Lake Minnetonka Aquatic Herbicide Demonstration Project

Draft Report

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Summary

In 2006 a project was initiated on Lake Minnetonka to demonstrate the potential of aquatic herbicides to provide selective control of Eurasian watermilfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*). Three plots were established on Carman, Gray's, and Phelp's bays. Three different herbicide treatments were used including triclopyr, 2,4-D, and a recently developed combination of endothall and 2,4-D. The distribution and abundance of aquatic plants in the plots were monitored during May or June on the day of treatment, early July, and mid-August.

Caution should be exercised in interpretation of these results due to the lack of information on the plant communities in the year before treatment, the lack of replication of plots within treatments, and the limited information from un-treated reference plots.

All three herbicide applications maintained low Eurasian watermilfoil density for the entire summer. Based on percent occurrence data, the combination of endothall and 2,4-D was not as successful as in previous demonstrations in other lakes. Previous demonstrations utilized 2,4-D applied as liquid DMA™ 4, but label restrictions did not allow use of DMA™ 4 in the relatively small plot on Carman Bay. The 2,4-D was

therefore applied using the granular formulation Aqua-Kleen®, which had not been previously tested in combination with endothall. The slow release of herbicide from the granules probably resulted in insufficient 2,4-D in contact with the plants. Curly-leaf pondweed was not abundant in any of the plots, though the combination of endothall and 2,4-D appeared to control the plant.

Native plants were abundant in all treated plots following the herbicide applications. Carman Bay contained the most diverse native plant community including several species that are sensitive to 2,4-D and triclopyr. This may have resulted because of natural diversity in Carman Bay, or the early spring treatment may have controlled Eurasian watermilfoil before species sensitive to 2,4-D and triclopyr were actively growing. The cause could not be determined due to the lack of pre-treatment data from the previous year. Early spring application of 2,4-D and triclopyr may also improve their selectivity. Future monitoring will determine whether the control of Eurasian watermilfoil and curly-leaf pondweed resulting from treatments in 2006 will persist in subsequent seasons.

Introduction

In Minnesota generally and on Lake Minnetonka in particular, there is interest in the potential of aquatic herbicides to provide selective control of Eurasian watermilfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*). Selective control of dicotyledonous plants, which include Eurasian watermilfoil, may be achieved with 2,4-D (Green and Westerdahl 1990) and triclopyr (Netherland and Getsinger 1992), which are commonly used systemic herbicides (Getsinger et al. 1997, Poovey et al. 2004). Endothall is a broad-spectrum herbicide (Netherland et al. 1991), which can be used to control a wide range of aquatic plants. Research has shown that endothall can be used to selectively control curly-leaf pondweed with careful selection of application rates (Skogerboe and Getsinger 2002) and seasonal timing (Poovey et al. 2002). Additional research has shown that low rates of endothall combined with 2,4-D can provide selective control of two invasive exotic species, Eurasian watermilfoil and curly-leaf pondweed, if applied in early spring when most native species are dormant (Skogerboe and Getsinger 2006). To demonstrate the potential for selective control of Eurasian watermilfoil and curly-leaf pondweed, three different herbicide treatments were used in Minnetonka during 2006. Treatments included triclopyr, 2,4-D, and a recently developed combination of endothall and 2,4-D.

Methods

Three plots were created by the Lake Minnetonka Conservation District, one each on Carman Bay, Gray's Bay, and Phelp'sBay using GPS (Global Positioning System). The Carman Bay plot (15.2 acres) was treated on 2 May 2006 (Figure 1) with 1.0 mg/L active ingredient (ai) endothall formulated as Aquathol® K plus 0.5 mg/L ai 2,4-D formulated as Aqua-Kleen®. The Gray's Bay (11.3 acres) was treated on 6 June 2006 (Figure 2) with 150 lb/acre 2,4-D (~3.0 mg/L ai) formulated as Aqua-Kleen®, and Phelp'sBay (6.3 acres) was treated on 7 June 2006 (Figure 3) with 1.25 mg/L ai triclopyr formulated as Renovate™ 3. Two small un-treated reference sites were located near Carman Bay and also sampled.

