Medicine Lake
Endothall Treatment to Control
Curlyleaf Pondweed
2005

Status Report
Prepared
By

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Background

Medicine Lake is an important resource within the City of Plymouth that receives a considerable amount of recreational use. The lake has a history of degraded water quality conditions that potentially inhibits recreational use. The City of Plymouth developed a Water Resources Management Plan in 2000 that identified Medicine Lake as a high priority resource that requires water quality improvements. A Medicine Lake subcommittee was established to develop and facilitate a comprehensive management plan to pro-actively address the water quality issues. Water quality goals were developed for Medicine Lake to provide guidelines in making management decisions that would improve in-lake water quality conditions. Currently, Medicine Lake water quality conditions do not meet the established water quality goals. Due to the poor water quality conditions, the Environmental Protection Agency (EPA) has also placed Medicine Lake onto the list of Impaired Waters for excess nutrients in 2004.

The Medicine Lake subcommittee determined that curlyleaf pondweed is a significant factor inhibiting recreational use as well as potentially degrading the in-lake water quality. Curlyleaf pondweed is an exotic species that typically competes with other native plant species because of its unique life cycle. The plant germinates from turions (seed structures) in early fall when most native plants have died back, and the plant continues to grow slowly during the winter months. Curlyleaf pondweed growth increases substantially after ice-out due to an increase in light availability. According to preliminary aquatic plant surveys in the spring, Medicine Lake has approximately 30% to 40% surface area coverage of curlyleaf pondweed with nuisance growth conditions that inhibits recreational use. The plant begins to die-off (called senescence) after the completion of turion production by the end of June or early July. The senescence of curlyleaf pondweed provides an internal source of nutrients within Medicine Lake. Similar to other lakes dominated by curlyleaf pondweed, Medicine Lake has a characteristic total phosphorus spike that coincides with senescence. Nutrients released from the senescence process are in a soluble form readily available for algae uptake. Consequently, algae blooms frequently develop causing a decrease in water clarity. The senescence of curlyleaf pondweed exacerbates the eutrophication process by causing poor water quality conditions earlier in the season.

A primary initiative of the Medicine Lake subcommittee was the formation of a Medicine Lake Aquatic Vegetation Management Group (AVM). The group consisted of members from the City of Plymouth Engineering Department, Three Rivers Park District, Minnesota Department of Natural Resources (MNDNR), Bassett Creek Watershed District, Association of Medicine Lake Area Citizens (AMLAC), City of Medicine Lake, and several lakeshore residents. The AVM group developed an aquatic plant management plan to control exotic species and promote the growth of native species in an effort to improve water quality conditions for Medicine Lake. The plan proposed to chemically treat the entire littoral area of the lake with an aquatic herbicide (Endothall) to control curlyleaf pondweed. A herbicide treatment for the entire littoral area has not been previously considered as a viable management approach because MNDNR rules and regulations limit herbicide applications to 15% of the lake littoral area. Monitoring data (water quality data and aquatic plant vegetation surveys) was provided to demonstrate the potential impact curlyleaf pondweed has on Medicine Lake water quality. The data was used to request a variance from the MNDNR to allow for a herbicide application over the entire littoral area.

The proposed Medicine Lake herbicide treatment was considered a long-term management approach. Historically, curlyleaf pondweed management strategies have been primarily short-term approaches that temporarily control nuisance growth conditions to increase recreational use. Very few projects have considered a long-term management approach to control curlyleaf pondweed. The objective of the long-term management approach is to improve water quality conditions by reducing the amount of curlyleaf pondweed. Reducing the internal nutrient loading from curlyleaf pondweed senescence can potentially improve water clarity conditions and encourage native plant growth. Establishing a diverse native plant community can potentially inhibit the growth of curlyleaf pondweed and extend the longevity of the control programs. The MNDNR approved the project and granted a three-year variance (April 5, 2004) to the City of Plymouth for chemical control of curlyleaf pondweed in an area greater than 15% of the littoral area for Medicine Lake. Conditions of the permit required the implementation of an extensive monitoring program to determine whether project goals and objectives will be accomplished. The monitoring program was a collaborative effort among a group of agencies and consulting firms that included the following:

- **City of Plymouth** – Submission of application for the Medicine Lake herbicide treatment. Contact and obtain permission from City of Plymouth shoreline residents about herbicide application. Coordinate and schedule herbicide treatment with contractor.
- **City of Medicine Lake** – Contact and obtain permission from City of Medicine Lake shoreline residents about herbicide application.
- **Three Rivers Park District** – Perform an aquatic vegetation visual survey using GPS to identify curlyleaf pondweed nuisance growth areas and estimate acreage for treatment. Bi-weekly monitoring to determine seasonal changes in water quality for Medicine Lake. Analysis of curlyleaf pondweed samples for nutrient concentration and biomass estimates.
- **Lake Restoration** – Implement the Medicine Lake herbicide treatment with endothall (Aquathol-K). Monitor daily changes in water temperature to determine the time period for herbicide application.
- **Blue Water Science** – Collected curlyleaf pondweed stem density and biomass samples to determine herbicide treatment effectiveness.
- **US Army Corps of Engineers** – Point intercept aquatic macrophyte survey to monitor the diversity of the plant community for Medicine Lake.

