



Underwater View of Curlyleaf Pondweed in Medicine Lake, April 9, 2012

Curlyleaf Pondweed Assessment for Medicine Lake, Plymouth, Minnesota in 2012

	2004	2005	2006	2007	2008	2009	2010	2011	2012
Herbicide Application:	May 8-11	April 19, 21	April 18	no herbicide	May 12	May 1	April 23	May 9	May 10
Pre-Herbicide Plant Evaluation:	May 6	April 22	April 24	April 17	May 4	April 22	April 20	April 28	April 9
Post Herbicide Plant Evaluation and/or Curlyleaf Assessment	June 14	June 2	May 25	April 27, May 30	June 9	June 12	June 4	June 16	June 5
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	98.5 gallons 14.7 ac treated	405 gallons 59 ac treated

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Curlyleaf Pondweed Assessment for Medicine Lake, Plymouth, Minnesota in 2012

Overview: In Medicine Lake in 2012, curlyleaf pondweed growth was fairly widespread on the April 9, 2012 curlyleaf delineation. About 59 acres of curlyleaf were treated on May 10, 2012. A curlyleaf assessment was conducted on June 5, 2012 and most of the heavy growth of curlyleaf was controlled (Table 1).

Table 1. Curlyleaf pondweed treatment history in Medicine Lake from 2004-2012.

	Acres Treated with an Endothall Herbicide	Curlyleaf Control Result
2004	317	Complete control.
2005	325	Complete control.
2006	325	Complete control.
2007	0	Moderate to heavy regrowth.
2008	79.8	Good control.
2009	62.0	Good control.
2010	29.1	Good control.
2011	14.7	Poor control.
2012	59	Good control.

In Medicine Lake, a general curlyleaf growth pattern is beginning to emerge as yearly monitoring continues. Curlyleaf pondweed in Medicine Lake appears to exhibit heavy growth in the same areas at several locations on an annual basis. The areas of heavy growth are in the north and south ends and in the eastern side of the southwest lobe of the lake. In other areas, there are years of heavy growth and then years of light growth at the same location. The boom and bust growth cycles of curlyleaf pondweed in these specific areas are not well understood. It appears lake sediment conditions indicate an average long-term growth potential but predicting annual light or heavy growth of curlyleaf pondweed based on early season scouting remains challenging.

Recommendations for 2013: Heavy curlyleaf growth can hinder navigation and the curlyleaf dieback contributes nutrients to the water column that could be used by algae. This type of growth is the kind of growth that is considered for control. In 2013, if heavy curlyleaf growth is predicted based on an early season delineation, up to a maximum of 60 acres of heavy growth could be considered for treatment. In the future, for delineating areas to treat, the cumulative experience in Medicine Lake indicates if there are five or more curlyleaf stems collected on a rake sample in April there is a strong likelihood of heavy curlyleaf growth in that area in June. This approach could be used to help delineate areas to consider for treatment.

Curlyleaf Growth in 2012

Early Season Assessment: The entire nearshore area of Medicine Lake was surveyed and specific sampling and notes were taken at 11 sites on April 9, 2012. Curlyleaf pondweed stem densities were light, with the stems collected with a rake sample usually numbering less than 5 stems per rake. At several sites, curlyleaf stem densities were found at 5 stems/rake or greater with a maximum of 12 stems/rake (Table 2). A rake typically samples an area of about 0.1 m². Therefore stem densities were generally less than 50 stems/m² with a couple of areas having densities of around 100 stems/m². Based on the April 9, 2012 scouting results, treatment areas were delineated for herbicide applications.

Treatment: Six treatment areas with a total treatment area of 59 acres were treated using an endothall herbicide on May 10, 2012.

Follow-Up Assessment: On June 5, 2012, the entire nearshore area of Medicine Lake was surveyed and areas of heavy curlyleaf growth were noted (Table 2). Although 59 acres of curlyleaf were treated, control in treated areas was good and overall curlyleaf growth was mostly light.



Representative heavy growth of curlyleaf pondweed from an underwater perspective in Medicine Lake on April 18, 2012, prior to the 2012 herbicide treatment.

Table 2. Observations of curlyleaf pondweed density for April 9 and June 5, 2012.

Treatment Site	Depth (ft)	April 9, 2012 Map					June 5, 2012 Map			Notes
		Curlyleaf Density (scale 1 to 5)	Curlyleaf Stems on the Rake Sampler	Acres of Curlyleaf	Coontail Density	Eurasian Watermilfoil Density	Curlyleaf Density (scale 1 to 5)	Eurasian Watermilfoil Density (scale 1 to 5)	Coontail Density	
1	5	2	12	11.6 acres			0	3 - 4		
	5	2.5	20							
	6	2.5	15							
2	7.8	3	20-30	23.4 acres	1		0	2		
	7.8	3	20-25							
	8	3	20+							
3	10	1	6-7	2.8 acres		2				
4	7.5	1	4-5	2.6 acres	1					
5	7			1.4 acres			light	5		Some curlyleaf is alive, 3-4 feet below the surface.. Treatment was fair not good.
6	4	2	10-14	1.8 acres			0			Good control on curlyleaf however close to shore filamentous algae at density 4-5.
7	5	1	4-8	2.8 acres			0			Curlyleaf control is good, curlyleaf is all knocked down.
8	8	2	10-18	4.5 acres			0	2 - 3		Curlyleaf control is good.
	8	2	10-12							
	4.5	1	6-8							
	7	2	10-20							
9	4	1.5	6-8	5.2 acres			0	1 - 3		Curlyleaf is dead.
	8	1	6-8							
10	4	2	12	8.6 acres			0			Curlyleaf is gone. Good control.
11	8	3	9	9.0 acres			0		light	Good control. No curlyleaf standing.
	8	3	20							

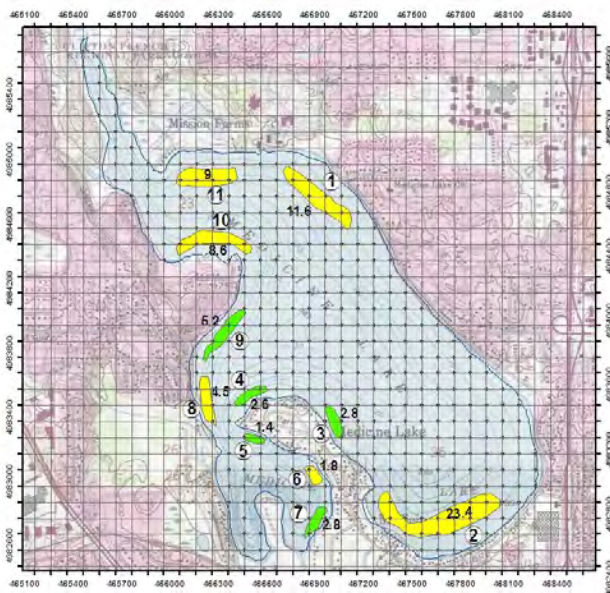


Figure 1a. Curlyleaf pondweed density at various sites on April 9, 2012 is shown with green shading = light growth, yellow shading = moderate growth. Curlyleaf was treated at the yellow shaded sites totaling 59 acres on May 30, 2012.

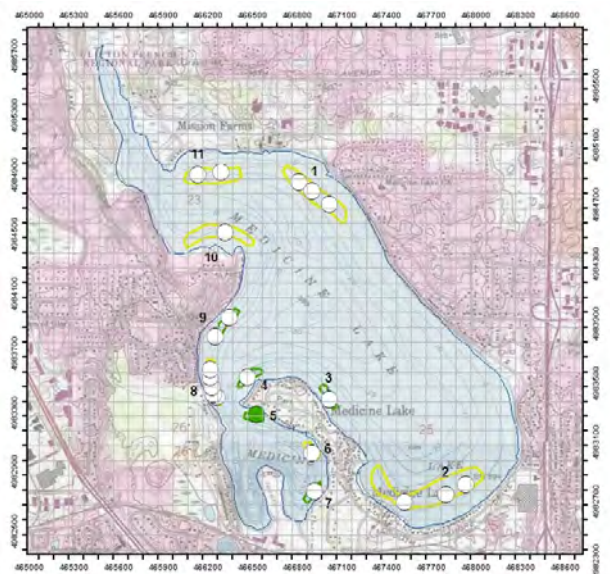


Figure 1b. Curlyleaf pondweed density at various sites on June 5, 2012 is shown with green shading = light growth, yellow shading = moderate growth. Curlyleaf was treated at the yellow shaded sites totaling 59 acres on May 30, 2012.

Curlyleaf Pondweed Growth Characteristics in April and June 2012

The methods for predicting the expansion and growth of curlyleaf pondweed for early season to late season is ongoing. In Medicine Lake, curlyleaf growth in 2012 was heavier than expected based on the April 9, 2012 assessment (Figure 3).

