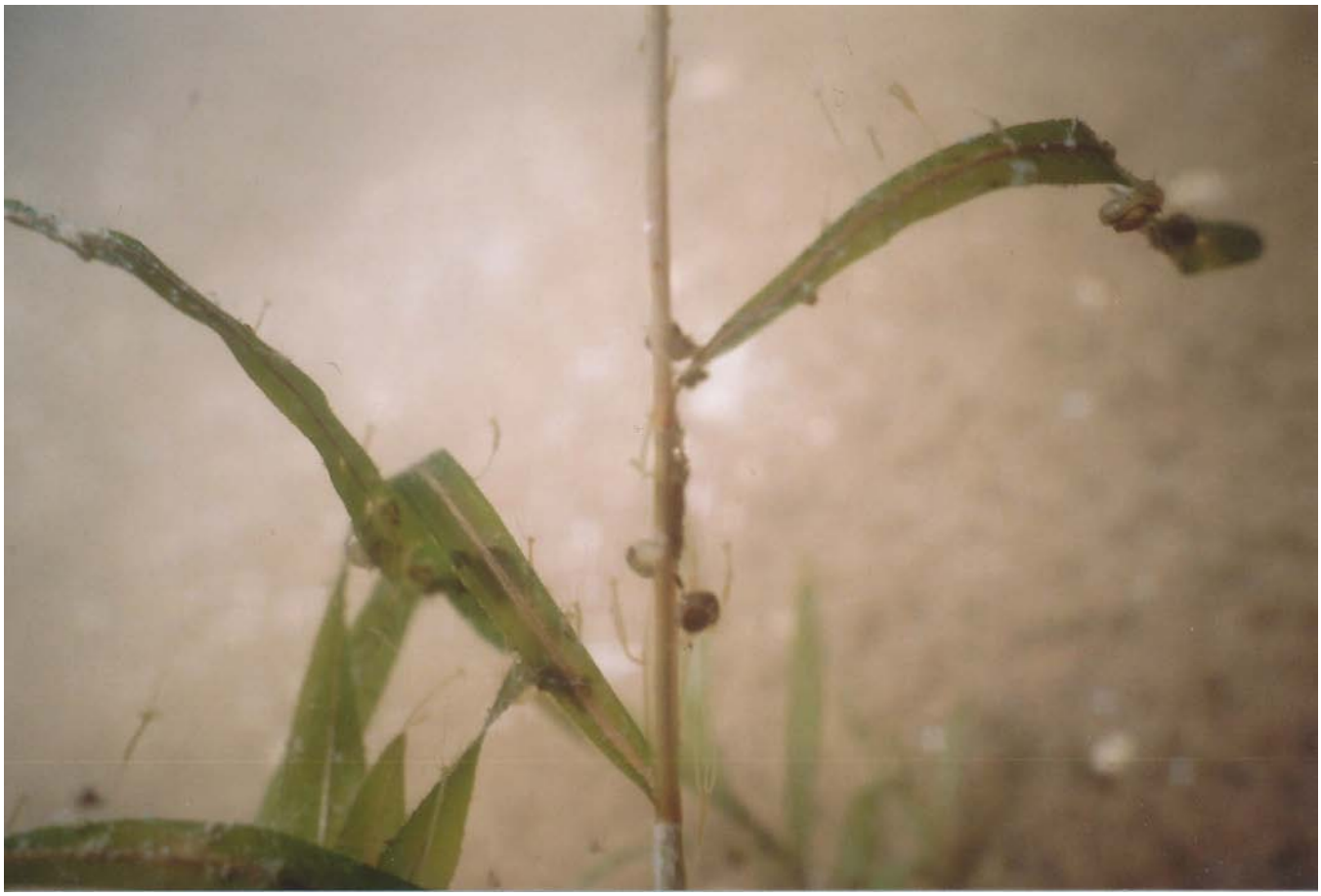

Curlyleaf Pondweed in Medicine Lake with Hydras and Snails, April 20, 2010

Curlyleaf Pondweed Density in Medicine Lake, Plymouth, Minnesota in 2010

	2004	2005	2006	2007	2008	2009	2010
Herbicide Application:	May 8-11	April 19, 21	April 18	no herbicide	May 12	May 1	April 23
Pre-Herbicide Plant Evaluation:	May 6	April 22	April 24	April 17	May 4	April 22	April 20
Post Herbicide Plant Evaluation and/or Curlyleaf Assessment	June 14	June 2	May 25	April 27, May 30	June 9	June 12	June 4
Herbicide Use:	1,668 gallons, 317 ac treated	1,400 gallons, 325 ac treated	1,400 gallons 325 ac treated	0 gallons (no herbicides used)	345 gallons 80 ac treated	415 gallons 62 ac treated	194 gallons 29 ac treated

Prepared for:
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December 2010

Curlyleaf Pondweed Density in Medicine Lake, Plymouth, Minnesota in 2010

Summary

Annual aggressive herbicide treatments treated at least 300 acres of curlyleaf in Medicine Lake in 2004, 2005, and 2006 with the objective to achieve long-term control of nuisance curlyleaf pondweed growth. The herbicide treatment, using Aquathol K, significantly reduced the spring density of curlyleaf pondweed at four monitoring sites in Medicine Lake following the application, indicating good annual control. It was also observed that pre-treatment stem densities had decreased in 2005, 2006, and 2007 compared to pre-project stem densities taken in 2004.

In 2007, there was no herbicide treatment. Early season stem densities on April 17, 2007 were low at all four sample sites. When re-sampling occurred about six weeks later, curlyleaf stem densities had increased at three of the four sample sites, reaching nuisance densities (arbitrarily set at 150 stems/m^2) at several individual quadrat locations.

In 2008, the early season curlyleaf stem density assessment was conducted on May 4, 2008. Curlyleaf stem densities had increased compared to 2007 early season (April 17, 2007) stem densities, but were still far below the early season stem densities recorded at the start of the project in 2004. On May 4, 2008 the early season survey, it was observed that curlyleaf runner formation had started but there were only two to three stems per turion. Because additional runner formation could result in substantial increases in curlyleaf stem densities herbicide treatments were conducted on known “hot spots” on the north and south ends of Medicine Lake totaling 80 acres. Herbicide was applied on or about May 12, 2008. Curlyleaf status was reevaluated on June 9, 2008. No viable stems were observed in the treated areas, although non-living stems were present. Two untreated areas were also monitored. In one untreated site, curlyleaf was abundant in density, but had a limited distribution. In the second untreated site, curlyleaf growth was sparse.

In 2009, it appeared that a selective herbicide treatment of 62 acres in Medicine Lake controlled the main areas of heavy growth. Because curlyleaf consistently produces moderate to heavy growth in several areas of Medicine Lake, annual herbicide applications may be necessary to control excessive curlyleaf growth.

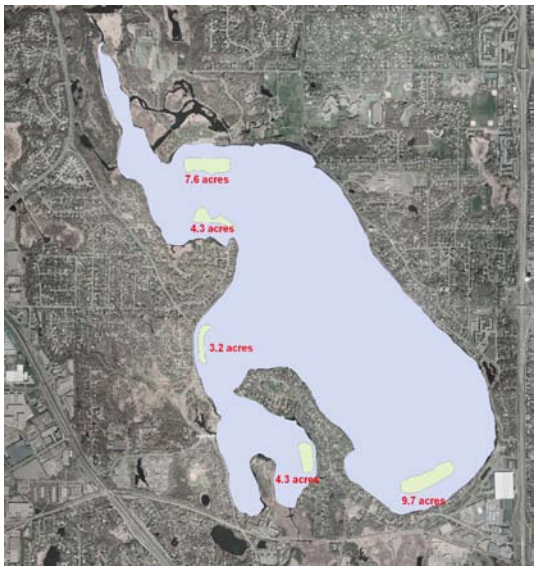
In 2010, a total of 29 acres of heavy curlyleaf pondweed growth were treated at five sites on the north, south, and west areas. This controlled most of the heavy growth of curlyleaf in Medicine Lake.

Curlyleaf Pondweed Densities at Four Sites in 2010: Curlyleaf stem densities were monitored on two dates in 2010, with sampling occurring in April and in June (Table 1). On April 20, viable stems at all four sites were found at a low density. Herbicides were applied on April 23 in the areas of Sites 1, 3, and 4.

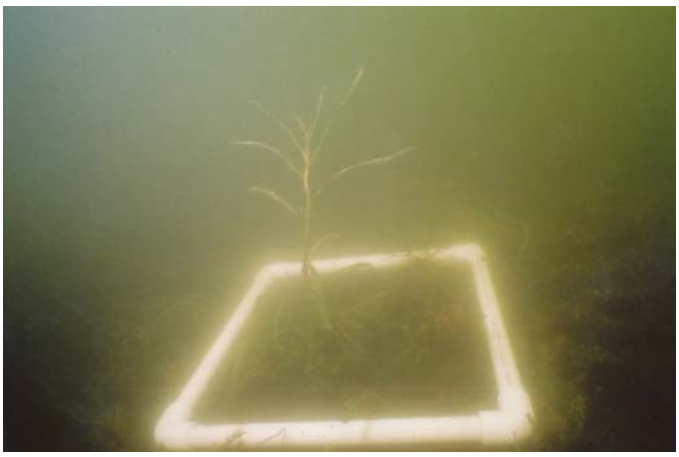
After the herbicide treatment, curlyleaf was not found at Site 1 on the June 4 sample date. Curlyleaf stem densities were light at the other treatment sites (Sites 3 and 4) and present at low densities at untreated Site 2.

Table 1. Curlyleaf pondweed stem densities at four sites in Medicine Lake in 2010.

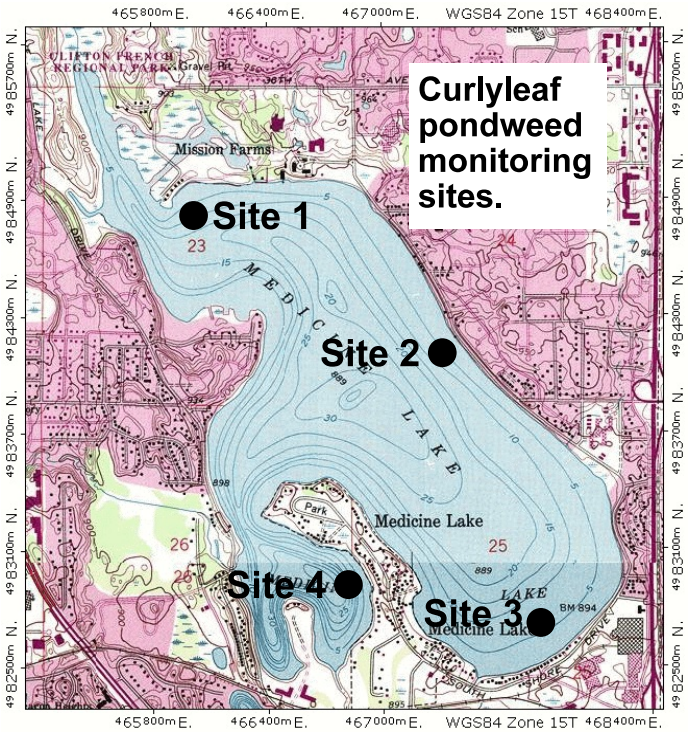
		April 20, 2010	June 4, 2010
		Curlyleaf Stems (stems/m^2)	Curlyleaf Stems (stems/m^2)
Site 1	6 ft	16	0
	9 ft	9	0
Site 2 (untreated)	6 ft	1	13
	9 ft	1	8
Site 3	6 ft	11	37
	9 ft	7	40
Site 4	6 ft	48	64
	9 ft	15	13
Average		14	22
6 ft average		19	29
9 ft average		8	15



Map of 2010 treatment areas.



Curlyleaf density at Site 1 on April 20, 2010 before a herbicide treatment on April 23, 2010.



Site map of four locations where stem densities were monitored.

Curlyleaf Pondweed Densities at Four Sites from 2004 - 2010: Stem densities at all four sites were high at the start of the curlyleaf control program in 2004 (Tables 1 and 2). Stem densities were measured on May 6, 2004 and this was the reference condition. After three years of aggressive herbicide treatment with over 300 acres treated per year (in 2004, 2005, and 2006), stem densities had declined when early season stem densities from 2007 - 2010 were compared to the May 6, 2004 measurements (Table 3).

The three consecutive years of herbicide treatment (2004, 2005, 2006) reduced the early season curlyleaf stem densities in Medicine Lake. Early season stem densities increased in 2008 compared to 2007 indicating curlyleaf stem density was coming back in several areas after areas were not treated in 2007. However two sites were treated in 2008 and early season stem densities were lower in 2009 compared to pretreatment stem densities in 2008. In 2009, three sites were treated, but curlyleaf growth was light at all four monitoring sites including monitoring Site 2 which was not treated. In 2010, three sites (1, 3, and 4) were treated and Site 2 was not treated. Curlyleaf pondweed stem densities were light at all four monitored sites (Tables 2 and 3 and Figure 1) .

Table 2. Summary of curlyleaf pondweed stem densities for both early and late spring (pre and post herbicide treatment) conditions for all four sites for 6 ft and 9 ft depths.

	Stem Density (#/m^2)						
Early Spring (Pre-Herbicide Conditions)							
	2004 (May 6)	**2005 (April 22)**	**2006 (April 24)**	**2007 (April 17)**	**2008 (May 4)**	**2009 (April 22)**	**2010 (April 20)**
6 ft	643 (n=40)	419 (n=40)	127 (n=40)	13 (n=40)	55 (n=40)	35 (n=40)	19 (n=40)
9 ft	472 (n=40)	143 (n=40)	44 (n=40)	14 (n=40)	71 (n=40)	23 (n=40)	8 (n=40)
Late Spring (Post Herbicide Conditions)							
	2004 (June 14)	**2005 (June 2)**	**2006 (May 25)**	**2007 (May 30)**	**2008 (June 9)**	**2009 (June 12)**	**2010 (June 4)**
6 ft	1 (n=40)	0 (n=40)	33 (n=40)	43 (n=40)	96 (n=40)	1 (n=40)	29 (n=40)
9 ft	1 (n=40)	0 (n=40)	24 (n=40)	111 (n=40)	135 (n=40)	3 (n=40)	15 (n=40)

Table 3. Summary of curlyleaf pondweed stem densities for early and late spring conditions for individual sites. Sites that were not treated are shown in blue shading.

