



Spring Lake on May 21, 2014

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# Aquatic Plant Surveys and Curlyleaf Pondweed Evaluation for Spring Lake, Scott County, Minnesota in 2014

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**No Open Lake Herbicide Application from 2007- 2014**

Curlyleaf Pondweed Delineation and Spring Plant Survey: May 21, 2014

Curlyleaf Pondweed Assessment and Early Summer Plant Survey: June 19, 2014

**Prepared for:**

**Prior Lake/Spring Lake  
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# Aquatic Plant Surveys and Curlyleaf Pondweed Evaluation for Spring Lake, Scott County, Minnesota in 2014

## Summary

Curlyleaf pondweed distribution and abundance were delineated on May 21, 2014 to determine if curlyleaf control was needed. Curlyleaf growth was observed at 10 out of 50 samples sites (Figure S1). Growth was relatively light and no curlyleaf treatment was conducted. A follow-up curlyleaf survey was conducted on June 19, 2014 to assess the status of curlyleaf pondweed in Spring Lake

The June curlyleaf assessment found curlyleaf distribution had expanded since the May 21 delineation but growth was still light (Figure S2). There has been no open water curlyleaf treatment in Spring Lake from 2007 through 2014.

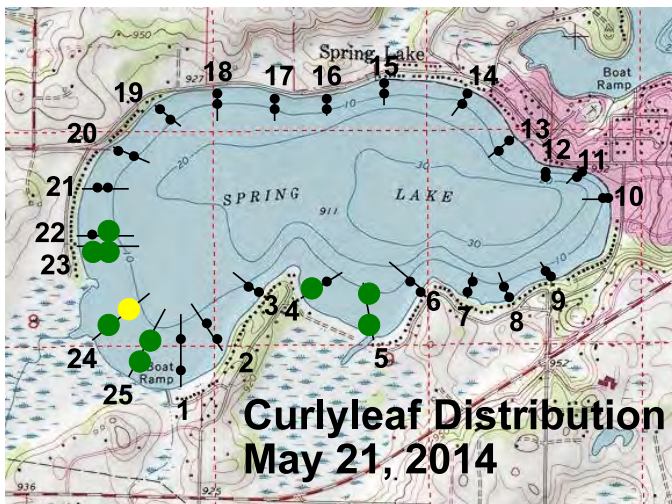


Figure S1. Map of curlyleaf pondweed for May 21 2014. Colored sample areas indicate the growth in May of 2014 for curlyleaf pondweed. Green = light growth and yellow = moderate growth.

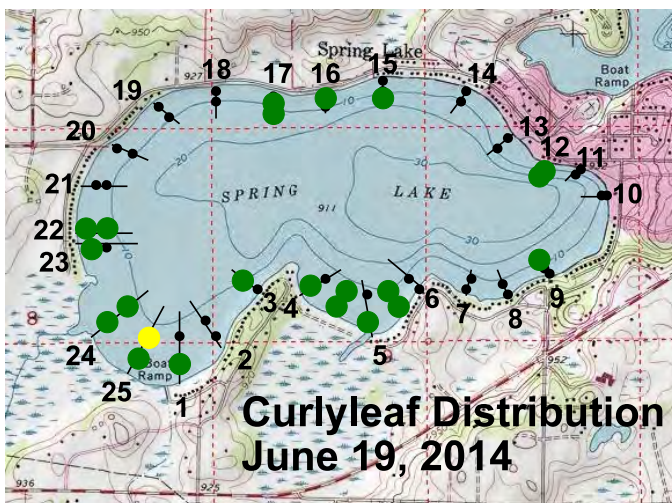


Figure S2. Map of curlyleaf pondweed sample points on 25 transects for June 19, 2014. Colored sample areas indicate the growth in late June, 2014 for curlyleaf pondweed. Green = light growth of curlyleaf pondweed and Yellow = moderate growth of curlyleaf pondweed.

**What's Next?** Treating heavy growth of curlyleaf pondweed based on early season curlyleaf distribution was conducted in Spring Lake from 2002 through 2006. However, there has been no treatment necessary due to light growth from 2007-2014. Stem density assessments have supported the treatment or no treatment decisions (Figure S3). However in 2014 there were 4 areas measuring a total of about 20 acres, that could have been treated based on the early season delineation. Determining what areas to treat to control excessive growth of curlyleaf pondweed has been an ongoing challenge. Curlyleaf growth in April and May is just starting to go into a rapid growth phase. However, not all early season curlyleaf growth will result in heavy curlyleaf growth in June. It appears there are factors that limit curlyleaf growth and significant variables are associated with sediment conditions. The question is how to best delineate areas to treat what could be heavy growth in June but not overtreating areas where growth wouldn't be a nuisance for the season. Currently, for Spring Lake, the method has been to use past treatment history combined with early season scouting and then a recheck to evaluate any treatment effects and see if curlyleaf areas were missed. Using this approach, 4 areas from the May delineation were predicted to produce heavy CLP growth in June. However, the subsequent June assessment found curlyleaf pondweed had reached moderate densities with very little heavy growth. In this case curlyleaf growth was apparently inhibited. It is possible iron dosing the incoming stream may have an impact on curlyleaf.

In 2015, curlyleaf delineation and assessment surveys are recommended. Previous sediment survey results indicate where light, moderate, and heavy curlyleaf growth are likely to occur based on sediment characteristics. These results combined with data from 2014 and then early season curlyleaf scouting in April or May will give confidence in areas to treat, if needed, in 2015. Areas to be treated with herbicides can be limited to areas of heavy growth. Areas where light growth is expected based on lake sediment characteristics could be left untreated.