This report provides a summary of the herbicide treatments from 2004-2005. The report includes monitoring data that was collected by the different agencies and consulting firms. The report will be submitted to the MNDNR as part of the permit application to control curlyleaf pondweed in Medicine Lake for 2006. The data will be further used to determine whether the herbicide application to control curlyleaf pondweed is a viable long-term management approach at improving in-lake water quality.

Results

Medicine Lake has had annual nuisance growth conditions of curlyleaf pondweed that inhibits recreational use. Aquatic vegetation surveys performed by Three Rivers Park District indicated that there was a minimum of 300 acres of annual curlyleaf pondweed growth. Typically, nuisance growth conditions are present on approximately 30% to 40% of the surface area of the lake. The lake had approximately 375 acres of curlyleaf pondweed in 2004, in which 90% of the acreage was considered nuisance growth that inhibited recreational use. However, nuisance growth conditions in 2005 were not as severe due to the successful herbicide treatment in 2004. Despite a decrease in nuisance growth conditions in 2005, curlyleaf pondweed was observed in the same locations as 2004. Consequently, the locations that were chemically treated in 2004 were treated again in 2005. The curlyleaf pondweed acreage estimated from the survey in 2004 and 2005 was used to determine the amount of Aquathol-K necessary for the herbicide treatment. The map (below) represents the area that was chemically treated in 2004 and 2005.

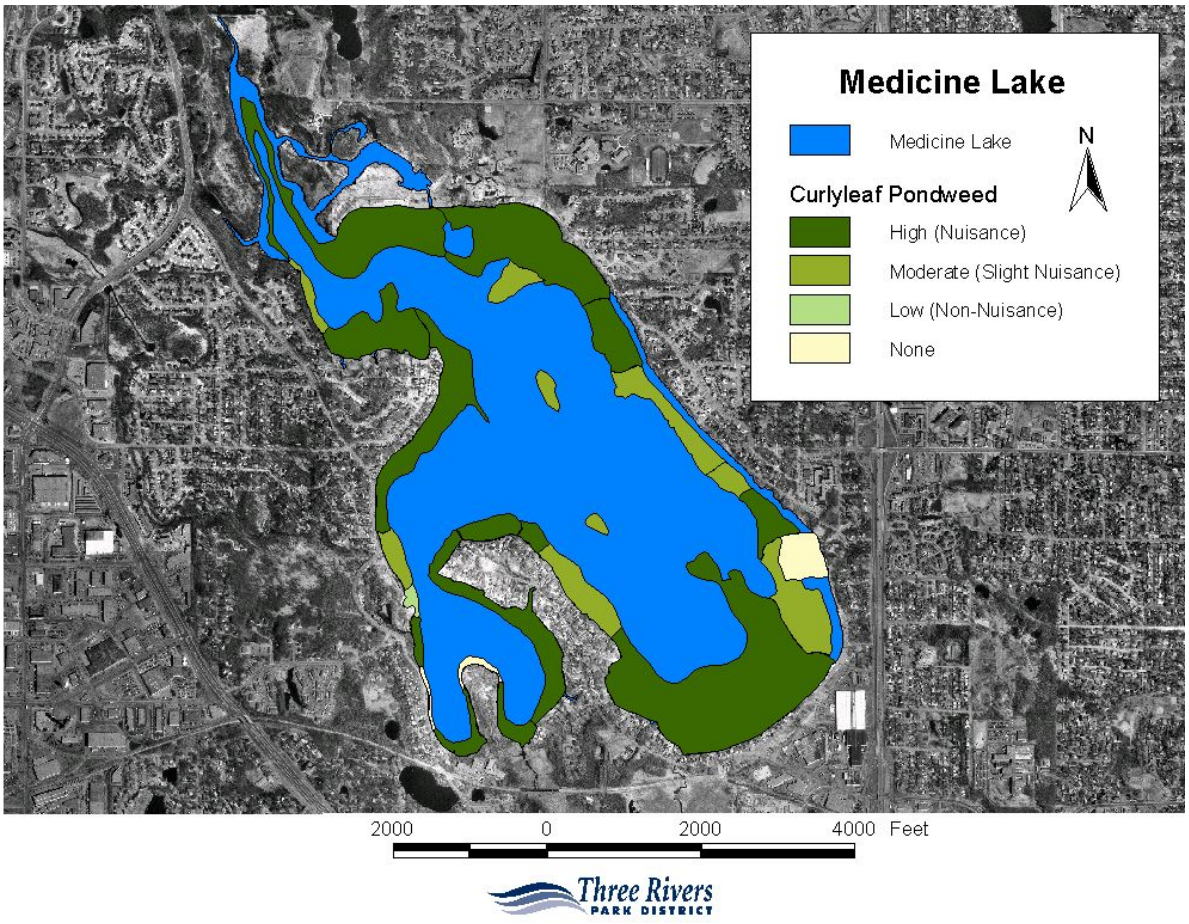

Figure 1: Curlyleaf pondweed survey on Medicine Lake.