At the request of the Minnesota Department of Natural Resources, the US Army Engineer Research and Development Center (ERDC), Vicksburg, MS, collected plant samples to evaluate the effectiveness of the herbicide treatments. The samples were collected by John Skogerboe, ERDC Eau Galle Aquatic Ecology Laboratory, Spring Valley, WI. Samples were collected from each plot on the day of treatment just prior to the herbicide applications to provide a reference for comparison to post treatment samples. Additional post-treatment sampling was conducted on 5-6 July 2006 and 14-15 August.

The lack of information on the plant communities in the year before treatment, the lack of replication of plots within treatments, and the limited information from un-treated reference plots indicate that caution should be exercised in interpretation of these results. Specifically, one cannot evaluate the potential effects of weather in 2006 on the growth of aquatic plants independently of the potential effects of treatment with herbicides. In addition, since there may be differences among the bays in growth of aquatic plants, as was shown previously by Madsen and Getsinger (1995), the inclusion of un –treated reference plots in only one of the three bays warrants further caution in interpretation of results. A final sampling will be conducted in June 2007.

Prior to conducting the first sampling, a 40x40 m grid was established for each treatment plot using computer mapping software. The grids were downloaded unto GPS (Global Positioning System) equipment accurate to 10 to 20 ft. Samples were collected using a 36-cm wide rake attached to a 3-m pole following the approach described by Crowell et al. (1994). At each sample point, the rake was lowered from the boat perpendicular to the bottom and then raised up to the water surface while slowly being twisted in a clockwise direction. Plant samples were returned the Eau Galle Aquatic Ecology Laboratory where each sample was separated by species. In some cases, plants could be identified to the level of genus, but not species. Consequently, they are reported as "taxa," which includes both genus and species. After separation, plants were dried in an oven at $60^{o}C$ to a constant weight. The average biomass for each species or genus was then computed to quantify species density.

Percent occurrence of plant species was calculated by dividing the number of points where a particular species was present by the total number of sample points in the treated plot. The average number of species per sample point in each plot, and total the number of native plant species in each plot was calculated.

Results and Discussion

Carman Bay, un-treated Reference

Eurasian watermilfoil percent occurrence (Table 1) was not significantly different between plant evaluations, however plant density (Table 2) did significantly increase between the May and July evaluations. Native plant occurrence and density both increased following the May plant evaluation indicating that most of the native plants were dormant in early May.

Carman Bay, endothall and 2,4-D

Treatment with a combination of endothall and 2,4-D did not significantly reduce the percent occurrence (Table 3) or density (Table 4) of Eurasian watermilfoil compared to the pretreatment sampling. The application was conducted in early spring when plant density should have been low compared to un-treated Eurasian watermilfoil in summer months. Eurasian watermilfoil density in the treated area did not increase by the July and August samplings. Percent occurrence of curly-leaf pondweed was reduced to 0 following the herbicide treatment.

No adverse effect on native species was apparent from the data presented. Native species included a range of monocots that are sensitive to endothall applied later in the season (Skogerboe and Getsinger 2002) and dicots that may be sensitive to 2,4-D and triclopyr. Endothall sensitive species present after the treatment included slender naiad (*Najas flexilis*), large-leaf pondweed (*Potamogeton amplifolius*), Illinois pondweed (*Potamogeton* illinoensis), clasping-leaf pondweed (*Potamogeton richardsonii*), flat-stem pondweed (*Potamogeton zosteriformis*), and sago pondweed (*Stukenia pectinata*). Triclopyr and 2,4-D sensitive species present after the treatment included northern milfoil (*Myriophyllum sibiricum*), water marigold (*Bidens beckii*), water stargrass (*Zosterella dubia*), and white water lily (*Nymphaea odorata*). Other species present that are generally not considered to be sensitive to any of the herbicide treatments in this demonstration included coontail (*Ceratophyllum demersum*), elodea (*Elodea canadensis*), and wild celery (*Vallisneria americana*) (Madsen and Getsinger 1995, Parsons et al. 2001, Skogerboe and Getsinger 2002). Native plant densities increased following the herbicide treatment for many species, and total native plant density more than doubled. No data were collected during the year prior to the treatment, so positive or adverse changes in the native plant community cannot be determined.

Gray's Bay, 2,4-D

The 2,4-D treatment significantly reduced Eurasian watermilfoil percent occurrence (Table 5) by 79% and plant density (Table 6) by 99% at the July plant evaluation. Percent occurrence and density appeared to increase slightly by the August plant evaluation indicating that some recovery or infestation may have occurred, although plant densities remained low. Curly-leaf pondweed percent occurrence declined from June to July, and was not present by August. Curly-leaf pondweed is a monocot and is therefore not sensitive to 2,4-D. The decline was therefore probably due to senescence, which usually begins in June.

