Stems of Curlyleaf Pondweed in Spring Lake on June 10, 2011

Aquatic Plant Surveys and Curlyleaf Pondweed Evaluation for Spring Lake, Scott County, Minnesota in 2011

No Open Lake Herbicide Application from 2007- 2011

Spring Plant Survey and Stem Density Assessment: May 12, 2011
Early Summer Plant Survey and Stem Density Assessment: June 10, 2011

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Summary

Overview: Based on curlyleaf pondweed data gathered on May 12 and June 10, 2011 and considering curlyleaf growth patterns for the 2007 through 2010 seasons and combined with lake sediment characteristics that were analyzed in 2008, no open water herbicide treatments were recommended for the areas that were treated from 2002-2006. This is the fifth consecutive year of no open water treatments. The areas that were formerly treated are between Transects 4 and 5 and between Transects 21 and 23 (areas are shown in Figure 1). Lake residents have the option of treating for curlyleaf in their riparian (nearshore areas), but indications are curlyleaf growth will be mostly light in water 4 to 7 feet deep around the lake.

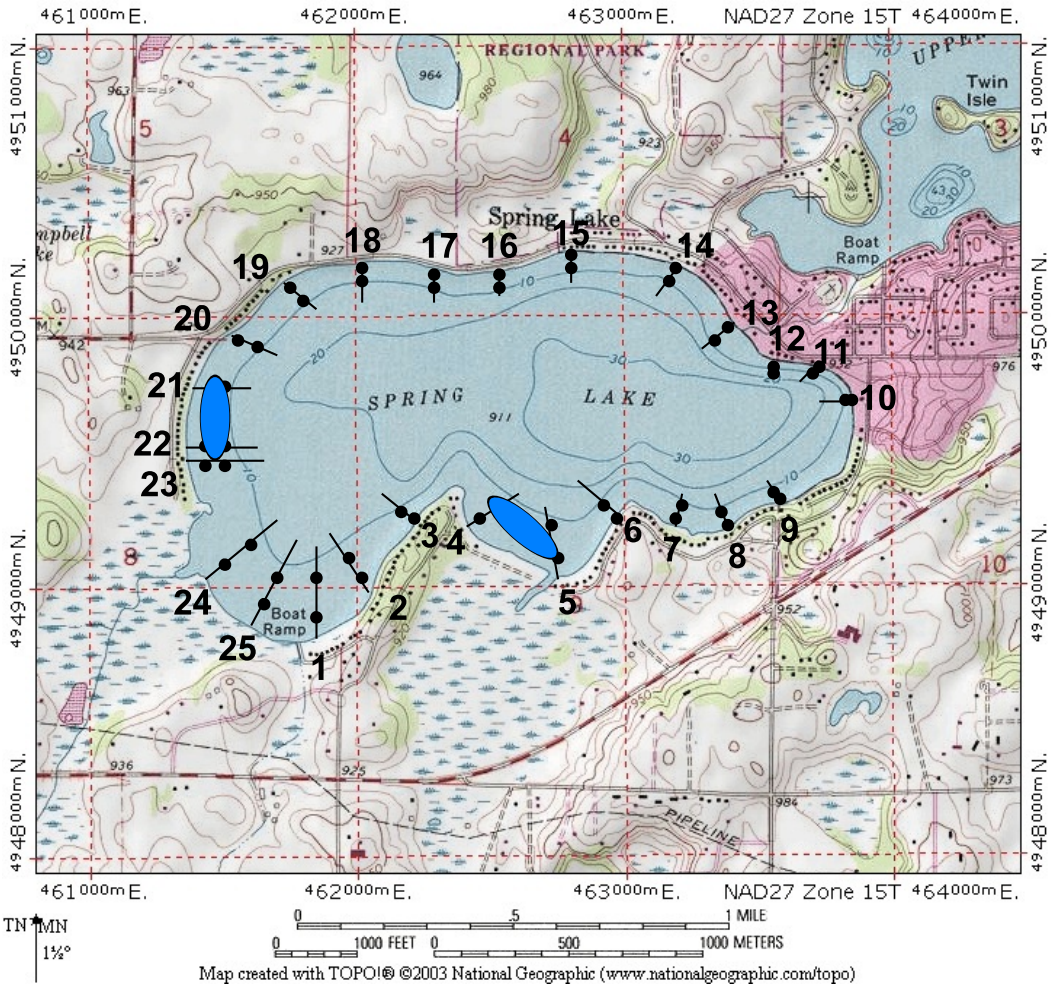


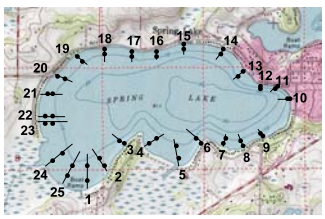
Figure 1. Map of treatment areas from 2002-2006 (5 years) are shown in dark blue shading. Sample sites for whole lake surveys are shown with black numbers. There are 50 aquatic plant survey sites and, in addition, there are two underwater evaluation sites located in the dark blue shaded areas.

Summary of Whole Lake Curlyleaf Pondweed Surveys for 2007-2011

Curlyleaf pondweed was found at 10 locations out of the 50 that were monitored on May 12, 2011 in the course of an aquatic plant survey that sampled two depths on 25 line transects. Curlyleaf growth was sparse in 2011 and has been sparse since 2007. From 2007 through 2011 there have been no open water herbicide applications (Table 1). (Transect and sample locations are shown in Figure 1.)

Table 1. Density of curlyleaf, at two depths, shallow (S) which is 0-4 feet, and deep (D) which is 5-8 feet, for each transect, for the early season plant surveys from 2007-2011. The density rating is on a scale from 0.5 to 5 with 5 being the highest density. For 2010 and 2011, the numbers in parentheses indicate the number of CLP stems found in the rakehead sampler.

Transect		2007		2008		2009		2010		2011	
		Curlyleaf Pondweed Plant Density		Curlyleaf Pondweed Plant Density		Curlyleaf Pondweed Plant Density		Curlyleaf Pondweed Plant Density		Curlyleaf Pondweed Plant Density	
		Apr 15	Jun 5	Apr 29	Jun 13	Apr 23	Jun 10	Apr 27	Jun 20	May 12	Jun 10
1	S		2			0.5	2				
	D			0.7	1	1					0.5 (1)
2	S									0.5 (1)	
	D		1.8		1						
3	S								1 (3)		
	D		1.5					0.5 (1)			
4	S			0.5			1				0.5 (1)
	D		1		0.5						0.5 (1)
5	S		0.7				0.5	1 (1)	1 (3)		2.5 (9)
	D							1 (1)	1.3 (3)		0.3 (1)
6	S				1						1 (1)
	D	1						0.5 (1)			
7	S	1	1		1					0.5 (1)	
	D	0.5	0.5								
8	S							0.5 (1)		0.5 (1)	
	D						0.5			1 (2)	
9	S		1					1 (1)	0.5 (2)		2 (8)
	D	0.5	1.8				0.5		0.5 (1)		
10	S		0.5								1 (2)
	D		1								
11	S										
	D										
12	S		1				1	1 (1)			
	D		1		0.3						
13	S										
	D	0.8	3.5		3						1 (2)
14	S	1	1		1			1 (1)	1 (1)	0.5 (1)	1 (4)
	D	1	2.8		1.5			0.3 (1)	1 (1)		1 (2)
15	S		3.5		1		2	1 (2)	1 (3)		
	D	1.3	2.8		2		0.3	1 (3)	1 (1)	0.5 (1)	0.5 (1)
16	S		1					1 (1.5)	1 (1)		0.8 (2)
	D	0.5	1.8					1 (1)	1 (2)		0.5 (2)
17	S	0.5						1 (4)			0.5 (1)
	D	0.3	2	0.3			0.3	1 (3)	1 (2)		
18	S	0.5			1			1 (3)			
	D	0.5	1	0.3				1 (4)		0.5 (1)	0.5 (1)
19	S		1				0.5	1 (2)	1 (1)		
	D								1 (3)		
20	S	0.5	2.8					0.5 (1)	1 (3)		
	D	0.5			1	0.3		0.5 (1)	0.5 (1)		
21	S		1.5				1	1 (1)	0.5 (1)	0.5 (1)	
	D		4								
22	S	1	1		1			1 (1)			
	D	1						0.3 (0.5)			
23	S	1					1		1 (4)	0.5 (1)	
	D	0.5	1		0.5						
24	S	1			1	1	2		1 (2)		
	D	0.5			1			1 (1.5)	1 (2)		
25	S	1	0.5		1	1	1		2 (6)	0.5 (1)	1 (3)
	D				1			1 (3)			0.8 (2)
Sites Where Curlyleaf Was Found		**22**	**29**	**4**	**19**	**5**	**14**	**25**	**21**	**10**	**18**



Curlyleaf Stem Densities at Two Treatment Locations on May 12 and June 10, 2011

Curlyleaf stem densities were determined by scuba diving at two depths for sample locations at Transect 4.5 and Transect 22 that were treated from 2002-2006. Ten quadrat samples were taken at two depths at each location. A total of 40 quadrat samples were taken on each date. The results for 2011 show curlyleaf was sparse and was found at low stem densities for spring and early summer (Table 2). These stem densities were similar to densities found from 2008 through 2010 and are low compared to pre-treatment stem densities from 2002 (Figure 2).

Table 2. Curlyleaf pondweed stem densities (stems/m^2) for 2011.

Quadrat	May 12, 2011 (stems/m^2)				June 10, 2011 (stems/m^2)			
	T4.5		T22		T4.5		T22	
	4 ft	5 - 6 ft	4 ft	5 - 6 ft	4 ft	5 - 6 ft	4 ft	5 - 6 ft
1	20	20	0	0	10	0	0	0
2	0	0	0	0	10	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0
	Ave: 2	**Ave: 2**	**Ave: 0**	**Ave: 0**	**Ave: 2**	**Ave: 0**	**Ave: 0**	**Ave: 0**

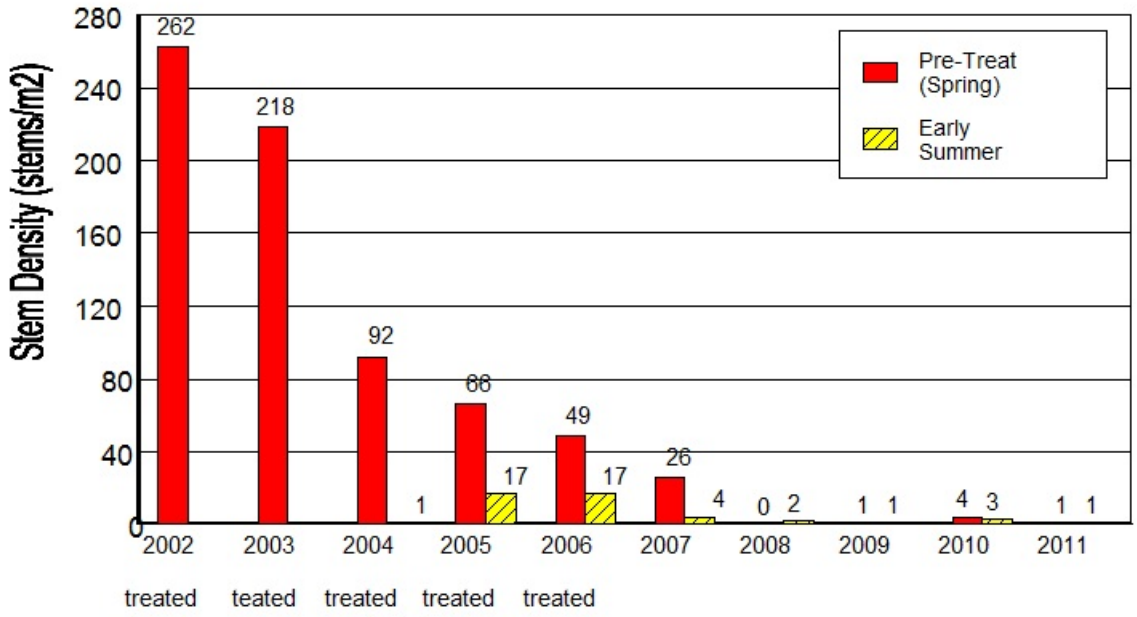


Figure 2. Curlyleaf stem densities for early season monitoring (using scuba diving) for 2002-2011.

Curlyleaf Pondweed Growth Characteristics in 2011

May 12, 2011

T4.5: Curlyleaf stem densities were sparse at Transect 4.5.

June 10, 2011

T4.5: Curlyleaf stem densities were sparse at Transect 4.5.

T22: No curlyleaf stems were found at Transect 22.

T22: No curlyleaf stems were found at Transect 22.

Figure 3. Underwater curlyleaf pondweed conditions at two sites that had been treated from 2002 through 2006. Curlyleaf growth remains sparse at these two locations in 2011.

Summary of Curlyleaf Pondweed Distribution and Abundance from 2000 - 2011

Transect	Depth	2000	2002	2003	2004		2005		2006		2007		2008		2009		2010		2011		Avg	Predicted growth based on lake soils
		Jun 3	Jun 7	May 15	May 2	Jun 14	Apr 20	Jun 1	Apr 26	Jun 2	Apr 15	Jun 5	Apr 29	Jun 13	Apr 23	Jun 10	Apr 27	Jun 2	May 12	Jun 10		
1	S	5	0.5	0	0	0	0	0	0	0	0	2	0	0	0.5	2	0	0	0	0	0.5	
	M	4	2	2	1	0	1	1	0.5	0	0	0	0.7	1	1	0	0	0	0	0.5	0.8	Heavy
2	S	4	0.5	0	0.5	0	0	2	1	0	0	0	0	0	0	0	0	0	0.5	0	0.4	
	M	5	2	4	0.5	0	0	0.3	0.7	0	0	1.8	0	1	0	0	0	0	0	0	0.8	Moderate
3	S	2	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0.5	1	0	0	0.3	Light
	M	4	2	0.5	0.5	0	0.5	1	0.8	0.5	0	1.5	0	0	0	0	0	0	0	0	0.6	Light
4	S	4	2	0.5	1	0	1	0	0	0	0	0	0.5	0	0	1	0	0	0	0.5	0.6	Moderate
	M	5	2.5	4	1	0	2	0.8	1.3	0.7	0	1	0	0.5	0	0	0	0	0	0.5	1.0	
5	S	2	2	0.5	1	0	2	1	1	0.5	0	0.7	0	0	0	0.5	1	1	0	2.5	0.8	
	M	5	3	2	2.5	0	0.5	0	2	1	0	0	0	0	0	0	1	1.3	0	0.3	1.0	Light
6	S	1.8	0	0	0.5	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0.3	
	M	2	2	1	1	0	0.5	0.5	2	0.3	1	0	0	0	0	0	0.5	0	0	0	0.6	Moderate
7	S	1	0.5	0	0	0	0	0	1	1	1	1	0	1	0	0	0	0	0.5	0	0.4	
	M	4.5	1.5	1	0	0.5	0.5	1	1.8	1	0.5	1.5	0	0	0	0	0	0	0	0	0.7	Light
8	S	1	1	0	0.5	0	0.3	1	0	0	0	0	0	0	0	0	0.5	0	0.5	0	0.3	
	M	3	1	1	0	0	0.5	1	0	0.3	0	0	0	0	0	0.5	0	0	1	0	0.4	Moderate
9	S	4	0.5	0	0	0	0	1	0	1	0	1	0	0	0	0	1	0.5	0	2	0.6	Moderate
	M	4	0.5	0.5	0.5	0	0	1	0.8	0.5	0.5	1.8	0	0	0	0.5	0	0.5	0	0	0.6	
10	S	2	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	1	0.2	
	M	4	0	0	0.5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0.3	Light
11	S	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	
	M	3	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	Moderate
12	S	3	0.5	0	0.5	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0.4	
	M	3	0.5	0	0.5	0	0	0	0	0	0	1	0	0.3	0	0	0	0	0	0	0.3	
13	S	0	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	
	M	2.7	1	0.5	0.5	0	0.5	0.7	1	1.7	0.8	3.5	0	3	0	0	0	0	0	1	0.9	Moderate
14	S	3	0.5	0.5	0.5	0	0	1	2	0.5	1	1	0	1	0	0	0.5	1	0.5	1	0.7	
	M	4	1.5	2	1	0	2	1.5	2	3	1	2.8	0	1.5	0	0	0.5	1	0	1	1.3	Moderate
15	S	2	1	0.5	2	0	0.3	1	1	2	0	3.5	0	1	0	2	1	1	0	0	1.0	
	M	2	0.5	3	1	1	1	1.5	1	2.5	1.3	2.8	0	2	0	0.3	1	1	0.5	0.5	1.2	Moderate
16	S	2	0	0.5	0.5	0	0.5	1	1.3	0	0	1	0	0	0	0	1	1	0	0.8	0.5	
	M	4	4	1	1	1	1	1	0.5	1.5	0.5	1.8	0	0	0	0	1	1	0	0.5	1.0	Moderate
17	S	2	1	0.5	1	0	1.5	1	1.5	2	0.5	0	0	0	0	0	1	0	0	0.5	0.7	Light
	M	4	2	2	1	0	1	0	1.5	1.7	0.3	2	0.3	0	0	0.3	1	1	0	0	1.0	
18	S	2	0	0.5	0.5	0	1	1	0	2	0.5	0	0	1	0	0	1	0	0	0	0.5	
	M	4	3	2	1	0	2	1.8	0.8	2.5	0.5	1	0.3	0	0	0	1	0	0.5	0.5	1.1	Light
19	S	3	1	3	0.5	0	0.5	1	0	3	0	1	0	0	0	0.5	1	1	0	0	0.8	
	M	5	1.5	2	0.5	0	0.3	0.3	0	0	0	0	0	0	0	0	0	1	0	0	0.6	Moderate
20	S	3	1	0.5	0.5	0	0	2	1.5	3	0.5	2.8	0	0	0	0	0.5	1	0	0	0.9	Moderate
	M	5	1.5	2	0.5	0	1.5	2	0.3	3	0.5	0	0	1	0.3	0	0.5	0.5	0	0	1.0	
21	S	2.5	0.5	0.5	0.5	0	0	1	0.5	3	0	1.5	0	0	0	1	1	0.5	0.5	0	0.7	Moderate
	M	5	2.5	3.5	0.5	0	2	0.5	1.3	3	0	4	0	0	0	0	0	0	0	0	1.2	
22	S	3	0.5	0	0	0	0	0	0.5	2	1	1	0	1	0	0	1	0	0	0	0.5	
	M	5	2	3	1	0	1	1	0.2	1	1	0	0	0	0	0	0.5	0	0	0	0.8	Moderate
23	S	2	1	0	0.5	0	0	0	0	1	1	0	0	0	0	1	0	1	0.5	0	0.4	
	M	4.7	4.5	3	0.5	0	1	1	0.8	1.3	0.5	1	0	0.5	0	0	0	0	0	0	1.0	Moderate
24	S	3	1	0.5	0.5	0	0	4	0.5	0	1	0	0	1	1	2	0	1	0	0	0.8	
	M	5	1.5	4	2	0	1.5	0.5	0.5	1.3	0.5	0	0	1	0	0	1	1	0	0	1.0	Moderate
25	S	2	1	0.5	0.5	0	1	2	1.8	2	1	0.5	0	1	1	1	0	2	0.5	1	1.0	
	M	4.7	3	4	0	0	1	1	1.7	0.5	0	0	0	1	0	0	1	0	0	0.8	1.0	Moderate
Number of Reds		23	2	4	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0		
Avg CLP Density													0.5	1.1	0.7	1.0	0.8	0.8	0.6	0.9		

Depth Zones:

S = 0 - 4 feet
M = 5 - 8 feet

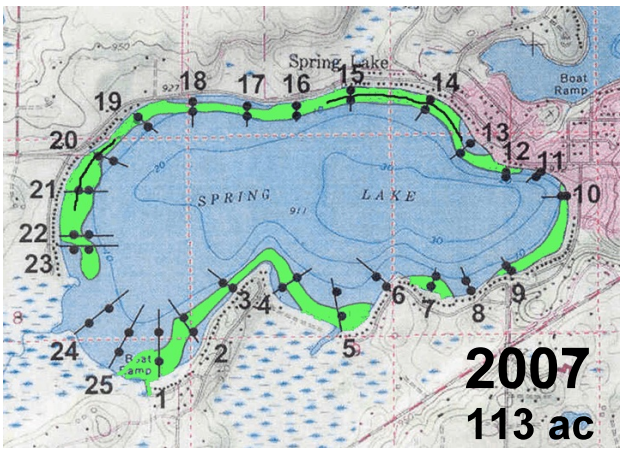
Figure 4. Summary of curlyleaf pondweed density for early summer aquatic plant surveys for Spring Lake from 2000 - 2011. Curlyleaf density is shown on a scale from 0.5 - 5 (with 5 being most dense) for each depth zone on all 25 transects for each survey. Colors are coded for density. A sediment survey was conducted on Spring Lake in 2008. Predicted curlyleaf growth (far right column) has been close to actual curlyleaf growth conditions.

