2010 Lake Manitou Aquatic Vegetation Management Plan Update
Fulton County, IN
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Prepared for:
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Executive Summary

SePRO Corporation was contracted by the Indiana Department of Natural Resources (IDNR) to update the 2005 Lake Manitou long-term integrated aquatic vegetation management plan. Funding for development of this update was provided by IDNR. SePRO completed updates in 2007, 2008 and 2009 following whole lake Sonar treatments for control of hydrilla (*Hydrilla verticillata*) (SePRO 2008, 2009, & 2010). Items covered in this update include the 2010 sampling results and discussion, a review of the 2010 vegetation management effort, and updates to the budget and action plans.

The focus of the Lake Manitou vegetation management plan was shifted due to the discovery of hydrilla in 2006. Eradication of hydrilla has been the primary aquatic plant management goal for Lake Manitou since the discovery. Hydrilla is an exotic invasive species that can form dense populations that disrupt ecosystems, displace native species, and impair fish and wildlife habitat. This was the first confirmed case of hydrilla in the Midwest. IDNR took quick action by closing all ramps, public and private, on the lake, and contracted the application of a fast-acting contact herbicide (i.e. Komeen; a.i. chelated copper) to reduce the potential for spread of vegetative fragments.

The Indiana Department of Administration and IDNR issued a Request for Proposal for hydrilla eradication on Lake Manitou on January 26, 2007. SePRO was awarded a contract for the hydrilla eradication project, and quickly teamed with ReMetrix LLC (Carmel, IN), Aquatic Control, Inc. (Seymour, IN) and Aquatic Weed Control, Inc (Syracuse, IN) to complete the project. Fluridone treatments were initiated in 2007 with the objective of maintaining > 6 ppb for 180 days. Applications were completed with a combination of Sonar AS and Sonar Q. No hydrilla was detected during the August 27 Tier 2 survey. Hydrilla tuber sampling was completed just prior to and 5 months after initial treatment and revealed hydrilla tuber numbers were significantly reduced (86% total reduction) from pretreatment densities, however, as expected viable tubers remained.

Modifications were made to the 2008 treatment prescription in an attempt to increase selectivity. Sonar pellet formulations were switched from Sonar Q, which was applied throughout the littoral zone in 2007, to Sonar PR, which was only applied to areas where hydrilla was previously documented and in a small inflow area. In addition, the whole lake concentration was to be maintained above 3 ppb instead of 6 ppb, with more frequent bump applications to minimize exposure of native species to relatively high concentrations. An initial treatment was completed in mid-May and followed by three bump applications in order to maintain fluridone levels. No hydrilla was detected during the 2008 Tier 2 surveys, but fragments were observed during FasTEST sample collection. The public boat ramp was opened in late June 2008. Tuber sampling indicated a 43% reduction had occurred in the tuber bank.

The same fluridone prescription used in 2008 was to be applied to the 2009 treatment program. Initial application was completed in mid-May and three bump applications were completed

during the summer of 2009. No hydrilla was detected during either Tier 2 survey. One damaged hydrilla fragment was discovered during the June 22nd vegetation monitoring. This was the only documented observation of vegetative hydrilla during the 2009 season. The six permanent tuber sampling sites were sampled on October 5th. Sampling indicated that a further 19% reduction in the tuber bank occurred in 2009.

A Manitou Summit meeting to review and discuss the hydrilla eradication program with outside personnel was held on December 8, 2009. Following this meeting it was decided that the general direction of the management using Sonar should be continued. The 2010 treatment prescription called for use of multiple Sonar formulations and further refined target doses with an initial 6 ppb target followed by maintenance of 2.5 to 5 ppb throughout the growing season. The initial 2010 application was completed on May 7th with a combination of Sonar AS and Sonar PR. Thirty four gallons of Sonar AS (6 ppb) and 1,020 pounds of Sonar PR were strategically applied to different areas of the lake. Sonar PR was applied to 19 different locations where hydrilla had been documented in previous surveys and one location at the inflow. Sonar AS (6 ppb) was spread evenly over the entire lake. Bump applications were completed on June 29th, August 12th, and September 8th. A combination of Sonar AS and PR was applied during the June and August bumps, while only Sonar AS was applied during the September bump. Tier 2 vegetation surveys were completed on June 15th and August 30th. No hydrilla was detected during either survey. However, supplemental dive surveys conducted June 9, 2010 did readily detect herbicide-stressed, vegetative hydrilla growing from tubers at multiple permanent tuber sampling stations. Five permanent tuber sampling stations were sampled on October 4th. Sampling indicated that a further 75% reduction in the tuber bank occurred in 2010 and levels of unsprouted tubers have been reduced 96% since the beginning of the IDNR hydrilla eradication efforts on Manitou starting in the spring of 2007.

The hydrilla control efforts on Lake Manitou have continued to be successful in taking steps towards the stated goal of eradication. Four years of management have significantly reduced hydrilla tuber densities, prevented new hydrilla tuber production, and restricted the potential for hydrilla to spread to other waters in the region. Future modifications to assessment protocols for vegetative hydrilla detection and quantification as well as improved efficiency of hydrilla tuber assessments should help modify management designs to push towards the final eradication objective while helping to promote native plant re-establishment and spread.

The following is a list of recommended actions specifically designed to continue toward the goal of hydrilla eradication in Lake Manitou:

1. Continue a multiple Sonar formulation strategy with seasonal flexibility to shift management strategy based on revised quantitative assessment results throughout the coming use season.

2. Complete two Tier 2 surveys and regularly scheduled reconnaissance surveys in order to monitor the treatment effectiveness and impacts on native vegetation.

3. Continue to focus tuber sampling efforts at the permanent monitoring stations in the fall. Based on revised assessment results, placement and numbers of permanent stations may be altered to enhance the efficiency of future tuber collection events. Depending on assessment findings, increased sampling may be expected as tuber densities decrease. Modifications to existing plans will take into consideration tuber densities, distribution, and attrition level in relation to control methods. Additionally, a goal for consecutive sampling events without finding tubers at the monitoring stations will be considered before aborting the active control phase of the eradication program.

4. Maintain ramp closures and inspections until sampling can be completed that indicates there is no vegetative hydrilla present in Lake Manitou or if new assessment protocols indicate that presence is no greater than recent years and poses no risk of hydrilla off-site movement. The actions to eradicate and isolate hydrilla to Lake Manitou have, without question, reduced the potential for spread to other waters in Indiana and the Midwest. On-going dialogue with regional DNRs and other resource managers is also encouraged to prioritize management on Manitou and have regional response plans ready and updated to address new hydrilla infestations.

5. Amidst a variety of critical invasive aquatic species issues in the region including Asian carp, IDNR should continue as much as feasible with public education efforts in an attempt to prevent additional hydrilla introductions to Lake Manitou and other lakes in the region. As IDNR intervention with Manitou's management approaches successful eradication outcome, it will become important for local private stakeholders to be educated on the implications for the lake and its future management.

Acknowledgements

Funding for vegetation sampling, herbicide treatment, and preparation of the aquatic vegetation management plan was provided by the IDNR through Lake and River Enhancement Funds. Aquatic Control, Inc., Aquatic Weed Control, Inc., ReMetrix LLC, and SePRO Corporation completed the fieldwork, data processing, and map generation. Special thanks to Mr. Doug Keller, Aquatic Invasive Species Coordinator from the IDNR, for his assistance on this plan. In addition, special thanks are given to the Lake Manitou Association for their efforts. Authors of this report are Dr. Mark Heilman of SePRO, Mr. Nathan Long of Aquatic Control, Inc., and Mr. Richard Dirks of ReMetrix LLC. The authors would like to acknowledge the valuable input from the staff of SePRO Corp., Aquatic Control, Inc., Aquatic Weed Control, Inc., and ReMetrix LLC. The authors would also like to acknowledge Dr. Robert Richardson and his graduate students at North Carolina State University including Justin Nawrocki for their collaborative interaction on monoecious hydrilla tuber distribution and management.

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1.0 INTRODUCTION

This report was created in order to update the Lake Manitou Aquatic Vegetation Management Plan. In 2004, the Lake Manitou Association was awarded a grant through the Lake and River Enhancement (LARE) program to complete the original Lake Manitou Aquatic Vegetation Management Plan. Aquatic Weed Control completed the original plan in March of 2005 (Donahoe & Keister 2005). The Association was awarded grants again in 2005 and 2006 to update the plan and these updates were also completed by Aquatic Weed Control (Donahoe & Keister 2006 & 2007). The Indiana Department of Natural Resources (IDNR) took over funding vegetation management on Lake Manitou in 2007 following the discovery of hydrilla.

The following management goals were established by the original plan:

1. Develop or maintain a stable diverse aquatic plant community that supports a good balance of predator and prey fish and wildlife species, good water quality, and is resistant to minor habitat disturbances and invasive species.

2. Direct efforts to preventing and/or controlling the negative impacts of aquatic invasive species.

3. Provide reasonable public access while minimizing the negative impacts on plant and wildlife species (Donahoe & Keister 2005).

The primary purpose of the 2010 vegetation sampling and plan update is to document recent hydrilla eradication activities and to adjust the management plan as needed following the discovery of hydrilla in Lake Manitou in 2006. SePRO completed updates to the plan in 2008, 2009, and 2010 (SePRO 2008, 2009, & 2010). Items covered include the 2010 sampling results, a review of the 2010 vegetation management activities, and updates to the action plan. Recent Lake Manitou invasive species treatment history is summarized below in Table 1.0.1.

Table 1.0.1. Lake Manitou Invasive Species Control History 2005-2010.

Year	Invasive Species Treated	Acres Treated	Product(s) Applied
2005	Eurasian watermilfoil	45	2,4-D
2006	Eurasian watermilfoil & Hydrilla	95 milfoil & 20 hydrilla	2,4-D & Copper (Komeen)
2007	Hydrilla	809 (whole lake)	Fluridone (Sonar AS & Sonar Q)
2008	Hydrilla	809 (whole lake)	Fluridone (Sonar AS & Sonar PR)
2009	Hydrilla	809 (whole lake)	Fluridone (Sonar AS & Sonar PR)
2010	Hydrilla	809 (whole lake)	Fluridone (Sonar AS & Sonar PR)

Lake Manitou is an 809-acre lake located in Fulton County, Indiana. The control of Eurasian watermilfoil was the primary objective of the original plan. This changed in August of 2006 when IDNR discovered hydrilla during a routine Tier 2 survey. This discovery precipitated a rapid response by IDNR Aquatic Invasive Species Coordinator, Doug Keller.

Upon confirmation of species, access to the lake was immediately closed to the public to prevent the potential for spread through boats and boat trailers (Figure 1.0.1). Due to a lack of viable hydrilla fragments following treatment, the public ramp was re-opened in June of 2008. In 2009 and 2010 the public ramp was closed, prior to treatment, and then reopened on July 1st of each year.

Figure 1.01. Public notices posted at Lake Manitou public launches.

Hydrilla is an exotic invasive species that can form dense populations that disrupt ecosystems, displace native species, and impair fish and wildlife habitat. It has unique physiological and biological characteristics that can create a competitive advantage over many native submersed plant species, and has been termed "The Perfect Aquatic Weed" (Langeland 1996). Hydrilla has a low light and CO_2 compensation point compared to some native submersed plant species (Van et al. 1976); can switch between C_3 and C_4 carbon utilization under limiting conditions (Rao et al. 2002); forms dense canopies at the water surface which limits light penetration (Haller and Sutton 1975); and can have up to 85% of its biomass in the top 2 feet of water. Hydrilla can create an environment that is difficult for other plant species to effectively grow and compete (Figure 1.01). If hydrilla was not eradicated or its spread contained, it likely would rapidly spread to other waters, form monocultures of vegetation, impede recreation, reduce biodiversity, and result in biological pollution in many shallow lakes of Indiana. Eradication of hydrilla continues to be the primary goal of vegetation management in Lake Manitou.

Figure 1.02. Once established, hydrilla can quickly colonize available habitat with monospecific stands, out-competing exsiting native or endemic species.

Lake Manitou was the first confirmed location of hydrilla in the Midwest. Hydrilla is the number one aquatic plant problem in the U.S. with more money expended on management than for any other aquatic plant species. Other states have taken aggressive approaches against hydrilla recognizing the potential impact this species can have on recreation, water conveyance, biodiversity, and water use. California legislatively mandated an eradication program after the plant was identified in the State in 1976; Washington and Maine enacted eradication programs shortly after identifying hydrilla; hydrilla was discovered in Wisconsin in 2007 with eradication efforts underway; recently hydrilla was identified in New York, Idaho, and Kansas with aggressive control program being initiated. Many of these programs have, at a minimum, minimized the potential for further spread of hydrilla within the state by keeping the population at the lowest possible level and decreasing vegetative production.

Hydrilla can be easily spread through fragmentation, so control of this species took precedence over all other aquatic vegetation control efforts on Lake Manitou. Shortly after discovery, IDNR personnel mapped the hydrilla population in Lake Manitou and contracted Aquatic Weed Control, Inc., to treat approximately 20 acres of hydrilla in the lake with Komeen (the Poet's Point area in the northern section of the lake, and near the City ramp). The treatment was effective in controlling extant hydrilla biomass in the treatment areas to reduce potential for

vegetation spread in Lake Manitou and downstream. Further surveys conducted independently by IDNR personnel and SePRO personnel (Figure 1.03) confirmed additional sites in the lake with hydrilla. This led to a Request for Proposal (RFP) for a comprehensive hydrilla eradication program for Lake Manitou.

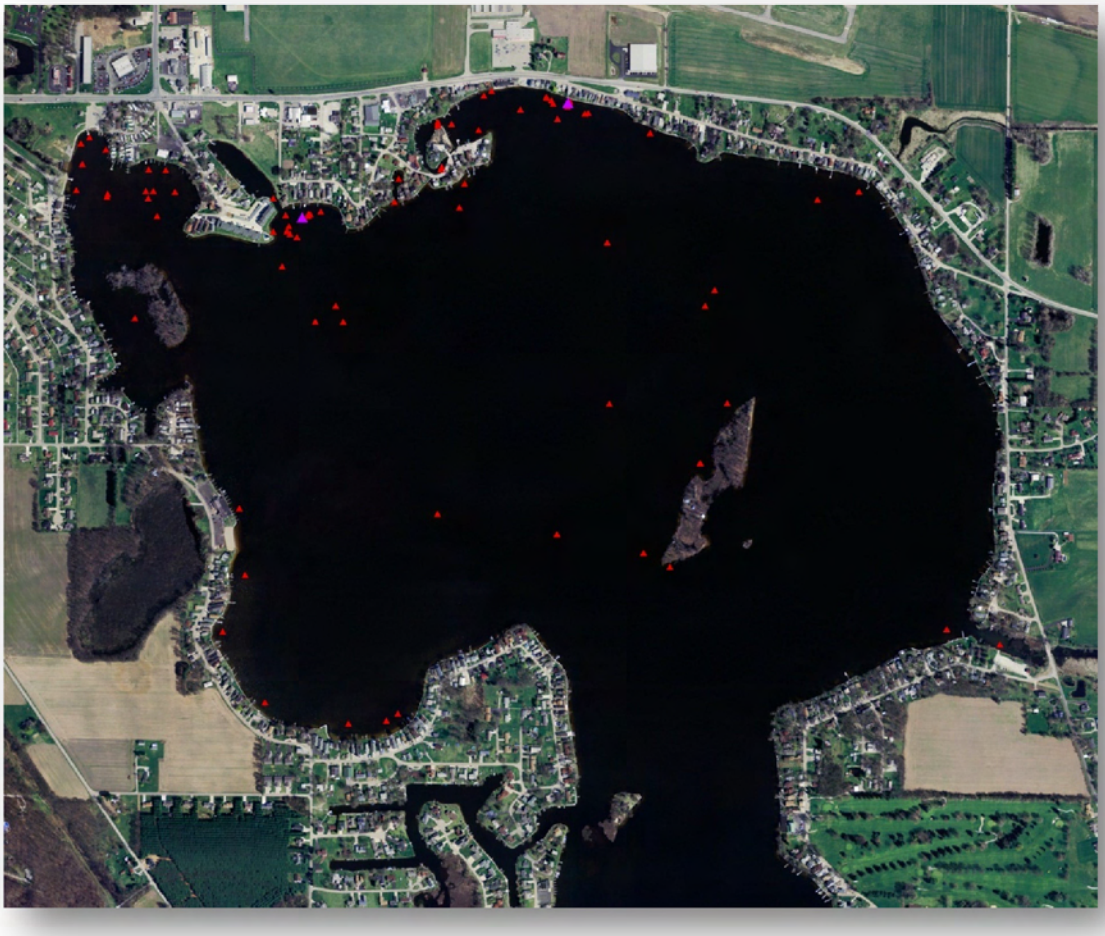

Figure 1.03. Lake Manitou hydrilla sightings 2006-2010. Note vegetative sitings by Dr. Heilman in 2010 indicated by purple markers. (Includes all sightings recorded by the project team and IDNR.)

SePRO Corporation was awarded the contract and assembled a team focused on the management of vegetation in Lake Manitou, with the objective of hydrilla eradication. The team consisted of personnel from Aquatic Control, Inc., Aquatic Weed Control, Inc., ReMetrix LLC, and SePRO. Fluridone treatments were initiated in 2007 with the objective of maintaining greater than 6 ppb for 180 days. Applications were on May 18 with a bump application on June 26. Applications were completed with a combination of Sonar AS and Sonar Q. A Tier 2 aquatic vegetation survey was completed on May 31 and indicated that hydrilla was severely damaged by the initial treatment. No hydrilla was detected during the August 27th Tier 2 survey. Hydrilla tuber sampling was completed just prior to, and five months after initial treatment and revealed

hydrilla tuber numbers were significantly reduced (86% total reduction) from pretreatment densities, however, as expected viable tubers remained. In addition to the tuber reduction, the treatment program also provided successful control of hydrilla biomass throughout the 2007 season.

Modifications were made to the 2008 treatment prescription in an attempt to increase selectivity. Sonar pellet formulations were switched from Sonar Q, which was applied throughout the littoral zone in 2007, to Sonar PR, which was only applied to areas where hydrilla was previously documented and in a small inflow area. In addition, the whole lake concentration was to be maintained above 3 ppb instead of 6 ppb, with more frequent bump applications to minimize exposure of native species to relatively high concentrations.

In 2008, Sonar treatments were initiated on May 14th. Sonar PR (2.2 ppb) was applied to 18 different locations where hydrilla had been documented in previous surveys and one location at the inflow. Sonar AS (6 ppb) was spread evenly over the entire lake. Bump applications were completed on June 30th, August 19th, and October 8th. A combination of Sonar AS and PR were applied during the June and August bumps while only Sonar AS was applied during the October bump. Tier 2 vegetation surveys were completed on June 16th and August 27th. No hydrilla was detected during either survey, and Chara (*Chara spp.)* was dominant in both surveys. Following the June Tier 2 survey, IDNR opened the public boat launch. However, during the June 26th reconnaissance survey four hydrilla plants and fragments were detected floating along the north shore. This was the only confirmed observation of hydrilla during the 2008 season, with the exception of sprouting tubers. The six permanent tuber sampling sites were sampled on September 19th. Sampling indicated that an additional 43% reduction in the tuber bank occurred in 2008.

In 2009 the hydrilla eradication team remained the same and a program similar to 2008 was initiated. The initial fluridone application was completed on May 14th as a combination of Sonar AS and PR. Thirty-six gallons of Sonar AS and 1,010 pounds of Sonar PR were strategically applied to different areas of the lake. Sonar PR was applied to 19 different locations where hydrilla had been documented during previous surveys and one location at the inflow. Sonar AS (6 ppb) was applied to the entire lake at rates that varied according to water depth. Bump applications were completed on June 17th, July 29th, and September 9th. A combination of Sonar AS and PR were applied during the June and July bumps while only Sonar AS was applied during the September bump. Tier II vegetation surveys were completed on June 16th and August 31st. No hydrilla was detected during either survey. One damaged hydrilla fragment was discovered during the June 22nd vegetation monitoring. This was the only documented observation of vegetative hydrilla during the 2009 season. The six permanent tuber sampling sites were sampled on October 5th. Sampling indicated that a further 19% reduction in the tuber bank occurred in 2009. The following sections will detail the progress of the 2010 hydrilla eradication program along with future Lake Manitou plant management plans.

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2.0 VEGETATION SAMPLING

Vegetation sampling activities were nearly identical in scope in 2010 relative to assessments in past years of program. Standard Tier 2 surveys (IDNR 2006) were completed on June 15th and August 30th to monitor the hydrilla population and quantify native species abundance. In addition, visual observations of the plant community were recorded throughout the season during FasTEST sampling. These observations aided in the timing of initial Sonar application, surveyed for potential hydrilla biomass, and provided insight into the progress of the treatments. Hydrilla tuber sampling was completed on October 4th to monitor depletion of the tuber bank. Table 2.0.1 is a summary of 2010 plant survey activities on Lake Manitou.

Table 2.0.1. Summary of 2010 Plant Surveys on Lake Manitou. 2010 herbicide treatment dates: May 7 (initial Sonar); June 29, August 12, and September 8 (Sonar bumps).

Date (2010)	Type of Survey
May 10	Reconnaissance Survey
June 7	Reconnaissance Survey
June 15	Tier 2 Survey
June 21	Reconnaissance Survey
July 6	Reconnaissance Survey
July 19	Reconnaissance Survey
August 2	Reconnaissance Survey
August 16	Reconnaissance Survey
August 30	Tier 2 Survey
August 30	Reconnaissance Survey
September 13	Reconnaissance Survey
September 28	Reconnaissance Survey
October 4 & 5	Tuber sampling
October 11	Reconnaissance Survey
November 1	Reconnaissance Survey

2.1 Reconnaissance Surveys

For reference: the initial Sonar treatment was conducted on May 7, 2010; bump treatments were conducted on June 29, August 12, and September 8, 2010. Details of the treatments can be found in Section 4.0.

Reconnaissance surveys were completed during FasTEST collections, and were the most frequent type of survey completed (Table 2.0.1). Surveyors followed a pre-established route designed to maneuver over formerly known areas of hydrilla (Figure 2.1.1) Along with collecting FasTEST samples, personnel recorded information at each of the eight sample sites on plant species presence, injury, cover, and growth ratings, Secchi depth, and surface temperature. Dissolved oxygen/temperature profiles were also taken at the predetermined FasTEST site 2. Water samples were collected on two occasions at FasTEST site 2 to monitor orthophosphate, total phosphorus, and chlorophyll α (water quality monitoring will be discussed further in Section 3.0). Individual monitoring data sheets are included in the Appendix.

Figure 2.1.1. FasTEST monitoring/vegetation reconnaissance survey route

Surveying, in conjunction with water sampling, provided a rapid and cost effective means of assessing the effectiveness of the treatment program. This information, combined with the FasTEST results, helped determine the timing and necessity of bump applications. A summary of the reconnaissance survey results for 2010 is provided below in Table 2.1.1

Table 2.1.1. 2010 FasTEST collection plant monitoring summary

Collection Date	Surface-Temp. Range (˚F)	Secchi Depth (ft)	Species Observed and Injury Rating[a]
May 10	59.5-62.7	8.2-10.1	Chara (2)
June 7	73.1-74.7	7.5-9.3	Chara (2)
June 21	78.5-81.0	3.4-4.6	Chara (2)
July 6	80.9-82.4	2.1-3.7	Chara (2)
July 19	82.9-80.2	2.4-3.8	Chara (2)
Aug 2	79.8-83.2	3.0-4.3	Chara (2)
Aug 16	81.1-83.1	2.8-4.2	n/a
Aug 30	78.5-80.4	5.2-2.9	Chara (2)
Sept 13	68.9-70.1	3.0-5.6	n/a
Sept 29	64.0-66.4	4.5-5.5	n/a
Oct 11	64.3-65.2	2.4-4.7	Chara (2)
Nov 1	48.4-52.8	3.9-4.5	Chara (2)

[a] Injury rating from 1-6 (1-healthy, 2-slight injury, 3-moderate injury, 4-severe injury, 5- dead plant, 6 – not present). Chara = *Chara* sp.; n/a = no plants found.

2.2 Tuber Sampling

2.2.1 Fall Tuber Sampling

Since the initiation of whole-lake hydrilla eradication efforts on Lake Manitou in 2007, the attrition of subterranean hydrilla turions (hereinafter referred to as tubers) has been monitored to confirm impacts of the multiple-year Sonar treatment program. On October 4, 2010, near the completion of the 4th year of consecutive whole-lake eradication treatment, tubers were monitored at each of five permanent stations established in 2007 – 2008 (Figure 2.2.1). Stations 2 - 5 were established at the start of the hydrilla eradication project in May 2007. Station 6 was added during sampling in May 2008. All six stations were monitored in September 2008 and October 2009. Station 1 was dropped from 2010 sampling since no tubers had been collected there for two consecutive seasons. The 2010 collection protocol called for an initial collection of 100 sediment cores at each station. At stations where the initial 100 cores did not yield collection of a tuber, an additional 50 cores were collected to boost sampling intensity. A description of the sediment sampling methods and objectives were previously described in the *Lake Manitou Aquatic Vegetation Management Plan Update, Fulton County, IN, March 14, 2008*.