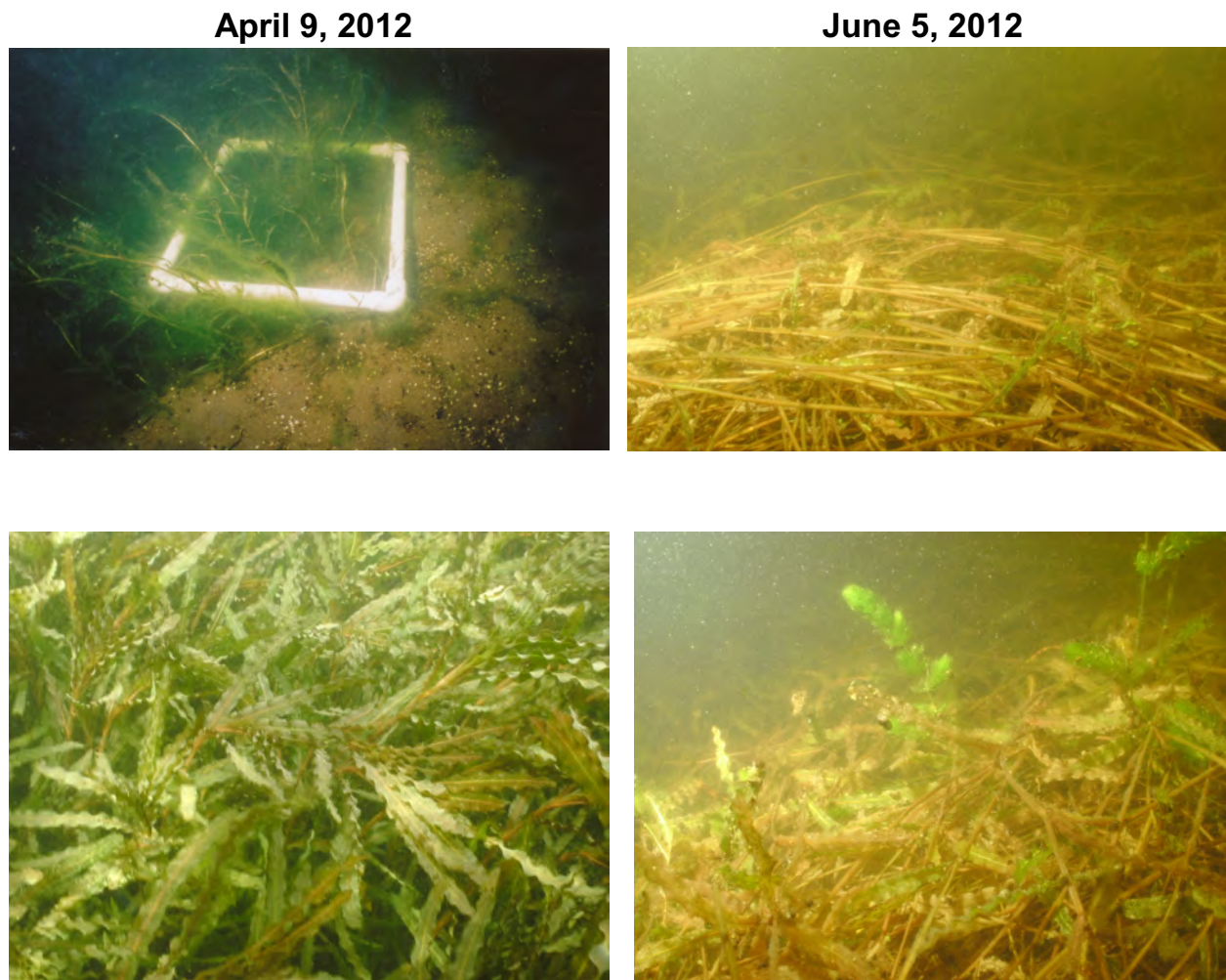


Figure 2. [left] Curlyleaf stem densities in April. [right] On June 5, 2012, viable curlyleaf growth was relatively rare in Medicine Lake.

Curlyleaf Pondweed Treatment and Response in 2012

In 2004, there was significant curlyleaf pondweed growth in Medicine Lake (Figure 3). This was the first year of an aggressive curlyleaf treatment program that ran from 2004-2006. There was no treatment in 2007 and curlyleaf started to grow back. Partial treatments have occurred from 2008-2012.

In 2012, 59 acres were treated and there was good control of heavy growth of CLP (Figures 4 and 5).

Curlyleaf Conditions Prior to Herbicide Treatment in 2004

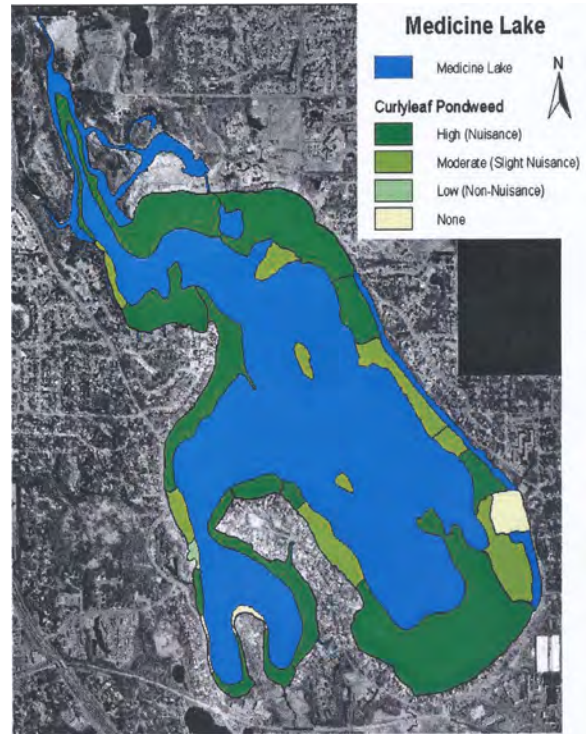


Figure 3. Curlyleaf density and distribution in 2004 (Source: Three Rivers Park District).

2012 Curlyleaf Treatment of 59 acres on May 10, 2012



Figure 4. Treatment areas are shown with red lines.

2012 Curlyleaf Growth on June 5, 2012

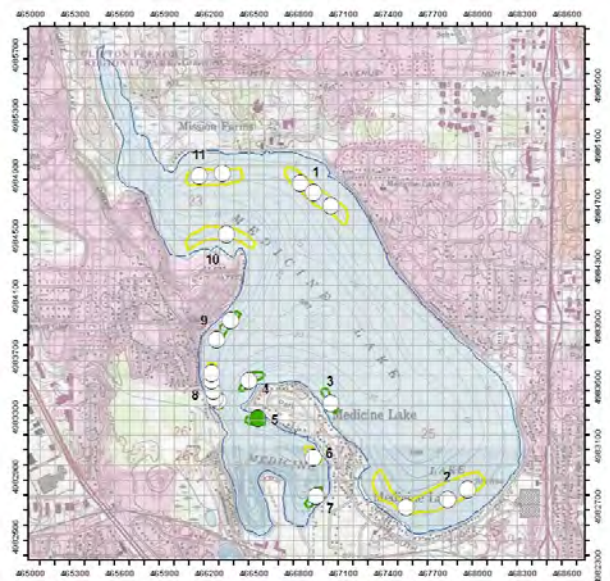


Figure 5. Curlyleaf densities on June 5, 2012 are shown with dots. White dots = no curlyleaf, green dots = light growth. No heavy curlyleaf growth was observed.

Comparing Curlyleaf Growth from 2010 to 2012

In 2010, curlyleaf control was fairly effective (Table 3 and Figure 6) with a small acreage of heavy growth found on June 7, 2010 (in a plant survey conducted by Three Rivers Park District)(Figure 6). In 2011, treatments did not control all the heavy growth of curlyleaf pondweed. After treatment in 2011, there were about 65 acres of heavy curlyleaf growth in June of 2011 compared to about 5 acres of heavy curlyleaf growth in June of 2010. In 2012, the curlyleaf control was overall good. Only a few live stems of curlyleaf were found during the June 5 survey.

Table 3. Curlyleaf pondweed density on a scale from 1 to 5 with 5 the densest. NC = not checked.

Site	2010*		2011		2012	
	April 20	June 4	April 28	June 16	April 9	June 5
1	0-1	1	1	4.5	2.5	0
2	NC	1	0	1	3	0
3	NC	1	1	1	1	0
3.5	NC	2	NC	5	NC	NC
4	0-1	2	0	5	1	0
4.1	NC	2	NC	5	NC	NC
4.5	NC	1	NC	5	NC	NC
5	0	1	0	0		0
6	1	1	0	2	2	0
6.5	NC	1	NC	4	NC	NC
7	0-1	1	0	0	1	0
8	1	1	1-2	5	2	0
9	0-1	2	1-2	4.5	1.5	0
9.5	0-1.5	1	NC	0	NC	NC
10	1	1	1	1-4	2	0
10.5	0-0.5	1	NC	2-4	NC	NC
11	1-2	2	1	1-5	3	0
12	1	2	1-2	4-5	NC	NC
13	0	1	1	1-2	NC	NC
13.5	1-2	2	NC	2-5	NC	NC
14	1-2	1	1	1-2	NC	NC
14.5	NC	1	NC	2-5	NC	NC
15	1-2	1	1-2	4-5	NC	NC
16	1-1.5	2	1-2	5	NC	NC
17	1-2	3.5	1-2	4-5	NC	NC