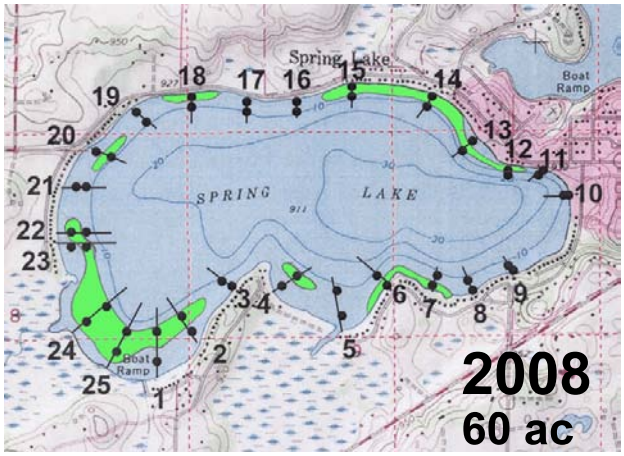
Curlyleaf Pondweed Coverage in 2011: Spring Lake is a 580 acre eutrophic lake in Scott County, Minnesota with a history of nuisance curlyleaf pondweed growth going back to the 1980s. In 2000, heavy growth of curlyleaf pondweed was estimated at 180 acres. Major nuisance areas of curlyleaf were managed annually in Spring Lake from 2002 through 2006 (5-years). In 2006, there was an estimated 150 acres of curlyleaf pondweed but at mostly low to moderate abundance, prior to treatment. From 2007 through 2011, herbicides have not been applied in offshore areas. However, the coverage of curlyleaf has not increased in this time span. It is not clear why curlyleaf has been under control. In 2007, curlyleaf covered about 113 acres and in 2008 curlyleaf covered about 60 acres in June. In 2009 through 2011, curlyleaf covered about 50 to 90 acres and no heavy growth was observed (Figure 1).

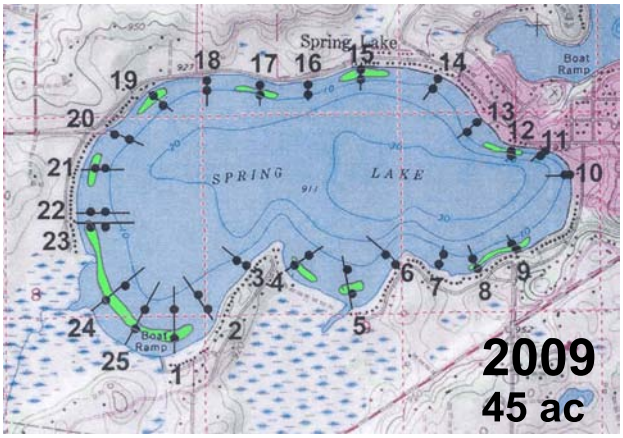
Table 1. Curlyleaf treatment history for 2002 through 2011.

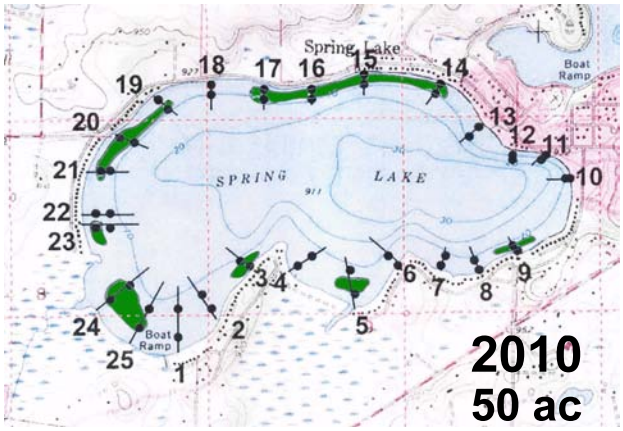
	Between T4 & T5	Between T19-25	Shorelines
2002	herbicides (14 ac)	harvesting (60 ac)	herbicides (individual permits)
2003	herbicides (14 ac)	harvesting (74 ac)	herbicides (individual permits)
2004	herbicides (14 ac)	herbicides (45 ac)	herbicides (individual permits)
2005	herbicides (14 ac)	herbicides (45 ac)	herbicides (individual permits)
2006	herbicides (14 ac)	herbicides (45 ac)	herbicides (individual permits)
2007	no treatment	no treatment	no treatment
2008	no treatment	no treatment	herbicides (individual permits)
2009	no treatment	no treatment	herbicides (individual permits)
2010	no treatment	no treatment	herbicides (individual permits)
2011	no treatment	no treatment	herbicides (individual permits)

Recommendations for 2012: Based on the findings for the last three years, no offshore herbicide treatments for the areas of T4-T5 (14 ac) and T19-25 (45 ac) are expected. However, early season scouting and plant surveys should be conducted to monitor potential curlyleaf problems. A late summer survey is recommended as well. It appears native plants may be increasing in Spring Lake and this survey would document the dynamics of the aquatic plant community.









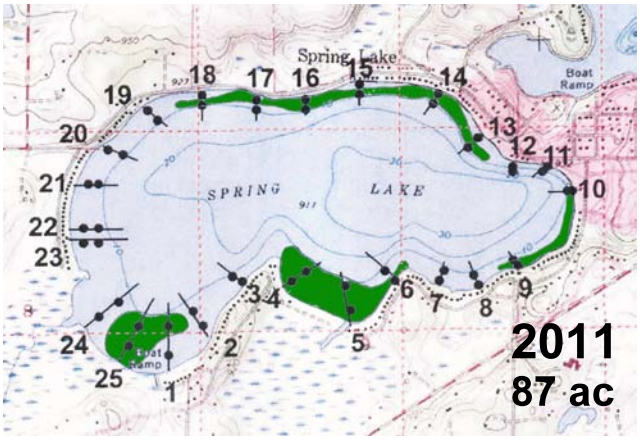


Figure 1. Curlyleaf pondweed distribution from 2007 through 2011.

Figure 2. Curlyleaf pondweed growth was very heavy in 2000.

Figure 3. Curlyleaf pondweed growth was light in 2010.

Aquatic Plant Surveys in 2011: Two aquatic plant surveys were conducted in Spring Lake in 2011. The first was in May and the second was after curlyleaf had reached a mature status in June.

From May to June, species increased in occurrence and several new species sprouted. In 2011 and for the fifth year in a row, curlyleaf pondweed did not produce significant nuisance conditions.

Table 2. Summary of aquatic plant results from two plant surveys conducted in 2011.

	May 12, 2011 Spring Survey (50 stations)		June 10, 2011 Early Summer Survey (50 stations)	
	% occur	Density	% occur	Density
Claspingleaf	--	--	2	0.5
Coontail	16	0.6	22	0.8
Curlyleaf	20	0.5	36	0.9
Elodea	2	0.5	4	0.8
Stringy pondweed	--	--	64	0.7
Water celery	--	--	2	1.0
Filamentous algae	8	0.5	4	0.4
Number of Submerged Species	3	--	6	--

Plant Survey Results Over the Years: Since 1948, a number of species within the aquatic plant community have appeared and others have disappeared. The percent occurrence of the native plants elodea and water stargrass have decreased since 2000. Curlyleaf distribution and curlyleaf density are lower in 2011 compared to 2000. Curlyleaf changes observed in the lake may be due to the curlyleaf management program.

Overall, the native aquatic plant community has been fairly stable for a number of years.

Table 3. List of aquatic plants found in past surveys. Surveys from 1948 to 1988 were conducted by MnDNR. Surveys in 2000 and 2002 through 2011 were conducted by Blue Water Science. Numbers for plant species in 2000 and 2002 through 2011 represent percent occurrence.

Year	1948	1973	1982	1986	1988
Date (month.day)	9.18	7.9	8.16	7.2	8.15
Secchi disc (ft)	2.6	3.0	3.3	--	2.5
Lesser duckweed (*Lemna minor*)				X	R
Duckweed (*Lemna sp*)			O		
White waterlilies (*Nymphaea tuberosa*)					
Greater duckweed (*Spirodela polyrhiza*)				X	
Coontail (*Ceratophyllum demersum*)	R	O	A	X	O
Chara (*Chara sp*)					
Elodea (*Elodea canadensis*)			O		O
Moss (*Drepanocladus sp*)					
Naiads (*Najas flexilis*)					
Berchtold's pondweed (*Potamogeton berchtoldi*)	R	O			
Curlyleaf pondweed (*P. crispus*)			R	X	
Variable pondweed (*P. gramineus*)	R	C	O		
Floatingleaf (*P. natans*)	R	C			P
Stringy pondweed (*P. pusillus*)					
Claspingleaf (*P. Richardsonii*)	R	C			O
Stringy pondweed (*P. strictifolius*)					
Narrowleaf pondweed (*P. sp*)			O	X	
Sago* (*Stuckenia pectinata*)	R	C			C
Star duckweed (*Lemna trisulca*)		C			
Wild celery (*Vallisneria americana*)			O		P
Mud plantain* (*Zosterella dubia*)	R	R	C		C
Number of submerged species	7	8	8	5	8

* Stuckenia pectinata = Potamogeton pectinatus Mud plantain = water stargrass Zosterella dubia = Heteranthera dubia

Table 3. Concluded.

Year	2000		2002		2003	2004			2005			2006			2007			2008			2009			2010		2011	
Date (month.day)	6.3	9.3	6.7	9.3	5.15	5.2	6.14	8.27	4.20	6.1	8.18	4.26	6.2	9.1	4.15	6.5	7.13	4.29	6.12	8.13	4.23	6.10	8.19	4.27	6.2	5.12	6.10
Secchi disc (ft)	7.0					7.1	7.2	3.5	16.7	6.9	2.0	4.7	5.0	2.0				2.3	3.9		3.5	6.2	2.9		2.2		5.6
Lesser duckweed (*Lemna minor*)																	2										
Duckweed (*Lemna sp*)											6																
White waterlilies (*Nymphaea tuberosa*)																											
Greater duckweed (*Spirodela polyrhiza*)								2																			
Coontail (*Ceratophyllum demersum*)		29	4	22		13	28	40	8	14	58	16	26	50	22	28	30	8	30	16	4	8	24	18	26	16	22
Chara (*Chara sp*)		4		2			4									2				8		2		12			
Elodea (*Elodea canadensis*)		25	8	18	6	25	48	68	22	54	76	64	68	48	20	6	2			4			4	2	2	2	4
Moss (*Drepanocladus sp*)																		1									
Naiads (*Najas flexilis*)																							6				
Berchtold's pondweed (*Potamogeton berchtoldi*)																											
Curlyleaf pondweed (*P. crispus*)	98	40	86	4	72	78	6	10	58	72	12	64	64	2	44	58		5	38	8	10	28	18	50	42	20	36
Variable pondweed (*P. gramineus*)																											
Floatingleaf (*P. natans*)																											
Stringy pondweed (*P. pusillus*)		2	6	8	2			4		6	8		20			26											
Claspingleaf (*P. Richardsonii*)				10				6		2	4		2	4		2	2		2	2		2	6		4		2
Stringy pondweed (*P. strictifolius*)														2	2		2			24		14	66	52	34		64
Narrowleaf pondweed (*P. sp*)																						2					
Sago* (*Stuckenia pectinata*)	40	15		36	2		24	6		6	14			6		8	2	1	24	8		24	20		26		
Star duckweed (*Lemna trisulca*)																											
Wild celery (*Vallisneria americana*)		6		16			2	22		2	32		2	18		6	12			18		2	18		4		2
Mud plantain* (*Zosterella dubia*)		17		22				24			30			4						8			24				
Number of submerged species	2	8	4	9	4	3	6	9	3	7	9	3	6	8	4	8	6	4	4	9	2	8	9	5	7	3	6

* Stuckenia pectinata = Potamogeton pectinatus Mud plantain = water stargrass Zosterella dubia = Heteranthera dubia

Spring Lake Curlyleaf Growth Potential Based on Lake Sediment Characteristics

A Spring Lake sediment survey was conducted on August 13, 2008. Lake sediment sampling results from 2008 have been used to predict lake bottom areas that have the potential to support heavy curlyleaf pondweed plant growth. Based on the key sediment parameters of pH, sediment bulk density, organic matter, and the Fe:Mn ratio (McComas, unpublished), the predicted growth characteristics of curlyleaf pondweed are shown in Figure 5.

Except for two sites, curlyleaf pondweed growth is predicted to produce mostly light to moderate growth around the lake based on lake sediment characteristics (Figure 5)(*a key to growth characteristics is shown on the next page*).

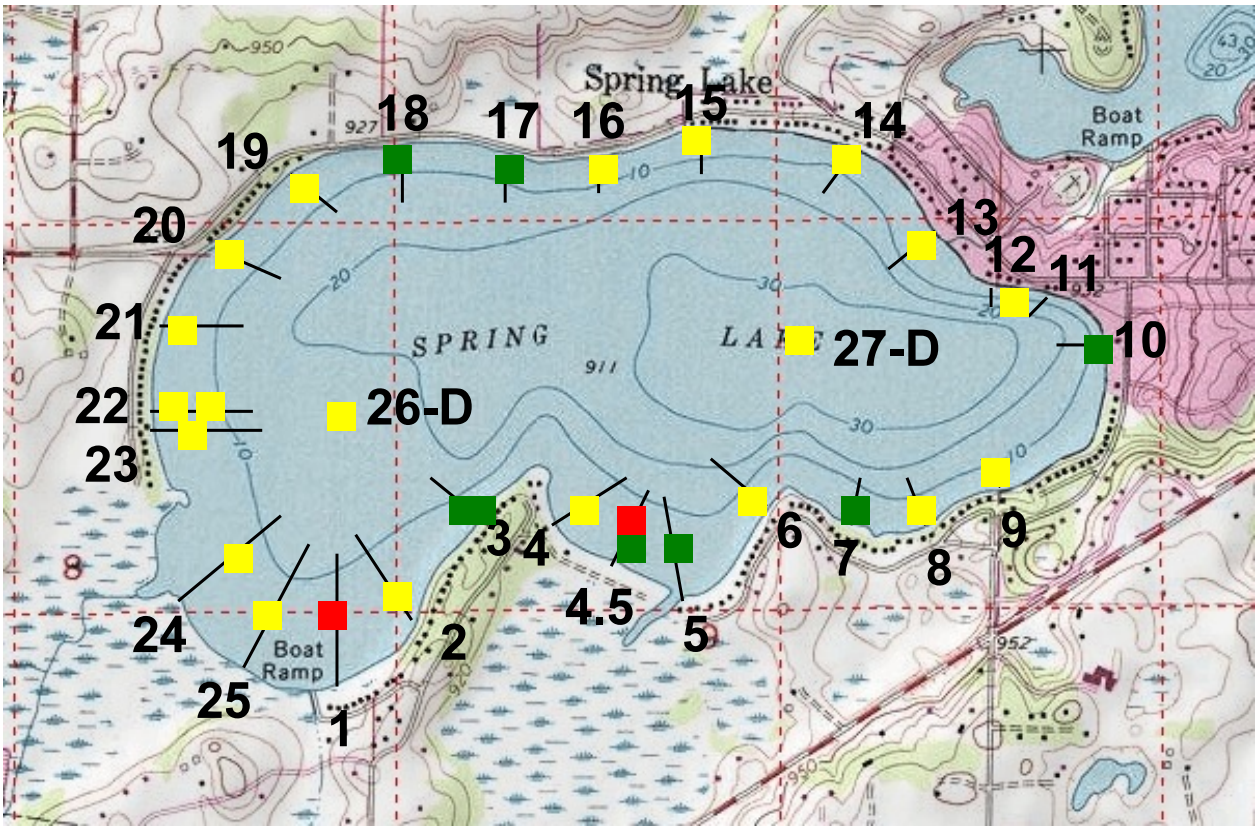
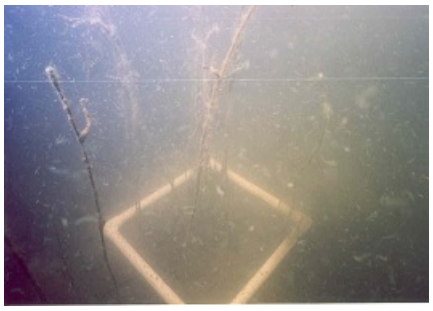


Figure 5. Sediment sample locations are shown with a square. The square color indicates the potential for curlyleaf pondweed growth to occur at that site. Key: green = light; yellow = moderate; red = heavy. A key that illustrates the three types of growth is shown on the next page.