In fall 2010 sampling, a total of 6 tubers were collected from 700 total core samples: 5 in core samples and one floating sprouted (clearly dislodged by the core sampler) (Table 2.2.1). Unlike previous year's sampling events, the floating tuber collected at station 4 in this year's collection event was included in assessment results this year since it was only tuber detected at the station. Unsprouted tubers collected in the October 2010 survey were not assayed for viability, but based on 2007 (100% viable) and 2008 (83% viable) tests, it is likely that the vast majority remain viable. At station 2, one sago pondweed tuber was also collected in one of the sediment cores.

Table 2.2.1. Summary data for six permanent hydrilla tuber monitoring stations sampled October 4, 2010. 100 4-inch diameter (0.0876 ft^2 = π × 0.167' × 0.167') core samples were taken at Station 2. 150 cores were taken at Stations 3, 4, 5, and 6. Tubers were not collected at station 6, and no aboveground turions were found at any of the stations.

Site	GPS Waypoint	Sprouting hydrilla tubers	Non-sprouting hydrilla tubers	Number of core samples
Dollar Store Bay Station 2	084 T1	0	3	100
White Dock Station 3	085 T1	1	0	150
Poet's Point Station 4	086 T1	1 [a]	0	150
Poet's Bay Station 5	087 T1	0	1	150
Lighthouse North Station 6	057 T1	0	0	150
Total		**1**	**4**	**700**

[a] One floating sprouted hydrilla tuber collected.

Figure 2.2.1. Location of the six permanent tuber sampling stations. Sites 1 through 5 were established May 2007. Site 6 was established May 2008. Note: Site 1 was abandoned in 2010 since no tubers had been collected there for the two prior seasons.

2.2.2 Tuber Sampling Summary (2007-2010 data)

The hydrilla management plan on Lake Manitou and associated control methods have been highly successful at reducing hydrilla tuber densities. Following four consecutive Sonar treatments, overall measured tuber abundance (sprouted and non-sprouting with corrections for sampling area) has decreased by 99% at the permanent sampling stations between May 2007 (pre-treatment) and October 2009 (Table 2.2.2 and Chart 2.2.1). Over the four season period, sprouting tuber density has decreased 99% and non-sprouting tuber density has decreased 96%. Looking at annual trends in attrition rate, the total tuber density (sprouting and non-sprouting) was reduced by 88% following the 1st year of Sonar treatment, with an additional 42% reduction after the second year, and an additional 19% reduction after the third year. Following this most recent fourth cycle of treatment, total tuber density decreased 75%, a much sharper decline than in the last two years of management. Annual reductions in sprouted tuber density were 95%, 41%, 31%, and 67% respectively over the four years of collection, while non-sprouted tubers declined by 68%, 42%, 14%, and 78% respectively over the same period of time.

Analysis of these three-year results indicates a variable tuber attrition rate at the six permanent monitoring stations on the lake (Charts 2.2.1, 2.2.2, and 2.2.3). During the first three cycles of Sonar treatment, measured attrition rate declined by approximately half each annual cycle of management. In 2010, tuber attrition was sharply greater than 2008 or 2009. While it is not possible to ascertain with certainty the mechanisms behind these trends, they could be the result of different year-to-year climatic conditions. Anecdotally, warm early spring conditions in 2010 may have favored an earlier and more vigorous germination of dormant tubers than previous seasons. In supplemental diver surveys conducted by SePRO in early June at the time of the first Tier 2 vegetation survey, Sonar-injured hydrilla plants growing from germinated tubers were detected at several of the permanent tuber monitoring stations. While these plants were geospatially very isolated and clumped in their distribution, they were sufficiently common to collect in a short period of survey (Figure 2.2.1). The small size and spatial distribution of diver-collected hydrilla would validate the inability to collect hydrilla via rake sampling in Tier 2 surveys since 2008.

Regardless of the exact mechanism(s) for annual differences, unlike recent seasons, tuber dormancy appears reduced in this last annual cycle of management with Sonar herbicide. The latest figures on tuber attrition suggest a much shorter time frame for reaching theoretical hydrilla tuber bank depletion or eradication than suggested by tuber survey results in 2009. At the end of 2009, projections of decline in tuber abundance based on non-linear regression as well as constant attrition rate based on the last two collection results (19%) indicated that total attrition of the tuber bank (described as >99.5% of original May 2007 total numbers) would take between 8.6 – 14.7 years (Chart 2.2.2). This post-2009 projected increase in the number of projected annual cycles of whole-lake treatment compared to post 2008 projected range of 2.6 – 4.5 years to reach functional eradication of the lake's hydrilla tuber bank. 2010 results indicating greater hydrilla tuber attrition leads to a revised projected range 4.8 to 6.7 seasons of management. This new projection suggests between 1-3 additional cycles of Sonar management similar to the last four would reach 99.5% reduction in the tuber bank. The

increasing difficulty associated with finding decreasing numbers of tubers at the various permanent monitoring stations suggests potential altered role for this monitoring effort in future management cycles. With Tier 2 surveys not finding hydrilla and tuber densities approaching levels very difficult to quantify even with great logistical effort, alternate assessment approaches may be critical to provide solid quantitative data to guide future program direction on Manitou.

As described in previous project updates, the overall reductions in the hydrilla tuber bank on Lake Manitou have achieved containment and prevented spread to other Indiana lakes. However, a full eradication goal remains to be achieved. Annual changes in rate of tuber bank attrition as indicated by tuber collections at the various permanent monitoring stations have made projections of final tuber bank depletion difficult from year to year. 2010 results provide reason for greater optimism on prospects for full eradication. However, continued tuber finds with the relatively small overall bottom area represented by current sediment core collection protocol along with diver observations of relatively common spring 2010 abundance indicate that hydrilla remains capable of rebounding in Lake Manitou without continued management. With the shorter window projected for tuber reductions approaching 100%, the stated IDNR objective of complete hydrilla eradication appears more achievable and should remain as the program's ultimate goal. This outlook should be tempered with findings of hydrilla recovery 10 years or more into eradication efforts in the Northeast and Pacific Northwest, but the risk that hydrilla poses to other Indiana lakes and aquatic ecosystems throughout the Upper Midwest continues to merit a highly aggressive management philosophy for complete long-term eradication / containment.

Figure 2.2.2. Hydrilla collected on June 9, 2010 via brief dive survey of permanent tuber sites.

Table 2.2.2. Sprouted, Unsprouted, and Total Hydrilla Tubers Corrected For Sampled Area: A – Per Square Foot; B – Per Acre. Also presented are Annual Percent Reductions and Percent Reductions since 2007 Start of Manitou Hydrilla Management Program

A. Tubers Per Square Foot	Sprouted Tubers Per Square Foot						Unsprouted Tubers Per Square Foot						Total Tubers Per Square Foot (Sprouted and Unsprouted)					
	May 14-17 2007	Sept. 17 2007	May 12-14 2008	Sept. 15 2008	Oct. 5-6 2009	Oct. 4 2010	May 14-17 2007	Sept. 17 2007	May 12-14 2008	Sept. 15 2008	Oct. 5-6 2009	Oct. 4 2010	May 14-17 2007	Sept. 17 2007	May 12-14 2008	Sept. 15 2008	Oct. 5-6 2009	Oct. 4 2010
Station 1 WPT83	1.83	0.22	nd[a]	0.00	0.00	nd**	0.00	0.00	nd[a]	0.00	0.00	**nd****	1.83	0.22	nd[a]	0.00	0.00	**nd****
Station 2 WPT84	3.65	0.00	nd[a]	0.91	0.00	0.00	4.79	0.46	nd[a]	1.37	0.11	**0.34**	8.45	0.46	nd[a]	2.28	0.11	**0.34**
Station 3 WPT85	7.76	0.46	nd[a]	0.00	0.00	0.08	3.20	0.46	nd[a]	0.23	0.00	**0.00**	10.96	0.91	nd[a]	0.23	0.00	**0.08**
Station 4 WPT86	9.13	0.43	nd[a]	0.00	0.00	0.08	0.46	1.72	nd[a]	0.46	0.34	**0.00**	9.59	2.15	nd[a]	0.46	0.34	**0.08**
Station 5 WPT87	2.51	0.15	nd[a]	0.23	0.34	0.00	0.68	0.76	nd[a]	0.23	1.48	**0.08**	3.20	0.91	nd[a]	0.46	1.83	**0.08**
Station 6 WPT57	nd[a]	nd[a]	0.91	0.00	0.34	0.00	nd	nd	0.46	0.23	0.11	**0.00**	nd	nd	1.37	0.23	0.46	**0.00**
ALL SITES	**4.98**	**0.24**	**0.91**	**0.14**	**0.10**	0.03	**1.83**	**0.59**	**0.46**	**0.34**	**0.29**	**0.07**	**6.80**	**0.83**	**1.37**	**0.49**	**0.39**	**0.10**

B. Tubers Per Acre	Sprouted Tubers Per Acre						Unsprouted Tubers Per Acre						Total Tubers Per Acre (Sprouted and Unsprouted)					
	May 14-17 2007	Sept. 17 2007	May 12-14 2008	Sept. 15 2008	Oct. 5-6 2009	Oct. 4 2010	May 14-17 2007	Sept. 17 2007	May 12-14 2008	Sept. 15 2008	Oct. 5-6 2009	Oct. 4 2010	May 14-17 2007	Sept. 17 2007	May 12-14 2008	Sept. 15 2008	Oct. 5-6 2009	Oct. 4 2010
Station 1 WPT83	79,562	9,750	nd[a]	0	0	**nd****	0	0	nd[a]	0	0	**nd****	79,562	9,750	nd[a]	0	0	**nd****
Station 2 WPT84	159,123	0	nd[a]	39,781	0	**0**	208,849	19,890	nd[a]	59,671	4,973	**14,918**	367,973	19,890	nd[a]	99,452	4,973	**14,918**
Station 3 WPT85	338,137	19,890	nd[a]	0	0	**3,315**	139,233	19,890	nd[a]	9,945	0	**0**	477,370	39,781	nd[a]	9,945	0	**3,315**
Station 4 WPT86	397,808	18,765	nd[a]	0	0	**3,315**	19,890	75,058	nd[a]	19,890	14,918	**0**	417,699	93,823	nd[a]	19,890	14,918	**3,315**
Station 5 WPT87	109,397	6,630	nd[a]	9,945	14,918	**0**	29,836	33,151	nd[a]	9,945	64,644	**3,315**	139,233	39,781	nd[a]	19,890	79,562	**3,315**
Station 6 WPT57	nd[a]	nd[a]	39,781	0	14,918	**0**	nd[a]	nd[a]	19,890	9,945	4,973	**0**	nd[a]	nd[a]	59,671	9,945	19,890	**0**
ALL SITES	**216,805**	**10,548**	**39,781**	**6,216**	**4,262**	**1,421**	**79,562**	**25,616**	**19,890**	**14,918**	**12,787**	**2,841**	**296,367**	**36,164**	**59,671**	**21,134**	**17,049**	**4,262**
Percent Reduction Year to Year	**n/a**	**95**	**n/a**	**41**	**31**	**67**	**n/a**	**68**	**n/a**	**42**	**14**	**78**	**n/a**	**88**	**n/a**	**42**	**19**	**75**
Percent Reduction Since May 2007	**n/a**	**95**	**n/a**	**97**	**98**	**99**	**n/a**	**68**	**n/a**	**81**	**84**	**96**	**n/a**	**88**	**n/a**	**93**	**94**	**99**

[a] nd indicates not determined

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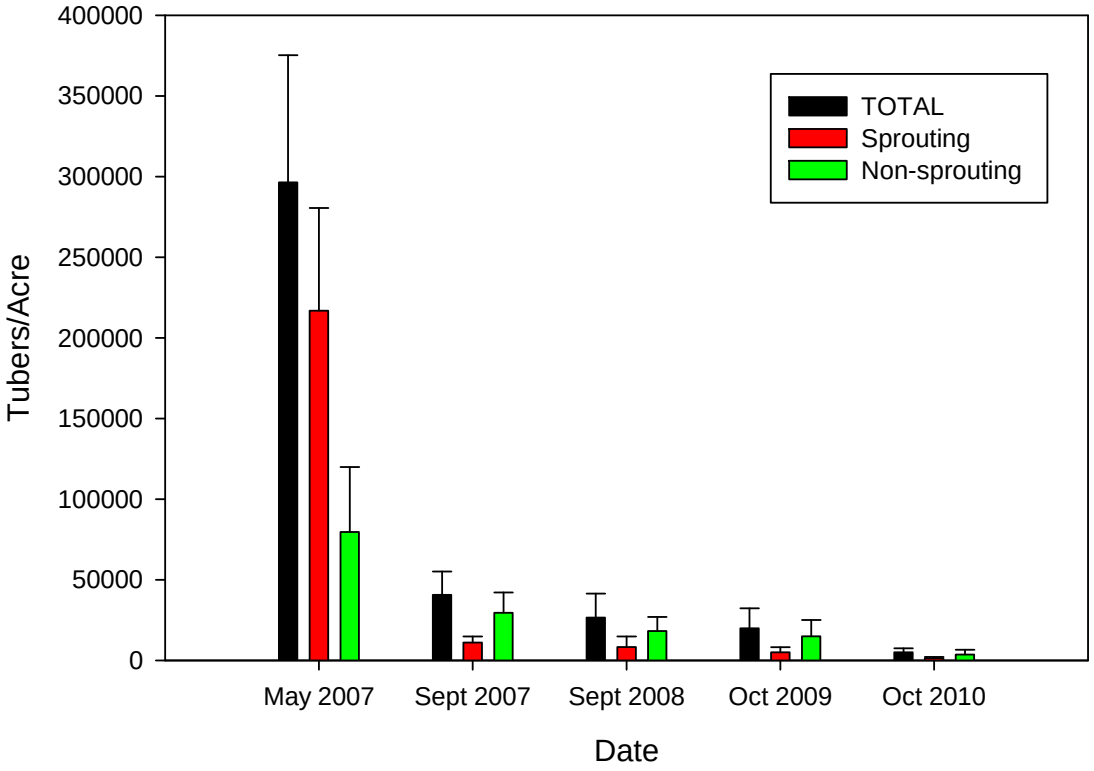

Chart 2.2.1. Overall changes in monoecious hydrilla tuber abundance in Lake Manitou following four consecutive years of Sonar treatments (spouting + non-sprouting = total).

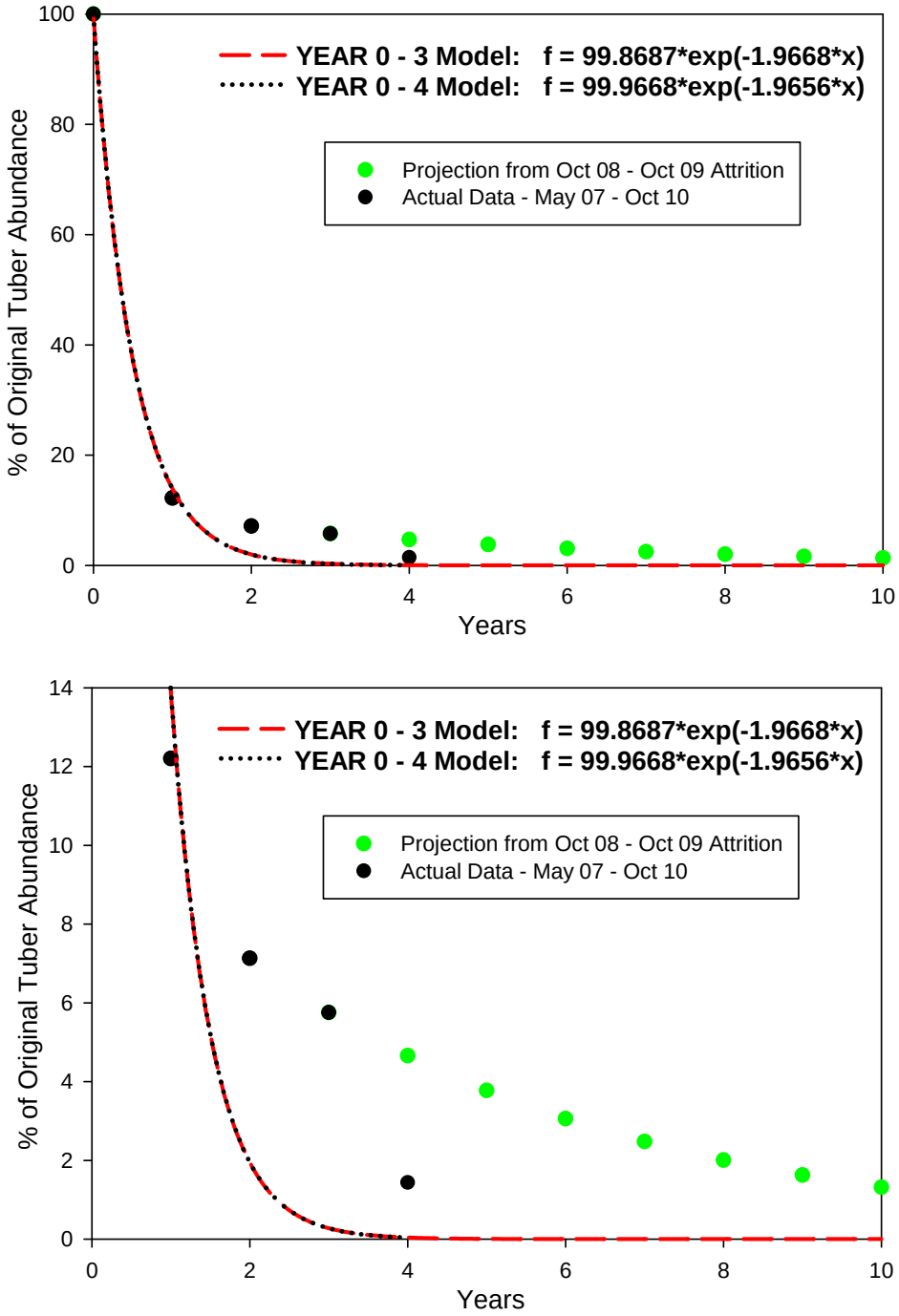

Chart 2.2.2. The attrition rate of hydrilla tubers on Lake Manitou based on 2010 Results and 2009 Projections. Year 1 (88%), Year 2 (42%), Year 3 (19%), and Year 4 (75%) reductions (black dots) are from actual data and include both sprouted and unsprouted tubers; all subsequent reductions (years 4 through 10 – green dots) were based on reductions observed during year 3 (Oct '08 – Oct '09: 19%). Graph lines represent predicted attrition rate based on non-linear regression analysis incorporating Year 0 – 3 data (red dashed line) or Year 0 – 4 data (black dotted line). Minimal differences exist between the two regressions. The top graph shows full 100% vertical axis while the bottom graph zooms in upon lower section of vertical axis for improved resolution of projected long-term annual trends.

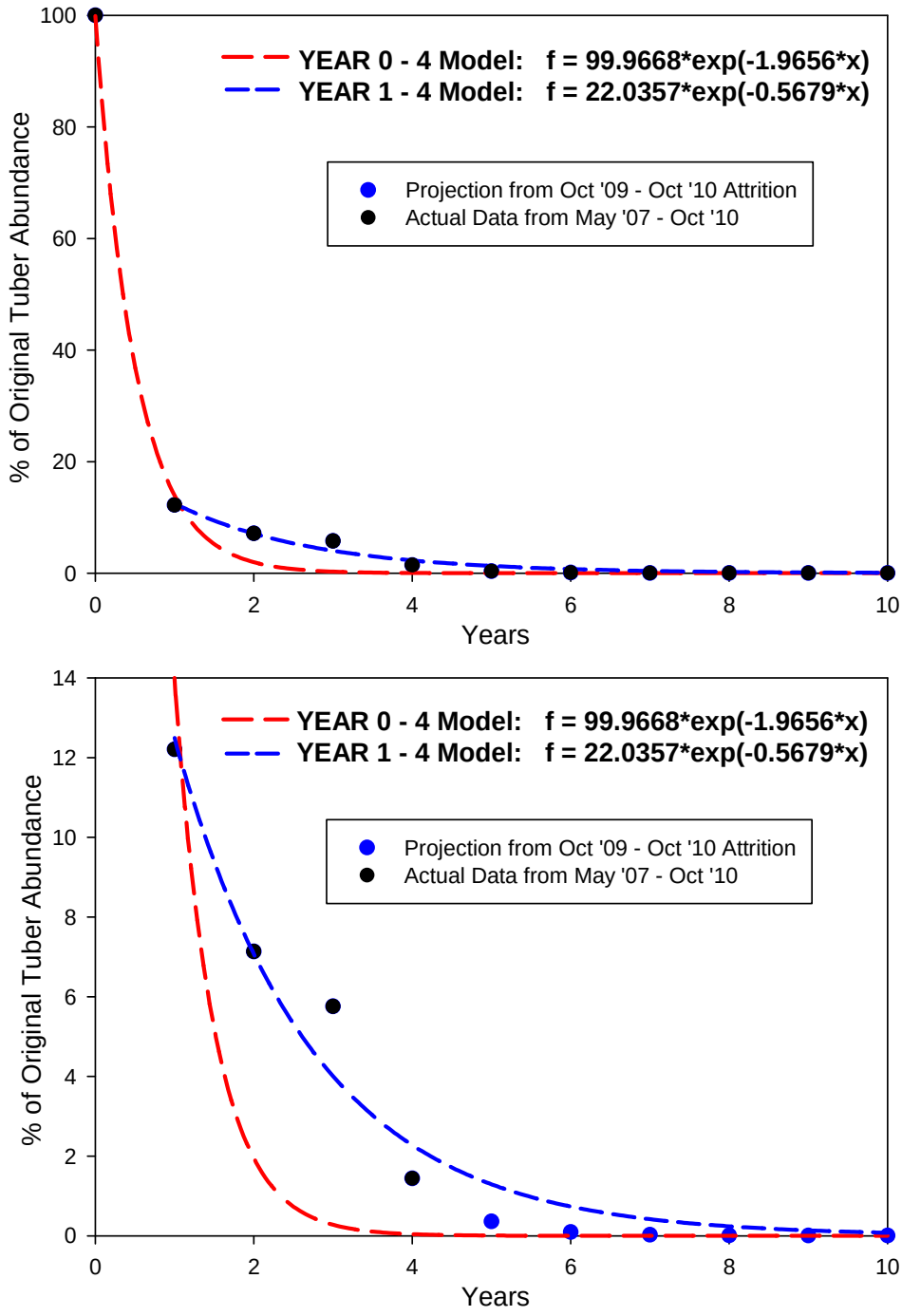

Chart 2.2.3. The attrition rate of hydrilla tubers on Lake Manitou based on 2010 Results and 2010 Projections. Year 1 (88%), Year 2 (42%), Year 3 (19%), and Year 4 (75%) reductions (black dots) are from actual data and include both sprouted and unsprouted tubers; all subsequent reductions (years 5 through 10 –blue dots) were based on reductions observed during year four (Oct '09 – Oct '10: 75%). Graph lines represent predicted attrition rate based on non-linear regression analysis incorporating Year 0 – 4 data (red dashed line) and Year 1 – 4 data (blue dashed line). Omission of Year 0 data did markedly improve regression fit of Year 1 – 4 results. The top graph shows full 100% vertical axis while the bottom graph zooms in upon lower section of vertical axis for improved resolution of projected long-term annual trends.

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2.3 Tier 2 Surveys

For reference: the initial Sonar treatment was conducted on May 7, 2010; bump treatments were conducted on June 29, August 12, and September 8, 2010. Details of the treatments can be found in Section 4.0.

Tier 2 surveys were completed on June 15th and August 30th. Tier 2 surveys were included in the vegetation monitoring program to quantify species diversity and abundance, allow for pre- and post-treatment comparisons of the plant community, and locate additional areas of hydrilla. The design of the Lake Manitou point-intercept survey was based on the LARE protocol (IDNR 2006). A total of 122 sites were sampled in the spring and late summer (Figure 2.3.1).