No adverse effect on native species was apparent from the data presented, although no 2,4-D sensitive species were present in the treated area prior to the herbicide application. Native plant density did not increase significantly until after the July plant evaluation. Robbins pondweed (*Potamogeton robbinsii*) in particular increased between the July and August plant evaluations. No pre-treatment data were collected during the year prior to the treatment, so positive or adverse changes in the native plant community cannot be determined.

Phelp's Bay, triclopyr

The triclopyr treatment significantly reduced Eurasian watermilfoil percent occurrence (Table 7) by 63% and plant density (Table 8) by 86% at the July plant evaluation. Percent occurrence and density continued to decline slightly by the August plant evaluation. The total reduction in plant density from June to August was 99%. Some decline in curly-leaf pondweed percent occurrence from June to July, and then declined to 0 by August. Curly-leaf pondweed is a monocot and is therefore not sensitive to 2,4-D, so the decline was due to senescence, which usually begins in June.

No adverse effect on native species was apparent from the data presented, although no 2,4-D sensitive species were present in the treated area prior to the herbicide application. Native plant density increased significantly following the herbicide treatment. Several species declined significantly between the July and August plant evaluations including slender naiad, large-leaf pondweed, flat-stem pondweed, and sago pondweed. This probably was due to environmental conditions. No data were collected during the year prior to the treatment, so positive or adverse changes in the native plant community cannot be determined. Overall, these results are similar to those reported for Phelp's Bay following treatment with triclopyr in 1994 (Madsen and Getsinger 1995).

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Figure 1. Carman Bay herbicide treatment plot (15.2 acres).
Treated 2 May 2006 with 1 mg/L ai endothall and 0.5 mg/L ai 2,4-D. Also shown are two un-treated reference plots, which are marked with flags.

