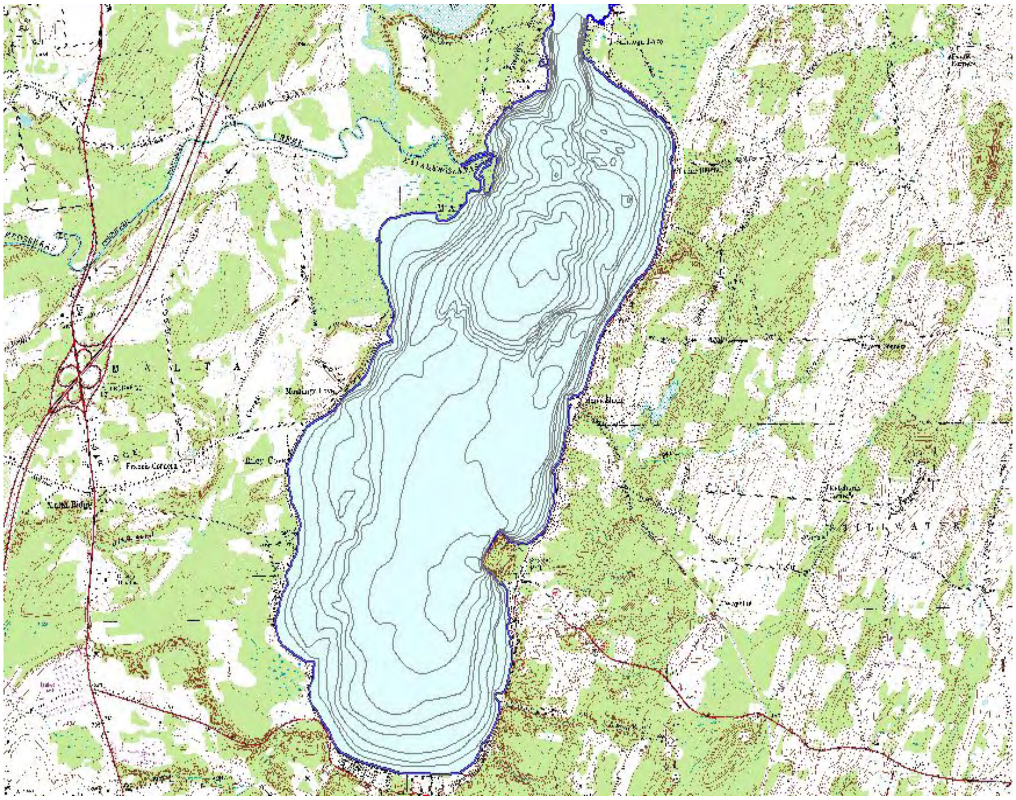
Saratoga Lake

Long-Term Aquatic Vegetation Management Plan



Final Report

December 2005

Prepared for:

SARATOGA LAKE PROTECTION & IMPROVEMENT DISTRICT

Prepared by:

AQUATIC CONTROL TECHNOLOGY, INC.
POND AND LAKE MANAGEMENT SPECIALISTS

Table of Contents

Table of Contents

EXECUTIVE SUMMARY

The aquatic plant community of Saratoga Lake was assessed in 2004 in order to develop a long-term management plan targeting the reduction of non-native and invasive weed growth. This project was commissioned by the Saratoga Lake Protection and Improvement District (SLPID), which has overseen management efforts at the lake since its formation in 1986. Developing a long-term vegetation management plan for Saratoga Lake was a specific recommendation in Land to Lake Perspectives: A Watershed Management Plan for Saratoga Lake that was completed for SLPID by the LA Group, P.C. in 2002. Efforts undertaken in 2004 included a comprehensive aquatic vegetation survey, review of past management activities, evaluation of available vegetation management alternatives, and the formulation of specific management recommendations for Saratoga Lake.

The main basin of Saratoga Lake encompasses approximately 3850 surface acres and nearly one-third of lake or 1300 acres constitutes the littoral zone, which currently supports rooted plant growth. Introduced Eurasian watermilfoil has been the dominant nuisance weed in Saratoga Lake since the early 1980's. A 1982 study reported 870 acres of problematic Eurasian watermilfoil growth in the lake. This led to the formation of SLPID and an active management program that utilized limited winter drawdowns and a sizeable mechanical harvesting program. Over the next decade these strategies appeared to contribute to a reduction of Eurasian watermilfoil cover, with a 1994 study reporting only 445 acres of dense growth. However, the reduction in Eurasian watermilfoil cover occurred in the shallow lake margins where the management efforts were concentrated and effectively selected for native plant species that were more tolerant of drawdown and harvesting and have also reached problematic densities in some locations. Simultaneous improvements in water quality through nutrient reduction efforts in the lake's expansive watershed increased water clarity and allowed Eurasian watermilfoil to colonize deeper water areas. By 2004, the Eurasian watermilfoil coverage had expanded to 736 acres, with most of the expansion found in deeper water sections of the lake. Typical mid-summer conditions produce several hundred acres of dense Eurasian watermilfoil beds that mat to the surface in 7-12 feet of water and extend out more than 1000 feet from shore in many locations. These Eurasian watermilfoil beds are not impacted by the 3-foot winter drawdown and are too expansive to be completely harvested with the current program. Impairment to the recreational use of the lake and negative impacts to the freshwater ecosystem are considerable.

Demonstration weed management projects evaluated as part of the Watershed Management Plan completed in 2002 suggested that development of a long-term, integrated management plan was needed to improve Eurasian watermilfoil control in Saratoga Lake. The focus of this study commissioned by SLPID in 2004 was to document current conditions in Saratoga Lake, evaluate management alternatives, identify management objectives and develop a specific long-term aquatic vegetation management program. Based on the current expanse of Eurasian watermilfoil cover and other invasive weed growth found in the littoral zone, it was determined that a program integrating drawdown, harvesting and herbicide treatments was needed to achieve significant improvements in the management of nuisance weed growth at Saratoga Lake. Winter drawdowns are already being performed to the maximum extent practicable. This leaves expansion of the harvesting program and the incorporation of large-scale herbicide treatments as the realistic strategies to focus on for improved control.

The current harvesting program, which utilizes 2-3 medium to large sized harvesters operating for nearly 20 consecutive weeks, is only effectively managing approximately 250 acres in the lake. Where much of the harvesting work is concentrated close to shore to improve access to the lake, it does not even address one-third of the problematic Eurasian watermilfoil beds. The harvesting effort would need to be at least tripled to attempt removal of all nuisance Eurasian watermilfoil growth. Annual operating and capitol expenses would need to be increased to $250,000-$300,000 and this may still not solve the problem as Eurasian watermilfoil growth would continue throughout the summer growing season and there would likely continue to be issues with windblown plant fragments that escape the harvesting operation. Integrating large-scale herbicide treatments may yield more satisfactory results with similar annual expenditures. Given current state regulations, only Sonar (active ingredient fluridone) or Aquathol (active ingredient endothall) could likely be used for large-scale treatment work at Saratoga Lake. Use of systemic-acting herbicides like Sonar that kill the plant roots and are capable of providing multiple years of effective milfoil control would likely be preferable. However, contact-acting herbicides like Aquathol that kill the actively growing plant may be more appropriate for spot-treatments of smaller areas and control of regrowth. Due to the size and configuration of Saratoga Lake and the expanse of the Eurasian watermilfoil infestion, herbicide treatments on large blocks, such as one-third, one-half or the whole lake, will likely produce the most effective results.