		Sites (average of 6 ft and 9 ft depths)(#/m^2)				Average (all sites)
		1	**2**	**3**	**4**	
2004	early	667	680	611	273	558
	late	2	2	0	0	1
2005	early	304	408	27	385	281
	late	0	0	0	0	0
2006	early	31	114	130	68	86
	late	0	16	73	25	29
2007	early	8	16	9	23	14
	late	61	80	152	15	77
2008	early	131	83	18	20	63
	late	0	59	0	402	116
2009	early	43	21	3	49	29
	late	4	0	0	5	2
2010	early	13	1	9	32	14
	late	0	11	39	39	12

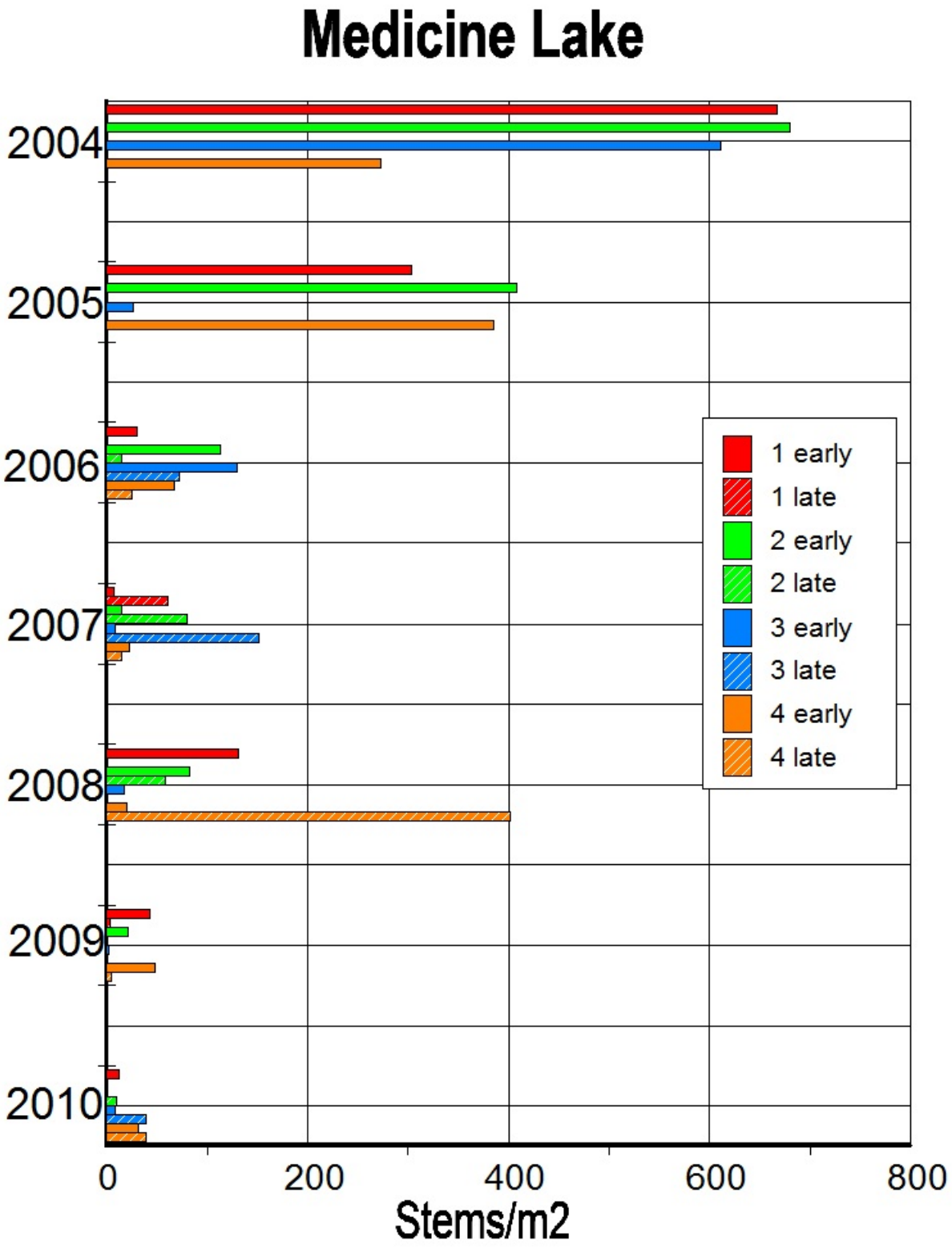
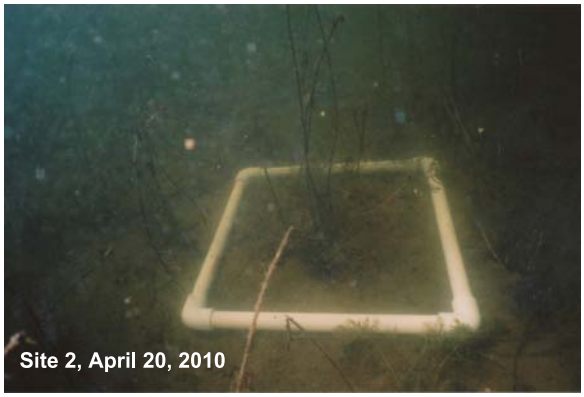


Figure 1. Medicine Lake curlyleaf pondweed stem densities from 2004-2010 for four sites for early and late spring conditions. Initial stem densities were high in 2004. Data are from Table 3 (p. iii).

Medicine Lake Curlyleaf Conditions in April and June, 2010

April 20, 2010



June 4, 2010

Curlyleaf conditions at four sample sites. White frame is a 0.1m^2 quadrat.

Curlyleaf Pondweed Density in Medicine Lake, Plymouth, Minnesota in 2010

Introduction

In 2004, 2005, and 2006, herbicide treatments covering over 300 acres each year using Aquathol K (active ingredient is an endothal salt) to control curlyleaf pondweed were conducted in Medicine Lake (886 acres). No treatments were conducted in 2007 and selective treatments were conducted in 2008 (80 acres), in 2009 (62 acres), and in 2010 (29 acres)(Table 1).

The short term objective has been to reduce, to the greatest extent possible, the occurrence of the non-native plant, curlyleaf pondweed. The long-term objective has been to reduce the standing crop of curlyleaf pondweed to non-nuisance conditions on a long-term basis.

Initially a three-year whole-lake herbicide treatment program was conducted followed by a year of no treatment and has then followed by three years of selective treatments. This study summarizes results of the seventh year of the program. Curlyleaf density and biomass were sampled at four sites around Medicine Lake. At each site, 6 foot and 9 foot depths were monitored. In addition, other work was conducted to monitor water quality and to characterize the entire aquatic plant community using a point-intercept survey (not included in this report).

Figure 1. Herbicides were applied just below the lake surface in 2004-2006 and in 2008 and 2009.

Methods

Curlyleaf stem density and biomass have been sampled at four sites and at two depths on two dates from 2004 through 2010 (Table 1). The four site locations are shown in Figure 2.

Curlyleaf was sampled prior to herbicide effects and then after herbicide effects in 2004, 2005 and 2006 (Table 1). No herbicides were used in 2007 and curlyleaf was sampled on April 17, 27, and May 30. Herbicide was applied to Sites 1 and 3 on about May 12 in 2008 and was sampled on May 4 and June 9. In 2009, herbicide was applied in Sites 1, 3, and 4 and curlyleaf was sampled on April 22 and June 12. In 2010, herbicide was applied in Sites 1, 3, and 4 and curlyleaf was sampled on April 20 and June 4.

Table 1. Sampling dates for the curlyleaf pondweed evaluation.

	2004	2005	2006	2007	2008	2009	2010
Herbicide Application:	May 8-11	April 19, 21	April 18	no herbicide	May 12	May 1	April 23
Pre-Herbicide Plant Evaluation:	May 6	April 22	April 24	April 17	May 4	April 22	April 20
Post Herbicide Plant Evaluation and/or Curlyleaf Assessment	June 14	June 2	May 25	April 27, May 30	June 9	June 12	June 4
Herbicide Use:	1,668 gallons, 317 ac treated	1,400 gallons, 325 ac treated	1,400 gallons 325 ac treated	0 gallons (no herbicides used)	345 gallons 80 ac treated	415 gallons 62 ac treated	194 gallons 29 ac treated

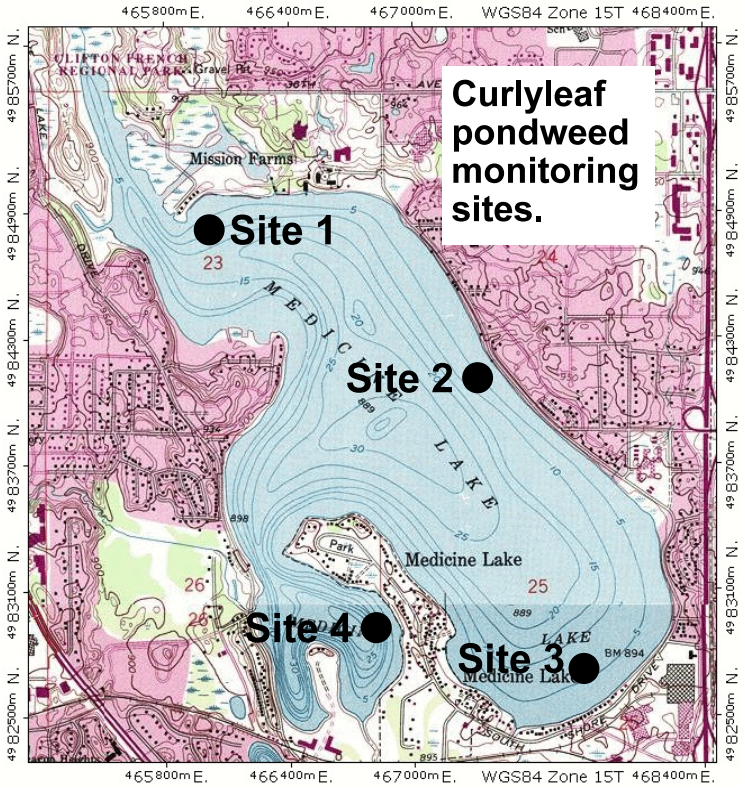


Figure 2. Site locations of four plant sampling sites. At each site, plants at 6 feet and 9 feet were sampled.

Stem Density and Biomass Methods: For each year, two depths (6 feet and 9 feet) have been sampled at each of four sites for a total of eight sites per sample date. At each site a total of ten curlyleaf stem density samples were taken using a 0.10 m^2 quadrat (Figure 3). The ten stem density samples were randomly collected along a 50 meter transect line that ran parallel to the shoreline at each site. Other plant species were counted if present.

At each site, stems were collected from quadrat samples, dried at 105^{o}C and weighed. Dry weight determinations were made by Three Rivers Park District Lab in 2004, 2005, and 2006 and by Blue Water Science in 2007, 2008, 2009, and 2010.

Figure 3. A 0.10 m^2 quadrat was used to quantify curlyleaf stem densities.

Curlyleaf Treatment Areas in 2010: Scouting to delineate curlyleaf pondweed treatment areas was conducted on April 20, 2010. Based on the curlyleaf delineation five individual sites were delineated for treatment. A total of 29.1 acres of curlyleaf pondweed was treated on April 23, 2010. A map of the treated areas is shown in Figure 4. A follow-up survey was conducted on June 4, 2010 to evaluate overall curlyleaf control and to specifically monitor four sites for curlyleaf stem densities.

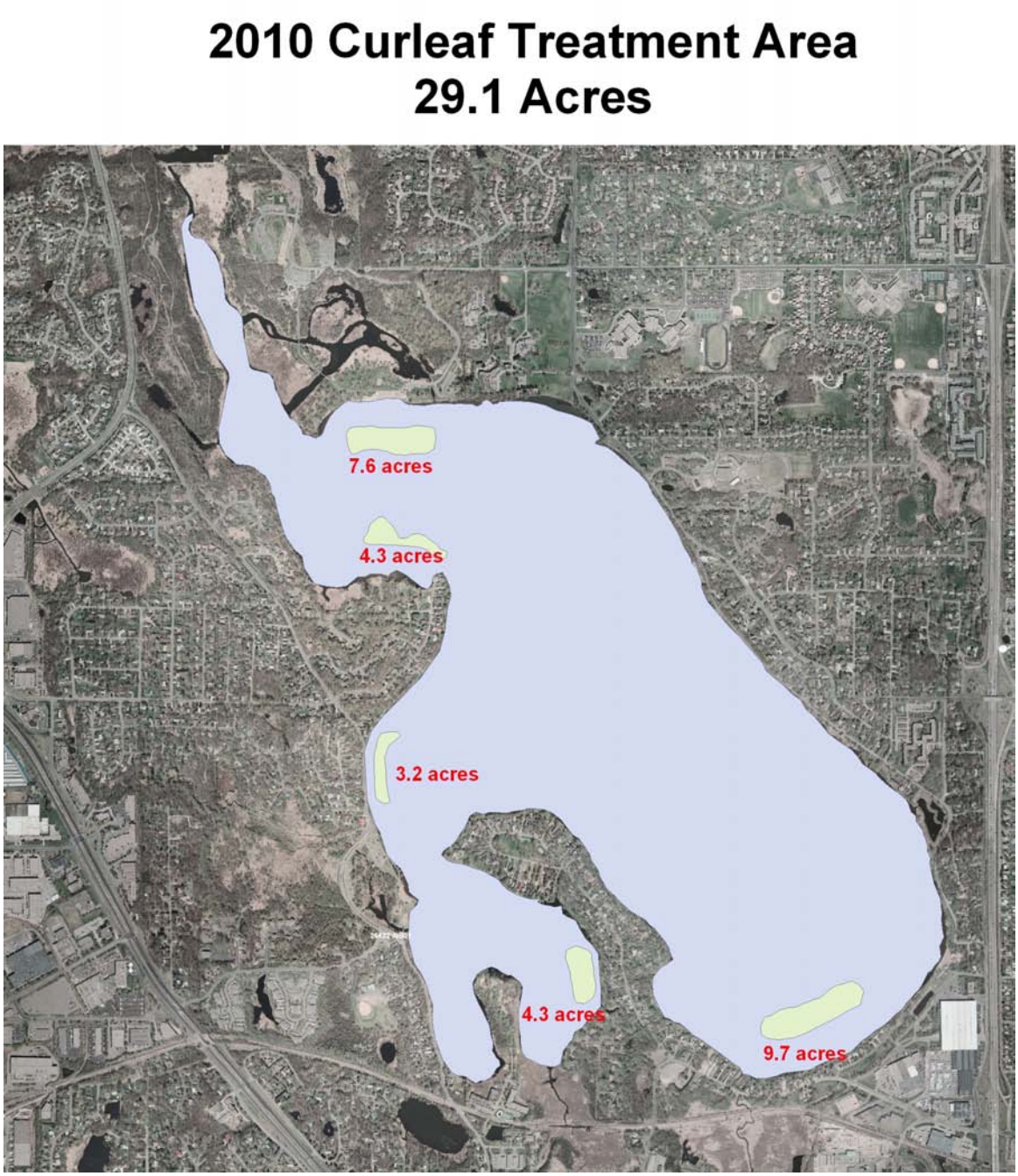


Figure 4. Treatment areas are shown in green (source: MnDNR).