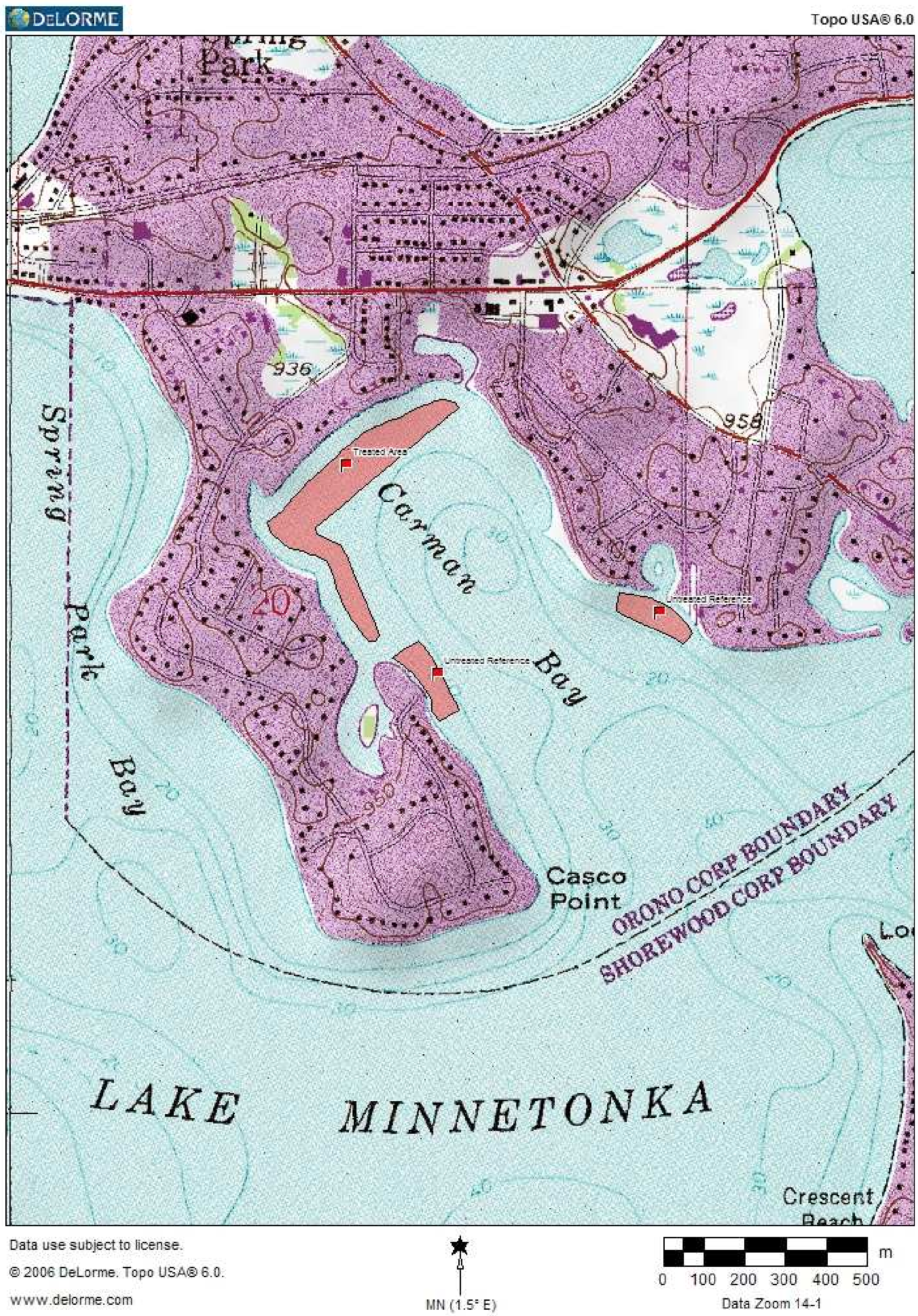

Figure 2. Gray's Bay herbicide treatment plot (11.3 acres). Treated 10 June 2006 with 150 lbs/acre 2,4-D