Ultimately, significant improvements to the long-term management of Eurasian watermilfoil and other nuisance weed growth on Saratoga Lake will require a considerable financial commitment. Current technologies are not capable of eradicating nuisance species like Eurasian watermilfoil, so management efforts must be sustained to realize long-term improvements. Regulatory changes and the development of new technologies such as different herbicides or formulations are also inevitable, so the management plan must remain fluid and be constantly refined to best meet the management objectives and best serve the numerous user groups at Saratoga Lake.

1. INTRODUCTION

In the 1970's Eurasian watermilfoil was discovered in Saratoga Lake. Since that time residents, visitors, and researchers have witnessed an alarming increase in the milfoil population throughout the entire lake basin. In the past few decades the invasive milfoil has come to inhabit much of the lakes littoral zone, now accounting for a vast majority of the lake's aquatic vegetation cover, over 700 acres. Eurasian watermilfoil is a notoriously invasive non-native plant that has become the focus of lake restoration efforts across the United States. Like many non-native plants, Eurasian watermilfoil has a natural advantage over most native aquatic plant species because it has few natural restraints inhibiting its growth. Eurasian watermilfoil is particularly problematic because if its tendency to reach and often "mat" the water's surface, creating not only aesthetic issues, but also inhibiting many recreational activities.

Efforts to manage the milfoil and other nuisance plant growth in Saratoga Lake have been ongoing since the mid 1980's and have included limited winter drawdowns, annual harvesting of the shoreline littoral zone and more recently demonstration herbicide treatments and milfoil weevil stocking program.

In 2002 The L.A. Group, P.C., located in Saratoga Springs, NY, created "A Watershed Management Plan of Saratoga Lake" which called for the development of a long-term aquatic vegetation management plan to help gain control of the overwhelming milfoil presence in the lake. This report is the culmination of an effort to develop a long-term plan for aquatic plant management within the Saratoga Lake basin. The following text has drawn from many of the previous works concerning Saratoga Lake and aims to develop comprehensive guide to management options currently available for combating an inundation of Eurasian watermilfoil. The balance of this report contains reviews of data collected by Aquatic Control and a variety of other involved parties, both past and present. The information is reviewed in light of the situation currently facing Saratoga Lake and is used to develop a fluid management plan which can be used and tailored to the present and future aquatic vegetation management needs at Saratoga Lake.

2. REVIEW OF AVAILABLE DATA

Principal sources for the majority of background information reviewed for this project included the Land to Lake Perspectives: A Watershed Management Plan for Saratoga Lake, completed by the The LA Group, P.C., July 2002, the Saratoga Lake Phase I Diagnostic Feasibility Study and Management Plan by Hardt et al. completed in September 1983, and Saratoga Lake Aquatic Plant Survey – 2004 completed in December 2004 by the Darrin Fresh Water Institute. However, the primary source of information regarding Saratoga's history, watershed description, water quality, and lake morphology is the aforementioned Land to Lake Perspectives.

2.1 HISTORY

Historical references to Lake Saratoga date back to 1899 when a study on the lake was ordered by the New York Governor, Theodore Roosevelt. This study was primarily conducted to investigate pollution due to water discharges fro the textile and leather industries. The study did not address the physical attributes of Saratoga Lake, nor did it address the chemical water quality of the lake at that time. A similar study was conducted in 1932 by the Conservation Department, again no significant information regarding lake morphology or water quality was collected. It was not until the late 1900's that significant data concerning the physical and chemical characteristics of the lake were collected. Between 1972 and 1982 the EPA conducted studies addressing in-lake water quality, leading to the formation of the Saratoga County Sewer District, and the Saratoga Lake Protection and Improvement District (SLPID). The former of these formed in 1977 and is responsible for the diversion of sewage from a major portion of the lake's watershed, as well as the elimination of lake adjacent septic systems. The later, formed in 1986, has been responsible for much of the research funding and lake maintenance in recent years.

Since the initial study conducted in 1899, the majority of the work concerning Saratoga Lake has been focused on nutrient loading, and much of the effort in this respect was focused on identifying sources of excessive nutrient loading. Although previous research and community action has lead to a successful diversion of almost all point source nutrient loaders, Saratoga Lake still suffers from somewhat elevated phosphorus and nitrogen levels likely due to the expansive size of the watershed and the myriad of land uses within its margins. More recently the issue of Eurasian watermilfoil has taken the forefront of discussion, and has motivated new and more comprehensive studies. By the early 1980's Eurasian watermilfoil, along with another non-native aquatic plant, curlyleaf pondweed, had come to dominate the aquatic vegetative community of Saratoga Lake. In Hardt et al., both Eurasian watermilfoil and curlyleaf pondweed were recorded as dense in their "Overall Relative Abundance" (Hardt et al., 1983). As early as 1981, experimental management techniques were being investigated on Saratoga Lake for the control of Eurasian watermilfoil. Since the onset of the milfoil invasion, a majority of effort and resources regarding Saratoga Lake have been fueled by the effort to control the milfoil population.

For years now, milfoil and other nuisance aquatic plants have been harvested on Saratoga Lake in an effort to maintain open water conditions. Harvesting has proved to be a difficult and sometimes less than optimal strategy in maintaining open waterways and shoreline access points, milfoil has come to dominate great expanses of the lake, and continues to be an ongoing problem. As a result of expansive milfoil population a good deal of research has been conducted on Saratoga Lake in the past few decades, leading to a number of comprehensive data pertaining to not only the lake's vegetation, but also its morphology and water chemistry.

In the following sections, some of the more pertinent characteristics of Saratoga Lake are discussed in regards to their importance to nuisance weed growth. The following is not intended to be a reference, but rather is intended to summarize the major characteristics of Saratoga Lake so they can be considered while constructing a management plan. For more comprehensive reading/findings on Saratoga Lake please refer to:

The LA Group, P.C. Land to Lake Perspectives: A Watershed Management Plan for Saratoga Lake.Saratoga Springs: New York, 2002.

Hardt, Frederick W., George Hodgson, and Gerald F. Mikol. Saratoga Lake Phase I Diagnostic Feasibility Study and Management Plan. New York, 1983.

Eichler, Lawrence, and Charles Boyen. Saratoga Lake Aquatic Plant Survey – 2004. New York: Darrin Fresh water Institute, 2004.

2.2 LAKE CHARACTERISTICS

Saratoga Lake is a natural glacier formed lake with a north-south orientation typical of large basins formed by the retreating continental glaciers. Saratoga Lake has 14 tributaries which account for the majority of surface fed waters from its 244 square mile drainage basin. The lake has only one primary outlet, Fish Creek, which drains to the northeast of the lake. Water levels in Saratoga Lake are regulated by a water level control structure located on the Fish Creek outlet, approximately 6.2 miles downstream from the Route 9P Bridge. (The LA Group, P. C., 2002)

Table 1 – Lake Characteristics

Mean Length	4.5 miles
Mean Width	1.5 miles
Maximum Depth	96 feet
Mean Depth	26 feet
Area	6.01 square miles
Volume	31,250,000,000 gal.
Shoreline Length	23 miles