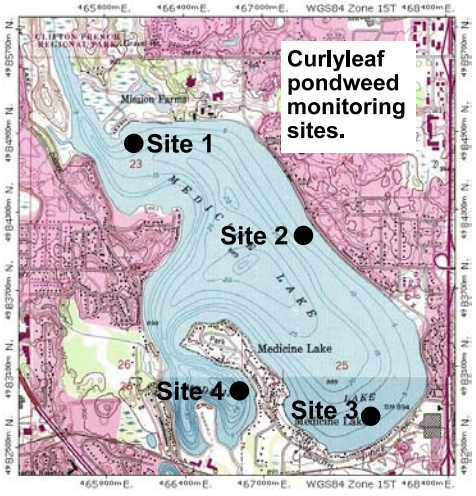
Results of Sampling at Four Sites on April 20 and June 4, 2010

April 20, 2010 - Pretreatment Data: A summary from each of the four sampling sites for curlyleaf pondweed stem densities for 2010 conditions is shown in Table 2. For April 20, 2010 stem density results were low to moderate for Sites 1, 2, 3, and 4. The average curlyleaf stem density for each site was below heavy growth densities where 150 stems/m^2 or more are defined as heavy growth).

Table 2. Medicine Lake curlyleaf stem counts for April 20, 2010 for Sites 1, 2, 3, and 4. Plant data collected by Steve McComas, Blue Water Science, and Kevin Springbob, City of Plymouth.

CURLYLEAF PONDWEED STEM DENSITIES (stems per m2) **- April 20, 2010**

	Site							
	1		2		3		4	
GPS Coord (UTM) Zone: WGS 84	E04 65 990 N49 84 811		E04 67 340 N49 84 115		E04 67 840 N49 82 689		E04 66 871 N49 82 854	
Quadrat	Stem Density (#/m^2)		Stem Density (#/m^2)		Stem Density (#/m^2)		Stem Density (#/m^2)	
	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft
1	10	40	10	10	10	10	50	20
2	20	0	0	0	40	20	60	30
3	10	0	0	0	30	20	80	0
4	30	0	0	0	20	20	30	0
5	40	0	0	0	10	0	50	10
6	10	0	0	0	0	0	40	20
7	10	0	0	0	0	0	30	40
8	30	0	0	0	0	0	60	20
9	0	30	0	0	0	0	70	0
10	0	20	0	0	0	0	10	10
Average Curlyleaf Stem Density (stems/m^2)	***16***	***9***	***1***	***1***	***11***	***7***	***48***	***15***



Two other aquatic plant species were also observed on April 22, 2009 and stem densities for Eurasian watermilfoil and coontail are shown in Table 3. Coontail was more common then milfoil at all four sites.

Table 3. Medicine Lake curlyleaf stem counts for April 20, 2010 for four sites and two depths at each site (locations are shown in Figure 1) for Eurasian watermilfoil and coontail.

EURASIAN WATERMILFOIL STEM DENSITIES - APRIL 20, 2010

	Site							
	1		2		3		4	
GPS Coord (UTM) Zone: WGS 84	E04 65 990 N49 84 811		E04 67 340 N49 84 115		E04 67 840 N49 82 689		E04 66 871 N49 82 854	
Quadrat	Stem Density (#/m²)		Stem Density (#/m²)		Stem Density (#/m²)		Stem Density (#/m²)	
	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft
1	0	10	10	10	10	0	0	0
2	0	20	0	10	0	0	0	0
3	0	0	0	10	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
Average Eurasian Watermilfoil Stem Density (stems/m²)	***0***	***3***	***1***	***3***	***1***	***0***	***0***	***0***

COONTAIL STEM DENSITIES - APRIL 20, 2010

	Site							
	1		2		3		4	
GPS Coord (UTM) Zone: WGS 84	E04 65 990 N49 84 811		E04 67 340 N49 84 115		E04 67 840 N49 82 689		E04 66 871 N49 82 854	
Quadrat	Stem Density (#/m²)		Stem Density (#/m²)		Stem Density (#/m²)		Stem Density (#/m²)	
	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft
1	20	20	10	10	30	30	10	20
2	30	20	10	10	30	30	20	20
3	30	20	0	10	30	20	10	10
4	20	20	0	10	40	20	20	10
5	30	20	0	0	30	10	20	0
6	30	0	0	0	40	0	0	0
7	20	10	0	0	0	0	0	0
8	10	20	0	0	0	0	0	0
9	20	0	0	0	0	0	0	0
10	20	20	0	0	0	0	0	0
Average Coontail Stem Density (stems/m²)	***23***	***15***	***2***	***4***	***20***	***11***	***8***	***6***

June 4, 2010 - Post Treatment Data: After the curlyleaf pondweed herbicide treatment on April 23, curlyleaf pondweed stem densities were evaluated on June 4, 2010 and results are shown in Table 4. No curlyleaf was found at Site 1 and curlyleaf pondweed stem densities were light to moderate at Sites 2, 3, and 4. Although Site 2 was not treated, curlyleaf densities were light.

At Site 4, curlyleaf had not completely died back at the 6-foot depth but curlyleaf growth was restricted to a narrow band, not wider than 20 meters.

Table 4. Medicine Lake curlyleaf stem counts for June 4, 2010 for four sites and two depths at each site (locations are shown in Figure 1). Plant data collected by Steve McComas, Blue Water Science, June 4, 2010.

CURLYLEAF PONDWEED STEM DENSITIES - JUNE 4, 2010

	Site							
	1		2		3		4	
GPS Coord (UTM) Zone: WGS 84	E 04 65 990 N 49 84 811		E 04 67 340 N 49 84 115		E 04 67 840 N 49 82 689		E 04 66 871 N 49 82 854	
Quadrat	Stem Density (#/m²)		Stem Density (#/m²)		Stem Density (#/m²)		Stem Density (#/m²)	
	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft
1	0	0	20	30	40	40	40	10
2	0	0	10	20	20	110	80	40
3	0	0	20	30	0	0	60	60
4	0	0	0	0	100	60	120	20
5	0	0	0	0	20	70	140	0
6	0	0	10	0	0	120	50	0
7	0	0	30	0	30	0	70	0
8	0	0	20	0	40	0	40	0
9	0	0	0	0	20	0	40	0
10	0	0	20	0	10	0	0	0
Average Curlyleaf Stem Density (stems/m²)	***0***	***0***	***13***	***8***	***37***	***40***	***64***	***13***

On June 4, 2010, two other aquatic plant species were observed and stem densities are shown in Table 5. Milfoil growth was light at all four sites. Coontail had moderate growth at Site 3, otherwise growth was light at the other sites.

Table 5. Medicine Lake stem counts for Eurasian watermilfoil and coontail for June 4, 2010.

EURASIAN WATERMILFOIL STEM DENSITIES - JUNE 4, 2010

	Site							
	1		2		3		4	
GPS Coord (UTM) Zone: WGS 84	E 04 65 990 N 49 84 811		E 04 67 340 N 49 84 115		E 04 67 840 N 49 82 689		E 04 66 871 N 49 82 854	
Quadrat	Stem Density (#/m²)		Stem Density (#/m²)		Stem Density (#/m²)		Stem Density (#/m²)	
	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft
1	0	0	0	0	0	20	20	0
2	0	0	0	0	0	30	10	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
Average Eurasian Watermilfoil Stem Density (stems/m²)	***0***	***0***	***0***	***0***	***0***	***5***	***3***	***0***

COONTAIL STEM DENSITIES - JUNE 4, 2010

	Site							
	1		2		3		4	
GPS Coord (UTM) Zone: WGS 84	E 04 65 990 N 49 84 811		E 04 67 340 N 49 84 115		E 04 67 840 N 49 82 689		E 04 66 871 N 49 82 854	
Quadrat	Stem Density (#/m²)		Stem Density (#/m²)		Stem Density (#/m²)		Stem Density (#/m²)	
	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft
1	0	0	0	20	0	40	0	20
2	0	0	0	20	0	60	0	40
3	0	0	0	30	0	80	0	20
4	0	0	0	50	0	100	0	30
5	0	0	0	0	0	0	0	40
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	100	0	0
8	0	0	0	0	0	100	0	0
9	0	0	0	0	0	100	0	0
10	0	0	0	0	0	100	0	0
Average Coontail Stem Density (stems/m²)	***0***	***0***	***0***	***12***	***0***	***68***	***0***	***15***

A summary of stem counts for three aquatic plant species monitored on April 20 and June 4, 2010 are shown in Table 6. Curlyleaf stem densities declined from April to June at Site 1 and increased slightly at the other three sites, but did not top out, primarily because of the herbicide application (Sites 3 and 4) or sediments weren't conducive to heavy growth (Site 2). Eurasian watermilfoil growth was light at all four sites. Coontail stem density decreased from April to June at the 6-foot depth and increased at 3 out of 4 sites at the 9-foot depth.

Table 6. Summary of aquatic plant stem counts for curlyleaf pondweed, Eurasian watermilfoil, and coontail for April 20 and June 4, 2010. All stem counts represent an average of 10 quadrats per depth for each date. Blue shading for Site 2 represents an untreated site.

CURLYLEAF PONDWEED

		April 20, 2010	June 4, 2010
1	6	16	0
	9	9	0
2	6	1	13
	9	1	8
3	6	11	37
	9	7	40
4	6	48	64
	9	15	13

EURASIAN WATERMILFOIL

		April 20, 2010	June 4, 2010
1	6	0	0
	9	3	0
2	6	1	0
	9	3	0
3	6	1	0
	9	0	5
4	6	0	3
	9	0	0

COONTAIL

		April 20, 2010	June 4, 2010
1	6	23	0
	9	15	0
2	6	2	0
	9	4	12
3	6	20	0
	9	11	68
4	6	8	0
	9	6	15

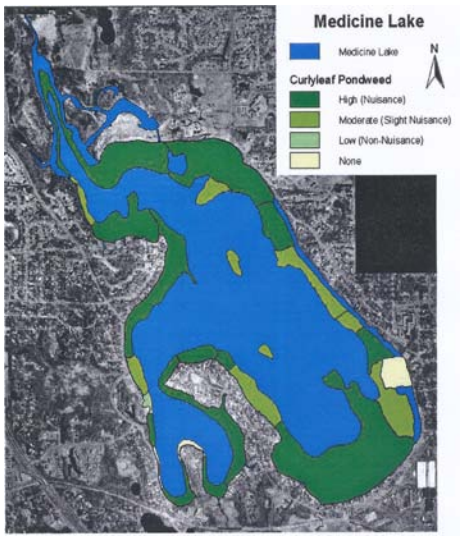
Curlyleaf Biomass in 2010: Curlyleaf pondweed biomass for April 20 and June 4, 2010 is summarized in Table 7. The early spring average dry weight of curlyleaf is about 0.13 grams-dry weight/stem and the late spring is about 0.33 grams dry weight/stem. Overall, curlyleaf biomass was light at all four sites.

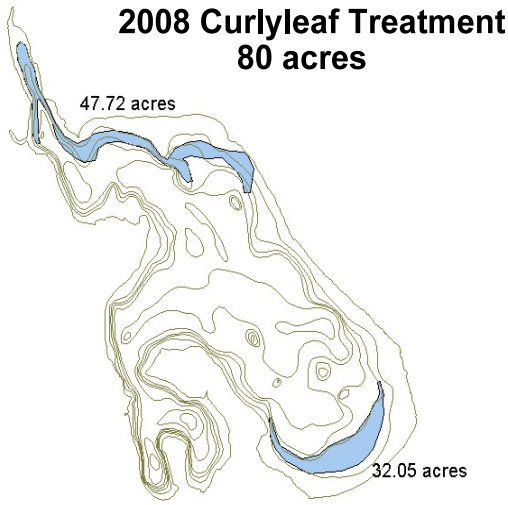
Table 7. Medicine Lake curlyleaf dry weight results for April 20, and June 4, 2010 (analyzed by Blue Water Science).

CURLYLEAF PONDWEED BIOMASS - APRIL 20, 2010 AND JUNE 4, 2010

Site	Depth (ft)	Stems (#/m^2)	Average Dry weight/stem (g)	Dry Wt. (g/m^2)
APRIL 20, 2010 - CURLYLEAF				
1	6	16	0.13 (n=15)	2.1
1	9	9		1.2
2	6	1	0.13	0.1
2	9	1		0.1
3	6	11	0.13	1.4
3	9	7		0.9
4	6	48	0.13	6.2
4	9	15		2.0
JUNE 4, 2010 - CURLYLEAF				
1	6	0	0.33 (n=19)	0
1	9	0		0
2	6	13	0.33	4.3
2	9	8		2.6
3	6	37	0.33	12.2
3	9	40		13.2
4	6	64	0.33	21.1
4	9	13		4.3

Curlyleaf Treatment Areas for 2004 - 2010





2004-2006 Treatment Areas. Treatment areas covered essentially the green shaded areas, encompassing 300-325 acres.