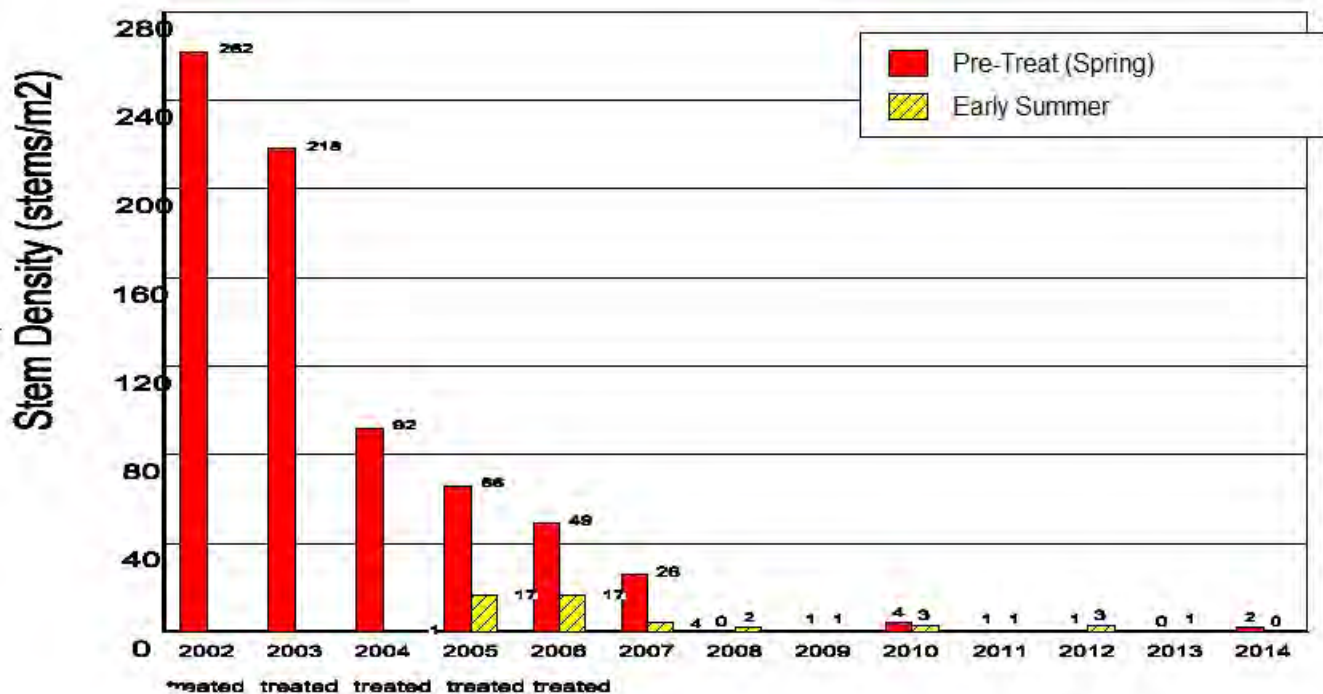


Figure S3. Curlyleaf stem densities for early season monitoring for 2002-2014 for two sites in Spring Lake. Curlyleaf stem densities have been low since 2007 and no treatment has occurred.

# Aquatic Plant Surveys and Curlyleaf Pondweed Evaluation for Spring Lake, Scott County, Minnesota in 2014

## Introduction and Methods

Spring Lake has an area of 592 acres with a littoral area of 290 acres (source: MnDNR). An initial curlyleaf pondweed delineation was conducted on May 21, 2014. A follow-up curlyleaf pondweed assessment was conducted on June 19, 2014 to characterize the status of curlyleaf pondweed at it's peak growing period. Fifty sample locations on 25 transects are shown in Figure 1 and were selected based on areas where curlyleaf had been found in the past. A chart showing examples of curlyleaf growth conditions are shown on the next page.

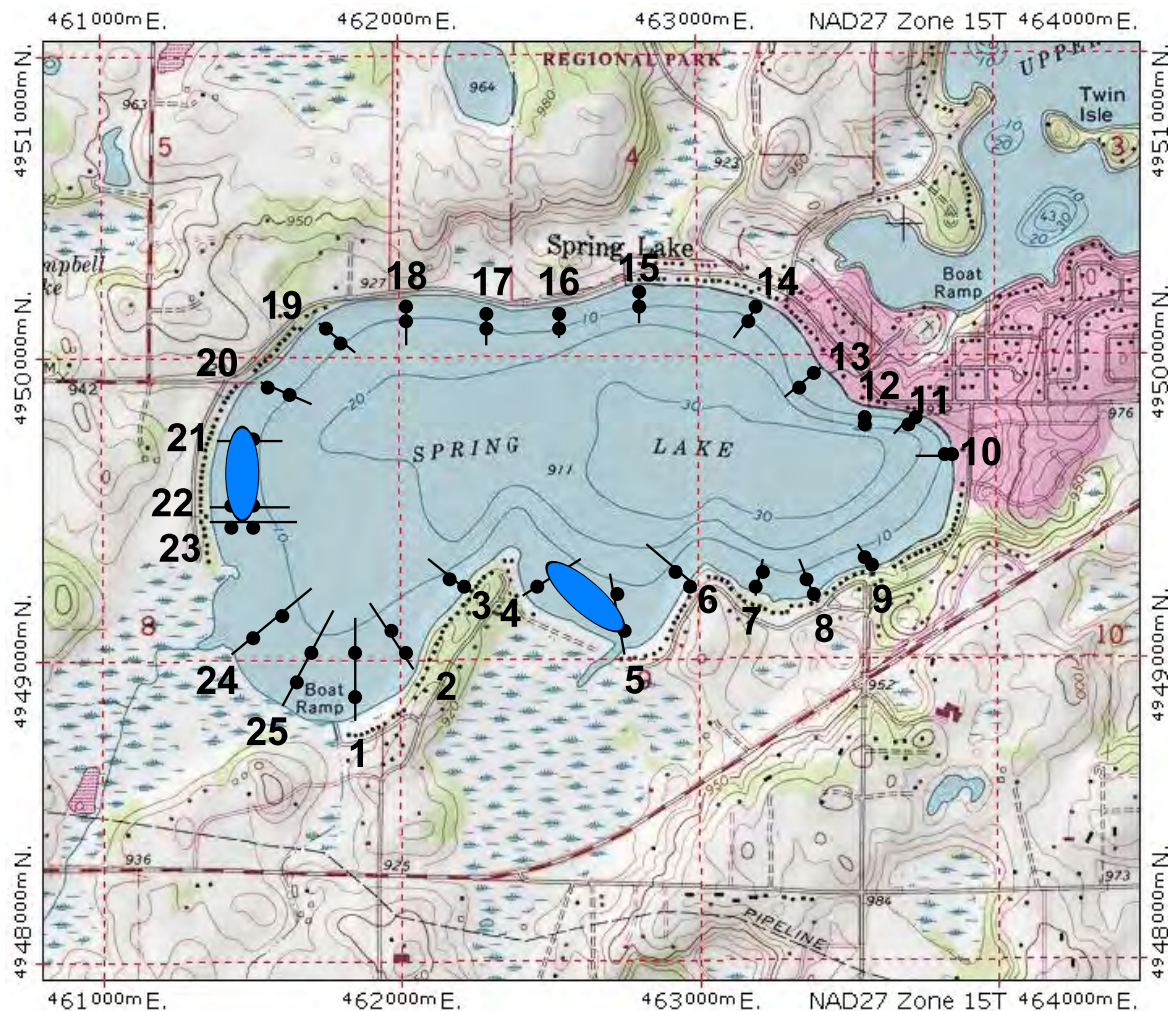


Figure 1. Transect and sample sites for whole lake plant surveys are shown with black numbers. There are 50 aquatic plant sample sites. There are two underwater evaluation sites located in the dark blue shaded areas. Map of treatment areas form 2002-2006 (5 years) are shown in dark blue shading.