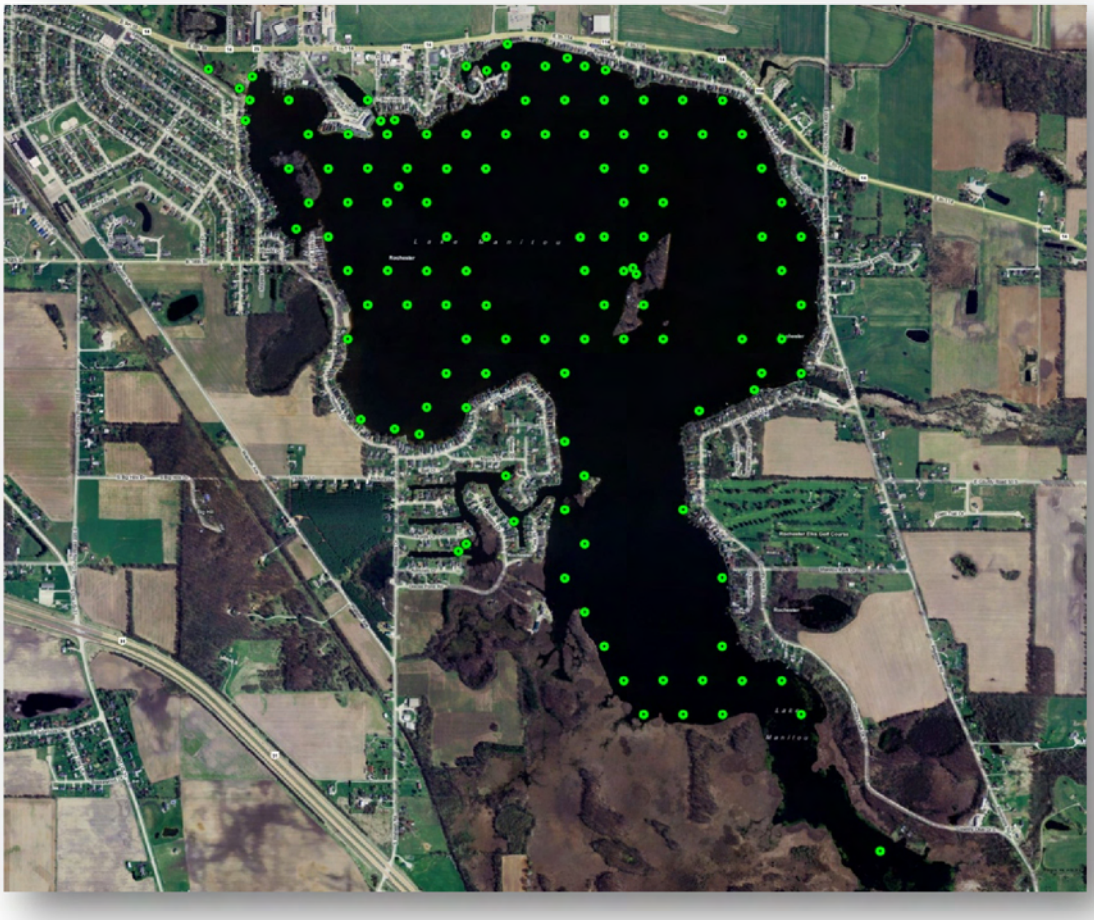

Figure 2.3.1. Tier 2 vegetation sample sites visited in 2010.

2.3.1 Spring Tier 2 Survey Results

The spring survey was conducted on June 15th. One rake drag was completed at each survey location. Plant density and injuring ratings were recorded for individual species (Table 2.3.1). Vegetation was collected to a maximum depth of six feet. Aquatic vegetation was present at

40.9% of the sites. Four native submersed plant species were collected along with one non-native species. The maximum number of species per site was 3; the mean species collected per site was 0.43. The species diversity index was 0.47 (Table 2.3.2).

Table 2.3.1. Plant rating scales used during the Tier 2 surveys.

Density Ratings	Injury Ratings
0: No plants retrieved	1: Healthy
1: 1-20% of rake teeth filled	2: Slight Injury
3: 20-99% of rake teeth filled	3: Moderate Injury
5: 100%+ of rake teeth filled	4: Severe Injury
8: Plant present but unranked	5: Dead Plant

Table 2.3.2. Occurrence and Abundance of Submersed Aquatic Plants in Lake Manitou. All depths: June 15, 2010.

Occurrence and Abundance of Submersed Aquatic Plants in Lake Manitou (all depths).								
County:	Fulton	Total Sites:	122				Mean species/site:	0.44
Date:	6/15/10	Sites with plants:	50				SE Mean species/site:	0.05
Secchi (ft):	7	Sites with native plants:	50				Mean native species/site:	0.43
Max Plant Depth (ft):	7	Number of species:	5				SE Mean natives/site:	0.05
Trophic Status:	Meso	# of native species:	4				Species diversity:	0.47
		Maximum species/site:	3				Native species diversity:	0.43

All Depths	Frequency of Occurrence	Rake score frequency per sp				Plant Dominance
Species		0	1	3	5	
Chara	31.1	68.9	29.5	0.8	0.8	7.2
Sago pondweed	5.7	94.3	4.1	0.0	1.6	2.5
Coontail	4.9	95.1	4.1	0.0	0.8	1.6
Curlyleaf pondweed	1.6	98.4	1.6	0.0	0.0	0.3
Flatstem pondweed	0.8	99.2	0.8	0.0	0.0	0.2
Filamentous Algae	64.8					
Other species observed: spatterdock. hibiscus. white water lily. cattail. purple loosestrife						

Chara (*Chara sp*.) was present at the highest percentage of sample sites (31.1%) and had the highest dominance rating (Figure 2.3.2). Sago pondweed (*Potamogeton pectinatus*) ranked second in percent occurrence and dominance (Figure 2.3.3). Common coontail ranked third in frequency (4.9%). Curlyleaf pondweed, an invasive species, was collected at two sites (Figure 2.3.4) while flatstem pondweed (*Potamogeton zosteriformis*) was collected at a single location. Cattail (*Typha sp*.), spatterdock (*Nuphar sp.)*, hibiscus (*Hibiscus sp*.), white water lily (*Nymphaea tuberosa),* and purple loosestrife (*Lythrum salicaria*) were observed but not collected with the rake. Filamentous algae were present at 64.8% of sites.

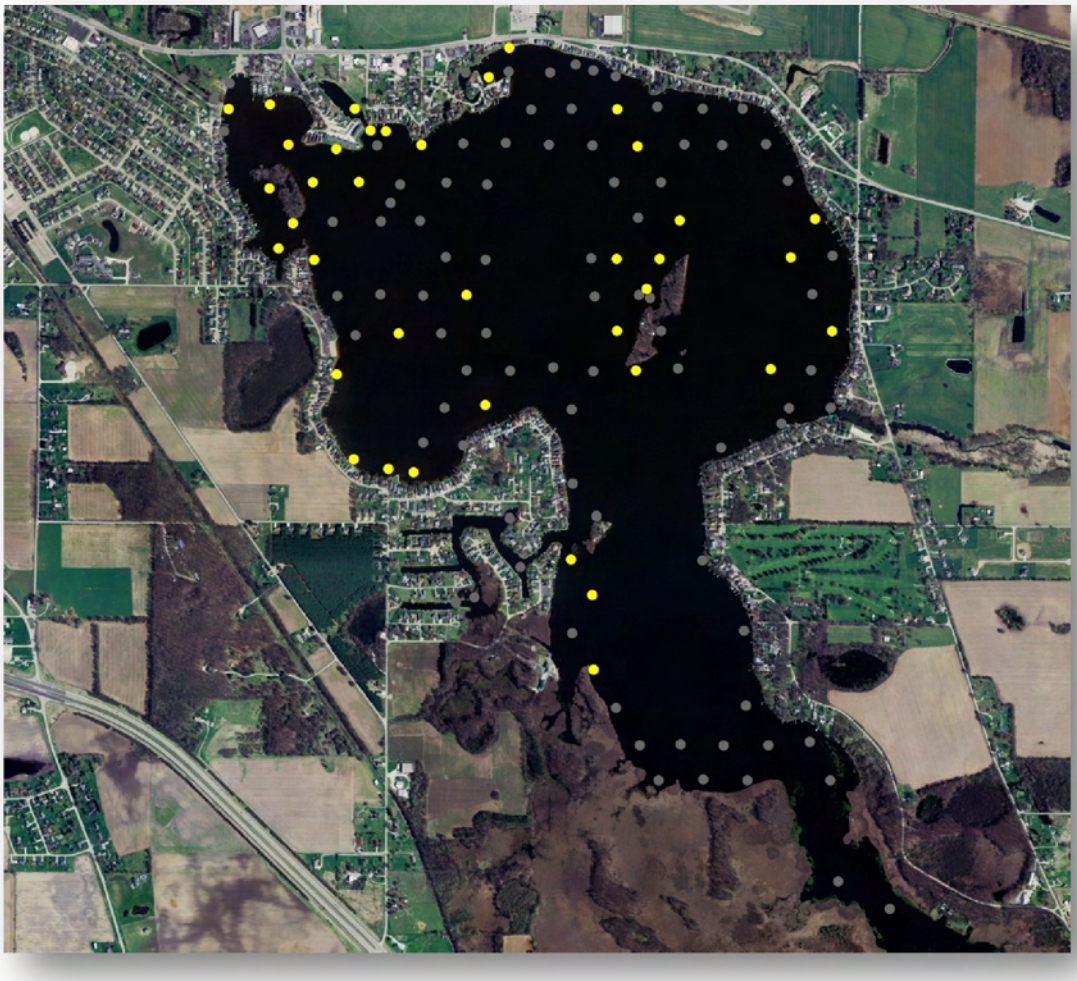

Figure 2.3.2. Lake Manitou, Chara distribution, June 15, 2010.

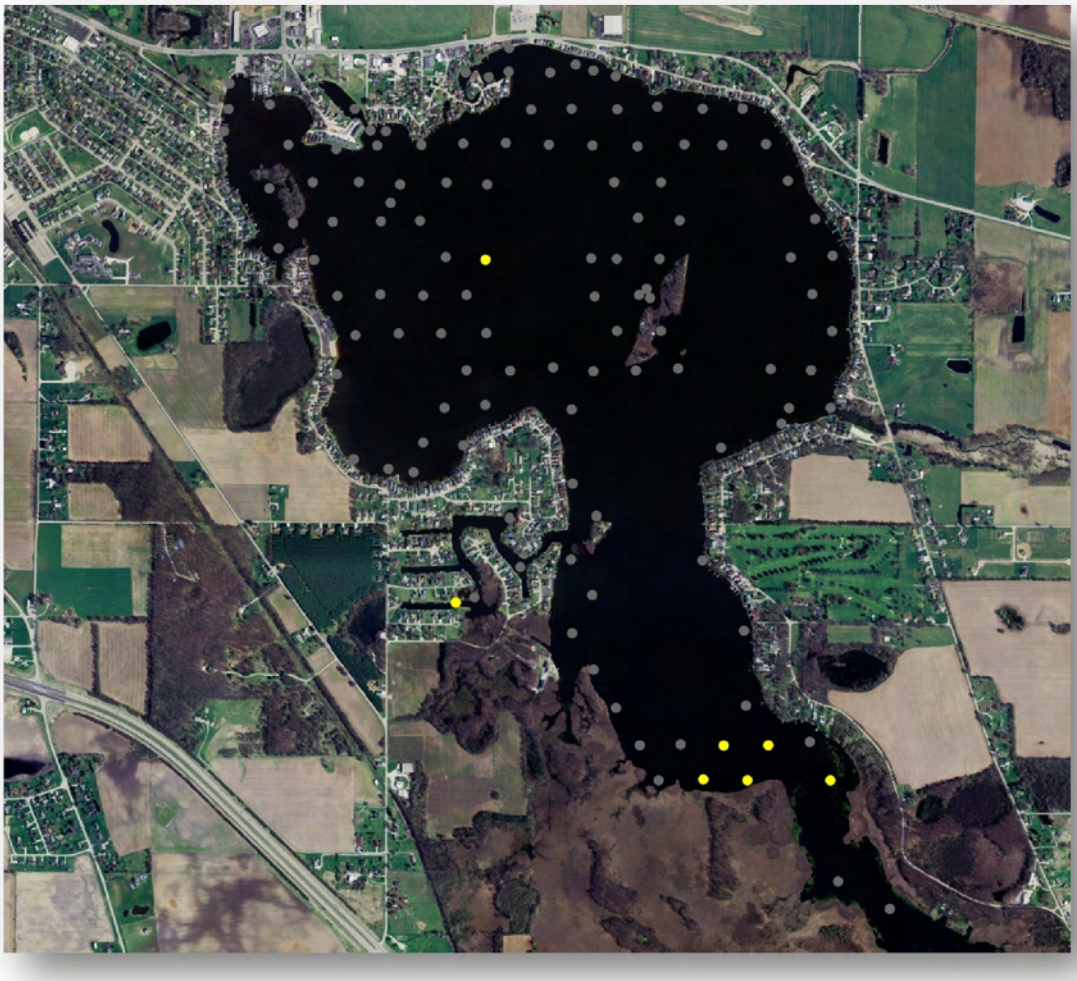

Figure 2.3.3. Lake Manitou, sago pondweed distribution, June 15, 2010.

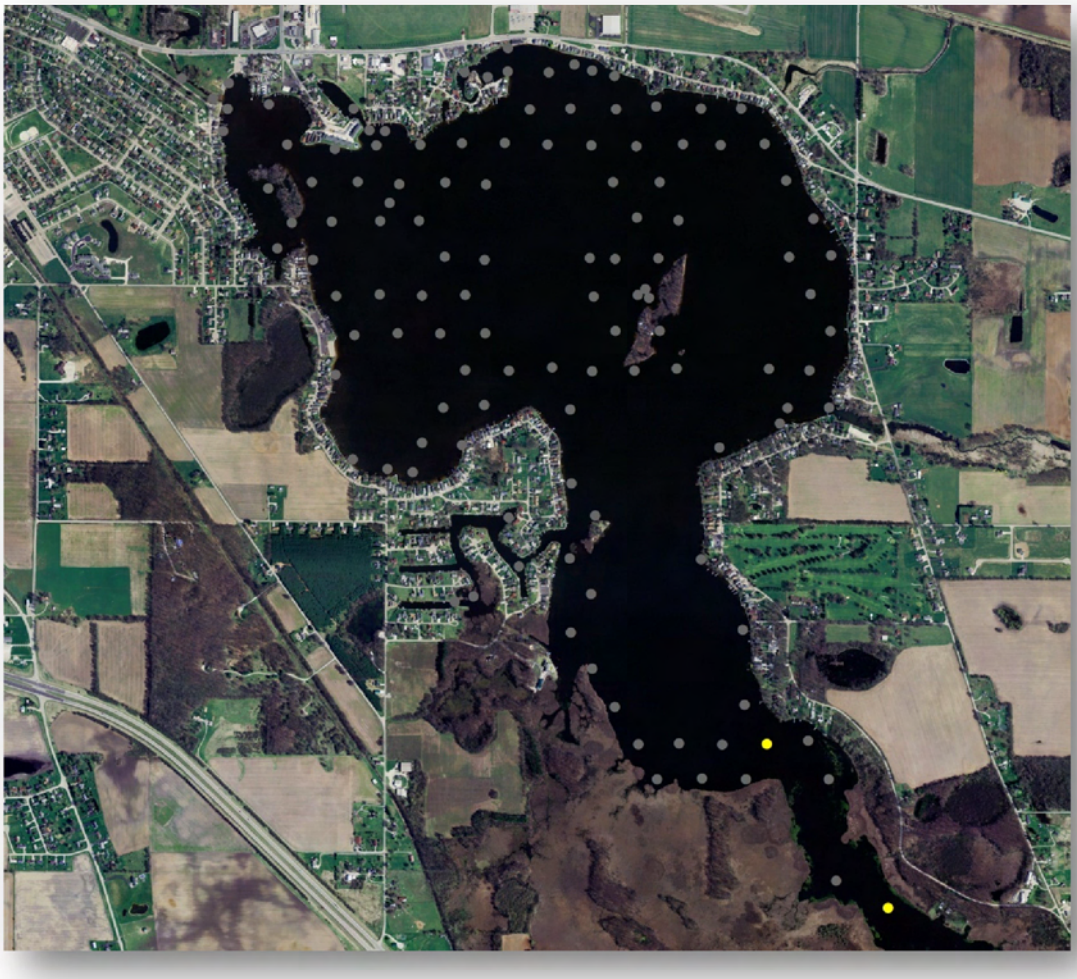

Figure 2.3.4. Lake Manitou, curlyleaf pondweed distribution, June 15, 2010.

It is also important to look at the species distribution throughout different depth ranges. Most of the plant growth was limited to shallow water. Seventy sites were sampled in the 0-5 foot depth range. Aquatic vegetation was present at 60.0% of the shallow sites. A total of 5 species were collected and the average number of species collected per site was 0.51. Chara occurred at the highest percentage of shallow sites (44.3%) and also had the highest dominance rating. Filamentous algae were present at 90.0% of the shallow sites (Table 2.3.3).

Table 2.3.3. Occurrence and Abundance of Submersed Aquatic Plants in Lake Manitou. 0-5 feet: June 15, 2010.

Occurrence and Abundance of Submersed Aquatic Plants in Lake Manitou (0-5 ft).									
County: Fulton		Total Sites:	70				Mean species/site:	0.51
Date: 6/15/10		Sites with plants:	42				SE Mean species/site:	0.06
Secchi (ft):	7	Sites with native plants:	42				Mean native species/site:	0.48
Max Plant Depth (ft):	7	Number of species:	5				SE Mean natives/site:	0.06
Trophic Status:	Meso	# of native species:	4				Species diversity:	0.51
		Maximum species/site:	3				Native diversity:	0.46
Depth: 0 to 5 ft		**Frequency of Occurrence**	**Rake score frequency per sp.**				**Plant Dominance**	
Species			**0**	**1**	**3**	**5**		
Chara		44.3	57.1	41.4	1.4	1.4	10.6	
Sago pondweed		10.0	90.0	7.1	0.0	2.9	4.3	
Coontail		7.1	92.9	5.7	0.0	1.4	2.6	
Curlyleaf pondweed		2.9	97.1	2.9	0.0	0.0	0.6	
Flatstem pondweed		1.4	98.6	1.4	0.0	0.0	0.3	
Filamentous Algae		90.0						

The 5-10 foot depth range also contained vegetation, but at a very low level. Twenty-seven sites were sampled within this range. Chara occurred at 25.9% of sites and common coontail was collected at a single location within this depth range. Filamentous algae were present at 55.6% of the sample sites within the 5-10 foot range (Table 2.3.4).

Table 2.3.4. Occurrence and Abundance of Submersed Aquatic Plants in Lake Manitou. 5-10 feet: June 15, 2010.

Occurrence and Abundance of Submersed Aquatic Plants in Lake Manitou (5-10 ft).									
County: Fulton		Total Sites:	27				Mean species/site:	0.30
Date: 6/15/10		Sites with plants:	8				SE Mean species/site:	0.09
Secchi (ft):	7	Sites with native plants:	8				Mean native species/site:	0.30
Max Plant Depth (ft):	7	Number of species:	2				SE Mean natives/site:	0.09
Trophic Status:	Meso	# of native species:	2				Species diversity:	0.22
		Maximum species/site:	1				Native diversity:	0.22
Depth: 5 to 10 ft		**Frequency of Occurrence**	**Rake score frequency per sp.**				**Plant Dominance**	
Species			**0**	**1**	**3**	**5**		
Chara		25.9	74.1	25.9	0.0	0.0	5.2	
Coontail		3.7	96.3	3.7	0.0	0.0	0.7	
Filamentous Algae		55.6						

2.3.2 Summer Tier 2 Survey Results

The methods described in Section 2.3.1 were utilized again on August 30, 2010 (summer survey). Results of the sampling are listed in Table 2.3.5. Plants were growing to a maximum depth of 7 feet. Aquatic vegetation was present at 28.7% of the sites. A total of five species were collected. The maximum number of species per site was 2, the mean species collected per site was 0.33, and the species diversity index was 0.57.

Table 2.3.5. Occurrence and Abundance of Submersed Aquatic Plants in Lake Manitou. All depths: August 30, 2010.

Occurrence and Abundance of Submersed Aquatic Plants in Lake Manitou (all depths).					
County:	Fulton	Total Sites:	122	Mean species/site:	0.33
Date:	8/31/10	Sites with plants:	35	SE Mean species/site:	0.05
Secchi (ft):	4.5	Sites with native plants:	35	Mean native species/site:	0.32
Max Plant Depth (ft):	7	Number of species:	5	SE Mean natives/site:	0.05
Trophic Status:	Meso	# of native species:	4	Species diversity:	0.57
		Maximum species/site:	2	Native species diversity:	0.55

All Depths	Frequency of Occurrence	Rake score frequency per sp.				Plant Dominance
Species		0	1	3	5	
Chara	19.7	80.3	17.2	0.8	1.6	5.6
Sago pondweed	7.4	92.6	5.7	0.8	0.8	2.5
Coontail	4.1	95.9	1.6	0.0	2.5	2.8
Bladderwort	0.8	99.2	0.8	0.0	0.0	0.2
Curlyleaf pondweed	0.8	99.2	0.8	0.0	0.0	0.2
Filamentous Algae	57.4					
Other species observed: spatterdock, hibiscus, white water lily, cattail, purple loosestrife						

Chara was present at the highest percentage of sample sites and also had the highest dominance rating (Figure and Table 2.3.5). Sago pondweed ranked second in percent occurrence (7.4%) (Figure 2.3.6). Common coontail ranked third in frequency, (4.1%) (Figure 2.3.7) while bladderwort and curly leaf pondweed were collected at single sites. Filamentous algae were collected at 57.4% of sites. Spatterdock, hibiscus, white water lily, cattail, and purple loosestrife were observed but not collected in a rake sample.

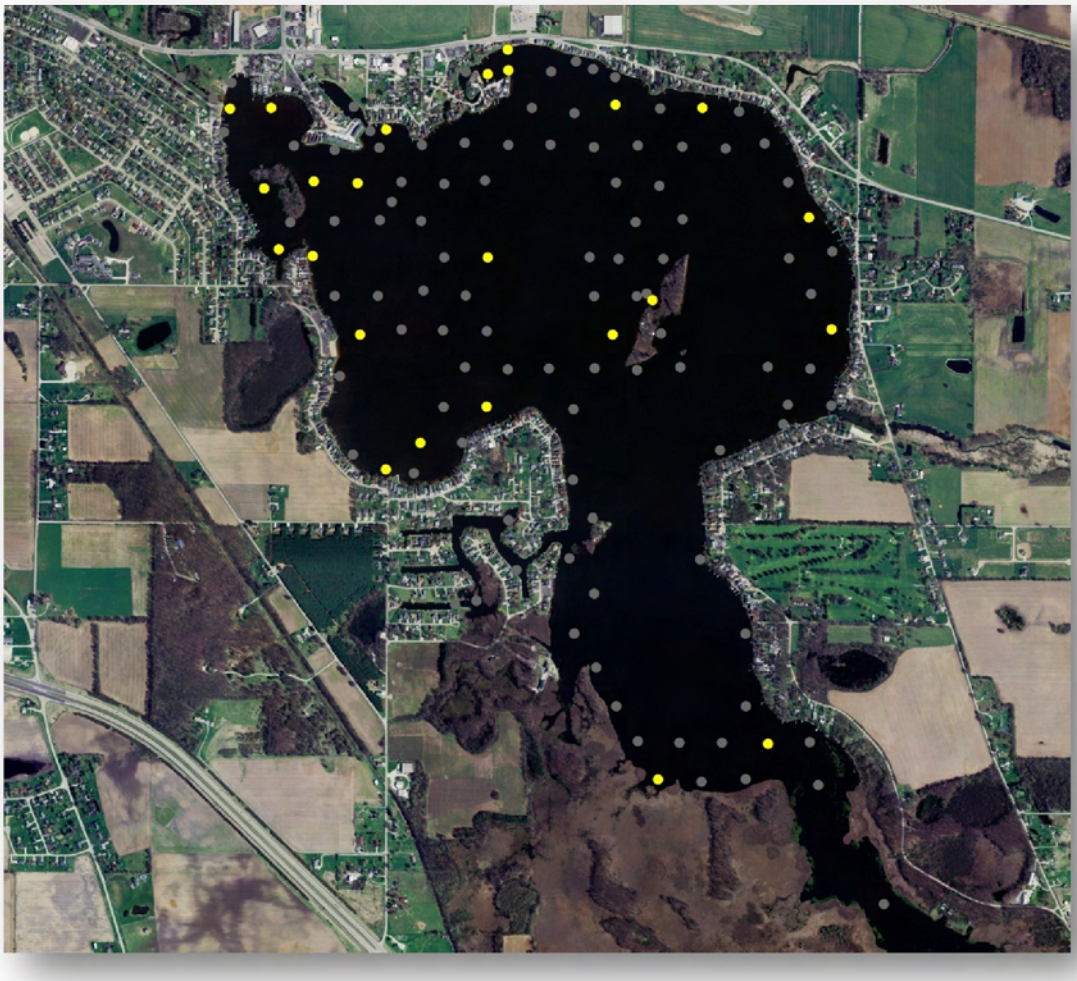

Figure 2.3.5. Lake Manitou, Chara distribution, August 30, 2010.