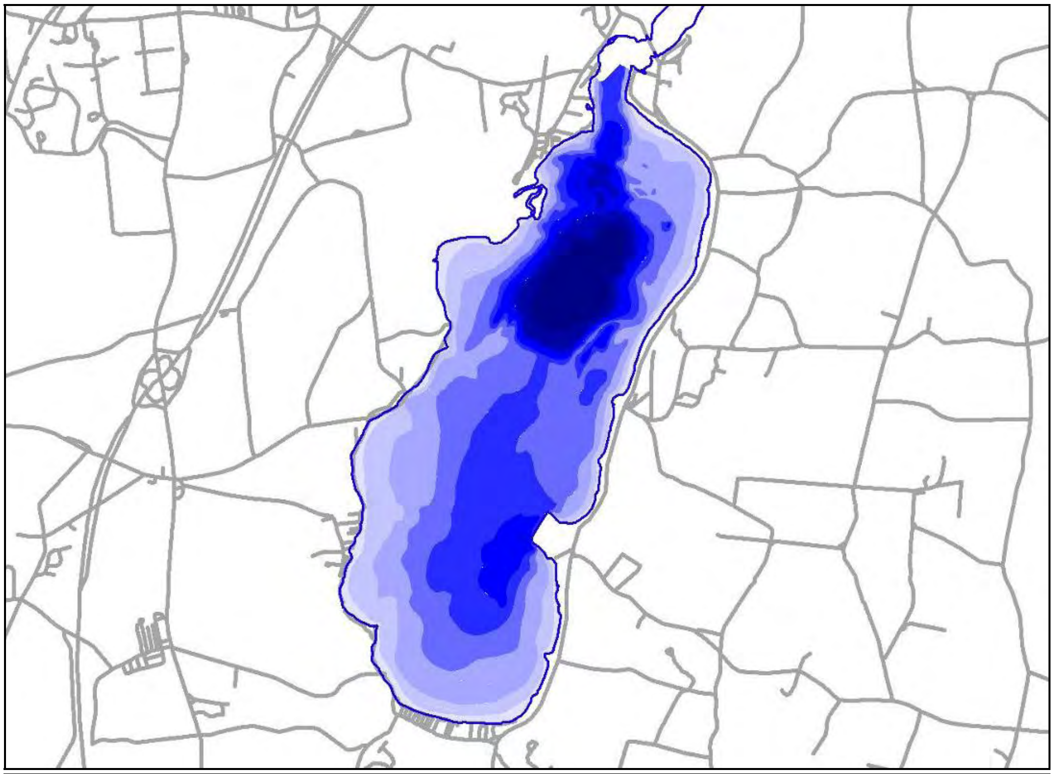
Saratoga Lake is comprised of one large basin, with two deep holes, one in the northern end of the lake, and the other at the southern end, 95 feet and 59 feet, respectively. It is a dimictic lake that appears to thermally stratify in June based on available historic data. The thermocline (at least a 2 degree Celsius drop in temperature within a 1 meter change in depth) initially becomes established around 6 meters and then gradually descends to about 10 meters during the summer months, effectively isolating water below the 10 meter mark. The gradual fall of the thermocline also stops any deep water mixing as it envelops the deep water channel around 8.5 meters, causing anaerobic conditions to develop below this point.

The Saratoga Lake Phase I Diagnostic Feasibility Study and Management Plan (Hardt, et al., 1983) reported a mean annual outflow rate of $3.31x10^8 m^3 yr^{-1}$. Using the reported water volume for the lake ($1.25x10^8$ m^3), this translates into a rough retention time of 0.37 years and flushing rate of 2.6 times per year. (p.132)

Detailed morphometric data on Saratoga Lake were presented in the 1983 report (Hardt, et. al) and the LA Group, P.C. 2002. The summary table below was adapted from the LA Group, P.C 2002 report. (p. 37)

A comprehensive bathymetric map was prepared CT Male, Inc. for 1983 D/F Study. The lake has been described as having two distinct basins. The north basin contains the deepest point on the lake with a maximum depth of 95 feet. The southern basin is considerably shallower. A small deep hole area reaching a maximum depth of 60 feet is found just south of Snake Hill along the eastern shoreline.

Figure 1- Existing Bathymetry



2.3 WATERSHED

Saratoga Lake has a reported watershed area that is 244 square miles. The watershed includes portions of ten towns, and accounts for 30 percent of the land found in Saratoga County. The drainage basin that feeds Saratoga Lake encompasses 14 different tributaries, four of which contribute a significant amount of surface water fed to Saratoga Lake, most importantly Kayaderosseras Creek, which accounts for nearly 90% of the surface water entering the Lake (Hardt et al., p,132) In all, it is estimated that nearly 99% of the water that arrives in Saratoga Lake is either from surface water runoff or direct precipitation. Of the annual inflow to Saratoga Lake nearly 97% is discharged via outflow in Fish Creek.

Numerous studies have been performed on the watershed over the years, particularly on Kayaderosseras Creek which has been identified as major nutrient contributor, accounting for nearly 90% of the phosphorus and nitrogen being introduced to the lake in 1983 (Hardt et al., 1983). Since 1983, the total amount of phosphorus being introduced though Kayaderosseras Creek has dropped significantly, however, elevated levels of nutrients still exist, a situation that is most likely attributable to the increased development in the watershed in the past 25 years (The LA Group, 2002). Most of the watershed supports moderate to heavy development, and non-point source pollution is undoubtedly significant. The lake to watershed ratio of Saratoga Lake is about 40:1. By typical standards it is assumed that any lake with a ratio of greater than 5:1 is greatly influenced by the characteristics of its surrounding watershed. For this reason, it can easily be determined that the water chemistry of Saratoga Lake is strongly influenced by the surrounding communities and is therefore at the mercy of the activities being conducted within its watershed.

2.4 WATER QUALITY

Water quality has been regularly monitored in Saratoga Lake since the 1983 D/F Study. The lake actively participates in the New York Citizens' Statewide Lake Assessment Program (CSLAP) and over the past several years, a number of water quality parameters have been monitored on multiple occasions during the summer by Adirondack Ecologists. Summaries of parameters that most directly effect aquatic vegetation and algae growth follow.

Previous water quality investigations determined that Saratoga Lake is a phosphorus limited lake, with N:P ratios of approximately 25:1. Still both phosphorus and nitrogen loading appears to be considerable. In-lake phosphorus concentrations in surface waters generally greater that 24 ppb in the 1983 (Hardt et al.) report and were reported to be approximately 16 ppb The LA Group P.C. in 2002 (The LA Group) Phosphorus concentrations in excess of 20 µg/l are generally considered to be sufficient to stimulate algal blooms. Internal loading may also be considerable, as much higher phosphorus concentrations have been reported in the anoxic hypoliminion waters when the lake is thermally stratified during the summer months.

The pH readings appear to trend nearly neutral in the lake. The pH values drop with depth, which is typically seen in productive waterbodies with elevated algal densities. Alkalinity values run moderately high (70-100 mg/l as $CaCO_3$) suggesting that the lake is moderately to well buffered against acid additions.

Temperature and dissolved oxygen profiling performed in 2003 by Adirondack Ecologists produced similar results between both the north and south portions of the basin. A thermocline was generally encountered between 8 and 10 meters. Dissolved oxygen concentrations were near saturation in the epilimnion, while the hypolimnion waters were anoxic. Recent temperature/dissolved oxygen profiling suggests that Saratoga Lake is slow to develop strong thermal stratification. A noticeable thermocline does not appear to develop until late June.