**Methods:** Curlyleaf pondweed densities are represented on a scale of 1 to 5 with 5 being densest.

### Light Growth Conditions

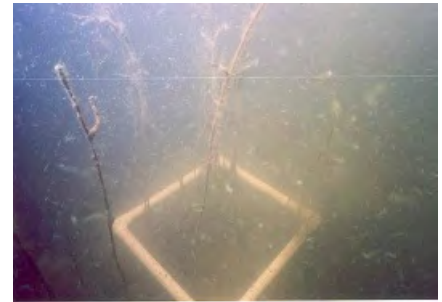
Plants rarely reach the surface.

Navigation and recreational activities are not generally hindered.

Stem density: 0 - 160 stems/m<sup>2</sup>

Biomass: 0 - 50 g-dry wt/m<sup>2</sup>

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<sup>2</sup>

Biomass: 50 - 85 g-dry wt/m<sup>2</sup>

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<sup>2</sup>

Biomass: >300 g-dry wt/m<sup>2</sup>

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.*

# Curlyleaf Pondweed Delineation and Spring Aquatic Plant Survey on May 21, 2014 in Spring Lake

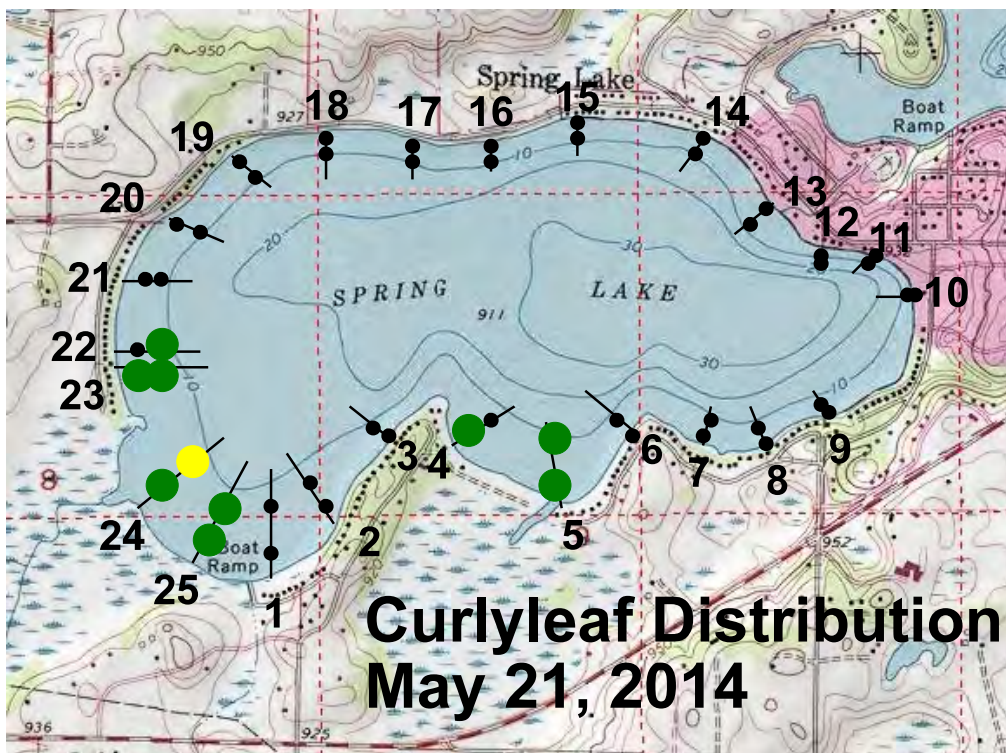
A curlyleaf delineation using an aquatic plant transect survey was conducted on May 21, 2014 and curlyleaf was found at low densities at 10 out of 50 sites (Table 1 and Figure 2). Curlyleaf pondweed treatments were proposed for 4 curlyleaf control areas in 2014, however no treatment occurred in 2014. A total of four submerged plant species were observed.

**Table 1. Aquatic plant densities based on rake sampling for May 21, 2014. Densities are based on a scale from 1 to 5 with 5 being the densest. Curlyleaf stems per rake sample were also noted. Gray shading indicates additional sites that were sampled. Those points are shown in Figure 3.**

Delineation Point	Transect	Depth (ft)	Coontail	Curlyleaf pondweed Density	Curlyleaf pondweed Stems	Elodea	Stringy pondweed	No Plants
	1	4						1
	1	6			0			1
	2	4						1
	2	6	1					
	3	4						1
	3	7						1
	4	5		2	0, 5			
	4	6	1		0			
1		4		2	4, 10			
2		5		1	3, 3			
3		6			0			1
4		4			0, 0, 0, 0, 0			1
5		4			0, 0, 0, 0, 0			1
5		6			0, 0, 0, 0, 0			1
5		6			0, 0, 0, 0, 0			1
	5	4			0			1
6, 7	5	5		2, 2	5, 6			
8		6		3	3, 8			
9		6		3	4, 14			
	6	4			0			1
	6	7			0			1
	7	4			0			1
	7	7			0, 0			1
	8	4			0			1
	8	6			0			1
	9	4			0			1
	9	7			0			1
	10	4			0			1
	10	8			0			1
	11	4			0			1
	11	7			0			1
	12	4			0			1
	12	7			0			1
	13	4			0			1
	13	6			0			1
10		5			0			1
	14	4			0			1
	14	7			0			1
	15	4			0			1
	15	7			0			1
	16	4			0			1
	16	6			0			1
	17	4			0			1
	17	7			0			1
	18	4			0			1
	18	6			0			1
	19	4			0			1
	19	7			0			1
	20	4			0			1

**Table 1. Aquatic plant densities based on rake sampling for May 21, 2014. Densities are based on a scale from 1 to 5 with 5 being the densest. Curlyleaf stems per rake sample were also noted. Gray shading indicates additional sites that were sampled. Those points are shown in Figure 3.**

Delineation Point	Transect	Depth (ft)	Coontail	Curlyleaf pondweed Density	Curlyleaf pondweed Stems	Elodea	Stringy pondweed	No Plants
	20	7			0			1
	21	4			0			1
11	21	7			0			1
	22	4			0, 0, 0, 0, 0, 0, 0, 0, 0, 0			1
12	22	6		1	0, 0, 0, 0, 0, 0, 0, 0, 0, 2			
13	23	5		2	0, 0, 0, 2, 4			
14	23	7		1	0, 0, 0, 1			
15		6	1	1	0, 3			
16		5		2	4, 5			
17	24	5	1	2	0, 5	1		
18	24	6		3	6, 10			
19		5	1	2	5			
20				2	3, 4			
	25	4		1	0, 1			
	25	5		1	3			
21		5	1		0, 0	1	1	
<b>Average occurrence (50 sites)</b>			1	1.8		1	1	1
<b>% occurrence</b>			6	17		2	1	45
<b>% occurrence</b>			12	34		4	2	90