The riparian property rights of all shoreline owners were recognized. Permission from the shoreline residents was obtained by the City of Plymouth and the City of Medicine Lake in all areas of the proposed chemical application that were closer than 150 feet from the lake shoreline. The property owners were contacted at least two to three months prior to the herbicide application. The majority of the Medicine Lake shoreline residents (99%) were in favor of the herbicide treatment to control curlyleaf pondweed. Those property owners that were not in favor of the herbicide treatment were identified on a map. The herbicide treatment was only applied to those designated areas in which permission was granted.

The Medicine Lake herbicide (Aquathol-K) treatment in 2005 occurred from April 19 through April 22. The herbicide treatment in 2005 was considerably earlier than the treatment in 2004 (May 8 through May 11, 2004). Lake Restoration applied aquathol-K to achieve a target concentration between 1 and 1.5 mg/L. There was approximately 1400 gallons of aquathol-K applied to approximately 320 acres of the lake in 2005. The time period of the herbicide treatment was water temperature dependent. Aquathol-K is a contact herbicide that is effective at killing curlyleaf pondweed at water temperatures as low as 55° F to 60° F. The temperatures in 2005 were considerably warmer earlier in the spring in comparison to temperatures observed in 2004. The herbicide treatment was completed early in spring to ensure that the curlyleaf pondweed was eradicated prior to the development of turions. The typical length of the curlyleaf pondweed plants during the time period of treatment was between 21 to 27 inches with 10 or 11 nodes. The curlyleaf pondweed plants in 2004 and 2005 did not develop turions prior to the herbicide treatment. Consequently, it was anticipated that there would be less curlyleaf pondweed in subsequent years following the treatment.

To determine the effectiveness of the herbicide treatment at controlling curlyleaf pondweed, stem density aquatic macrophyte surveys were conducted prior to and after the herbicide treatments for each year (Table 1 & 2). Blue Water Science sampled stem densities at four separate sites on Medicine Lake. The specific locations of the sites sampled in 2004 and 2005 were similar between years. Each site was sampled at ten random locations with a 0.1-m^2 quadrant for 6 ft and 9 ft depth intervals. The pre-treatment surveys indicated that stem densities of curlyleaf pondweed were considerably less the first year after initial herbicide treatment. Based on data for sites surveyed at 6 foot depth intervals, the average stem densities the initial year of the herbicide treatment in 2004 was 643 stems/m^2 (Table 1). The average stem densities decreased to 419 stems/m^2 in 2005 the year after the initial herbicide treatment in 2004 (Table 1). These differences were more significant for sites surveyed at 9 foot depth intervals, in which the average stem densities decreased from 472 stems/m^2 in 2004 to 143 stems/m^2 in 2005 (Table 1). The post treatment surveys for each year further suggested that the herbicide application has been effective in killing the curlyleaf pondweed. After the herbicide treatments in 2004 and 2005, the post treatment surveys indicate that there was very little to no curlyleaf pondweed found in Medicine Lake (Table 2). Based on the preliminary data, the surveys suggest that consecutive whole-lake herbicide treatments have been effective in reducing the amount of curlyleaf pondweed in Medicine Lake.

Table 1: Pre-Treatment Quadrant Surveys in 2004 and 2005.

Site	Stem Density at 6-ft Depth		Stem Density at 9-ft Depth	
	2004 (Stems/m^2)	2005 (Stems/m^2)	2004 (Stems/m^2)	2005 (Stems/m^2)
1	761	415	572	192
2	928	600	432	215
3	555	11	666	43
4	327	650	219	120
Average	**643**	**419**	**472**	**143**

Table 2: Post-Treatment Quadrant Survey in 2004 and 2005.

Site	Stem Density at 6-ft Depth		Stem Density at 9-ft Depth	
	2004 (Stems/m^2)	2005 (Stems/m^2)	2004 (Stems/m^2)	2005 (Stems/m^2)
1	1	0	2	0
2	3	0	1	0
3	0	0	0	0
4	0	0	0	0
Average	**1**	**0**	**1**	**0**

Data collected by Steve McComas and Jo Stuckert, Blue Water Science

An aquatic macrophyte survey was conducted in Medicine Lake to assess potential changes in the plant community relative to the herbicide treatments. The U.S. Army Corps of Engineers performed point-intercept surveys in April, June, and September in 2004 and 2005. Each survey was a compilation of 200 to 220 sampling points within the littoral area (depth ≤ 15 ft) of Medicine Lake (personal communication John Skogerboe). The point-intercept method is a qualitative approach in which plant species are collected and identified from two rake throws at each sampling point. The surveys that occurred pre-treatment and post-treatment further indicated that the herbicide was effective at killing curlyleaf pondweed as well as reducing the amount of curlyleaf pondweed the year following initial treatment. The frequency of occurrence for curlyleaf pondweed decreased from 52% in April (pre-treatment) to 7% in June (post-treatment) in 2004; and the frequency of occurrence decreased from 37% in April (pre-treatment) to 5% in June (post-treatment) of 2005 (Table 3). During the early spring, there was not much diversity in the native plant community. The early spring herbicide treatment occurs during a time period when very few native plants have germinated. The fall (September) surveys in 2004 and 2005 further indicate that the treatment did not appear to affect the native plant community.