Curlyleaf Pondweed Growth Characteristics

(source: Steve McComas, Blue Water Science, unpublished)

Light Growth Conditions



Plants rarely reach the surface.

Navigation and recreational activities are not generally hindered.

Stem density: 0 - 160 stems/m^2
Biomass: 0 - 50 g-dry wt/m^2
Estimated TP loading: <1.7 lbs/ac

MnDNR rake sample density equivalent for light growth conditions: 1, 2, or 3.

Moderate Growth Conditions

Broken surface canopy conditions.

Navigation and recreational activities may be hindered.

Lake users may opt for control.

Stem density: 100 - 280 stems/m^2
Biomass: 50 - 85 g-dry wt/m^2
Estimated TP loading: 2.2 - 3.8 lbs/ac

MnDNR rake sample density equivalent for moderate growth conditions: 2, 3 or sometimes, 4.

Heavy Growth Conditions

Solid or near solid surface canopy conditions.

Navigation and recreational activities are severely limited.

Control is necessary for navigation and/or recreation.

Stem density: 400+ stems/m^2
Biomass: >300 g-dry wt/m^2
Estimated TP loading: >6.7 lbs/ac

MnDNR rake sample density has a scale from 1 to 4. For certain growth conditions where plants top out at the surface, the scale has been extended: 4.5 is equivalent to a near solid surface canopy and a 5 is equivalent to a solid surface canopy. Heavy growth conditions have rake densities of a 4 (early to mid-season with the potential to reach the surface), 4.5, or 5.

Spring Lake, Scott County (ID: 70-54)

Lake area: 580 acres
Littoral area: 290 acres (MnDNR)

1. Introduction

Spring Lake is a 580 acre fertile lake in Scott County, Minnesota. Eurasian watermilfoil has not been found in Spring Lake (as of June of 2011). The Prior Lake/Spring Lake Watershed District authorized an aquatic evaluation to characterize the plant community for 2011 with an emphasis on the long term effects of herbicide treatments on curlyleaf pondweed control. The contact herbicide, Aquathol K, was applied to areas of heavy growth of curlyleaf pondweed from 2002 through 2006. There have been no major treatment efforts in 2007 through 2011. In 2011, Steve McComas of Blue Water Science, conducted aquatic plant surveys on Spring Lake on May 12 (early spring) and on June 10 (early summer). In addition, curlyleaf pondweed stem counts were made by scuba diving for early spring and early summer conditions.

2. Aquatic Plant Survey Methods for 2011

Aquatic Plant Surveys: Two aquatic plant surveys were conducted in Spring Lake in 2011. The objectives of the surveys were to evaluate the distribution of curlyleaf pondweed as well as other plant species in Spring Lake.

The survey technique was a line transect method with a stratified random sampling component. This survey method used transects spread around the lake perimeter with two depth strata per transect. We used 25 line transects for each plant survey (Figure 1) and a recording sonar (Lowrance X-16) to delineate the depths of plant colonization. Two depths (0-4 feet and 5-8 feet) representing two strata were sampled on each transect. Aquatic plants were sampled with a rake at several points within a depth strata to characterize plant species presence and density. For each zone on a transect, at least three rake samples were taken. Plant species were identified and a density rating of 0.5 to 5 was assigned with 5 being the highest density. For each species, a density rating was averaged for each sample zone.

Transects were recorded using a GPS NAD 27 conus datum (Figure 1).

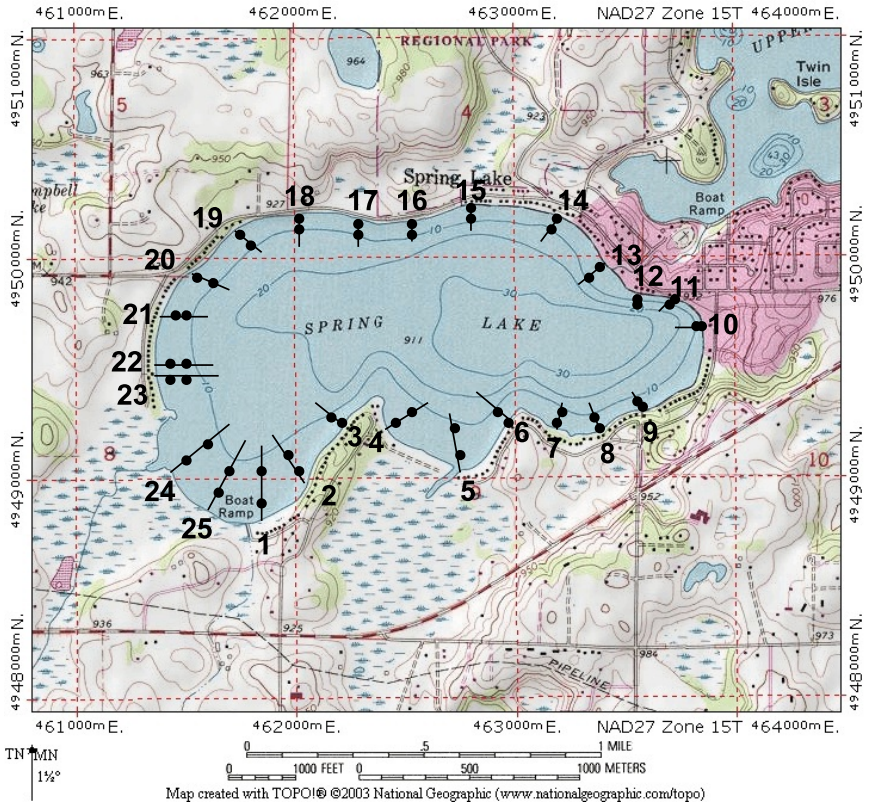


Figure 1. Transect map for the aquatic plant surveys conducted on Spring Lake in 2011 and a description of transect locations.

Transect Number	GPS Coordinates (NAD 27)		Description
	North	East	
1	49 48 968	04 61 916	Left of boat landing, right of big boulder wall
2	49 49 084	04 62 000	Shoreline deck
3	49 49 335	04 62 200	Green boat house on shore
4	49 49 332	04 62 540	Around the point, purple marten bird house
5	49 49 324	04 62 680	Going in on the inlet
6	49 49 270	04 62 890	In-between 2 wood retaining walls
7	49 49 345	04 63 200	Tan stucco house, flat roof
8	49 49 300	04 63 360	Wooden stairs, left of 3-story house.
9	49 49 411	04 63 572	Narrow 3 story gray house
10	49 49 493	04 63 745	Gray house right of culvert
11	49 49 688	04 63 760	2 tier boulder wall next to a private landing
12	49 49 790	04 63 573	Ranch house with flag pole in yard
13	49 49 860	04 63 447	Left of yellow house with a boat house and 2nd story deck
14	49 50 140	04 63 093	Next to a brown 2-story boat house with boulder wall
15	49 50 177	04 62 783	2nd from last house before natural shore, wood deck
16	49 50 123	04 62 549	No homes on shoreline, undeveloped before the bend in the shoreline
17	49 50 114	04 62 335	Left of bend, where big rocks start, right of marina dock
18	49 50 132	04 62 107	Single dock with a brick barn behind it
19	49 50 050	04 61 806	Beige house with basement walkout with stone wall, 2nd house from end
20	49 49 961	04 61 634	Large wood retaining wall covered with vegetation
21	49 49 818	04 61 466	Between 2 willows with a rock rip-rap shore
22	49 49 609	04 61 452	Tan house with screen porch on left
23	49 49 450	04 61 472	Right of channel inflow, 2nd house from inlet
24	49 49 117	04 61 634	Left of inlet next to dock.
25	49 48 978	04 61 700	1st dock to right of landing

Methods - Continued

Curlyleaf Stem Counts: Curlyleaf pondweed stem density was evaluated by scuba diving at two sampling locations on two sample dates. One sampling location was a south-central site, between transects 4 and 5 and the second location was on the west side of the lake between transects 20 and 23. The first stem density monitoring date was on May 12, 2011 and the second stem density monitoring date was conducted on June 10, 2011 after curlyleaf had grown to peak abundance. At each site, ten stem density samples were randomly collected along a 50 meter transect line that ran parallel to shore in 4 to 6 feet of water. Stem densities were counted within a 0.10 meter^2 quadrat. The quadrat, which is a square frame measuring 33 cm x 33 cm was placed on the sediments and all stems within the square frame were counted.

Figure 2. Steve McComas, Blue Water Science, used a 0.10 meter^2 quadrat to quantify curlyleaf stem densities.

3. Results of Aquatic Plant Evaluations

3.1. Aquatic Plant Survey for May 12, 2011

The first plant survey found a low occurrence of curlyleaf pondweed, along with a low density rating. Native plant diversity was low with the other plant species found, in addition to curlyleaf pondweed, being coontail and elodea (Table 1). Curlyleaf covered 48 acres, and no surface matting growth was observed. A plant distribution map of curlyleaf pondweed is shown in Figure 3.

The occurrence and plant density rating for each species on each of the transects is found in Table 2.

Table 1. Spring Lake aquatic plant occurrences and densities for the May 12, 2011 survey based on 25 transects and 2 depths, for a total of 50 stations. Density ratings are 1-5 with 1 being low and 5 being most dense.

	Depth 0-4 feet (25 stations)			Depth 5-8 feet (25 stations)			All Depths (50 stations)		
	Occur	% Occur	Density	Occur	% Occur	Density	Occur	% Occur	Density
Coontail (*Ceratophyllum demersum*)	4	16	0.6	4	16	0.6	8	16	0.6
Elodea (*Elodea canadensis*)	1	4	0.5	--	--	--	1	2	0.5
Curlyleaf pondweed (*Potamogeton crispus*)	6	24	0.5	4	16	0.5	10	20	0.5
Curlyleaf pondweed stems	6	24	1.0	4	16	1.0	10	20	1.0
Filamentous algae	2	8	0.5	2	18	0.4	4	8	0.5

Table 2. Site data for transects for Spring Lake for May 12, 2011.

	1		2		3		4		5		6		7		8		9	
	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8
Coontail							1	1	0.5	0.5			0.5					
Elodea											0.5							
Curlyleaf pondweed			0.5										0.5		0.5	0.5		
Curlyleaf - stems			*1*										*1*		*1*	*1*		
Filamentous algae												0.5			0.5			

	10		11		12		13		14		15		16		17		18	
	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8
Coontail																		
Elodea																		
Curlyleaf pondweed										0.5		0.5						0.5
Curlyleaf - stems										*1*		*1*						*1*
Filamentous algae							0.5	0.3										

	19		20		21		22		23		24		25	
	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8
Coontail												0.5	0.5	0.5
Elodea														
Curlyleaf pondweed					0.5				0.5				0.5	
Curlyleaf - stems					*1*				*1*				*1*	
Filamentous algae														

Figure 3. Curlyleaf pondweed found on the May 12, 2011 aquatic plant survey.

May 2011 Aquatic Plant Conditions

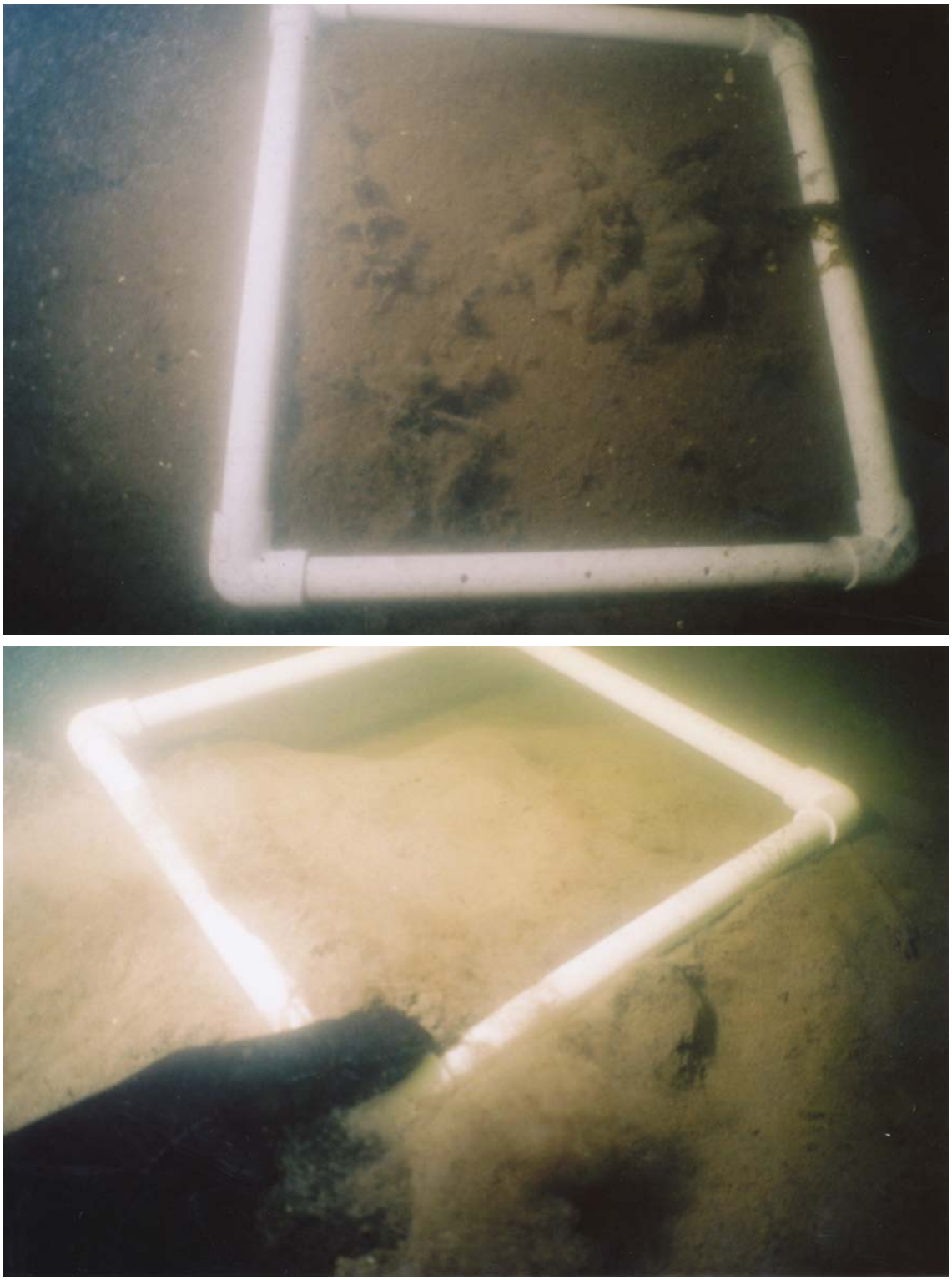


Figure 4. Curlyleaf pondweed conditions in the May 12, 2011 survey. [top] Curlyleaf stem densities were sparse at Transect 4.5. [bottom] Curlyleaf stem densities were sparse at Transect 22.

3.2. Aquatic Plant Survey for June 10, 2011

The second aquatic plant survey was conducted about 6 weeks after the first survey. No major herbicide applications were conducted in 2011. Curlyleaf pondweed had a broad distribution compared to the April survey, but still exhibited a relatively low density. Coontail and sago pondweed were also common (Tables 3 and 4). The coverage of curlyleaf pondweed was estimated at 87 acres and it increased compared to the 48 acres of coverage found in the May 12, 2011 survey.

Table 3. Spring Lake aquatic plant occurrences and densities for the June 10, 2011 survey based on 25 transects and 2 depths, for a total of 50 stations. Density ratings are 1-5 with 1 being low and 5 being most dense.

	Depth 0-4 feet (25 stations)			Depth 5-8 feet (25 stations)			All Depths (50 stations)		
	Occur	% Occur	Density	Occur	% Occur	Density	Occur	% Occur	Density
Coontail (*Ceratophyllum demersum*)	5	20	1.0	6	24	0.6	11	22	0.8
Elodea (*Elodea canadensis*)	2	8	0.8	--	--	--	2	4	0.8
Curlyleaf pondweed (*Potamogeton crispus*)	9	36	1.2	9	36	0.7	18	36	0.9
Curlyleaf pondweed stems	9	36	3.4	9	36	1.4	18	36	2.4
Claspingleaf pondweed (*P. Richardsonii*)	1	4	0.5	--	--	--	1	2	0.5
Stringy pondweed (*P. strictifolius*)	21	84	0.8	11	44	0.5	32	64	0.7
Water celery (*Vallisneria americana*)	1	4	1.0	--	--	--	1	2	1.0
Filamentous algae	1	4	0.5	1	4	0.3	2	4	0.4

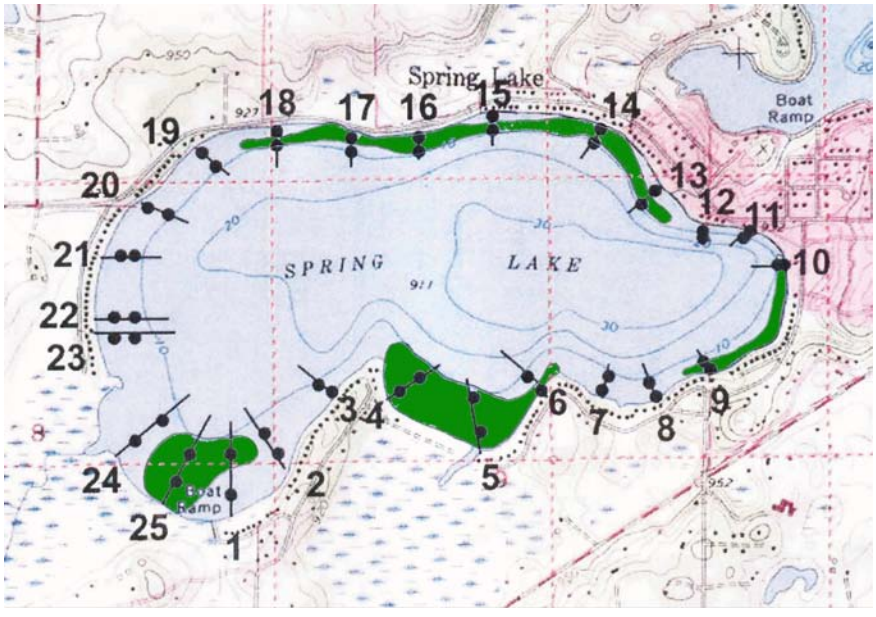


Figure 5. Curlyleaf pondweed coverage for June 10, 2011 was estimated at 87 acres.