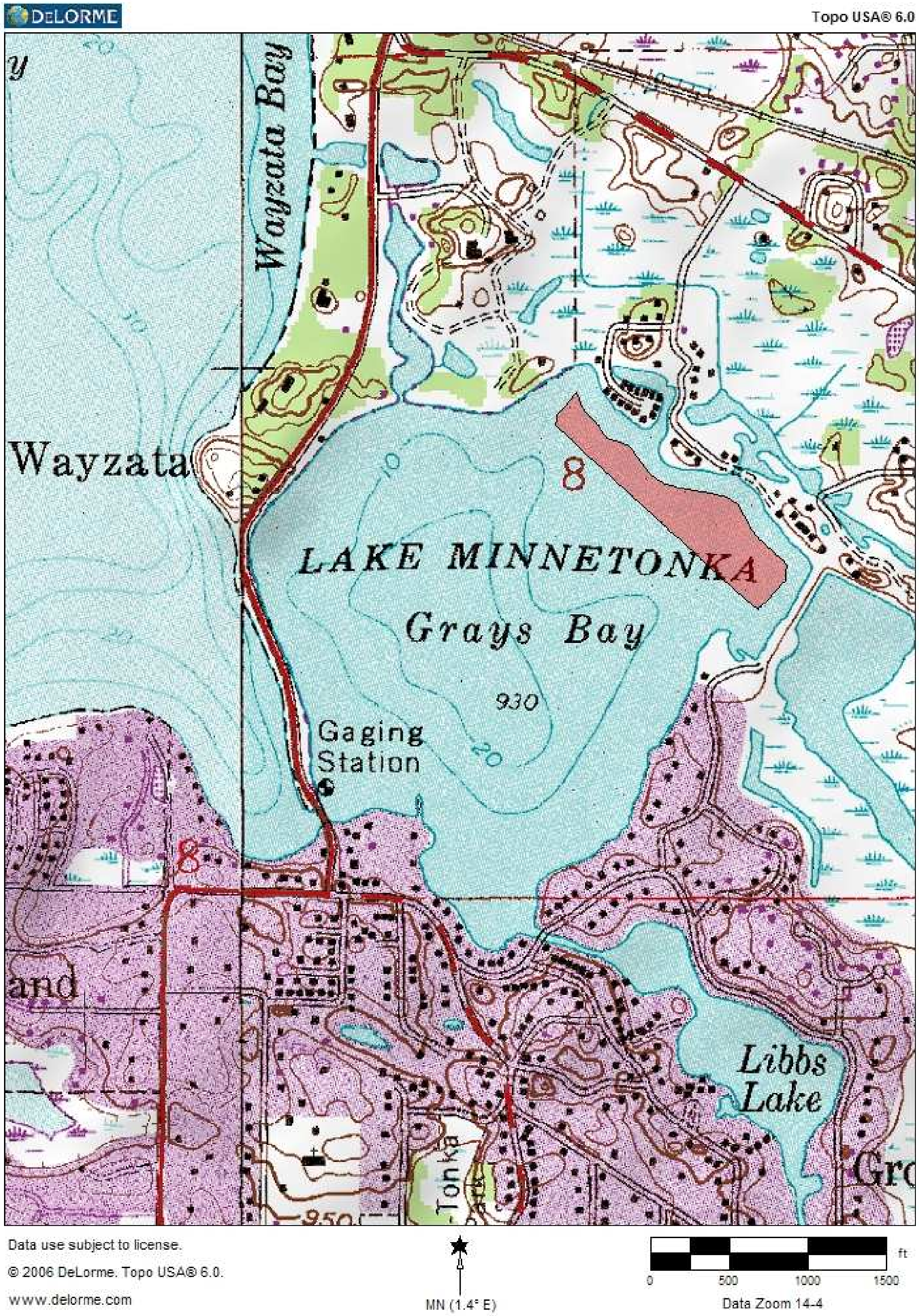

Figure 3. Phelp'sBay herbicide treatment plot (6.2 acres). Treated 6 June 2006 with 1.25 mg/L ai triclopyr