* sites in 2010 correspond to sites in 2011

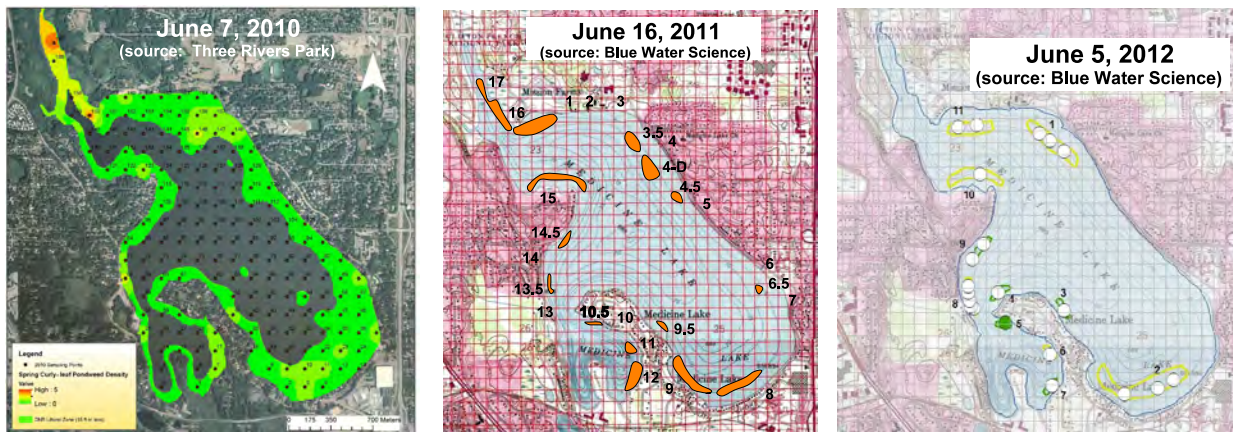
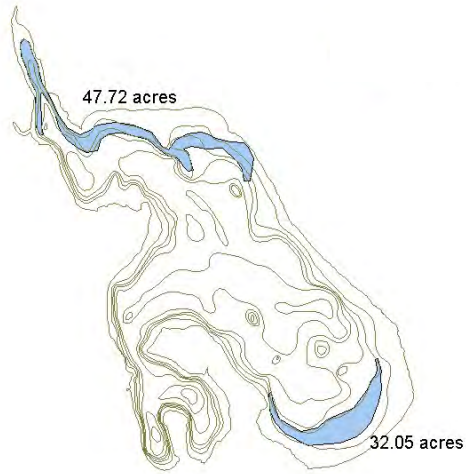


Figure 6. [left] Curlyleaf density on June 7, 2010. Orange shading represents a high density of curlyleaf growth (source: Three Rivers Park District). [middle] Curlyleaf density on June 16, 2011. Orange shading represents a high density of curlyleaf growth. [right] Curlyleaf density on June 5, 2012. White circles indicate sample locations, no curly leaf was found.

Curlyleaf Pondweed Treatment Areas from 2008-2012

2008 Curlyleaf Treatment - 80 acres



2009 Curlyleaf Treatment - 62 acres



2010 Curlyleaf Treatment - 29.1 acres



2011 Curlyleaf Treatment - 14.7 acres



2012 Curlyleaf Treatment - 59 acres



Tracking Curlyleaf Pondweed Density at Four Locations from 2004-2012

Curlyleaf stem densities at four locations were evaluated with scuba diving and quadrat sampling in 2012 (Figures 7 and 8). These same four locations have been checked since 2004. In 2012, Sites 1 through 4 were treated and stem densities decreased from April to June, indicating the herbicide application was effective.

Table 4. Curlyleaf pondweed stem densities at four sites in Medicine Lake in 2012.

		April 18, 2012	June 5, 2012
		Curlyleaf Stems (stems/m ²)	Curlyleaf Stems (stems/m ²)
Site 1	6 ft	463	0
	9 ft	367	0
Site 2	6 ft	250	0
	9 ft	177	5
Site 3	6 ft	443	0
	9 ft	517	0
Site 4	6 ft	454	0
	9 ft	101	0
Average		347	0.6
6 ft average		403	0
9 ft average		291	1.3



Figure 7. A quadrat is a square frame laid down on the bottom. All plant stems within the 0.1 m² square are counted.

2012 Curlyleaf Treatment - 59 acres

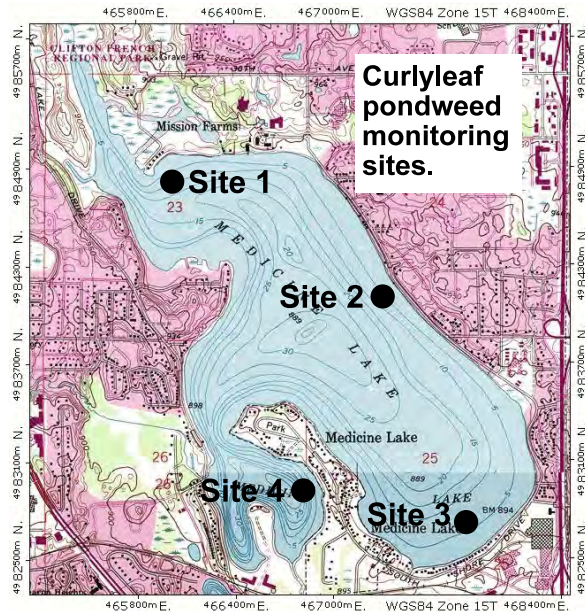


Figure 8. [left] Curlyleaf treatment areas are shown with red shading. [right] Curlyleaf monitoring sites to collect stem densities are shown with black dots.

Underwater Curlyleaf Pondweed Growth Characteristics in 2012

April 18, 2012

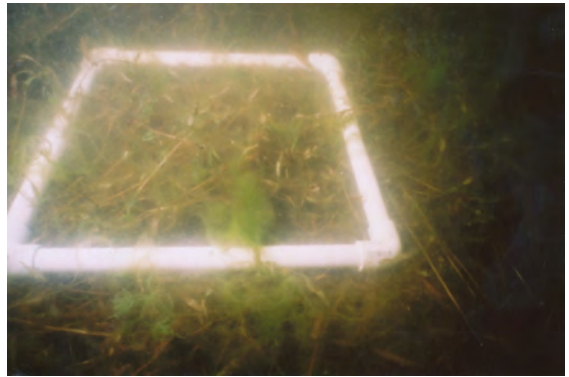


Site 1

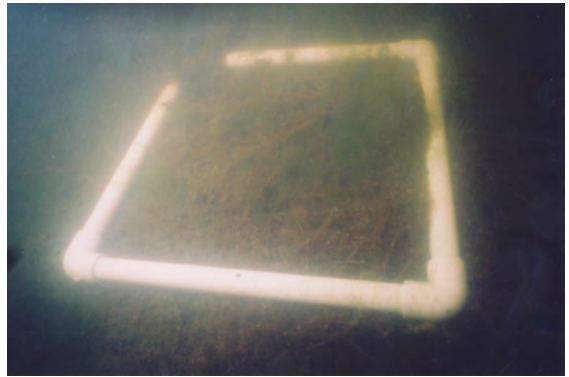
June 5, 2012



Site 2



Site 3



Site 4



Curlyleaf Pondweed Densities at Four Sites from 2004 - 2012: A summary of curlyleaf pondweed stem densities from the four permanent sample sites that have been monitored since 2004 is shown in Table 5. Stem densities at all four sites were high at the start of the curlyleaf control program in 2004 (Table 5). 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 - 2012 were compared to the May 6, 2004 measurements (Table 5).

The three consecutive years of herbicide treatment (2004, 2005, 2006) reduced the early season curlyleaf stem densities in Medicine Lake. Curlyleaf was not treated in 2007 and the late season curlyleaf stem densities increased at 3 out of 4 sites. Early season stem densities increased in 2008 compared to 2007 indicating curlyleaf stem density was coming back in 3 out of 4 sites that were not treated in 2007. Two sites were treated in 2008 with good control. At the untreated Site 4, curlyleaf increased from the early to late season sampling. In 2009, three sites were treated, and late season 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 (Table 5 and Figure 9) .

In 2011, the same three sites were treated that were treated in 2010 and 2009. However, in 2011, curlyleaf stem density control was not nearly as effective as compared to 2009 and 2010.

In 2012, Sites 1, 3, and 4 were treated and viable curlyleaf was not observed (Table 5). At Site 2, curlyleaf was not treated directly, but stem densities decreased from April to June.

Table 5. Summary of curlyleaf pondweed stem densities for early (typically April) and late season (typically June) 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
2011	early	24	2	28	89	36
	late	171	8	155	149	121
2012	early	415	214	480	278	347
	late	0	3	0	0	0.6

