Methods

Data Collection: A total of 25 ponds and three lakes were selected by the City of Bloomington and were sampled by Blue Water Science in June, July, and August of 2009.

Pond water samples were analyzed for total phosphorus. Secchi disc readings were also taken to measure water transparency. In addition, aquatic plant coverage was estimated and dominant plant species were noted each month.

Pond Modeling: Phosphorus modeling was conducted for all 25 ponds. Watershed areas and pond areas were provided by the City. In addition, the City of Bloomington sampled stormwater runoff from June through October for flows into Round Pond. A June through August flow weighted mean was 390 ppb. This runoff value was considered to be representative for a typical watershed runoff value for the City of Bloomington for the summer of 2009.

For pond phosphorus modeling, the MnLEAP model was used. Several modeling scenarios were run and included:

- Predicting pond phosphorus concentration based on an average monitored runoff value of 390 ppb-TP determined by the City of Bloomington.
- Estimating phosphorus loading to a pond based on a TP runoff concentration of 390 ppb.
- Using a back-calculation to estimate phosphorus loading to a pond based on the 2009 summer phosphorus pond concentration.

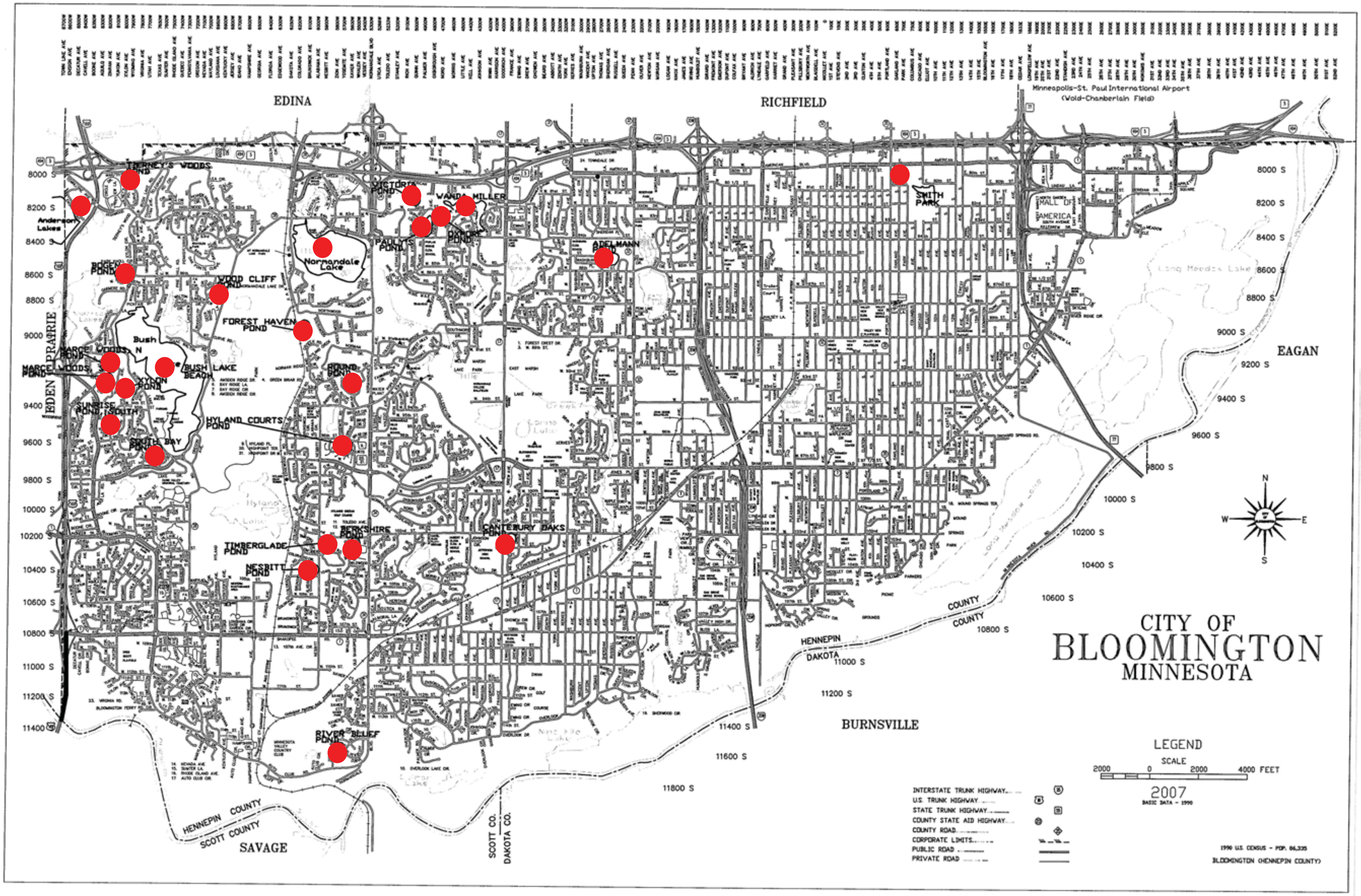


Figure 1. Locations of the 28 Bloomington ponds are shown with red dots.

Results

A total pf 25 ponds and three lakes were sampled in June, July, and August and results for Secchi disc, total phosphorus, and conductivity are shown in Table 1.

Phosphorus: Pond phosphorus concentrations ranged from a low of 34 ppb (Smith Park Pond in June) to a high of 1,710 ppb (Marce Woods N in July)(Table 1). A wide range of phosphorus concentrations were found indicating a variety of factors were influencing phosphorus levels in the ponds.

Secchi Disc: Secchi disc readings ranged from a low of 0.2 feet (Marce Woods N) to a number of readings where the Secchi disc was observed on the pond bottom (Table 1).

Conductivity: Conductivity is a measure of dissolved salts in the pond's water. Conductivity was moderate to high in June and July and then decreased in every pond in August. It appears rainfall from July 27 to the August sample dates generated enough runoff to dilute the ponds with water lower in conductivity then was in the ponds. Runoff in August would have a lower conductivity then runoff in April through June which would be influenced by salt from street salting over the winter. The ratio of conductivity from July to August reflects runoff inputs to the ponds. A high ratio indicates a high runoff in August producing dilution with low conductivity runoff going into the pond water. A low ratio indicates a low amount of runoff and a low dilution effect.

For example, Victoria and Adelmann ponds have a high ratio, indicating a large watershed runoff input relative to the pond volume. Round and Oxmore ponds have a low ratio indicating less runoff from the watershed relative to the pond volume.

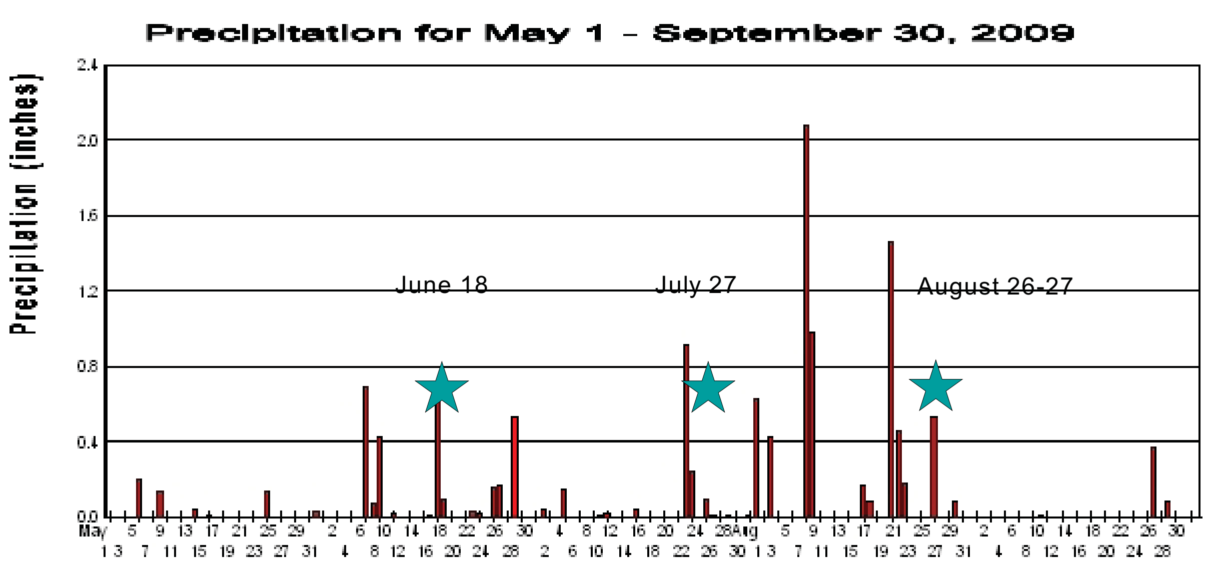


Figure 2. Daily rainfall from May 1 through September 30, 2009 recorded at the Minneapolis-St. Paul airport. Bloomington pond sample dates are shown with a star.