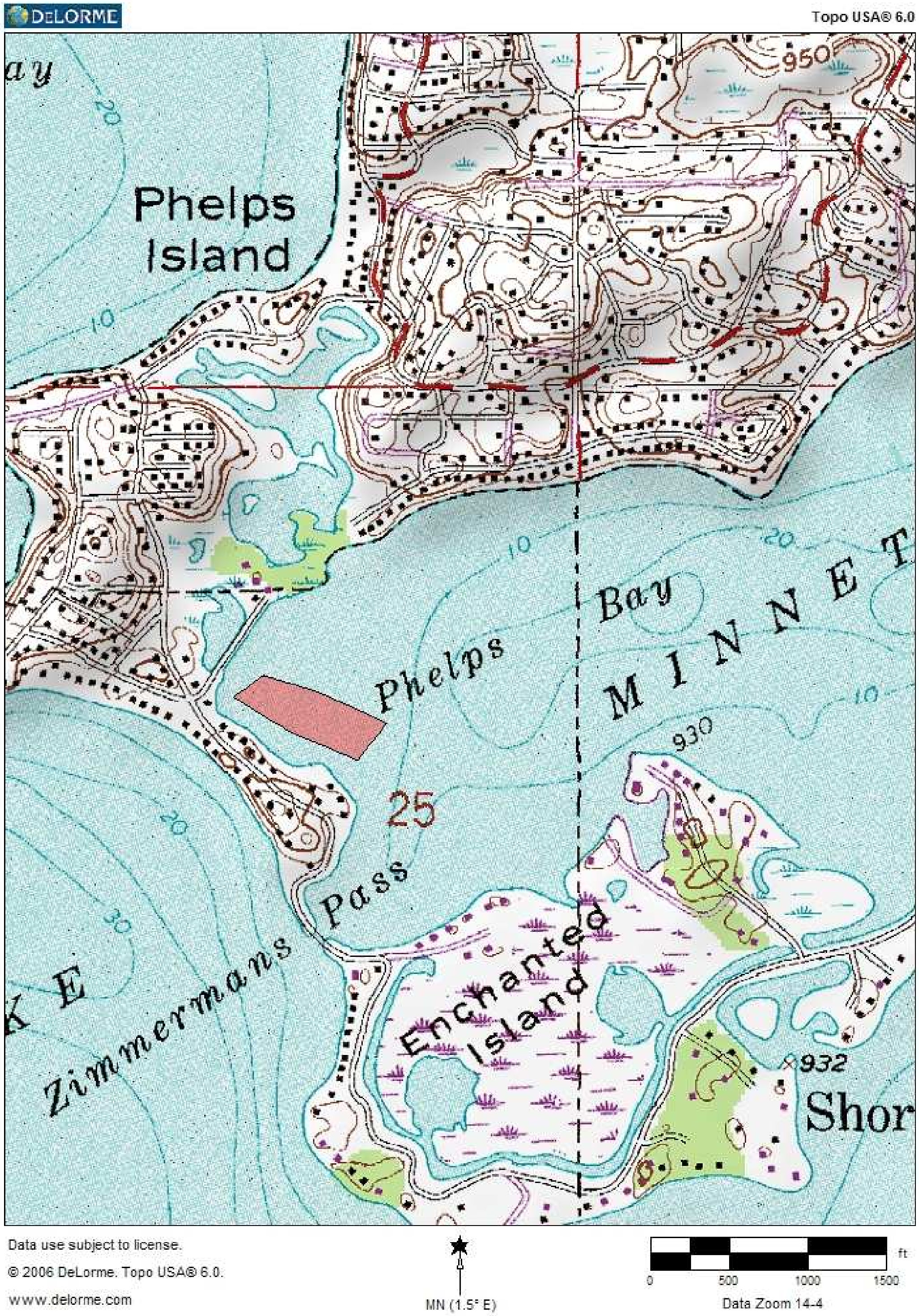

Table 1. Plant diversity data for untreated Reference Areas

Percent Occurrence Results: Carman Bay	2 May 06	5 Jul 06	15 Aug 06
Exotic Submersed vascular taxa: (%)			
Eurasian watermilfoil	95	90	85
curly-leaf pondweed	10	10	0
Submersed vascular taxa: (%)			
Coontail	60	65	50
Elodea	5	10	5
Slender naiad	5	20	20
Big-leaf pondweed	5	5	0
Clasping-leaf pondweed	0	25	15
Flat-stem pondweed	5	30	35
Sago pondweed	0	15	10
Wild celery	0	5	5
Floating-leaved plants: (%)			
White water lily	0	0	0
Submersed non-vascular taxa: (%)			
Chara sp.	0	5	0
Number of Sample Sites	20	20	20
Total number of taxa	7	10	10
Average number of taxa per sampling site	2.7	3.1	3.2
Average number of native taxa per sampling site	1.3	2.5	2.6

Table 2. Plant density data for untreated reference sites

Plant Abundance Results: Carman Bay	Mean biomass per rake sample, g dry weight		
	2 May 06	**5 Jul 06**	**15 Aug 06**
Submersed exotic vascular taxa:			
Eurasian watermilfoil	5.2 + 1.6	42.3 + 4.3	35.5 + 2.3
Curly-leaf pondweed	0.0 + 0.0	0.0 + 0.0	0.0 + 0.0
Submersed native vascular taxa:			
Coontail	6.0 + 1.1	8.3 + 2.5	6.2 + 1.9
Elodea	0.3 + 0.2	0.4 + 0.2	0.3 + 0.1
Slender naiad	0.4 + 0.2	2.0 + 1.1	3.1 + 1.5
Big-leaf pondweed	0.8 + 0.8	0.0 + 0.0	0.0 + 0.0
Illinois pondweed	0.0 + 0.0	0.0 + 0.0	0.3 + 0.3
Clasping-leaf pondweed	0.0 + 0.0	2.4 + 1.2	1.6 + 0.7
Flat-stem pondweed	0.2 + 0.2	1.0 + 0.7	1.3 + 1.1
Sago pondweed	0.0 + 0.0	0.2 + 0.1	0.0 + 0.0
Wild celery	0.0 + 0.0	0.2 + 0.2	0.2 + 0.1
Total	12.9 + 3.1	56.8 + 6.2	48.5 + 5.8
Total exotics	5.2 + 0.9	42.3 + 5.6	35.5 + 5.3
Total native species	7.7 + 1.4	14.5 + 2.9	13.0 + 3.1

Table 3. Plant diversity data for Carman Bay treated 2 May 2006 with 1 mg/L endothall and 0.5 mg/L 2,4-D

Percent Occurrence Results: Carman Bay

	2 May 06	5 Jul 06	15 Aug 06
Exotic Submersed vascular taxa: (%)			
Eurasian watermilfoil	85	85	83
Curly-leaf pondweed	33	0	4
Submersed vascular taxa: (%)			
Coontail	80	87	83
Elodea	28	28	22
Water marigold	0	22	22
Northern milfoil	0	4	30
Slender naiad	7	22	26
Big-leaf pondweed	2	19	13
Illinois pondweed	0	11	13
Clasping-leaf pondweed	2	52	22
Flat-stem pondweed	9	43	26
Sago pondweed	0	24	17
Wild celery	0	15	30
Water stargrass	0	24	22
Floating-leaved plants: (%)			
White water lily	0	17	17
Submersed non-vascular taxa: (%)			
Chara sp.	0	17	9
Number of Sample Sites	46	46	46
Total number of taxa	8	15	16
Average number of taxa per sampling site	2.5	4.6	4.4
Average number of native taxa per sampling site	1.3	3.8	3.5