**Figure 2. Map of curlyleaf pondweed for May 21 2014. Colored sample areas indicate the growth in May of 2014 for curlyleaf pondweed. Green = light growth and yellow = moderate growth.**

## Curlyleaf Delineation in Spring Lake, May 21, 2014

A full aquatic plant survey using transects was combined with additional sampling to delineate areas of potential heavy growth of curlyleaf in June. The delineation points were shown in Table 1. Based on the curlyleaf plant survey and extra sampling sites 4 areas of potential heavy curlyleaf growth were delineated and are shown in Figure 3. The criteria used to predict heavy curlyleaf growth in June was a rake sample with four or more curlyleaf stems sampled in May.



**Figure 3. Curlyleaf delineation in Spring Lake on May 21, 2014. Curlyleaf was growing and 4 areas had potential heavy growth that was delineated. Green dots = light curlyleaf growth, yellow dots = moderate growth, and red dots = heavy growth. Black dots = no curlyleaf.**



## Curlyleaf Pondweed Assessment on June 19, 2014 in Spring Lake

No treatment of curlyleaf occurred in 2014. Curlyleaf growth was rechecked on June 19, 2014, which was the peak growing period for curlyleaf in lakes in the area. A total of 50 sites were monitored with rake sampling on June 19, 2014. Curlyleaf was found at 18 sample sites out of the 50 that were monitored (Table 2). Curlyleaf distribution increased from May, but curlyleaf growth was mostly light (Figure 4). Curlyleaf abundance did not increase significantly from May to June.

Curlyleaf pondweed was the most abundant plant in the June assessment.

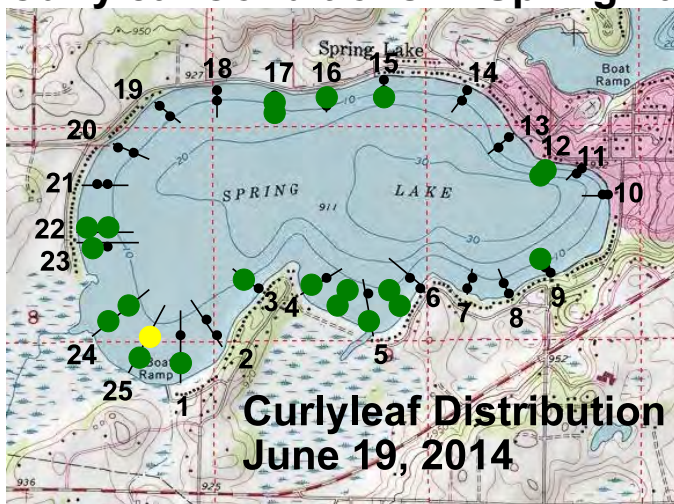
**Table 2. Aquatic plant densities based on rake sampling for June 19, 2014. Densities are based on a scale from 1 to 4 with 3 being the densest. Curlyleaf stems per rake sample were also noted. Areas with green shading are predicted to have light to moderate growth at the peak of the curlyleaf growth cycle.**

Site	Depth (ft)	Coontail	Curlyleaf	CLP - stems	Sago	Stringy	Water celery	No Plants
T 1	6		1	2				
T 1	7	1						
T 2	6					2, 1		
T 2	9							1
T 3	6					1	1	
T 3	9		1, 0	1, 0				
T 4	6		1	4		1		
T 4	9	1				1		
T 4.5	5	2	2	10	12	14		
T 4.5	6					2		
T 5	6					2		
T 5	6		3, 0	20, 0				
T 5	8	1						
T 5.5	5		2, 3	12, 20		1		
T 5.5	5		3	20				
T 6	6					2		
T 6	8					1		
T 7	6					2		
T 7	8							1
T 8	6							1
T 8	8							1
T 9	6					1		
T 9	8		1	2		1		
T10	6					1		
T10	7							1
T11	6					1		
T11	8							1
T12	5		2	10				
T12	6		2	6		1		
T13	5					1		
T13	7					1		
T14	6							1
T14	7							1
T15	6							1
T15	7		1	1				
T16	6		1	1		1		
T16	9							1
T17	6		1	2		1		
T17	10		1	1				
T18	5							1

**Table 2. Aquatic plant densities based on rake sampling for June 19, 2014. Densities are based on a scale from 1 to 4 with 3 being the densest. Curlyleaf stems per rake sample were also noted. Areas with green shading are predicted to have light to moderate growth at the peak of the curlyleaf growth cycle.**

Site	Depth (ft)	Coontail	Curlyleaf	CLP - stems	Sago	Stringy	Water celery	No Plants
T18	9					1		
T19	6							1
T19	8							1
T20	5					1	1	
T20	7						1	1
T21	4				1			1
T21	7					1		
T22	5	1	1	1	2	4	3	
T22	8		1	2			6	
T23	6		1	1		1		
T23	8							1
T24	6	3	1	4				
T24	7	1	1	4				
T25	6	2	1	4				
T25	7		4, 1	30, 2				
<b>Average</b>		<b>1.4</b>	<b>1.6</b>	<b>7.0</b>	<b>4.0</b>	<b>1.7</b>	<b>2.4</b>	<b>1.0</b>
<b>occurrence (50 sites)</b>		<b>9</b>	<b>18</b>	<b>31</b>	<b>4</b>	<b>29</b>	<b>5</b>	<b>35</b>
<b>% occur</b>		<b>18</b>	<b>36</b>	<b>62</b>	<b>8</b>	<b>58</b>	<b>10</b>	<b>70</b>