Medicine Lake has a diverse native plant community in which 20 species were present (Table 3). The dominant native species present were *Ceratophyllum demersum* (Coontail) and *Vallisneria americana* (Wild Celery) (Table 3). Despite a diverse native plant community, the only substantial increase in percent occurrence for native species was *Elodea canadensis* (3.6% in September 2004 to 13.7% in September 2005). It was anticipated that the decrease in curlyleaf pondweed would further encourage the development of a native plant community. Unfortunately, the continued growth of curlyleaf pondweed appears to inhibit the development of a native plant community. Typically, there is early fall germination of curlyleaf pondweed from viable turions that reside in the sediments from pervious years production. The percent occurrence of curlyleaf pondweed that germinated in the fall (September) of 2004 was 12.3%. However, there was no curlyleaf pondweed found in the fall survey of 2005. These findings suggest that the consecutive herbicide treatments occurring prior to the development of curlyleaf pondweed turion production has reduced the viable seed bank within the lake sediments. Consequently, the native plant community will may become further established with the continued efforts to control curlyleaf pondweed.

Table 3: Medicine Lake Point-Intercept Aquatic Macrophyte Survey Summary by Species.

Species	Percent Occurrence					
	2004			2005		
	April	June	September	April	June	September
Ceratophyllum demersum	31	24	39	12	30	39
Elodea canadensis	2	5	4	6	11	14
Myriophyllum spicatum	13	0	8	3	13	18
Myriophyllum sibiricum	0	1	0	0	0	0
Potamogeton crispus	87	11	12	37	5	0
Najas flexilis	0	3	5	0	2	8
Nuphar advena	0	9	6	3	8	8
Nymphaea oderata	4	20	15	2	16	16
Potamogeton amplifolius	0	0	1	0	1	0
Potamogeton illinoensis	0	3	2	0	3	3
Potamogeton foliosus	1	0	1	0	0	1
Potamogeton praelongus	0	1	1	0	1	1
Potamogeton robbinsii	0	0	2	0	0	0
Potamogeton zosteriformis	1	1	1	0	0	0
Scirpus validus	0	3	3	0	3	3
Stukenia pectinata	0	8	16	0	20	15
Vallisneria americana	0	24	27	0	30	33
Zosterella dubia	0	0	7	0	6	5
Zannichellia palustris	0	1	1	1	1	0
Chara spp.	7	42	13	8	26	17

Data collected and Analyzed by John Skogerboe, US Army Corps of Engineers

Table 4: Medicine Lake Point-Intercept Aquatic Macrophyte Survey Summary.

Category	2004			2005		
	April	June	September	April	June	September
% Potamogeton crispus	87%	11%	12%	37%	5%	0%
% Myriophyllum spicatum	13%	0%	8%	3%	13%	18%
% Native Species	43%	59%	63%	23%	64%	64%
Native Species/point	0.30	1.03	1.54	0.27	1.57	1.61
Number of Species	7	15	19	8	16	15

Data collected and Analyzed by John Skogerboe, US Army Corps of Engineers

There was a concern that eradicating curlyleaf pondweed would cause Medicine Lake to shift toward a plant community dominated by Eurasian water milfoil. Medicine Lake periodically has nuisance growth conditions of Eurasian water milfoil. The Three Rivers Park District has harvested portions of the lake with nuisance growth conditions to improve recreational opportunities. The point-intercept macrophyte surveys indicated that Eurasian water milfoil frequency of occurrence was relatively low (8%) the first year of treatment in 2004 (Table 4). However, the percent occurrence of Eurasian water milfoil increased substantially to 18% in 2005 (Table 4). Based on the point-intercept survey in 2005, Eurasian water milfoil has become the third most common aquatic plant specie in Medicine Lake. Preliminary data suggests that Eurasian water milfoil distribution may be increasing. A decrease in curlyleaf pondweed would certainly improve the opportunity for a diverse native plant community to become established. Establishing a diverse native plant community could potentially inhibit the growth of curlyleaf pondweed and extend the longevity of the control program. However, Eurasian water milfoil could potentially inhibit the development of a diverse native plant community. Consequently, efforts to continue monitoring the changes in the plant community are important. Medicine Lake management efforts may have to consider controlling Eurasian water milfoil to encourage establishment of a diverse native plant community.

A primary objective of the long-term management approach to controlling curlyleaf pondweed is improving in-lake water quality conditions. Medicine Lake was monitored bi-weekly to determine seasonal changes in water quality. Prior to the herbicide treatments in 2004, Medicine Lake has had a characteristic total phosphorus spike coinciding with curlyleaf pondweed senescence at the end of June and beginning of July. In 2004, there was an increase in phosphorus concentration that corresponded to the time period of the initial herbicide treatment (Figure 2). A similar response was not observed in 2005. The sampling interval prior to and after the herbicide treatment may have missed the potential phosphorus spike; or the phosphorus spike did not occur due to the decrease curlyleaf pondweed abundance (Figure 3). Sampling efforts in 2006 will incorporate an improved sampling interval to monitor the potential changes in water quality relative to the herbicide treatment.