The Secchi disk depth readings have improved greatly since 1972 indicating a vast improvement in water clarity over the past few decades. In 1982 Secchi disk readings were estimated to range between 2.4m – 1.4m from May thru September (Hardt, et al., 1983). By comparison, Secchi disk readings between 1993-1997 ranged from 1.2m – 7.05m, with a five year average of 3.09m. Although much of the initial improvement in clarity is likely attributable to the diversion of municipal sanitary waste away from the lake, a more recent spike in Secchi disk readings appears to be correlated to the introduction of Zebra muscles in 1995-1996. Since this time Secchi disk readings have increased substantially, resulting in an average Secchi depth of 5.6m in 1997. (The LA Group, p. 40)

2.5 PHYTOPLANKTON

Saratoga Lake is a biologically productive lake. Extensive phytoplankton monitoring was reported in the 1983 Hardt et al. report. For this study, year-round monitoring was conducted and species from six algal divisions (over 100 individual species) were recorded between 1981-1982. Several different taxa of diatoms, green algae and blue-green algae were found. Normal seasonal algal succession patterns were evident, especially with the diatoms that generally favor cooler water and the blue-green algae that often peak during late summer and at the spring and fall turnover events. Green algae appeared to maintain the most consistent densities in all basins. Shifts in algal dominance have likely occurred over the years, especially as nutrient loading from the watershed has changed. (Hardt, et al., 1983)

2.6 FISHERY

The fishery in Saratoga Lake is reported to be diverse harboring such warm water species such as large and smallmouth bass, chain pickerel, yellow and white perch, bluegill, pike and other common species. The Division of Fisheries and Wildlife has also routinely stocked the lake with walleye, along with extensive stocking of brown trout in Saratoga Lake's largest tributary, Kayaderosseras Creek. (Hardt, et al., 1983, http://www.dec.state.ny.us)

2.7 AQUATIC VEGETATION – 2004 SURVEY

As mentioned earlier, the dramatic shift in the aquatic vegetation community over the past few decades has been the impetus for most of the work done on the lake since the 1980's. Since that time, extensive vegetation surveys have been conducted on Saratoga Lake to inventory and map, not only Eurasian watermilfoil and curlyleaf pondweed, but also the other native and nonnative plants in the lake basin. The most recent and comprehensive study regarding aquatic vegetation, Saratoga Lake Aquatic Plant Survey – 2004 was completed in December 2004 by the Darrin Fresh Water Institute (Appendix B).

The survey upon which this report was based took place during the months of August and September and included two survey techniques, a point intercept survey, and a line intercept survey. For the point intercept potion of the survey, 325 different points were surveyed visually and with collection sampling with the use of a throw-rake. The line intercept potion of the survey was a more comprehensive underwater survey conducted by SCUBA divers. This portion of the survey included the inspection of eight transects. "Each transect was 100 meters long, divided into 1-meter segments, and extended from the shore to the maximum depth of the littoral zone (approx. 6 meters in depth in Saratoga Lake) (Eichler et al., 2004). " At each on meter interval a $0.1m^2$ quadrant was placed and percent cover of species within that quadrant was recorded. (Eichler et al., 2004) Darrin Freshwater Institute (DFWI) performed a similar line-intercept survey in 1994. Replicating the line-intercept survey methods provided a valuable look at how the plant community changed over the past decade.

Though the course DFWI's 2004 survey twenty-eight aquatic species were identified: 21 submersed species; 3 floating-leafed species, 1 floating species; 3 emergent species. Eurasian watermilfoil was the most abundant and widely distributed plant, encountered at 69% of the line intercepts and 54% of the point intercepts (Eichler et al., p. 8) Although results varied between the two survey methods, their survey confirmed the dominance of Eurasian watermilfoil, but showed substantial populations of native plants. In all, native species were encountered at nearly 70% of all the points surveyed, while the three exotic species, Eurasian watermilfoil, curly-leaf pondweed, and European Water Chestnut (*Trapa natans L.*), were encountered at approximately 55% of the points sampled during the line intercept survey. Eurasian watermilfoil was most frequently encountered using the point-intercept method. Of the native species encountered coontail (*Ceratophyllum demersum*), (*Zosterella dubia*), water celery (*Vallisneria americana*) and southern naiad (*Najas guadalupensis*) were the most common.

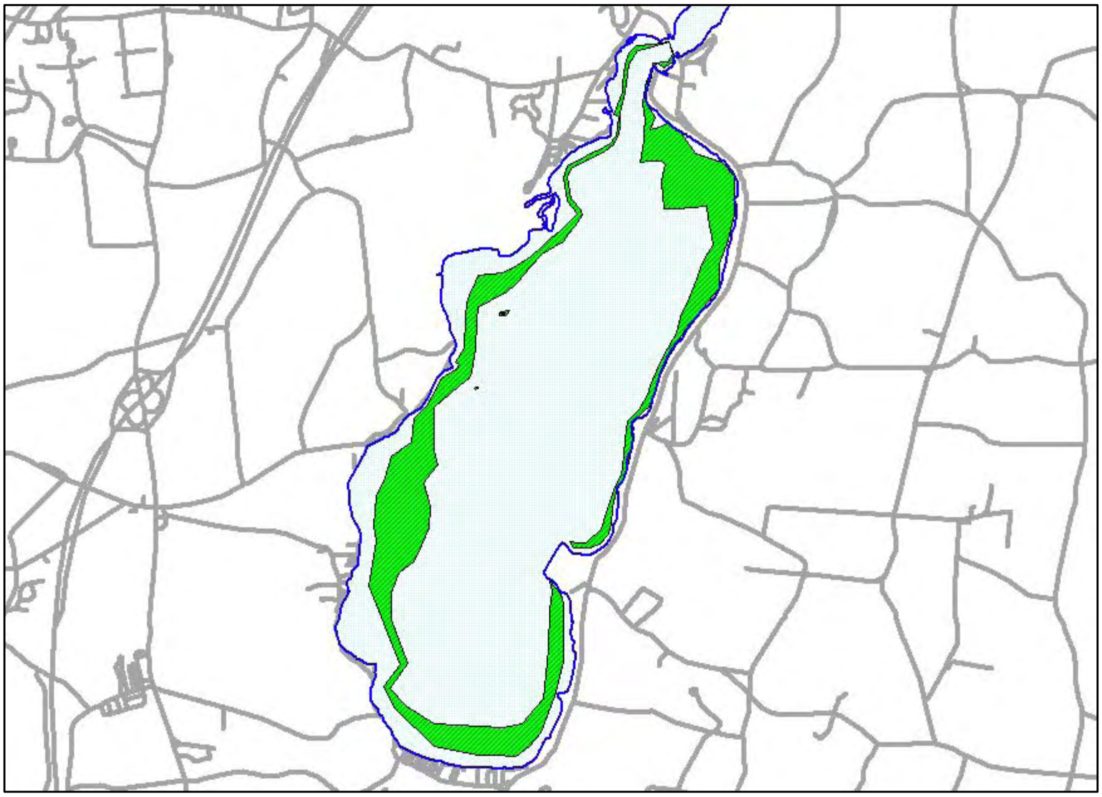
Significant fluctuations in the amount of dense Eurasian watermilfoil growth were noted between the Hardt et al survey in 1992 and 1994 and 2004 surveys completed by DFWI.

Table 2 – Reported Milfoil Cover

Survey Year	Acres of Dense Eurasian Watermilfoil Growth
1982	870 acres
1994	445 acres
2004	736 acres

Reasons for the dramatic reduction in milfoil cover seen between 1982 and 1994 are unclear and are discussed further in the DFWI Report (Appendix B). One possibility suggested by DFWI (page18, Appendix B) is that the annual winter drawdown program that was instituted in 1984 caused a reduction in milfoil growth in the shallow portions of the littoral zone. It is also possible that improvements in water clarity and the canopy growth pattern of milfoil facilitated dense growth in deeper portions of the lake. Seasonal variations in milfoil growth and occasional milfoil "crashes" have also been documented in other Northeast lakes, including Chautauqua Lake (Reinhardt pers. comm.).