Table 1. Results of sampling 25 ponds and three lakes for three months for Secchi disc, total phosphorus, and conductivity. Blue shading indicates lakes.

Pond Name	Pond Surface Area (ac)	Average Depth (ft)	Max Depth (ft)	Total Phosphorus (ppb)			Secchi Disc (ft)			Conductivity			
				June 18, 2009	July 27, 2009	August 26-27, 2009	June 18, 2009	July 27, 2009	August 26-27, 2009	June 18, 2009	July 27, 2009	August 26-27, 2009	July: Aug Ratio
1. Adelmann	6.6	2.6	3.7	257	171	137	1.5	2 - B	1.7	550	405	110	3.7
2. NW Anderson	179	4	10	375	326	ND	--	1 - B	ND	470	590	ND	--
3. Berkshire	0.56	3	6.5	473	514	353	2.5	1	3 - B	350	340	195	1.7
4. Bogen	5	2.5	4.2	233	277	175	1 - B	1 - B	0.9	280	295	105	2.8
5. Bush Lake	188	9.8	35	25	16	17	>5	>5	5.5	350	290	285	1
6. Canterbury Oaks	0.84	1.8	4.5	274	344	382	0.9	1	0.5	450	370	208	1.8
7. Forest Crest	0.45	3	6.5	--	--	236	--	--	2	--	--	150	--
8. Forest Haven	7.18	3.5	7.5	61	50	38	2.5	3 - B	5	270	255	190	1.3
9. Hyland Court	1.65	3	5	91	74	72	1.2	3 - B	2.7	260	255	109	2.3
10. Marce Woods, N	0.85	1.5	3.5	913	1710	155	0.2	0.2	1.5 - B	310	290	90	3.2
11. Marce Woods, S	1.12	2	6	528	691	267	2 - B	0.5	2.5 - B	490	420	130	3.2
12. Normandale Lake	112	4.2	10	70	95	93	3.5	2 - B	2.3	600	600	450	1.3
13. Nesbitt	1.13	3.5	5.5	306	235	116	3.9	3 - B	3.5 - B	190	210	85	2.5
14. Oxmore	2.29	3	6.2	26	47	78	--	3 - B	2.7	600	800	650	1.2
15. Paulys	7.66	4.24	6.75	96	dry	54	--	0.5 - B (est)	4.3	650	dry	210	--
16. Pickfair	0.69	2.5	5.5	451	184	254	1.8 - B	0.5	4.5	710	550	200	2.8
17. River Bluff	0.69	3	5.5	315	259	294	0.8	1	0.4	300	320	250	1.3
18. Round	2.49	4.49	5.83	211	162	223	4	3 - B	4.5	310	280	230	1.2
19. Smith Park	7.06	4 (-)	-791.5	34	50	51	5.7	5.1	3.4	430	385	120	3.2
20. South Bay	2.33	2.5	9	56	145	183	2 - B	1	1.1	430	385	319	1.2
21. Sunrise, S	2	1	2	292	312	241	1.5 - B	1 - B	1.2	370	280	110	2.6
22. Skriebakken	20.08	3.5	8	97	79	108	3 - B	2 - B	4.5	350	320	250	1.3
23. Tierney's Woods, NW	0.28	3	4.2	253	396	208	1.5 - B	0.5	0.9	600	510	180	2.8
24. Timberglade	3.09	1.5	3.5	317	381	399	3.5 - B	1.5	2.5	220	190	130	1.5
25. Victoria	2.32	3	4.5	42	57	70	3	2 - B	2 - B	550	620	140	4.4
26. Wanda Miller	14	3	5	75	64	81	3 - B	2 - B	4.5	450	315	100	3.2
27. Wood Cliff	0.89	1	1.8	357	no sample	288	1.5 - B	NA	1 - B	330	no sample	120	--
28. Xylon	0.43	1.2	3	ND	541	284	--	0.5 - B	3	ND	110	75	1.5
28. Xylon - 2				610	ND	ND	NA			320	ND	ND	

Pond Treatment in 2009

Several treatment techniques were used to control excessive aquatic plants and algae in a number of Bloomington Ponds in 2009. Descriptions of the chemical treatments and non-chemical treatments are shown in Table 2.

Table 2. Description of treatment methods used for the Bloomington ponds in 2009.

Aqua-Kleen	Aqua-Kleen is a herbicide and the active ingredient is 2,4-D. It is a systemic herbicide that is absorbed and moves within the plant to the site of action. It acts more slowly than a contact herbicide, but quicker than Sonar. It controls Eurasian watermilfoil and can control water lilies.
Avast:	Avast is the trade name for a fluridone herbicide. It is very similar to Sonar.
Barley straw:	Barley is an organic carbon amendment. Barley straw is installed contained in mesh bags. Barley is suppose to reduce phosphorus in ponds and control algae and possibly duckweed. It is a new technique an still in development.
Copper sulfate:	Copper sulfate is primarily an algaecide. Copper is toxic to algae and is usually added to a pond as a complexed copper compound to prevent a rapid precipitation of copper carbonate, which makes copper inert and no longer effective.
Cutrine plus:	Cutrine is a chelated copper algaecide. It is complexed to keep it from precipitating too rapidly. It is considered to be more effective than copper sulfate because it stays active longer.
Galleon:	Galleon is a herbicide and the active ingredient is penoxsulam. It is a non-selective systemic herbicide that requires a very long exposure period (60 days). It controls submersed, floating, and emergent plants. It's mode of action is by disrupting synthesis of amino acids.
Habitat:	Habitat is a herbicide and the active ingredient is imazapyr. It is a broad spectrum systemic herbicide used for emergent plants (such as cattails) and floatingleaf plants (such as lilies) with control in 2-4 weeks. It is not used for submersed plants. Its mode of action is by interrupting DNA synthesis and cell growth (action is similar to the herbicide Rodeo).
Hydrothol/ Aquathol:	Hydrothol and aquathol are herbicides and the active ingredient is endothall. It is a fast-acting non-selective contact herbicide used for a variety of aquatic plants including curlyleaf pondweed. Contact herbicides kill all plant cells that they contact.
Reward	Reward is a herbicide and the active ingredient is diquat. It is a fast-acting non-selective contact herbicide used for a variety of submersed aquatic plants. It's mode of action kills the vegetative part of the plant but does not kill the roots. It is suitable for spot treatments. Turbid water or dense algal blooms can interfere with its effectiveness.
Skimming:	Skimming is a process of physically removing surface growth of duckweed, watermeal, and filamentous algae using a specially designed net to round up the vegetation and remove it from the pond.
Sonar:	Sonar is a herbicide and the active ingredient is fluridone. It is a non-selective systemic herbicide that requires a very long exposure period (30-60 days). It is used for submersed plants and duckweed and watermeal. Its mode of action is by disrupting carotenoid synthesis.
Weedtrine D:	Weedtrine is the tradename for a diquat herbicide. It is very similar to Reward.
WhiteCap	WhiteCap is the trade name for a fluridone herbicide. It is very similar to Sonar.

Pond Treatments and Aquatic Plant Coverage: A total of 16 out of 25 ponds had some type of treatment in 2009 (Table 3). Sonar, an herbicide used for aquatic plant control, was used in 9 of the ponds and Galleon, an herbicide used for aquatic plant control was used in 6 ponds in combination with Sonar. However, duckweed (DW) and watermeal (WM) were not always controlled with herbicides.

For example Marce Woods - North, Marce Woods - South, and Pickfair were treated with Sonar and Galleon and duckweed and watermeal still had 90% to 100% coverage. Several ponds with Sonar usage had very little surface growth. These ponds included Canterbury Oaks, South Bay, Sunrise, and Xylon. Results from barley straw and skimming techniques used to control duckweed and watermeal were mixed. Round Pond had satisfactory control and Nesbitt Pond had control for 1 out of 3 months for duckweed and watermeal. Copper sulfate was used on three ponds and surface coverage control was satisfactory. However, for 10 ponds with no treatment, surface coverage by duckweed or watermeal was low and was not a problem.