Medicine Lake

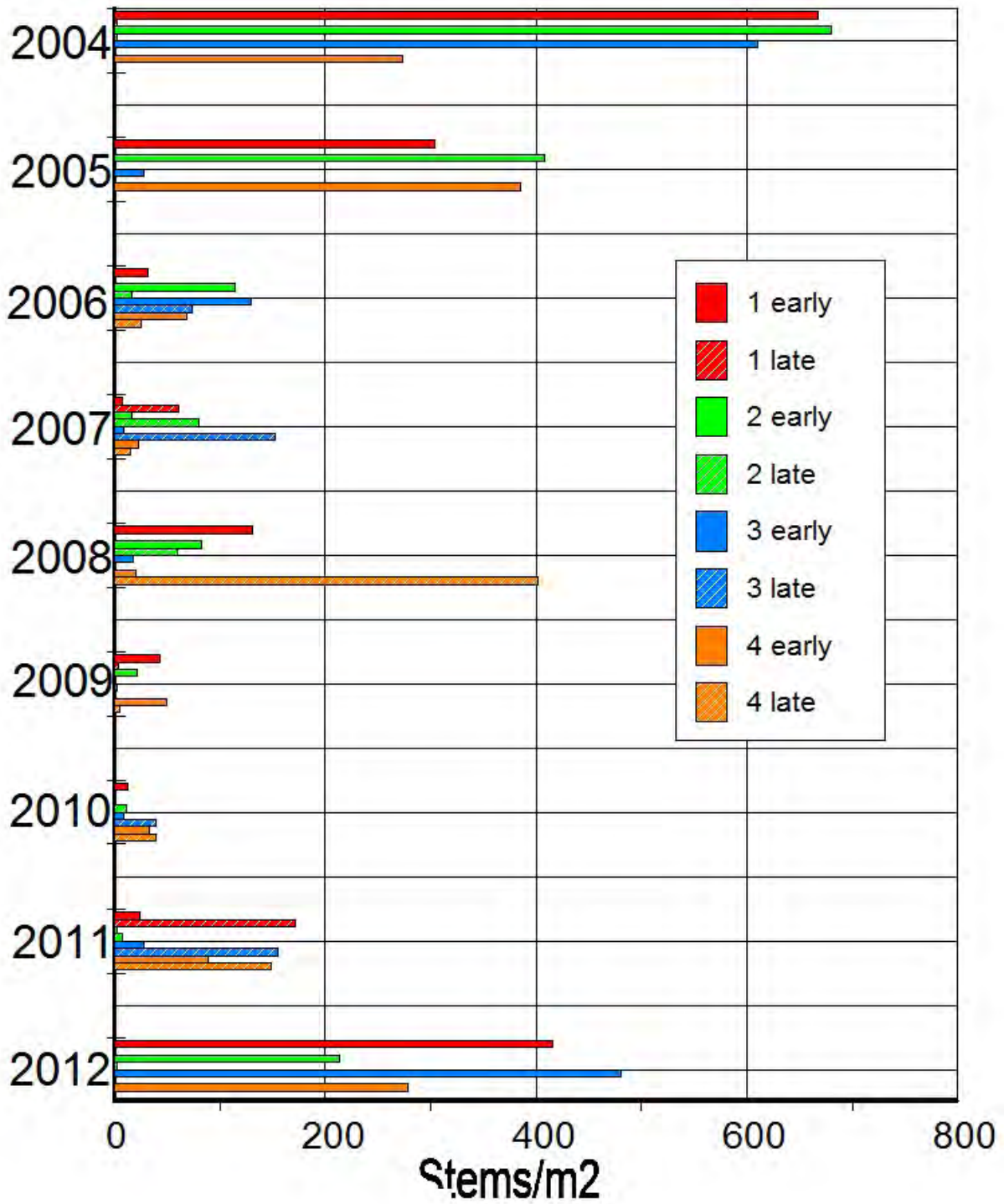


Figure 9. Medicine Lake curlyleaf pondweed stem densities from 2004-2012 for four sites for early and late spring conditions. Initial stem densities were high in 2004.

Discussion and Recommendations for 2013

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

Much was learned from this aggressive CLP distribution control program, chiefly, that a three-year lake-wide treatment would not keep curlyleaf from coming back in Medicine Lake. Starting in 2008, the CLP distribution control strategy changed to a CLP biomass control strategy, where only the heavy curlyleaf growth was treated using selective treatments. This CLP biomass control strategy has been employed from 2008 through 2012.

Selective treatments of 29 to 80 acres from 2008 to 2010 were effective for controlling heavy CLP growth. In 2011, 14.7 acres were treated and heavy CLP growth resulted in about 65 acres. This selective treatment attempt was not very effective. In 2012, a total of 59 acres of CLP was treated and no heavy growth of CLP was observed.

The 65 acres of heavy curlyleaf growth observed in 2011 is about the maximum that has been found in Medicine Lake in years past and is not likely to be greater than that amount, although curlyleaf growth could be present in other areas, but at light to moderate levels. A likely curlyleaf treatment range for 2013 is between 30 to 60 acres.

Predicting the exact acres of heavy growth with subsequent early season herbicide treatments remains challenging. It is recommended that in 2013, early season scouting should be combined with previous growth history and lake sediment information to delineate areas to treat. The CLP biomass control strategy which just treats areas of heavy growth is a more cost-effective and ecologically-sound option than the CLP distribution management strategy which treats all curlyleaf, regardless of growth status.

There appears to be a potential for ongoing heavy curlyleaf growth in specific areas in Medicine Lake. 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 Based on Lake Sediments

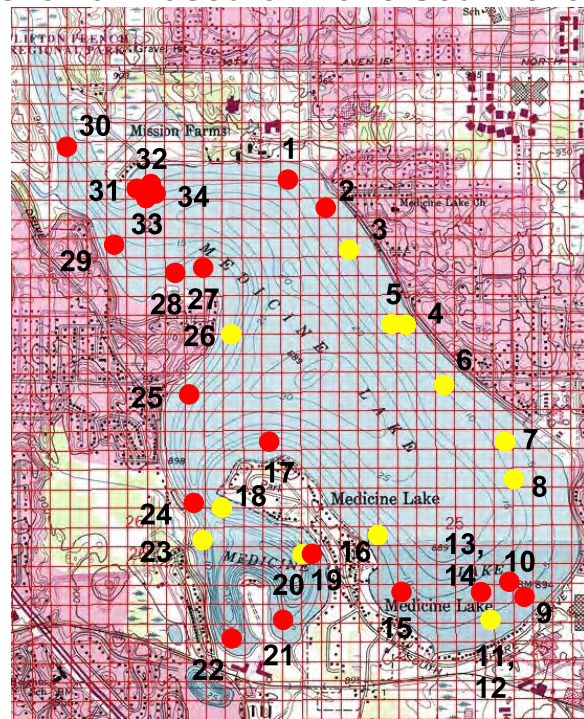


Figure 10. Sediment sample locations are shown with a circle. The circle color indicates the type of curlyleaf pondweed growth predicted to occur at that site. Key: green = light; yellow = moderate; red = heavy.

APPENDIX

Summary of Curlyleaf Pondweed Overall Treatment Results and Stem Density at Four Sites from 2004-2012

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 from 2008 through 2012 (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 then followed annually with selective treatments. Over the course of the curlyleaf control program, curlyleaf density and biomass have been 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 delineate treatment areas and to characterize the aquatic plant community.



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

Methods

Curlyleaf stem density has been sampled at four sites and at two depths on two dates from 2004 through 2012 (Table 1). The four site locations are shown in Figure 2.

Table 1. Sampling dates for the curlyleaf pondweed evaluation.

	2004	2005	2006	2007	2008	2009	2010	2011	2012
Herbicide Application:	May 8-11	April 19, 21	April 18	no herbicide	May 12	May 1	April 23	May 9	May 10
Pre-Herbicide Plant Evaluation:	May 6	April 22	April 24	April 17	May 4	April 22	April 20	April 28	April 9
Post Herbicide Plant Evaluation and/or Curlyleaf Assessment	June 14	June 2	May 25	April 27, May 30	June 9	June 12	June 4	June 16	June 5
Herbicide Use:	1,668 gallons, 317 ac treated	1,400 gallons, 325 ac treated	1,400 gallons, 325 ac treated	0 gallons (no herbicide s used)	345 gallons, 80 ac treated	415 gallons, 62 ac treated	194 gallons, 29 ac treated	98.5 gallons, 14.7 ac treated	405 gallons, 59 ac treated

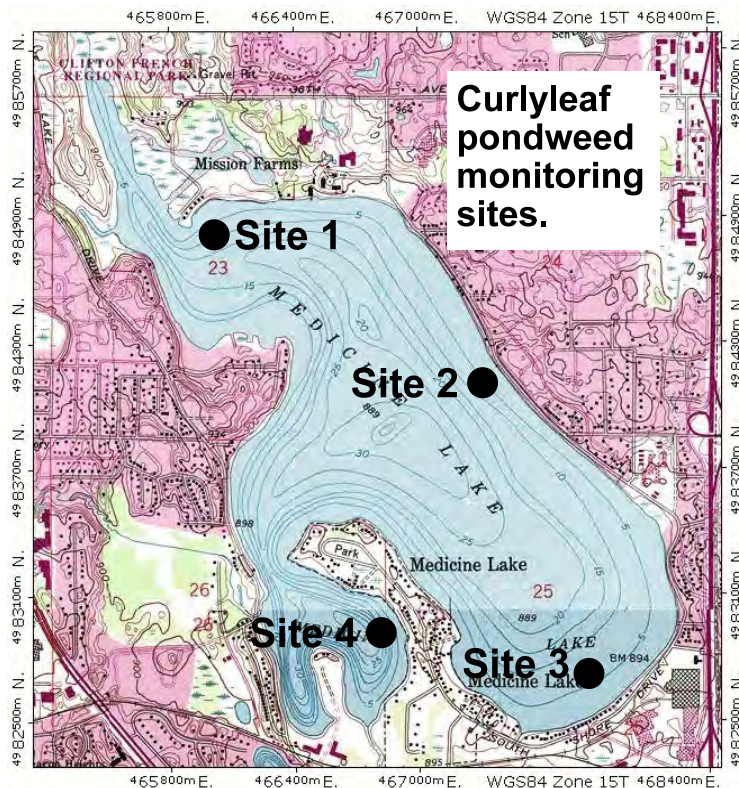


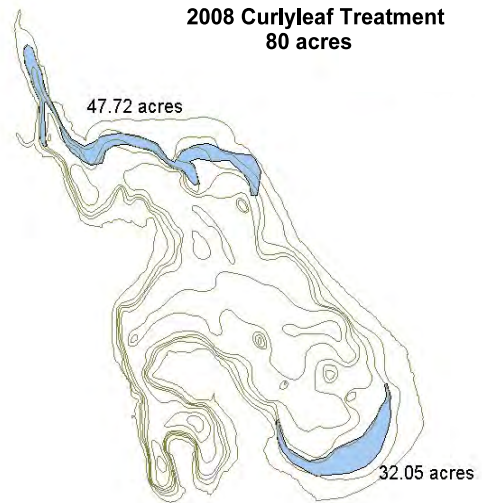
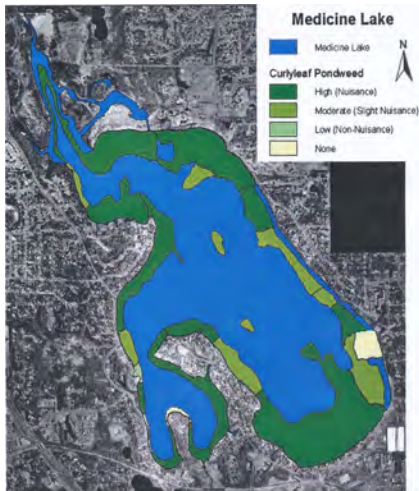
Figure 2. Site locations of four plant sampling sites. At each site, plants at 6 feet and 9 feet were sampled.