Table 4. Site data for transect data for Spring Lake for June 10, 2011.

	1		2		3		4		5		6		7		8		9	
	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8
Coontail	0.5						2	0.5	0.5	0.7								
Elodea											1							
Curlyleaf pondweed		0.5					0.5	0.5	2.5	0.5	1						2	
Curlyleaf - stems		*1*					*1*	*1*	*9*	*1*	*1*						*8*	
Claspingleaf																		
Stringy pondweed	0.5		0.5		2	1	1	0.3	1	0.3	1	0.5	0.5	0.5	1		0.5	0.5
Water celery											1							
Filamentous algae													0.5			0.3		

	10		11		12		13		14		15		16		17		18	
	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8
Coontail																		
Elodea																		
Curlyleaf pondweed	1							1	1	1		0.5	1	0.5	0.5			0.5
Curlyleaf - stems	*2*							*2*	*4*	*2*		*1*	*2*	*2*	*1*			*1*
Claspingleaf					0.5													
Stringy pondweed					0.3	0.5	2		0.5		0.5				0.5	0.3	0.5	
Water celery																		
Filamentous algae																		

	19		20		21		22		23		24		25	
	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8	0- 4	5- 8
Coontail						0.5		0.3			1	0.5	1	1
Elodea	0.5													
Curlyleaf pondweed													1	1
Curlyleaf - stems													*3*	*2*
Claspingleaf														
Stringy pondweed	1		0.5		0.5	0.5			1	0.3	1	0.5	0.5	
Water celery														
Filamentous algae														

June 2011 Aquatic Plant Conditions

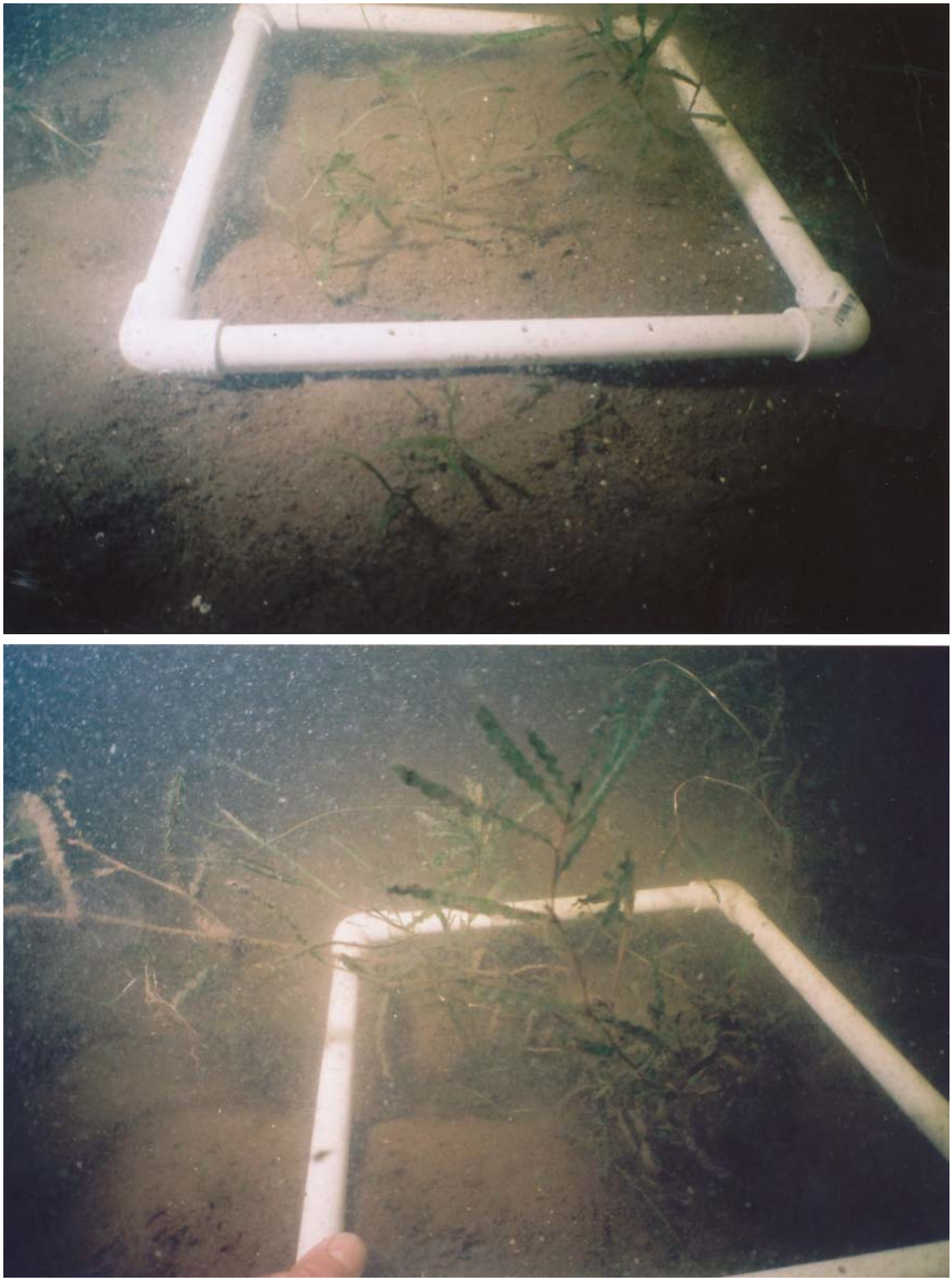


Figure 6. Aquatic plant growth in Spring Lake on June 10, 2011 was spotty.

3.3. Curlyleaf Stem Densities for May l 2 and June 10, 2011

Table 5. Density of curlyleaf, at two depths, shallow (S) which is 0-4 feet, and deep (D) which is 5-8 feet, for each transect, for the early season plant surveys in 2007 through 2010.

Transect		May 10, 2011			June 10, 2011		
		Curlyleaf Pondweed Plant Density			Curlyleaf Pondweed Plant Density		
		Density	Rake Stems	Stems/m²	Density	Rake Stems	Stems/m²
1	S						
	D				0.5	1	10
2	S	0.5	1	10			
	D						
3	S						
	D						
4	S				0.5	1	10
	D				0.5	1	10
5	S				2.5	9	90
	D				0.5	1	10
6	S				1	1	10
	D						
7	S	0.5	1	10			
	D						
8	S	0.5	1	10			
	D	0.5	1	10			
9	S				2	8	80
	D						
10	S				1	2	20
	D						
11	S						
	D						
12	S						
	D						
13	S						
	D				1	2	20
14	S				1	4	40
	D	0.5	1	10	1	2	20
15	S						
	D	0.5	1	10	0.5	1	10
16	S				1	2	20
	D				0.5	2	20
17	S				0.5	1	10
	D						
18	S						
	D	0.5	1	10	0.5	1	10
19	S						
	D						
20	S						
	D						
21	S	0.5	1	10			
	D						
22	S						
	D						
23	S	0.5	1	10			
	D						
24	S						
	D						
25	S	0.5	1	10	1	3	30
	D				1	2	20
Sites Where Curlyleaf Was Found		**10**	**1**	**10**	**18**	**3.9**	**39**

Curlyleaf Stem Densities on the South and West Sides of Spring Lake:

Curlyleaf densities, which is a measure of abundance, were low at the sample sites in 2009. At Transects 4 and 5, no curlyleaf was observed in April and only a few stems were observed in June (Table 6). At Transect 22, no curlyleaf was observed in April and curlyleaf was sparse in June. In June, an extra sampling station was added at Transect 22. In 2007, stem densities at 4-5 feet averaged 152 stems/m^2. In 2008, stem densities were only 2 stems/m^2.

Table 6. Curlyleaf pondweed stem densities (stems/m^2) for 2011.

Quadrat	May 12, 2011 (stems/m^2)				June 10, 2011 (stems/m^2)			
	T4.5		T22		T4.5		T22	
	4 ft	5 - 6 ft	4 ft	5 - 6 ft	4 ft	5 - 6 ft	4 ft	5 - 6 ft
1	20	20	0	0	10	0	0	0
2	0	0	0	0	10	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0
	Ave: 2	**Ave: 2**	**Ave: 0**	**Ave: 0**	**Ave: 2**	**Ave: 0**	**Ave: 0**	**Ave: 0**

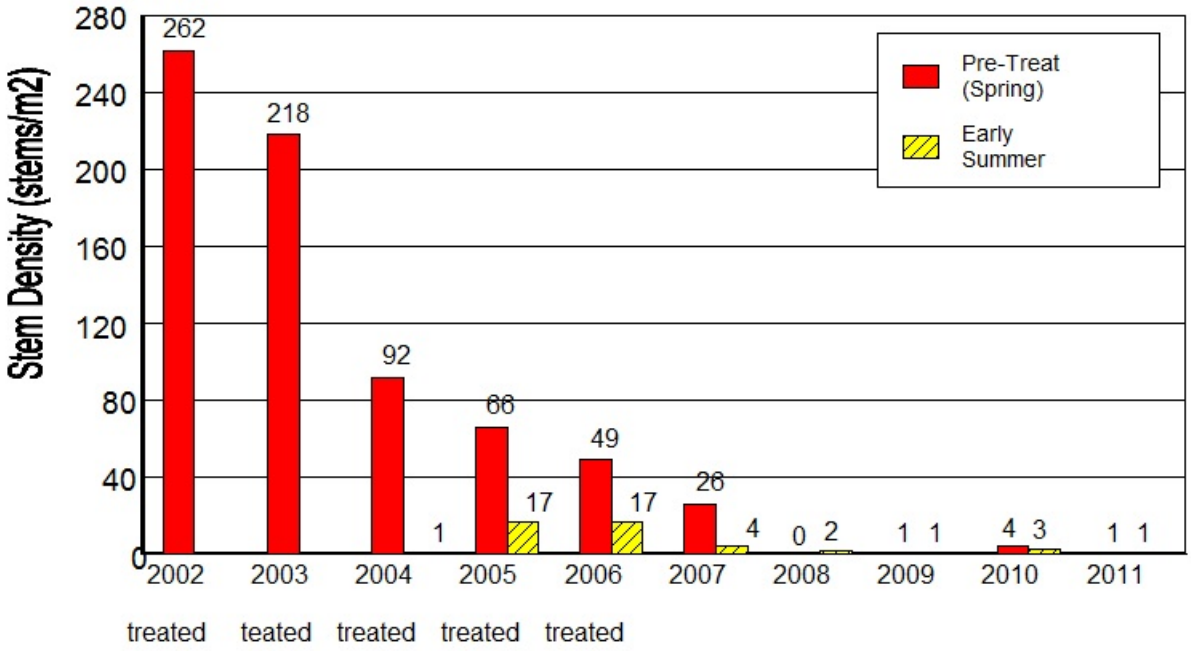


Figure 7. Curlyleaf stem densities for early season monitoring (using scuba diving) for 2002-2011.

4. Aquatic Plant Evaluation Summaries

4.1. Summary of Early Summer Aquatic Plant Surveys from 2000 - 2011

Curlyleaf pondweed often has been the dominant plant species in the first survey of the season in Spring Lake based on line transect aquatic plant surveys from 2000 through 2011 (Table 7).

Overall, the percent occurrence of curlyleaf appears to have diminished since 2000. Because growing conditions have been prime from 2003 through 2011, a bumper crop of curlyleaf would be expected. Nuisance growth has been kept in check with harvesting (2002 and 2003) and with herbicides (2002 - 2006). From 2007 through 2011, no herbicides have been applied. Heavy growth developed in only about 5 acres in 2007, but since then heavy growth has not been observed. It is not clear why curlyleaf has declined in 2007, 2008, 2009, and 2010 with no herbicide applications, but it may be due to the influence of iron dosing which has occurred during this time period. In other studies (McComas, unpublished), it has been found that adding iron to a lake inhibits curlyleaf growth.

Table 7. Spring Lake aquatic plant percent occurrences for the early summer aquatic plant surveys in 2000 and 2002-2011.

	Percent Occurrence of Plant Species								
	2000 (n=50 stations)	2002 (n=50 stations)	2003 (n=52 stations)	2004 (n=52 stations)		2005 (n=50 stations)		2006 (n=50 stations)	
	June 3 (no treatment)	June 7 (herbicides May 21 harvesting May 24)	May 15 (herbicides May 13 harvesting June 5)	May 2	June 14 (herbicides April 30)	Apr 20	June 1 (herbicides April 14)	Apr 26	June 2 (herbicides April 21)
Treatment effect	no treatment (ref conditions)	should have a treatment effect	prior to treatment effect	prior to treatment effect	should have a treatment effect	prior to treatment effect	should have a treatment effect	prior to treatment effect	should have a treatment effect
Coontail (*Ceratophyllum demersum*)	--	4	--	13	28	8	14	16	26
Chara (*Chara sp*)	--	--	--	--	4	--	--	--	--
Moss (*Drepanocladus sp*)	--	--	--	--	--	--	--	--	--
Elodea (*Elodea canadensis*)	--	8	6	25	48	22	54	64	68
Curlyleaf pondweed (*Potamogeton crispus*)	**98**	**86**	**72**	**79**	**6**	**58**	**72**	**64**	**64**
Stringy pondweed (*P. pusillus*/strictifolius)	—	6	2	--	--	--	6	--	20
Claspingleaf pondweed (*P. Richardsonii*)	--	--	--	--	--	--	2	--	2
Narrowleaf pondweed (*P.sp or strictifolius*)	--	--	--	--	--	--	--	--	--
Sago pondweed (*Stuckenia pectinata*)	4	--	2	--	24	--	6	--	
Wild celery (*Vallisneria americana*)	--	--	--	--	2	--	2	--	2
Filamentous algae	--	38	20	17	78	10	52	12	10
Number of species	2	4	4	3	6	3	7	3	6

	Percent Occurrence of Plant Species									
	2007 (n=50 stations)		2008 (n=50 stations)		2009 (n=50 stations)		2010 (n=50 stations)		2011 (n=50 stations)	
	April 15 & 22	Jun 5	Apr 29	Jun 13	Apr 23	Jun 10	Apr 27	Jun 2	May 12	Jun 10
Treatment effect										
Coontail (*Ceratophyllum demersum*)	22	28	8	30	4	8	18	26	16	22
Chara (*Chara sp*)	--	2	--	--	--	2	12	--	--	--
Moss (*Drepanocladus sp*)	--	--	1	--	--	--	--	--	--	--
Elodea (*Elodea canadensis*)	20	6	--	--	--	--	2	2	2	4
Curlyleaf pondweed (*Potamogeton crispus*)	**44**	**58**	**5**	**38**	**10**	**28**	**50**	**42**	**20**	**36**
Stringy pondweed (*P. pusillus*/strictifolius)	2	26	--	--	--	14	--	--	--	64
Claspingleaf pondweed (*P. Richardsonii*)	--	2	--	2	--	2	--	4	--	2
Narrowleaf pondweed (*P.sp or strictifolius*)	--	--	--	--	--	2	52	34	--	--
Sago pondweed (*Stuckenia pectinata*)	--	8	1	24	--	24	--	26	--	--
Wild celery (*Vallisneria americana*)	--	6	--	--	--	2	--	4	--	2
Filamentous algae	16	6	4	18	6	6	2	18	8	4
Number of species	4	8	4	4	2	8	5	7	3	6

4.2. Summary of Early Summer Curlyleaf Pondweed Stem Densities from 2002 - 2011

Curlyleaf pondweed stem densities have been monitored at several sites since 2002 using stem counts made by scuba diving. Overall, stem count results indicate that curlyleaf pondweed stem density has decreased in Spring Lake (Figure 8 and Table 8).

Mechanical harvesting and annual aggressive herbicide treatments were used to treat two major curlyleaf areas (which were estimated at 60 acres) in Spring Lake from 2002 through 2006 with the objective to achieve long-term control of nuisance curlyleaf pondweed growth. Harvesting an open-lake area on the west side of the lake removed 50 to 70% of the curlyleaf in the season of harvesting. There appeared to be a significant decrease in curlyleaf stem densities from 2002 to 2003 and an even greater decrease from 2003 to 2004 (Figure 9). Herbicide use also produced significant stem density decreases. Results of early season herbicide treatment, using Aquathol K, significantly reduced the density of curlyleaf pondweed at the south central site and maintained low stem densities for the last three years at the area that was formerly harvested.

In 2007 through 2011 there were no herbicide treatments nor harvesting. Early season stem densities were low in 2007 through 2011 (Tables 8 and 9). When re-sampling occurred about six weeks later, curlyleaf stem densities were still low (Tables 8 and 9). An additional site was monitored in 2007 at Transect 21. This area had moderate to heavy stem density in a narrow band in water depths 4 to 5 feet (Table 9). In 2008 through 2011 light growth of curlyleaf was observed at Transect 4-5 or at Transect 22 (Tables 8 and 9).