Submerged aquatic plants were found in 15 of the ponds and in 10 ponds no submerged plants were observed. Submerged plants could help to minimize duckweed coverage and could lower pond phosphorus concentrations. All ten ponds that currently do not have submersed aquatic plants have the potential to support plants. One of the pond water quality goals will be to increase the distribution of native submersed plants.

Pond Phosphorus Concentrations and Secchi Disc Transparency for 2009: The June-August average for total phosphorus (TP) and for Secchi disc transparency is shown in Table 4 (data for individual months is shown in Table 1). Summer average total phosphorus concentrations ranged from a low of 45 ppb for Smith Park to a high of 926 ppb for Marce Woods - North.

A goal for stormwater pond phosphorus concentrations is 150 ppb because a Central Hardwood Forest Ecoregion stream phosphorus value is 150 ppb. If stormwater ponds can maintain phosphorus concentrations at around 150 ppb, then the outflow from a stormwater pond will deliver an ecoregion stream phosphorus concentration to downstream waterbodies. Nine ponds had a June-August average phosphorus concentration of 150 ppb or less.

Table 3. Aquatic plant treatment methods, aquatic plant coverage, and dominant plants observed in the Bloomington ponds for 2009. Green shading indicates 90-100% coverage with duckweed or watermeal. Red shading indicates no submerged aquatic plants observed.

Pond Name	Pond Surface Area (ac)	Average Depth (ft)	Max Depth (ft)	Treatment Notes	% Surface Coverage			Dominant Plants		
					June 18, 2009	July 27, 2009	August 26-27, 2009	June 18, 2009	July 27, 2009	August 26-27, 2009
1. Adelmann	6.6	2.6	3.7	--	0%	3% DW	2% DW	elodea (50%), stringy pw	elodea (30%), stringy pw - common	elodea, stringy pw
2. NW Anderson	179	4	10	--	40% FA	50% FA	--	variety of submerged	unchecked	unchecked
3. Berkshire	0.56	3	6.5	--	0%	0%	0%	no plants	no plants	no plants
4. Bogen	5	2.5	4.2	--	1% FA	0%	0%	stringy pw (90%)	sago pw (80%)	no plants
5. Bush Lake	188	9.8	35	--	0%	0%	0%	chara (3), floatingleaf (2)	nearshore: chara, EWM, NWM, floatingleaf	lilies, coontail, elodea, stringy pw
6. Canterbury Oaks	0.84	1.8	4.5	Sonar, Galleon	8% DW	0%	0%	no plants	no plants	no plants (algae bloom)
7. Forest Crest	0.45	3	6.5	--	NA	NA	100% DW	NA	NA	no plants
8. Forest Haven	7.18	3.5	7.5	--	35% WL	50% WL	50% WL	coontail, curlyleaf, elodea, sago	coontail, narrowleaf pw (40%)	coontail, curlyleaf, elodea, stringy pw
9. Hyland Court	1.65	3	5	--	0%	10% FA	0%	curlyleaf (80%), stringy pw (5%)	curlyleaf pw, stringy pw (40%) (3 fountains)	curlyleaf, duckweed on shoreline, stringy pw
10. Marce Woods, N	0.85	1.5	3.5	Sonar, Galleon	100% DW	100% DW	90% DW	no plants	no plants	no plants
11. Marce Woods, S	1.12	2	6	Sonar, Galleon	100% WM 2% DW	100% WM	90% WM	no plants	no plants	no plants
12. Normandale Lake	112	4.2	10	Reward	10% DW 25% WL	60% FA 40% WL	30% DW/WM 40% WL	coontail, curlyleaf, elodea	unchecked	coontail, curlyleaf, elodea, flatstem
13. Nesbitt	1.13	3.5	5.5	Barley, Skimming	100% DW	70% DW	100% DW	no plants	no plants	no plants
14. Oxmore	2.29	3	6.2	Copper sulfate	5% FA	0%	0%	stringy pw	chara, sago pw, stringy pw 30-50%), FA on bottom in patches	stringy pw (crayfish kill)
15. Paulys	7.66	4.24	6.75	Copper sulfate, Habitat	40% WL	40% WL	25%WL	stringy pw	coontail, stringy pw	terrestrial plants
16. Pickfair	0.69	2.5	5.5	Sonar, Galleon	20% WM 60% DW	100% DW	100% DW	no plants	no plants	no plants
17. River Bluff	0.69	3	5.5	--	0%	0%	0%	sago pw (5-10%)	water stargrass (5%) aeration system	stringy pw
18. Round	2.49	4.49	5.83	Barley, skimming	60% WM	15% WM	25% (95% WM 5% DW)	no plants	no plants	no plants
19. Smith Park	7.06	4	9	Copper sulfate	19% FA	20% FA	5% FA	coontail (1%), elodea (40%) stringy pw (5%)	elodea, coontail plants out to 6 ft	coontail, elodea
20. South Bay	2.33	2.5	9	Sonar	2% DW	5% FW, DW	0%	curlyleaf (5%), sago (100%)	curlyleaf, sago (30-40%), stringy pw	arrowhead, chara, coontail, stringy pw
21. Sunrise, S	2	1	2	Sonar	5% DW	50% WM	10% WM	chara or nitella (20%)	coontail - trace	watermeal, chara
22. Skriebakken	20.08	3.5	8	--	65% WL 2% DW	65% WL DW trace	50% WL	coontail, elodea, narrowleaf pw, stringy pw	coontail (70%), flatstem	coontail, elodea, stringy pw
23. Tierney's Woods, NW	0.28	3	4.2	Sonar, Galleon	0%	0%	0%	no plants	no plants	no plants
24. Timberglade	3.09	1.5	3.5	Sonar	10%	50% DW	95% DW	elodea (100%), flatstem pw, naiad, stringy pw	coontail (was dying back - herbicides), elodea, flatstem	no plants
25. Victoria	2.32	3	4.5	--	2% FA 5% WL	2% WL 4% FA	5% WL 4% FA	none - trace benthic algae	Cabbage (common), coontail, elodea 5 dead bullheads in small area	cabbage, coontail, elodea, floatingleaf pw, naiads
26. Wanda Miller	14	3	5	Habitat	25% WL	60% WL	60% WL	bladderwort, cabbage, coontail, stringy pw	cootail (60%), flatstem, floatingleaf	cabbage, coontail, elodea
27. Wood Cliff	0.89	1	1.8	--	0%	100% FA	20%	narrowleaf pw (50%)	60% dry, 3 inch deep	narrowleaf (50%)
28. Xylon	0.43	1.2	3	Sonar, Galleon	not checked	30% FA, DW, WM	0%	not checked	no plants (blue dye)	no plants (blue dye)

* DW = duckweed; FA = filamentous algae; pw = pondweed; WL = white lilies; WM = watermeal

Table 4. Summer averages for total phosphorus (TP) and Secchi disc readings.