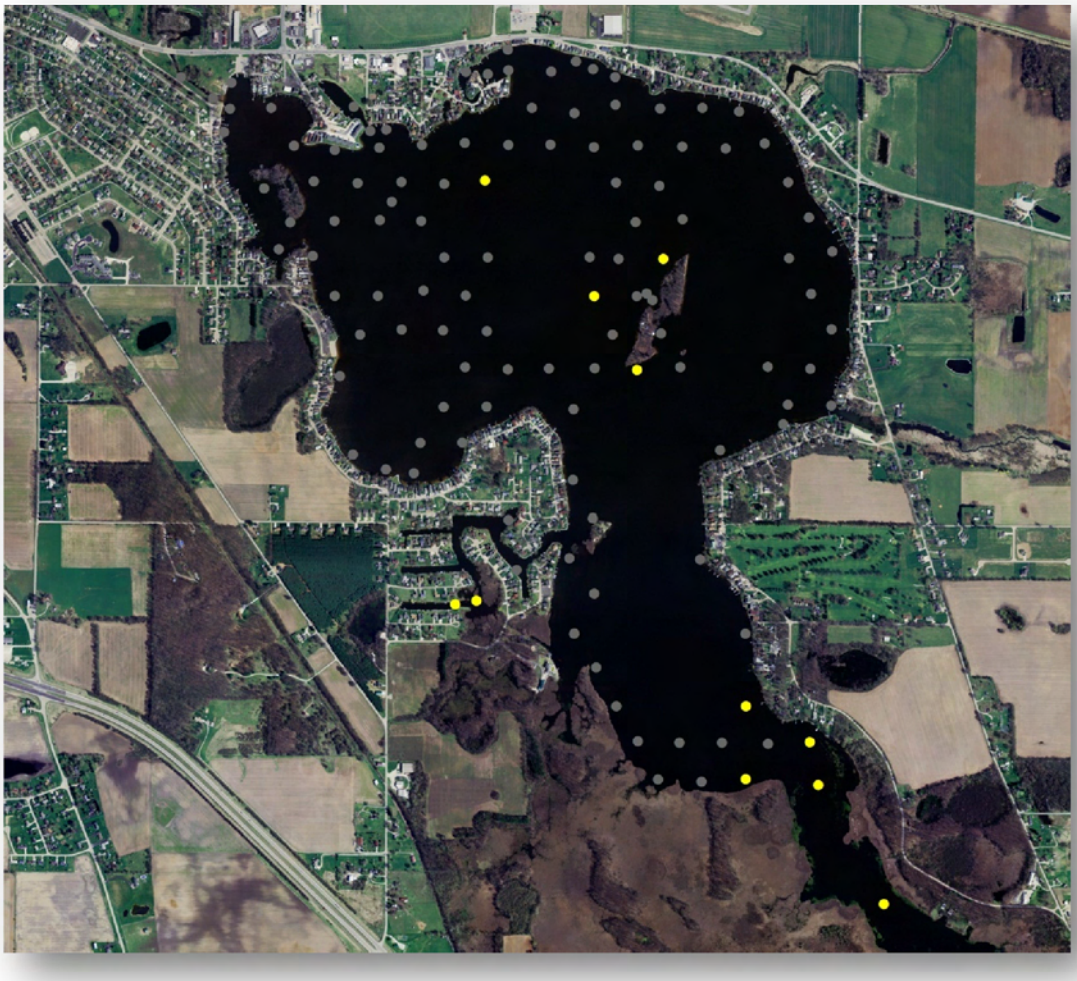

Figure 2.3.6. Lake Manitou, sago pondweed distribution, August 30, 2010.

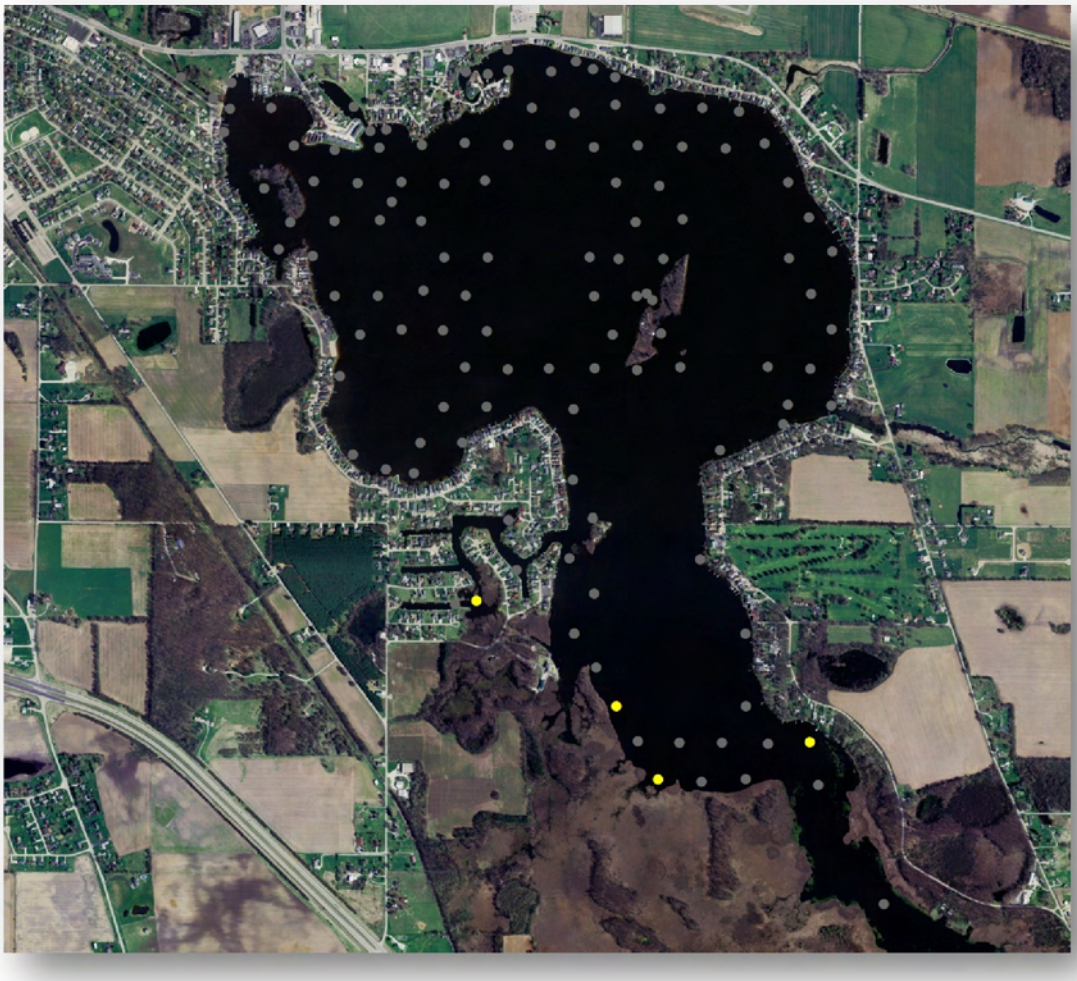

Figure 2.3.7. Lake Manitou, coontail distribution, August 30, 2010.

Seventy-six sites were sampled in the 0-5 foot depth range. Aquatic vegetation was present at 42.1% of the shallow sites. A total of 4 species were collected and the average number of species collected per site was 0.38. Chara occurred at the highest percentage of shallow sites (28.9%) and also had the highest dominance rating. Sago pondweed ranked second in frequency followed by coontail and curlyleaf pondweed. Filamentous algae were present at 81.6% of the shallow sites (Table 2.3.6).

Table 2.3.6. Occurrence and Abundance of Submersed Aquatic Plants in Lake Manitou. 0-5 feet: August 30, 2010.

Occurrence and Abundance of Submersed Aquatic Plants in Lake Manitou (0-5 ft).					
County:	Fulton	Total Sites:	76	Mean species/site:	0.38
Date:	8/31/10	Sites with plants:	32	SE Mean species/site:	0.06
Secchi (ft):	4.5	Sites with native plants:	32	Mean native species/site:	0.37
Max Plant Depth (ft):	7	Number of species:	4	SE Mean natives/site:	0.06
Trophic Status:	Meso	# of native species:	3	Species diversity:	0.57
		Maximum species/site:	2	Native diversity:	0.54

Depth: 0 to 5 ft	Frequency of Occurrence	Rake score frequency per sp.				Plant Dominance
Species		0	1	3	5	
Chara	28.9	71.1	25.0	1.3	2.6	8.4
Sago pondweed	11.8	88.2	9.2	1.3	1.3	3.9
Coontail	6.6	93.4	2.6	0.0	3.9	4.5
Curlyleaf pondweed	1.3	98.7	1.3	0.0	0.0	0.3
Filamentous Algae	81.6					

Twenty four sites fell within the 5-10 foot depth range and only 3 of the sites contained vegetation. Chara occurred at 8.3% of sites and bladderwort was collected at a single location within this depth range. Filamentous algae were present at 33.3% of the sample sites within the 5-10 foot range (Table 2.3.7).

Table 2.3.7. Occurrence and Abundance of Submersed Aquatic Plants in Lake Manitou. 5-10 feet: August 31, 2010.

Occurrence and Abundance of Submersed Aquatic Plants in Lake Manitou (5-10 ft).					
County:	Fulton	Total Sites:	24	Mean species/site:	0.13
Date:	8/31/10	Sites with plants:	3	SE Mean species/site:	0.07
Secchi (ft):	4.5	Sites with native plants:	3	Mean native species/site:	0.13
Max Plant Depth (ft):	7	Number of species:	2	SE Mean natives/site:	0.07
Trophic Status:	Meso	# of native species:	2	Species diversity:	0.44
		Maximum species/site:	1	Native diversity:	0.44

Depth: 5 to 10 ft	Frequency of Occurrence	Rake score frequency per sp.				Plant Dominance
Species		0	1	3	5	
Chara	8.3	91.7	8.3	0.0	0.0	1.7
Bladderwort	4.2	95.8	4.2	0.0	0.0	0.8
Filamentous Algae	33.3					

2.3.3 Tier 2 Survey Discussion

For reference: the initial Sonar treatment was conducted on May 7, 2010; bump treatments were conducted on June 29, August 12, and September 8, 2010. Details of the treatments can be found in Section 4.0.

Annual Tier 2 surveys have been completed on Lake Manitou since 2004. Aquatic Weed Control, Inc. completed surveys in 2004, 2005 and 2006 and Aquatic Control and ReMetrix completed Tier 2 surveys in 2007, 2008, 2009, and 2010. The primary objective of this vegetation management plan is the eradication of hydrilla. Hydrilla was detected during the 2007 spring Tier 2 survey but was not observed or collected during the 2008, 2009, or 2010 surveys. Before the introduction of hydrilla, Eurasian watermilfoil control was the primary objective of vegetation management. Milfoil is highly susceptible to low doses of Sonar, and has not been observed since the May 2007 survey.

The hydrilla eradication treatment with Sonar was expected to temporarily alter the makeup of the submersed native plant community. Prior to the whole lake treatments, eelgrass occurred at the highest percentage of sample sites, but was either not collected or collected at low levels since treatment. Chara, sago pondweed and common coontail are now the most frequently occurring species. The changes in percent occurrence in the last eleven Tier 2 surveys are illustrated in Table 2.3.8 and Chart 2.3.1.

Table 2.3.8. Percent occurrence of species in Lake Manitou in the last eleven Tier 2 surveys.

Species	% of survey sites identified										
	Aug-04	Aug-05	Aug-06	May-07	Aug-07	Jun-08	Aug-08	Jun-09	Aug-09	Jun-10	Aug-10
hydrilla (Hydrilla verticillata)				3.3%							
Eurasian watermilfoil (Myriophyllum spicatum)	27.5%	30.0%	2.9%	5.0%							
curlyleaf pondweed (Potamogeton crispus)				3.3%				1.6%		1.6%	0.8%
common coontail (Ceratophyllum demersum)	26.4%	11.0%	24.3%	36.4%	7.4%		0.8%	0.8%	0.8%	4.9%	4.1%
Chara (Chara spp.)	12.1%	10.0%	10.0%	24.0%	38.8%	50.0%	33.9%	18.9%	2.5%	31.1%	19.7%
naiad species (Najas spp.)	11.0%	23.0%									
slender naiad (Najas flexillis)			8.6%				0.8%				
sago pondweed (Potamogeton pectinatus)	14.3%	16.0%	10.0%	20.7%	0.8%	6.5%	3.2%	9.8%	4.2%	5.7%	7.4%
eelgrass (Vallisneria americana)	50.5%	61.0%	42.9%	60.3%	6.6%			0.8%			
flatstem pondweed (Potamogeton zosteriformis)				4.1%						0.8%	
largeleaf pondweed Potamogeton amplifolius)				2.5%				0.8%			
variable pondweed (Potamogeton gramineus)				0.8%							
common bladderwort (Utricularia vulgaris)					0.8%		0.8%	0.8%	0.8%		0.8%
Illinois pondweed (Potamogeton illinoensis)	1.1%	2.0%	5.7%								
water stargrass (Heteranthera dubia)									0.8%		

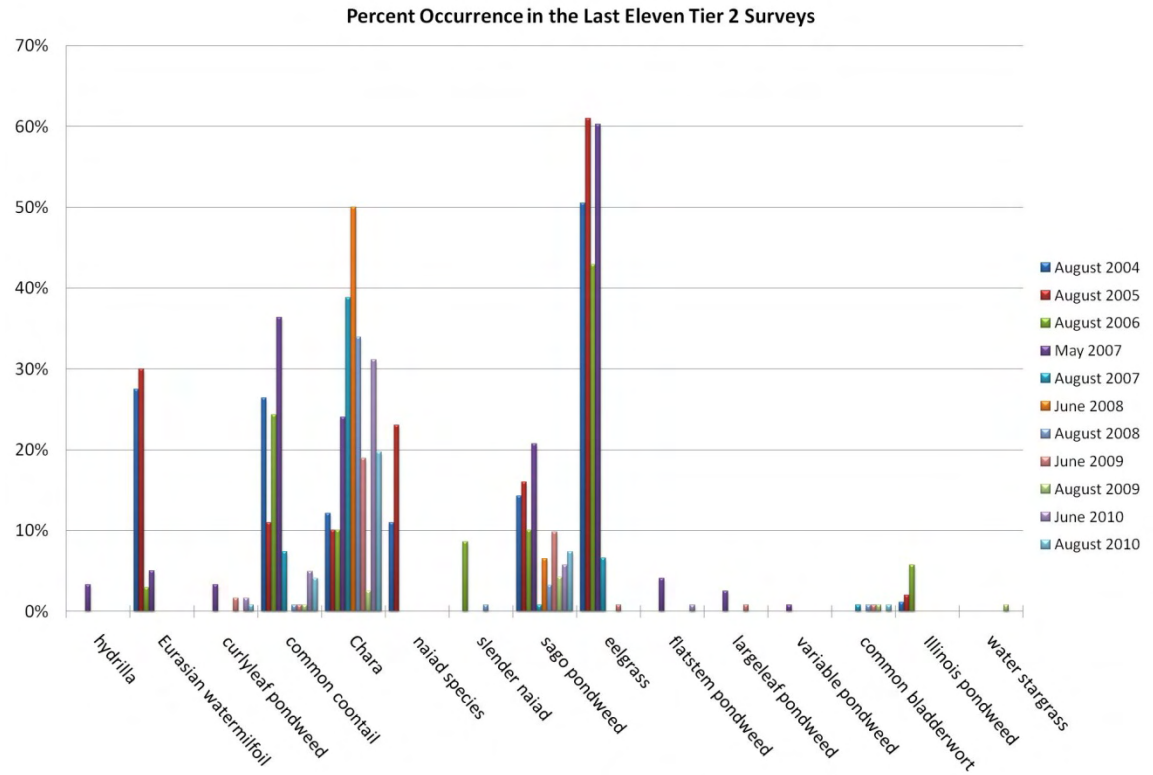

Chart 2.3.1. Percent occurrence of species in Lake Manitou in the last eleven Tier 2 surveys (data from Table 2.3.8). (As discussed elsewhere in this report, hydrilla was found on Lake Manitou June 26, 2008, June 22, 2009 and June 15, 2010. However these discoveries were not made as a result of a Tier 2 survey and therefore are not represented within these data).

Tier 2 surveys not only provide information on individual species changes, they also provide data on lake-wide changes of submersed aquatic plant diversity and abundance. Table 2.3.9 and Chart 2.3.2 compare the percentage of sample sites with vegetation, native diversity index, and the number of native species collected in the last eleven surveys. Figure 2.3.8 shows the change in total species abundance between the spring and summer surveys. All whole-lake post-treatment metrics have declined when compared to pre-treatment data. These metrics should continue to be monitored over time. Submersed vegetation metrics are expected to increase once the hydrilla eradication project is completed. Changes are being made to the application rates in an attempt to increase selectivity without jeopardizing the primary objective of hydrilla eradication.

Table 2.3.9. Comparison of number of sample sites, % of sites with vegetation, native diversity index, and number of native species collected in the last eleven Tier 2 surveys.

Survey Date	Number of Sample Sites	% of sites with vegetation	Native Diversity Index	Number of Native Species Collected
Aug 2004[1]	95	83.5%	0.72	6
Aug 2005[2]	100	79.0%	0.72	6
Aug 2006[3]	70	56.0%	0.74	7
May 2007	119	92.0%	0.73	7
Aug 2007	111	47.0%	0.46	5
June 2008	121	56.2%	0.20	2
Aug 2008	121	39.7%	0.26	5
June 2009	122	28.7%	0.55	6
Aug 2009	119	8.4%	0.69	5
June 2010	122	40.9%	0.43	5
Aug 2010	122	28.6%	0.55	4

[1]Donahoe & Keister 2005. [2]Donahoe & Keister 2006. [3]Donahoe & Keister 2007.

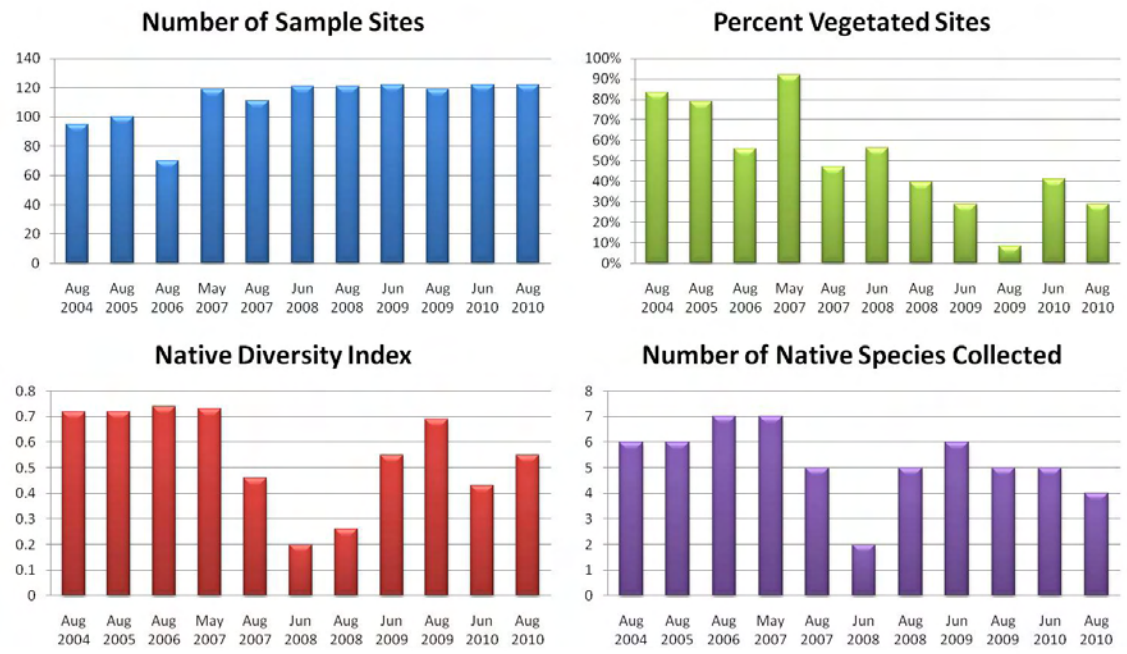

Chart 2.3.2. Comparison of number of sample sites, % of sites with vegetation, native diversity index, and number of native species collected in the last eleven Tier 2 surveys. (Data are from Table 2.3.9)

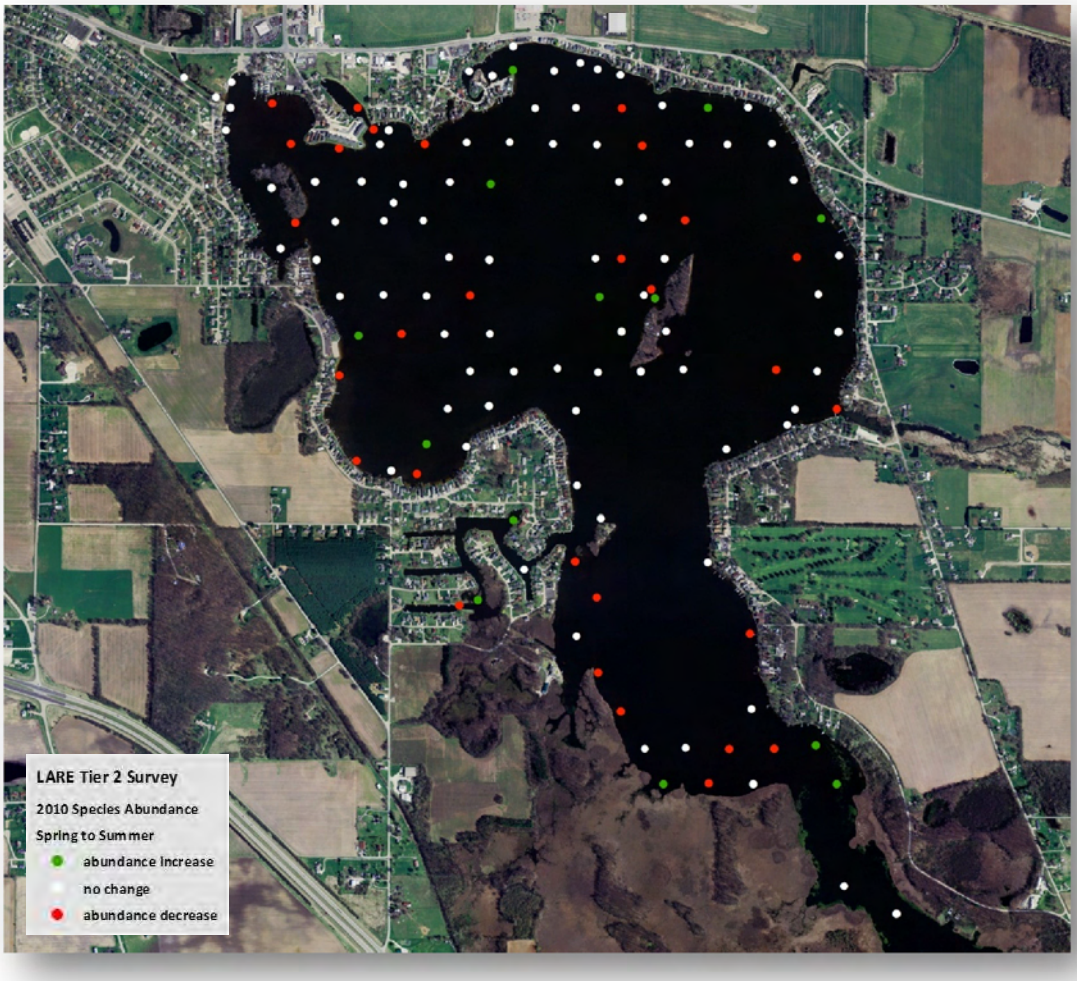

Figure 2.3.8. Lake-wide change in total species abundance, June 15, 2010 to August 30, 2010. Green markers indicate an increase in species present, white markers indicate no change, and red markers indicate a decrease in species present from June to August.

2.4 Additional Surveys

2.4.1 Hydroacoustic Survey for Precision Sonar Application

ReMetrix completed a bathymetric analysis of Lake Manitou based on hydroacoustic data collected October 5, 2006. A grid of single-beam hydroacoustic depth points were collected across the lake, and data between transects were modeled to create contours and a bathymetric surface for the entire lake. The results of the bathymetric analysis have been used to help plan every Sonar application. An accurate determination of water volume at the time of treatment is calculated based on measured thermocline depth (Table 2.4.1, paired with Table 4.1.1) to ensure accurate Sonar treatments. The data have enabled treatments to achieve more consistent, evenly distributed lake-wide Sonar concentrations than would otherwise have been achieved using regular application techniques.

Table 2.4.1. Water volume estimation calculations for Lake Manitou.

Mean Depth = 10.67 Feet				Total Volume = 8,631 Acre Feet			
Interval (ft)	**Surface Acres**	**Acre Feet**	**Cumulative Acre Feet**	**Interval (ft)**	**Surface Acres**	**Acre Feet**	**Cumulative Acre Feet**
Surface – 1’	808	768	8,631	23’- 24’	129	124	1,234
1’-2’	740	719	7,863	24’- 25’	121	117	1,110
2’-3’	697	673	7,144	25’- 26’	114	111	993
3’-4’	644	609	6,471	26’- 27’	108	105	882
4’-5’	565	496	5,862	27’- 28’	102	98	777
5’-6’	432	391	5,366	28’- 29’	95	91	679
6’-7’	357	334	4,975	29’- 30’	88	85	588
7’- 8’	318	307	4,641	30’- 31’	82	79	503
8’- 9’	297	288	4,334	31’- 32’	76	73	424
9’- 10’	280	273	4,046	32’- 33’	69	66	351
10’- 11’	266	260	3,773	33’-34’	62	58	285
11’- 12’	254	248	3,513	34’-35’	54	51	227
12’- 13’	242	236	3,265	35’-36’	47	43	176
13’- 14’	231	225	3,029	36’-37’	39	37	133
14’- 15’	220	215	2,804	37’-38’	34	31	96
15’- 16’	209	204	2,589	38’-39’	28	24	65
16’- 17’	199	194	2,385	39’-40’	21	18	41
17’- 18’	189	184	2,191	40’-41’	15	11	23
18’- 19’	179	174	2,007	41’-42’	8	7	12
19’- 20’	169	164	1,833	42’-43’	5	3	5
20’- 21’	159	155	1,669	43’-44’	2	1	2
21’- 22’	150	145	1,514	44’-45’	<1	<1	1
22’- 23’	140	135	1,369				

Water volume calculations for Lake Manitou based on hydroacoustic data collected 10/5/2006. ReMetrix

2.4.2. Other vegetation Surveys

In an effort to become more familiar with Lake Manitou and get a “hands-on” look at lake-bottom conditions, Dr. Mark Heilman used snorkeling gear to make observations of the lake bed at several of the permanent tuber sampling stations on June 15, 2010. During this informal survey, Dr. Heilman observed numerous sprouted hydrilla plants emerging from the sediment, however all observed vegetative structures showed signs of severe fluridone injury and no stems appeared to remain viable.