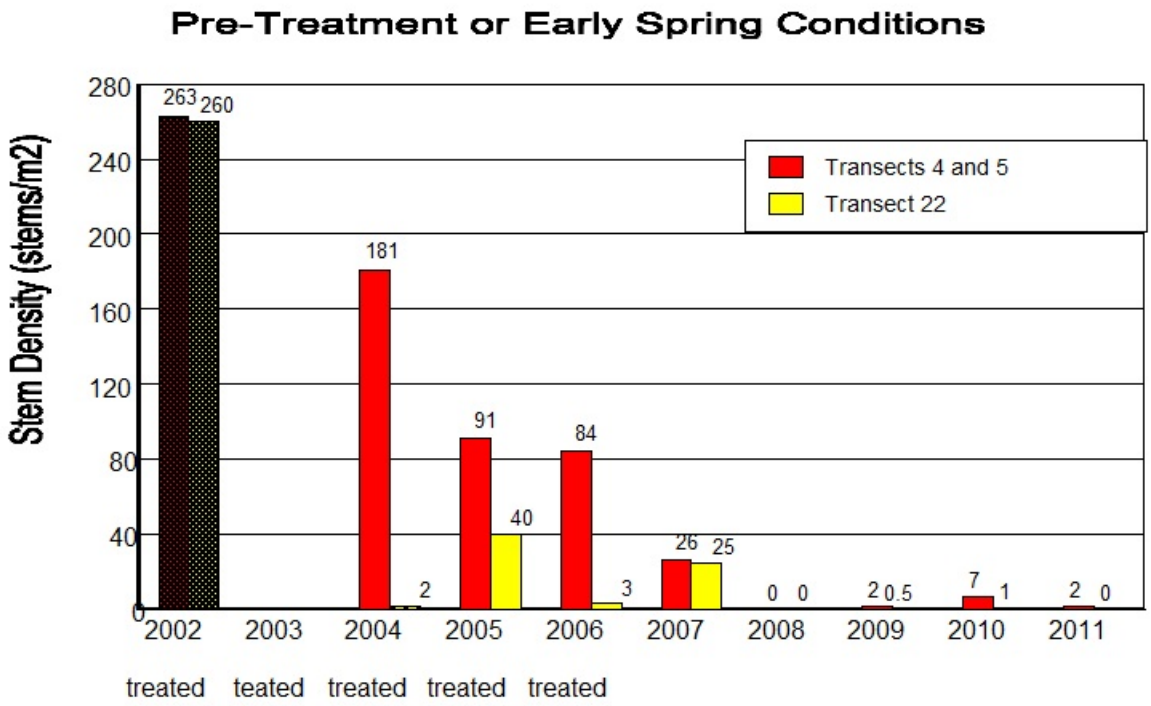


Figure 8. Stem densities represent early season conditions, prior to the effects of that summer's treatment. Densities in 2002 represent conditions prior to control programs using either harvesting or herbicides. For Transect 22, stem densities in 2003 and 2004 represent the effects of harvesting in the 2002 and 2003 growing season (the graph bars are striped). From 2004 through 2006, herbicides were used for control in the Transect 22 area. Herbicide applications were made for five consecutive years from 2002 through 2006 on Transect 4 and 5.

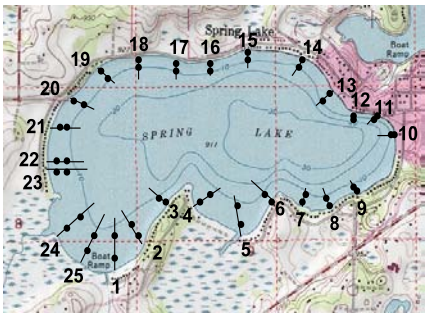
Pre and Post Curlyleaf Pondweed Stem Densities from 2002-2011: Curlyleaf pondweed stem densities have been monitored at two sites in Spring Lake since 2002. After the first year of harvesting at the West site in 2002, curlyleaf pondweed stem density remained high (Table 10), but harvesting did reduce the amount of matted curlyleaf area compared to previous years. After the second year of harvesting in 2003, stem densities were reduced compared to 2002.

Herbicide treatments in 2002 and 2003 did not appear to reduce stem densities at the South-Central site. In 2003, stem densities were similar to 2002 at the South-Central site. However, the herbicides did prevent curlyleaf from matting at the surface. They also appeared to reduce turion formation in this area. In 2004, 2005, and 2006 at both sample sites, prior to herbicide effects, curlyleaf pondweed stem densities were less compared to 2002. The herbicide treatments in 2004, 2005, and 2006 were effective and stem densities were dramatically less at the site following the herbicide treatment.

In 2007 through 2011 stem densities have been low in both early and late spring sampling.

Table 8. Stem densities for curlyleaf pondweed from 2002 through 2011.

Year	Sample Date	Stem Densities (stems/m^2)			
		South-Central Site (between Transects 4 to 5)		West Site (between Transects 20 - 23)	
		Treatment	Stem Density (stems/m^2)	Treatment	Stem Density (stems/m^2)
2002	June 7 (post treatment)	Herbicide: May 21	263 (n=3)	Harvested: May 10-24	260 (n=3)
2003	June 16 (post treatment)	Herbicide: May 13	281 (n=10)	Harvested: May 31-Jun 5	154 (n=10)
2004	May 2 (pre-treatment)	Herbicide: April 30	181 (n=10)	Herbicide: April 30	2 (n=10)
	June 14 (post treatment)		0 (n=10)		2 (n=10)
2005	April 20 (pre-treatment)	Herbicide: April 14	91 (n=10)	Herbicide: April 14	40 (n=10)
	May 23 (post treatment)		14 (n=10)		20 (n=10)
2006	April 25 (pre-treatment)	Herbicide: April 21	36 (sand)(n=5) 108 (muck)(n=10)	Herbicide: April 21	3 (n=10)
	June 2 (post treatment)		24 (n=10)		9 (n=10)
2007	April 15 & 22	no treatment	26 (n=20)	no treatment	25 (n=20)
	June 5		7 (n=20)		0 (n=20)
2008	April 29	no treatment	0 (n=20)	no treatment	0 (n=20)
	June 12		0 (n=20)		4 (n=20)
2009	April 23	no treatment	2 (n=20)	no treatment	0.5 (n=20)
	June 10		1 (n=20)		0 (n=20)
2010	April 27	no treatment	7 (n=20)	no treatment	1 (n=20)
	June 2		6 (n=20)		0 (n=20)
2011	May 12	no treatment	2 (n=20)	no treatment	0 (n=20)
	June 10		2 (n=20)		0 (n=20)



Transect map

Table 9. Curlyleaf pondweed stem densities for 2002 through 2011 showing individual quadrat results.

	2002	2003	2004		2005		2006	
	Post Treatment	Post Treatment	Pre- Treatment	Post Treatment	Pre- Treatment	Post Treatment	Pre- Treatment	Post Treatment
	Herbicide Applied: May 21	Herbicide Applied: May 13		Herbicide Applied: April 30		Herbicide Applied: April 14		Herbicide Applied: April 21
	June 7, 2002 (stems/m^2)	June 16, 2003 (stems/m^2)	May 2, 2004 (stems/m^2)	June 14, 2004 (stems/m^2)	April 20, 2005 (stems/m^2)	May 23, 2005 (stems/m^2)	April 25, 2006 (stems/m^2)	June 2, 2006 (stems/m^2)
South-central Site (Transects 4 & 5) Herbicide treatments: 2002 - 2006	290	230	190	0	60	50	70, 30	30
	290	340	150	0	50	0	100, 50	70
	210	190	50	0	80	0	120, 60	120
		230	60	0	100	0	170, 30	20
		290	130	0	130	0	160, 10	0
		460	200	0	50	20	110	0
		280	210	0	100	40	100	0
		230	190	0	80	0	110	0
		260	270	0	190	10	60	0
		300	360	0	70	20	80	0
	Ave: 263	Ave: 281	Ave: 181	Ave: 0	Ave: 91	Ave: 14	Ave: 84	Ave: 24
West Site (Transect 22) Harvesting conducted: 2002, 2003, and a herbicide treatment applied: 2004, 2005, and 2006	Harvested Area: May 10 - 24	Harvested Area: May 31-Jun 5		Herbicide Applied: April 30		Herbicide Applied: April 14		Herbicide Applied: April 21
	210	170	0	0	20	0	10	10
	240	110	0	10	60	0	10	20
	330	310	10	0	80	0	10	10
		170	0	0	20	0	0	40
		20	0	0	40	50	0	10
		100	0	10	0	60	0	0
		130	0	0	50	30	0	0
		210	0	0	60	10	0	0
		230	0	0	40	50	0	0
		90	10	0	30	20	0	0
	Ave: 260	Ave: 154	Ave: 2	Ave: 2	Ave: 40	Ave: 20	Ave: 3	Ave: 9

	2007						2008				2009				2010			
	Spring Evaluation			Early Summer Evaluation			Spring Evaluation		Early Summer Evaluation		Spring Evaluation		Early Summer Evaluation		Spring Evaluation		Early Summer Evaluation	
				No Herbicide					No Herbicide				No Herbicide				No Herbicide	
	April 16, 2007 (stems/m^2)			June 5, 2007 (stems/m^2)			April 29, 2008 (stems/m^2)		June 13, 2008 (stems/m^2)		April 23, 2009 (stems/m^2)		June 10, 2009 (stems/m^2)		April 27, 2010 (stems/m^2)		June 2, 2010 (stems/m^2)	
	4 ft	5-6 ft	7 ft	4 ft	5-6 ft	7 ft	4-5 ft	6 ft	4 ft	6 ft	4 ft	5-6 ft	4 ft	5-6 ft	4 ft	5-6 ft	4 ft	5-6 ft
South-central Site (Transects 4 & 5) Herbicide treatments: 2002 - 2006	0	0	0	0	0	0	0	0	10	10	0	10	20	0	40	20	40	20
	0	0	0	0	0	0	0	0	20	0	0	10	0	0	0	20	20	10
	0	80	0	0	0	0	0	0	0	0	0	20	0	0	20	20	10	0
	0	50	30	0	0	0	0	0	0	0	0	0	0	0	0	20	10	0
	0	30	10	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	110	0	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	130	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	20	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	50	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ave: 0	Ave: 47	Ave: 4	Ave: 14	Ave: 0	Ave: 0	Ave: 0	Ave: 0	Ave: 3	Ave: 1	Ave: 0	Ave: 4	Ave: 2	Ave: 0	Ave: 6	Ave: 8	Ave: 8	Ave: 3
West Site (Transect 22) Harvesting conducted: 2002, 2003, and a herbicide treatment applied: 2004, 2005, and 2006	5 ft	6 ft		4 ft	5 ft	6 ft	4-5 ft	6 ft	4 ft	6 ft	4 ft	5-6 ft	4 ft	5-6 ft	4 ft	5-6 ft	4 ft	5-6 ft
	13	0		0	0	0	0	0	10	10	0	10	0	0	0	10	0	0
	10	0		0	0	0	0	0	10	20	0	0	0	0	0	0	0	0
	7	0		0	0	0	0	0	20	0	0	0	0	0	0	0	0	0
	2	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1	2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ave: 42	Ave: 7		Ave: 0	Ave: 0	Ave: 0	Ave: 0	Ave: 0	Ave: 4	Ave: 3	Ave: 0	Ave: 1	Ave: 0	Ave: 0	Ave: 0	Ave: 1	Ave: 0	Ave: 0
West Site (Transect 21) Harvesting conducted: 2002, 2003, and a herbicide treatment applied: 2004, 2005, and 2006					4-5 ft	6 ft				4-5 ft								
					160	0				10								
					90	0				10								
					120	0				0								
					160	0				0								
					280	0				0								
					160	0				0								
					200	0				0								
					120	0				0								
					80	0				0								
					150	0				0								
					Ave: 152	Ave: 0				Ave: 2								

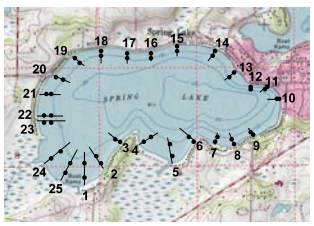
Table 9. Concluded.

	2011			
	Spring Evaluation		Early Summer Evaluation	
			No Herbicide	
	May 12, 2011 (stems/m^2)		June 10, 2011 (stems/m^2)	
	4 ft	5-6 ft	4 ft	5-6 ft
South-central Site (Transects 4 & 5) Herbicide treatments: 2002 - 2006	20	20	10	0
	0	0	10	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	Ave: 2	Ave: 2	Ave: 2	Ave: 0
West Site (Transect 22) Harvesting conducted: 2002, 2003, and a herbicide treatment applied: 2004, 2005, and 2006	4 ft	5-6 ft	4 ft	5-6 ft
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	Ave: 0	Ave: 0	Ave: 0	Ave: 0
West Site (Transect 21) Harvesting conducted: 2002, 2003, and a herbicide treatment applied: 2004, 2005, and 2006				

Curlyleaf Distribution from 2007 to 2011 (non-treatment years): Curlyleaf pondweed density increased from May 12 to June 10 at nine sites and decreased at eleven sites (Table 10). Curlyleaf was more common in 2011 than in previous years but curlyleaf was more abundant in 2007.

Table 10. Density of curlyleaf, at two depths, shallow (S) which is 0-4 feet, and deep (D) which is 5-8 feet, for each transect, for the early season plant surveys from 2007-2011. The density rating is on a scale from 0.5 to 5 with 5 being the highest density. For 2010 and 2011, the numbers in parentheses indicate the number of CLP stems found in the rakehead sampler.

		2007		2008		2009		2010		2011	
Transect		Curlyleaf Pondweed Plant Density		Curlyleaf Pondweed Plant Density		Curlyleaf Pondweed Plant Density		Curlyleaf Pondweed Plant Density		Curlyleaf Pondweed Plant Density	
		Apr 15	Jun 5	Apr 29	Jun 13	Apr 23	Jun 10	Apr 27	Jun 20	May 12	Jun 10
1	S		2			0.5	2				
	D			0.7	1	1					0.5 (1)
2	S									0.5 (1)	
	D		1.8		1						
3	S								1 (3)		
	D		1.5					0.5 (1)			
4	S			0.5			1				0.5 (1)
	D		1		0.5						0.5 (1)
5	S		0.7				0.5	1 (1)	1 (3)		2.5 (9)
	D							1 (1)	1.3 (3)		0.3 (1)
6	S				1						1 (1)
	D	1						0.5 (1)			
7	S	1	1		1					0.5 (1)	
	D	0.5	0.5								
8	S							0.5 (1)		0.5 (1)	
	D						0.5			1 (2)	
9	S		1					1 (1)	0.5 (2)		2 (8)
	D	0.5	1.8				0.5		0.5 (1)		
10	S		0.5								1 (2)
	D		1								
11	S										
	D										
12	S		1				1	1 (1)			
	D		1		0.3						
13	S										
	D	0.8	3.5		3						1 (2)
14	S	1	1		1			1 (1)	1 (1)	0.5 (1)	1 (4)
	D	1	2.8		1.5			0.3 (1)	1 (1)		1 (2)
15	S		3.5		1		2	1 (2)	1 (3)		
	D	1.3	2.8		2		0.3	1 (3)	1 (1)	0.5 (1)	0.5 (1)
16	S		1					1 (1.5)	1 (1)		0.8 (2)
	D	0.5	1.8					1 (1)	1 (2)		0.5 (2)
17	S	0.5						1 (4)			0.5 (1)
	D	0.3	2	0.3			0.3	1 (3)	1 (2)		
18	S	0.5			1			1 (3)			
	D	0.5	1	0.3				1 (4)		0.5 (1)	0.5 (1)
19	S		1				0.5	1 (2)	1 (1)		
	D								1 (3)		
20	S	0.5	2.8					0.5 (1)	1 (3)		
	D	0.5			1	0.3		0.5 (1)	0.5 (1)		
21	S		1.5				1	1 (1)	0.5 (1)	0.5 (1)	
	D		4								
22	S	1	1		1			1 (1)			
	D	1						0.3 (0.5)			
23	S	1					1		1 (4)	0.5 (1)	
	D	0.5	1		0.5						
24	S	1			1	1	2		1 (2)		
	D	0.5			1			1 (1.5)	1 (2)		
25	S	1	0.5		1	1	1		2 (6)	0.5 (1)	1 (3)
	D				1			1 (3)			0.8 (2)
Sites Where Curlyleaf Was Found		22	29	4	19	5	14	25	21	10	18



4.3. Summary of Past Survey Results

Since 1948, some species within the aquatic plant community have appeared and others have disappeared. The percent occurrence of the native plant elodea may have decreased since 2000 but others such as stringy pondweed may have increased (Table 11). Curlyleaf distribution and curlyleaf density are lower in 2011 compared to 2000. Curlyleaf changes observed in the lake may be due to the curlyleaf management program.

Overall, the native aquatic plant community has been fairly stable for a number of years.

Native Aquatic Plant Status: Roughly ten different submerged aquatic plant species in late summer surveys have been reported in Spring Lake since 1948. In the summer of 2011, five native species and one non-native species were observed. This is about average compared to previous surveys. The distribution of native plants is fairly broad, but their density is low and they only grew out to about 6-feet of water depth in June. Two factors are probably limiting their distribution and density: lack of sunlight penetration due to algae blooms and uprooting impacts from roughfish.

Curlyleaf Pondweed Status: Curlyleaf pondweed is a non-native plant that grew to nuisance conditions in early summer in Spring Lake until control efforts were initiated in 2002. It first showed up in Spring Lake plant surveys in 1982. Curlyleaf along with stringy pondweed were the dominant plant in early summer in 2011 (Table 11). Curlyleaf grows out to 8 feet of water depth. It appears the overall curlyleaf distribution is decreasing and acres of coverage has gone down from 180 in 2000 to 150 in 2006 to 113 in 2007. Acres of nuisance growth that reach the surface or within inches of the surface also have declined since 2000 from an estimated 87 acres to 0 acres from 2003 through 2006 with 5 acres observed in 2007 and 0 acres in 2008-2011. There has been no herbicide control from 2007-2011.

Eurasian Watermilfoil Status: Eurasian watermilfoil was not found in Spring Lake in 2011. Eurasian watermilfoil is present in both Upper and Lower Prior Lakes, which are downstream from Spring Lake. It is more than likely that Eurasian watermilfoil will become established in Spring Lake in the future.

Figure 8. Snails and hydras were common on curlyleaf pondweed on April 20, 2005.

Table 11. List of aquatic plants found in past surveys. Surveys from 1948 to 1988 were conducted by MnDNR. Surveys in 2000 and 2002 through 2011 were conducted by Blue Water Science. Numbers for plant species in 2000 and 2002 through 2011 represent percent occurrence.