### Curlyleaf Conditions in Spring Lake, June 19, 2014



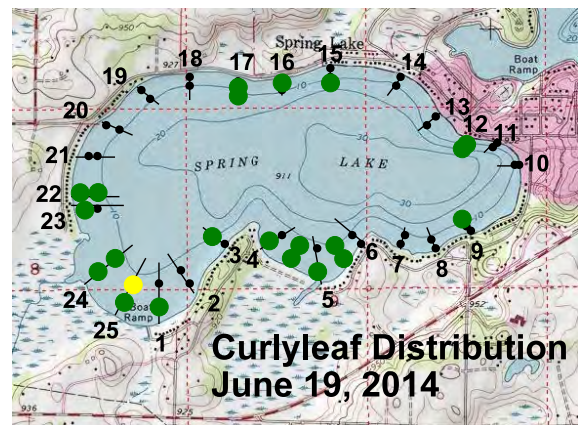
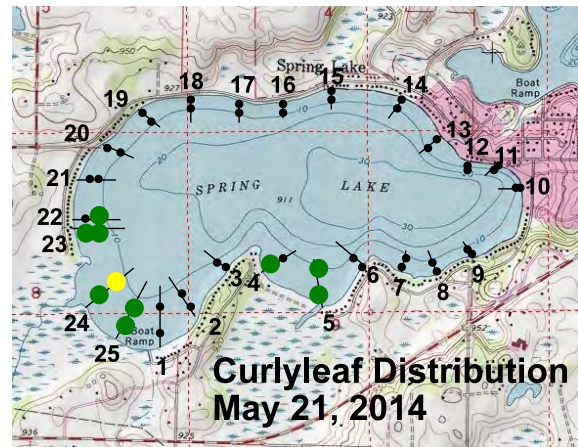
**Figure 4. Map of curlyleaf distribution in Spring Lake on June 19, 2014. Green circles = curlyleaf density of a "1" or "2" and Yellow circles = curlyleaf density of a "3".**

# Comparison of Early Season to Late Season Curlyleaf Growth

Light growth of curlyleaf pondweed was found in the May 21, 2014 delineation (Table 3). There were no open water herbicide treatments in 2014. A curlyleaf assessment on June 19, 2014 found curlyleaf to be growing at mostly light densities (Table 3 and Figure 5). Curlyleaf pondweed did not significantly increase in abundance from May to June although it was predicted to. Some factors may have limited curlyleaf growth in Spring Lake in 2014.

**Table 3. Comparison of curlyleaf pondweed stem densities based on rake sampling for May 21 and June 19, 2014. Densities are based on a scale from 1 to 5 with 5 being the densest.**

site	depth (ft)	May 21	June 19
T1	S		1 (2)
	D		
T2	S		
	D		
T3	S		
	D		1 (1)
T4	S	2 (5)	1 (4)
	D		
T5	S	2 (6)	2 (10)
	D	2 (6)	
T6	S		
	D		
T7	S		
	D		
T8	S		
	D		
T9	S		
	D		1 (2)
T10	S		
	D		
T11	S		
	D		
T12	S		2 (10)
	D		1 (6)
T13	S		
	D		
T14	S		
	D		
T15	S		
	D		1 (1)
T16	S		1 (1)
	D		
T17	S		1 (2)
	D		1 (1)
T18	S		
	D		
T19	S		
	D		
T20	S		
	D		
T21	S		
	D		
T22	S		1 (1)
	D	1 (2)	1 (2)
T23	S	2 (5)	1 (1)
	D	1 (4)	
T24	S	2 (4)	1 (4)
	D	3 (10)	1 (4)
T25	S	1 (1)	1 (4)
	D	1 (3)	3 (16)



**Figure 5. Maps of curlyleaf pondweed distribution are shown on the top (early season - May) and bottom (late season - June) maps.**

## Curlyleaf Stem Densities Collected by Scuba Diving at Two Treatment Locations on May 21 and June 19, 2014

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 2014 show curlyleaf was sparse and was found at low stem densities for spring and early summer (Table 4). These stem densities were similar to densities found from 2008 through 2014 and are low compared to pre-treatment stem densities from 2002 where there were over 250 stems/m<sup>2</sup> (Figure 7).

**Table 4. Curlyleaf pondweed stem densities (stems/m<sup>2</sup>) for 2014.**

Quadrat	May 21, 2014 (stems/m <sup>2</sup> )				June 19, 2014 (stems/m <sup>2</sup> )			
	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	0	0	0	0	0	0	0	0
2	0	0	0	0	0	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	20	0	0	0	0
<b>AVE</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>



**Figure 6. A couple of helpers from the Prior Lake/Spring Lake Watershed District for the June plant survey on Spring Lake.**

**Curlyleaf Plant Density Based on Scuba Diving from 2002 - 2014:** Rake sampling was used to collect 10 samples of curlyleaf stem densities at 4 feet and 5 feet for 10 sites at each depth at two locations in early and late season dates. Data from the two sites (n=40) for each date are shown in Figure 7. Curlyleaf stem densities have been very low since 2007.

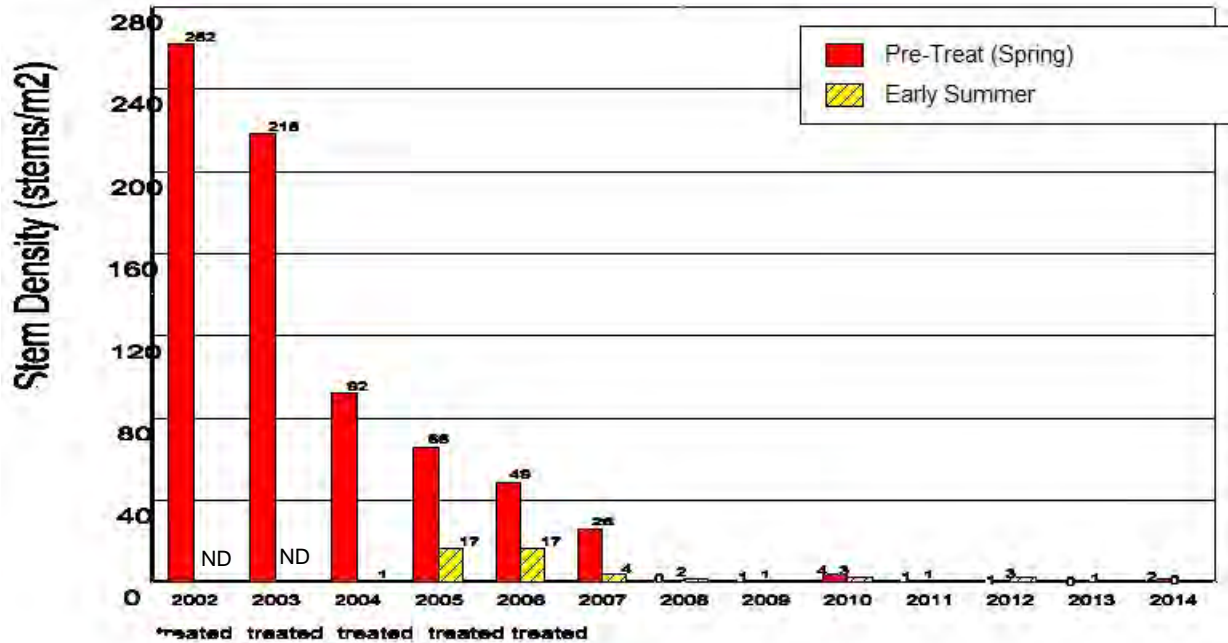


Figure 7. Curlyleaf stem densities (stems/m<sup>2</sup>) for early season and late season monitoring (using scuba diving) for 2002-2014 (ND = no data).