3.0 WATER QUALITY MONITORING

Basic water quality monitoring was included in the management plan to document changes in these parameters throughout the treatment season. Sampling was originally conducted May, July and September at one-foot depths from FasTEST Site 2. In 2010, only two samples were collected (June 6 and September 13) in order to reduce project costs. Laboratory analysis included phosphorous (total and ortho) and chlorophyll *a*. Water samples were collected by Aquatic Weed Control, Inc and shipped to GEI Consultants Laboratory in Littleton, Colorado for analysis. This laboratory was utilized because of their low detection limits on phosphorous and nitrogen nutrients (2 µg/L - parts per billion). Chlorophyll detection limits were 0.0001 mg/L (0.1 mg/cubic meter).

In addition to the periodic water quality sampling, Aquatic Weed Control biologist recorded dissolved oxygen and temperature profiles at FasTEST sample Site 2 on May 10, June 7 & 21, July 6 & 19, August 2, 16 & 30, September 13 & 28, October 11, and November 1. (Table 3.0.1). These data were used to monitor thermocline depths for calculating Sonar bump treatments. The thermocline depth is important in calculating Sonar application rates and placement of Sonar pellets. Sonar generally does not mix below the thermocline, and slight thermal stratification can inhibit mixing into deeper waters. A thermocline defines a narrow, horizontal stratification boundary between cooler, deeper water and warmer, shallow water.

A thermocline is defined as a 1˚C temperature change over a depth of 1 meter. Each stratification zone has a discrete water volume that can be calculated and used to more precisely calibrate treatment rates (Table 2.4.1), often reducing the amount of Sonar applied. However, the thermocline depth changes throughout the season and must continually be monitored.

Secchi transparency readings were taken throughout the 2010 season (Table 3.0.2). Secchi measurements ranged from a maximum of 10.1 feet on May 10 to a low of 2.1 feet on July 6 and August 2 (Table 3.0.3). Overall, minimum Secchi depths in 2010 seemed consistent with the historical average while maximum Secchi depths averaged almost three feet deeper when compared with the historical data.

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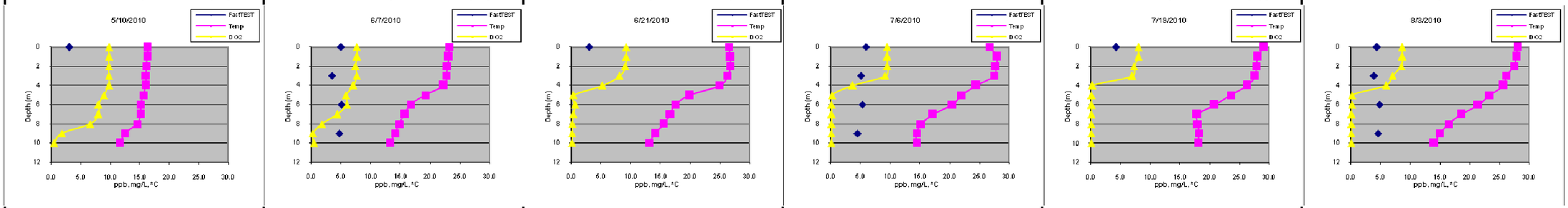
Table 3.0.1. 2010 Temperature and Dissolved Oxygen Profiles (FasTEST also included).

DAT -->	5/10/2010	3		6/7/2010	31		6/21/2010	45		7/6/2010	7		7/19/2010	20		8/2/2010	34	
Depth (m)	FastTEST	Temp	D O_2	FastTEST	Temp	D O_2	FastTEST	Temp	D O_2	FastTEST	Temp	D O_2	FastTEST	Temp	D O_2	FastTEST	Temp	D O_2
0	3.0	16.3	9.73	5.0	23.2	7.66	3.0	26.5	9.26	5.9	26.7	9.48	4.2	29.1	7.99	4.4	28.1	8.63
1		16.2	9.72		23.2	7.67		26.7	9.25		28.0	9.51		28.1	7.96		27.8	8.65
2		16.1	9.72		22.9	7.47		26.7	9.11		27.8	9.52		27.8	7.29		27.4	8.49
3		16.1	9.74	3.5	22.7	7.63		26.3	8.13	5.1	27.4	9.13		27.7	6.95	3.9	26.1	7.04
4		16.0	9.71		22.3	7.08		24.9	5.22		24.5	3.69		26.3	0.28		25.7	5.92
5		15.6	8.85		19.2	5.83		19.8	0.30		22.1	0.21		23.6	0.15		23.4	0.23
6		15.2	7.96	5.1	16.7	5.99		17.5	0.63	5.3	20.4	0.16		20.8	0.12	4.8	21.4	0.18
7		15.1	7.96		15.7	4.32		16.6	0.29		17.2	0.14		17.9	0.1		18.6	0.14
8		14.6	6.57		14.8	1.79		15.6	0.14		15.2	0.12		18.1	0.09		16.5	0.12
9		12.4	1.76	4.7	14.1	0.25		14.1	0.11	4.5	14.4	0.11		18.2	0.08	4.6	14.9	0.11
10		11.6	0.43		13.2	0.43		13.1	0.10		14.4	0.10		18.1	0.08		14.0	0.11



DAT -->	8/16/2010	4		8/30/2010	18		9/13/2010	5		9/28/2010	20		10/11/2010	33		11/1/2010	54	
Depth (m)	FastTEST	Temp	D O_2	FastTEST	Temp	D O_2	FastTEST	Temp	D O_2	FastTEST	Temp	D O_2	FastTEST	Temp	D O_2	FastTEST	Temp	D O_2
0	3.9	27.6	7.88	2.2	26.9	8.44	7.1	21.4	9.12	6.9	18.4	9.27	5.9	17.8	11.72	4.7	10.7	11.69
1		27.7	7.88		26.7	8.49		21.2	9.19		18.4	9.22		17.8	11.76		10.8	11.63
2		27.6	7.82		26.4	8.33		20.8	9.05		18.4	9.13		17.7	11.87		10.7	11.57
3	4.0	27.6	7.79		25.7	7.86	6.8	20.4	8.85		18.5	9.03		16.9	11.58	4.4	10.7	11.39
4		26.4	2.98		24.9	6.62		19.9	7.58		18.5	8.99		16.1	9.36		10.7	11.29
5		24.3	0.25		24.1	3.12		19.8	7.15		18.4	8.89		15.6	7.73		10.7	11.26
6	4.5	22.4	0.17		22.4	0.26	6.7	19.7	6.17		18.3	8.04		15.3	6.86	4.5	10.7	11.22
7		18.8	0.14		19.6	0.19		19.6	5.75		18.3	6.68		15.2	6.53		10.7	11.22
8		16.8	0.12		17.8	0.14		18.9	3.45		18.3	6.41		15.1	5.94		10.6	11.14
9	4.4	15.5	0.12		17.9	0.14	4.3	14.6	0.22		17.5	1.66		15.1	5.84	4.5	10.5	11.08
10		14.6	0.11		18.4	0.14		13.8	0.19		14.3	0.26		15.0	4.76		10.4	11.15

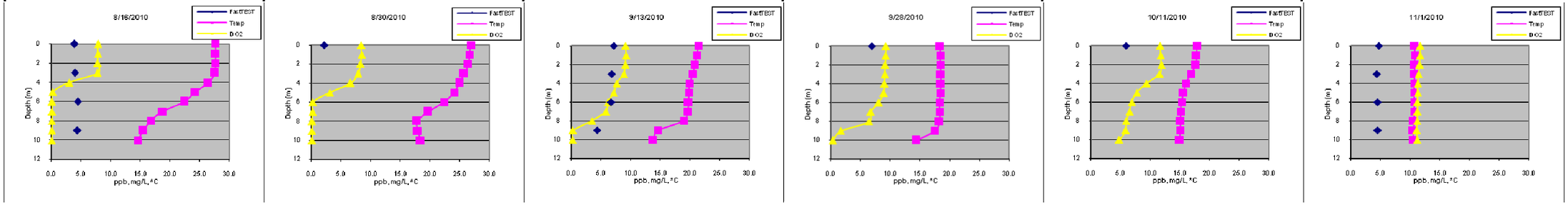


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Table 3.0.2. 2010 Secchi depths recorded on Lake Manitou (May to November, 2010).

Site	5/10	6/7	6/21	7/6	7/19	8/3	8/16	8/30	9/13	9/28	10/11	11/1
1	**6.5**	**6.5**	3.8	3.2	3.8	3.8	3.8	4.4	4.3	3.2	4.2	3.9
2	8.3	7.5	4.3	3.5	3.5	3.7	2.9	4.6	4.9	4.3	5.3	4.2
3	**5**	**5**	4.3	2.8	3.6	3.9	3.3	3.6	4.5	**5**	3.4	4.5
4	**5**	**5**	3.4	2.1	2.6	3.0	3.1	3.6	3.0	3.8	3.3	4.1
5	8.2	7.8	4.6	3.2	3.4	4.3	4.1	5.0	5.0	4.8	4.2	4.1
6	**5**	**5**	3.4	3.5	3.4	3.4	4.1	**5**	4.4	4.4	4.1	3.9
7	10.1	9.3	4.4	3.7	3.5	4.2	4.2	5.2	5.6	5.0	4.7	4.0
9	**5**	**5**	**5**	2.4	2.4	2.1	2.8	2.9	**5**	**5**	2.4	**5**
mean	6.6	6.4	4.2	3.1	3.3	3.6	3.5	4.3	4.6	4.4	4.0	4.2

Bold text indicates the lake bottom was visible at the water depth listed.
Site locations can be seen in Figures 2.1.1 or 4.2.1.

Table 3.0.3. Summary of Secchi depths recorded on Lake Manitou 1999-2010. (1999 to 2004 data from Fascher & Jones 2006.)

Year	Minimum	Maximum	Jul-Aug Mean	Observations
1999	2.8	5.4	3.1	10
2000	2.6	6.3	3.2	11
2001	2.5	5.5	3.7	13
2002	2.5	7.2	3.8	15
2003	2.5	10.4	3.3	14
2004	2.7	4.1	3.3	12
2007*	2.6	9.0	3.9	80
2008*	2.1	8.6	3.3	95
2009*	2.3	6.2	3.8	96
2010*	2.1	10.1	3.5	96

*2007 - 2010 data are by authors of this report and are added for comparison with historical data.

Table 3.0.4. Water quality data collected from Lake Manitou in 2010.

Sample Date	Total P (µg/L)	Ortho P (µg/L)	Chlorophyll *a* (µg/L)
6/7/2010	15	3	4.1
9/13/2010	21.5	3	15.8

No historical ortho-phosphorus measurements were available for comparison with these results, but historical data for total phosphorous and chlorophyll α readings were collected from 1999-2004 by the Indiana Volunteer Lake Monitors (summarized in Table 3.0.5). Comparison of the data indicates little change in these metrics following the past four years of Sonar treatment. Chlorophyll α concentration was highest in September 2010 at 15.8 and lowest in June at 4.1 for an average of 10 µg/L across the two samples. The average is slightly higher than the data recorded for 2009 samples. Total P ranged from 15 to 21.5 µg/L compared to 23 to 47 µg/L during 2009. Ortho P was 3 µg/L in both June and September sampling.

Table 3.0.5. Total phosphorus, ortho-phosphorus, and chlorophyll *a* measurements collected from Lake Manitou, 1999-2010. (Data from 1999 to 2004 from Fascher & Jones 2006.)

	Minimum Total P (µg/L)	Maximum Total P (µg/L)	Minimum Ortho P (µg/L)	Maximum Ortho P (µg/L)	Minimum Chl *a* (µg/L)	Maximum Chl *a* (µg/L)
1999	47.0	63.0	n.a.	n.a.	4.8	17.4
2000	58.0	71.0	n.a.	n.a.	9.7	18.9
2001	1.8	10.3	n.a.	n.a.	35.0	66.0
2002	0.0	7.1	n.a.	n.a.	24.0	77.0
2003	2.5	10.4	n.a.	n.a.	20.0	37.0
2004	12.3	15.9	n.a.	n.a.	31.0	66.0
2007*	15	37	<2	5	3.8	12.7
2008*	17	38	1	3	7.1	12.4
2009*	23	47	3	16	7.7	10.0
2010*	15	21.5	3	3	4.1	15.8

"n.a." means "not available"
*2007 - 2010 data are by authors of this report and are added for comparison with historical data.

The 2010 water quality data continues to show the lake-wide treatment for hydrilla eradication program is having negligible effects on the water quality parameters monitored, despite vegetation surveys indicating a significant reduction in submersed aquatic vegetation since the start of the program. A similar water quality sampling schedule would be beneficial as the hydrilla eradication and re-vegetation by native plants progresses.

4.0 2010 VEGETATION CONTROL

The eradication of hydrilla was the primary objective of this Lake Manitou Aquatic Vegetation Management Plan. Due to the extensive reproductive capability of monoecious hydrilla through fragmentation, turions, and tubers, an aggressive prescription using the systemic herbicide Sonar was selected for the eradication project. Similar approaches have been taken in the States of Washington, Massachusetts, Maine, California and Kansas.

The initial lack of flow data for Lake Manitou resulted in the preparation of a treatment protocol based on static water conditions, with inclusion of additional "bump" treatments to sustain a Sonar residual in the lake for a period of 180 days at a lethal dose for hydrilla. Subsequent water flow data provided by the Indiana Department of Water indicated relatively long retention times, with a long-term (18-year) average of ~50% volume turnover from the period of April to September. This period would coincide with chemical control operations. However, large rain events cause the retention time to be much shorter (<30 days). Therefore, maintenance of an effective dose of Sonar for hydrilla required regularly scheduled monitoring of Sonar residue and periodic "bump" treatments as necessary.

SePRO collected hydrilla samples from Lake Manitou and conducted a PlanTEST at the SePRO Research and Technology Campus (SRTC) in Whitakers N.C. The PlanTEST is a proprietary test developed by SePRO Corporation that uses key biochemical parameters (Sprecher et al. 1998) to determine the plants inherent susceptibility to Sonar. The test was used to direct Sonar treatment recommendations by providing an indication of concentrations necessary for control. Plants were collected from Lake Manitou in September 2006 to conduct preliminary PlanTEST. The hydrilla in Lake Manitou responded favorably to Sonar under laboratory conditions (Figure 4.0.1). SePRO's recommended treatment protocol was based on results of the initial/preliminary PlanTEST, extensive experience in hydrilla control throughout the U.S., and proprietary modeling of Sonar dissipation from various formulations.

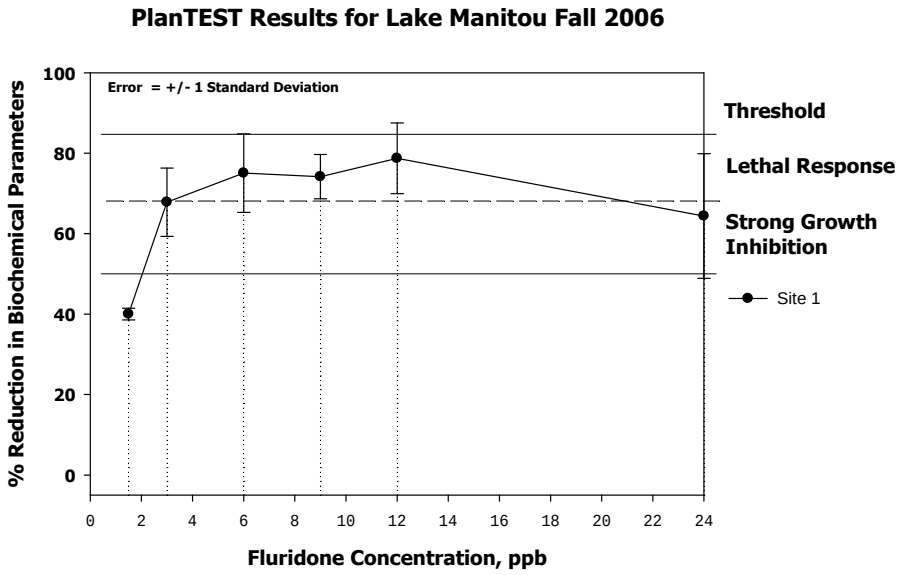

Chart 4.0.1 PlanTEST Results for Lake Manitou.

Figure 4.0.1. Lake Manitou hydrilla susceptibility to Sonar (PlanTEST).

Initially, the treatment prescription recommended for Lake Manitou was a minimum three year program, followed by comprehensive analysis of collected data and recommendations for either extension of this program or alternative management procedures to achieve eradication of hydrilla. Each year, relatively long exposure time to Sonar will be necessary to control the

standing crop of hydrilla, prevent production of new tubers, and to control biomass sprouting from existing tubers.

The 2007 application maintained targeted levels of fluridone throughout the growing season and no hydrilla was observed that year. Modifications were made to the 2008 treatment prescription in an attempt to increase selectivity. Sonar pellet formulations were switched from Sonar Q, which was applied throughout the littoral zone in 2007, to Sonar PR, which was only applied to areas where hydrilla was previously documented and in a small inflow area. In addition, the whole lake concentration was to be maintained above 3 ppb instead of 6 ppb, with more frequent bump applications to minimize exposure of native species to relatively high concentrations. This same treatment strategy was used in 2008 and 2009. In 2010, target Sonar rates were further refined based on successful target rate attainment and control outcomes in past seasons. In 2010, an initial 6 ppb target rate was utilized with repeat 'bump' applications seeking to maintain herbicide rate in a range of 2.5 – 5 ppb.

4.1 Sonar Application

For reference: the initial Sonar treatment was conducted on May 7, 2010; bump treatments were conducted on June 29, August 12, and September 8, 2010. Details of the treatments can be found in Section 4.0

Due to above normal, early spring temperatures in northern Indiana that would encourage earlier hydrilla growth, the initial Sonar application was completed approximately one week earlier than in past seasons. On May 7, 2010, the first application was made by Aquatic Control, Inc., with SePRO Corporation and ReMetrix personnel on site for technical assistance. The lake was posted with signage for public notification prior to application. Sonar AS was applied at a concentration of 6.0 ppb along with pelletized Sonar PR to 19 zones (Figure 4.1.2) at concentrations ranging from 40-100 ppb (total of 2.2 ppb). A thermocline was detected at 9 meters (Table 4.1.1). The lake volume of 7,854 acre feet was used in the Sonar AS calculation.

Sonar AS was applied with a custom built Carolina Skiff, 19-foot fiberglass boat equipped with a 90hp engine. The boat was equipped with a custom built herbicide application unit designed for accurate application of low dose Sonar AS. Travel routes and rates were pre-determined using information generated by the one-foot bathymetric contour survey and water volume table provided by ReMetrix. The actual Sonar AS and Sonar PR application travel routes are illustrated in Figure 4.1.1. Sonar PR was applied to 19 different locations (18 previous hydrilla locations and one inflow location) (Figure 4.1.2). A custom built herbicide blower on a 19-foot Carolina Skiff was used for application of the granular Sonar PR product.

Table 4.1.1. Water Temperature and dissolved oxygen profiles associated with Sonar application dates. (Thermocline depths are indicated by a thicker line between rows).

	6-May (Trtmt 5/7)		29-Jun (Trtmt (6/29)		8-Sep (Trtmt 9/8)	
Depth (m)	**Temp (C)**	**D.O. (mg/L)**	**Temp (C)**	**D.O. (mg/L)**	**Temp (C)**	**D.O. (mg/L)**
Subsurface	21.3	10.2	27.4	8.2	20.4	7.9
1	20.6	10.3	27.4	8.3	20.4	7.8
2	20.0	10.6	27.4	8.3	20.4	7.8
3	19.7	10.8	27.4	7.6	20.4	7.8
4	19.3	9.7	27.4	6.3	20.4	7.8
5	19.0	9.2	27.1	5.5	20.4	7.8
6	18.9	9.2	25.9	0.6	20.4	7.7
7	18.8	8.9	24.5	0.4	20.4	7.8
8	18.2	8.1	21.2	0.3	20.4	7.7
9	17.7	7.9	19.5	0.3	20.4	7.7
10	16.4	6.1	18.3	0.3	20.4	7.7
11	15.2	4.6	17.7	0.3	20.3	6.5
12	14.7	3.5	17.3	0.3		
13	14.1	2.5				

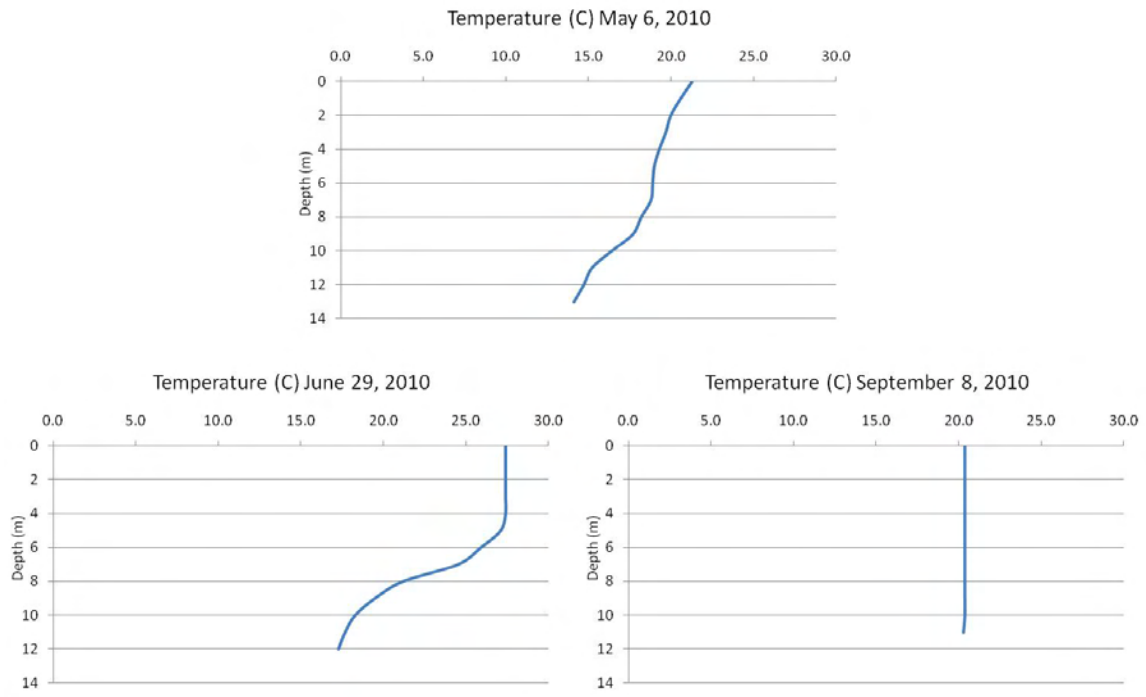

Chart 4.1.1. Water Temperature profiles associated with Sonar application dates.

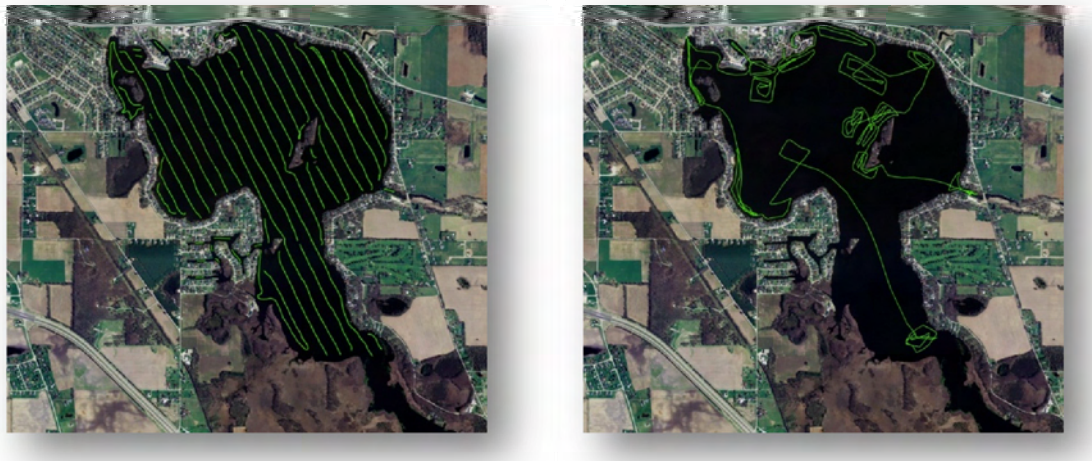

Figure 4.1.1. Initial application tracks for Sonar AS (*left map*) and Sonar PR (*right map*), May 7, 2010.