Stem Density 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 m² 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.



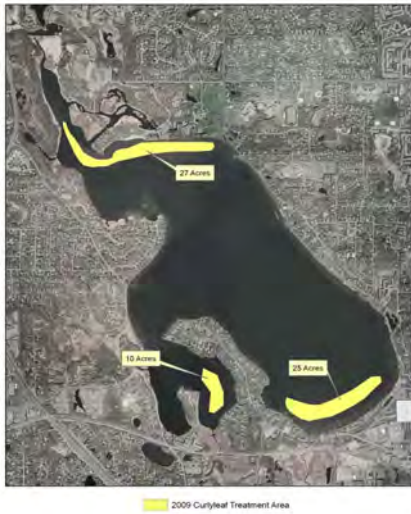
Figure 3. A 0.10 m² quadrat was used to quantify curlyleaf stem densities.

Curlyleaf Treatment Areas for 2004 - 2012



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

2009 Curlyleaf Treatment - 62 ac



2010 Curleaf Treatment Area 29.1 Acres



2011 Curlyleaf Treatment - 14.7 acres



2012 Curlyleaf Treatment - 59 acres



Figure 4. Maps of curlyleaf treatment areas for 2004-2006 (upper left) and for 2008-2012 show where curlyleaf was treated. There was no treatment in 2007.

Summary of Curlyleaf Pondweed Stem Densities for 2004-12

Table 2. 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
2011 (May 4)	35	1	15	135	47	12	3	41	43	25
2012 (April 18)	463	250	443	454	403	367	177	517	101	291

	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
2011 (June 16)	216	10	172	281	170	125	6	138	16	71
2012 (June 5)	0	0	0	0	0	0	5	0	0	1.3

Table 3. 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)	2011 (May 4)	2012 (April 18)
6 ft	643 (n=40)	419 (n=40)	127 (n=40)	13 (n=40)	55 (n=40)	35 (n=40)	19 (n=40)	47 (n=40)	403 (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)	25 (n=40)	291 (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)	2011 (June 16)	2012 (June 6)
6 ft	1 (n=40)	0 (n=40)	33 (n=40)	43 (n=40)	96 (n=40)	1 (n=40)	29 (n=40)	170 (n=40)	0 (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)	71 (n=40)	1.3 (n=40)

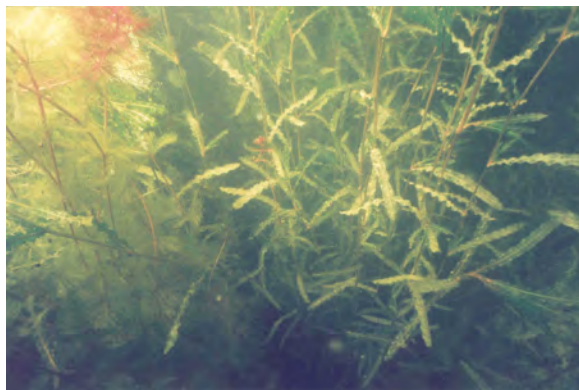
Medicine Lake Curlyleaf Pondweed Notes: 2004 to 2012

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/m²) 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.

In 2011, early season monitoring delineated 14.7 acres of curlyleaf to be treated. After the herbicide treatment, control was poor overall.



In 2012, early season monitoring delineated 59 acres of curlyleaf to be treated. After the herbicide treatment, control in the treated areas was good.

Figure 6. [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. Heavy curlyleaf growth has been limited in 2008, 2009, 2010, and 2012 with partial lake treatments.

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.

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.

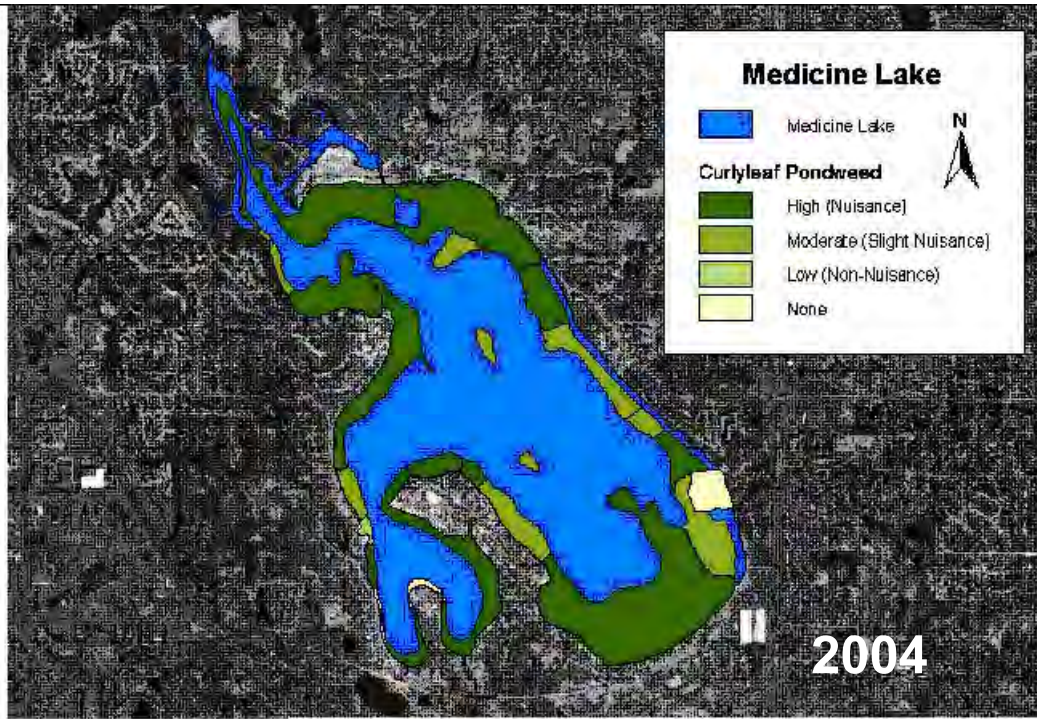
Table 6. Curlyleaf regrowth from seeds. Assume seed density of 1,445 seeds/m² and a germination rate of 0.001%. After turion production is re-established, assume 60% germination rate of turions (from Rogers and Breen 1980).

	Year 1	Year 2	Year 3
Early Season Stem Density (stems/m²)	0.01445 stems/m² (assume 0.001% germination of seeds and a seed density of 1,445 seeds/m ²)	0.87 stems/m² (assume 60% germination of 1.445 turions/m ² from Year 1)	52 stems/m² (assume 60% germination of 87 turions/m ² from Year 2)
Late Season Stem Density (stems/m²)	0.1445 stems/m² (runners produce 10 stems)	8.70 stems/m² (each sprouted turion produces runners and results in 10 stems/turion)	520 stems/m² (each sprouted turion produces 10 stems. 520 stems/m ² in year 3 represents heavy growth of curlyleaf)
Turions Produced (turions/m²)	1.445 turions/m² (each of the 10 stems produces 10 turions)	87 turions/m² (each of the 10 stems produces 10 turions)	5,200 turions/m² (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.