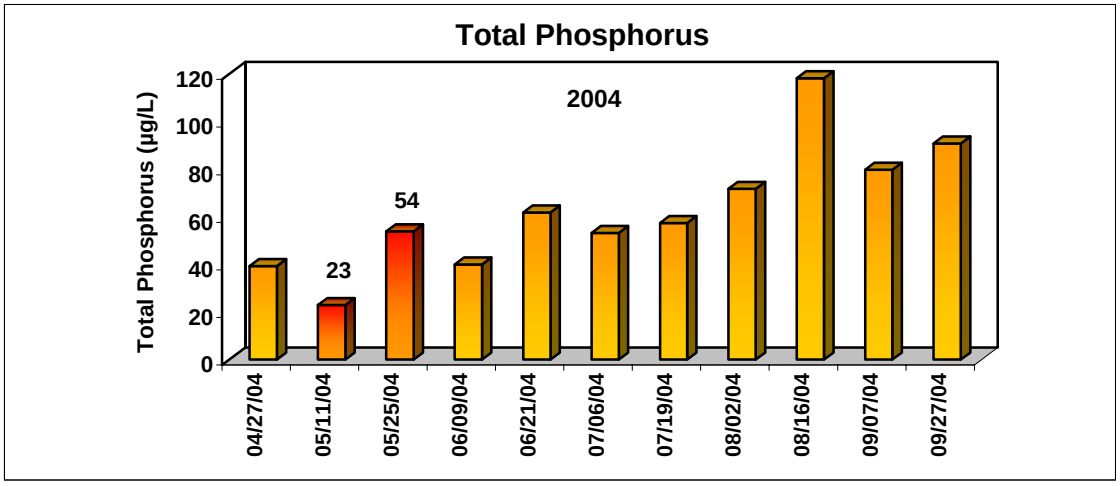

Figure 2: Seasonal Changes in total phosphorus concentration for Medicine Lake in 2004.

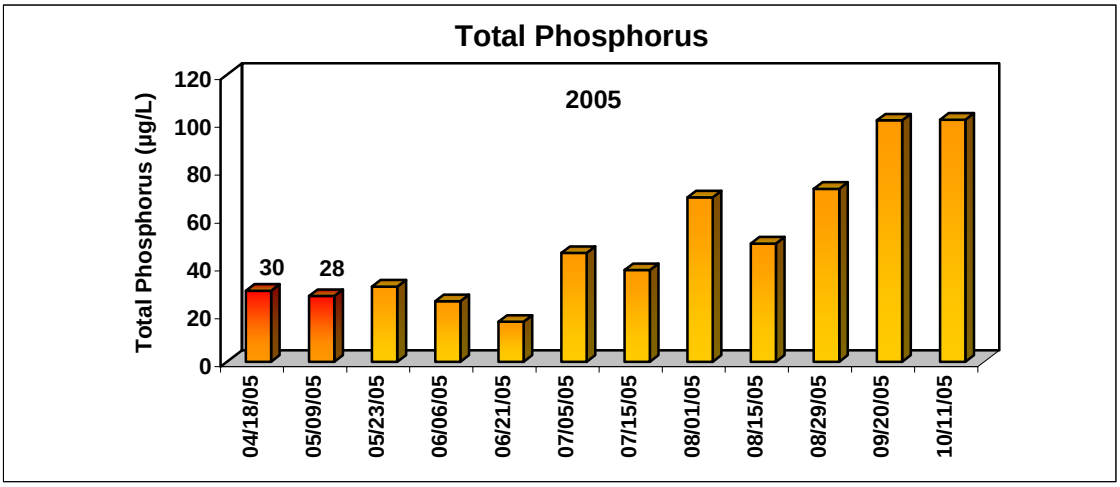

Figure 3: Seasonal changes in total phosphorus concentration for Medicine Lake in 2005.

To estimate the amount of phosphorus released from the die-off of curlyleaf pondweed due to the herbicide treatment, Three Rivers Park District performed phosphorus analysis on the biomass samples collected from the aquatic macrophyte quadrant survey in 2004 (Table 5). Based on the phosphorus analysis from biomass samples, the die-off of curlyleaf pondweed released approximately 1050 pounds of phosphorus as a consequence of the herbicide treatment (Table 5). It was anticipated that total phosphorus concentrations will further decrease as a result of consecutive herbicide treatments to reduce curlyleaf pondweed abundance. Preliminary analysis of water quality data (1995-2005) indicated that average phosphorus concentrations calculated from May through mid-July (the time period of typical curlyleaf pondweed growth and senescence) were lower in 2005 (Figure 4). It was speculated that this was partially attributed to the reduced amount of curlyleaf pondweed from consecutive herbicide treatments. Despite less curlyleaf pondweed in 2005, the decrease in phosphorus concentration from May through mid-July was not significant enough to result in a significant difference in the annual average total phosphorus concentrations for the entire growing season from 1995 through 2005 (Figure 6). It is anticipated that phosphorus concentrations will continue to decrease with the further reduction in curlyleaf pondweed and the establishment of a native plant community.