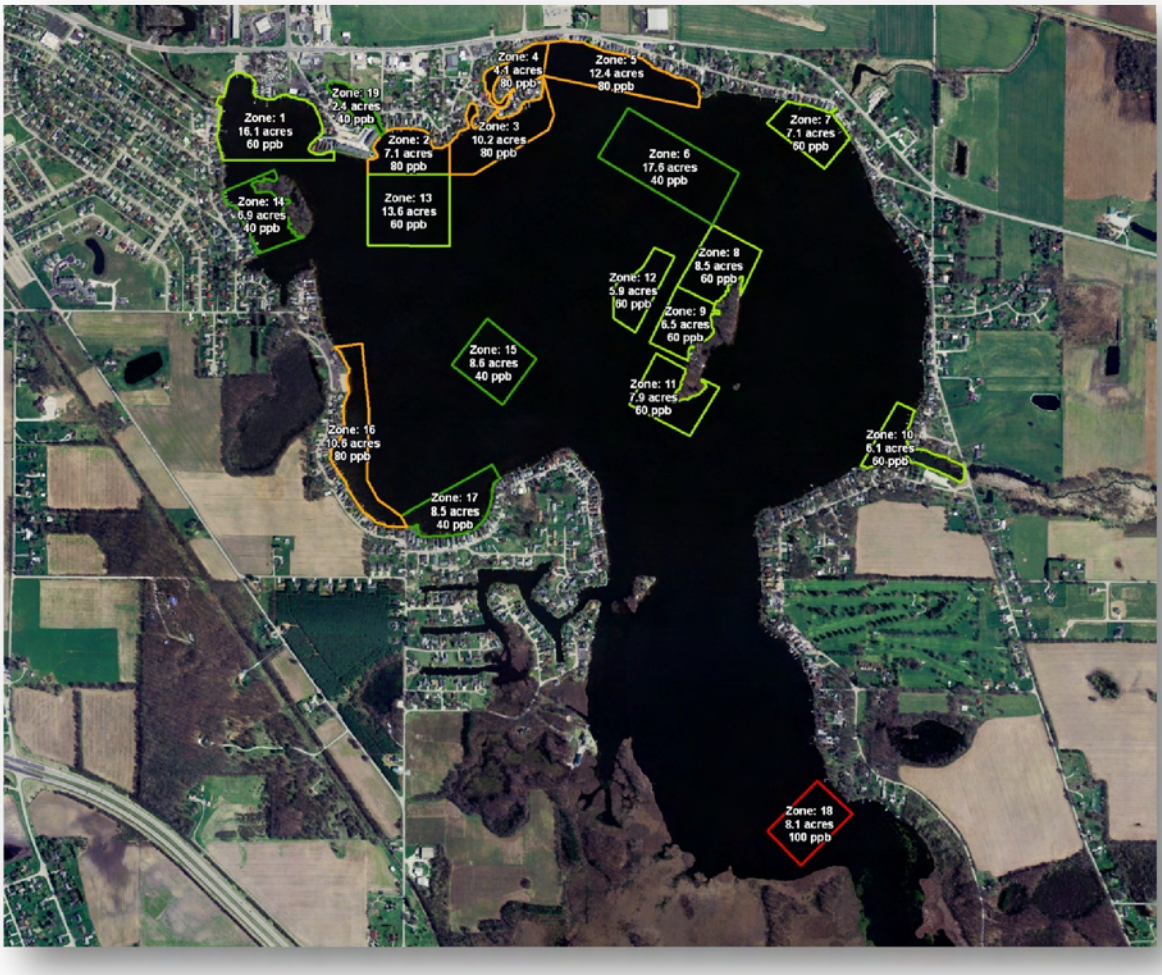

Figure 4.1.2. Sonar PR application prescription map, May 7, 2010.

The first bump treatment was completed on June 29 (54 days after initial treatment) with a combination of Sonar AS and PR. The bump treatment was conducted when residues had dropped to a 3.3 ppb lake-wide average on June 21. Sonar AS was applied at concentration of 2.7 ppb and Sonar PR was applied at a concentration of 1.1 ppb. Sonar AS was applied evenly over the entire lake while Sonar PR was applied to the 19 previously selected locations. A thermocline had formed at 6 meters (Table 4.1.1). Figure 4.1.3 displays the actual application routes from the first bump treatment.

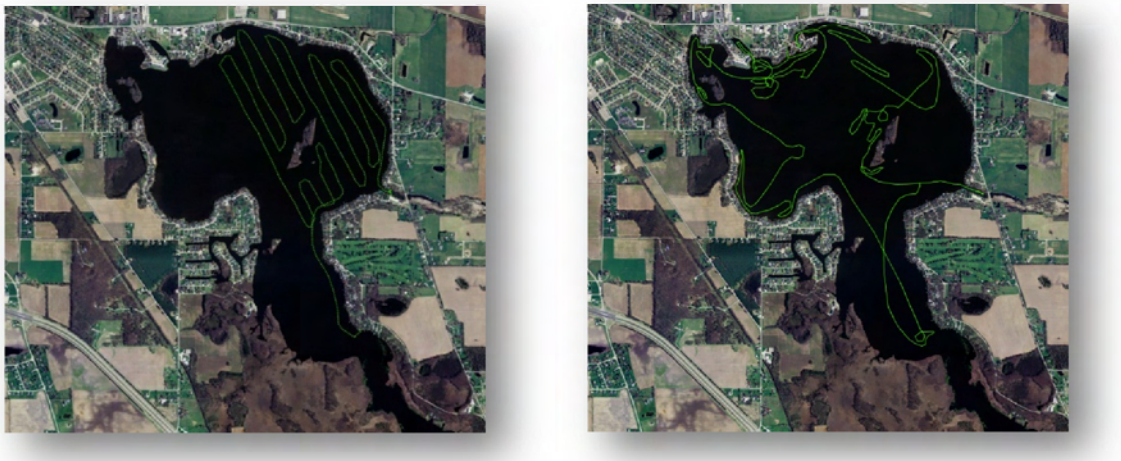

Figure 4.1.3. First "bump application" tracks for Sonar AS (*left map*) and Sonar PR (*right map*), June 29, 2010. The GPS hardware failed during the Sonar AS application, however Sonar AS was applied to the entire water body folowing similar transect lines as the initial Sonar AS application.

The final Sonar PR application was completed on August 12th. Sonar PR was applied at a concentration of 1.1 ppb to the same predetermined areas. The lake-wide fluridone average was 4.2 ppb on August 3rd, so there was no need for a Sonar AS bump. Figure 4.1.4 displays the actual application routes from the final Sonar PR application.

Figure 4.1.4. Second "bump application" tracks for Sonar PR on August 12, 2010 (*left map*), and Sonar AS on September 8, 2010 (*right map*).

FasTEST samples indicated that the fluridone concentration had dropped to a lake-wide average of 1.9 ppb by August 30th. A third and final bump treatment was completed on September 8th with Sonar AS. Sonar AS was applied at concentration of 3.1 ppb. There was no thermocline detected just prior to application (Table 4.1.1). It was somewhat early for the lake to have been destratified, but abnormally low temperatures and heavy winds had occurred for several days prior to application which may have led to lake mixing at the time of treatment. Figure 4.1.4 (right map) displays the actual application routes from the final bump treatment. Please see the following discussion on monitoring results for the final bump in Section 4.2.

4.2 Herbicide Residue Monitoring

The FasTEST was used to monitor fluridone concentration 3, 12, 31, 45, 60, 73, 88, 101, 115, 129, 144, 157, and 178 days following initial treatment. The FasTEST ensured the target concentrations were achieved and maintained through October 15th. FasTEST samples were collected from eight permanent stations located throughout Lake Manitou (Figure 4.2.1 & Table 4.2.1). Thirteen sets of surface samples were collected and results are summarized in Table 4.2.2, and Chart 4.2.1. Results indicate the concentration was maintained above 2.5 ppb for the majority of the 2010 growing season. The objective was to maintain >2.5 ppb until October 15th as it was determined that hydrilla would unlikely be able to sprout from a tuber and form a new tuber after that period.

Figure 4.2.1. Permanent FasTEST sample locations during 2010.

Samples analyzed on August 30 indicated a 2.2 ppb decrease in Sonar levels in the second half of August, and an additional application of Sonar was therefore made on September 8. It was shortly after confirmed that an analytical equipment malfunction had occurred that escaped detection under typical quality control procedures. The malfunction resulted in the SePRO laboratory reporting FasTEST results approximately 2 ppb lower than actual for the lake as confirmed by the higher than target FasTEST numbers quantified for samples following the final

September 8 application. SePRO discussed the situation with DNR and provided reimbursement for the portion of Sonar product applied on September 8 that exceeded target levels for this year's program.

Table 4.2.1. Latitude and longitude coordinates for the eight FasTEST monitoring stations.

Site	Latitude	Longitude
1	N 41˚ 03' 26.0"	W 86˚ 10' 44.9"
2	N 41˚ 03' 05.9"	W 86˚ 11' 15.3"
3	N 41˚ 03' 35.3"	W 86˚ 10' 29.6"
4	N 41˚ 03' 31.5"	W 86˚ 11' 26.1"
5	N 41˚ 03' 05.0"	W 86˚ 10' 20.4"
6	N 41˚ 02' 23.3"	W 86˚ 10' 32.1"
7	N 41˚ 02' 43.5"	W 86˚ 10' 34.7"
9*	N 41˚ 02' 48.8"	W 86˚ 11' 01.4"

*Station 8 was removed after 2007; Station 9 was added in 2008.

Table 4.2.2. Concentration of 2010 FasTEST results from surface water samples. Vertical black lines indicate when "bump" treatments were made.

	5/10	5/19	6/7	6/21	7/6	7/19	8/3	8/16	8/30	9/13	9/28	10/11	11/1	Season
DAT[a] -->	**3**	**12**	**31**	**45**	**7**	**20**	**35**	**4**	**18**	**5**	**20**	**33**	**54**	**178**
Sites	**---------- Sonar Concentration (ppb) ----------**													
1	3.8	6.2	5.6	3.2	5.7	4.9	5.2	4.9	3.2	7.2	6.5	5.7	3.9	**5.1**
2	3.0	5.9	5.0	3.0	5.9	4.2	4.4	3.9	2.2	7.1	6.9	5.9	4.7	**4.8**
3	4.2	6.4	5.2	3.3	6.5	4.8	4.2	4.2	2.3	6.8	6.2	5.8	4.5	**5.0**
4	4.3	5.6	4.1	3.3	7.0	4.8	3.9	3.9	1.5	7.2	6.1	5.9	5.2	**4.8**
5	3.8	5.1	3.5	11.6	5.6	4.4	4.0	4.0	1.4	6.8	6.0	5.7	4.7	**5.1**
6	4.0	5.2	3.0	2.9	5.6	4.6	3.7	3.6	1.6	6.8	5.9	5.2	4.3	**4.3**
7	3.7	5.0	4.0	3.5	5.6	4.2	3.9	3.7	1.4	6.7	6.0	5.7	4.1	**4.4**
9	3.8	5.6	4.7	3.9	9.5	5.2	4.1	4.4	1.9	6.9	6.0	5.9	5.2	**5.2**
Lake Avg	**3.8**	**5.6**	**4.4**	**3.3**	**6.4**	**4.6**	**4.2**	**4.1**	**1.9**	**6.9**	**6.2**	**5.7**	**4.6**	**4.8**

[a] DAT represents the number of days after the last treatment.

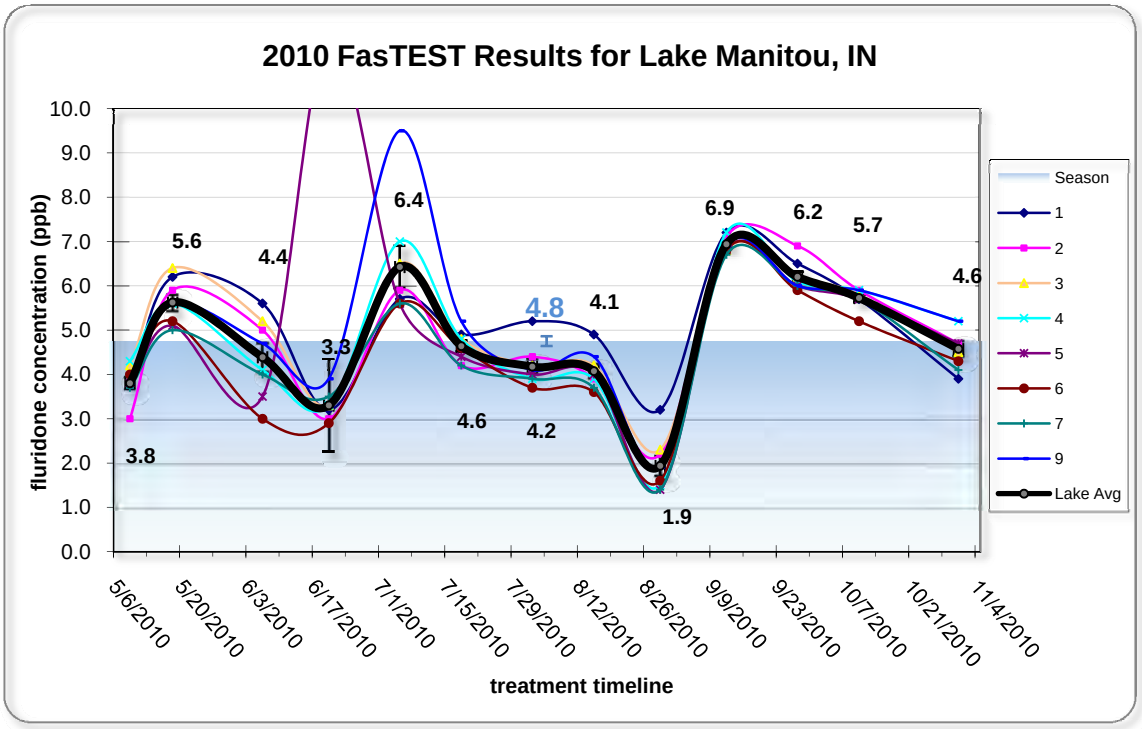

Chart 4.2.1. Sonar concentration by FasTEST site during 2010. The heavy black line, error bars and data labels represent the whole-lake average at each sampling. The blue background and corresponding blue error bar and data label represents the season-long average concentration from May through November 2010.

5.0 ACTION PLAN UPDATE

Four consecutive years of whole-lake Sonar (fluridone) applications have continued to control vegetative hydrilla, reduce hydrilla tuber banks, helped prevent the spread of hydrilla to other lakes and have had minimal impacts on the overall water quality of Lake Manitou. These treatments have come at an expense to the state of Indiana, but the expense of this aggressive action can be well justified in comparison to the outcome of less proactive management that unfortunately led to aggressive expansion of hydrilla into the Southeast and Mid-Atlantic US with major ecological and economic impact in last several decades. The state should be commended for its aggressive commitment to containing and eradicating hydrilla on Lake Manitou and preventing this invasive species expansion into Indiana waters.

The continued recommendation to IDNR for 2011 will be initiation of a Sonar management plan at the same scale and intensity conducted in the last two years. The primary benefit of whole-lake Sonar treatment is an ability to target submersed invasive species like hydrilla throughout an infested body of water. In an eradication program, unless spatial distribution of the target species—in this case hydrilla—can be conclusively determined, partial treatment strategies cannot insure complete treatment of an invasive population and therefore significantly increase risk that the target species will escape direct treatment, successfully reproduce, and pose an on-going threat for expansion within the managed system. Large-scale or whole-lake management protocols with Sonar greatly increase confidence that isolated, difficult to locate hydrilla throughout an entire system will receive lethal doses of herbicide and eliminate risk of plant establishment and successful new tuber deposition. Any successful hydrilla establishment and tuber formation, no matter how isolated, poses a clear risk to reaching eradication objectives and can translate rapidly into a complete loss of multiple-year management success.

5.1 Diagnostic Data for Precision Sonar Application

Hydrilla produces large numbers of tubers that can remain dormant in the sediment for several years. This fact makes eradication difficult but not impossible. Based on current tuber attrition rates observed on Lake Manitou to date as part of a growing nationwide dataset on monoecious hydrilla population response to management, projected number of consecutive annual treatments with Sonar to reach tuber bank eradication in Manitou has decreased relative to earlier 2009 projections. Following three years of slowing rates of tuber attrition, the higher attrition measured following a successful fourth annual cycle of management projects to a 4.8 to 6.7-year horizon for complete eradication. As presented at the December 2009 summit on status of the Manitou hydrilla program, eradication efforts like Pickerel Pond in Maine (now 8 consecutive cycles of Sonar with tubers still being found) and Pipe/Lucerne Lakes in Washington (11 cycles of Sonar between 1995 – 2007) confirm that complete eradication of hydrilla tubers requires a sustained long-term commitment. Recent data from NC State University monitoring of tuber populations on Lake Gaston in NC/VA indicates that the hydrilla tuber bank can double in a single year without Sonar treatment (Nawrocki, et al. 2009). These data reinforce that if treatments end prior to full elimination of the Manitou tuber bank, tuber densities may return

to pre-treatment levels within a few years. The first four years of Sonar application have resulted in successful control of hydrilla with greater than 95% reductions in tubers and apparent prevention of hydrilla spread to other waters of Indiana. The timing of treatments coincided with hydrilla tuber sprouting, which is expected to be similar in 2011. Over the four cycles of management, the eradication program has impacted native submersed plant community, which was expected due to the importance placed on successful hydrilla control and the overall low species richness. In 2008, modifications were made to the Sonar formulation, concentration, and application frequency and distribution to maintain emphasis on hydrilla control and attempt to improve selectivity. These modifications were continued in 2009 with no major adjustment. After multiple reviews of past Sonar dissipation and performance in Manitou, two potential management options were described for the 2010 program. One based on a multiple formulation strategy, while the other focused on partial targeted application with Sonar pellets. Ultimately, refinements were made to the program for 2010 that changed the criteria for triggering bump applications. In previous years, residue values of 3.0 ppb or less triggered a bump application to return whole-lake average residue values to 6.0 ppb, (initial dose). The changes in 2010 dictated a lower residue value of 2.5 ppb would initiate a bump application to target lower lake-wide average residues of 5.0 ppb. In 2011, new observations regarding hydrilla tuber bank attrition and outcomes of various monitoring efforts suggest a need for continued refinement of the Manitou hydrilla management program. IDNR has reinforced that reducing herbicide pressure and encouraging greater growth and expansion of native aquatic vegetation in Manitou is a desirable, near-future management goal. In light of this objective and documentation of tuber depletion approaching eradication objective, the following management initiatives are broadly recommended for future hydrilla control efforts on Manitou:

1) Re-design and implement improved hydrilla monitoring protocols to develop additional quantitative data on the distribution and abundance of remaining vegetative hydrilla and hydrilla tubers in Lake Manitou. Current use of standard spring and late summer Tier 2 LARE vegetation assessments, while continuing to be needed for understanding broad long-term trends in aquatic plant diversity on the lake, have failed since 2007 to provide quantitative data documenting continued hydrilla presence. While of great importance in documenting progress towards hydrilla eradication from Manitou, the sharp reductions in hydrilla tuber density since the beginning of the eradication effort in 2007 have required increasing the intensity of sediment core collection for tuber counts in the remaining permanent monitoring stations. In 2010, only four unsprouted tubers were found in 700 sediment cores. For both vegetative and tuber monitoring for hydrilla, revised protocols should enhance the quantitative data available to IDNR for decisions on overall management direction for Lake Manitou.

2) Implement another large-scale (whole-lake) Sonar application plan similar to 2007-2010 that will continue to build off of historical experiences on the lake while tightly customizing application design based on additional quantitative hydrilla monitoring protocols. In 2009, details of Sonar application strategy were suggested as two paths:

one based on multiple formulations and the other based on using solely Sonar pellet formulations for more targeted, partial treatment. In the last three years, an application protocol utilizing multiple formulations of Sonar (fluridone) has been designed and further refined to best meet the hydrilla eradication objectives for the project. This protocol allows for higher concentrations applied to areas with known hydrilla while minimizing concentrations on the whole lake and minimizing pellet application to the entire littoral zone. The overall rate of Sonar used compared to previous years with this integrated approach has been adjusted down slightly in each of the last two seasons based on management experience on the lake. In 2010, the maintenance range for Sonar dose to 2.5 – 5 ppb (following initial 6 ppb target) was formally refined and successfully implemented. However, a continued analysis of historic precipitation records during the May-Sept period over the last 20 years (Table 5.1.1) indicates that 2007-2009 were years with slightly lower than mean or median seasonal rainfall, while the late spring and early summer of 2010 showed higher than normal levels of rainfall. In 2010, spring/summer precipitation could potentially have been less favorable for Sonar retention as the immediate Manitou watershed did not receive the greater amounts of late spring precipitation observed in other areas of the state. The mid-late summer of 2010 in Indiana also transitioned abruptly into hot, drought conditions that improved hydrologic conditions on Manitou for Sonar use. An above average rainfall pattern throughout the 2011 treatment cycle could dictate greater Sonar quantities than recent cycles to achieve refined Sonar target levels. Any Sonar program should continue routine FasTEST collection to follow herbicide levels and adjust with bump treatment modifications as needed.

3) Based on described criteria for hydrilla distribution and abundance developed using additional quantitative assessment protocols, plans can be made to shift Sonar application strategy towards more targeted, partial treatments, likely using appropriate Sonar pellet technology for specific target areas in the lake based on potential exchange, sediment type, and timing relative to the seasonal program.

Table 5.1.1. May through September monthly precipitation records from 1990-2010 for the Fulton County Airport just north of Lake Manitou in Rochester, Indiana. 2007 – 2010 records are compared to 20-year mean and median seasonal precipitation.

	Monthly Precipitation (inches)					
	May	**Jun**	**Jul**	**Aug**	**Sept**	**TOTAL**
1990	5.8	4.5	8.7	12.4	1.7	**33.1**
1991	3.3	2.1	2.8	3.3	1.7	**13.2**
1992	2.0	2.5	5.7	2.4	5.7	**18.3**
1993	4.4	5.4	4.5	3.2	7.1	**24.6**
1994	2.2	3.9	4.3	2.6	1.4	**14.4**
1995	5.1	5.9	1.8	4.5	0.5	**17.8**
1996	7.0	3.9	9.3	1.5	3.4	**25.1**
1997	5.7	3.6	6.4	4.2	5.9	**25.8**

1998	4.7	7.3	9.5	3.3	1.2	**26.0**
1999	3.2	4.2	1.4	3.2	2.5	**14.5**
2000	5.0	6.3	3.5	5.0	4.4	**24.2**
2001	4.2	4.1	8.5	5.6	3.2	**25.6**
2002	6.4	2.1	3.3	3.3	1.9	**17.0**
2003	6.3	2.0	9.3	2.0	5.3	**24.9**
2004	6.3	4.6	4.0	9.6	1.0	**25.5**
2005	2.3	3.5	4.0	2.7	4.4	**16.9**
2006	6.0	2.6	6.1	5.4	2.7	**22.8**
2007	2.3	2.5	5.1	6.6	1.1	**17.6**
2008	4.1	5.6	1.6	2.6	3.6	**17.5**
2009	5.2	2.9	2.7	5.3	1.5	**17.6**
2010	6.0	5.7	4.2	1.5	3.0	**20.4**
MEAN	**4.6**	**4.1**	**5.1**	**4.3**	**3.0**	**21.1**
MEDIAN	**5.0**	**3.9**	**4.3**	**3.3**	**2.7**	**20.4**

Difference from 20-Year Mean Precipitation

	May	Jun	Jul	Aug	Sept	TOTAL	% Diff
2007	-2.3	-1.6	0.0	2.3	-1.9	**-3.5**	**-16.5%**
2008	-0.5	1.5	-3.5	-1.7	0.6	**-3.6**	**-17.0%**
2009	0.6	-1.2	-2.4	1.0	-1.5	**-3.5**	**-16.5%**
2010	1.4	1.6	-0.9	-2.8	0.0	**-0.7**	**-3.3%**

Difference from 20-Year Median Precipitation

	May	Jun	Jul	Aug	Sept	TOTAL	% Diff
2007	-2.7	-1.4	0.8	3.3	-1.6	**-2.8**	**-13.7%**
2008	-0.9	1.7	-2.7	-0.7	0.9	**-2.9**	**-14.2%**
2009	0.2	-1.0	-1.6	2.0	-1.2	**-2.8**	**-13.7%**
2010	1.0	1.8	-0.1	-1.8	0.3	**0.0**	**0.0%**

The original Manitou AMVP established three management goals:

1) Develop or maintain a stable diverse aquatic plant community that supports a good balance of predator and prey fish and wildlife species, good water quality, and is resistant to minor habitat disturbances and invasive species.
2) Direct efforts to preventing and/or controlling the negative impacts of aquatic invasive species.
3) Provide reasonable public access while minimizing the negative impacts on plant and wildlife species

Even after the introduction of hydrilla to Lake Manitou, the overall aquatic plant management objectives remain relatively the same: establish a diverse aquatic plant community, control aquatic invasive species, and provide reasonable public access. Currently, controlling hydrilla

and eradicating this invasive species is paramount to the other objectives outlined in this plan. It is not unreasonable and should remain a goal to implement the other objectives long-term. Some of these objectives are realistic while hydrilla control is ongoing, and recent changes to the hydrilla control program were implemented and suggested future actions proposed here to balance eradication efforts vs. other lake management objectives. Although the native species richness in Lake Manitou has historically been low, species affected by current management actions should recover to some extent during and/or following eradication efforts. Some minor introduction of additional native species may be justified long-term, as the plant community was historically dominated by a single species (i.e. eelgrass).