Figure 8. Curlyleaf pondweed conditions in May (left) and June (right). Curlyleaf was patchy in Spring Lake in 2014. Numerous curlyleaf stem densities shown in the photo on the right was rare.

# Review of Spring Lake Aquatic Plants Over the Years

**Summary of Whole Lake Curlyleaf Pondweed Surveys for 2007-2014:** Curlyleaf pondweed was found at 10 locations out of the 50 that were monitored on May 21, 2014 in the course of an aquatic plant survey that sampled two depths on 25 line transects. Curlyleaf growth was sparse in 2014 and has been sparse since 2007. From 2007 through 2014 there have been no open water herbicide applications (Table 5). (Transect and sample locations are shown in Figure 1.)

**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 from 2007-2014. The density rating is on a scale from 0.5 to 5 with 5 being the highest density. For 2010 through 2014, the numbers in parentheses indicate the number of CLP stems found in the rakehead sampler.**

Transect		2007		2008		2009		2010		2011		2012		2013		2014	
		Curlyleaf Plant Density		Curlyleaf Plant Density		Curlyleaf Plant Density		Curlyleaf Plant Density		Curlyleaf Plant Density		Curlyleaf Plant Density		Curlyleaf Plant Density		Curlyleaf Plant Density	
		Apr 15	Jun 5	Apr 29	Jun 13	Apr 23	Jun 10	Apr 27	Jun 20	May 12	Jun 10	Apr 17	Jun 5	May 29	Jun 24	May 21	Jun 19
1	S		2			0.5	2							1 (1)	1		1 (2)
	D			0.7	1	1					0.5 (1)						
2	S									0.5 (1)							
	D		1.8		1							0.5 (1)					
3	S								1 (3)								
	D		1.5					0.5 (1)									1 (1)
4	S			0.5			1					0.5 (1)				2 (5)	1 (4)
	D		1		0.5							0.5 (1)			1 (3)		
5	S		0.7				0.5	1 (1)	1 (3)			2.5 (9)				2 (6)	2 (10)
	D							1 (1)	1.3 (3)			0.3 (1)	1 (3)		3 (12, 14, 16)	2 (6)	
6	S				1							1 (1)					
	D	1						0.5 (1)					0.5 (3)				
7	S	1	1		1					0.5 (1)							
	D	0.5	0.5										0.5 (2)				
8	S							0.5 (1)		0.5 (1)			1 (2)				
	D						0.5			1 (2)							
9	S		1					1 (1)	0.5 (2)			2 (8)	1 (1)				
	D	0.5	1.8				0.5		0.5 (1)						1 (1)		1 (2)
10	S		0.5									1 (2)	1 (1)				
	D		1												1 (1)		
11	S																
	D																
12	S		1				1	1 (1)									2 (10)
	D		1		0.3												1 (6)
13	S												1 (3)				
	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)						1 (1)
16	S		1					1 (1.5)	1 (1)			0.8 (2)			1 (2)		1 (1)
	D	0.5	1.8					1 (1)	1 (2)			0.5 (2)		0.5 (1)			
17	S	0.5						1 (4)				0.5 (1)					1 (2)
	D	0.3	2	0.3			0.3	1 (3)	1 (2)								1 (1)
18	S	0.5			1			1 (3)									
	D	0.5	1	0.3				1 (4)		0.5 (1)	0.5 (1)	0.3 (3)	0.5 (1)				
19	S		1					1 (2)	1 (1)								
	D								1 (3)			0.5 (1)			1 (2)		
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										1 (1)				
22	S	1	1		1			1 (1)									1 (1)
	D	1						0.3 (0.5)								1 (2)	1 (2)
23	S	1					1		1 (4)	0.5 (1)						2 (5)	1 (1)
	D	0.5	1		0.5										1 (2)	1 (4)	
24	S	1			1	1	2		1 (2)						2 (4)	1 (4)	
	D	0.5			1			1 (1.5)	1 (2)					1	1 (2)	3 (10)	1 (4)
25	S	1	0.5		1	1	1		2 (6)	0.5 (1)	1 (3)				2 (10)	1 (1)	1 (4)
	D				1			1 (3)			0.8 (2)			1	3 (20)	1 (3)	3 (16)
<b>Sites Where Curlyleaf Was Found</b>		<b>22</b>	<b>29</b>	<b>4</b>	<b>19</b>	<b>5</b>	<b>14</b>	<b>25</b>	<b>21</b>	<b>10</b>	<b>18</b>	<b>6</b>	<b>8</b>	<b>3</b>	<b>12</b>	<b>10</b>	<b>18</b>

# Summary of Curlyleaf Pondweed Distribution and Abundance from 2000 - 2014

Transect	Depth	2000	2002	2003	2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		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	Apr 17	Jun 5	May 29	Jun 24	May 21	June 19			
1	S	5	0.5	0	0	0	0	0	0	0	0	2	0	0	0.5	2	0	0	0	0	0	0	0	1	1		1	0.5	
	M	4	2	2	1	0	1	1	0.5	0	0	0	0	0.7	1	1	0	0	0	0.5	0	0	0					0.7	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	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	0.5	0					0.8	Moderate	
3	S	2	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0.5	1	0	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	0				1	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	0			2	1	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	0	0		1			0.9		
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	0			2	2	0.9		
	M	5	3	2	2.5	0	0.5	0	2	1	0	0	0	0	0	0	1	1.3	0	0.3	0	1		3	2	1.1	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	0				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	0.5	0				0.5	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	0				0.3			
	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	0.5				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	1				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	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	1		1		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	1	0			1	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	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	0		1		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	0				0.0			
	M	3	0	0	0.5	0	0	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	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	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	1	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	0				0.8	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	0				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	0	0				1.2	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	0	0				0.9			
	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	0	0			1	1.1	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	0		1	1	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	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	0			1	0.6	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	0	0			1	0.9			
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	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	0.3	0.5				1.0	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	0				0.7			
	M	5	1.5	2	0.5	0	0.3	0.3	0	0	0	0	0	0	0	0	0	1	0	0	0.5	0		1		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	0				0.8	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	0	0		1		0.9			
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	0				0.6	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	0	1				1.1			
22	S	3	0.5	0	0	0	0	0	0.5	2	1	1	0	1	0	0	1	0	0	0	0	0			1	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	0			1	1	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	0			2	1	0.5		
	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	0	0		1	1	0.9	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	0			2	1	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	0	0		1	1	3	1	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	0	0		2	1	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	0	0		1	3	1	1.1	Moderate	
Number of Reds		23	2	4	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	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	0.6	1.0	1.0	1.6	1.7	1.2		

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 - 2014. 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. Purple shading in transect column indicates transect areas that were harvested or treated with herbicides from 2002-2006 (blue shading for years of treatment). There has been no treatment from 2007-2014. Purple shading in Transect column indicates transect areas that were harvested or treated with herbicides from 2002-2006 (blue shading for years of treatment). There has been no treatment from 2007-2014.**

**Curlyleaf Pondweed Treatment and Coverage from 2002 - 2014:** 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 2014, 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 2014, curlyleaf covered about 50 to 90 acres and no heavy growth was observed (Figure 12).