Figure 2 – 2004 Milfoil Beds Reported by DFWI



The coverage and distribution of dense Eurasian watermilfoil beds reported by DFWI in 2004 have been fairly consistent since 2000, when Aquatic Control Technology, Inc. performed the first Sonar herbicide demonstration treatment on the lake. Early season growth of curlyleaf pondweed (*Potamogeton crispus*) has also been observed between 2000 and 2004, even though this species was not significant during DFWI's 2004 survey due to its early season growth patterns. Curlyleaf pondweed appears to grow in most areas where dense milfoil growth is found. Plant density varies, but overall curlyleaf pondweed is much lower than milfoil. Early season plant surveys performed in late April 2000 before the first Sonar herbicide demonstration treatment documented that curlyleaf pondweed was more prevalent than Eurasian watermilfoil in the South Plot, while the reverse was true in the North Plot. Findings of the pre-treatment survey in the North Plot in early May 2003 were similar with Eurasian watermilfoil more abundant than curlyleaf pondweed. Eurasian watermilfoil appears to grow aggressively during the month of May and it quickly overtakes the curlyleaf pondweed growth. By late May or early June, Eurasian watermilfoil has reached the surface in 10-12 feet of water.

For a more in-depth discussion regarding the aquatic vegetation in Saratoga Lake please refer to:

Eichler, Lawrence, and Charles Boyen. Saratoga Lake Aquatic Plant Survey – 2004. New York: Darrin Fresh water Institute, 2004. (Appendix B)

"New York State Department of Environmental Conservation". Fish Stocking in New York March 3, 2005. <http://www.dec.state.ny.us/website/dfwmr/fish/foe4clst.html>

3. BATHYMETRIC SURVEY UPDATE

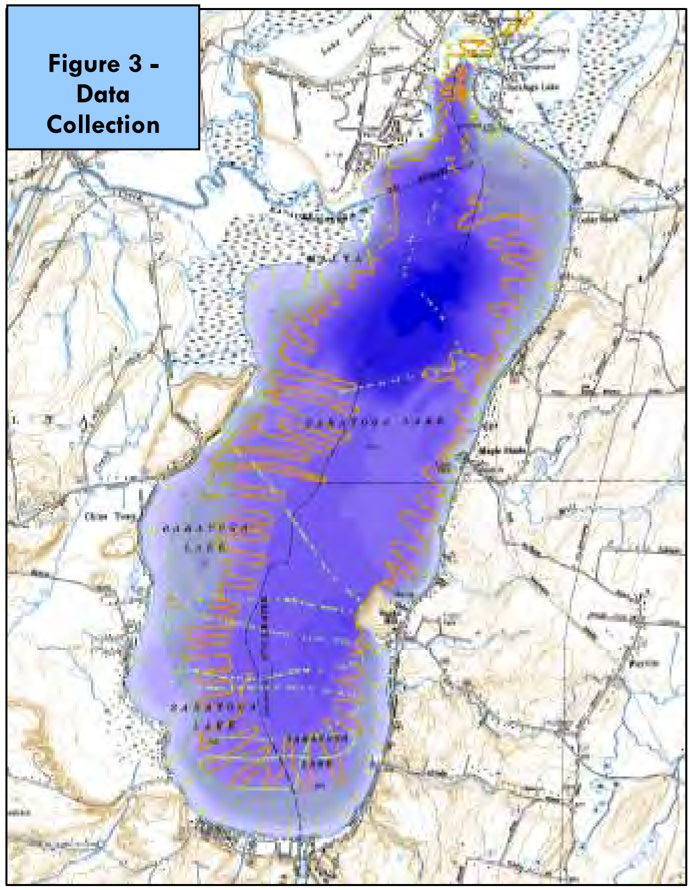


Figure 3 - Data Collection

Bathymetric mapping was completed in 1981 as part of the 1983 D/F Study. C.T. Male Associates, P.C. used an automated system that recorded positional data from two shore mounted transponders and collected water depth measurements with a digital echosounder. Depth accuracy was estimated to be within 0.15 meters. Data collection was complicated in areas of the littoral zone (less than 4.5 meters) where dense plant growth prohibited boat travel Manual
measurements were used to supplement these portions of the lake. (Hardt et. al. 1983)

Accurate bathymetric contours are needed to determine volumetric calculations for whole-lake or large area herbicide treatments. Due to the potential for changes in the bathymetric contours over the past 20 years, it was necessary to verify and update the 1981 bathymetric map. This involved evaluating existing data sets and collecting new field data.

Three different data sets were utilized to compare to the 1981 map and produce updated contour lines. C.T. Male has resurveyed water depth along the shoreline of Saratoga Lake in 2002 for the Saratoga Lake Association. This data set was geospatially referenced with sub-meter positional accuracy and it provided numerous readings extending from shore to a maximum water depth of approximately 6 feet. DFWI utilized a differential GPS system (Garmin GPSmap 168) during their point intercept vegetation survey in 2004. Water depths were recorded at each location. Sonar readings were recorded in deeper sections of the lake, while a weighted fiberglass tape measure was used to obtain water depths in areas with high plant biomass.

Aquatic Control conducted field surveys on October 21, 2004 and November 18, 2004 to collect additional water depth measurements. Animas Geographic Technology, Inc. provided technical assistance and systems support to Aquatic Control. AGT developed a real-time data collection application that combined differential GPS input from a Trimble Pro XRS receiver with SONAR data to create a new three dimensional spatial data representation of the lake bed. The application runs on a Pocket PC running Microsoft Windows Mobile 2003 and ESRI's ArcPad to display the relevant GIS data layers as well as the real-time GPS / bathymetry data that is being collected.

Figure 4- New Bathymetry

This system allowed for the rapid collection of thousands of water depth measurements. Collection efforts were focused on portions of the lake that would potentially fall within the epilimnion after the lake thermally stratifies during the summer months. Like the previous automated depth collection systems used on Saratoga Lake, this system was obscured by high plant biomass. Manual measurements were made using a weighted fiberglass tape within the dense milfoil beds to supplement the automated data collection.

AGT then utilized GIS based software to process the three data sets and develop new bathymetric contours for Saratoga Lake. The results suggest that the bathymetric contours have remained relatively unchanged over the past 20 years. The only notable differences were in the shallow portions of the lake. These areas are probably subject to the greatest sediment deposition from runoff and plant decomposition.

The total lake volume calculated from the updated bathymetric contours was very close to what was reported in the 1983 D/F Study.

Table 3 – Lake Volume

1981 volume	105,400 acre-feet
2004 volume	104,500 acre-feet

The difference between the two volume calculations is less than one percent and is probably within the margin of error considering the different survey techniques that were used. There are subtle changes between the contour lines and these changes will be reflected in the new volumetric calculations that AGT prepared by depth interval. This data will be critical when calculating treatment volumes for various portions of the lake.