Aquatic Plant Conditions in the Early and Late Curlyleaf Season

Curlyleaf Pondweed Community in 2004 and 2007

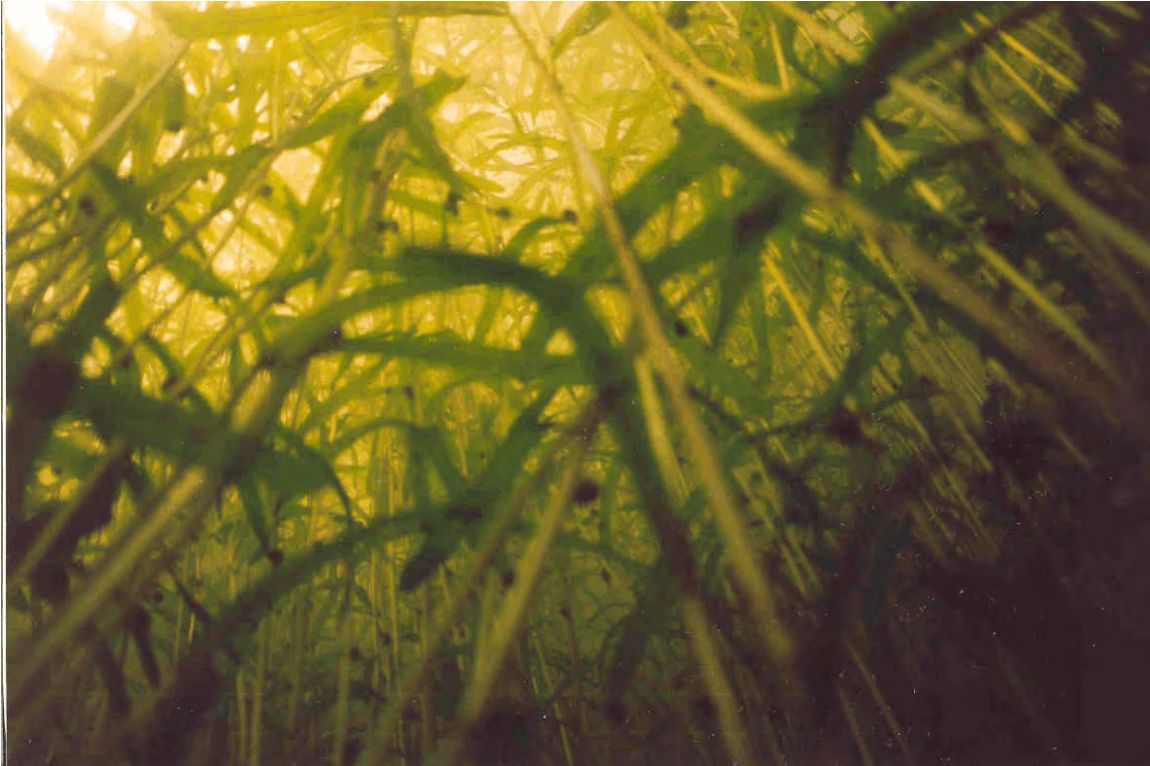


(prepared by Three Rivers Park District)



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

2004: Pre-herbicide Conditions



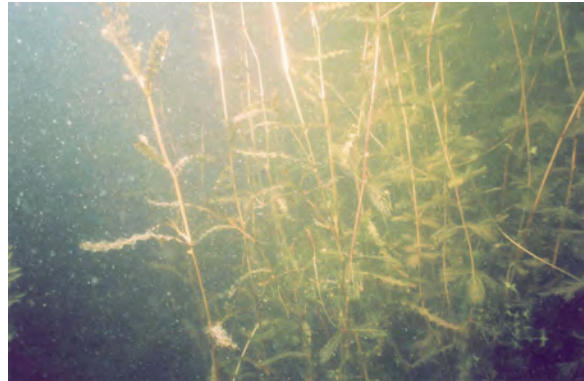
Site 1. [top] Curlyleaf was 2 to 3 feet tall on May 6, 2004.

[bottom] Stem densities in 6 feet of water were high averaging 555 stems/m².

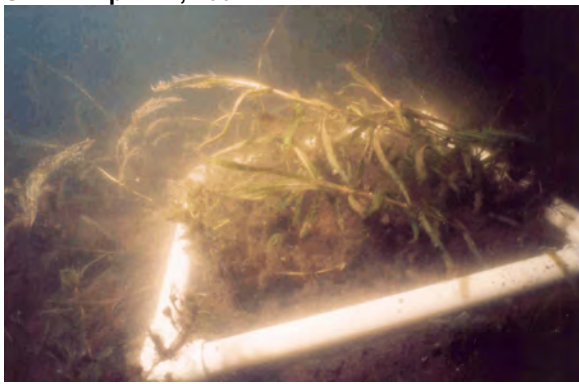
Photographic Inventory of Four Medicine Lake Sample Sites, 2007



SITE 1: April 17, 2007



SITE 1: May 30, 2007



SITE 2: April 17, 2007



SITE 2: May 30, 2007



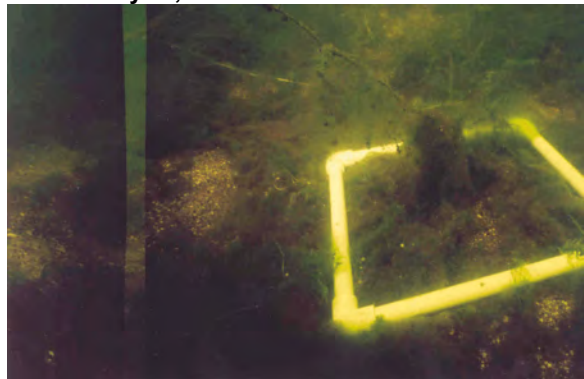
SITE 3: April 17, 2007



SITE 3: May 30, 2007



SITE 4: April 17, 2007



SITE 4: May 30, 2007

Medicine Lake Curlyleaf Conditions in May and June, 2008

May 4, 2008



Site 1, May 4, 2008

June 9, 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

Medicine Lake Curlyleaf Conditions in April and June, 2009

April 22, 2009

June 12, 2009



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 0.1m² quadrat.

Aquatic Plant Conditions in Early and Late Spring

April 20, 2010

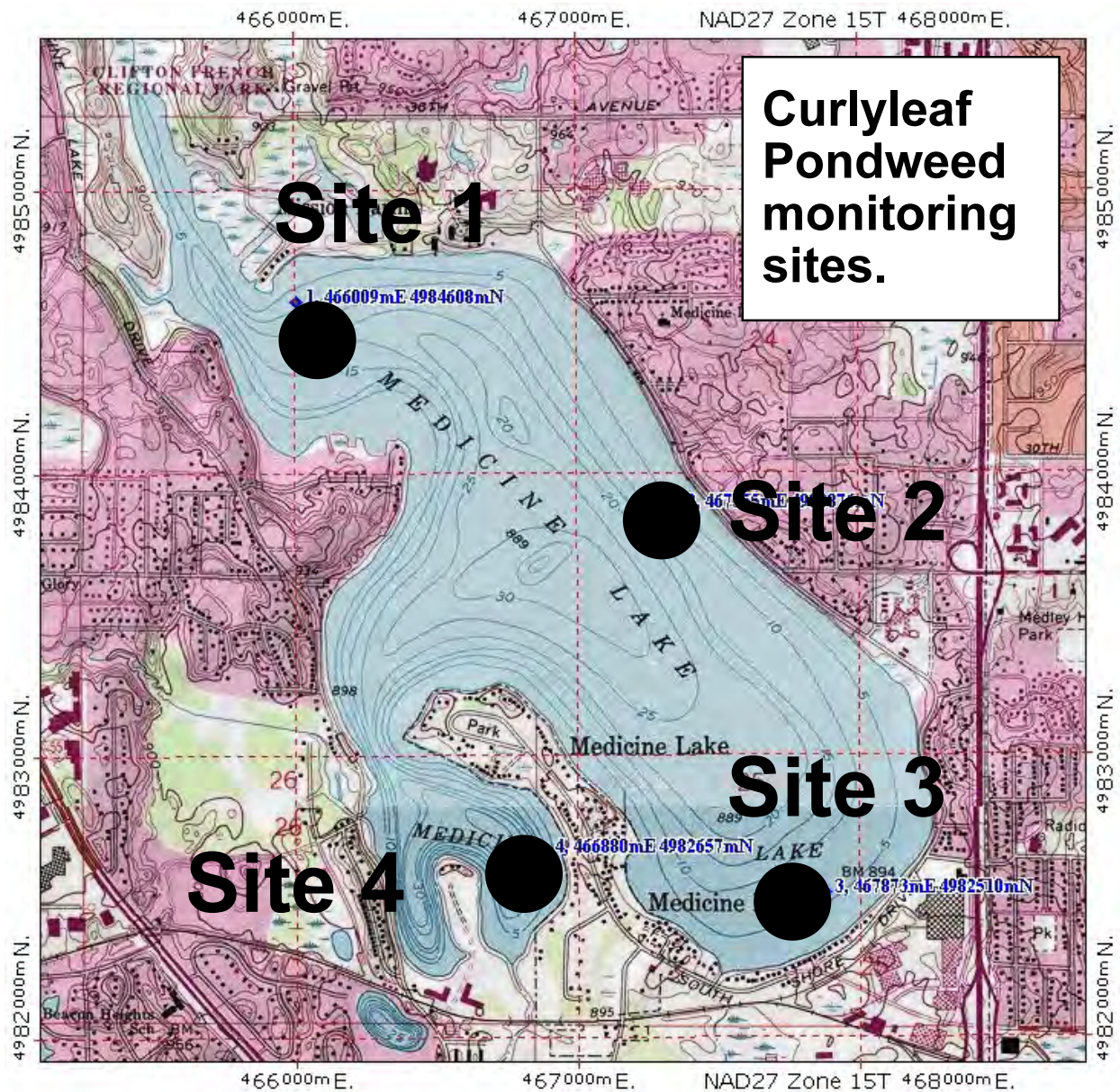


June 4, 2010



Figure 2. [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.

Curlyleaf Stem Densities in Early and Late Curlyleaf Season from 2004-2012



Results of Sampling on May 6 and June 14, 2004

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/m²) are shown in parentheses.

	Site							
	1		2		3		4	
	6 ft: 04 66 009 E 49 84 608 N		6 ft: 04 67 355 E 49 83 876 N		6 ft: 04 67 873 E 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/m²)	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	
	6 ft: 04 66 009 E 49 84 608 N		6 ft: 04 67 355 E 49 83 876 N		6 ft: 04 67 873 E 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/m²)	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.	