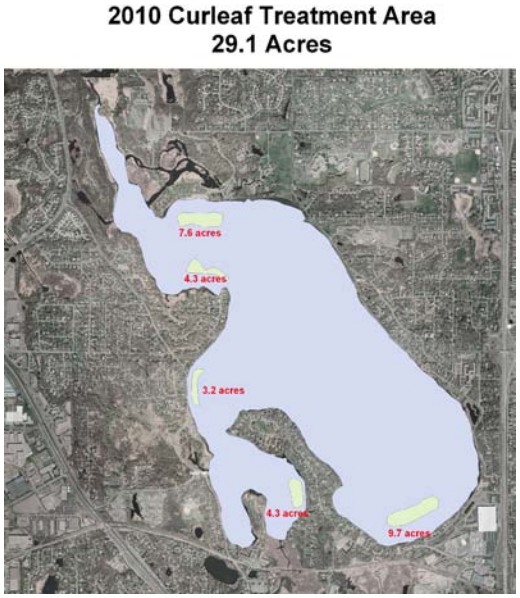


Figure 5. Maps of curlyleaf treatment areas for 2004-2006 (upper left) and for 2008-2010 (other three maps) show where curlyleaf was treated. There was no treatment in 2007.

Summary of Curlyleaf Pondweed Stem Densities for 2004-2010

Table 8. Summary of curlyleaf pondweed stem densities prior to the effects of herbicide treatment and after the herbicide treatment at each of the four sites for 2004 through 2010. Blue shading indicates sites where no treatment occurred.

	Pre-Herbicide Condition (stems/m^2)									
	6-foot Depth Sites					9-foot Depth Sites				
	1	2	3	4	AVE	1	2	3	4	AVE
2004 (May 6)	761	928	555	327	643	572	432	666	219	472
2005 (April 22)	415	600	11	650	419	192	215	43	120	143
2006 (April 24)	24	205	159	121	127	38	22	100	15	44
2007 (April 17)	1	17	5	29	13	14	15	12	16	14
2008 (May 4)	146	32	17	25	55	116	133	19	15	71
2009 (April 22)	54	19	1	66	35	32	23	4	31	23
2010 (April 20)	16	1	11	48	19	9	1	7	15	8

	Post Herbicide Condition (stems/m^2)									
	6-foot Depth Sites					9-foot Depth Sites				
	1	2	3	4	AVE	1	2	3	4	AVE
2004 (June 14)	1	3	0	0	1	2	1	0	0	1
2005 (June 2)	0	0	0	0	0	0	0	0	0	0
2006 (May 24)	0	14	66	50	33	0	17	79	0	24
2007 (May 30)	41	77	33	20	43	81	83	270	9	111
2008 (June 9)	0	59	0	323	96	0	58	0	480	135
2009 (June 12)	5	0	0	0	1	2	0	0	9	3
2010 (June 4)	0	13	37	64	29	0	8	40	13	15

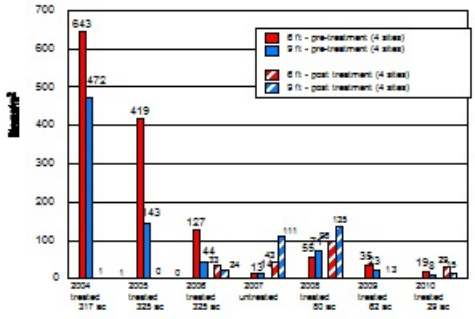


Figure 6. Pre-treatment and post treatment of Medicine Lake curlyleaf pondweed stem densities representing an average from four sites from 2004-2010 at 6-foot and 9-foot water depths.

Summary of Curlyleaf Pondweed Biomass for 2004 - 2010

Table 9. Summary of curlyleaf pondweed biomass prior to herbicide treatments and after herbicide treatments for 2004 through 2009. Blue shading indicates sites not treated in 2007, 2008, 2009, and 2010.

		Pre-Herbicide Biomass (g/m^2)				Post Herbicide Biomass (g/m^2)			
		1	2	3	4	1	2	3	4
2004	6	89	72	87	31	0.03	0.06	0	0
	9	44	37	82	21	0.06	0.04	0	0
2005	6	46	72	0.6	59	0	0	0	0
	9	27	19	3.9	14	0	0	0	0
2006	6	2	10	13	11	0	2	30	9
	9	4	1	8	1	0	3	36	0
2007	6	0.1	1	0.4	3	33	54	10	7
	9	2	1	1	1	37	22	141	3
2008	6	10	3	2	2	0	11	0	65
	9	9	16	2	3	0	15	0	110
2009	6	10	2	0.1	8	2	0	0	0
	9	3	3	0.4	5	2	0	0	3
2010	6	2	0.1	1	6	0	4	12	21
	9	1	0.1	1	2	0	3	13	4

Table 10. Biomass data from four monitoring sites from 2004 - 2010.

BIOMASS SUMMARY - EARLY SPRING RESULTS						
Site	6 ft			9 ft		
	Ave Stem Dry Wt	# of stems/m^2	Dry Wt (g/m^2)	Ave Stem Dry Wt	# of stems/m^2	Dry Wt (g/m^2)
2004 - May 6						
1	0.12	761	89	0.08	572	44
2	0.08	928	72	0.09	432	37
3	0.16	555	87	0.12	666	82
4	0.10	327	31	0.10	219	21
2005 - April 22						
1	0.11	415	46	0.14	192	27
2	0.12	600	72	0.09	215	19
3	0.05	11	1	0.09	43	4
4	0.09	650	59	0.08	176	14
2006 - April 24						
1	0.10	24	2	0.11	38	4
2	0.05	205	10	0.06	22	1
3	0.08	159	13	0.08	100	8
4	0.09	121	11	0.09	15	1
2007 - April 17						
1	0.11*	1	0.1	0.11*	14	2
2	0.08*	17	1	0.08*	15	1
3	0.07*	5	0.4	0.10*	12	1
4	0.09*	29	3	0.09*	16	1
2008 - May 4						
1	0.07	146	10	0.08	116	9
2	0.08	32	3	0.12	133	16
3	0.10	17	2	0.12	19	2
4	0.08	25	2	0.17	15	3
2009 - April 22						
1	0.18	54	10	0.09	32	3
2	0.11	19	2	0.11	23	3
3	0.09	1	0.1	0.09	4	0.4
4	0.12	66	8	0.16	31	5
2010 - April 20						
1	0.13	16	2	0.13	9	1
2	0.13	1	0.1	0.13	1	0.1
3	0.13	11	1	0.13	7	1
4	0.13	48	6	0.13	15	2

Table 10. Biomass data from four monitoring sites from 2004 - 2010.

BIOMASS SUMMARY - LATE SPRING RESULTS						
Site	6 ft			9 ft		
	Ave Stem Dry Wt	# of stems/m^2	Dry Wt (g/m^2)	Ave Stem Dry Wt	# of stems/m^2	Dry Wt (g/m^2)
2004 - May 6						
1	0.03	1	0.03	0.03	2	0.06
2	0.02	3	0.06	0.04	1	0.04
3	--	0	0	--	0	0
4	--	0	0	--	0	0
2005 - April 22						
1	--	0	0	--	0	0
2	--	0	0	--	0	0
3	--	0	0	--	0	0
4	--	0	0	--	0	0
2006 - April 24						
1	--	0	0	--	0	0
2	0.12	14	2	0.19	17	3
3	0.46	66	30	0.46	79	36
4	0.18	50	9	--	0	0
2007 - April 17						
1	0.40	41	33	0.36	81	37
2	0.62	77	54	0.22	83	22
3	0.41	33	10	0.47	270	141
4	0.27	20	7	0.11	9	3
2008 - June 9						
1	0.15	0	0	0.26	0	0
2	0.18	59	11	0.25	58	15
3	0.18	0	0	0.25	0	0
4	0.20	323	65	0.23	480	110
2009 - June 12						
1	0.35	5	2	0.35	5	2
2	--	0	0	--	0	0
3	--	0	0	--	0	0
4	--	0	0	0.35	9	3
2010 - June 4						
1	--	0	0	--	0	0
2	0.33	13	4	0.33	8	3
3	0.33	37	12	0.33	40	13
4	0.33	64	21	0.33	13	4

* estimated dry weight, based on average dry weights from early season values from the previous three years.

Aquatic Plant Conditions in Early and Late Spring

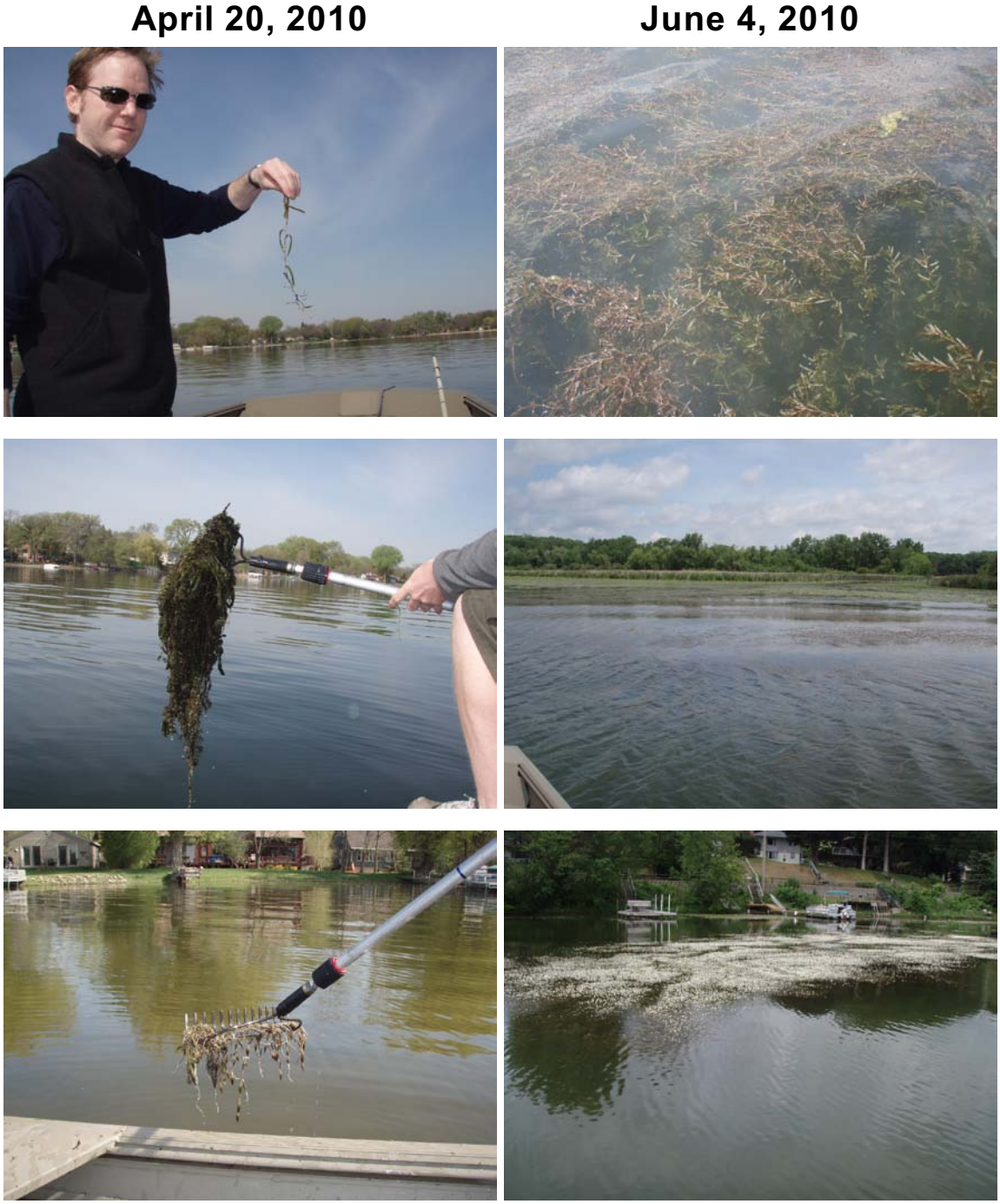


Figure 7. [top] Curlyleaf was sparse to common in April 20, 2010. Although 29 acres of curlyleaf was treated on April 23, 2010, some curlyleaf remained. The curlyleaf patch in the upper right is in the north arm, close to shore and was not treated.
[middle] Coontail was common in April and common to abundant in June.
[bottom] Buttercup was common in some areas in April and had produced white flowers along some stretches of the western shoreline in June.

Medicine Lake Curlyleaf Pondweed Notes: 2004 to 2010

Annual aggressive herbicide treatments were used to treat all known curlyleaf areas (which were estimated at 300 acres) in Medicine Lake from 2004 through 2006 with the objective to achieve long-term control of nuisance curlyleaf pondweed growth. The early season herbicide treatment, using Aquathol K, significantly reduced the spring density of curlyleaf pondweed at four monitoring sites in Medicine Lake following the application, indicating there was good annual control.

It was also observed that pre-treatment stem densities had decreased in 2005, 2006, and 2007 compared to pre-project stem densities taken in 2004.

In 2007, there was no herbicide treatment. Early season stem densities on April 17, 2007 were low at all four sample sites. Although some areas had curlyleaf present, the decision was made to not treat the lake. When re-sampling occurred about six weeks later, curlyleaf stem densities had increased at three of the four sample sites, reaching nuisance densities (arbitrarily set at 150 stems/m^2) at several individual quadrat locations. Curlyleaf pondweed stem densities declined slightly from the April to May at one sample site.

In 2008, early season monitoring of curlyleaf pondweed by the US ACE, MnDNR, and Blue Water Science found curlyleaf was widespread in Medicine Lake, with slightly higher densities in the north and south ends of the lake. A total of 80 acres were treated in the North and South ends of Medicine Lake and heavy growth of curlyleaf was limited in Medicine Lake in 2008.

In 2009, early season monitoring delineated 62 acres of curlyleaf to be treated. After a herbicide treatment, no heavy growth of curlyleaf was observed in Medicine Lake in 2009.

In 2010, early season monitoring delineated 29.1 acres of curlyleaf to be treated. After the herbicide treatment, only small patches of heavy curlyleaf growth were observed.

Figure 8. [top] Curlyleaf pondweed at Site 3 on May 30, 2007. There was no treatment in 2007. [bottom] Curlyleaf pondweed grew to the surface in several areas in Medicine Lake on May 30, 2007. Surfacing curlyleaf growth has been limited in 2008, 2009, and 2010.

Medicine Lake Curlyleaf Pondweed Observations and Speculation

- The three year annual application of the herbicide, Aquathol K, that treated over 300 acres per year eliminated nuisance aquatic plant conditions on an annual basis, but did not eliminate curlyleaf regrowth the following year in Medicine Lake.