Table 4 – Lake Volume Calculations

Depth	Depth midpoint	Area	Acres	Cum Area	Cum Acres	Acre Feet
0	1.5	867199.588335	214.288834	15546236.644929	3841.543478	321.4333
3	4.5	1084655.843936	268.023232	14679037.056593	3627.254644	1206.105
6	7.5	2504513.268657	618.876249	13594381.212658	3359.231413	4641.572
9	10.5	767986.161024	189.772760	11089867.944001	2740.355164	1992.614
12	13.5	666996.462310	164.817761	10321881.782977	2550.582405	2225.04
15	16.5	828498.624014	204.725655	9654885.320667	2385.764644	3377.973
18	19.5	1217534.490533	300.858130	8826386.696653	2181.038989	5866.734
21	22.5	830317.765545	205.175173	7608852.206120	1880.180859	4616.441
24	25.5	633199.534189	156.466391	6778534.440575	1675.005686	3989.893
27	28.5	708257.245297	175.013482	6145334.906386	1518.539295	4987.884
30	31.5	1164345.335942	287.714856	5437077.661089	1343.525813	9063.018
33	34.5	760361.173364	187.888592	4272732.325146	1055.810958	6482.156
36	38	396937.741419	98.085062	3512371.151782	867.922366	3727.232
40	41.5	88455.243487	21.857680	3115433.410363	769.837304	907.0937
43	48	656165.842186	162.141467	3026978.166876	747.979624	7782.79
53	58	605406.954855	149.598722	2370812.324690	585.838157	8676.726
63	68	550468.518800	136.023193	1765405.369835	436.239435	9249.577
73	78	479746.139198	118.547382	1214936.851036	300.216242	9246.696
83	88	615031.763177	151.977055	735190.711838	181.668860	13373.98
93	93	120158.948661	29.691805	120158.948661	29.691805	2761.338
					Total Acre Feet	**104496.3**

4. EVALUATION OF MANAGEMENT OPTIONS

The following section aims to outline and discuss a variety of available aquatic plant management options. Each management tool is discussed in reference to the situation facing Saratoga Lake, spelling out both advantages and disadvantages of the particular technique. The first part of this section reviews non-chemical aquatic vegetation management techniques. This discussion is followed by an in-depth look at mechanical harvesting and chemical treatment options. Together these three sections provide a comprehensive outline of the aquatic vegetation management tools available for use in the state of New York.

4.1 NON-CHEMICAL OPTIONS

4.1.1 Manual Removal and Benthic Barriers

Hand-pulling, suction harvesting (or hand pulling with suction removal) and benthic barrier installations are the principal manual plant control strategies used for submersed aquatic plant growth. These three approaches are generally used to control small localized patches of dense plant growth, however had-pulling and suction harvesting can be useful in controlling widely scattered aquatic growth. The limitations of these control measures often restricts their application to newly discovered, pioneer infestations or as follow-up to a larger scale management strategy such as chemical treatment or drawdown. It is usually ineffective and often counter-productive to apply these strategies to large-scale control efforts.

Table 5 - Comparison of Hand-Pulling, Suction Harvesting and Benthic Barriers

Approach	Typical Application	Advantages	Limitations	Approximate Unit Cost
Hand-Pulling	Widely scattered plants <500 stems per acre	Highly selective Can utilize trained volunteers in some cases	Impractical for large areas with milfoil coverage greater than ~1-5%. Reduced visibility from poor water clarity or suspended sediments from a mucky bottom	<$500 acre
Suction Harvesting	Small scattered to moderate infestations (< 1 acre in size)	More efficient than hand pulling for higher plant densities	Equipment difficult to relocate Additional staff required Increased turbidity Very high cost	$5000 - $14,500 acre
Benthic Barriers	Small dense patches (< 0.25 acres)	Quick control for small areas Prevents reinfestation Barriers can be reused	Non-selective, kills all plants and may impact macroinvertebrates and other non-target organisms Barriers require routine maintenance Very high cost per acre	>$25,000 - $50,000 /acre

Presently, all of the nuisance milfoil growth is beyond levels where these strategies can be effectively used at Saratoga Lake. Review of these techniques is provided in the event that these strategies are utilized as part of an integrated management program at some point in the future, or if they are considered for small scale control around individual shorefronts.

I. Hand-Pulling

Hand-pulling of submersed plants like milfoil involves dislodging plants from the bottom sediments and placing the entire plant in mesh collection bags. A person in a support boat is usually needed to empty the mesh collection bags and to collect plant fragments missed by the hand-pullers. The actual hand-pulling work can be accomplished by an individual equipped with a mask and snorkel in shallow water areas, but often SCUBA divers are required if water depths exceed 4 feet. Other factors that may complicate a hand-pulling effort include limited water clarity, highly flocculent or muddy or contaminated sediments that are easily suspended and reduce clarity, firm bottom substrate that prevents complete root removal, and dense cover of native species.

A large-scale hand-pulling project has been underway for several years at Upper Saranac Lake in Franklin County, New York with relative success. Eurasian watermilfoil was found in the lake in 1996. A program to control Eurasian watermilfoil was initiated in 1998 using benthic barriers and hand-pulling. Efforts were unable to prevent the reestablishment and further spread of the plant. In 2004, an extensive three-year hand-pulling initiative was launched to reduce Eurasian watermilfoil cover to manageable levels. Reportedly $250,000 was expended in 2004, involving over 30 full-time divers and support staff. Similar hand-pulling efforts are planned for the over the next two years. (Martin 2005)

Another large-scale Eurasian watermilfoil hand-pulling effort has been underway at Lake George for several years. The program has been targeting the removal of numerous small infestations around the lake. Benthic barriers and suction harvesting are also being used. The total number of plants removed during the 2002, 2003 and 2004 seasons are 11,605, 16,239 and 9,387 respectively (Lyman and Eichler 2005). This milfoil density is much lower than what is found at Saratoga Lake. During the 2000-2001 Weevil Stocking Study, Adirondack Ecologists reported milfoil stem densities of 17 stems per 0.1 m^2 and 24 stems per m^2. These translate to well over 500,000 milfoil stems per acre. There were 736 acres of dense milfoil beds on Saratoga Lake in 2004.

At Saratoga Lake, hand-pulling is not a useful option for milfoil control since much of the present milfoil growth is both dense and expansive. However, were successful control of milfoil gained, hand-pulling may prove to be a useful tool in the future for the removal of recolonizing low density milfoil growth (less than one percent) or less than 500 plants per acre (Wagner 2003). It may also be applicable for moderate density (less than 10 percent cover) in some of the smaller, localized patches. Cost will likely vary depending on milfoil density, area of infestation and staff being utilized.

Hand-pulling continues to be an effective strategy for controlling water chestnut (*Trapa natans*) at Saratoga Lake. The Saratoga Lake Association (SLA) initiated a successful program to control small localized infestations of this non-native plant that were established in backwater coves in the "Ditch" area and around the mouth of the Kayderosseras Creek inlet. Several consecutive years of hand-pulling by volunteers prevented additional spread of this highly invasive plant and controlled the existing infestation. Monitoring and hand-pulling will be continued by SLA and SLPID to prevent this plant from becoming reestablished. Hand-pulling could also be an effective means of rapidly removing a new localized infestation of another non-native species like hydrilla (*Hydrilla verticillata*), which has been found in Connecticut, Massachusetts and Maine waterbodies within the past five years.

II. Suction Harvesters

Suction harvesters typically involve the use of a pump on a boat or barge and with two SCUBA divers to operate a pair of suction lines. Plants are dislodged from the sediment by hand, fed into the suction line and discharged into a mesh collection basket on the boat or barge. Suction harvesting essentially makes hand-harvesting more efficient. It is best suited for controlling just small areas with sparse to moderate growth that would require a considerable hand-pulling effort. Due to the potential turbidity generated with this technique, floating fragment barriers are sometimes used to isolate the area where the barge and divers are working to capture fragments. This limits the mobility of the unit, making it less efficient and substantially more costly to cover large areas with widely scattered plant growth. Typical suction harvesting operations require a crew of 3-4 personnel with per acre costs between $4000-$10,000.