Pond Name	Water-shed Size (ac)	Direct Water-shed (ac)	Indirect Water-shed (ac)	Pond Surface Area (ac)	Water-shed to Pond Ratio	Average Depth (ft)	Max Depth (ft)	Actual TP (2009) (Jun, Jul, Aug Average) (ppb)	Actual Secchi Disc (2009) (Jun, Jul, Aug Average) (feet)
1. Adelmann	127	53	74	6.6	19	2.6	3.7	188	1.7+
2. NW Anderson	>587	587	?	179	3.3	4	10	351**	--
3. Berkshire	18	3	15	0.56	32	3	6.5	447	2.2+
4. Bogen	59	14	45	5	12	2.5	4.2	228	1.0+
5. Bush Lake	1285	778	507	188	6.8	9.8	35	19	6.0+
6. Canterbury Oaks	15	6	8	0.84	18	1.8	4.5	333	0.8
7. Forest Crest	23	9	14	0.45	51	3	6.5	236*	2+
8. Forest Haven	56	27	28	7.18	7.8	3.5	7.5	50	3.5+
9. Hyland Court	25	5	19	1.65	15	3	5	79	2.3+
10. Marce Woods, N	26	4	22	0.85	31	1.5	3.5	926	0.6+
11. Marce Woods, S	33	7	26	1.12	30	2	6	495	1.7+
12. Normandale Lake	21,556	161	21395	112	193	4.2	10	86	2.6+
13. Nesbitt	42	6	36	1.13	37	3.5	5.5	219	3.5+
14. Oxmore	10	10	0	2.29	4.4	3	6.2	50	2.9+
15. Paulys	96	13	83	7.66	13	4.24	6.75	75**	2.4+
16. Pickfair	85	6	79	0.69	123	2.5	5.5	296	2.3+
17. River Bluff	12	5	7	0.69	17	3	5.5	289	0.7
18. Round	26	9	17	2.49	10	4.5	5.83	199	3.8+
19. Smith Park	444	31	413	7.06	63	4	8 est	45	4.7
20. South Bay	16	16	0	2.33	6.7	2.5	9	128	1.4+
21. Sunrise, S	13	9	4	2	6.5	1	2	282	1.2+
22. Skriebakken	319	49	270	20.08	16	3.5	8	95	3.2+
23. Tierney's Woods, NW	6	3	3	0.28	21	3	4.2	286	1.0+
24. Timberglade	93	49	44	3.09	30	1.5	3.5	366	2.5+
25. Victoria	68	16	52	2.32	29	3	4.5	56	2.3+
26. Wanda Miller	166	50	116	14	12	3	5	73	3.2+
27. Wood Cliff	21	21	0	0.89	24	1	1.8	322**	1.3+
28. Xylon	2	2	0	0.43	4.7	1.2	3	412**	1.8+

Notes
* One month of data
** Two months of data

Comparing Actual Pond Total Phosphorus Concentrations to Modeled Pond TP: Average summer total phosphorus (TP) pond concentrations for 2009 had a wide range of results (summarized in Table 4). Pond TP models were run for all 25 ponds to determine if the predicted pond TP from the model was similar to the observed pond TP. When running the model, an inflow phosphorus concentration had to be selected. A summer average runoff TP concentration of 390 ppb was used and was based on flow weighted mean runoff TP concentrations collected by the City of Bloomington from June through August, 2009 in the Round Pond watershed (Table 5). It was assumed the runoff TP concentration of 390 ppb was representative of urban runoff that flowed into Bloomington ponds in 2009 and 390 ppb-TP was used as the input for all 25 model runs.

Based on the runoff concentration of 390 ppb, pond models were run and results are shown in column 6 of Table 6. These pond concentrations were than compared to actual pond TP concentrations shown in column 5 of Table 6. For most of the ponds, (13 out of 25) the actual pond TP concentrations were higher than the predicted pond TP based on a TP runoff concentration of 390 ppb. This indicates for the 13 ponds that more phosphorus was coming into the ponds than the phosphorus associated with runoff at 390 ppb-TP. The source of extra phosphorus could be from the watershed or from internal sources.

Table 5. Stormwater runoff samples collected from an inflow to Round Pond were analyzed for total phosphorus in 2009. Data were reported by City of Bloomington.

Date - 2009	Total Phosphorus (ppb)	Total Phosphorus Load (pounds)	Rainfall (inches)	Period (hours)	Volume (gallons)
June 16	260	0.17	0.77	5.8	57,418
June 27	470	0.11	0.40	1.5	19,795
July 9	310	0.08	0.15	1.0	8,804
July 21	460	0.16	0.67	3.0	40,540
August 7	400	0.18	1.37	5.0	52,559
August 19	430	0.38	1.88	5.0	106,912
June-August	388 (average)	1.08 (total)	5.24 (total)	3.6 (average)	286,028 (total)
Oct 6	420	0.14	1.40	6.0	39,993
Oct 21	580	0.14	0.55	6.0	29,673
Oct 29	550	0.26	0.60	12.25	56,396

Likewise, the estimated phosphorus loading to the ponds (column 7), backed calculated from the actual pond TP concentrations, is higher for 13 ponds than the estimated loading based on a TP runoff concentration of 390 ppb (Column 8). When another model simulation was run to match the estimated runoff TP concentration to produce the observed pond TP concentration, the runoff TP concentration was often way above the standard residential runoff concentration of 390 ppb (Column 9).

Table 6. Summary of actual pond TP concentrations and modeling results (using the MnLEAP model) that estimate pond TP, runoff TP, and TP loading for several scenarios.

1. Pond Name	2. Water-shed Size (ac)	3. Pond Surface Area (ac)	4. Pond Average Depth (ft)	5. Actual Pond TP Conc (2009) (Jun, Jul, Aug avg) (ppb)	6. Predicted MnLEAP Pond TP Based on Typical Residential Runoff of 390 ppb	7. Estimated TP Load Based on Actual Pond TP for 2009 (kg/yr)	8. Estimated TP Load Based on Runoff TP Conc of 390 ppb	9. Estimated Runoff TP Conc into Pond for 2009 (ppb)	10. Goal for Pond TP Conc (ppb)	11. Estimated TP Load Needed to Meet Pond TP Goal (kg/yr)	12. Estimated Runoff TP Conc Needed to Meet Pond TP Goal (ppb)	13. Reduction of TP in kg/yr Needed to Meet Pond TP Goal (kg/yr)
1. Adelmann	127	6.6	2.6	188	172	31	27	445	150	23	337	8
2. NW Anderson	587++	179	4	351**	--	--	--	--	--	--	--	--
3. Berkshire	18	0.56	3	447	188	12	4	1,285	150	3	292	9
4. Bogen	59	5	2.5	228	148	24	13	744	150	13	406	11
5. Bush Lake	1285	188	9.8	19	--	--	--	--	--	--	--	--
6. Canterbury Oaks	15	0.84	1.8	333	185	7	3	878	150	2	300	5
7. Forest Crest	23	0.45	3	236*	212	5	5	447	150	3	254	2
8. Forest Haven	56	7.18	3.5	50	114	4	12	100	150	19	605	ok
9. Hyland Court	25	1.65	3	79	151	2	5	150	150	2	150	0
10. Marce Woods, N	26	0.85	1.5	926	222	36	5	2,645	150	3	242	33
11. Marce Woods, S	33	1.12	2	495	205	22	7	1,274	150	5	265	17
12. Normandale Lake	21,556	112	4.2	86	--	--	--	--	--	--	--	--
13. Nesbitt	42	1.13	3.5	219	187	11	9	480	150	7	290	4
14. Oxmore	10	2.29	3	50	99	1	2	110	150	4	800	ok
15. Paulys	96	7.66	4.24	75**	125	10	21	180	150	27	515	ok
16. Pickfair	85	0.69	2.5	296	265	20	18	446	150	9	202	11
17. River Bluff	12	0.69	3	289	157	6	3	945	150	2	364	4
18. Round	26	2.49	4.49	199	115	13	6	940	150	8	595	5
19. Smith Park	444	7.06	4	45	208	15	92	59	150	61	258	ok
20. South Bay	16	2.33	2.5	128	124	4	4	410	150	5	531	ok
21. Sunrise, S	13	2	1	282	168	6	3	846	150	2	330	4
22. Skriebakken	319	20.08	3.5	95	145	38	68	210	150	71	410	ok
23. Tierney's Woods, NW	6	0.28	3	286	167	3	1	835	150	1	335	2
24. Timberglade	93	3.09	1.5	366	222	37	19	750	150	12	238	25
25. Victoria	68	2.32	3	56	183	3	14	82	150	11	297	ok
26. Wanda Miller	166	14	3	73	139	15	36	150	150	40	438	ok
27. Wood Cliff	21	0.89	1	322**	231	7	4	598	150	3	228	4
28. Xylon	2	0.43	1.2	412**	143	2	0	2,090	150	0.4	420	0.8

Notes
* One month of data
**Two months of data

Interpreting Sampling and Modeling Results

Water quality in Smith Park Pond and in Victoria Pond were a surprise. Both have a large watershed to pond area ratio yet both had some of the best water quality of the ponds tested (Table 7). The average TP runoff concentration is estimated at 390 ppb (based on runoff monitoring conducted by the City of Bloomington). In our study it is estimated that 9 out of 25 ponds receive runoff of around 390 ppb or less. It turns out that ponds that had an estimated runoff TP concentration of around 390 ppb or less, also met the pond TP goal of 150 ppb. The black line after South Bay divides the ponds that met the 150 ppb goal from ponds that had a TP concentration greater than 150 ppb. For the remaining 16 ponds, either watershed TP runoff concentrations are high or internal phosphorus loading is significant and contributes to the elevated pond TP concentration.