**Table 6. Curlyleaf treatment history for 2002 through 2014.**

	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)
2012	no treatment	no treatment	herbicides (individual permits)
2013	no treatment	no treatment	herbicides (individual permits)
2014	no treatment	no treatment	herbicides (individual permits)

**Recommendations for 2015:** Based on the findings for the last few 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 10.** Curlyleaf pondweed growth was very heavy in 2000.



**Figure 11.** Curlyleaf pondweed growth was thin in 2014 at the same location as shown in Figure 10.



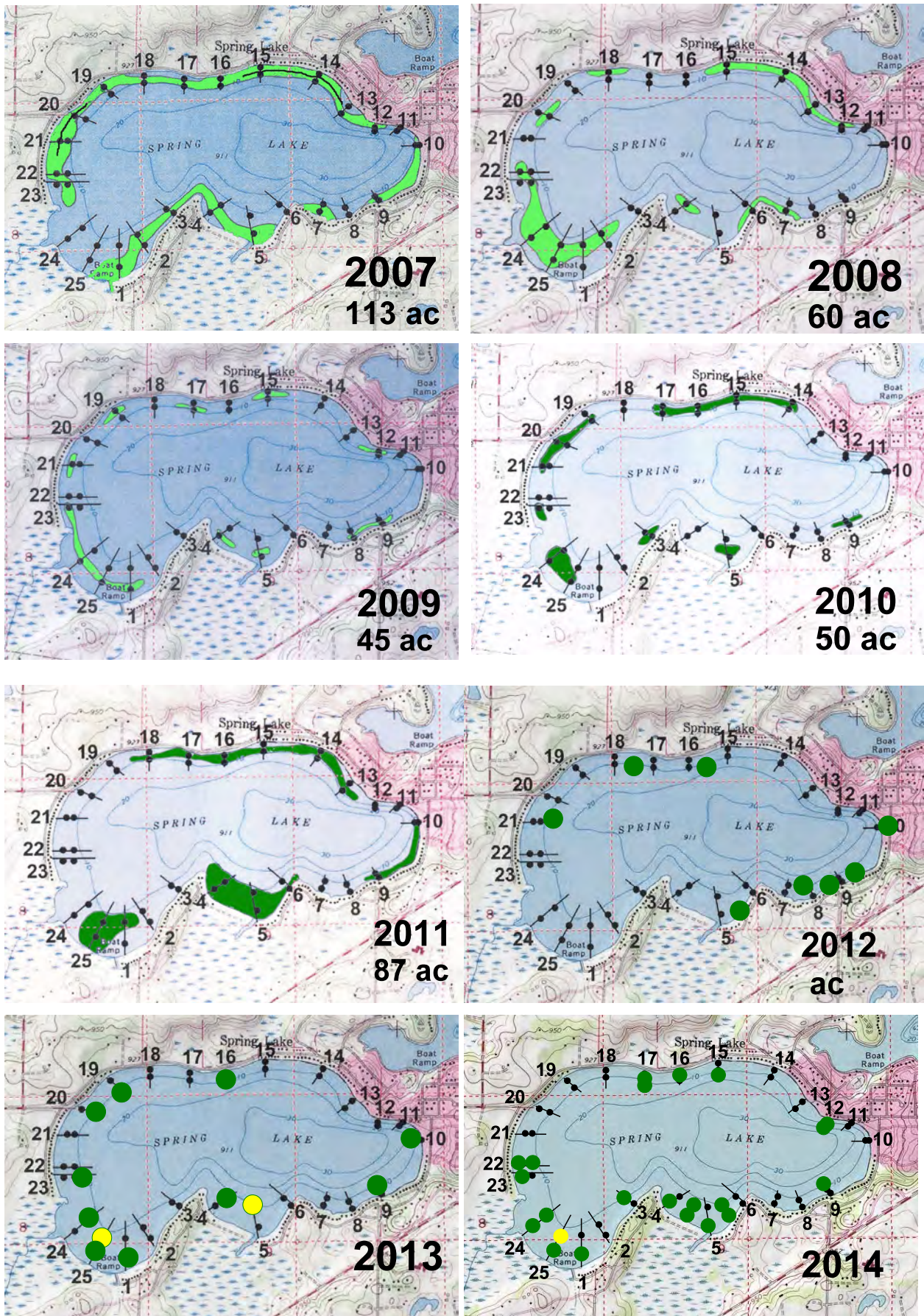


Figure 12. Curlyleaf pondweed distribution during the peak growing season from 2007 through 2014.

## Summary of All Species in Aquatic Plant Surveys from 1948 - 2014

Since 1948, a number of plant species within the aquatic plant community have appeared and others have disappeared (Table 7). The percent occurrence of the native plants elodea and water stargrass have decreased since 2000. Curlyleaf distribution and curlyleaf density are lower in 2014 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 but stringy pondweed, a native plant, may be increasing which is an encouraging sign that native plants are starting to increase.



Figure 13. Aquatic plants in Spring Lake on June 19, 2014.

**Table 7. List of aquatic plants found in past surveys. Surveys from 1948 to 1988 were conducted by MnDNR. Surveys in 2000 and 2002 through 2014 were conducted by Blue Water Science. Numbers for plant species in 2000 and 2002 through 2014 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 ( <i>Lemna minor</i> )				X	R
Duckweed ( <i>Lemna sp</i> )			O		
White waterlilies ( <i>Nymphaea tuberosa</i> )					
Greater duckweed ( <i>Spirodela polyrhiza</i> )				X	
Coontail ( <i>Ceratophyllum demersum</i> )	R	O	A	X	O
Chara ( <i>Chara sp</i> )					
Elodea ( <i>Elodea canadensis</i> )			O		O
Moss ( <i>Drepanocladus sp</i> )					
Naiads ( <i>Najas flexilis</i> )					
Berchtold's pondweed ( <i>Potamogeton berchtoldi</i> )	R	O			
Curlyleaf pondweed ( <i>P. crispus</i> )			R	X	
Variable pondweed ( <i>P. gramineus</i> )	R	C	O		
Floatingleaf ( <i>P. natans</i> )	R	C			P
Stringy pondweed ( <i>P. pusillus</i> )					
Claspingleaf ( <i>P. Richardsonii</i> )	R	C			O
Stringy pondweed ( <i>P. strictifolius</i> )					
Narrowleaf pondweed ( <i>P. sp</i> )			O	X	
Sago* ( <i>Stuckenia pectinata</i> )	R	C			C
Star duckweed ( <i>Lemna trisulca</i> )		C			
Wild celery ( <i>Vallisneria americana</i> )			O		P
Mud plantain* ( <i>Zosterella dubia</i> )	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 7. Concluded.