Year	1948	1973	1982	1986	1988
Date (month.day)	9.18	7.9	8.16	7.2	8.15
Secchi disc (ft)	2.6	3.0	3.3	--	2.5
Lesser duckweed (*Lemna minor*)				X	R
Duckweed (*Lemna sp*)			O		
White waterlilies (*Nymphaea tuberosa*)					
Greater duckweed (*Spirodela polyrhiza*)				X	
Coontail (*Ceratophyllum demersum*)	R	O	A	X	O
Chara (*Chara sp*)					
Elodea (*Elodea canadensis*)			O		O
Moss (*Drepanocladus sp*)					
Naiads (*Najas flexilis*)					
Berchtold's pondweed (*Potamogeton berchtoldi*)	R	O			
Curlyleaf pondweed (*P. crispus*)			R	X	
Variable pondweed (*P. gramineus*)	R	C	O		
Floatingleaf (*P. natans*)	R	C			P
Stringy pondweed (*P. pusillus*)					
Claspingleaf (*P. Richardsonii*)	R	C			O
Stringy pondweed (*P. strictifolius*)					
Narrowleaf pondweed (*P. sp*)			O	X	
Sago* (*Stuckenia pectinata*)	R	C			C
Star duckweed (*Lemna trisulca*)		C			
Wild celery (*Vallisneria americana*)			O		P
Mud plantain* (*Zosterella dubia*)	R	R	C		C
Number of submerged species	7	8	8	5	8

* Stuckenia pectinata = Potamogeton pectinatus Mud plantain = water stargrass Zosterella dubia = Heteranthera dubia

Table 11. Concluded.

Year	2000		2002		2003	2004			2005			2006			2007			2008			2009			2010		2011	
Date (month.day)	6.3	9.3	6.7	9.3	5.15	5.2	6.14	8.27	4.20	6.1	8.18	4.26	6.2	9.1	4.15	6.5	7.13	4.29	6.12	8.13	4.23	6.10	8.19	4.27	6.2	5.12	6.10
Secchi disc (ft)	7.0					7.1	7.2	3.5	16.7	6.9	2.0	4.7	5.0	2.0				2.3	3.9		3.5	6.2	2.9		2.2		5.6
Lesser duckweed (*Lemna minor*)																	2										
Duckweed (*Lemna sp*)											6																
White waterlilies (*Nymphaea tuberosa*)																											
Greater duckweed (*Spirodela polyrhiza*)								2																			
Coontail (*Ceratophyllum demersum*)		29	4	22		13	28	40	8	14	58	16	26	50	22	28	30	8	30	16	4	8	24	18	26	16	22
Chara (*Chara sp*)		4		2			4									2				8		2		12			
Elodea (*Elodea canadensis*)		25	8	18	6	25	48	68	22	54	76	64	68	48	20	6	2			4			4	2	2	2	4
Moss (*Drepanocladus sp*)																		1									
Naiads (*Najas flexilis*)																							6				
Berchtold's pondweed (*Potamogeton berchtoldi*)																											
Curlyleaf pondweed (*P. crispus*)	98	40	86	4	72	78	6	10	58	72	12	64	64	2	44	58		5	38	8	10	28	18	50	42	20	36
Variable pondweed (*P. gramineus*)																											
Floatingleaf (*P. natans*)																											
Stringy pondweed (*P. pusillus*)		2	6	8	2			4		6	8		20			26											
Claspingleaf (*P. Richardsonii*)				10				6		2	4		2	4		2	2		2	2		2	6		4		2
Stringy pondweed (*P. strictifolius*)														2	2		2			24		14	66	52	34		64
Narrowleaf pondweed (*P. sp*)																						2					
Sago* (*Stuckenia pectinata*)	40	15		36	2		24	6		6	14			6		8	2	1	24	8		24	20		26		
Star duckweed (*Lemna trisulca*)																											
Wild celery (*Vallisneria americana*)		6		16			2	22		2	32		2	18		6	12			18		2	18		4		2
Mud plantain* (*Zosterella dubia*)		17		22				24			30			4						8			24				
Number of submerged species	2	8	4	9	4	3	6	9	3	7	9	3	6	8	4	8	6	4	4	9	2	8	9	5	7	3	6

* Stuckenia pectinata = Potamogeton pectinatus Mud plantain = water stargrass Zosterella dubia = Heteranthera dubia

Summary of Curlyleaf Pondweed Distribution and Abundance from 2000 - 2011:

Transect	Depth	2000	2002	2003	2004		2005		2006		2007		2008		2009		2010		2011		Avg	% Red	Predicted growth based on lake soils
		Jun 3	Jun 7	May 15	May 2	Jun 14	Apr 20	Jun 1	Apr 26	Jun 2	Apr 15	Jun 5	Apr 29	Jun 13	Apr 23	Jun 10	Apr 27	Jun 2	May 12	Jun 10			
1	S	5	0.5	0	0	0	0	0	0	0	0	2	0	0	0.5	2	0	0	0	0	0.5	12	
	M	4	2	2	1	0	1	1	0.5	0	0	0	0.7	1	1	0	0	0	0	0.5	0.8	12	Heavy
2	S	4	0.5	0	0.5	0	0	2	1	0	0	0	0	0	0	0	0	0	0.5	0	0.4	12	
	M	5	2	4	0.5	0	0	0.3	0.7	0	0	1.8	0	1	0	0	0	0	0	0	0.8	25	Moderate
3	S	2	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0.5	1	0	0	0.3	0	Light
	M	4	2	0.5	0.5	0	0.5	1	0.8	0.5	0	1.5	0	0	0	0	0	0	0	0	0.6	12	Light
4	S	4	2	0.5	1	0	1	0	0	0	0	0	0.5	0	0	1	0	0	0	0.5	0.6	12	Moderate
	M	5	2.5	4	1	0	2	0.8	1.3	0.7	0	1	0	0.5	0	0	0	0	0	0.5	1.0	25	
5	S	2	2	0.5	1	0	2	1	1	0.5	0	0.7	0	0	0	0.5	1	1	0	2.5	0.8	0	
	M	5	3	2	2.5	0	0.5	0	2	1	0	0	0	0	0	0	1	1.3	0	0.3	1.0	12	Light
6	S	1.8	0	0	0.5	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0.3	0	
	M	2	2	1	1	0	0.5	0.5	2	0.3	1	0	0	0	0	0	0.5	0	0	0	0.6	0	Moderate
7	S	1	0.5	0	0	0	0	0	1	1	1	1	0	1	0	0	0	0	0.5	0	0.4	0	
	M	4.5	1.5	1	0	0.5	0.5	1	1.8	1	0.5	1.5	0	0	0	0	0	0	0	0	0.7	12	Light
8	S	1	1	0	0.5	0	0.3	1	0	0	0	0	0	0	0	0	0.5	0	0.5	0	0.3	0	
	M	3	1	1	0	0	0.5	1	0	0.3	0	0	0	0	0	0.5	0	0	1	0	0.4	0	Moderate
9	S	4	0.5	0	0	0	0	1	0	1	0	1	0	0	0	0	1	0.5	0	2	0.6	12	Moderate
	M	4	0.5	0.5	0.5	0	0	1	0.8	0.5	0.5	1.8	0	0	0	0.5	0	0.5	0	0	0.6	12	
10	S	2	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	1	0.2	0	
	M	4	0	0	0.5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0.3	12	Light
11	S	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	
	M	3	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	Moderate
12	S	3	0.5	0	0.5	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0.4	0	
	M	3	0.5	0	0.5	0	0	0	0	0	0	1	0	0.3	0	0	0	0	0	0	0.3	0	
13	S	0	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	
	M	2.7	1	0.5	0.5	0	0.5	0.7	1	1.7	0.8	3.5	0	3	0	0	0	0	0	1	0.9	0	Moderate
14	S	3	0.5	0.5	0.5	0	0	1	2	0.5	1	1	0	1	0	0	0.5	1	0.5	1	0.7	0	
	M	4	1.5	2	1	0	2	1.5	2	3	1	2.8	0	1.5	0	0	0.5	1	0	1	1.3	12	Moderate
15	S	2	1	0.5	2	0	0.3	1	1	2	0	3.5	0	1	0	2	1	1	0	0	1.0	0	
	M	2	0.5	3	1	1	1	1.5	1	2.5	1.3	2.8	0	2	0	0.3	1	1	0.5	0.5	1.2	0	Moderate
16	S	2	0	0.5	0.5	0	0.5	1	1.3	0	0	1	0	0	0	0	1	1	0	0.8	0.5	0	
	M	4	4	1	1	1	1	1	0.5	1.5	0.5	1.8	0	0	0	0	1	1	0	0.5	1.0	25	Moderate
17	S	2	1	0.5	1	0	1.5	1	1.5	2	0.5	0	0	0	0	0	1	0	0	0.5	0.7	0	Light
	M	4	2	2	1	0	1	0	1.5	1.7	0.3	2	0.3	0	0	0.3	1	1	0	0	1.0	12	
18	S	2	0	0.5	0.5	0	1	1	0	2	0.5	0	0	1	0	0	1	0	0	0	0.5	0	
	M	4	3	2	1	0	2	1.8	0.8	2.5	0.5	1	0.3	0	0	0	1	0	0.5	0.5	1.1	12	Light
19	S	3	1	3	0.5	0	0.5	1	0	3	0	1	0	0	0	0.5	1	1	0	0	0.8	0	
	M	5	1.5	2	0.5	0	0.3	0.3	0	0	0	0	0	0	0	0	0	1	0	0	0.6	12	Moderate
20	S	3	1	0.5	0.5	0	0	2	1.5	3	0.5	2.8	0	0	0	0	0.5	1	0	0	0.9	0	Moderate
	M	5	1.5	2	0.5	0	1.5	2	0.3	3	0.5	0	0	1	0.3	0	0.5	0.5	0	0	1.0	12	
21	S	2.5	0.5	0.5	0.5	0	0	1	0.5	3	0	1.5	0	0	0	1	1	0.5	0.5	0	0.7	0	Moderate
	M	5	2.5	3.5	0.5	0	2	0.5	1.3	3	0	4	0	0	0	0	0	0	0	0	1.2	25	
22	S	3	0.5	0	0	0	0	0	0.5	2	1	1	0	1	0	0	1	0	0	0	0.5	0	
	M	5	2	3	1	0	1	1	0.2	1	1	0	0	0	0	0	0.5	0	0	0	0.8	12	Moderate
23	S	2	1	0	0.5	0	0	0	0	1	1	0	0	0	0	1	0	1	0.5	0	0.4	0	
	M	4.7	4.5	3	0.5	0	1	1	0.8	1.3	0.5	1	0	0.5	0	0	0	0	0	0	1.0	25	Moderate
24	S	3	1	0.5	0.5	0	0	4	0.5	0	1	0	0	1	1	2	0	1	0	0	0.8	12	
	M	5	1.5	4	2	0	1.5	0.5	0.5	1.3	0.5	0	0	1	0	0	1	1	0	0	1.0	25	Moderate
25	S	2	1	0.5	0.5	0	1	2	1.8	2	1	0.5	0	1	1	1	0	2	0.5	1	1.0	0	
	M	4.7	3	4	0	0	1	1	1.7	0.5	0	0	0	1	0	0	1	0	0	0.8	1.0	25	Moderate
Number of Reds		23	2	4	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0			
Avg CLP Density													0.5	1.1	0.7	1.0	0.8	0.8	0.6	0.9			

Depth Zones:

S = 0 - 4 feet
M = 5 - 8 feet

Figure 9. Summary of curlyleaf pondweed density for early summer aquatic plant surveys for Spring Lake from 2000 - 2010. Curlyleaf density is shown on a scale from 1 - 5 (with 5 being most dense) for each depth zone on all 25 transects for each survey. An "X" in a box means no sample at that depth. Colors are coded for density. A sediment survey was conducted on Spring Lake in 2008. Predicted curlyleaf growth (far right column) has been close to actual curlyleaf growth conditions.

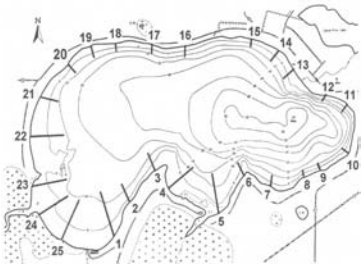
5. Discussion of the Curlyleaf Pondweed Management Program

5.1. Summary of Herbicide and Harvesting Effects from 2002 - 2011

Since 2002, the Prior Lake/Spring Lake Watershed District has been aggressively managing curlyleaf pondweed using mechanical harvesting (2002 & 2003) and herbicide application (2002-2006). A summary of activities and results is shown in Table 12.

Table 12. Summary of herbicide and harvesting activities for 2002 through 2011.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
South - Central Site (between Transects 4 & 5)										
Herbicide Treatments in 2002 - 2006	14 acres (between transects 4 & 5)	14 acres (between transects 4 & 5)	14 acres	14 acres	14 acres	no herbicides	no herbicides	no herbicides	no herbicides	no herbicides
Application date	May 21	May 13	April 30	April 14	April 21	--	--	--	--	--
Herbicide	Aquathol	Aquathol	Aquathol	Aquathol	Aquathol	--	--	--	--	--
Amount added (43.0% is active ingredient)	32 gallons	39 gallons	40 gallons	40 gallons	40 gallons	--	--	--	--	--
Water temperature	58°F	58°F	54°F	54°F	58°F	--	--	--	--	--
Target concentration (active ingredient)	1.0 ppm	1.0 ppm	1.0 ppm	1.0 ppm	1.0 ppm	--	--	--	--	--
Actual application rate	0.81 ppm	0.81 ppm	0.81 ppm	0.81 ppm	0.81 ppm	--	--	--	--	--
Plant height at time of application	8 - 18 inches	8 - 28 inches	4 - 10 inches	4 - 10 inches	4 - 14 inches	--	--	--	--	--
Effectiveness	no canopy observed, 40 to 50% plant elimination, viable plants still present.	no canopy observed, 30 to 40% plant elimination, viable plants still present	no canopy observed, 98% curlyleaf control	no canopy observed, plants present, no turions observed	no canopy observed, plants present, no turions observed	no canopy observed, plants present	no canopy observed plants are sparse	no canopy observed plants are sparse	no canopy observed plants are sparse	no canopy observed plants are sparse
Shoreline Herbicide Treatment										
Application date	May 24	May 13 and 27 (62°F)	April 30 (54°F)	April 14 (54°F)	Apr 21 (58°F)	no herbicides	no herbicides	no herbicides	--	--
Application rate	0.5 gal/lot = 1 gal/ac-ft = 1.3 ppm-active ingredient	1.5 ppm active ingredient	1.3 - 1.5 ppm active ingredient	1.3 - 1.5 ppm active ingredient	1.3 - 1.5 ppm active ingredient	--	--	--	--	--
West Site (Transects 19-25)										
Harvesting in 2002 and 2003	60 acres	74 acres	0	0	0	0	0	0	0	0
Treatment dates	up to May 24	May 31 - June 5	April 30	April 14	April 21	--	--	--	--	--
Harvesting hours	65+	100	0	0	0	0	0	0	0	0
Volume of curlyleaf removed (wet wt)	310 cu yds	450 cu yds	0	0	0	0	0	0	0	0
Acres harvested	50+	74 (some redundancy)	0	0	0	0	0	0	0	0
Acres treated with herbicide	0	0	45 (172 gallons)	45 (172 gallons)	46 (168 gallons)	no herbicides	no herbicides	no herbicides	no herbicides	no herbicides
Effectiveness	some canopy left 40-70% of curlyleaf removed	some canopy left, 50- 75% of curlyleaf removed	no canopy 98% curlyleaf control	no canopy, plants present, no turions observed	no canopy observed	plants present: scarce around transects 22-25, more common at transect 21	plants are scarce	plants are scarce	plants are scarce	plants are scarce



Transect locations.

5.2. Lake Sediment Survey Indicates Low to Moderate Potential for Future Curlyleaf Growth

A Spring Lake sediment survey was conducted on August 13, 2008. Results indicated curlyleaf growth is predicted to be low to moderate for most of the lake. A couple of sites appear to have sediment characteristics that would be conducive to heavy growth. From 2007 - 2011 curlyleaf growth has been light, but it could be more abundant in a few areas in the future.

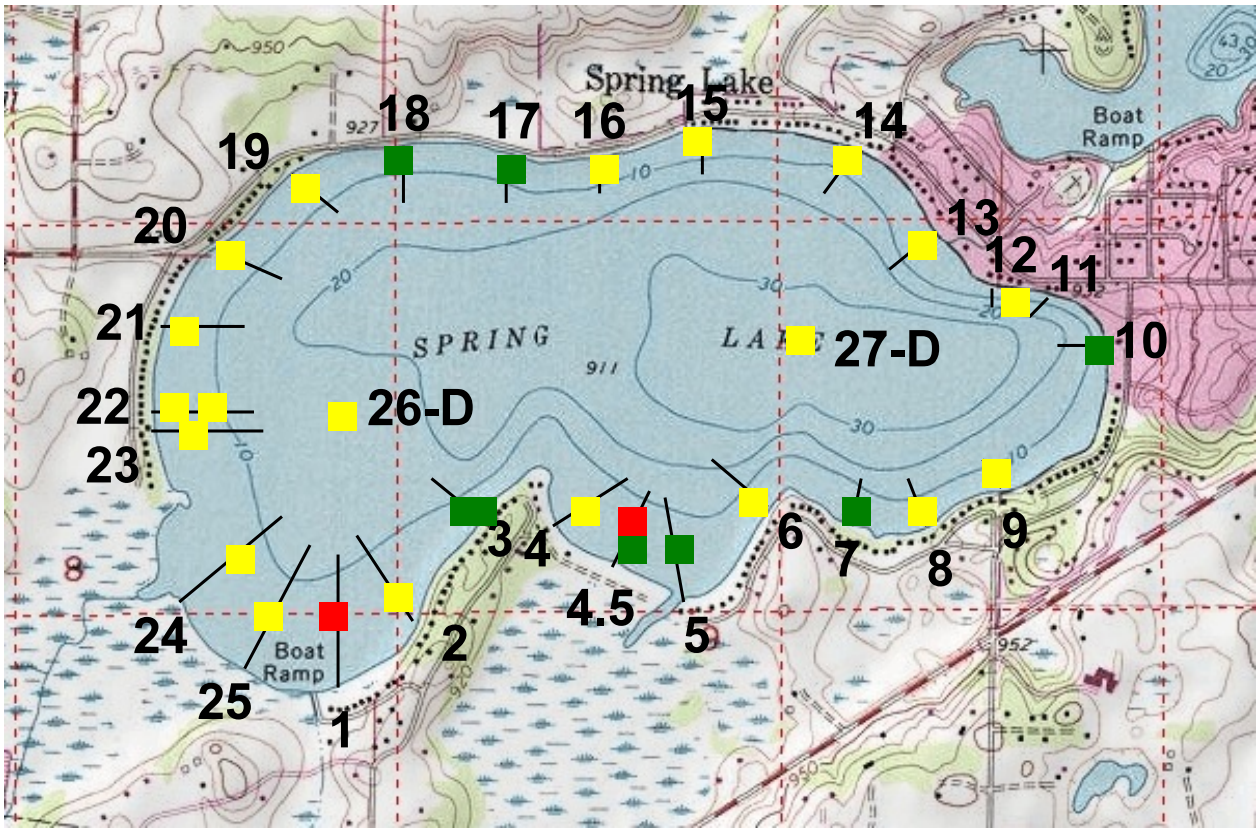


Figure 10 . Sediment sample locations are shown with a square. The square color indicates the potential for nuisance curlyleaf pondweed to occur at that site. Key: green = low; yellow = medium; red = high potential.