Table 7. Listing of pond TP concentrations from the lowest (Smith Park) to the highest (Marce Woods N). The three lakes are shown at the bottom of the table.

Pond Name	Pond Area (ac)	Actual Pond TP Conc (2009) (Jun, Jul, Aug avg) (ppb)	Watershed to Pond Area Ratio	Treatment in 2009	Estimated runoff TP conc into pond (ppb)	Reduction of TP in kg/yr Needed to Meet Pond TP Goal of 150 ppb (kg/yr)	Reduction of TP in kg per watershed acre Needed to Meet Pond TP Goal of 150 ppb (kg/ac)
19. Smith Park	7.06	45	63	Copper sulfate	59	ok	--
8. Forest Haven	7.18	50	7.8	--	100	ok	--
14. Oxmore	2.29	50	4.4	Copper sulfate	110	ok	--
25. Victoria	2.32	56	29	--	82	ok	--
26. Wanda Miller	14	73	12	Habitat	150	ok	--
15. Paulys	7.66	75	13	Copper sulfate, Habitat	180	ok	--
9. Hyland Court	1.65	79	15	--	150	0	--
22. Skriebakken	20.08	95	16	--	210	ok	--
20. South Bay	2.33	128	6.7	Sonar	410	ok	--
1. Adelmann	6.6	188	19	--	445	8	0.06
18. Round*	2.49	199	10	Barley, skimming	940	5	0.19
13. Nesbitt*	1.13	219	37	Barley, Skimming	480	4	0.1
4. Bogen	5	228	12	--	744	11	0.19
7. Forest Crest	0.45	236	51	--	447	2	0.09
21. Sunrise, S	2	282	6.5	Sonar	846	4	0.31
23. Tierney's Woods, NW	0.28	286	21	Sonar, Galleon	835	2	0.33
17. River Bluff*	0.69	289	17	--	945	4	0.33
16. Pickfair*	0.69	296	123	Sonar, Galleon	446	11	0.13
27. Wood Cliff	0.89	322	24	--	598	4	0.15
6. Canterbury Oaks	0.84	333	18	Sonar, Galleon	878	5	0.33
24. Timberglade	3.09	366	30	Sonar	750	25	0.27
28. Xylon	0.43	412	5	Sonar, Galleon	2,090	2	0.8
3. Berkshire	0.56	447	32	--	1,285	9	0.5
11. Marce Woods, S	1.12	495	30	Sonar, Galleon	1,274	17	0.52
10. Marce Woods, N	0.85	926	31	Sonar, Galleon	2,645	33	1.27
5. Bush Lake	188	19	6.8	--	--		NA
12. Normandale Lake	112	86	193	Reward	--	NA	NA
2. NW Anderson	179	351	3.3	--	--	NA	NA

* Bioverse in 2005

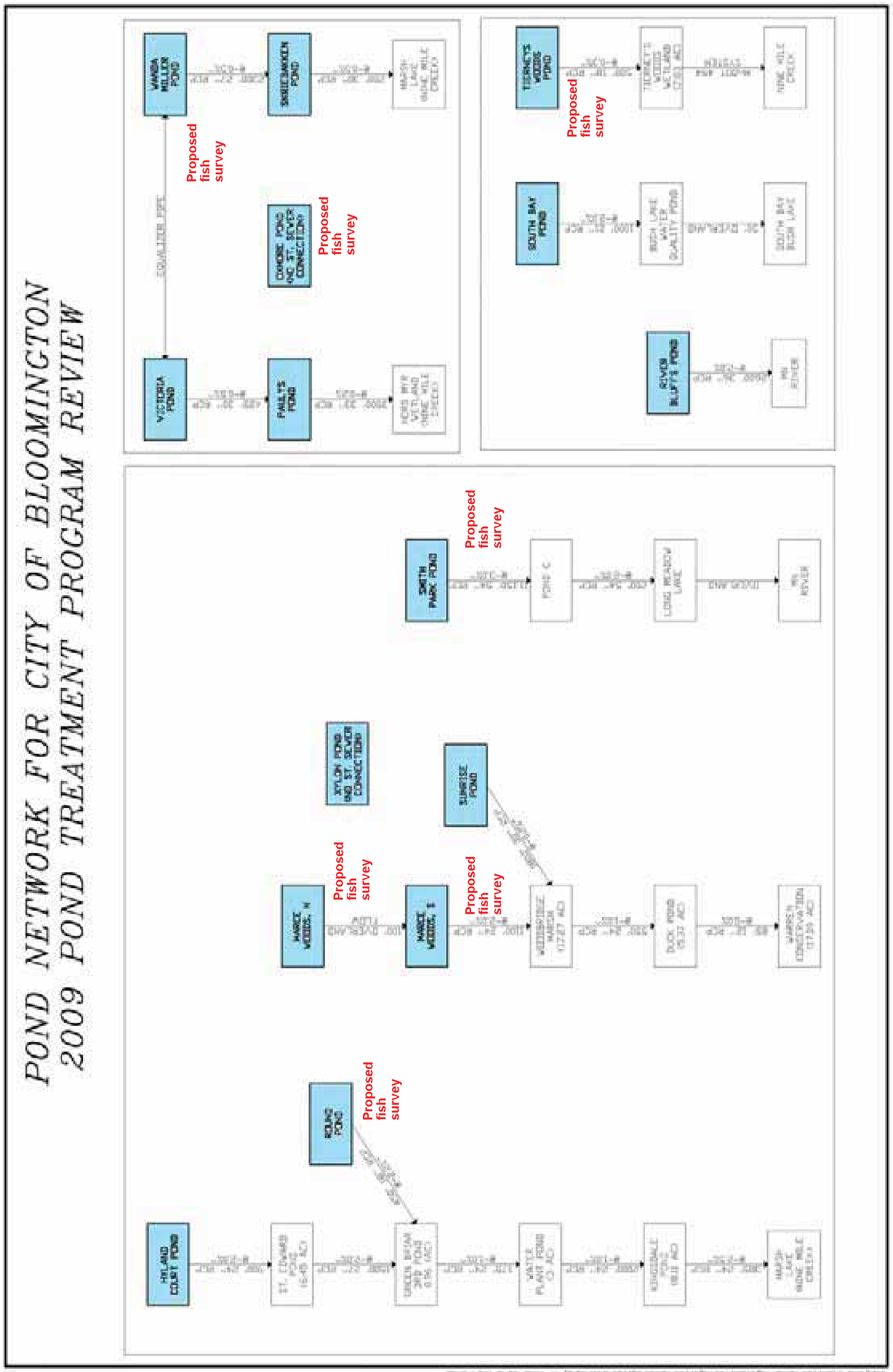
Stormwater Pond Network: Many of the stormwater ponds in the City of Bloomington are connected to other ponds. The network of the ponds sampled in this study and the water bodies they outflow to are shown on the next two pages (study ponds are shown in blue shading).