Results of Sampling on April 22 and June 2, 2005

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/m²)	45.7	26.9	72.0	19.4	0.6	3.9	58.5	14.1

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

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	
	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/m²)	2.4	4.2	10.3	1.3	12.7	8.0	10.9	1.4

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	
	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 m²)	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/m²)	0	0	1.7	3.2	30.4	36.3	9.0	0

Results of Sampling on April 17 and May 30, 2007

Table 7. Medicine Lake curlyleaf stem counts for four sites and two depths at each site. Plant data collected by Steve McComas and Jo Stuckert, Blue Water Science. Secchi disc transparency was 5.4 feet. Red shading indicates stem densities at nuisance conditions (>150 stems/m²).

CURLYLEAF PONDWEED STEM DENSITIES - APRIL 17, 2007

	Site							
	1		2		3		4	
	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	
GPS Coord (UTM)(NAD 27)	Stem Density (#/m ²)		Stem Density (#/m ²)		Stem Density (#/m ²)		Stem Density (#/m ²)	
Quadrat	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

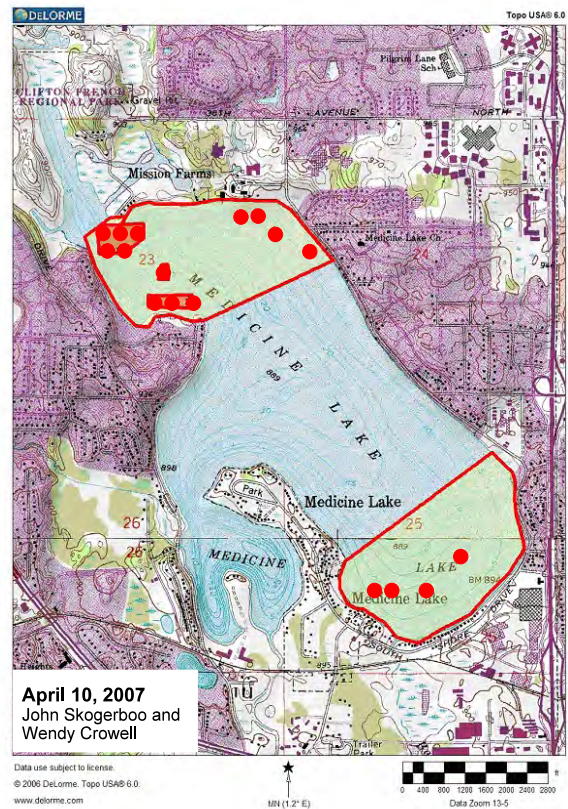
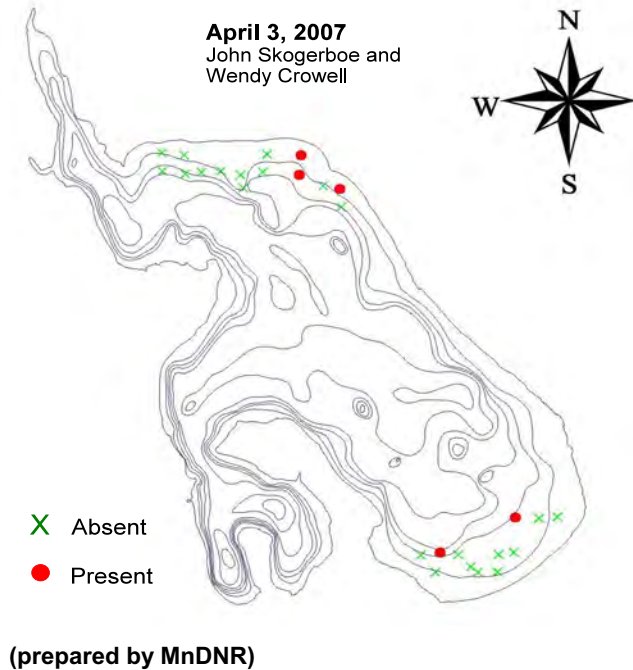
	Site							
	1		2		3		4	
	E 04 63 978 N 49 84 560		E 04 67 443 N 49 83 809		E 04 67 861 N 49 82 421		E 04 66 836 N 49 82 735	
GPS Coord (UTM)(NAD 27)	Stem Density (#/m ²)		Stem Density (#/m ²)		Stem Density (#/m ²)		Stem Density (#/m ²)	
Quadrat	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft
1	10	0	40	20	40	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

CURLYLEAF PONDWEED STEM DENSITIES - MAY 30, 2007

	Site							
	1		2		3		4	
	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	
GPS Coord (UTM)(NAD 27)	Stem Density (#/m ²)		Stem Density (#/m ²)		Stem Density (#/m ²)		Stem Density (#/m ²)	
Quadrat	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/m²)	41	81	77	83	33	270	20	9

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 the US Army Corps of Engineers)

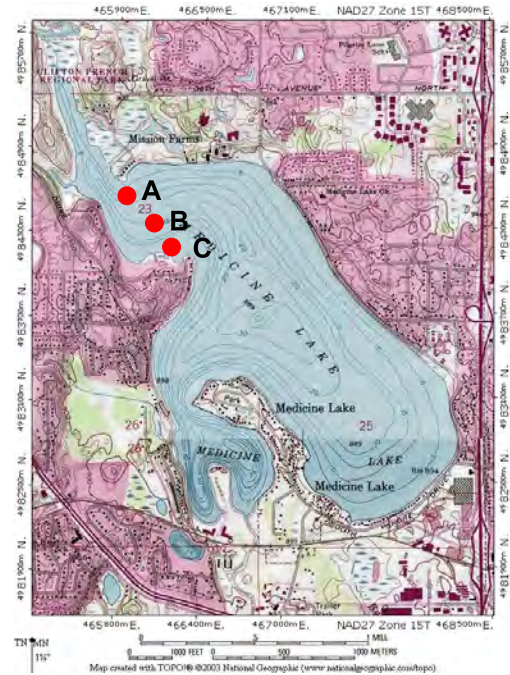
Early April plant evaluations were conducted to assess the status of curlyleaf pondweed at several locations in Medicine Lake in 2007. After ice-out, curlyleaf has the potential to spread and grow rapidly.

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 8). 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 8. 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.

GPS Coord (UTM) Zone: NAD 27	Site				
	A			C	
	E 04 65 900 N 49 84 580			E 04 66 836 N 49 82 735	
Quadrat	Stem Density (#/m ²)			Stem Density (#/m ²)	
	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 on May 4 and June 9, 2008

Table 9. 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

GPS Coord (UTM)(NAD 27)	Site							
	1		2		3		4	
	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/m²)	146	116	32	133	17	19	25	15

Medicine Lake, Hennepin County
Curly Leaf Pondweed Proposed treatment areas (80 acres)
based on April 28 and 30, 2008 field work
Mapping: Wendy Crowell, May 2, 2008

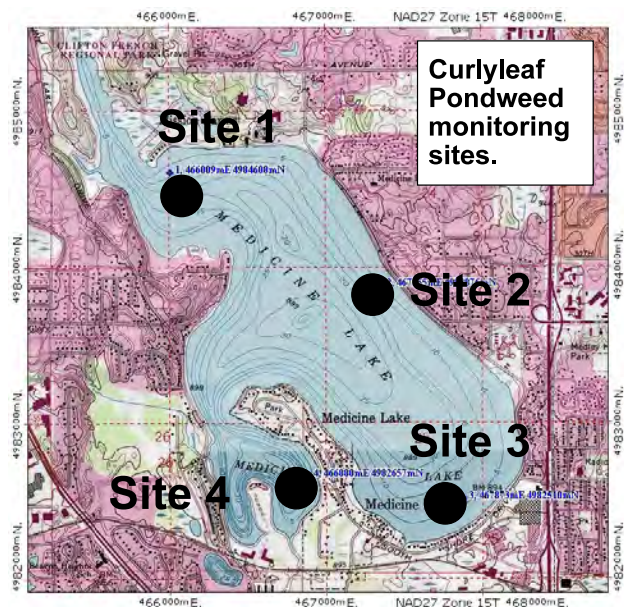
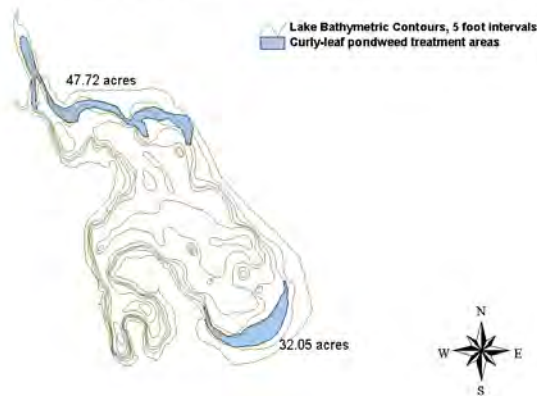


Table 10. Medicine Lake curlyleaf stem counts for June 9, 2008 for four sites and two depths at each site (locations are shown in Figure 1). Plant data collected by Steve McComas, Blue Water Science, June 9, 2008. Red shading indicates stem densities at nuisance densities (>150 stems/m²). Stem densities shown in parentheses represent non-viable stems.

CURLYLEAF PONDWEED STEM DENSITIES - JUNE 9, 2008

	Site							
	1		2		3		4	
	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	
GPS Coord (UTM)(NAD 27)	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/m²)	0 (236)	0 (197)	59	58	0 (115)	0 (134)	323	480

EURASIAN WATERMILFOIL STEM DENSITIES - JUNE 9, 2008

	Site							
	1		2		3		4	
	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	
GPS Coord (UTM)(NAD 27)	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/m²)	54	14	56	79	25	18	2	3

Results of Sampling on April 22 and June 12, 2009

Table 11. Medicine Lake curlyleaf stem counts for April 22, 2009 for four sites and two depths at each site (locations are shown in Figure 1).