Table 5: Medicine Lake estimated total phosphorus loading from curlyleaf pondweed in 2004.

Site	Acreage	Average Biomass (g dry wt/m^2)	Average TP Conc. (mg/g dry wt)	Average (lbs TP/Acre)	TP Loading (pounds)
1	147.3	83.4	4.80	3.19	469.8
2	42.2	92.1	2.29	1.86	78.4
3	136.3	92.8	3.73	3.08	419.7
4	50.0	38.6	4.91	1.65	82.6
Total					**1050**

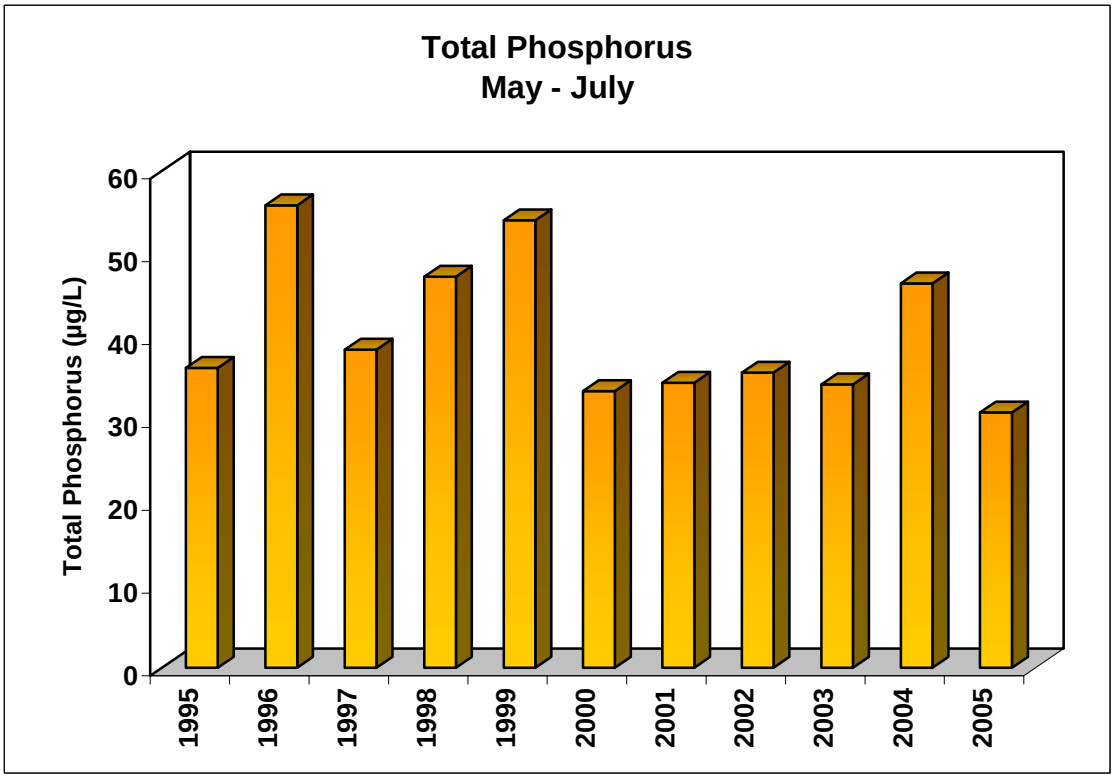

Figure 4: Medicine Lake average total phosphorus concentration from May through mid-July.