- 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 can continue to artificially induce a lower stem density condition the following year.

- It is uncertain how many years of aggressive treatment are necessary to eliminate nuisance growth on a long term basis.

- Curlyleaf growth is strongly influenced by the substrate. If stem densities are artificially reduced, as can occur with herbicides, and herbicide applications cease, curlyleaf will grow to satisfy substrate characteristics within a year or two.

- Long-term nuisance control of curlyleaf may be difficult to achieve unless substrate composition changes occur that limits curlyleaf growth.

- Curlyleaf stem densities may be correlated with sediment conditions. Under the right sediment conditions, stem densities will be naturally high. Under less hospitable sediment conditions, stem densities will be naturally low.

- Herbicide treatments that target areas of heavy curlyleaf growth while leaving areas of light growth untreated is a management option.

- Selective treatment of 80 acres in 2008, 62 acres in 2009, and 29 acres in 2010, controlled heavy growth of curlyleaf pondweed.

Long-term Curlyleaf Control Is a Challenge

In Medicine it appears it will be difficult to achieve long term control of curlyleaf pondweed. Even if it was possible to destroy all curlyleaf turions in a lake there would still be a potential for curlyleaf reestablishment. Curlyleaf could come back from seed germination. Although the seed germination rate is low (estimated at a germination rate of 0.001%. Rogers and Breen 1980*) it occurs. Seed germination has the potential to repopulate a lake in 3 to 4 years (Table 11). Therefore, because curlyleaf can come back from seeds it is probable that long term control of curlyleaf is unlikely.

From data on Medicine Lake as well as other lakes, indicates if sediment conditions are conducive to growth, curlyleaf will grow. Therefore, annual treatments are a good option. Since long-term control with existing techniques is unlikely, treating only areas that produce nuisance growth, while leaving other areas alone is a consideration.

Selective treatments would achieve nearly the same results as whole lake treatments and are less expensive.

Table 11. Curlyleaf regrowth from seeds. Assume seed density of 1,445 seeds/m^2 and a germination rate of 0.001%. After turion production is re-established, assume 60% germination rate of turions (from Rogers and Breen 1980).

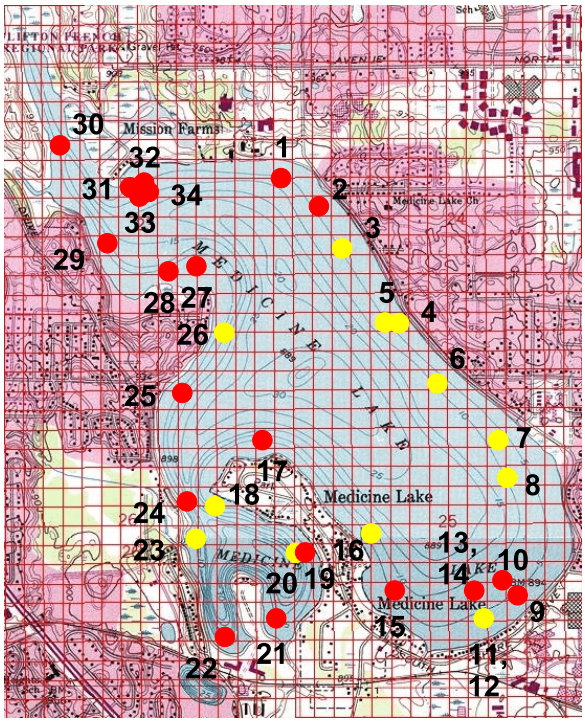
	Year 1	Year 2	Year 3
Early Season Stem Density (stems/m^2)	**0.01445 stems/m^2** (assume 0.001% germination of seeds and a seed density of 1,445 seeds/m^2)	**0.87 stems/m^2** (assume 60% germination of 1.445 turions/m^2 from Year 1)	**52 stems/m^2** (assume 60% germination of 87 turions/m^2 from Year 2)
Late Season Stem Density (stems/m^2)	**0.1445 stems/m^2** (runners produce 10 stems)	**8.70 stems/m^2** (each sprouted turion produces runners and results in 10 stems/turion)	**520 stems/m^2** (each sprouted turion produces 10 stems. 520 stems/m^2 in year 3 represents heavy growth of curlyleaf)
Turions Produced (turions/m^2)	**1.445 turions/m^2** (each of the 10 stems produces 10 turions)	**87 turions/m^2** (each of the 10 stems produces 10 turions)	**5,200 turions/m^2** (each of the 10 stems produces 10 turions. There is a potential for nuisance growth conditions from here on.)

* *Rogers,K.H. and C.M. Breen. 1980. Growth and reproduction of* Potamogeton crispus *in a South African lake. Journal of Ecology 68:561-571.*

Curlyleaf Pondweed Sediment Survey Helps Target Control Areas

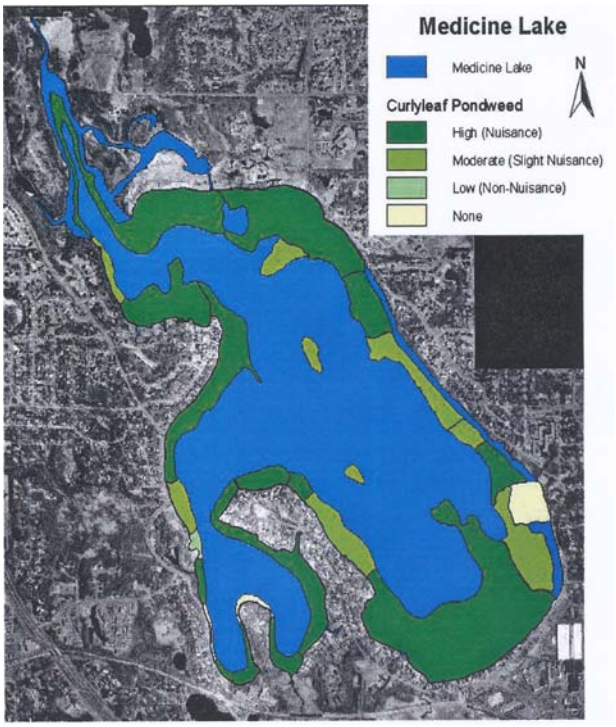
Lake sediment sampling results from 2009 have been used to predict lake bottom areas that have the potential to support three types of curlyleaf pondweed plant growth: light, moderate, or heavy based on the key sediment parameters of pH, the Fe:Mn ratio, sediment bulk density, and organic matter (McComas, unpublished). Curlyleaf pondweed growth is predicted to produce a combination of moderate growth (where plants may occasionally top out in a broken canopy) and heavy growth (mostly a solid canopy) in Medicine Lake. The north and south ends of the lake appear to be conducive to heavy growth with some areas of heavy growth in the southwestern lobe.

Predicted Curlyleaf Pondweed Growth



Sediment sample locations are shown with a circle. The circle color indicates the type of curlyleaf pondweed growth predicted to occur at that site. Key: green = light; yellow = moderate; red = heavy.

Actual Curlyleaf Pondweed Growth - 2004



Curlyleaf pondweed coverage for 2004 (pre-herbicide) conditions (source: Three Rivers Park District).

Review of Curlyleaf Management Strategies

After a decade of curlyleaf management research two major management strategies have emerged. The first is an aggressive curlyleaf control strategy where the whole lake is treated (or at least all the curlyleaf areas are treated) for a number of years and then spot treatments are implemented. The second strategy involves treating just the nuisance growth of curlyleaf pondweed on an annual basis. Advantages, disadvantages, and costs are shown below.

	Strategies	
	1. Whole Lake Curlyleaf Control	**2. Nuisance Curlyleaf Control**
Approach	Treat all curlyleaf pondweed for up to 8 consecutive years to reduce turions and limit growth. Then after the whole lake treatment program is completed, only treat nuisance areas.	Treat only nuisance areas and leave non-nuisance areas alone. Treatment can be guided based on lake sediment testing to determine areas of potential nuisance growth.
Advantages	There will rarely be any heavy growth of curlyleaf, especially through the whole lake treatment years. If all areas of growth are nuisance growth, then whole lake treatments are cost-effective too.	Theoretically, areas of nuisance growth should be limited with the spot treatment applications. Also, harvesting can be used for spot control.
Disadvantages	It is uncertain how many years of whole lake aggressive treatments are needed. Because curlyleaf can germinate from seeds, it is unlikely curlyleaf will be eradicated even if all turions are destroyed after an aggressive program is completed.	Curlyleaf growth from year to year is variable. Trying to treat areas early, before curlyleaf reaches full maturity, may miss some areas. Conversely, in some years, areas could be treated that wouldn't produce nuisance growth. In these cases, over treatment would occur.
10-year Cost	Assume there are 300 acres of curlyleaf in a lake. Assume a herbicide cost of $400/acre. Then a whole lake treatment is $120,000/year. Assume an annual treatment for 7 years = $840,000. Assume no treatment is needed for the next three years (although spot treatments would be needed in the fourth year (year 11). Total 10-year cost: $840,000.	Assume 300 acres of curlyleaf with 80 acres of nuisance growth. Assume a herbicide cost of $400/acre. Then a nuisance treatment cost is 80 acres x $400 = $32,000. Assume an annual treatment for 10 consecutive years = $320,000. Total 10-year cost: $320,000.

Discussion and Recommendations for 2011

Plant management in Medicine Lake keeps evolving. A 3-year lake-wide curlyleaf pondweed control program involving the treatment of between 317 to 325 acres was conducted in 2004, 2005, and 2006. This was a distribution-minimization management strategy where all curlyleaf was treated with the objective to restrict curlyleaf by diminishing or depleting all turions in the lake. No treatment was conducted in 2007. During the 2007 growing season, curlyleaf re-growth was uneven with some areas showing light growth and other areas approaching heavy growth.

Much was learned from this important program, chiefly, that a three-year lake-wide treatment would not keep curlyleaf from coming back. Starting in 2008, the distribution management strategy evolved into a biomass reduction management strategy, where only the heavy curlyleaf growth was treated. This biomass management strategy was employed in 2008, 2009 and 2010.

Results in 2010 showed treatment produced good curlyleaf control and although it was still present in some areas, heavy growth was restricted to small block areas. In 2010, 29 acres were treated compared to the 300 acres treated in the lake-wide program. This 90% reduction in treatment area still achieved the goal of reducing nuisance growth of curlyleaf in recreational areas.

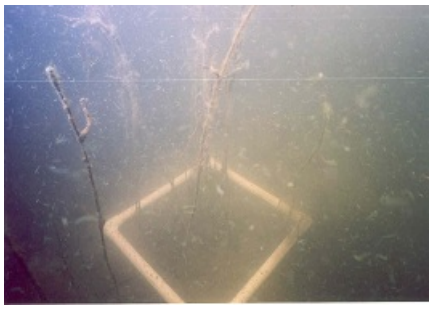
It is recommended that in 2011, early season scouting should be used to delineate areas to treat. The biomass reduction management strategy is a more cost-effective option than the distribution management strategy.

Appendix

Curlyleaf Pondweed Growth Characteristics

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

Non-Nuisance 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 non-nuisance conditions: 1, 2, or 3.

Light Nuisance 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 light nuisance conditions: 3 or 4.

Heavy Nuisance Conditions

Solid or near solid surface canopy conditions.

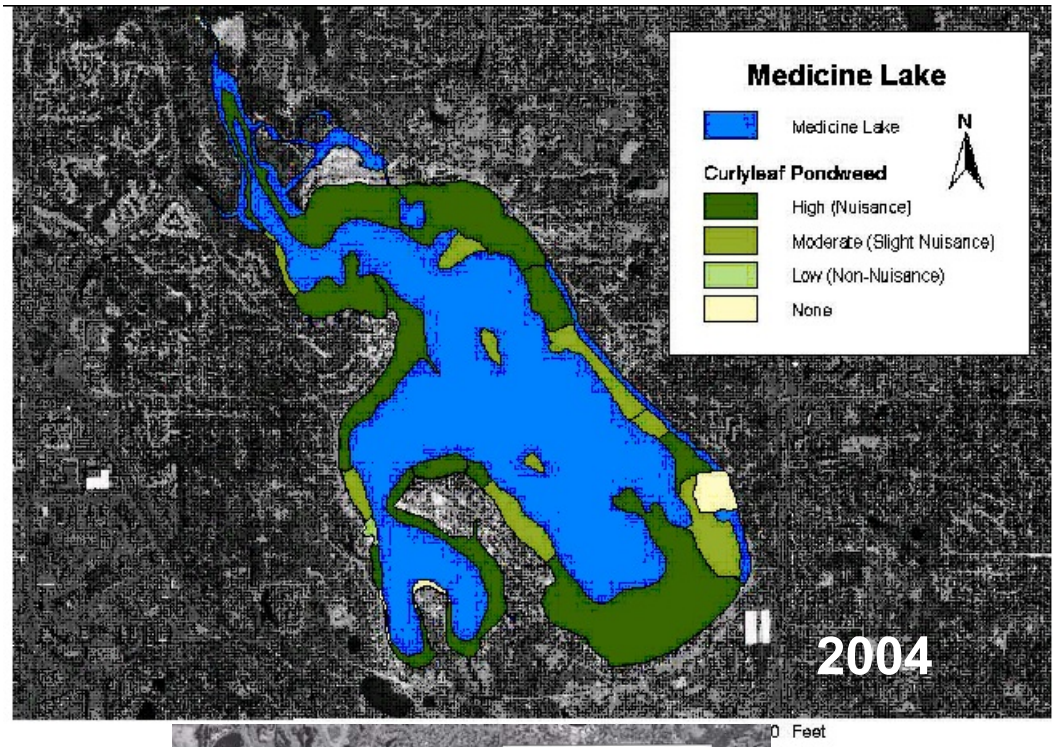
Navigation and recreational activities are severely limited.

Control is necessary for navigation and/or recreation.