Aside from high unit costs and the amount of labor required, suction harvesting can present some non-target impacts. It is somewhat less selective than hand-pulling, especially after the turbidity increases as the operation gets underway. Other plants besides milfoil will inadvertently be harvested. Macroinvertebrates either attached to plants or dislodged from the sediment during uprooting will be removed. The turbidity and suspended sediments produced using this approach is also more significant than hand-pulling (VT DEC 2004). Benthic organisms may be also smothered when the sediment settles-out. There is also a potential health and safety concern should contaminated sediments be re-suspended in the water column. For these reasons, it is impractical for suction harvesting to be considered a suitable strategy for large-scale milfoil control efforts at Saratoga Lake. Use of this technique will likely be limited to control of moderate to dense infestations in small areas after substantial control of the milfoil has been attained.

III. Benthic/Bottom Barriers

Several materials have been commercially manufactured to serve as benthic or bottom barriers in lakes. Typically, barriers are weighted to the lake bottom and kill plants through compression and blockage of sunlight. They are most effective for use in small areas around docks and swim areas. Large installations can become cost-prohibitive, with material costs exceeding $20,000 per acre, and may interfere with the utilization of bottom sediments by aquatic organisms. They are also non-selective, killing all plants that are covered and affecting macroinvertebrates as well. Plants are usually effectively controlled within 1-2 months of installation, so they could be moved to control plants in multiple locations within the same year. However, the labor required for installation and removal makes annual retrieval and redeployment impractical. Barriers must be routinely checked to insure that excess billowing/uplifting does not occur that could endanger swimmers or entangle boat props. Other routine maintenance typically involves removal, cleaning and redeployment to discourage plant growth on the barrier. Maintenance efforts and cost can be substantial, especially for larger installations. Observations at Saratoga Lake also indicate that fisherman can hook the net and damage it.

Benthic barriers can be cost limiting on any area of scale, and should not be considered for use on large areas of growth like those in Saratoga Lake. Generally, benthic barriers are only recommended for areas less than one-quarter acre in size. Bottom barrier installations will likely be limited to infestations of dense growth around private docks and swimming areas or in high use areas of the lake.

4.1.2 Biological Controls

The introduction of herbivorous insects and fish is often considered to be a natural and potentially long-term management strategy to control excessive aquatic vegetation. Sterile or triploid grass carp (*Ctenopharyngidon idella*) that consume aquatic plants are regularly used as a management strategy in southern tier states, and are used in a New York and Connecticut waterbodies by special permit. They have been stocked in Lake Mahopac in Carmel, NY and some other fairly large lakes, but nothing approaching the size of Saratoga Lake. They reportedly do not show a feeding preference for milfoil and are therefore not recommended for use in a productive lake with a diverse native plant community like Saratoga Lake. Non-selective vegetation removal on a large scale would have serious impacts on fish habitat and the overall lake ecology.

I. Milfoil Weevil

Most of the work with herbaceous aquatic insects in the region has focused on the control of Eurasian watermilfoil. A native aquatic weevil (*Euhrychiopsis lecontei*) that developed a preference for Eurasian watermilfoil over its native host species (*Myriophyllum sibiricum*) was first identified in Vermont after natural milfoil declines were observed in several lakes. The weevil generated a considerable amount of interest and study over the past decade. It is now being commercially reared and stocked as a milfoil control strategy. The weevil does not eradicate milfoil, but instead destroys apical meristems or growth points on the plant and reduces the buoyancy of the stems, causing the plants to collapse towards the bottom. A number of milfoil infested lakes in the northeast have attempted weevil stocking programs. Some significant milfoil reductions have been reported, but there have been oscillations between the milfoil and weevil densities, resulting in unpredictable levels of milfoil control. Limitations include availability of shoreline cover for overwintering weevils and fish predation.

Adirondack Ecologists conducted a two-year experimental weevil stocking program at Saratoga Lake between 2000 and 2001. Experimental stocking sites located on the north side of Snake Hill were selected due to the high milfoil stem densities and since this location was far removed from the demonstration Sonar herbicide treatment plots along the northeast and south shorelines. While it was determined that the weevils successfully overwintered and reproduced and that there was an indigenous weevil population in the lake, impacts on the milfoil plants were not significant enough to qualify the stocking program as being successful. In reality, it would likely take many more years for weevil population to become sizeable enough for milfoil control to be noticeable at Saratoga Lake considering the extent of the milfoil infestation. However, the success of the weevils would likely be challenged by on-going mechanical harvesting operations and potentially fish predation. Reports on other large scale weevil stocking programs in the Northeast suggest that they have provided marginal relief at best.

Weevil stocking remains unproven as a dependable milfoil management strategy. It is probably unreasonable to expect lake users to wait for several years, without using other strategies to control nuisance milfoil, to see if a weevil stocking program would be effective. At this time, weevil introduction is not viewed as an effective lake-wide milfoil control technique for Saratoga Lake.

4.1.3 Drawndown

Lowering water levels during the winter months to expose aquatic plants to freezing and desiccation (drying) is a commonly used management approach in northern climates, and is currently used at Saratoga Lake. Although drawdown can be relatively effective it is limited by the constraints of the lake and its control structure. Currently, drawdown in Saratoga Lake only lowers the winter water level by approximately two feet. The drawdown does expose parts the littoral zone with depths of less than two feet and causes ice scour and sediment disruption to about 3-4 feet. In 2004, DFWI reported a considerable reduction of milfoil growth in shallow portions of the littoral zone (<1.5 meters), which may very well be attributable to the winter drawdown program. Further lowering of the lake level is constrained by the dam and outlet structure. Given the potential for impacts to lake fauna and flora, adjacent wetlands, shallow wells and downstream impacts from increased flow rates, it is unlikely that deeper drawdowns would be permitted even if they were hydraulically feasible.

4.1.4 Mechanical Removal

Several different approaches have been used to mechanically remove aquatic vegetation. The most commonly employed strategies in the northeast include dredging, harvesting and hydro-raking. Other mechanical techniques like rotovating/rototilling have been used on a limited basis elsewhere across the country with anecdotal if any demonstrated project experience in the northeast.

Mechanical control of Eurasian watermilfoil is generally not recommended in large waterbodies like Saratoga Lake because of the potential for plant segmentation and further spread of milfoil. However, since harvesting has been in practice for milfoil control in Saratoga Lake for many years the potential for further spread through increased fragmentation is negligible. Brief reviews of the potential applicability of hydro-raking and dredging are provided, followed by a comprehensive discussion of the harvesting program at Saratoga Lake.

4.1.5 Hydro-Raking

Mechanical hydro-raking involves the removal of aquatic plants and their attached root structures. Hydro-rakes are best described as floating backhoes. The barge is powered by paddle wheels similar to a harvester, and it is equipped with a hydraulic arm that is fitted with a York Rake attachment. The rake tines dig through the bottom sediments, dislodging the plants in water depths up to approximately 12 ft. Many hydro-rakes do not have on-board storage, so each rake full needs to be deposited directly on-shore or else onto a separate transport barge. Plants with large, well-defined root structures like waterlilies and emergent species are most efficiently removed through hydro-raking. In some cases, control of these and similar species can be attained for 2-3 years or longer.