5.3. Spring Lake Curlyleaf Pondweed Observations and Speculation

- Mechanical harvesting was conducted for two years in the western end of the lake. The harvesting operation reduced matting conditions from 100% down to at least 50% reduction of the area in the season that harvesting occurred.

- After two years of harvesting in 2002 and 2003, stem densities declined slightly in the first year (measured in 2003) and declined significantly after the second year of harvesting (measured in 2004).

- This western area was treated with herbicides for the next three years (2004, 2005, 2006). Curlyleaf densities have remained low in this area including 2007 - 2011 which were years of no herbicide use.

- Five years of herbicide treatment in the south-central side of Spring Lake eliminated nuisance curlyleaf growth in the season of treatment.

- In general, use of herbicides that kill curlyleaf before it produces turions appears to reduce the stem density of next year's curlyleaf "crop".

- Continued use of herbicides seems to induce a lower stem density condition the following year.

- In Spring Lake when treatment was discontinued in areas where repeated herbicide applications had produced lower stem densities, curlyleaf stem densities have remained low. It may be that sediment conditions that were conducive to abundant growth in the past have changed and are not conducive to abundant growth now.

5.4. Recommended Curlyleaf Control Strategy

Based on results of the Spring Lake curlyleaf control program, and from other curlyleaf control programs, a reasonable curlyleaf control option for 2012 is to only treat areas of moderate to heavy growth.

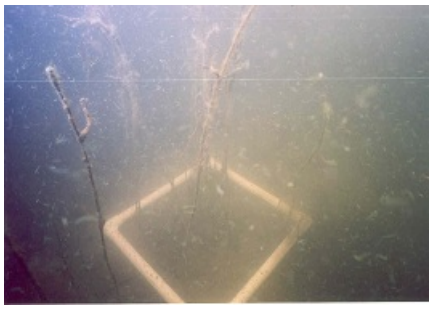
Results of monitoring curlyleaf growth patterns over the last few years and lake sediment sampling results indicate the potential to produce low to moderate growth around Spring Lake. Surveys in April of 2012 should be used to specifically delineate treatment areas for an early May herbicide application.

Figure 11. Stem densities have steadily declined from 2007 to 2008 to 2009 and have remained low in 2010 and 2011 (not shown). In the most heavily infested area, curlyleaf stem densities were measured between 80 to 280 stems with an average of 10 quadrat determinations averaging 152 stems/m^2 in 2007. This type of growth is in a range of light to moderate growth characteristics (see chart of growth definitions on the next page). Growth has been light in 2008 and 2009.

Curlyleaf Pondweed Growth Characteristics

(source: Steve McComas, Blue Water Science, unpublished)

Light Growth Conditions



Plants rarely reach the surface.

Navigation and recreational activities are not generally hindered.

Stem density: 0 - 160 stems/m^2
Biomass: 0 - 50 g-dry wt/m^2
Estimated TP loading: <1.7 lbs/ac

MnDNR rake sample density equivalent for light growth conditions: 1, 2, or 3.

Moderate Growth Conditions

Broken surface canopy conditions.

Navigation and recreational activities may be hindered.

Lake users may opt for control.

Stem density: 100 - 280 stems/m^2
Biomass: 50 - 85 g-dry wt/m^2
Estimated TP loading: 2.2 - 3.8 lbs/ac

MnDNR rake sample density equivalent for moderate growth conditions: 2, 3 or sometimes, 4.

Heavy Growth Conditions

Solid or near solid surface canopy conditions.

Navigation and recreational activities are severely limited.

Control is necessary for navigation and/or recreation.

Stem density: 400+ stems/m^2
Biomass: >300 g-dry wt/m^2
Estimated TP loading: >6.7 lbs/ac

MnDNR rake sample density has a scale from 1 to 4. For certain growth conditions where plants top out at the surface, the scale has been extended: 4.5 is equivalent to a near solid surface canopy and a 5 is equivalent to a solid surface canopy. Heavy growth conditions have rake densities of a 4 (early to mid-season with the potential to reach the surface), 4.5, or 5.

APPENDIX

Curlyleaf Conditions for Transects 4 and 5 from 2000 - 2007

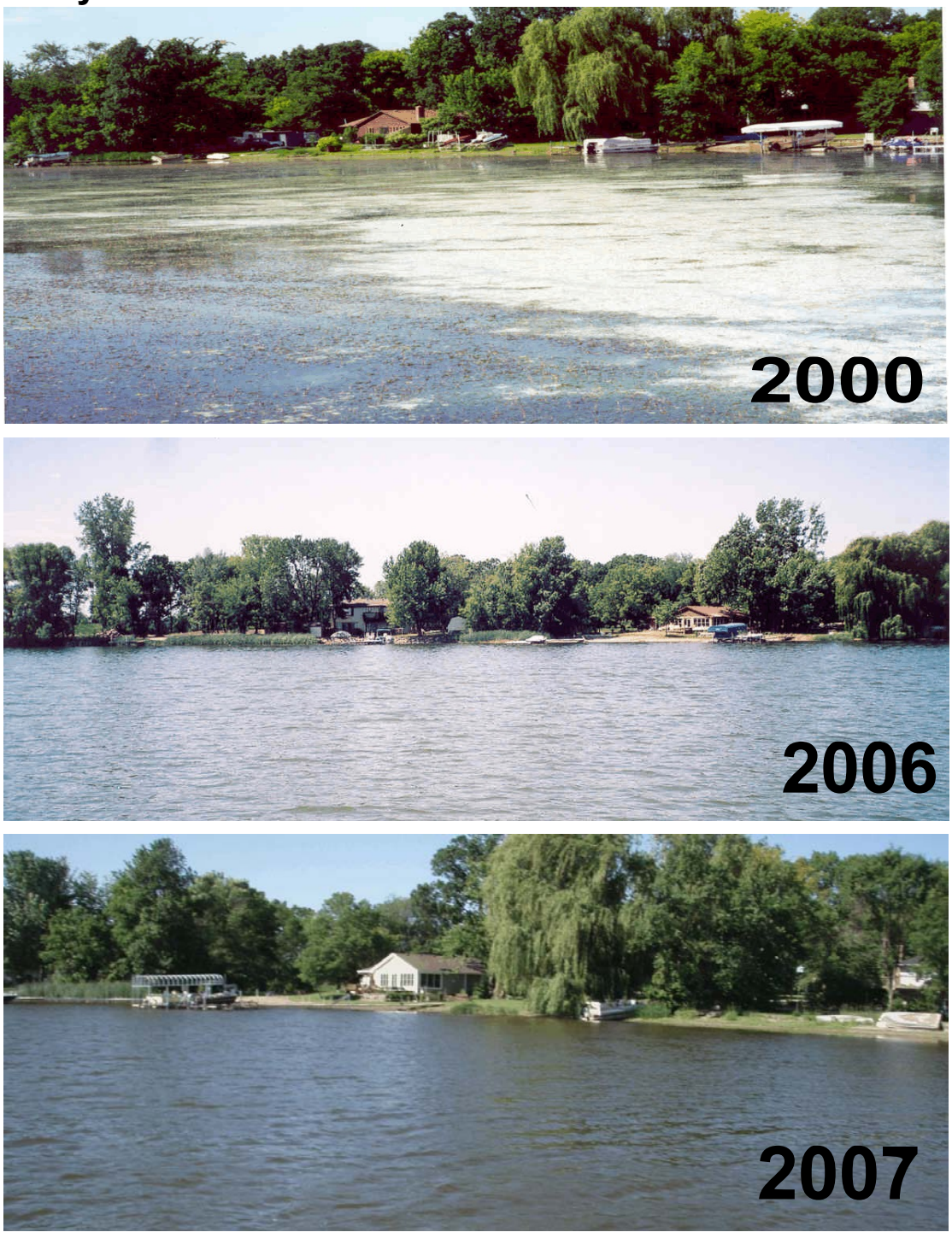


Figure A-1. [top] June 3, 2000: No curlyleaf treatment conducted in this area in 2000. Curlyleaf was found in matted conditions between Transects 4 and 5.
[middle] June 2, 2006: This area treated with herbicides from 2002-2006. No curlyleaf matting was observed from 2002 - 2006.
[bottom] June 8, 2007: This area was not treated with herbicides in 2007. No curlyleaf matting was observed.

Curlyleaf Conditions for Transects 20 - 23 from 2000 - 2007

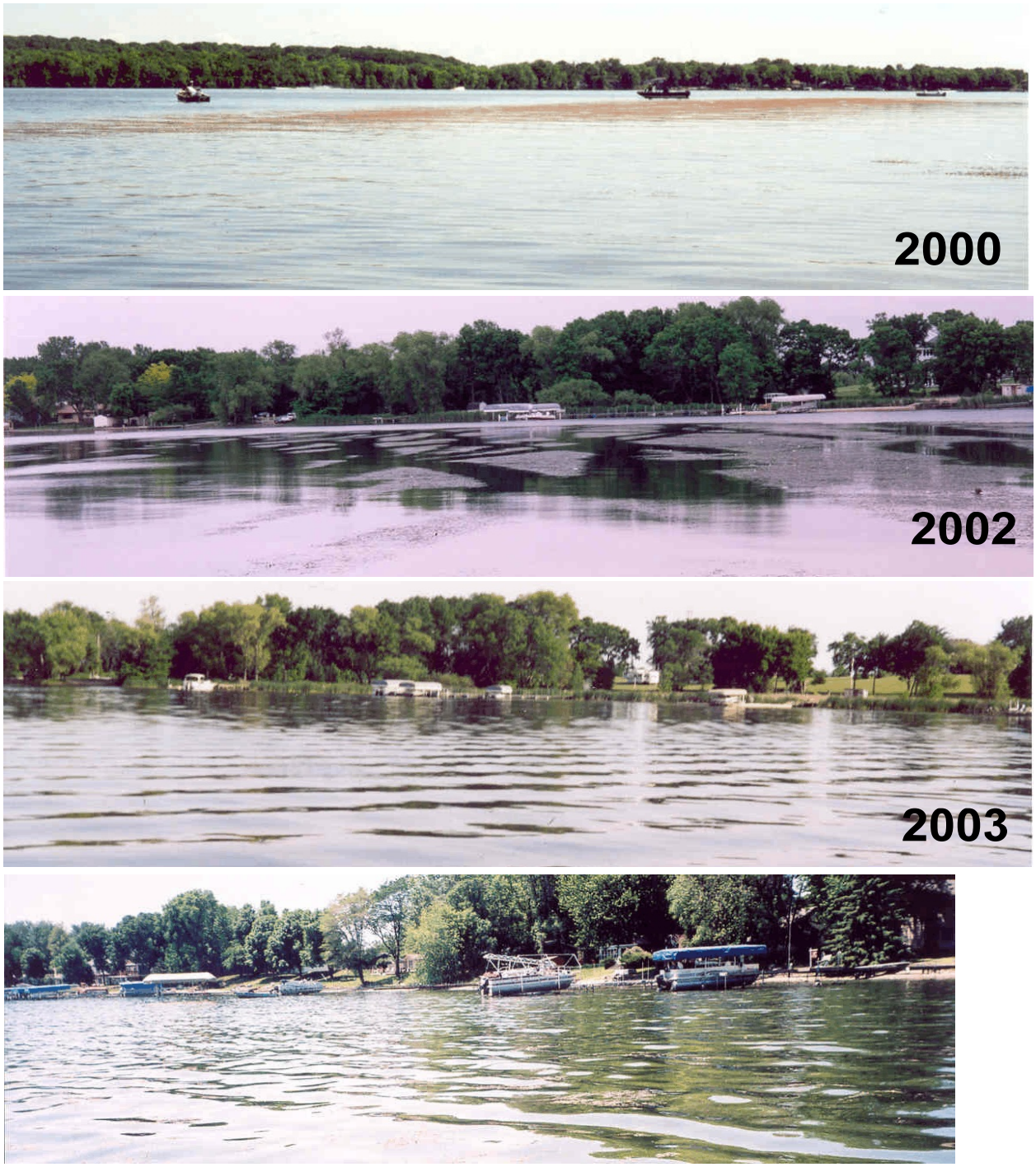


Figure A-2. [top] June 3, 2000: No curlyleaf control was conducted in this area in 2000. Curlyleaf was topping out in the areas around Transects 20 - 23.
[upper mid] June 7, 2002: Weed-free channels are observed in harvested area.
[lower mid] June 16, 2003: Plants were harvested in this area and no serious surface matting was observed in this location in 2003.
[bottom] No curlyleaf matting has been observed in this area in 2004, 2005, or 2006. Here are conditions on June 2, 2006.

Underwater Views for 2002

Post Herbicide Conditions

Figure A-3. Herbicides were applied on May 21.
[top and middle] Curlyleaf pondweed conditions on June 7, 2002: South Central Site, Transects 4 and 5. Some curlyleaf was still standing but most of the curlyleaf has been knocked down.
[bottom] Curlyleaf pondweed conditions on June 20, 2002: most of the curlyleaf had died back from the effect of the herbicide application.

Post Harvesting Conditions

Figure A-4. Harvesting was conducted up to May 24, 2002 at the West Site (Transects 19-25).
[top and middle] Curlyleaf conditions on June 7, 2002: Some plants were still standing but plants were dying in areas that were cut.
[bottom] Curlyleaf conditions on June 20, 2002: Cut plants were not growing back.

Underwater Views for 2003

Post Herbicide Conditions

Figure A-5. Herbicides were applied to this area on May 13, 2003.
[top] June 16, 2003: Curlyleaf was standing in some areas and absent in other areas. Overall, there was approximately 50-60% curlyleaf coverage in the herbicide treated area.
[bottom] June 16, 2003: In the herbicide treated area, curlyleaf stem densities were high in some areas, however, turion production was low.

Post Harvesting Conditions

Figure A-6. This area was harvested from May 31 - June 5. [top] June 16, 2003: In the harvested area (Transects 19-25), channels were cut through curlyleaf beds.
[bottom] June 16, 2003: In the harvested area, curlyleaf pondweed stem density was less than in the area treated with herbicides.

Underwater Views for 2004

Pre-Herbicide Conditions

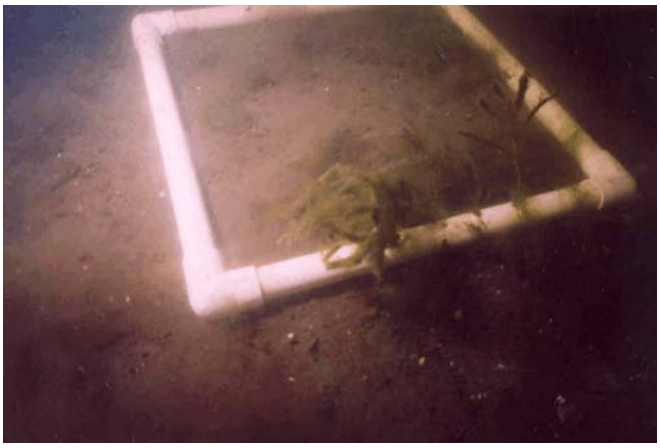
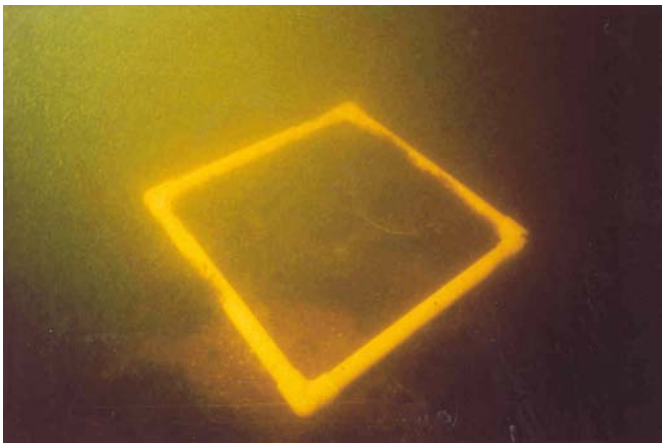


Figure A-7. Herbicides were applied on April 30, 2004. [top and bottom] Curlyleaf on May 2, 2004 in Spring Lake, between Transects 4 and 5: Curlyleaf was still green on May 2 and where it was present, it was only several inches tall.

Post Herbicide Conditions



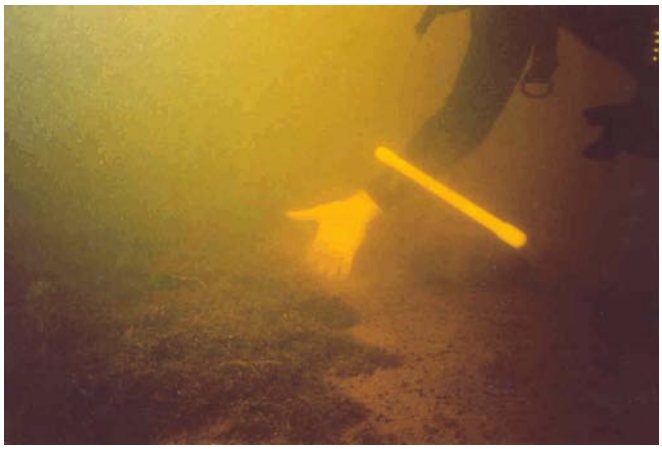


Figure A-8. Herbicides were applied on April 30, 2004. [top] Curlyleaf pondweed conditions on June 14, 2004 South-Central site (Transects 4 and 5): Curlyleaf was sparse.
[bottom] West site (Transect 22): curlyleaf was sparse.