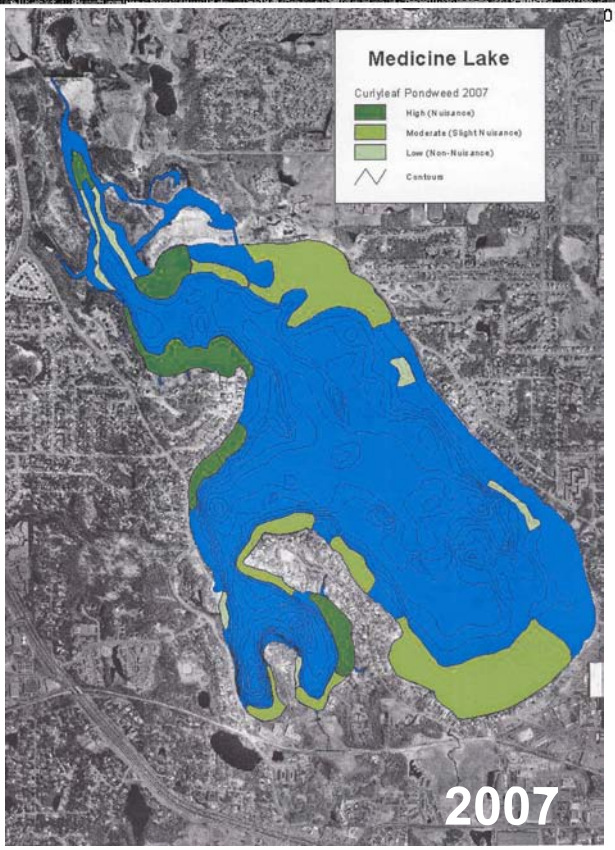
Stem density: 400+ stems/m^2
Biomass: >300 g-dry wt/m^2
Estimated TP loading: >6.7 lbs/ac

MnDNR rake sample density has a scale from 1 to 4. For heavy nuisance 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.

Curlyleaf Pondweed Community in 2004 and 2007



(prepared by Three Rivers Park District)



May 29, 2007 (prepared by Three Rivers Park District)

Results of Sampling on May 6 and June 14, 2004

The average of ten curlyleaf stem densities (#/m^2) ranged from 219 (Site 4, 9 feet) to 928 (Site 2, 6 feet). Generally, curlyleaf was less dense at the deeper depth of 9 feet than at 6 feet (Table 1).

Table 1. Medicine Lake curlyleaf stem counts and biomass for May 6, 2004 for four sites and two depths at each site. Coontail was also observed at Site 1 and coontail stem densities (stems/m^2) are shown in parentheses.

	Site							
	1		2		3		4	
GPS Coord (UTM)	**6 ft: 04 66 009 E 49 84 608 N**		**6 ft: 04 67 355 E 49 83 876 N**		**6 ft: 04 67 873E 49 82 510 N**		**6 ft: 04 66 880 E 49 82 657 N**	
Sample	**Stem Density (#/m^2)**		**Stem Density (#/m^2)**		**Stem Density (#/m^2)**		**Stem Density (#/m^2)**	
	6 ft	**9 ft**	**6 ft**	**9 ft**	**6 ft**	**9 ft**	**6 ft**	**9 ft**
1	850	430 (20)*	550	580	620	840	400	140
2	1,380 (20)*	560	870	720	570	610	520	260
3	250 (20)	900 (20)	1,260	550	730	750	280	510
4	410 (10)	450	610	270	640	760	620	100
5	1,250	750 (10)	840	390	670	660	640	370
6	580 (10)	860 (20)	1,090	460	620	690	60	120
7	870 (20)	420 (20)	880	270	380	740	140	180
8	610	370 (40)	470	320	350	620	80	240
9	740 (10)	440	1,640	500	500	450	320	120
10	670 (10)	540 (90)	1,070	260	470	540	210	150
Average Curlyleaf Stem Density	***761***	***572***	***928***	***432***	***555***	***666***	***327***	***219***
Average g/stem	***0.117 (n=414 stems)***	***0.076 (n=189 stems)***	***0.078 (n=268 stems)***	***0.086 (n=185 stems)***	***0.157 (n=192 stems)***	***0.123 (n=220 stems)***	***0.096 (n=120 stems)***	***0.097 (n=191 stems)***
Estimated Biomass (g/m^2)	***89.0***	***43.5***	***72.4***	***37.2***	***87.1***	***81.9***	***31.4***	***21.2***

* number in parenthesis indicates number of coontail stems found at that site.

Table 2. Medicine Lake curlyleaf stem counts and biomass for June 14, 2004 for four sites and two depths at each site.

	Site							
	1		2		3		4	
GPS Coord (UTM)	**6 ft: 04 66 009 E 49 84 608 N**		**6 ft: 04 67 355 E 49 83 876 N**		**6 ft: 04 67 873E 49 82 510 N**		**6 ft: 04 66 880 E 49 82 657 N**	
Quadrat	**Stem Density (#/m^2)**		**Stem Density (#/m^2)**		**Stem Density (#/m^2)**		**Stem Density (#/m^2)**	
	6 ft	**9 ft**	**6 ft**	**9 ft**	**6 ft**	**9 ft**	**6 ft**	**9 ft**
1	10	10	10	10	0	0	0	0
2	0	10	20	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	0	0	0	0	0
Average Curlyleaf Stem Density	***1***	***2***	***3***	***1***	***0***	***0***	***0***	***0***
Average g/stem	***0.03***	***0.03***	***0.02***	***0.04***	***--***	***--***	***--***	***--***
Estimated Biomass (g/m^2)	***0.03***	***0.06***	***0.06***	***0.04***	***0***	***0***	***0***	***0***
Notes	Scattered coontail & filamentous algae		Curlyleaf resprouting in sand - small plants. Water celery present.		Coontail 1-3 stems/quadrat on 5 different samples.		1 curlyleaf plant found at 3 feet not on transect. Water celery at 7 ft to 5 ft 2-4 stems /quadrat.	

2004: Pre-herbicide Conditions

Site 3. [top] Curlyleaf was 2 to 3 feet tall on May 6, 2004.
[bottom] Stem densities in 6 feet of water were high averaging 555 stems/m^2.

Results of Sampling on April 22 and June 2, 2005

Stem Densities: Stem densities on April 22, 2005, ranged from 11 to 1,200 stems/m^2. In three out of the four stations, stem densities were higher in the 6-foot sample area compared to the 9-foot depth (Table 3).

Table 3. Medicine Lake curlyleaf stem counts for April 22, 2005 for four sites and two depths at each site (locations are shown in Figure 1). Plant data collected by Steve McComas and Jo Stuckert, Blue Water Science, April 22, 2005. Medicine Lake was treated on April 19 and 21, 2005. Typical plant length was 21-27 inches with 10 or 11 nodes. Secchi disc transparency was 6.0 feet.

Site	1		2		3		4	
GPS Coord (UTM)	6 ft: 04 66 009 E 49 84 608 N		6 ft: 04 67 355 E 49 83 876 N		6 ft: 04 67 873E 49 82 510 N		6 ft: 04 66 880 E 49 82 657 N	
Quadrat	Stem Density (#/m^2)		Stem Density (#/m^2)		Stem Density (#/m^2)		Stem Density (#/m^2)	
	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft
1	430	250	1,090	240	30	20	1,070	80
2	380	190	90	110	10	100	1,200	200
3	370	70	1,080	440	10	40	990	190
4	390	80	1,000	400	20	0	790	140
5	480	300	690	120	0	0	420	120
6	470	270	300	70	0	20	410	180
7	280	250	330	250	0	10	300	230
8	300	210	390	140	0	110	450	250
9	390	130	480	160	0	90	200	250
10	660	170	550	220	40	40	670	120
Average Curlyleaf Stem Density	***415***	***192***	***600***	***215***	***11***	***43***	***650***	***176***
Average g/stem	***0.11***	***0.14***	***0.12***	***0.09***	***0.05***	***0.09***	***0.09***	***0.08***
Estimated Biomass (g/m^2)	***45.7***	***26.9***	***72.0***	***19.4***	***0.6***	***3.9***	***58.5***	***14.1***

Stem Densities: No standing curlyleaf pondweed was found at the four sample sites on June 2, 2005 (Table 4).

Table 4. Medicine Lake curlyleaf stem counts for June 2, 2005 for four sites and two depths at each site (locations are shown in Figure 1). Plant data collected by Steve McComas and Jo Stuckert, Blue Water Science, June 2, 2005. Medicine Lake was treated on April 19 and 21, 2005. Typical plant length was 21-27 inches with 10 or 11 nodes. Secchi disc transparency was 6.0 feet.

Site	1		2		3		4	
GPS Coord (UTM)	6 ft: 04 66 009 E 49 84 608 N		6 ft: 04 67 355 E 49 83 876 N		6 ft: 04 67 873E 49 82 510 N		6 ft: 04 66 880 E 49 82 657 N	
Quadrat	Stem Density (#/m^2)		Stem Density (#/m^2)		Stem Density (#/m^2)		Stem Density (#/m^2)	
	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 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	0	0	0	0	0
Average Curlyleaf Stem Density	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***

Results of Sampling on April 24, and May 25, 2006

Stem Densities: Stem densities on April 24, 2006, ranged from 0 to 320 stems/m^2. In three out of the four stations, stem densities were higher in the 6-foot sample area compared to the 9-foot depth (Table 5).

Biomass: Curlyleaf biomass estimates ranged from 1.3 g-dry wt/m^2 at Site 2 to 12.7 g-dry wt/m^2 at Site 3. Site 1 had the lowest curlyleaf biomass of the four sites.

Table 5. Medicine Lake curlyleaf stem counts for April 24, 2006 for four sites and two depths at each site (locations are shown in Figure 1). Plant data collected by Steve McComas and Jo Stuckert, Blue Water Science, April 24, 2006. Medicine Lake was treated on April 18, 2005. Typical plant length was 21-27 inches with 10 or 11 nodes. Secchi disc transparency was 7.1 feet.

	Site							
	1		2		3		4	
GPS Coord (UTM)	6 ft: 04 66 007 E 49 84 595 N		6 ft: 04 67 348 E 49 83 915 N		6 ft: 04 67 897 E 49 82 499 N		6 ft: 04 66 850 E 49 82 660 N	
Quadrat	Stem Density (#/m^2)		Stem Density (#/m^2)		Stem Density (#/m^2)		Stem Density (#/m^2)	
	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft
1	50	60	210	20	140	60	120	20
2	70	50	260	40	190	170	190	20
3	90	80	190	30	150	110	180	50
4	0	0	320	20	70	70	40	20
5	0	0	190	30	90	120	190	20
6	0	90	130	20	180	80	110	10
7	0	100	250	30	160	70	80	0
8	10	0	130	0	220	70	130	0
9	20	0	180	30	240	110	90	10
10	0	0	190	0	150	140	80	0
Average Curlyleaf Stem Density	***24***	***38***	***205***	***22***	***159***	***100***	***121***	***15***
Average wt/stem (g)	***0.10***	***0.11***	***0.05***	***0.06***	***0.08***	***0.08***	***0.09***	***0.09***
Estimated Biomass (g/m^2)	***2.4***	***4.2***	***10.3***	***1.3***	***12.7***	***8.0***	***10.9***	***1.4***

Stem Densities: Curlyleaf pondweed was found at Sites 2, 3, and 4 on May 25, 2006 (Table 6). Site 3 had the highest density of curlyleaf pondweed at both 6-foot and 9-foot depths.

Biomass: Curlyleaf biomass estimates ranged from 0 g-dry wt/m^2 to 36.3 g/m^2 at Site 3. Although significant biomass was found at Site 3, no turions were present and it is possible the plants were close to dying back.

Table 6. Medicine Lake curlyleaf stem counts for May 25, 2006 for four sites and two depths at each site (locations are shown in Figure 1). Plant data collected by Steve McComas and Jo Stuckert, Blue Water Science, May 25, 2006. Medicine Lake was treated on April 18, 2006.

	Site							
	1		2		3		4	
GPS Coord (UTM)	**6 ft: 04 66 009 E 49 84 608 N**		**6 ft: 04 67 355 E 49 83 876 N**		**6 ft: 04 67 873E 49 82 510 N**		**6 ft: 04 66 880 E 49 82 657 N**	
Quadrat	**Stem Density (#/m^2)**		**Stem Density (#/m^2)**		**Stem Density (#/m^2)**		**Stem Density (#/m^2)**	
	6 ft	**9 ft**	**6 ft**	**9 ft**	**6 ft**	**9 ft**	**6 ft**	**9 ft**
1	0	0	20	40	70	80	130	0
2	0	0	0	50	30	140	0	0
3	0	0	0	0	0	90	0	0
4	0	0	0	0	10	30	0	0
5	0	0	0	0	20	210	40	0
6	0	0	40	30	120	60	50	0
7	0	0	0	0	50	40	40	0
8	0	0	20	0	90	120	60	0
9	0	0	0	50	180	0	180	0
10	0	0	60	0	90	20	0	0
Average Curlyleaf Stem Density (#/0.1 m^2)	***0***	***0***	***14***	***17***	***66***	***79***	***50***	***0***
Average wt/stem (g)	***--***	***--***	***0.12***	***0.19***	***0.46***	***0.46***	***0.18***	***--***
Estimated Biomass (g/m^2)	***0***	***0***	***1.7***	***3.2***	***30.4***	***36.3***	***9.0***	***0***

Results of Sampling on April 17 and May 30, 2007

A summary from each of the four sampling sites for curlyleaf pondweed stem densities for 2007 conditions is shown in Tables 7 and 8. Stem density results for April 17, 2007 were lower compared to stem densities on May 30, 2007. Eurasian watermilfoil stem densities were high in several quadrats on April 17, 2007.

Table 7. Medicine Lake curlyleaf stem counts for April 17, 2007 for four sites and two depths at each site (locations are shown in Figure 1). Plant data collected by Steve McComas and Jo Stuckert, Blue Water Science, April 17, 2007. Secchi disc transparency was 5.4 feet.