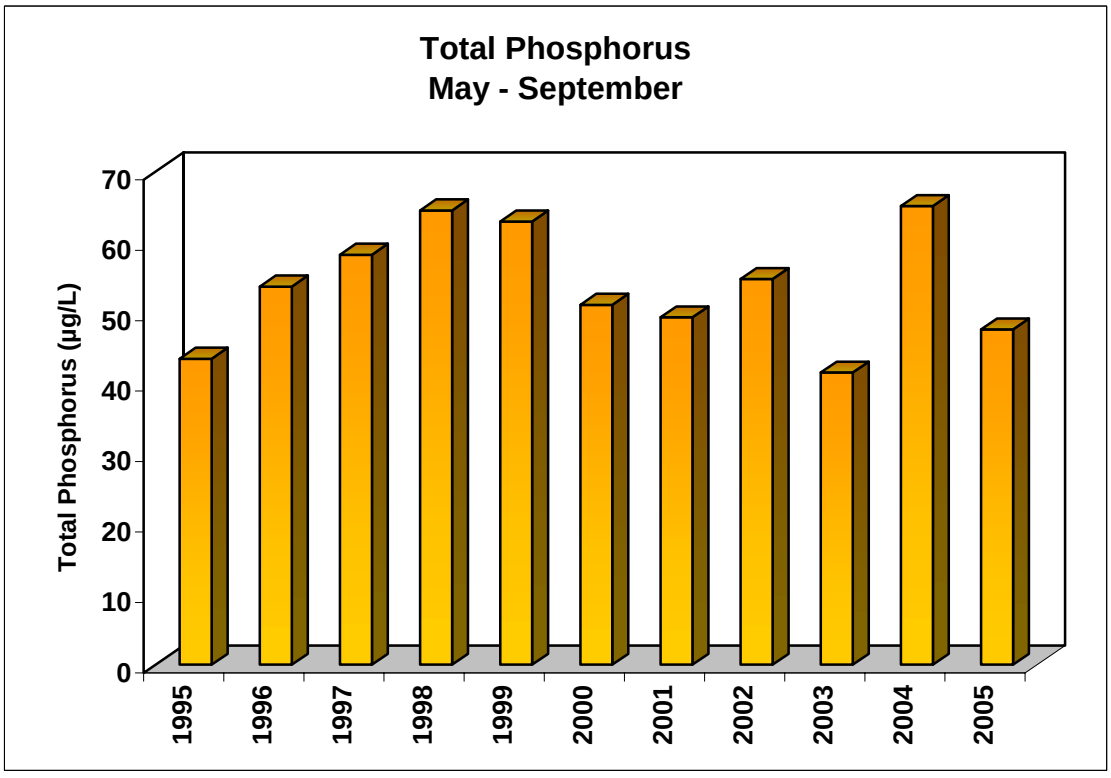

Figure 5: Medicine Lake average total phosphorus concentration from May – September.

The in-lake nutrients that are available for algae have an impact on water clarity conditions. The nutrients released from the die-off of curlyleaf pondweed are in a soluble form that is readily available for algae uptake. Typically, Medicine Lake has an algae bloom following curlyleaf pondweed senescence at the end of June or beginning of July. An objective of controlling curlyleaf pondweed is reducing the excessive amount of nutrients released after senescence to improve water quality conditions. It is anticipated that a decrease in phosphorus concentrations will reduce the severity of potential algae blooms and improve water clarity conditions. Despite a decrease in phosphorus concentrations from May through mid-July in 2005, there were no significant differences in chlorophyll-a concentrations and secchi depth transparency (Figure 6). The conditions during the early spring treatments in 2004 and 2005 were not conducive for the development of an algae bloom. The water temperatures were relatively cool for several weeks following the treatments inhibiting the growth of algae. Consequently, algae blooms did not develop until early summer when water temperatures were warmer (Figure 7 & 8). Medicine Lake has excess external and internal nutrient loading that inhibit improvements in water quality conditions. Due to these excessive amounts of nutrients, Medicine Lake typically develops poor water quality conditions during the summer. It is still too early to determine whether curlyleaf pondweed management efforts will reduce in-lake nutrients enough to improve water quality conditions.

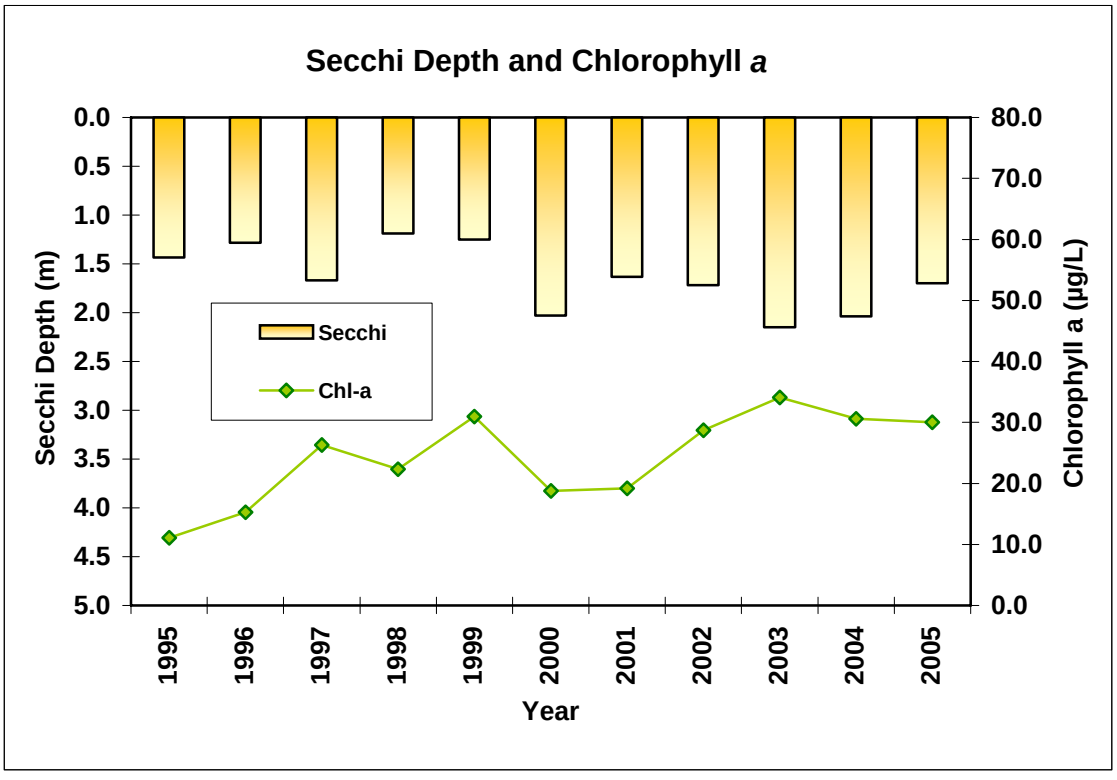

Figure 6: Annual changes in secchi depth and chlorophyll-a concentrations for Medicine Lake.