Year	2000		2002		2003	2004			2005			2006			2007			2008			2009			2010		2011		2012		2013		2014	
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	4.17	6.5	5.29	6.24	5.21	6.19
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					15.5	
Lesser duckweed ( <i>Lemna minor</i> )																2																	
Duckweed ( <i>Lemna sp</i> )											6																						
White waterlilies ( <i>Nymphaea tuberosa</i> )																																	
Greater duckweed ( <i>Spirodela polyrhiza</i> )								2																									
Coontail ( <i>Ceratophyllum demersum</i> )		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	4	30	3	6		16
Chara ( <i>Chara sp</i> )		4		2			4									2				8		2		12									
Elodea ( <i>Elodea canadensis</i> )		25	8	18	6	25	48	68	22	54	76	64	68	48	20	6	2			4			4	2	2	2	4	2			2		
Moss ( <i>Drepanocladus sp</i> )																		1															
Naiads ( <i>Najas flexilis</i> )																							6										
Berchtold's pondweed ( <i>Potamogeton berchtoldi</i> )																																	
Curlyleaf pondweed ( <i>P. crispus</i> )	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	14	16	5	23	20	36
Variable pondweed ( <i>P. gramineus</i> )																																	
Floatingleaf ( <i>P. natans</i> )																																	
Stringy pondweed ( <i>P. pusillus</i> )		2	6	8	2		4		6	8			20			26																	
Claspingleaf ( <i>P. Richardsonii</i> )				10			6		2	4		2	4		2	2		2	2		2	6		4		2			2				
Stringy pondweed ( <i>P. strictifolius</i> )														2	2		2			24		14	66	52	34		64	36	92	5	16		48
Narrowleaf pondweed ( <i>P. sp</i> )																					2												
Sago* ( <i>Stuckenia pectinata</i> )	40	15		36	2		24	6		6	14			6		8	2	1	24	8		24	20		26						16		6
Star duckweed ( <i>Lemna trisulca</i> )																																	
Wild celery ( <i>Vallisneria americana</i> )		6		16			2	22		2	32		2	18		6	12			18		2	18		4		2		6				10
Mud plantain* ( <i>Zosterella dubia</i> )		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	4	4	4	5	1	5

\* *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 14.

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 14).

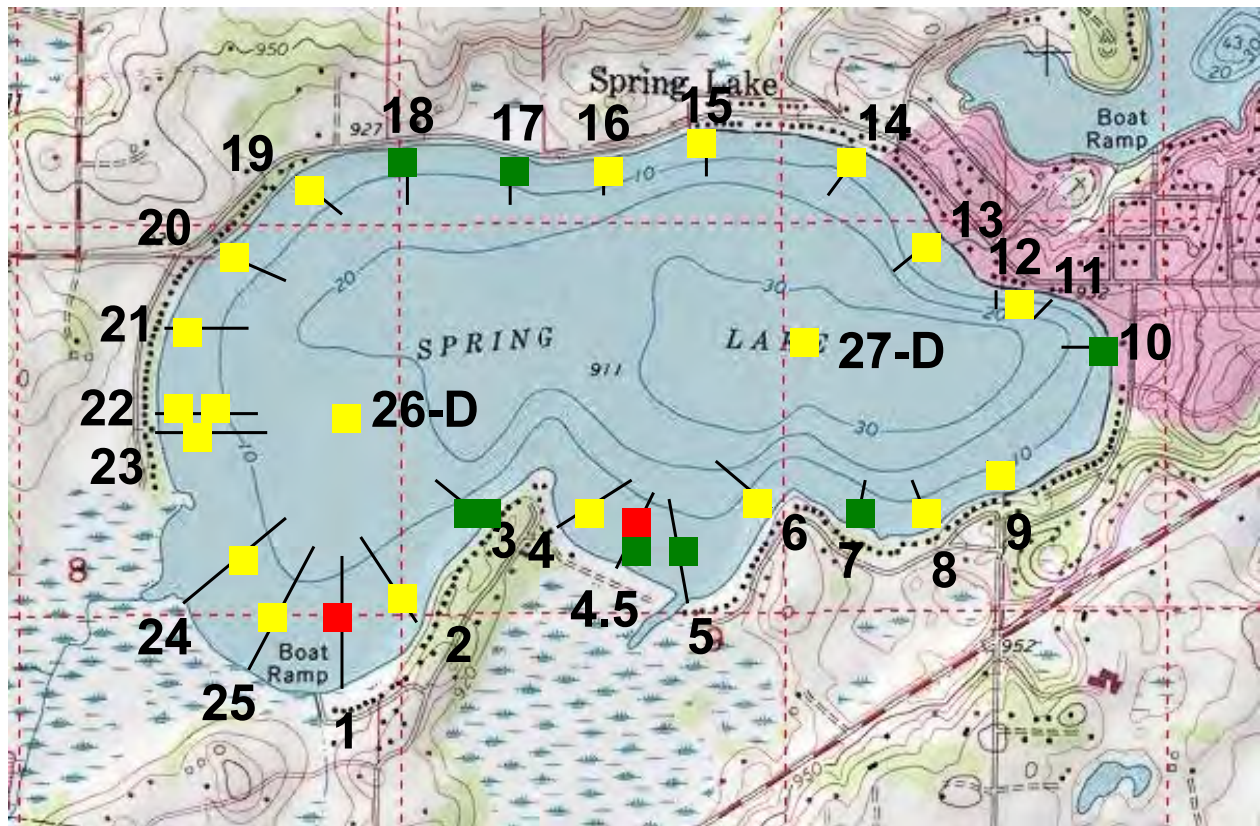


Figure 14. Sediment sample locations are shown with a square. The square color indicates the potential for curlyleaf pondweed growth to occur at that site. Key: green = light; yellow = moderate; red = heavy. A key that illustrates the three types of growth is shown on the next page.