CURLYLEAF PONDWEED STEM DENSITIES - APRIL 17, 2007

	Site							
	1		2		3		4	
GPS Coord (UTM)(NAD 27)	E 04 63 978 N 49 84 560		E 04 67 443 N 49 83 809		E 04 67 861 N 49 82 421		E 04 66 836 N 49 82 735	
Quadrat	Stem Density (#/m²)		Stem Density (#/m²)		Stem Density (#/m²)		Stem Density (#/m²)	
	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft
1	10	40	30	0	20	40	0	40
2	0	10	60	0	20	0	0	0
3	0	10	0	30	10	0	100	0
4	0	20	0	50	0	0	60	0
5	0	0	0	0	0	60	40	60
6	0	0	30	0	0	0	40	20
7	0	0	50	50	0	0	30	0
8	0	0	0	0	0	0	0	0
9	0	40	0	0	0	20	0	40
10	0	20	0	20	0	0	20	0
Average Curlyleaf Stem Density (stems/m²)	***1***	***14***	***17***	***15***	***5***	***12***	***29***	***16***

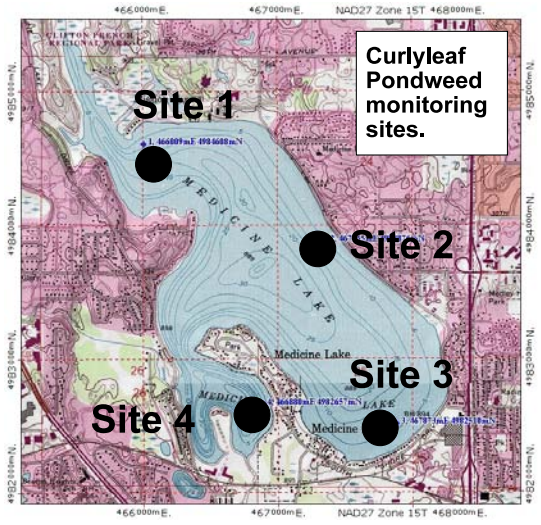
EURASIAN WATERMILFOIL STEM DENSITIES - APRIL 17, 2007

	Site							
	1		2		3		4	
GPS Coord (UTM)(NAD 27)	E 04 63 978 N 49 84 560		E 04 67 443 N 49 83 809		E 04 67 861 N 49 82 421		E 04 66 836 N 49 82 735	
Quadrat	Stem Density (#/m²)		Stem Density (#/m²)		Stem Density (#/m²)		Stem Density (#/m²)	
	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft
1	10	0	40	20	40	0	0	0
2	0	0	20	30	60	30	0	0
3	0	20	30	0	40	60	0	0
4	0	70	40	0	30	60	20	20
5	0	30	50	0	20	20	20	0
6	0	0	0	30	60	0	10	0
7	0	0	20	20	80	0	0	10
8	0	20	50	0	40	40	0	0
9	0	10	40	40	60	90	0	0
10	0	0	0	20	0	20	0	20
Average Eurasian Watermilfoil Stem Density (stems/m²)	***1***	***15***	***29***	***16***	***43***	***32***	***5***	***5***

Table 8. Medicine Lake curlyleaf stem counts for May 30, 2007 for four sites and two depths at each site (locations are shown in Figure 1). Plant data collected by Steve McComas, Blue Water Science, May 30, 2007. Red shading indicates stem densities at nuisance densities (>150 stems/m^2).

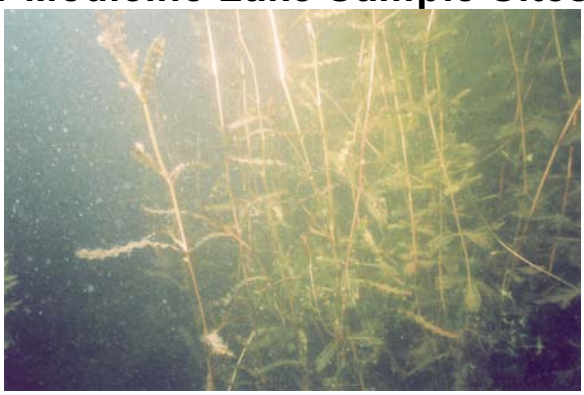
CURLYLEAF PONDWEED STEM DENSITIES - MAY 30, 2007

	Site							
	1		2		3		4	
GPS Coord (UTM)(NAD 27)	E 04 63 978 N 49 84 560		E 04 67 443 N 49 83 809		E 04 67 861 N 49 82 421		E 04 66 836 N 49 82 735	
Quadrat	Stem Density (#/m^2)		Stem Density (#/m^2)		Stem Density (#/m^2)		Stem Density (#/m^2)	
	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft
1	0	90	10	70	30	250	30	40
2	0	140	110	60	30	300	40	0
3	0	40	90	170	10	400	30	0
4	20	140	50	40	60	230	30	0
5	90	0	100	0	0	140	0	0
6	140	0	130	70	0	320	0	0
7	60	0	60	60	30	210	0	0
8	0	70	40	100	40	280	30	0
9	100	130	100	120	130	250	30	20
10	0	200	80	140	0	320	10	30
Average Curlyleaf Stem Density (stems/m^2)	***41***	***81***	***77***	***83***	***33***	***270***	***20***	***9***



Photographic Inventory of Four Medicine Lake Sample Sites, 2007

SITE 1: April 17, 2007



SITE 1: May 30, 2007

SITE 2: April 17, 2007

SITE 2: May 30, 2007

SITE 3: April 17, 2007

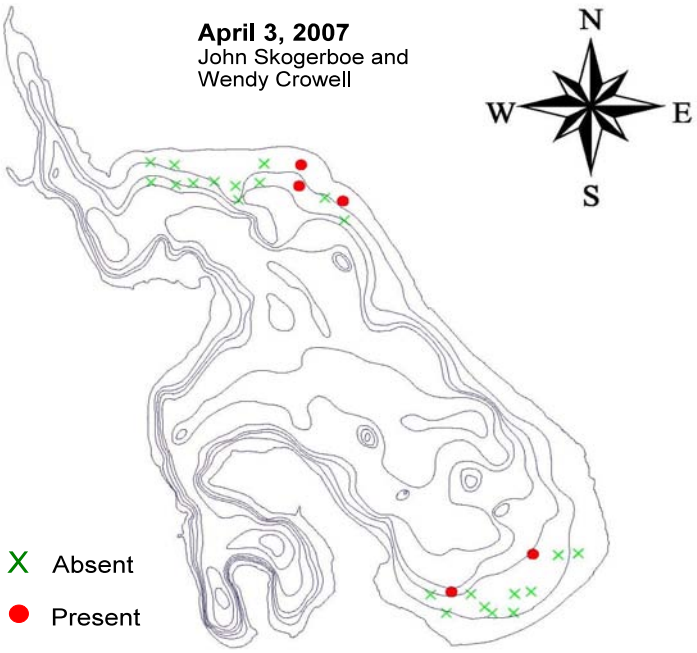
SITE 3: May 30, 2007

SITE 4: April 17, 2007

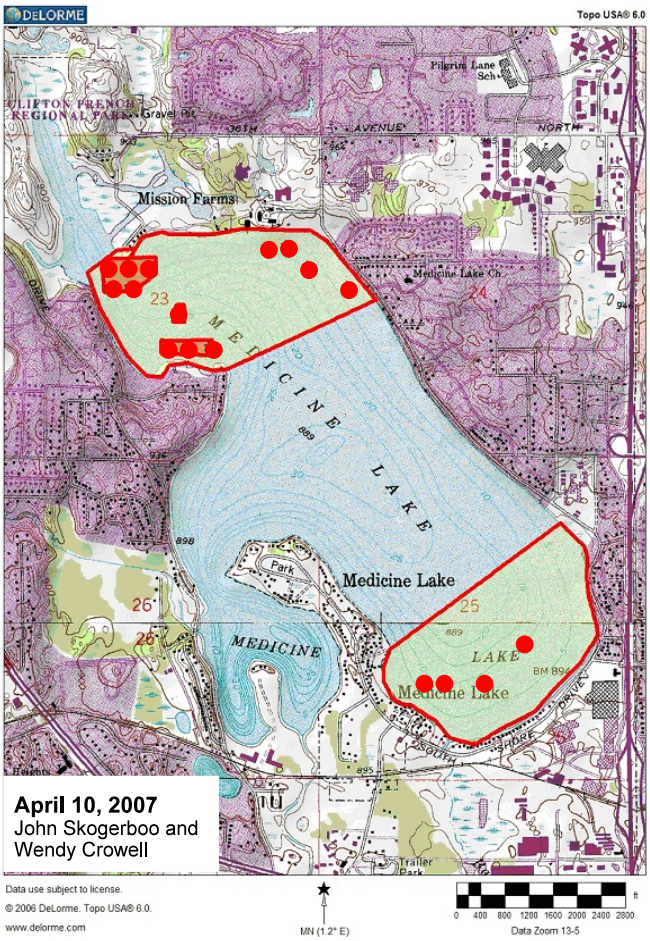
SITE 4: May 30, 2007

Curlyleaf Pondweed Growth Characteristics in 2007

On the first lake visit of 2007, curlyleaf was rare on April 3. On the next visit on April 10, curlyleaf was more abundant on April 10. Curlyleaf sampling was conducted by John Skogerboe, US ACE, and Wendy Crowell, MnDNR.



(prepared by MnDNR)



(prepared by the US Army Corps of Engineers)

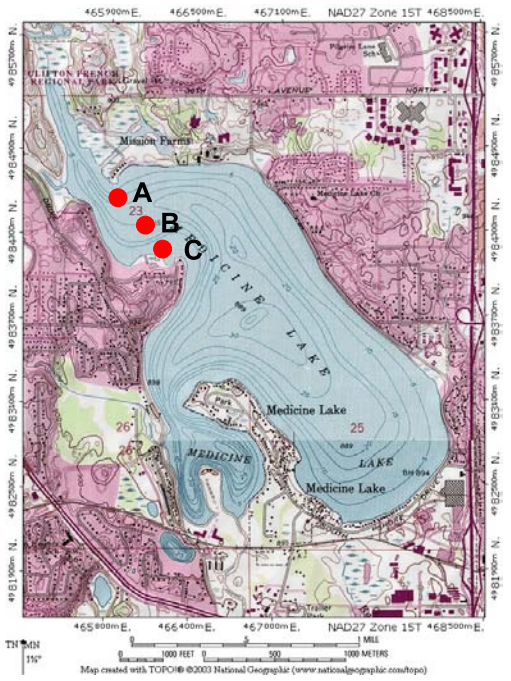
Early April plant evaluations were conducted to assess the status of curlyleaf pondweed at several locations in Medicine Lake in 2007. After ice-out, curlyleaf has the potential to spread and grow rapidly.

Medicine Lake Curlyleaf Pondweed Check April 27, 2007

Based on a curlyleaf assessment in mid-April, by John Skogerboe, U.S.Army Corps of Engineers, three sites were delineated as having curlyleaf at densities high enough to consider treatment. These three sites in Medicine Lake were monitored on April 27, 2007 by Blue Water Science to check curlyleaf pondweed densities. The three sites are labeled A, B, and C (see map below) and stem densities were determined at sites A and C by scuba diving methods (Table 9). Site A has stem densities averaging over 150 stems/m2 at a 6-foot depth. Site C averaged less than 150 stems/m2 based on 10 quadrat readings. However, out of the 10 readings, several individual quadrat densities were approaching nuisance densities. The total acreage of nuisance growth for sites A, B, and C was estimated at about 15 acres.

Table 9. Medicine Lake curlyleaf stem counts for April 27, 2007 for two sites (locations are shown on the map). Plant data collected by Steve McComas and Jo Stuckert, Blue Water Science, April 27, 2007. Secchi disc transparency was 7.2 feet.

	Site				
	A			C	
GPS Coord (UTM) Zone: NAD 27	E 04 65 900 N 49 84 580			E 04 66 836 N 49 82 735	
Quadrat	Stem Density (#/m²)			Stem Density (#/m²)	
	4 ft	5 ft	6 ft	5 ft	6-7 ft
1	30	100	250	110	20
2	50	80	160	110	40
3	10	80	100	120	20
4	20	60	80	130	30
5	0	40	180	80	0
6	0	0	230	60	0
7	0	0	300	0	0
8	0	0	320	0	0
9	0	0	0	0	0
10	0	0	0	0	0
Average Curlyleaf Stem Density (stems/m²)	***11***	***36***	***162***	***61***	***11***
MnDNR Rating	***0 - 1***	***2***	***2 - 3***	***2***	***1***
Stems on Rake	***1***	***2 - 3***	***8 - 12***	***2 - 3***	***1***



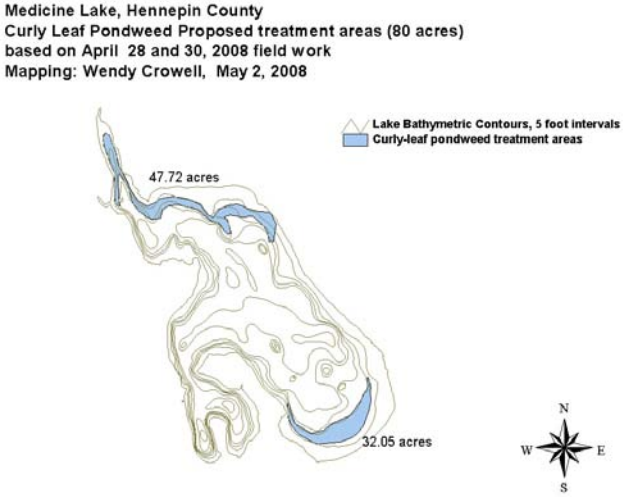
Results of Sampling May 4 and June 9, 2008

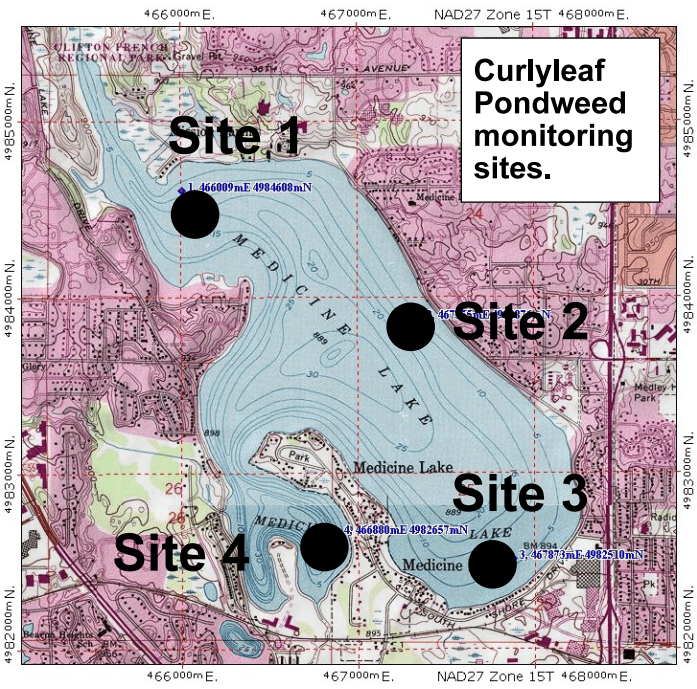
Curlyleaf Stem Densities: A summary from each of the four sampling sites for curlyleaf pondweed stem densities for 2008 conditions is shown in Tables 10 and 11. Stem density results for May 4, 2008 were high for a number of readings at Sites 1 and 2. At other locations, curlyleaf was below nuisance densities (150 stems/m^2 or more are defined as a nuisance).