Table 4. Plant density data for Carman Bay, treated 2 May 2006 with 1 mg/L endothall and 0.5 mg/L 2,4-D

Plant Abundance Results: Carman Bay	Mean biomass per rake sample, g dry weight		
	2 May 06	**5 Jul 06**	**15 Aug 06**
Submersed exotic vascular taxa:			
Eurasian watermilfoil	4.7 + 1.1	8.6 + 2.1	5.4 + 1.7
Curly-leaf pondweed	0.0 + 0.0	0.0 + 0.0	0.0 + 0.0
Submersed native vascular taxa:			
Coontail	5.7 + 1.3	11.0 + 2.3	5.4 + 1.8
Elodea	0.5 + 0.5	1.2 + .7	0.0 + 0.0
Water marigold	0.0 + 0.0	0.8 + 0.4	2.0 + 1.6
Northern milfoil	0.0 + 0.0	0.0 + 0.0	2.7 + 1.7
Slender naiad	1.9 + 1.9	2.5 + 1.4	2.2 + 1.7
Big-leaf pondweed	0.8 + 0.8	0.0 + 0.0	0.0 + 0.0
Illinois pondweed	0.0 + 0.0	0.0 + 0.0	0.3 + 0.3
Clasping-leaf pondweed	0.0 + 0.0	2.8 + 1.2	1.1 + 0.6
Flat-stem pondweed	0.0 + 0.0	1.5 + 0.6	1.7 + 1.3
Sago pondweed	0.0 + 0.0	0.2 + 0.1	0.0 + 0.0
Wild celery	0.0 + 0.0	0.3 + 0.2	0.2 + 0.1
Water stargrass	0.0 + 0.0	0.5 + 0.3	3.5 + 2.9
Floating-leaved plants			
White water lily	0.0 + 0.0	0.0 + 0.0	0.6 + 0.6
Submersed non-vascular taxa			
Chara sp.	0.0 + 0.0	0.4 + 0.4	0.5 + 0.4
Total	13.6 + 2.2	29.5 + 3.9	25.7 + 4.6
Total exotics	4.7 + 1.1	8.6 + 2.1	5.4 + 1.7
Total native species	8.9 + 2.3	20.9 + 3.6	20.3 + 4.9

Table 5. Plant diversity data for Gray's Bay treated 10 June 2006 with 150 lbs/acre 24-D

Percent Occurrence Results: Gray's Bay

	6 Jun 06	6 Jul 06	14 Aug 06
Exotic Submersed vascular taxa: (%)			
Eurasian watermilfoil	85	18	29
Curly-leaf pondweed	9	3	0
Submersed vascular taxa: (%)			
Coontail	50	64	58
Elodea	27	18	35
Water marigold	0	6	6
Northern milfoil	3	0	0
Slender naiad	3	39	24
Big-leaf pondweed	9	25	18
Illinois pondweed	0	30	29
Clasping-leaf pondweed	3	18	24
Robbins pondweed	33	48	38
Flat-stem pondweed	18	15	20
Sago pondweed	3	9	30
Wild celery	0	9	0
Submersed non-vascular taxa: (%)			
Chara sp.	9	9	6
Number of Sample Sites	33	33	33
Total number of taxa	11	13	11
Average number of taxa per sampling site	2.4	3.1	2.5
Average number of native taxa per sampling site	1.4	2.9	2.2

Table 6. Plant density data for Gray's Bay, treated 10 June 2006 with 150 lbs/acre 2,4-D