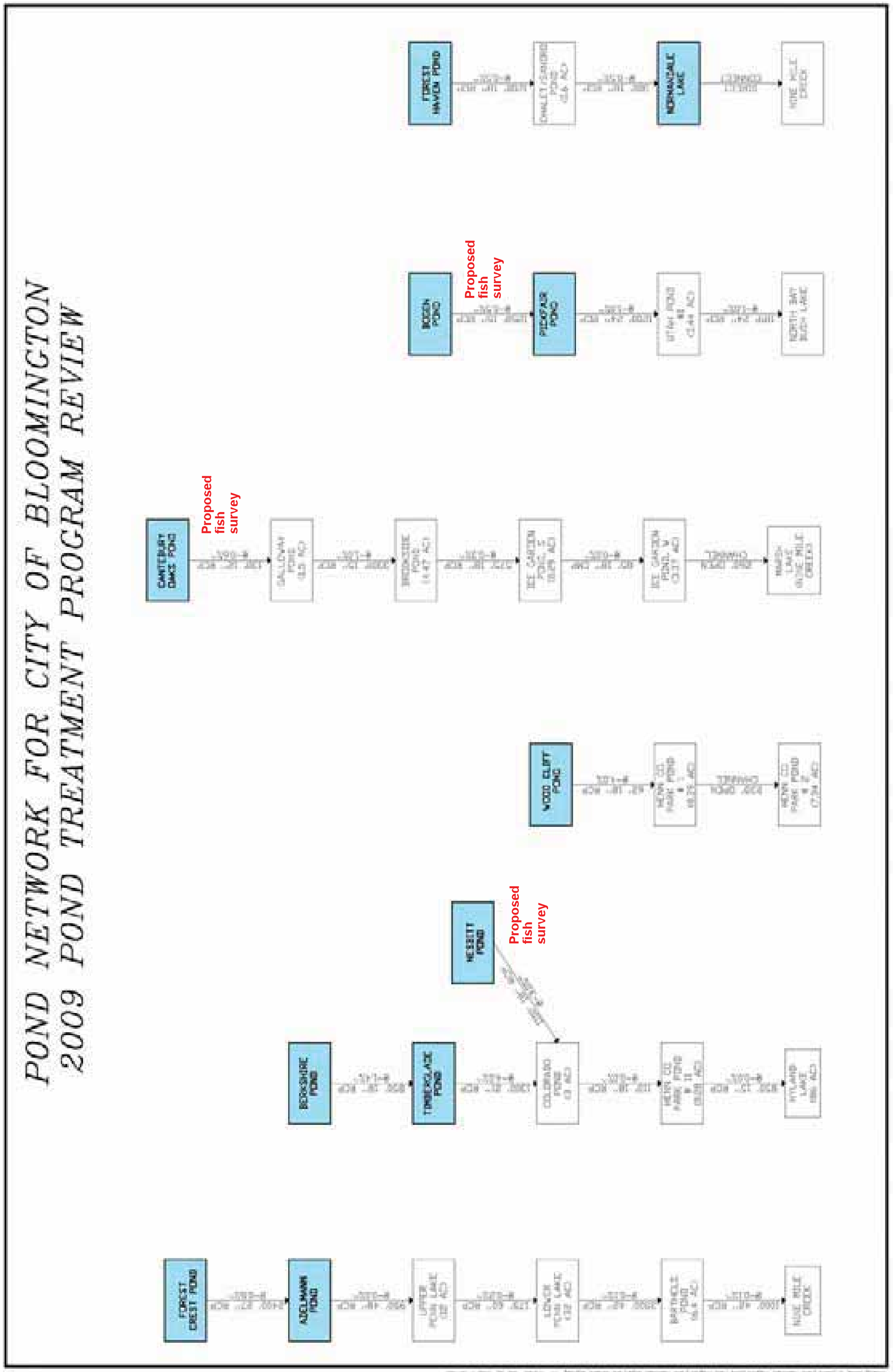
Two ponds, Xylon and Oxmore, are not connected to the stormwater sewer network.

A number of other ponds are at the head of the watershed with no inflow from other subwatersheds. These ponds have smaller watershed area to pond area ratios compared to downstream ponds. Sometimes the smaller watershed to pond ratio results in lower pond TP concentrations compared to ponds with larger ratios. That was not always the case for this study.

Also, recent work (McComas 2008) has found that stormwater ponds can support a variety of fish, with the most common species being fathead minnows, bullheads, goldfish, and sunfish. Other work has shown that in shallow wetland systems, minnows and other small fish can elevate phosphorus levels and eliminate submersed aquatic plants (Zimmer et al 2005). Because stormwater ponds are similar to shallow wetland systems, fish could have an impact on water quality in stormwater ponds (McComas 2008).

Also, because stormwater ponds are connected to other stormwater ponds, there may be a winter refuge somewhere in the pond network that allows fish to avoid winterkill conditions. A number of fish surveys are proposed to evaluate fish conditions in the Bloomington pond network and candidate ponds are marked on the next two pages.


POND NETWORK FOR CITY OF BLOOMINGTON
2009 POND TREATMENT PROGRAM REVIEW
Proposed fish survey
Proposed fish survey
Proposed fish survey
Proposed fish survey
Proposed fish survey
Proposed fish survey
Proposed fish survey


POND NETWORK FOR CITY OF BLOOMINGTON
2009 POND TREATMENT PROGRAM REVIEW
FOREST CREST POND
ADELMANN POND
BERKSHIRE POND
TIMBERGLADE POND
NESBITT POND
Proposed fish survey
WOOD CLIFF POND
CANTERBURY OAKS POND
Proposed fish survey
BOEN POND
PICKFAIR POND
Proposed fish survey
FOREST HAVEN POND
NORMANDALE LAKE

Key Findings of This Study

Based on how pond conductivity readings were lowered with rainfall from July to August, it appears several ponds receive significant volume of runoff from rainfall compared to the volume of the pond, and therefore have a potential to be impacted by watershed nutrient runoff. These ponds include the following:

Victoria
Wanda Miller
Adelman
South Bay
Marce Woods N
Marce Wood S
Bogen
Pickfair

Several ponds appear to have less than significant stormwater inflow influences based on conductivity readings from July to August and include:

Oxmore
Round
South Bay

Round Pond had a high estimated runoff TP concentration at 940 ppb-TP based on modeling. However, monitoring by the City of Bloomington found a summer runoff TP average of stormwater inflows into Round Pond of about 390 ppb-TP. It may be that fish or some other type of internal loading are contributing pond phosphorus concentrations. The 940 ppb-TP runoff concentration is determined from a back-calculation based on the pond TP.

In addition, for Round Pond watershed runoff volume is predicted to be low, based on conductivity readings from July to August. However, because no plants were present in the pond, it may be fish are foraging in the sediments and keeping plants from growing. If fish are present, they may be impacting water quality by feeding in the sediments and contributing to elevated pond total phosphorus concentrations.

Smith Park has a large watershed:pond ratio of 63, yet has good water quality. It may be that submerged aquatic plants are helping to keep phosphorus concentrations low.

The subwatershed with Victoria, Wanda Miller, Paulys, and Skriebakken Ponds all have good water quality. Why is that?

Both Marce Woods North and South have high pond TP and no submerged plants. A fish survey would be helpful to determine if fish are a factor contributing to the elevated pond phosphorus concentration and a lack of plants.

Timberglade Pond had a Sonar herbicide treatment in 2009. It appears submerged plants were controlled but duckweed came on strong in August. It is clear that duckweed and watermeal are difficult to control with herbicides.

Pond Recommendations and Considerations

The goals for pond management are several-fold and include the following:

1. Maintain and/or enhance stormwater treatment function by maintaining stormwater pond TP concentrations of 150 ppb or less.

2. Maintain aesthetic values so ponds serve as a neighborhood natural resource. For the most part, limiting filamentous algae or duckweed below 30% coverage will be effective for a neighborhood pond.

3. Increase and/or maintain submersed aquatic plants in all ponds. A goal of 40% bottom coverage would help sustain good water quality.

It is assumed other watershed practices will be ongoing. These practices include street sweeping and ongoing information and education programs concerning residential phosphorus control projects. These projects include items such as rain gardens, rain barrels, lawn maintenance, low fertilizer use and others.

The overall pond management program discussed in this report is designed to assess the source of phosphorus to the ponds (runoff or internal), determine what is limiting submersed plant growth in some ponds, and implement projects that meet pond management goals.

To meet pond management goals, a mix of conventional and new management techniques have been proposed for individual ponds with the intention to improve pond water quality and aesthetics. A summary of the techniques is shown below.

Conventional Techniques

Algaecides:

Copper sulfate and cutrine plus: used to control open water algae and filamentous (floating) algae.

Herbicides:

Avast or Sonar: used to control submerged plants and for duckweed and watermeal
Galleon: used for control of a wide-variety of aquatic plants including duckweed and watermeal.

New Management Techniques

Barley straw: Latest research findings (McComas, unpublished) indicate adding barley straw to a pond acts as an organic carbon amendment which stimulates organic carbon-limited microbial growth. Because barley straw has a low phosphorus content, as microbes grow by decomposing the organic carbon in the barley straw they out-compete algae for phosphorus in the water column and can reduce the phosphorus concentration in the whole pond (Figure 8). There is strong evidence this also reduces algal growth as is shown with an increase in water clarity (Figure 9).