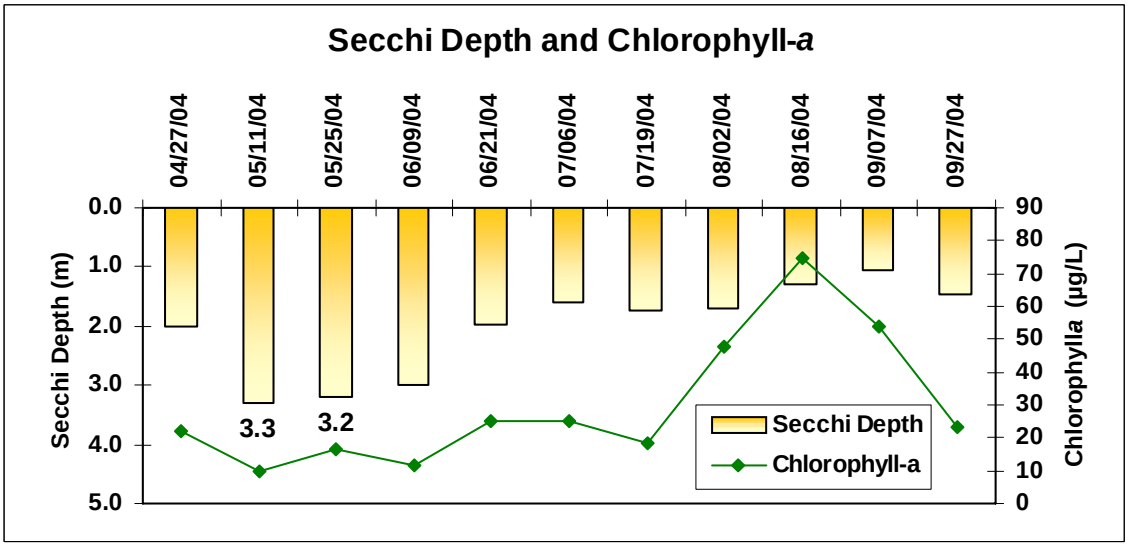

Figure 7: Seasonal changes in secchi depth and chlorophyll-a concentrations for Medicine Lake in 2004.

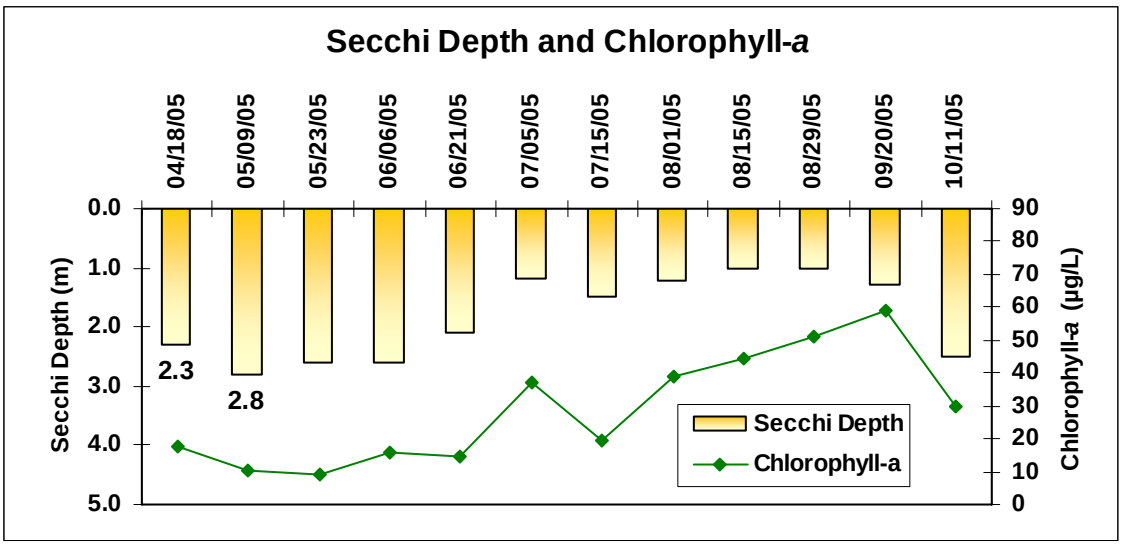

Figure 8: Seasonal changes in secchi depth and chlorophyll-a concentrations for Medicine Lake in 2005.