Plant Abundance Results: Gray's Bay	**Mean biomass per rake sample, g dry weight**		
	6 Jun 06	**6 Jul 06**	**14 Aug 06**
Submersed exotic vascular taxa:			
Eurasian watermilfoil	26.4 + 4.3	0.2 + 0.2	2.0 + 1.0
Curly-leaf pondweed	0.6 + 0.4	0.0 + 0.0	0.0 + 0.0
Submersed native vascular taxa:			
Coontail	3.4 + 1.4	1.9 + 0.9	5.7 + 3.5
Elodea	0.8 + 0.2	0.0 + 0.0	0.3 + 0.1
Northern milfoil	0.1 + 0.1	0.0 + 0.0	0.0 + 0.0
Slender naiad	0.1 + 0.1	0.0 + 0.0	0.7 + 0.4
Big-leaf pondweed	0.3 + 0.2	2.0 + 0.9	0.0 + 0.0
Illinois pondweed	0.0 + 0.0	0.0 + 0.0	0.6 + 0.3
Clasping-leaf pondweed	0.0 + 0.0	0.4 + 0.3	1.1 + 0.6
Robbins pondweed	4.3 + 2.0	3.8 + 1.3	12.0 + 7.2
Flat-stem pondweed	1.8 + 0.9	1.0 + 0.5	3.4 + 2.4
Sago pondweed	0.1 + 0.1	0.0 + 0.0	0.2 + 0.2
Wild celery	0.0 + 0.0	0.2 + 0.2	2.1 + 1.5
Submersed non-vascular taxa			
Chara sp	0.6 + 0.4	0.0 + 0.0	0.9 + 0.9
Total	38.4 + 3.8	9.6 + 2.7	28.1 + 8.4
Total exotics	27.0 + 4.5	0.2 + 0.2	2.0 + 1.0
Total native species	11.4 + 2.7	9.4 + 2.6	26.1 + 8.2

Table 7. Plant diversity data for Phelp'sBay treated 6 June 2006 with 1.25 mg/L triclopyr

Percent Occurrence Results: Phelp'sBay

	7 Jun 06	5 Jul 06	15 Aug 06
Exotic Submersed vascular taxa: (%)			
Eurasian watermilfoil	100	37	20
Curly-leaf pondweed	37	11	0
Submersed vascular taxa: (%)			
Coontail	58	89	100
Elodea	11	5	10
Water marigold	0	6	10
Slender naiad	5	16	10
Big-leaf pondweed	11	21	10
Clasping-leaf pondweed	5	11	10
Flat-stem pondweed	26	63	20
Sago pondweed	0	47	0
Wild celery	0	0	10
Water stargrass	0	5	0
Floating-leaved plants: (%)			
White water lily	0	5	0
Submersed non-vascular taxa: (%)			
Chara sp.	0	11	6
Number of Sample Sites	19	19	19
Total number of taxa	8	13	10
Average number of taxa per sampling site	2.4	3.2	2.0
Average number of native taxa per sampling site	1.4	2.7	1.8

Table 8. Plant density data for Phelp'sBay, treated 6 June 2006 with 1.25 mg/L triclopyr

Plant Abundance Results: Phelp'sBay	Mean biomass per rake sample, g dry weight		
	7 Jun 06	**5 Jul 06**	**15 Aug 06**
Submersed exotic vascular taxa:			
Eurasian watermilfoil	40.3 + 5.2	5.8 + 3.9	0.5 + 0.4
Curly-leaf pondweed	1.6 + 0.6	0.0 + 0.0	0.0 + 0.0
Submersed native vascular taxa:			
Coontail	4.6 + 1.8	7.9 + 2.4	10.4 + 6.2
Elodea	0.8 + 0.6	0.3 + 0.3	0.1 + 0.1
Water marigold	0.0 + 0.0	0.0 + 0.0	0.3 + 0.3
Big-leaf pondweed	0.3 + 0.2	0.2 + 0.2	0.0 + 0.0
Illinois pondweed	0.0 + 0.0	0.0 + 0.0	3.8 + 3.8
Clasping-leaf pondweed	0.1 + 0.1	1.0 + 0.8	0.6 + 0.6
Flat-stem pondweed	1.1 + 06	2.1+ 0.9	0.5 + 0.3
Wild celery	0.0 + 0.0	0.0 + 0.0	1.6 + 1.6
Water stargrass	0.0 + 0.0	0.0 + 0.0	0.8 + 0.8
Submersed non-vascular taxa			
Chara sp.	0.0 + 0.0	0.7 + 0.7	0.0 + 0.0
Total	49.1 + 5.4	18.1 + 4.8	18.6 + 8.8
Total exotics	41.9 + 6.1	5.8 + 3.9	0.5 + 0.4
Total native species	7.3 + 2.2	12.2 + 3.4	18.1 + 8.8