Underwater Views for 2005

Pre-Herbicide Conditions

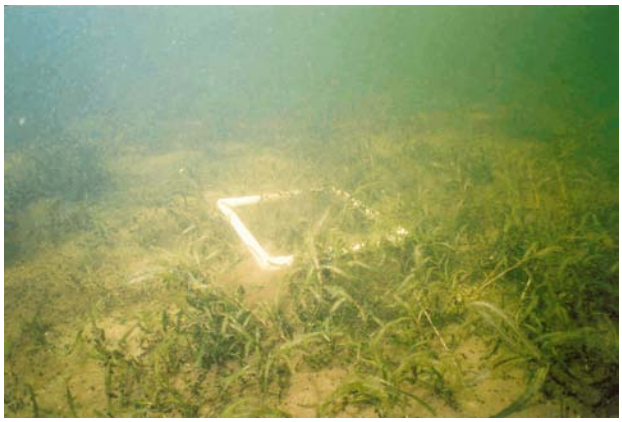
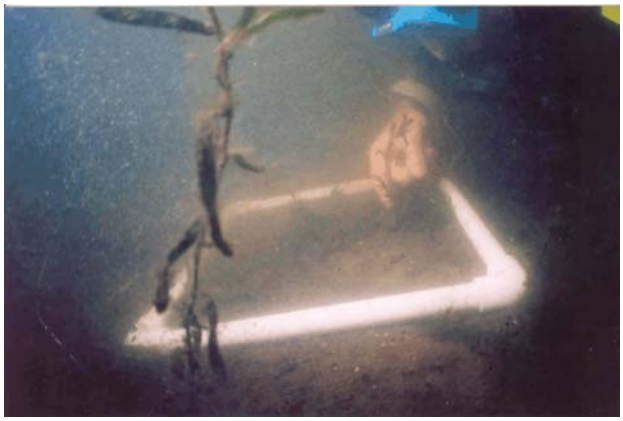


Figure A-9. Herbicides were applied on April 14, 2005.

[top, middle, bottom] Curlyleaf on April 20, 2005: Curlyleaf was present at most sites and its height was from 6 to 24 inches.

Post Herbicide Conditions



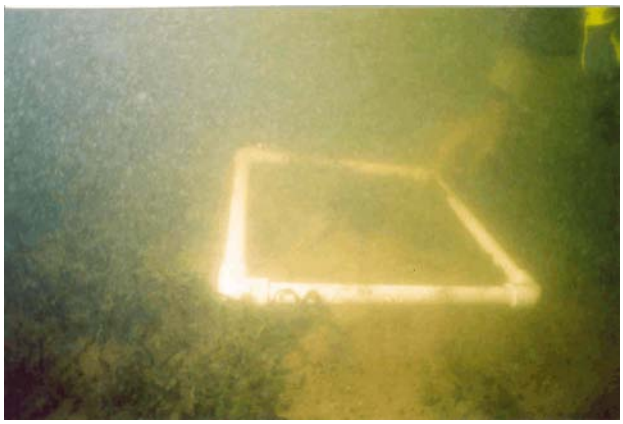
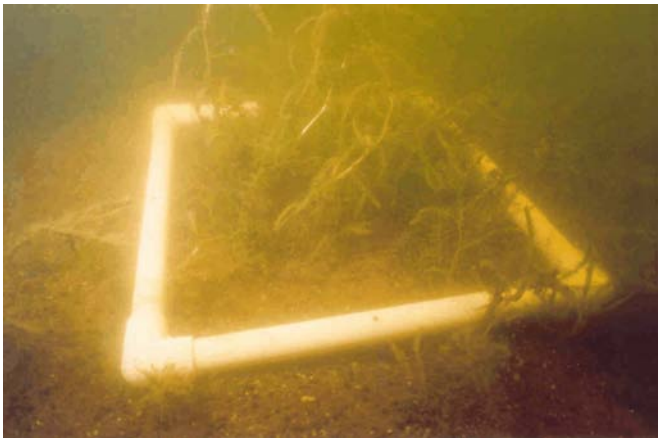


Figure A-10. Herbicides were applied on April 14, 2005.
[top, middle, bottom] Curlyleaf on May 23, 2005: Although curlyleaf was present at many sites, it was no taller than 24 inches and turions appeared to be absent.

Underwater Views for 2006

Pre-Herbicide Conditions



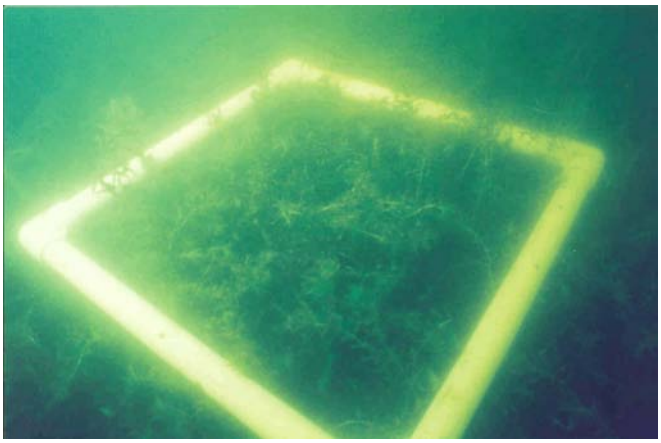


Figure A-11. Herbicides were applied on April 21, 2006. [top] Curlyleaf on April 25, 2006 at Transect 4. [bottom] Curlyleaf was found at Transect 22 on April 26, 2006. Actually, elodea was dominant.

Post Herbicide Conditions

Figure A-12. Herbicides were applied on April 21, 2006. [top] Curlyleaf was present on April 25, 2006 at Transect 22. [bottom] Curlyleaf was present, but turions were not observed.

Underwater Views for 2007

April 2007
Early Spring Conditions

June 2007
Early Summer Conditions

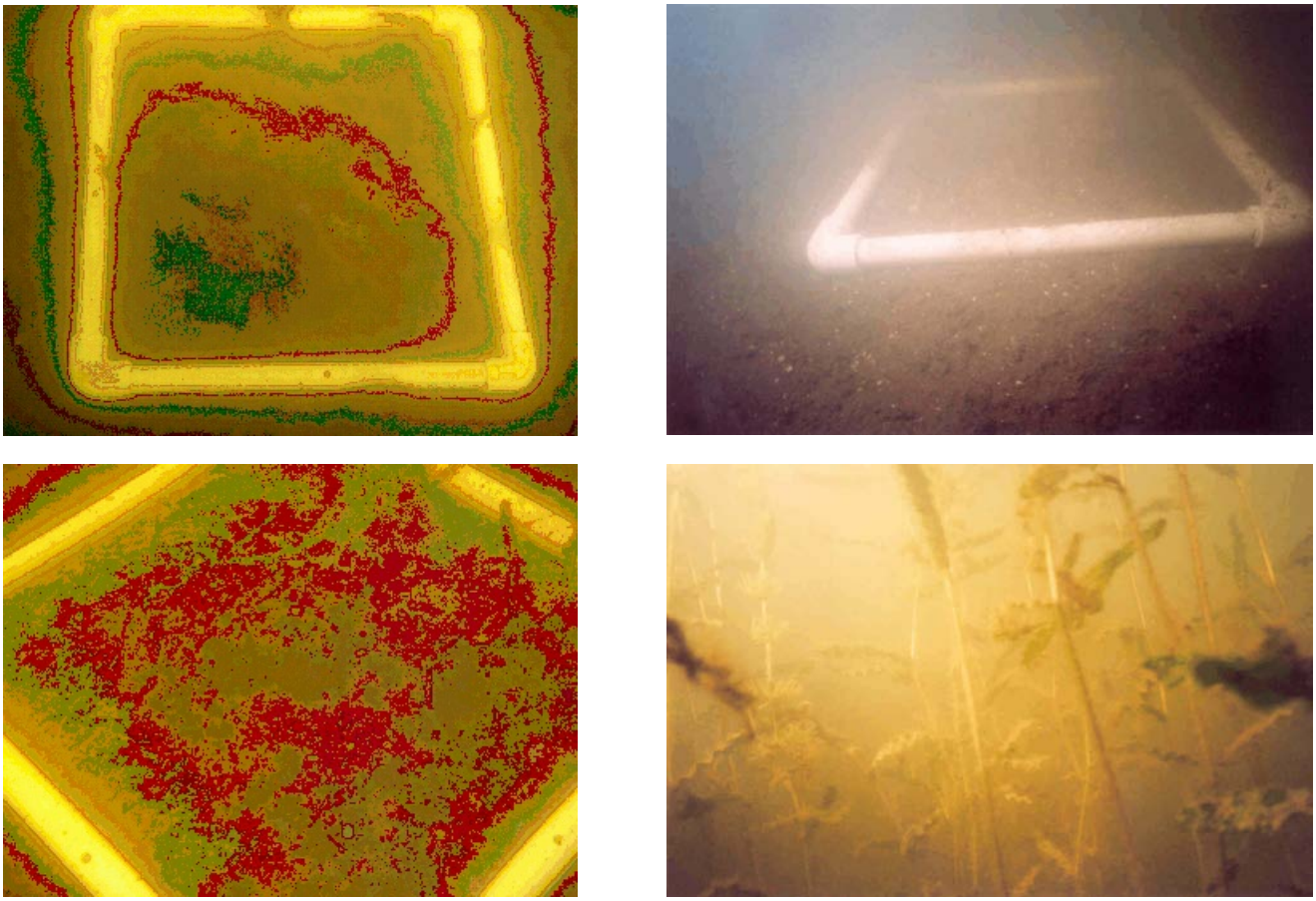


Figure A13. [left] Curlyleaf was sparse in April 2007.
[right] In June, curlyleaf had decreased in some sites and increased in other areas.

April 2008
Early Spring Conditions

June 2008
Early Summer Conditions

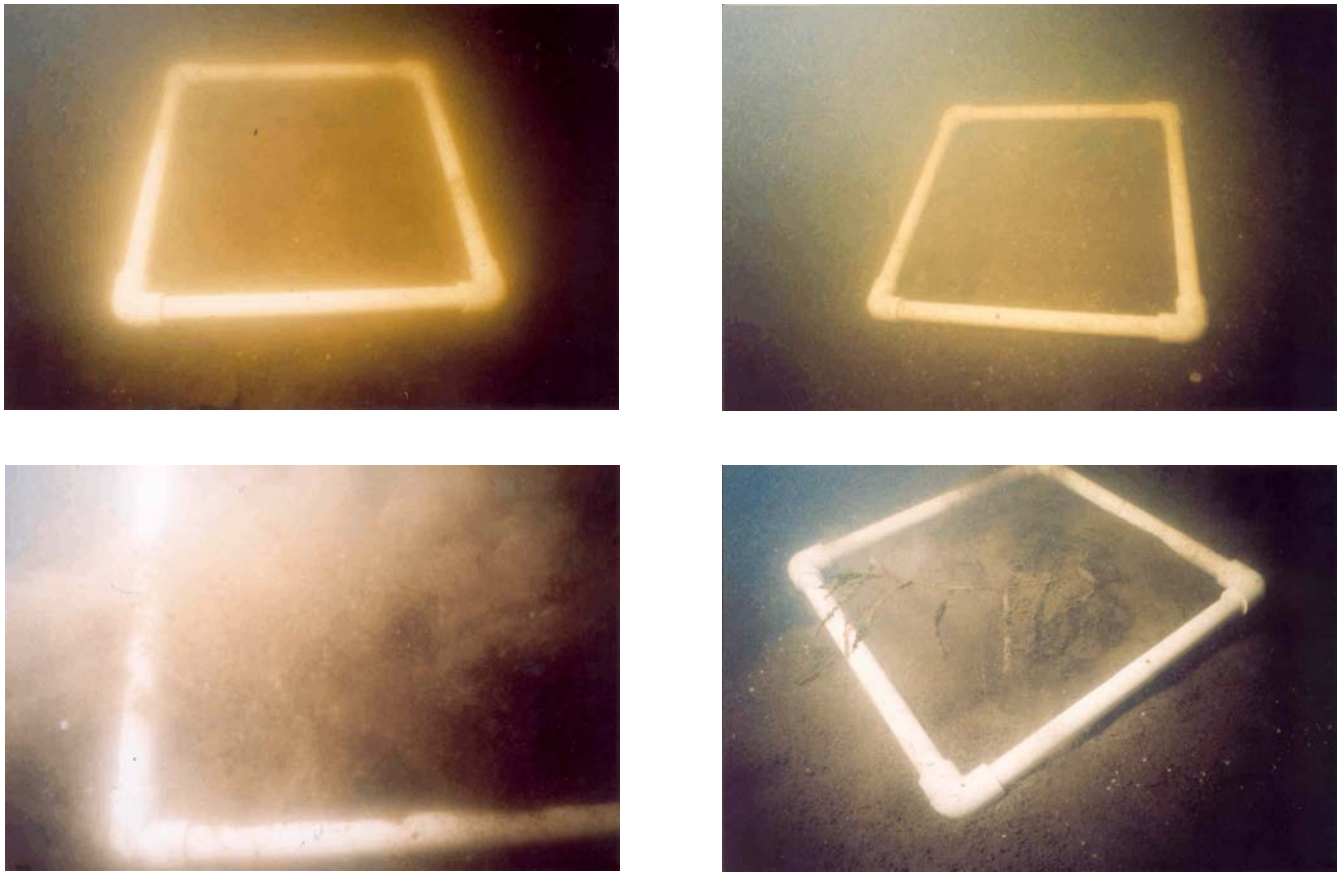


Figure A14. [left] Curlyleaf was no sampled in the quadrat in April 2008 (Transect 22). [right] In June 2008, curlyleaf was found in a few of the quadrats sampled (Transect 22).

April 2009 Aquatic Plant Conditions

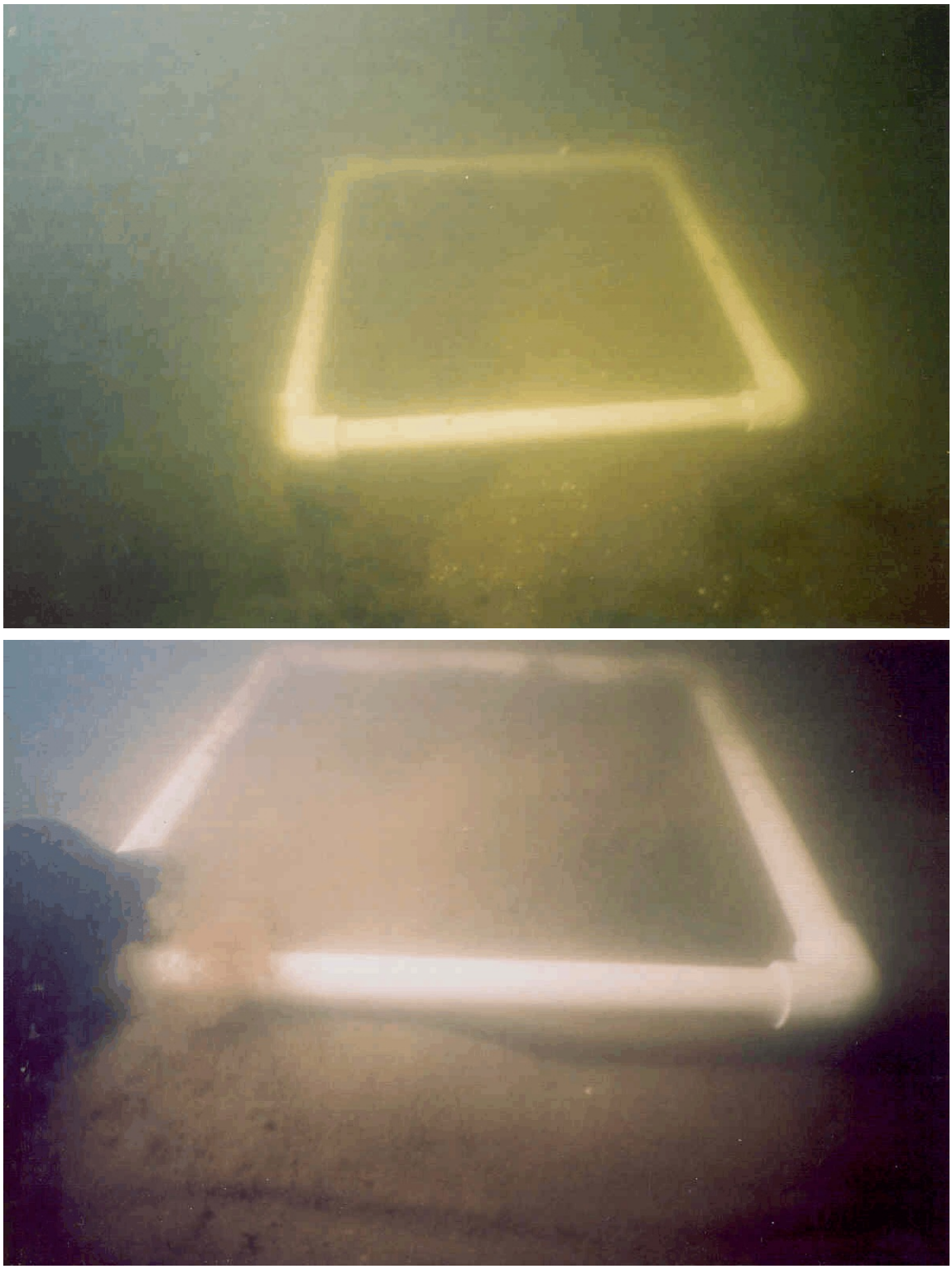


Figure A15. Aquatic plants were sparse in the April 23, 2009 survey. [top] Transect 4. [bottom] Transect 22.

June 2009 Aquatic Plant Conditions

Figure A16. (Top) Aquatic plants were scarce.
(Bottom) Curlyleaf pondweed was sampled at 14 out of 50 sites on June 10, 2009.

April 2010 Aquatic Plant Conditions

Figure A17. Curlyleaf pondweed conditions in the April 27, 2010 survey. [top] Curlyleaf stem densities were sparse at Transect 4.5. [bottom] Curlyleaf stem densities were sparse at Transect 22. Hydras, a coelenterate, shown attached to curlyleaf leaves. Hydras are in the same phylum as jellyfish.

June 2010 Aquatic Plant Conditions

Figure A18. Aquatic plant growth in Spring Lake on June 2, 2010 was spotty. Some locations had lush plant growth while other locations had little or no plant growth.