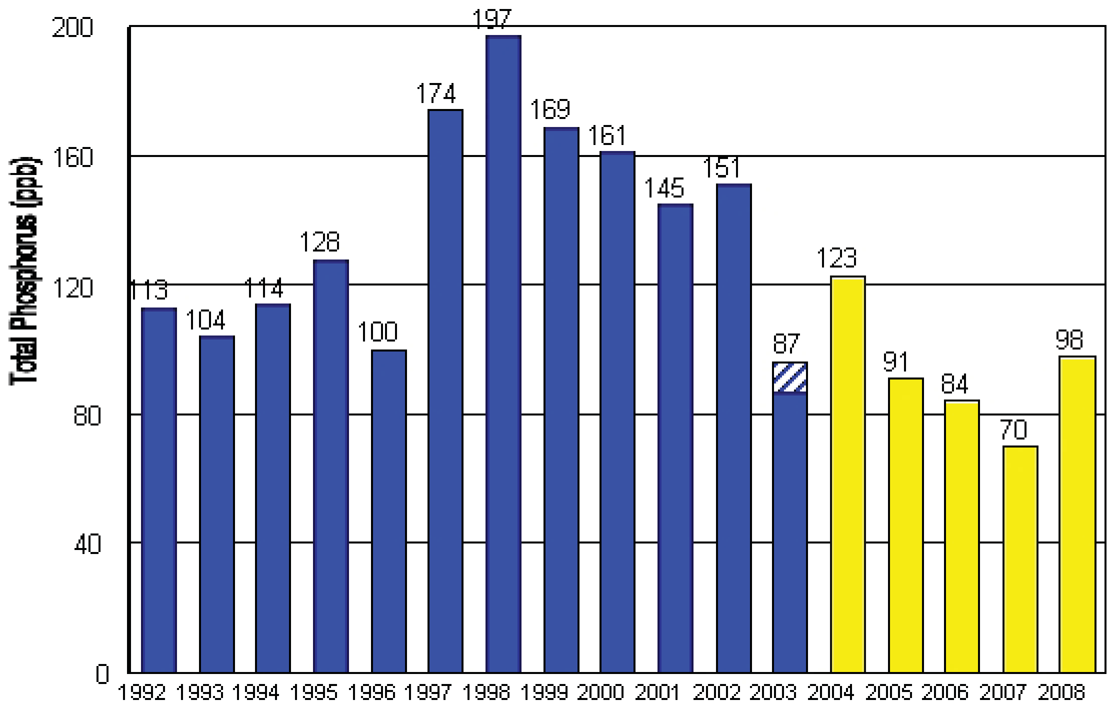


Figure 8. Total phosphorus concentration in Powderhorn Lake, Minneapolis, MN, associated with the use of barley straw. Years without barley are shown in blue. Years with barley are shown in yellow.

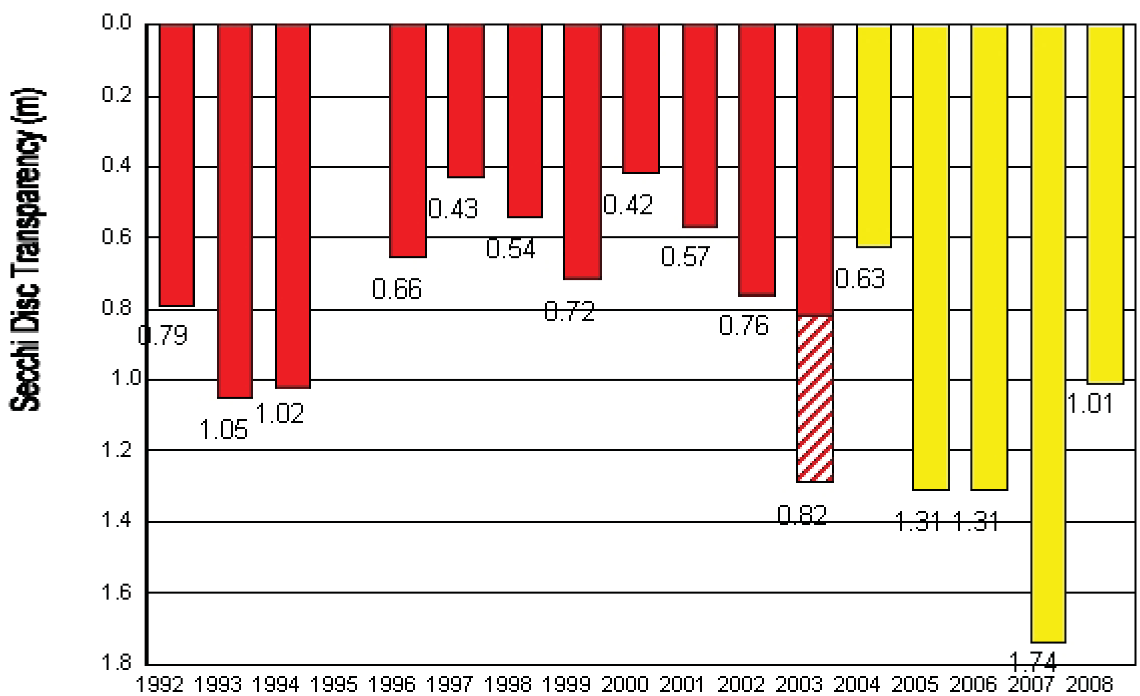


Figure 9. Secchi disc transparency in Powderhorn Lake, Minneapolis, MN, associated with the use of barley straw. Years without barley are shown in red and years with barley are shown in yellow.

It appears barley straw can reduce pond TP. It doesn't matter if the source of phosphorus is from the watershed or from internal sources, the microbial growth will take the phosphorus out of the water column.

Barley straw was used in two ponds (Nesbit and Round) in Bloomington in 2009 and some decrease in phosphorus over the summer was noted (Figure 10).

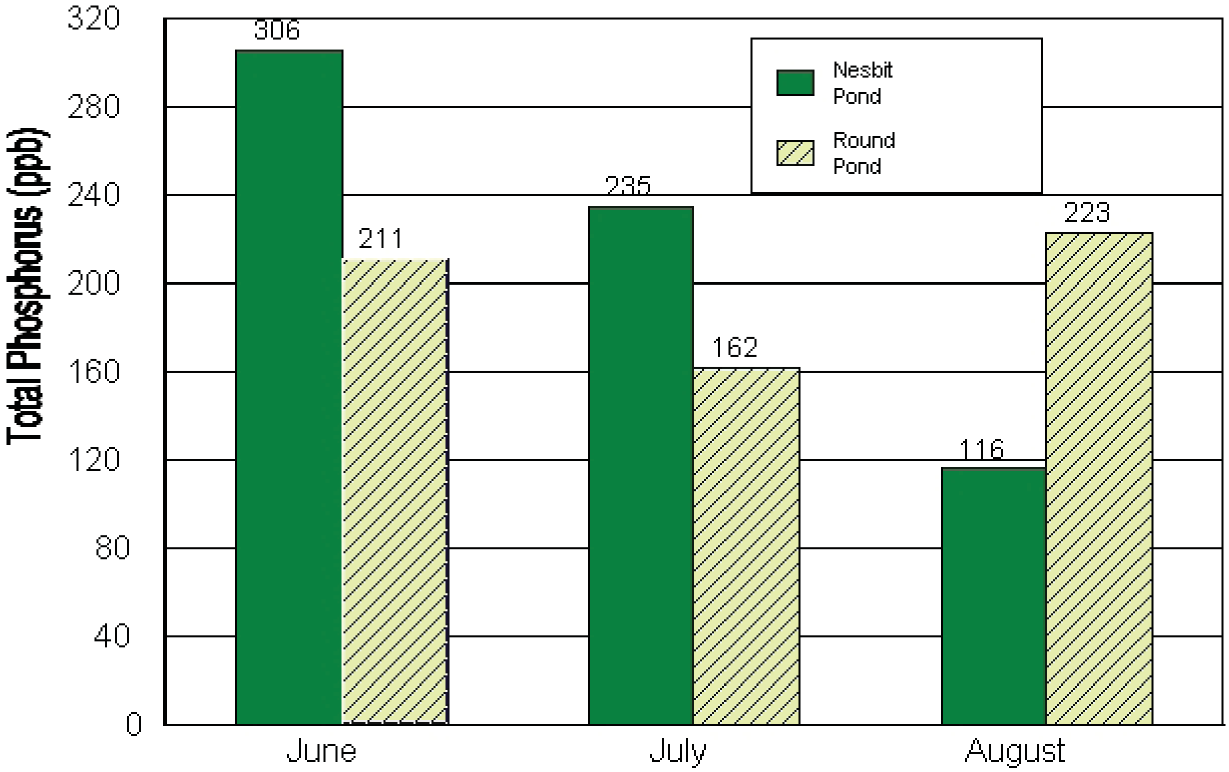


Figure 10. Phosphorus concentrations for Nesbit and Round Ponds for June, July, and August, 2009. Nesbit showed a decrease over the summer and Round Pond showed a decrease from June to July, but then an increase in August.