5.2 Budget Update

Budget review and updated cost projections are based on contract parameters.

The 2010 project cost was down 24% under 2009 due to a combination of 1) a slightly refined target range for Sonar dose following initial application and 2) minimal precipitation and resulting good Sonar retention in the mid-late summer. Project cost remained well below the anticipated budget cap for the project.

Table 5.2.1. Budget update for 2010.

Year	Actual expenditures
2007	$349,920
2008	$317,549
2009	$351,949
2010	$268,076

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6.0 PUBLIC AND REGIONAL REGULATORY INTERACTION

The on-going hydrilla eradication effort on Lake Manitou is a resounding success for preventing spread to other lakes in Indiana and the Midwest. With many aquatic invasive issues, including the recent activity regarding possible Asian carp spread to the Great Lakes, it is important for IDNR to promote successful management in Manitou. This success needs to be put in context with local stakeholders who have enjoyed recreational benefits of weed-free conditions over the last four years but may experience different lake conditions as the hydrilla eradication effort eventually transitions to a lower intensity management approach favoring greater native plant growth.

In terms of 2011 public access, it is still recommended that IDNR maintain ramp closures and inspections until spring sampling can be completed that indicates there is no vegetative hydrilla present in Lake Manitou or if new assessment protocols indicate that presence is no greater than recent years and poses no risk of hydrilla off-site movement.

Additionally, routine dialogue with Midwest regulators and resource managers on the threat of hydrilla should be initiated or maintained to help prevent or limit hydrilla expansion into more Midwest lakes. Rapid response plans should be revisited and adjusted as needed to current regulations and technical considerations (e.g., NPDES, possible improved assessment tools and techniques). The success of Manitou should be appropriately reviewed with various Midwest DNR groups to reinforce the value of past and current management expenditures to help maintain eradication funding for this project and have funds to aggressively react to possible future regional hydrilla infestations.

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APPENDIX

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Lake Manitou Hydrilla Eradication Program – YEAR 4

Initial Sonar Application Summary – May 7, 2010 (Friday).

Contractor (SePRO) and sub-contractors (Aquatic Control and ReMetrix, LLC) made the initial Sonar (fluridone) treatment for year four, targeting hydrilla eradication in Lake Manitou, IN.

Prescription Planning

No modifications were made to the treatment prescription this year. Similar to last year, it is assumed this methodology might require more bump treatments due to the tighter range of targeted concentrations and smaller distribution of Sonar slow-release pellets. The strategy employed the use of initial Sonar liquid and pellet application to start the season, followed by at least two subsequent "bump" treatments to maintain lake-wide concentrations.

A temperature and DO_2 profile completed May 6, 2010 indicated no thermal stratification. Assuming isothermal conditions, herbicide prescription maps were calibrated to apply Sonar liquid to the entire water volume. Sonar granular product was prescribed for littoral areas only; no adjustments to calculated doses were thus necessary. Like 2007, 2008, and 2009, Sonar liquid was applied using variable rate technology. Output varied according to depth of the water and speed of the vessel. Sonar PR (Precision Release) was applied to 19 zones that historically contained hydrilla. Target ppb rates were prescribed based upon potential for dilution, lake morphometry, and tuber presence. No pellet applications were planned to water deeper than 12 feet.

Application Equipment

Sonar A.S. (liquid) was applied using a GPS-coupled precision-application injection pump that adjusted rate based upon speed and water depth. A feedback log was saved to produce an "as applied" map. Northwest-southeast transect lines on 100 meter spacing were used to guide the liquid application. Sonar PR (pellet) was applied at varied ppb rates with a hopper-fed blower. GPS positioning was used to insure applications were kept within prescription boundaries.

Application notes

Prescription maps were derived from hydroacoustic depth data taken on October 5, 2006. Not all areas displayed within the Web Atlas as "shoreline" were accessible to the Sonar AS application vessel. GPS tracks and the "as-applied" log record the precise spatial positioning of the application. The equipment was triple-rinsed according to standard procedures and rinsate applied over the deepest areas in the lake. A total of 36 gallons of Sonar AS was applied. Sonar PR was applied to all areas as prescribed. A GPS record was kept to track the position of the vessel. The tracks do not necessarily represent the exact locations where granular applications were made, but rather a record of the granular vessel's position throughout the day's activities. A total of 1010 lbs of Sonar PR was applied to the 19 zones.

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LARE Tier 2 Survey Raw Data 6/15/2010

WPT	Lat	Long	Number of Species	Number of Natives	Depth	Rake score	Curlyleaf pondweed	Fil. Algae	Chara	Sago pondweed	Coontail	Flatstem pondweed
1	41.0609	-86.17843	0	0	4	0		P				
2	41.06142	-86.18021	0	0	5	0		P				
3	41.05924	-86.1881	1	1	4	1		P	1			
4	41.05921	-86.18875	1	1	4	1		P	1			
5	41.0553	-86.17996	0	0	6	0						
6	41.05695	-86.18784	0	0	5	0		P				
7	41.05406	-86.17718	0	0	4	0		P				
8	41.04456	-86.18524	2	2	4	1				1		1
9	41.0603	-86.1952	0	0	3	0		P				
10	41.0609	-86.19662	0	0	3	0						
11	41.03551	-86.16812	2	1	1	5	1				5	
12	41.03916	-86.17678	0	0	1	0		P				
13	41.03912	-86.17497	1	1	3	1		P		1		
14	41.0392	-86.17338	1	1	2	5		P		5		
15	41.03875	-86.17026	1	1	2	5				5		
16	41.04039	-86.17759	0	0	4	0		P				
17	41.04025	-86.17583	0	0	6	0		P				
18	41.04029	-86.17409	1	1	5	1		P		1		
19	41.0403	-86.17235	3	2	4	1	1	P		1	1	
20	41.04031	-86.17057	1	1	4	1		P			1	
21												
22	41.04149	-86.17858	1	1	3	1		P			1	
23	41.04152	-86.17311	0	0	4	0		P				
24	41.0428	-86.17948	1	1	3	1		P	1			
25												
26	41.04377	-86.18035	0	0	4	0		P				
27	41.04377	-86.17334	1	1	6	1		P			1	
28	41.04453	-86.18439	0	0	1	0		P				
29	41.04501	-86.1795	1	1	3	1		P	1			
30	41.0461	-86.18044	1	1	1	1		P	1			
31	41.04595	-86.17508	0	0	1	0						
32	41.04719	-86.18302	0	0	11	0						
33	41.04733	-86.17958	0	0	4	0		P				
34	41.04847	-86.18036	0	0	5	0		P				
35	41.04945	-86.18648	0	0	5	0		P				
36	41.04946	-86.18499	0	0	1	0		P				
37	41.05072	-86.18577	0	0	6	0		P				
38	41.05066	-86.18387	1	1	5	1		P	1			
39	41.05078	-86.18034	0	0	7	0		P				
40	41.05064	-86.17142	0	0	13	0		P				
41	41.05074	-86.16973	1	1	4	1		P			1	
42	41.05179	-86.18995	1	1	4	1		P	1			
43	41.05177	-86.1849	0	0	6	0						
44	41.05178	-86.18318	0	0	4	0		P				
45	41.05181	-86.1814	0	0	5	0						
46	41.05181	-86.17945	0	0	6	0		P				
47	41.05184	-86.17769	1	1	5	1		P	1			
48	41.05192	-86.17586	0	0	8	0		P				
49	41.0519	-86.17243	1	1	6	1		P	1			
50	41.05202	-86.17079	0	0	5	0						
51	41.05301	-86.18918	0	0	5	0						
52	41.05298	-86.1874	1	1	5	1			1			
53	41.053	-86.18563	0	0	5	0						
54	41.05302	-86.18388	0	0	5	0						
55	41.05293	-86.17865	1	1	5	1		P	1			
56	41.05296	-86.17679	0	0	3	0		P				
57	41.05291	-86.16979	1	1	6	1		P	1			
58	41.0543	-86.19016	0	0	5	0						
59	41.05415	-86.18856	0	0	6	0						
60	41.05407	-86.18675	0	0	4	0						
61	41.05424	-86.18489	1	1	5	1			1			
62	41.05413	-86.17949	0	0	6	0						
63	41.05412	-86.17764	0	0	5	0		P				
64	41.05425	-86.17063	0	0	6	0						
65	41.0554	-86.19107	1	1	4	1		P	1			
66	41.05523	-86.18561	0	0	4	0						
67	41.05542	-86.18407	1	1	5	1				1		
68	41.05529	-86.17871	1	1	6	1			1			
69	41.05532	-86.17694	1	1	5	1		P	1			
70	41.05537	-86.17161	1	1	6	1		P	1			
71	41.05542	-86.16978	0	0	5	0		P				
72	41.05641	-86.19216	1	1	1	1			1			
73	41.05646	-86.19026	0	0	5	0						
74	41.05643	-86.18845	0	0	6	0		P				
75	41.05644	-86.18676	0	0	7	0						
76	41.05652	-86.17782	0	0	7	0						
77	41.05655	-86.17593	1	1	6	1			1			
78	41.05659	-86.17067	1	1	4	1		P	1			
79	41.05756	-86.19298	1	1	1	1		P	1			
80	41.05757	-86.19115	1	1	5	1			1			
81	41.05761	-86.18916	1	1	5	1		P	1			
82	41.0577	-86.18755	0	0	4	0		P				
83	41.05762	-86.1857	0	0	4	0						

84	41.05771	-86.18401	0	0	5	0		
85	41.05782	-86.17862	0	0	6	0	P	
86	41.05776	-86.17679	0	0	5	0		
87	41.05813	-86.17139	0	0	6	0	P	
88	41.05883	-86.19191	1	1	4	1		1
89	41.05858	-86.19007	1	1	4	1	P	1
90	41.05882	-86.18841	0	0	4	0	P	
91	41.0588	-86.18665	1	1	4	1	P	1
92	41.05877	-86.18495	0	0	5	0	P	
93	41.05881	-86.18324	0	0	5	0		
94	41.05876	-86.18144	0	0	6	0		
95	41.05882	-86.17971	0	0	6	0		
96	41.0588	-86.17796	1	1	6	1	P	1
97	41.0589	-86.17607	0	0	6	0	P	
98	41.05893	-86.17439	0	0	9	0		
99	41.05894	-86.17246	0	0	5	0	P	
100	41.05986	-86.19466	1	1	3	1		1
101	41.05994	-86.19282	1	1	3	5		5
102	41.05995	-86.18944	1	1	7	1	P	1
103	41.06005	-86.18215	0	0	5	0	P	
104	41.05995	-86.18052	0	0	5	0		
105	41.05998	-86.17874	1	1	4	1	P	1
106	41.06002	-86.17694	0	0	5	0	P	
107	41.05997	-86.17505	0	0	5	0	P	
108	41.05986	-86.17323	0	0	4	0	P	
109	41.06092	-86.18498	0	0	3	0	P	
110	41.06113	-86.18318	0	0	2	0	P	
111	41.06108	-86.18132	0	0	5	0	P	
112	41.06111	-86.17951	0	0	5	0	P	
113	41.05424	-86.1773	1	1	5	1	P	1
DK 1	41.06071	-86.19449	0	0	4	0	P	
DK 2	41.05927	-86.19456	0	0	4	0	P	
DK 3	41.06106	-86.18397	1	1	3	1	P	1
DK 4	41.06179	-86.18296	1	1	3	1	P	1
DK 5	41.05555	-86.19245	1	1	3	3	P	3
DK 6	41.04855	-86.18697	1	1	4	1	P	1
DK 7	41.04933	-86.18957	1	1	5	1	P	1
DK 8	41.04548	-86.18241	0	0	14	0		
DK 9	41.04945	-86.17431	0	0	15	0		
DK 10	41.0502	-86.17181	0	0	3	0		
DNR 1	41.04877	-86.18804	1	1	5	1	P	1

LARE Tier 2 Survey Raw Data 8/31/2010

WPT	Lat	Long	Number of Species	Number of Natives	Depth	Rake score	Curlyleaf pondweed	Fil. Algae	Chara	Sago pondweed	Coontail	Bladderwort
1	41.06090	-86.17843	0	0	5	0		P				
2	41.06142	-86.18021	0	0	4	0		P				
3	41.05924	-86.18810	1	1	4	1		P	1			
4	41.05921	-86.18875	0	0	4	0		P				
5	41.05530	-86.17996	0	0	6	0						
6	41.05695	-86.18784	0	0	5	0						
7	41.05406	-86.17718	1	1	4	1		P	1			
8	41.04456	-86.18524	1	1	5	5				5		
9	41.06030	-86.19520	0	0	1	0						
10	41.06090	-86.19662	0	0	1	0						
11	41.03551	-86.16812	2	2	2	5				1	5	
12	41.03916	-86.17678	1	1	1	1		P	1			
13	41.03912	-86.17497	0	0	3	0		P				
14	41.03920	-86.17338	1	1	3	3				3		
15	41.03875	-86.17026	2	2	5	2				1	5	
16	41.04039	-86.17759	0	0	3	0		P				
17	41.04025	-86.17583	0	0	6	0		P				
18	41.04029	-86.17409	0	0	5	0		P				
19	41.04030	-86.17235	2	2	4	1		P	1		1	
20	41.04031	-86.17057	2	1	4	5	1				5	
21												
22	41.04149	-86.17858	0	0	3	0		P				
23	41.04152	-86.17311	0	0	4	0		P				
24	41.04280	-86.17948	0	0	3	0		P				
25												
26	41.04377	-86.18035	0	0	4	0		P				
27	41.04377	-86.17334	0	0	5	0		P				
28	41.04453	-86.18439	1	1	2	1		P		1		
29	41.04501	-86.17950	0	0	3	0		P				
30	41.04610	-86.18044	0	0	2	0		P				
31	41.04595	-86.17508	0	0	2	0						
32	41.04719	-86.18302	1	1	7	1						1
33	41.04733	-86.17958	0	0	4	0						
34	41.04847	-86.18036	0	0	4	0		P				
35	41.04945	-86.18648	1	1	6	1		P	1			
36	41.04946	-86.18499	0	0	1	0		P				
37	41.05072	-86.18577	0	0	6	0		P				
38	41.05066	-86.18387	1	1	5	1		P	1			
39	41.05078	-86.18034	0	0	7	0						
40	41.05064	-86.17142	0	0	16	0						
41	41.05074	-86.16973	0	0	4	0		P				
42	41.05179	-86.18995	0	0	4	0		P				
43	41.05177	-86.18490	0	0	5	0						
44	41.05178	-86.18318	0	0	4	0		P				
45	41.05181	-86.18140	0	0	5	0						
46	41.05181	-86.17945	0	0	6	0		P				
47	41.05184	-86.17769	1	1	5	1		P		1		
48	41.05192	-86.17586	0	0	8	0		P				
49	41.05190	-86.17243	0	0	6	0						
50	41.05202	-86.17079	0	0	6	0						
51	41.05301	-86.18918	1	1	5	1			1			
52	41.05298	-86.18740	0	0	5	0						
53	41.05300	-86.18563	0	0	4	0						
54	41.05302	-86.18388	0	0	5	0						
55	41.05293	-86.17865	1	1	5	1		P	1			
56	41.05296	-86.17679	0	0	4	0		P				
57	41.05291	-86.16979	1	1	6	1		P	1			
58	41.05430	-86.19016	0	0	5	0		P				
59	41.05415	-86.18856	0	0	5	0						
60	41.05407	-86.18675	0	0	5	0						
61	41.05424	-86.18489	0	0	5	0						
62	41.05413	-86.17949	1	1	5	1		P		1		
63	41.05412	-86.17764	0	0	5	0		P				
64	41.05425	-86.17063	0	0	6	0						
65	41.05540	-86.19107	1	1	4	1		P	1			
66	41.05523	-86.18561	1	1	4	1		P	1			
67	41.05542	-86.18407	0	0	5	0						
68	41.05529	-86.17871	1	1	5	1			1			
69	41.05532	-86.17694	0	0	6	0						
70	41.05537	-86.17161	1	1	5	1		P		1		
71	41.05542	-86.16978	0	0	5	0						
72	41.05641	-86.19216	0	0	2	0		P				
73	41.05646	-86.19026	0	0	5	0						
74	41.05643	-86.18845	0	0	5	0						
75	41.05644	-86.18676	0	0	7	0						
76	41.05652	-86.17782	0	0	6	0		P				
77	41.05655	-86.17593	0	0	7	0						
78	41.05659	-86.17067	2	2	5	1		P	1		1	
79	41.05756	-86.19298	1	1	3	5			5			
80	41.05757	-86.19115	1	1	5	1		P	1			
81	41.05761	-86.18916	1	1	5	1		P	1			
82	41.05770	-86.18755	0	0	5	0		P				
83	41.05762	-86.18570	0	0	5	0						

84	41.05771	-86.18401	1	1	5	1			1
85	41.05782	-86.17862	0	0	5	0	P		
86	41.05776	-86.17679	0	0	6	0			
87	41.05813	-86.17139	0	0	5	0	P		
88	41.05883	-86.19191	0	0	4	0	P		
89	41.05858	-86.19007	0	0	4	0	P		
90	41.05882	-86.18841	0	0	4	0	P		
91	41.05880	-86.18665	0	0	4	0	P		
92	41.05877	-86.18495	0	0	5	0	P		
93	41.05881	-86.18324	0	0	5	0			
94	41.05876	-86.18144	0	0	5	0	P		
95	41.05882	-86.17971	0	0	6	0			
96	41.05880	-86.17796	0	0	5	0	P		
97	41.05890	-86.17607	0	0	6	0	P		
98	41.05893	-86.17439	0	0	7	0			
99	41.05894	-86.17246	0	0	6	0			
100	41.05986	-86.19466	1	1	5	1		1	
101	41.05994	-86.19282	1	1	3	3		3	
102	41.05995	-86.18944	0	0	6	0			
103	41.06005	-86.18215	0	0	5	0	P		
104	41.05995	-86.18052	0	0	5	0	P		
105	41.05998	-86.17874	0	0	5	1	P		
106	41.06002	-86.17694	0	0	5	0	P		
107	41.05997	-86.17505	1	1	5	1	P	1	
108	41.05986	-86.17323	0	0	4	0	P		
109	41.06092	-86.18498	0	0	4	0			
110	41.06113	-86.18318	1	1	3	1		1	
111	41.06108	-86.18132	0	0	5	0	P		
112	41.06111	-86.17951	0	0	5	0	P		
113	41.05424	-86.1773	0	0	4	0	P		
DK 1	41.06071	-86.19449	0	0	4	0	P		
DK 2	41.05927	-86.19456	0	0	5	0	P		
DK 3	41.06106	-86.18397	1	1	3	1	P	1	
DK 4	41.06179	-86.18296	1	1	3	5	P	5	
DK 5	41.05555	-86.19245	1	1	3	1	P	1	
DK 6	41.04855	-86.18697	0	0	4				
DK 7	41.04933	-86.18957	0	0	5	0			
DK 8	41.04548	-86.18241	0	0	9	0			
DK 9	41.04945	-86.17431	0	0	6	0			
DK 10	41.0502	-86.17181	0	0	2	0			
DNR 1	41.04877	-86.18804	1	1	5	1	P	1	

FasTEST Collection Vegetation Monitoring Data Sheets

May 10 – November 1, 2010

Lake Manitou Sample Collection

Injury:		Cover:		Growth:		Other Indicators:		
1	Healthy	1	80-100	1	From Apical Tips or Nodes	T	Topped out Vegetation	Biologist Name:
2	Slight injury	2	60-79	2	From Seeds	I	Suspected Insect Damage	
3	Moderate injury	3	40-59	3	From Root Crown or Rhizomes	P	Suspected Pathogen Damage	David Keister
4	Severe Injury	4	20-39	4	From Turions or Tubers	M	Mechanical Damage	Aquatic Weed Control
5	Dead plant	5	<19	5	From Perennial - shrub, tree, etc.	W	Water Fluctuation Damage	
6	Not present	6	Not present	6	No growth	E	End of Life Cycle	

Survey Date: 5/10/2010

Date of Treatment: 5/7/2010

Gauge Reading: gauge gone

Site	Species	Injury	Cover	Growth	Other	Photos	Secchi	Depth	H2OTemp	D O2	Notes
1	no plants		6				bottom visible	surface	60.4		depth 6.5 feet
2	no plants		6				8.3	surface	61.3	9.73	depth 30 feet
								1m	61.2	9.72	
								2m	61.0	9.72	
								3m	60.9	9.74	
								4m	60.8	9.71	
								5m	60.1	8.85	
								6m	59.3	7.96	
								7m	59.2	7.96	
								8m	58.2	6.57	
								9m	54.4	1.76	
								10m	52.9	0.43	
3	Algae present						bottom visible	surface	59.5		depth 5 feet
4	Chara	2	5	3			bottom visible	surface	60.0		depth 5 feet
5	no plants		6				8.2	surface	62.7		depth 18 feet
6	Algae present						bottom visible	surface	61.6		depth 4 feet
7	no plants		6				10.1	surface	61.7	9.76	depth 39 feet
								1m	61.7	9.71	
								2m	61.6	9.69	
								3m	61.5	9.61	
								4m	61.2	9.50	
								5m	61.2	9.44	
								6m	61.1	9.29	
								7m	60.8	9.15	
								8m	60.4	8.27	
								9m	60.0	7.58	
								10m	59.6	7.17	
								11m	58.2	5.19	
9	Chara	2	5	3			bottom visible	surface	59.5		depth 5 feet
											Summary
											sunny, windy, temp in mid 50's
											water temp range 59.5 - 62.7 degrees F
											Secchi Range from 8.2 - 10.1 ft
											Chara collected on rake, Curly leaf pondweed observed growing in south end of lake
											Rake samples taken at each shallow FasTEST Site
											No Hydrilla found
											portion of water level control at dam is missing

Lake Manitou Sample Collection

Injury:		Cover:		Growth:		Other Indicators:		
1	Healthy	1	80-100	1	From Apical Tips or Nodes	T	Topped out Vegetation	Biologist Name:
2	Slight injury	2	60-79	2	From Seeds	I	Suspected Insect Damage	
3	Moderate injury	3	40-59	3	From Root Crown or Rhizomes	P	Suspected Pathogen Damage	David Keister
4	Severe Injury	4	20-39	4	From Turions or Tubers	M	Mechanical Damage	Aquatic Weed Control
5	Dead plant	5	<19	5	From Perennial - shrub, tree, etc.	W	Water Fluctuation Damage	
6	Not present	6	Not present	6	No growth	E	End of Life Cycle	

Survey Date: 6/7/2010

Date of Treatment: 5/7/2010

Gauge Reading: gauge gone

Site	Species	Injury	Cover	Growth	Other	Photos	Secchi	Depth	H2OTemp	D O2	Notes
1	no plants		6				bottom visible	surface	73.5		depth 6.5 feet
2	no plants		6				7.5	surface	73.8	7.66	depth 30 feet
								1m	73.7	7.67	
								2m	73.2	7.47	
								3m	72.9	7.63	
								4m	72.1	7.08	
								5m	66.5	5.83	
								6m	62.1	5.99	
								7m	60.2	4.32	
								8m	58.7	1.79	
								9m	57.3	0.25	
								10m	55.8	0.43	
3	Algae present						bottom visible	surface	73.7		depth 5 feet
	Chara	2	5	3							
4	Algae present						bottom visible	surface	73.6		depth 5 feet
	Chara	2	5	3							
5	no plants		6				7.8	surface	73.7		depth 18 feet
6	Algae present						bottom visible	surface	74.5		depth 4 feet
7	no plants		6				9.3	surface	74.7	8.37	depth 39 feet
								1m	74.5	8.33	
								2m	74.1	8.17	
								3m	73.8	8.07	
								4m	73.6	7.93	
								5m	72.6	7.18	
								6m	64.8	4.76	
								7m	62.4	4.53	
								8m	60.9	3.56	
								9m	60.2	2.32	
								10m	59.0	0.57	
								11m	58.7	0.21	
9	Algae present						bottom visible	surface	73.1		depth 5 feet
	Chara	2	5	3							
											Summary
											sunny, calm, temp in mid 70's
											water temp range 73.1 - 74.7 degrees F
											Secchi Range from 7.5 - 9.3 ft
											Chara collected on rake, Curly leaf pondweed,
											coontail and sago observed in south end of lake as well as dnr access channel
											Rake samples taken at each shallow FasTEST Site
											No Hydrilla found
											2 sections of water level control at dam now missing