CURLYLEAF PONDWEED STEM DENSITIES (stems per m²) - April 22, 2009

	Site							
	1		2		3		4	
	Stem Density		Stem Density		Stem Density		Stem Density	
GPS Coord (UTM) Zone: WGS 84	04 65 992 49 84 810		04 67 349 49 84 127		04 67 839 49 82 737		04 66 841 49 82 904	
Quadrat	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft
1	40	20	30	30	10	30	110	50
2	60	70	20	110	0	10	140	160
3	70	20	10	20	0	0	110	30
4	50	30	0	30	0	0	60	20
5	80	0	0	40	0	0	200	30
6	60	0	30	0	0	0	0	20
7	0	40	30	0	0	0	0	0
8	0	60	40	0	0	0	40	0
9	180	80	10	0	0	0	0	0
10	0	0	20	0	0	0	0	0
Average Curlyleaf Stem Density (stems/m²)	54	32	19	23	1	4	66	31

EURASIAN WATERMILFOIL STEM DENSITIES - APRIL 22, 2009

	Site							
	1		2		3		4	
	Stem Density (#/m ²)		Stem Density (#/m ²)		Stem Density (#/m ²)		Stem Density (#/m ²)	
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	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	
	Stem Density (#/m ²)		Stem Density (#/m ²)		Stem Density (#/m ²)		Stem Density (#/m ²)	
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	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

Table 12. Medicine Lake stem counts for June 12, 2009.

CURLYLEAF PONDWEED STEM DENSITIES - JUNE 12, 2009

	Site							
	1		2		3		4	
	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	
GPS Coord (UTM) Zone: WGS 84	Stem Density (#/m ²)		Stem Density (#/m ²)		Stem Density (#/m ²)		Stem Density (#/m ²)	
Quadrat	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft
1	10	10	0	0	0	0	0 (320)	60
2	20	10	0	0	0	0	0 (320)	30
3	10	20	0	0	0	0	0 (50)	0
4	10	10	0	0	0	0	0 (80)	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 (270)	0
9	0	0	0	0	0	0	0 (120)	0
10	0	0	0	0	0	0	0	0
Average Curlyleaf Stem Density (stems/m²)	5	5	0	0	0	0	0 (116)	9

EURASIAN WATERMILFOIL STEM DENSITIES - JUNE 12, 2009

	Site							
	1		2		3		4	
	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	
GPS Coord (UTM) Zone: WGS 84	Stem Density (#/m ²)		Stem Density (#/m ²)		Stem Density (#/m ²)		Stem Density (#/m ²)	
Quadrat	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	
	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	
GPS Coord (UTM) Zone: WGS 84	Stem Density (#/m ²)		Stem Density (#/m ²)		Stem Density (#/m ²)		Stem Density (#/m ²)	
Quadrat	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

Results of Sampling on April 20 and June 4, 2010

Table 13. 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 Springob, City of Plymouth.

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

	Site							
	1		2		3		4	
	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/m²)	16	9	1	1	11	7	48	15

EURASIAN WATERMILFOIL STEM DENSITIES - APRIL 20, 2010

	Site							
	1		2		3		4	
	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	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	
	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	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

Table 14. 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	
	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 (#/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	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

EURASIAN WATERMILFOIL STEM DENSITIES - JUNE 4, 2010

	Site							
	1		2		3		4	
	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 (#/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	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	
	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 (#/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	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

Results of Sampling on May 4 and June 16, 2011

Table 15. Medicine Lake curlyleaf stem counts for May 4, 2011 for Sites 1, 2, 3, and 4. Plant data collected by Kevin Springob, City of Plymouth and Steve McComas, Blue Water Science.

CURLYLEAF PONDWEED STEM DENSITIES (stems per m²) - MAY 4, 2011

	Site							
	1		2		3		4	
	Stem Density (#/m ²)		Stem Density (#/m ²)		Stem Density (#/m ²)		Stem Density (#/m ²)	
GPS Coord (UTM) Zone: WGS 84	E04 65 984 N49 84 840		E04 67 340 N49 84 115		E04 67 830 N49 82 686		E04 66 862 N49 82 857	
Quadrat	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft
1	20	30	10	30	30	80	100	80
2	30	30	0	0	0	60	120	100
3	30	10	0	0	0	50	180	60
4	0	0	0	0	20	30	200	50
5	80	0	0	0	20	60	180	30
6	80	30	0	0	0	0	140	40
7	0	20	0	0	0	10	50	0
8	30	0	0	0	10	40	80	30
9	10	0	0	0	40	50	140	30
10	40	0	0	0	30	30	160	10
Average Curlyleaf Stem Density (stems/m²)	35	12	1	3	15	41	135	43

Table 16. Medicine Lake curlyleaf stem counts for June 16, 2011 for four sites and two depths at each site (locations are shown in Figure 1). Plant data collected by Steve McComas, Blue Water Science.

CURLYLEAF PONDWEED STEM DENSITIES - JUNE 16, 2011

	Site							
	1		2		3		4	
	Stem Density (#/m ²)		Stem Density (#/m ²)		Stem Density (#/m ²)		Stem Density (#/m ²)	
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	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft	6 ft	9 ft
1	70	120	30	30	160	180	300	0
2	160	160	30	30	80	200	220	0
3	340	140	40	0	60	80	340	50
4	200	160	0	0	260	60	350	40
5	390	80	0	0	200	100	160	0
6	220	120	0	0	150	190	160	0
7	160	100	0	0	250	160	420	20
8	240	60	0	0	200	100	380	0
9	160	180	0	0	180	110	160	40
10	220	130	0	0	180	200	320	20
Average Curlyleaf Stem Density (stems/m²)	216	125	10	6	172	138	281	16

Results of Sampling on April 18 and June 5, 2012

Table 17. Medicine Lake curlyleaf stem counts for April 18, 2012 for four sites and two depths at each site. Plant data collected by Steve McComas, Blue Water Science.

CURLYLEAF PONDWEED STEM DENSITIES - APRIL 18, 2012

GPS Coord (UTM) Zone: WGS 84 Quadrat	Site							
	1		2		3		4	
	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	
	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	190	120	310	160	190	450	440	120
2	130	210	240	140	980	530	380	0
3	1120	140	280	270	410	470	300	160
4	340	310	320	250	480	400	350	170
5	500	400	130	230	530	620	400	210
6	560	610	140	180	180	580	410	80
7	200	580	100	60	500	490	610	70
8	650	300	210	100	450	580	850	100
9	250	520	300	170	320	410	190	60
10	690	480	470	210	390	640	640	40
Average Curlyleaf Stem Density (stems/m²)	463	367	250	177	443	517	457	101

Table 18. Medicine Lake curlyleaf stem counts for June 5, 2012 for four sites and two depths at each site. Plant data collected by Steve McComas, Blue Water Science.

CURLYLEAF PONDWEED STEM DENSITIES - JUNE 5, 2012

GPS Coord (UTM) Zone: WGS 84 Quadrat	Site												
	1			2				3			4		
	E 04 65 990 N 49 84 811			E 04 67 325 N 49 84 132				E 04 67 840 N 49 82 678			E 04 66 841 N 49 82 852		
	Stem Density (#/m ²)			Stem Density (#/m ²)				Stem Density (#/m ²)			Stem Density (#/m ²)		
	6 ft (alive)	6 ft (dead)	9 ft	6 ft (alive)	6 ft (dead)	9 ft (alive)	9 ft (dead)	6 ft (alive)	6 ft (dead)	9 ft (dead)	6 ft (alive)	6 ft (dead)	9 ft (dead)
1	0	270	0	0	140	10	40	0	280	150	0	550	400
2	0	190	0	0	160	30		0	370	200	0	280	350
3	0	160	0	0	200	10		0	140	--	0	240	520
4	0	260	0	0	180	0		0	230	--	0	260	250
5	0	340	0	0	120	0		0	140	--	0	290	380
6	0	--	0	0	120	0		0	--	--	0	--	--
7	0	--	0	0	80	0		0	--	--	0	--	--
8	0	--	0	0	160	0		0	--	--	0	--	--
9	0	--	0	0	180	0		0	--	--	0	--	--
10	0	--	0	0	130	0		0	--	--	0	--	--
Average Curlyleaf Stem Density (stems/m²)	0	244	0	0	147	5		0	232	175	0	324	380

CHARA (CH), COONTAIL (CN), AND EURASIAN WATERMILFOIL (EWM) STEM DENSITIES - JUNE 5, 2012

GPS Coord (UTM) Zone: WGS 84 Quadrat	Site																							
	1						2						3						4					
	E 04 65 990 N 49 84 811						E 04 67 325 N 49 84 132						E 04 67 840 N 49 82 678						E 04 66 841 N 49 82 852					
	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		
	CH	CN	EWM	CH	CN	EWM	CH	CN	EWM	CH	CN	EWM	CH	CN	EWM	CH	CN	EWM	CH	CN	EWM	CH	CN	EWM
1	0	0	0	0	0	0	0	0	50	0	0	30	0	0	30	0	0	20	0	50	0	0	20	0
2	0	0	0	0	0	0	0	0	40	0	0	20	0	0	0	0	0	10	0	70	0	0	10	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	110	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Average Stem Density (stems/m²)	0	0	0	0	0	0	0	0	9	0	0	5	0	0	3	0	0	3	0	27	0	0	3	0