There is some evidence that barley straw can reduce filamentous algae and duckweed growth, but results in other ponds have been mixed.

Barley straw is installed in mesh bags and staked to the pond bottom to keep it in a small confined area. It is not obtrusive and bags and stakes are removed by the end of the summer (Figures 11 and 12).

Figure 11. Barley straw bales are enclosed in mesh bags.

Figure 12. Barley straw is anchored in a pond. Barley straw is documented to reduce phosphorus in ponds.

Skimming: Skimming is the use of fine-mesh nets to remove (skim) duckweed and watermeal off of the surface of a pond (Figure 13). It is a niche area at this time and only one commercial company offers it on a routine basis. However, it is an ecologically sound approach and has long-term benefits for wildlife and water quality from the perspective that it removes excess surface growth that allows light penetration which would enhance submerged plant growth. Also removing vegetation removes a small amount of phosphorus associated with the plant material that would otherwise recycle in the pond.

Figure 13. Example of skimming duckweed and watermeal off of a pond.

Fish Manipulations: An evolving area in stormwater pond management is assessing the impact of the fish community on pond phosphorus concentrations. Results from work on stormwater ponds in Apple Valley show minnows and bullheads appear to influence water quality in stormwater ponds (McComas 2008)(Table 8 and Figure 14). In 2007, in several Apple Valley ponds, fish surveys were conducted and pond TP was monitored. There was a significant winterkill in all three ponds over the 2007-2008 winter. In Ponds 2 and 12, fish populations decreased and TP decreased. In Pond 170, bluegills died off over the winter and were replaced with an explosion of small fish primarily minnows and young bullheads. Total phosphorus levels increased with the increase in fish in Pond 170 (Table 8).

For Bloomington ponds, the first step is to survey a number of stormwater ponds to assess the fish population and correlate the fish condition with the phosphorus condition. In the future, possible fish manipulations could be considered in order to manage phosphorus concentrations in the stormwater ponds.

Table 8. Apple Valley stormwater pond phosphorus and fish conditions for 2007 and 2008.

Pond	Size (ac)	Mean Depth (ft)	2007 TP Sept 27 (season avg) (ppb)	2008 TP Oct 23 (season avg) (ppb)	2007 Fish #/net (pounds)	2008 Fish #/net (pounds)
2	7.2	4.5	260 (144)	97	656 (22)	76 (1.0)
12	5.7	3.0	100 (226)	69 (88)	1,301 (2.9)	450 (1.5)
170	7.3	2.5	280 (236)	448 (512)	385 (9.5)	4,237 (30)

2007 | 2008

Figure 14. Apple Valley pond fish survey results for 2007 and 2008. Fish biomass was less in 2008 than 2007 for Ponds 2 and 12, but higher in Pond 170. Bluegill sunfish were found in Ponds 12 and 170 in 2007 but were not found in those ponds in 2008. A partial winterkill is the likely explanation.

Techniques Considered but Not Recommended

Ultra sound: Results are mixed for open water algae control. Duckweed and watermeal would not be impacted. Ultra sound is expensive to buy and operate and does not reduce phosphorus in ponds.

Bacterial additions: Results are mixed for algae control. Previously, bacterial products have been tried in several Bloomington ponds. Barley straw accomplishes the same thing as bacterial additions and is more cost effective.

Fountains: Sometimes physical movement of water moves duckweed to the pond edges and creates a clearing in the pond. Fountains should not cause any adverse impacts, but probability of algae control is low.

Aeration: Generally considered a method to control phosphorus release from pond sediments. However, the Bloomington ponds are shallow and usually already aerated. Aeration would not cause any adverse impacts, but algae may not be controlled.

Alum: Generally considered a sediment treatment to control the release of phosphorus from pond sediments. Could be useful in some cases for algae and duckweed control however more research is needed. Alum is available as solid pellets that can be distributed in the pond. It is more expensive than barley straw.

Iron filings incorporated into sand filters: Research is underway to assess the practicality of using sand filters impregnated with about 5% iron filings to treat stormwater pond outflows. Preliminary results by the University of Minnesota researchers are promising at the laboratory scale. This may be a stormwater management option in the future.

A summary of recommendations for pond management actions for 2010 is shown in Table 9. For several ponds, no action is considered to see how the pond reacts. Fish surveys will give insight to potential sources of phosphorus from bottom-feeding fish. Several herbicide applications are recommended to continue and several ponds are recommended to receive barley straw and/or skimming treatments.

Table 9. Pond treatments in 2009 and recommendations for 2010.

Pond Name	Pond Area (ac)	Actual Pond TP Conc (2009) (Jun, Jul, Aug avg)(ppb)	Estimated flow weighted mean conc (runoff TP conc)	Watershed to Pond Area Ratio	Aquatic Plant Status	Treatment in 2009	Recommendations for 2010
19. Smith Park	7.06	45	59	63	Sub plants, 5% FA	Copper sulfate	Copper sulfate, check DNR fish data
8. Forest Haven	7.18	50	100	7.8	Sub plants, 50% WL	--	
14. Oxmore	2.29	50	110	4.4	Sub plants	Copper sulfate	Fish survey
25. Victoria	2.32	56	82	29	Sub plants, 4% FA	--	
26. Wanda Miller	14	73	150	12	Sub plants, 60% WL	Habitat	Fish survey
15. Paulys	7.66	75	180	13	Sub plants, 30% WL	Copper sulfate, Habitat	Copper sulfate
9. Hyland Court	1.65	79	150	15	Sub plants	--	
22. Skriebakken	20.08	95	210	16	Sub plants, 5% FA	--	
20. South Bay	2.33	128	410	6.7	Sub plants	Sonar	
1. Adelmann	6.6	188	445	19	Sub plants	--	Fish survey
18. Round	2.49	199	940	10	No sub plants, 25-60% DW & WM	Barley, skimming	Barley, skim, fish survey
13. Nesbitt	1.13	219	480	37	No sub plants, 70-100% DW	Barley, Skimming	Barley, skim, fish survey
4. Bogen	5	228	744	12	Sub plants, 80-0% DW & WM	--	Fish survey
7. Forest Crest	0.45	236	447	51	No sub plants, 60% DW	WhiteCap	Skim
21. Sunrise, S	2	282	846	6.5	Sub plants - trace 10-50% WM	Sonar	Barley, skim
23. Tierney's Woods, NW	0.28	286	835	21	No sub plants	Sonar, Galleon	Barley, fish survey
17. River Bluff	0.69	289	945	17	Sub plants - trace	--	
16. Pickfair	0.69	296	446	123	No sub plants, 100% DW	Sonar, Galleon	Barley, skim
27. Wood Cliff	0.89	322	598	24	Dry - some plants	--	
6. Canterbury Oaks	0.84	333	878	18	No sub plants	Sonar, Galleon	Barley, fish survey
24. Timberglade	3.09	366	750	30	Sub plants 100%-0 DW 10-95%	Sonar	Barley
28. Xylon	0.43	412	2,090	5	No sub plants	Sonar, Galleon	
3. Berkshire	0.56	447	1,285	32	No sub plants	--	Barley
11. Marce Woods, S	1.12	495	1,274	30	No sub plants, 100% DW	Sonar, Galleon	Fish survey, Sonar, Galleon
10. Marce Woods, N	0.85	926	2,645	31	No sub plants, 100% DW	Sonar, Galleon	Fish survey, barley, skim
5. Bush Lake	188	19	--	6.8		--	
12. Normandale Lake	112	86	--	193		Reward	
2. NW Anderson	179	351	--	3.3		--	

sub plants = submerged plants, DW = duckweed; WM = watermeal; FA = filamentous algae; WL = water lily

APPENDIX A

Pond and Lake Conditions for June, July, and August 2009

Pictures of pond conditions over the summer are shown on the following pages.