Lake Manitou Sample Collection

Injury:		Cover:		Growth:		Other Indicators:		
1	Healthy	1	80-100	1	From Apical Tips or Nodes	T	Topped out Vegetation	Biologist Name:
2	Slight injury	2	60-79	2	From Seeds	I	Suspected Insect Damage	
3	Moderate injury	3	40-59	3	From Root Crown or Rhizomes	P	Suspected Pathogen Damage	David Keister
4	Severe Injury	4	20-39	4	From Turions or Tubers	M	Mechanical Damage	Aquatic Weed Control
5	Dead plant	5	<19	5	From Perennial - shrub, tree, etc.	W	Water Fluctuation Damage	
6	Not present	6	Not present	6	No growth	E	End of Life Cycle	

Survey Date: 6/21/2010

Date of Treatment: 5/7/2010

Gauge Reading: gauge gone

Site	Species	Injury	Cover	Growth	Other	Photos	Secchi	Depth	H2OTemp	D O2	Notes
1	no plants		6				3.8		79.0		depth 6.5 feet
2	no plants		6				4.3	surface	79.7	9.26	depth 30 feet
								1m	80.0	9.25	
								2m	80.1	9.11	
								3m	79.3	8.13	
								4m	76.9	5.22	
								5m	67.7	0.30	
								6m	63.5	0.63	
								7m	61.8	0.29	
								8m	60.0	0.14	
								9m	57.3	0.11	
								10m	55.6	0.10	
3	no plants						4.3		78.5		depth 5 feet
4	Chara	2	5	3			3.4		78.5		depth 5 feet
	Algae present										
5	no plants		6				4.6		80.8		depth 18 feet
6	Algae present						3.4		80.2		depth 4 feet
7	no plants		6				4.4	surface	81.0	11.34	depth 39 feet
								1m	81.0	11.36	
								2m	80.7	10.71	
								3m	78.5	7.09	
								4m	78.0	6.19	
								5m	75.2	3.38	
								6m	68.9	0.70	
								7m	64.8	0.22	
								8m	62.1	0.13	
								9m	60.6	0.12	
								10m	59.7	0.11	
								11m	58.7	0.11	
9	Chara	2	5	3			bottom visible		78.9		depth 5 feet
	Algae present										
											Summary
											cloudy, rainy, temp in mid 70's
											water temp range 78.9 - 80.8 degrees F
											Secchi Range from 8.2 - 10.1 ft
											Chara collected on rake, Curly leaf, sago and coontail observed growing in south end of lake
											Rake samples taken at each shallow FasTEST Site
											No Hydrilla found
											many dead fish is access channel (see pic) but not elswhere in lake. Appear to have been dumped

Lake Manitou Sample Collection

Injury:		Cover:		Growth:		Other Indicators:		
1	Healthy	1	80-100	1	From Apical Tips or Nodes	T	Topped out Vegetation	Biologist Name:
2	Slight injury	2	60-79	2	From Seeds	I	Suspected Insect Damage	
3	Moderate injury	3	40-59	3	From Root Crown or Rhizomes	P	Suspected Pathogen Damage	David Keister
4	Severe Injury	4	20-39	4	From Turions or Tubers	M	Mechanical Damage	Aquatic Weed Control
5	Dead plant	5	<19	5	From Perennial - shrub, tree, etc.	W	Water Fluctuation Damage	
6	Not present	6	Not present	6	No growth	E	End of Life Cycle	

Survey Date: 7/6/2010

Date of Treatment: 5/7/2010

Gauge Reading: gauge gone

Site	Species	Injury	Cover	Growth	Other	Photos	Secchi	Depth	H2OTemp	D O2	Notes
1	Algae present						3.2	surface	81.1		depth 6.5 feet
2	no plants		6				3.5	surface	80.1	9.48	depth 30 feet
								1m	82.4	9.51	
								2m	82.0	9.52	
								3m	81.4	9.13	
								4m	76.1	3.69	
								5m	71.7	0.21	
								6m	68.8	0.16	
								7m	62.9	0.14	
								8m	59.4	0.12	
								9m	58.0	0.11	
								10m	58.0	0.10	
3	Chara	2	5	3			2.8	surface	80.9		depth 5 feet
	Algae present										
4	Algae present						2.1	surface	80.9		depth 5 feet
5	no plants		6				3.2	surface	82.3		depth 18 feet
6	Algae present						3.5	surface	81.6		depth 4 feet
7	no plants		6				3.7	surface	82.4	9.45	depth 39 feet
								1m	82.0	9.50	
								2m	81.7	9.50	
								3m	81.5	9.40	
								4m	81.1	9.20	
								5m	76.2	2.39	
								6m	73.1	0.24	
								7m	68.8	0.19	
								8m	63.9	0.15	
								9m	62.0	0.14	
								10m	60.4	0.13	
								11m	59.2	0.12	
9	Chara	2	5	3			2.4	surface	81.5		depth 5 feet
	Algae present										
											Summary
											sunny, breezy, hot, low 90's
											water temp range 80.1-82.4 degrees F
											Secchi Range from 2.1-3.7 ft
											Flat-stemmed pondweed and contail observed in dnr access site channel (photo)
											Chara collected on rake, Curly leaf, sago and coontail observed growing in south end of lake
											Rake samples taken at each shallow FasTEST Site
											No Hydrilla found
											planktonic algae seems to be getting heavier-lake more green and lower secchi readings

Lake Manitou Sample Collection

Injury:		Cover:		Growth:		Other Indicators:		
1	Healthy	1	80-100	1	From Apical Tips or Nodes	T	Topped out Vegetation	Biologist Name:
2	Slight injury	2	60-79	2	From Seeds	I	Suspected Insect Damage	
3	Moderate injury	3	40-59	3	From Root Crown or Rhizomes	P	Suspected Pathogen Damage	David Keister
4	Severe Injury	4	20-39	4	From Turions or Tubers	M	Mechanical Damage	Aquatic Weed Control
5	Dead plant	5	<19	5	From Perennial - shrub, tree, etc.	W	Water Fluctuation Damage	
6	Not present	6	Not present	6	No growth	E	End of Life Cycle	

Survey Date: 7/19/2010

Date of Treatment: 5/7/2010

Gauge Reading: gauge gone

Site	Species	Injury	Cover	Growth	Other	Photos	Secchi	Depth	H2OTemp	D O2	Notes
1	no plants		6				3.8		82.1		depth 6.5 feet
	algae present										
2	no plants		6				3.5	surface	84.3	7.99	depth 30 feet
								1m	82.6	7.96	
								2m	82.1	7.29	
								3m	81.8	6.95	
								4m	79.3	0.28	
								5m	74.4	0.15	
								6m	69.5	0.12	
								7m	64.2	0.10	
								8m	64.5	0.09	
								9m	64.8	0.08	
								10m	64.6	0.08	
3	no plants						3.6		80.5		depth 5 feet
	algae present										
4	no plants		6				2.6		82.8		depth 5 feet
	Algae present										
5	no plants		6				3.4		83.8		depth 18 feet
6	Algae present						3.4		80.2		depth 4 feet
7	no plants		6				3.5	surface	82.9	11.34	depth 39 feet
								1m	82.5	11.36	
								2m	82.0	10.71	
								3m	81.8	7.09	
								4m	81.6	6.19	
								5m	80.4	3.38	
								6m	74.8	0.70	
								7m	69.4	0.22	
								8m	65.6	0.13	
								9m	62.8	0.12	
								10m	61.2	0.11	
								11m	59.9	0.11	
9	Chara	2	5	3			2.4		81.6		depth 5 feet
	Algae present										
											Summary
											Sunny, calm temp in mid 80's
											water temp range 80.2 - 84.3 degrees F
											Secchi Range from 2.4-3.8 ft
											Chara collected on rake, sago and coontail observed growing in south end of lake
											Rake samples taken at each shallow FasTEST Site
											No Hydrilla found
											water level control strucure appears to be repaired,

Lake Manitou Sample Collection

Injury:		Cover:		Growth:		Other Indicators:		
1	Healthy	1	80-100	1	From Apical Tips or Nodes	T	Topped out Vegetation	Biologist Name:
2	Slight injury	2	60-79	2	From Seeds	I	Suspected Insect Damage	
3	Moderate injury	3	40-59	3	From Root Crown or Rhizomes	P	Suspected Pathogen Damage	David Keister
4	Severe Injury	4	20-39	4	From Turions or Tubers	M	Mechanical Damage	Aquatic Weed Control
5	Dead plant	5	<19	5	From Perennial - shrub, tree, etc.	W	Water Fluctuation Damage	
6	Not present	6	Not present	6	No growth	E	End of Life Cycle	

Survey Date: 8/2/2010

Date of Treatment: 5/7/2010

Gauge Reading: gauge gone

Site	Species	Injury	Cover	Growth	Other	Photos	Secchi	Depth	H2OTemp	D O2	Notes
1	No plants						3.8	surface	81.0		depth 6.5 feet
2	no plants						3.7	surface	82.6	8.63	depth 30 feet
								1m	82.1	8.65	
								2m	81.4	8.49	
								3m	79.0	7.04	
								4m	78.3	5.92	
								5m	74.1	0.23	
								6m	70.6	0.18	
								7m	65.4	0.14	
								8m	61.7	0.12	
								9m	58.9	0.11	
								10m	57.2	0.11	
3	Algae present						3.9	surface	79.8		depth 5 feet
4	no plants						3.0	surface	81.2		depth 5 feet
5	no plants						4.3	surface	83.2		depth 18 feet
6	Algae present						3.4	surface	82.6		depth 4 feet
7	no plants						4.2	surface	82.9	8.79	depth 39 feet
								1m	82.1	8.80	
								2m	81.7	8.79	
								3m	80.6	6.78	
								4m	80.0	6.01	
								5m	79.5	5.08	
								6m	77.2	1.98	
								7m	70.4	0.14	
								8m	66.0	0.11	
								9m	63.2	0.10	
								10m	60.8	0.09	
								11m	59.0	0.08	
9	Chara	2	5	3			2.1	surface	80.5		depth 5 feet
	Algae present										
											Summary
											Sunny, calm temp in mid 80's
											water temp range 79.8-82.9 degrees F
											Secchi Range from 2.1-4.3ft
											Chara collected on rake, sago and coontail observed growing in south end of lake
											Rake samples taken at each shallow FasTEST Site
											No Hydrilla found

Lake Manitou Sample Collection

Injury:		Cover:		Growth:		Other Indicators:		
1	Healthy	1	80-100	1	From Apical Tips or Nodes	T	Topped out Vegetation	Biologist Name:
2	Slight injury	2	60-79	2	From Seeds	I	Suspected Insect Damage	
3	Moderate injury	3	40-59	3	From Root Crown or Rhizomes	P	Suspected Pathogen Damage	David Keister
4	Severe Injury	4	20-39	4	From Turions or Tubers	M	Mechanical Damage	Aquatic Weed Control
5	Dead plant	5	<19	5	From Perennial - shrub, tree, etc.	W	Water Fluctuation Damage	
6	Not present	6	Not present	6	No growth	E	End of Life Cycle	

Survey Date: 8/16/2010

Date of Treatment: 5/7/2010

Gauge Reading: gauge gone

Site	Species	Injury	Cover	Growth	Other	Photos	Secchi	Depth	H2OTemp	D O2	Notes
1	no plants						3.8	surface	82.4		depth 6.5 feet
2	no plants						2.9	surface	81.7	7.88	depth 30 feet
								1m	81.8	7.88	
								2m	81.7	7.82	
								3m	81.6	7.79	
								4m	79.6	2.98	
								5m	75.7	0.25	
								6m	72.3	0.17	
								7m	65.8	0.14	
								8m	62.2	0.12	
								9m	59.9	0.12	
								10m	58.2	0.11	
3	Algae present						3.3	surface	80.8		depth 5 feet
4	no plants						3.1	surface	82.3		depth 5 feet
5	no plants						4.1	surface	82.7		depth 18 feet
6	Algae present						4.1	surface	83.1		depth 4 feet
7	no plants						4.2	surface	82.5	8.25	depth 39 feet
								1m	82.7	8.17	
								2m	82.7	8.01	
								3m	82.5	7.41	
								4m	81.2	6.45	
								5m	80.0	1.61	
								6m	77.3	0.21	
								7m	72.6	0.16	
								8m	66.4	0.13	
								9m	62.0	0.11	
								10m	60.8	0.10	
								11m			
9	Algae present						2.8	surface	81.1		depth 5 feet
											Summary
											Sunny, windy temp in low 80's
											water temp range 80.8-82.7 degrees F
											Secchi Range from 2.8-4.2ft
											no plants collected on rake, sago pondweed growing in south end of lake
											Rake samples taken at each shallow FasTEST Site
											No Hydrilla found

Lake Manitou Sample Collection

Injury:		Cover:		Growth:		Other Indicators:		
1	Healthy	1	80-100	1	From Apical Tips or Nodes	T	Topped out Vegetation	Biologist Name:
2	Slight injury	2	60-79	2	From Seeds	I	Suspected Insect Damage	
3	Moderate injury	3	40-59	3	From Root Crown or Rhizomes	P	Suspected Pathogen Damage	David Keister
4	Severe Injury	4	20-39	4	From Turions or Tubers	M	Mechanical Damage	Aquatic Weed Control
5	Dead plant	5	<19	5	From Perennial - shrub, tree, etc.	W	Water Fluctuation Damage	
6	Not present	6	Not present	6	No growth	E	End of Life Cycle	

Survey Date: 8/30/2010

Date of Treatment: 5/7/2010

Gauge Reading: gauge gone

Site	Species	Injury	Cover	Growth	Other	Photos	Secchi	Depth	H2OTemp	D O2	Notes
1							4.4	surface	79.6		depth 6.5 feet
no plants											
2								surface	80.4	8.44	depth 30 feet
no plants							4.6	1m	80.0	8.49	
								2m	79.6	8.33	
								3m	78.3	7.86	
								4m	76.9	6.62	
								5m	75.3	3.12	
								6m	72.3	0.26	
								7m	67.3	0.19	
								8m	64.1	0.14	
								9m	64.3	0.14	
								10m	65.2	0.14	
3							3.6	surface	78.9		depth 5 feet
Algae present											
4							3.6	surface	79.8		depth 5 feet
no plants											
5							5.0	surface	78.5		depth 18 feet
no plants											
6							bottom visible	surface	79.6		depth 4 feet
Algae Present											
7							5.2	surface	79.3	8.81	depth 39 feet
no plants								1m	79.2	8.80	
								2m	79.2	8.79	
								3m	78.7	8.52	
								4m	78.0	7.52	
								5m	77.2	5.86	
								6m	76.2	3.58	
								7m	73.2	0.25	
								8m	68.0	0.19	
								9m	63.4	0.15	
								10m	61.3	0.13	
								11m	60.2	0.13	
9							2.9	surface	80.4		depth 5 feet
Chara		2	5	3							
Algae Present											**Summary**
											Sunny, breezy, temp in upper 80's
											water temp range 78.9-80.4. degrees F
											Secchi Range from 2.9-5.2ft
											chara collected on rake, sago pondweed and coontail growing in south end of lake
											Rake samples taken at each shallow FasTEST Site
											No Hydrilla found

Lake Manitou Sample Collection

Injury:		Cover:		Growth:		Other Indicators:		
1	Healthy	1	80-100	1	From Apical Tips or Nodes	T	Topped out Vegetation	Biologist Name:
2	Slight injury	2	60-79	2	From Seeds	I	Suspected Insect Damage	
3	Moderate injury	3	40-59	3	From Root Crown or Rhizomes	P	Suspected Pathogen Damage	David Keister
4	Severe Injury	4	20-39	4	From Turions or Tubers	M	Mechanical Damage	Aquatic Weed Control
5	Dead plant	5	<19	5	From Perennial - shrub, tree, etc.	W	Water Fluctuation Damage	
6	Not present	6	Not present	6	No growth	E	End of Life Cycle	

Survey Date: 9/13/2010

Date of Treatment: 5/7/2010

Gauge Reading: gauge gone

Site	Species	Injury	Cover	Growth	Other	Photos	Secchi	Depth	H2OTemp	D O2	Notes
1	Algae Present						4.3	surface	69.4		depth 6.5 feet
2	no plants						4.9	surface	70.5	9.1	depth 30 feet
								1m	70.1	9.19	
								2m	69.4	9.05	
								3m	68.8	8.85	
								4m	67.9	7.58	
								5m	67.6	7.15	
								6m	67.5	6.17	
								7m	67.2	5.75	
								8m	66.1	3.45	
								9m	58.2	0.22	
								10m	56.8	0.19	
3	algae present						4.5	surface	69.5		depth 5 feet
4	no plants						3.0	surface	68.9		depth 5 feet
5	no plants						5.0	surface	70.9		depth 18 feet
6	algae present						4.4	surface	70.3		depth 4 feet
7	no plants						5.6	surface	71.0	9.20	depth 39 feet
								1m	70.4	9.23	
								2m	70.0	9.15	
								3m	69.6	8.67	
								4m	69.1	7.95	
								5m	68.7	7.22	
								6m	68.6	6.88	
								7m	68.5	6.57	
								8m	68.3	5.99	
								9m	67.8	3.15	
								10m	64.7	0.26	
								11m	61.8	0.20	
9	Chara		2	5	3		bottom visible	surface	69.3		depth 5 feet
	algae present										
											Summary
											Sunny, breezy, temp in mid 70's
											water temp range 68.9-71.0 degrees F
											Secchi Range from 3.0 - 4.6 ft
											chara collected on rake, -reduced plant growth in south end of lake
											Rake samples taken at each shallow FasTEST Site
											No Hydrilla found

Lake Manitou Sample Collection

Injury:		Cover:		Growth:		Other Indicators:		
1	Healthy	1	80-100	1	From Apical Tips or Nodes	T	Topped out Vegetation	Biologist Name:
2	Slight injury	2	60-79	2	From Seeds	I	Suspected Insect Damage	
3	Moderate injury	3	40-59	3	From Root Crown or Rhizomes	P	Suspected Pathogen Damage	David Keister
4	Severe Injury	4	20-39	4	From Turions or Tubers	M	Mechanical Damage	Aquatic Weed Control
5	Dead plant	5	<19	5	From Perennial - shrub, tree, etc.	W	Water Fluctuation Damage	
6	Not present	6	Not present	6	No growth	E	End of Life Cycle	

Survey Date: 9/28/2010

Date of Treatment: 5/7/2010

Gauge Reading: gauge gone

Site	Species	Injury	Cover	Growth	Other	Photos	Secchi	Depth	H2OTemp	D O2	Notes
1							3.2	surface	65.2		depth 6.5 feet
no plants											
2							4.3	surface	65.1	9.27	depth 30 feet
no plants								1m	65.2	9.22	
								2m	65.2	9.13	
								3m	65.3	9.03	
								4m	65.3	8.99	
								5m	65.2	8.89	
								6m	65.0	8.04	
								7m	65.0	6.68	
								8m	64.9	6.41	
								9m	63.5	1.66	
								10m	57.8	0.26	
3							bottom visible	surface	64.0		depth 5 feet
algae present											
4							3.8	surface	65.0		depth 5 feet
no plants											
5							4.8	surface	65.1		depth 18 feet
no plants											
6							4.4	surface	65.1		depth 4 feet
algae present											
7							5.0	surface	66.4	8.56	depth 39 feet
no plants								1m	66.4	8.42	
								2m	66.6	8.23	
								3m	66.6	7.80	
								4m	66.7	7.30	
								5m	66.6	7.33	
								6m	66.5	7.13	
								7m	66.4	7.16	
								8m	66.3	6.07	
								9m	66.2	5.10	
								10m	65.8	3.96	
								11m	65.1	0.64	
9							bottom visible	surface	64.4		depth 5 feet
algae present											
											Summary
											Sunny, breezy, temp iin low 60's
											water temp range 64.0-65.2 degrees F
											Secchi Range from 3.2 - 5.0 ft
											no plants collected on rake- sago ad coontail observedin south end of lake
											Rake samples taken at each shallow FasTEST Site
											No Hydrilla found

Lake Manitou Sample Collection

Injury:		Cover:		Growth:		Other Indicators:		
1	Healthy	1	80-100	1	From Apical Tips or Nodes	T	Topped out Vegetation	Biologist Name:
2	Slight injury	2	60-79	2	From Seeds	I	Suspected Insect Damage	
3	Moderate injury	3	40-59	3	From Root Crown or Rhizomes	P	Suspected Pathogen Damage	David Keister
4	Severe Injury	4	20-39	4	From Turions or Tubers	M	Mechanical Damage	Aquatic Weed Control
5	Dead plant	5	<19	5	From Perennial - shrub, tree, etc.	W	Water Fluctuation Damage	
6	Not present	6	Not present	6	No growth	E	End of Life Cycle	

Survey Date: 10/11/2010

Date of Treatment: 5/7/2010

Gauge Reading: gauge gone

Site	Species	Injury	Cover	Growth	Other	Photos	Secchi	Depth	H2OTemp	D O2	Notes
1	Algae present						4.2	surface	65.0		depth 6.5 feet
2	no plants						4.3	surface	64.1	11.72	depth 30 feet
								1m	64.0	11.76	
								2m	63.8	11.87	
								3m	62.4	11.58	
								4m	60.9	9.36	
								5m	60.1	7.73	
								6m	59.5	6.86	
								7m	59.3	6.53	
								8m	59.2	5.94	
								9m	59.1	5.84	
								10m	59.0	4.76	
3	algae present						3.4	surface	65.2		depth 5 feet
4	no plants						3.3	surface	64.3		depth 5 feet
5	no plants						4.2	surface	66.8		depth 18 feet
6	algae present						4.1	surface	65.0		depth 4 feet
7	no plants						4.7	surface	64.9	11.99	depth 39 feet
								1m	64.8	12.01	
								2m	64.6	11.95	
								3m	63.0	10.35	
								4m	62.0	8.39	
								5m	61.6	7.13	
								6m	61.4	6.58	
								7m	61.2	5.64	
								8m	61.1	4.69	
								9m	60.9	4.09	
								10m	60.7	2.63	
								11m	60.6	1.71	
9	chara	2	5	3			2.4	surface	64.8		depth 5 feet
	Algae present										
											Summary
											sunny, calm, high in mid 70's
											water temp range 64.3 - 66.8 degrees F
											Secchi Range from 2.4 - 4.7 ft
											chara collected on rake- sago ad coontail observed in south end of lake
											planktonic algae may be getting a little heavier
											Rake samples taken at each shallow FasTEST Site
											No Hydrilla found

Lake Manitou Sample Collection

Injury:		Cover:		Growth:		Other Indicators:		
1	Healthy	1	80-100	1	From Apical Tips or Nodes	T	Topped out Vegetation	Biologist Name:
2	Slight injury	2	60-79	2	From Seeds	I	Suspected Insect Damage	
3	Moderate injury	3	40-59	3	From Root Crown or Rhizomes	P	Suspected Pathogen Damage	David Keister
4	Severe Injury	4	20-39	4	From Turions or Tubers	M	Mechanical Damage	Aquatic Weed Control
5	Dead plant	5	<19	5	From Perennial - shrub, tree, etc.	W	Water Fluctuation Damage	
6	Not present	6	Not present	6	No growth	E	End of Life Cycle	

Survey Date: 11/1/2010

Date of Treatment: 5/7/2010

Gauge Reading: gauge gone

Site	Species	Injury	Cover	Growth	Other	Photos	Secchi	Depth	H2OTemp	D O2	Notes
1	algae present						3.9	surface	50.9		depth 6.5 feet
2	no plants						4.2	surface	51.3	11.69	depth 30 feet
								1m	51.4	11.63	
								2m	51.3	11.57	
								3m	51.3	11.39	
								4m	51.2	11.29	
								5m	51.2	11.26	
								6m	51.2	11.22	
								7m	51.2	11.22	
								8m	51.1	11.14	
								9m	50.9	11.08	
								10m	50.8	11.15	
3	no plants						4.5	surface	51.9		depth 5 feet
4	chara	2	5	3			4.1	surface	48.4		depth 5 feet
	algae present										
5	no plants						4.1	surface	52.8		depth 18 feet
6	algae present						3.9	surface	51.2		depth 4 feet
7	no plants						4.0	surface	51.8	11.78	depth 39 feet
								1m	51.9	11.69	
								2m	51.9	11.40	
								3m	51.9	11.14	
								4m	52.0	11.07	
								5m	52.0	11.04	
								6m	52.0	11.03	
								7m	51.9	10.98	
								8m	51.9	10.78	
								9m	51.8	10.79	
								10m	51.7	10.76	
								11m	51.5	10.81	
9	chara	2	5	3			bottom visible	surface	49.5		depth 5 feet
	algae present										
											Summary
											sunny, windy, high in low 50's
											water temp range 48.4- 52.8 degrees F
											Secchi Range from 3.9 - 4.5 ft
											Chara collected on rake- natives in south end of lake dying back for winter
											planktonic algae not quite as prevalent as last trip
											Rake samples taken at each shallow FasTEST Site
											No Hydrilla found