Table 10. Medicine Lake curlyleaf stem counts for May 4, 2008 for four sites and two depths at each site (locations are shown in Figure 1). Plant data collected by Steve McComas, Blue Water Science, May 4, 2008. Secchi disc transparency was 4 feet.

CURLYLEAF PONDWEED STEM DENSITIES - MAY 4, 2008

	Site							
	1		2		3		4	
GPS Coord (UTM)(NAD 27)	E 04 63 978 N 49 84 560		E 04 67 443 N 49 83 809		E 04 67 861 N 49 82 421		E 04 66 836 N 49 82 735	
Quadrat	Stem Density (#/m^2)		Stem Density (#/m^2)		Stem Density (#/m^2)		Stem Density (#/m^2)	
	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft
1	50	310	60	480	0	30	20	30
2	200	50	30	100	40	20	10	0
3	210	60	0	150	20	20	0	20
4	40	0	10	40	10	40	0	10
5	80	40	7	0	20	50	10	0
6	80	180	40	10	30	0	40	50
7	120	80	50	160	20	20	50	0
8	260	120	10	240	20	10	30	30
9	140	0	20	40	10	0	70	10
10	280	320	30	110	0	0	20	0
Average Curlyleaf Stem Density (stems/m^2)	***146***	***116***	***32***	***133***	***17***	***19***	***25***	***15***





About a month later, on June 9, 2008, stem densities increased at 7 of 8 sites sampled. Stem densities declined at the 9 ft depth on Site 2. For Sites 1 and 3, stems were brown and lying down. They did not appear to be viable, however they were still counted.

Eurasian watermilfoil was common in the sites as well (Table 11).

Table 11. Medicine Lake curlyleaf stem counts for June 9, 2008 for four sites and two depths at each site (locations are shown in Figure 1). Plant data collected by Steve McComas, Blue Water Science, June 9, 2008. Red shading indicates stem densities at nuisance densities (>150 stems/m^2). Stem densities shown in parentheses represent non-viable stems.

CURLYLEAF PONDWEED STEM DENSITIES - JUNE 9, 2008

	Site							
	1		2		3		4	
GPS Coord (UTM)(NAD 27)	E 04 63 978 N 49 84 560		E 04 67 443 N 49 83 809		E 04 67 861 N 49 82 421		E 04 66 836 N 49 82 735	
Quadrat	Stem Density (#/m^2)		Stem Density (#/m^2)		Stem Density (#/m^2)		Stem Density (#/m^2)	
	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft
1	0 (130)	0 (190)	10	40	0 (100)	0 (200)	180	660
2	0 (300)	0 (27)	0	60	0 (120)	0 (250)	150	750
3	0 (300)	0 (210)	10	80	0 (70)	0 (100)	530	530
4	0 (290)	0 (120)	10	140	0 (0)	0 (310)	300	510
5	0 (260)	0 (40)	70	0	0 (30)	0 (0)	400	630
6	0 (80)	0 (140)	40	160	0 (80)	0 (50)	350	380
7	0 (160)	0 (110)	140	0	0 (250)	0 (220)	400	230
8	0 (330)	0 (310)	180	50	0 (310)	0 (0)	480	360
9	0 (400)	0 (280)	80	10	0 (150)	0 (70)	160	420
10	0 (110)	0 (300)	50	40	0 (40)	0 (140)	180	330
Average Curlyleaf Stem Density (stems/m^2)	***0 (236)***	***0 (197)***	***59***	***58***	***0 (115)***	***0 (134)***	***323***	***480***

EURASIAN WATERMILFOIL STEM DENSITIES - JUNE 9, 2008

	Site							
	1		2		3		4	
GPS Coord (UTM)(NAD 27)	E 04 63 978 N 49 84 560		E 04 67 443 N 49 83 809		E 04 67 861 N 49 82 421		E 04 66 836 N 49 82 735	
Quadrat	Stem Density (#/m^2)		Stem Density (#/m^2)		Stem Density (#/m^2)		Stem Density (#/m^2)	
	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft
1	30	10	40	100	10	10	0	0
2	50	50	60	120	20	10	0	0
3	30	10	60	80	0	10	0	0
4	50	10	80	160	0	0	10	10
5	150	20	60	80	10	0	10	10
6	110	40	80	40	10	60	0	10
7	80	0	0	60	30	30	0	0
8	20	0	100	100	60	20	0	0
9	20	0	60	90	80	40	0	0
10	0	0	20	50	30	0	0	0
Average Eurasian Watermilfoil Stem Density (stems/m^2)	***54***	***14***	***56***	***79***	***25***	***18***	***2***	***3***

Medicine Lake Curlyleaf Conditions in May and June, 2008

May 4, 2008	June 9, 2008
 Site 1, May 4, 2008	 Site 1, June 9, 2008
 Site 2, May 4, 2008	 Site 2, June 9, 2008
 Site 3, May 4, 2008	 Site 3, June 9, 2008
 Site 4, May 4, 2008	 Site 4, June 9, 2008

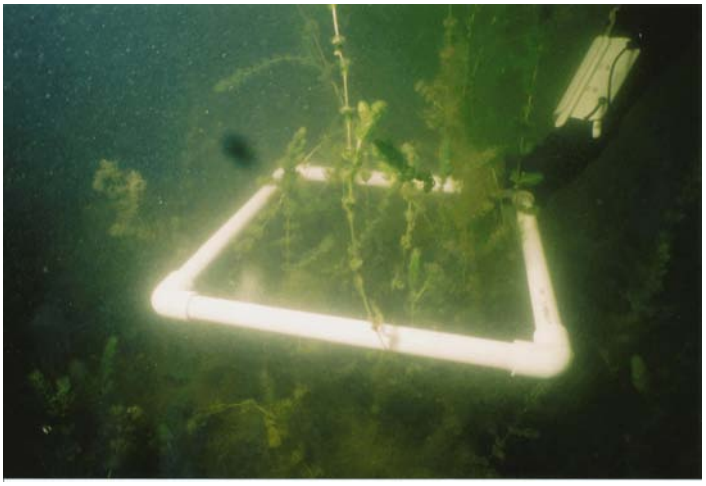
Results of Sampling April 22 and June 12, 2009

Curlyleaf Pondweed Densities in 2009: Curlyleaf stem densities were monitored on two dates in 2009, with sampling occurring in April and in June (Table 12). Herbicides were applied on May 1 in the areas of Sites 1, 3, and 4. On June 12, viable stems at all sites were found at a low density.

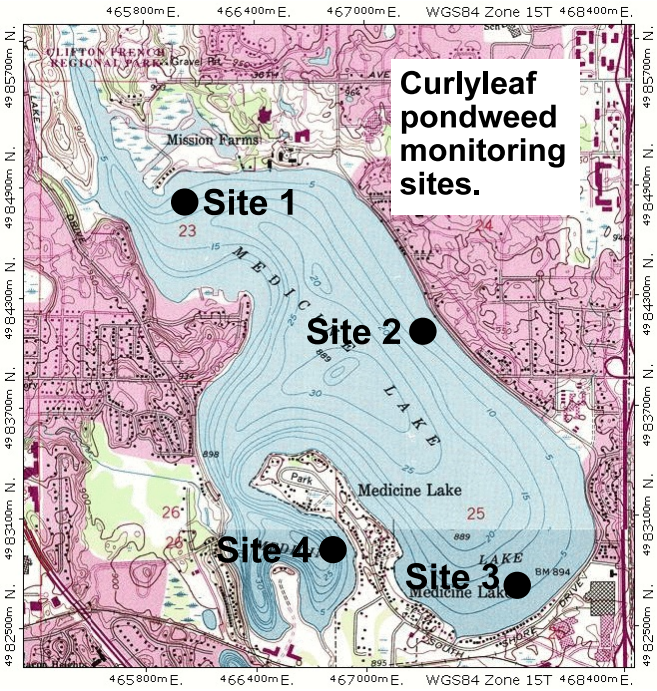
Curlyleaf was not found at the untreated site (Site 2) or at Site 3 on the June 12 sample date. Curlyleaf stem densities were light at the other two treatment sites (Sites 1 and 4) on the June 12 sample date.

Table 12. Curlyleaf pondweed stem densities at four sites in Medicine Lake in 2009.

		April 22, 2009	June 12, 2009
		Curlyleaf Stems (stems/m^2)	Curlyleaf Stems (stems/m^2)
Site 1	6 ft	54	5
	9 ft	32	2
Site 2 (untreated)	6 ft	19	0
	9 ft	23	0
Site 3	6 ft	1	0
	9 ft	4	0
Site 4	6 ft	66	0
	9 ft	31	9
Average		29	2
6 ft average		35	1
9 ft average		23	3



Curlyleaf dieback at Site 3 on June 12, 2009 after a herbicide treatment on May 1, 2009. No viable stems were observed at this location.



Two other aquatic plant species were also observed on April 22, 2009 and stem densities for Eurasian watermilfoil and coontail are shown in Table 13. Coontail was more common then milfoil at Sites 1, 3, and 4 and milfoil was more common at Site 2.

Table 13. Medicine Lake curlyleaf stem counts for April 22, 2009 for four sites and two depths at each site (locations are shown in Figure 1) for Eurasian watermilfoil and coontail.

EURASIAN WATERMILFOIL STEM DENSITIES - APRIL 22, 2009

	Site							
	1		2		3		4	
GPS Coord (UTM) Zone: WGS 84	E 04 65 992 N 49 84 810		E 04 67 349 N 49 84 127		E 04 67 839 N 49 82 737		E 04 66 841 N 49 82 904	
Quadrat	Stem Density (#/m²)		Stem Density (#/m²)		Stem Density (#/m²)		Stem Density (#/m²)	
	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft
1	0	0	30	0	0	0	0	0
2	0	0	30	40	10	0	0	0
3	30	10	10	0	0	0	40	10
4	30	20	0	0	20	0	10	0
5	20	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	0	0	10	30	0	0	0	0
8	0	0	0	60	0	0	0	0
9	0	0	0	50	0	0	0	0
10	0	0	0	10	0	0	0	0
Average Eurasian Watermilfoil Stem Density (stems/m²)	***8***	***3***	***8***	***19***	***3***	***0***	***5***	***1***

COONTAIL STEM DENSITIES - APRIL 22, 2009

	Site							
	1		2		3		4	
GPS Coord (UTM) Zone: WGS 84	E 04 65 992 N 49 84 810		E 04 67 349 N 49 84 127		E 04 67 839 N 49 82 737		E 04 66 841 N 49 82 904	
Quadrat	Stem Density (#/m²)		Stem Density (#/m²)		Stem Density (#/m²)		Stem Density (#/m²)	
	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft
1	0	0	0	0	50	50	0	30
2	30	0	0	20	50	50	0	40
3	0	0	0	0	50	50	0	0
4	0	0	0	0	50	50	0	0
5	20	20	0	0	50	50	40	40
6	20	20	0	0	60	60	40	40
7	20	20	0	0	60	60	40	40
8	20	20	0	0	60	60	40	40
9	20	20	0	0	60	60	40	40
10	20	20	0	0	60	60	40	40
Average Coontail Stem Density (stems/m²)	***15***	***12***	***0***	***2***	***55***	***55***	***24***	***31***

On June 12, 2009, two other aquatic plant species were observed and stem densities are shown in Table 14. Milfoil was abundant at Site 2 and was present but patchy at the other three sites. Coontail had moderate to heavy growth at Sites 1, 3, and 4 and had light growth at Site 2.

Table 14. Medicine Lake stem counts for Eurasian watermilfoil and coontail for June 12, 2009.

EURASIAN WATERMILFOIL STEM DENSITIES - JUNE 12, 2009

	Site							
	1		2		3		4	
GPS Coord (UTM) Zone: WGS 84	E 04 65 992 N 49 84 810		E 04 67 349 N 49 84 127		E 04 67 839 N 49 82 737		E 04 66 841 N 49 82 904	
Quadrat	Stem Density (#/m²)		Stem Density (#/m²)		Stem Density (#/m²)		Stem Density (#/m²)	
	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft
1	30	40	150	60	10	10	10	10
2	40	40	100	220	10	10	60	10
3	30	40	70	150	60	20	0	20
4	20	40	130	200	30	0	0	0
5	10	80	120	150	0	0	0	0
6	10	80	80	150	0	0	0	0
7	0	80	80	180	0	0	0	0
8	0	80	100	140	0	0	0	0
9	0	80	120	170	0	0	0	0
10	0	80	60	200	0	0	10	0
Average Eurasian Watermilfoil Stem Density (stems/m²)	***14***	***64***	***101***	***162***	***11***	***4***	***8***	***4***

COONTAIL STEM DENSITIES - JUNE 12, 2009

	Site							
	1		2		3		4	
GPS Coord (UTM) Zone: WGS 84	E 04 65 992 N 49 84 810		E 04 67 349 N 49 84 127		E 04 67 839 N 49 82 737		E 04 66 841 N 49 82 904	
Quadrat	Stem Density (#/m²)		Stem Density (#/m²)		Stem Density (#/m²)		Stem Density (#/m²)	
	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft
1	40	40	20	10	420	50	0	40
2	40	40	30	10	290	50	60	60
3	80	40	10	10	230	70	60	0
4	80	40	0	0	100	70	50	0
5	80	80	0	0	100	70	50	0
6	80	80	0	0	80	70	40	40
7	80	80	0	0	80	80	0	60
8	100	80	0	0	40	80	0	40
9	100	80	0	0	40	80	0	40
10	100	80	0	0	100	80	50	0
Average Coontail Stem Density (stems/m²)	***78***	***64***	***6***	***3***	***148***	***70***	***31***	***28***

Medicine Lake Curlyleaf Conditions in April and June, 2009

April 22, 2009

June 12, 2009