Hydro-raking is also sometimes favored for annual weed maintenance of public and private beach and swim areas, because removing the plant root structures often provides summer long control of submersed species. It is not well suited for large-scale submersed plant control. Plant removal efficiency is considerably lower than with harvesting, requiring 10 or more operating hours to clear a one-acre area compared to the 3-4 hours typically needed for a harvester. Raking the bottom sediments may also affect plant recolonization and favor species that thrive in disturbed sediments like milfoil. An Article 15 Protection of Waters Permit is also required from DEC for hydro-raking projects in New York State waterbodies.

Use of a hydro-rake has been considered at Saratoga Lake to help remove the windblown mats of plant fragments that collect along shore. A hydro-rake could be used to pull this material back from shore out to open water areas where it could then be collected by a harvester for disposal. This may be worth investigating further if floating plant fragments continue to be problematic.

4.1.6 Dredging

Dredging involves the removal of bottom sediment to add water depth. It controls aquatic vegetation through physical removal of the plant and root structures and nutrient-rich sediments, and by leaving nutrient-poor sediments less suitable for plant growth. There can also be the added benefit of increasing water depth below the photic zone or the depth that light can penetrate to support plant growth. This can be accomplished by various means. Dry-dredging involves draining the lake and using conventional excavation equipment. Wet-dredging, performed without lowering the water levels, uses drag-line equipment from shore or excavation equipment on floating barges. Hydraulic or suction dredging involves the use of a floating barge equipped with an auger cutting head that pumps a water and sediment slurry to nearby containment basins for dewatering. Dredging projects carry a high cost relative to other management techniques, and seldom is a cost-effective means of controlling rooted aquatic plants. Detailed planning and complicated, local, state and federal permits will also be required for most dredging projects. The permitting, data collection and planning process prior to implementation can take several months or longer.

Dredging is not a suitable strategy for wide scale aquatic vegetation control at Saratoga Lake. Operationally, the lake is too large, without ample access sites to stage a major dredging operation. Deepening the shoreline littoral zone beyond the photic zone is also impractical. Milfoil was regularly found growing to 8-12 feet. Achieving sufficient depth to discourage milfoil growth would leave steeply sloped shorelines that would be subject to erosion, create difficult access for recreation and would drastically alter the existing fish spawning and wildlife habitat. Dredging areas to depths less than 10-12 feet would leave them subject for rapid recolonization by milfoil and other opportunistic exotic plants. Milfoil is often one of the first plants to become reestablished in disturbed sediments. Dredging would be further complicated in many sections of Saratoga Lake by the shale and gravel bottom sediments.

Some consideration might be given to dredging select areas in Saratoga Lake to remove excessive sediment deposition. If this were the case, it would be worth exploring whether the project could be designed accordingly to provide rooted plant control post-dredging. Hydraulic dredging would be the most suitable approach in Saratoga Lake. This usually requires the creation of a dewatering pond where the slurry is pumped, allowed to settle out and then the water is returned to the lake. This requires identifying suitable land relatively close to the lake to create a large containment basin. Several acres would likely be required for any sizeable dredging operation. A new technique for mechanical dewatering of the hydraulic dredge slurry involves the use of belt filter presses. Special polymer coagulants are used to consolidate the dredge slurry and the water is then pressed out. The resulting material can be transported immediately by dump truck. This technique was recently used at Hardy Pond in Waltham, MA. This may be a preferable approach at Saratoga Lake as it would require a considerably smaller staging area for the shore-based disposal operations. Potential dredge contractors would need to be contacted to determine staging area requirements, but an area as small as one-half acre may be sufficient. Cost estimates for a hydraulic dredging operation utilizing mechanical dewatering will probably vary considerably and may be dictated by equipment availability. As is the case with any dredging operation, the larger the project the lower the unit cost for removal. Typical removal costs run between $5 and $15 per cubic yard. Deepening a one acre area by one foot produces over 1600 cubic yards of sediment. The mobilization cost is also expected to be high, possibly in the $30,000-$50,000 range. Potential dredge areas would need to be identified before more specific cost estimates can be calculated.

4.2 MECHANICAL HARVESTING

Harvesting was recommended as a short term management strategy for EWM control in the 1983 D/F Study and has been the primary weed control strategy employed since the mid 1980s. Estimates of harvesting efficiency presented in the 1983 D/F Study were based on a realistic harvesting operation that consisted of two harvesters operating for 90 days per year. It was projected that a harvesting effort of this magnitude could remove a maximum of approximately 250 acres (100 hectares) of dense vegetation growth per year. It was not expected that this would adversely impact the fish population because it would only be removing one-quarter to one-third of the dense vegetation growth documented in the lake utilized for spawning. The resulting removal rate was only projected to be 2-5% of the lake-wide juvenile fish population. Still operational safeguards to limit impacts to fish were recommended, such as harvesting in shallower areas early in the season and moving to deeper areas as the season progressed. Calculations showed that two harvesters operating for 90 days per year would not achieve significant phosphorus removal, but it was suggested that harvest efforts focus on the northeast and southern shoreline areas to target areas with the highest plant densities and potential for the greatest phosphorus removal. (Hardt et.al. 1983)

A sizeable harvesting operation has been performed on the since the mid-1980s. It is primarily a maintenance strategy to provide access to the open-water portions of the lake and it has not led to significant reductions in milfoil cover or biomass (LA Group, 2002). One advantage of harvesting is that is has been able target removal of all types of submersed vegetation where a cleared path through the weed beds is desired for boating or swimming uses. It has also been theorized that harvesting has prevented canopy formation by Eurasian watermilfoil and curlyleaf pondweed, which has sustained light penetration to the lake bottom and the resultant survival of understory native species (Eichler, et al., 2004).

The principal limitation of the current harvesting program is that it can only remove an estimated one-quarter to one-third of the nuisance weed growth. Continual harvesting of Eurasian watermilfoil often stimulates plant branching resulting in higher density milfoil growth. Escaping plant fragments continue to be problematic at Saratoga Lake. Floating plants accumulate along the shore, sometimes creating a dense mat of plant material that extends out 30-50 feet from shore and is 1-2 feet thick. While a percentage of these plant fragments are probably attributable to motor boat activity and fragmentation by wind and wave action, the harvesting operation is undoubtedly responsible for some.

4.2.1 Description of Current Harvesting Operations

Actual harvesting efforts at Saratoga Lake since the mid 1980s have largely followed the recommendations of the 1983 D/F Study. Most years there have been two harvesters operating on the lake for a 16-20 week period during the summer months. The harvesters are launched in early May and undergo a couple of weeks of annual maintenance work. The harvesting effort typically begins in earnest in mid-late May and continues until mid October. Current harvesting equipment owned by SLPID includes:

- 2004 Alpha Boat Harvester – 11.8 foot wide cut and 1,000 cu. ft. storage
- 1996 UMI Harvester – 7 foot wide cut and 460 cu. ft. storage
- 1984 UMI Harvester (to be stripped and scrapped in 2005)
- Shore Conveyor
- 2004 F350 Pickup Truck – with grain dump
- 1991 F350 Pickup Truck – stakebody (only used to haul harvesters)
- 1995 Tool Truck

For a portion of the 2004 season, all three harvesters were operating and both pickup trucks were being used for hauling. Due to breakdowns experienced with the older equipment, there are plans to strip and scrap the 1984 harvester in 2005 and the 1991 pickup truck will be reserved to haul the harvesting equipment.

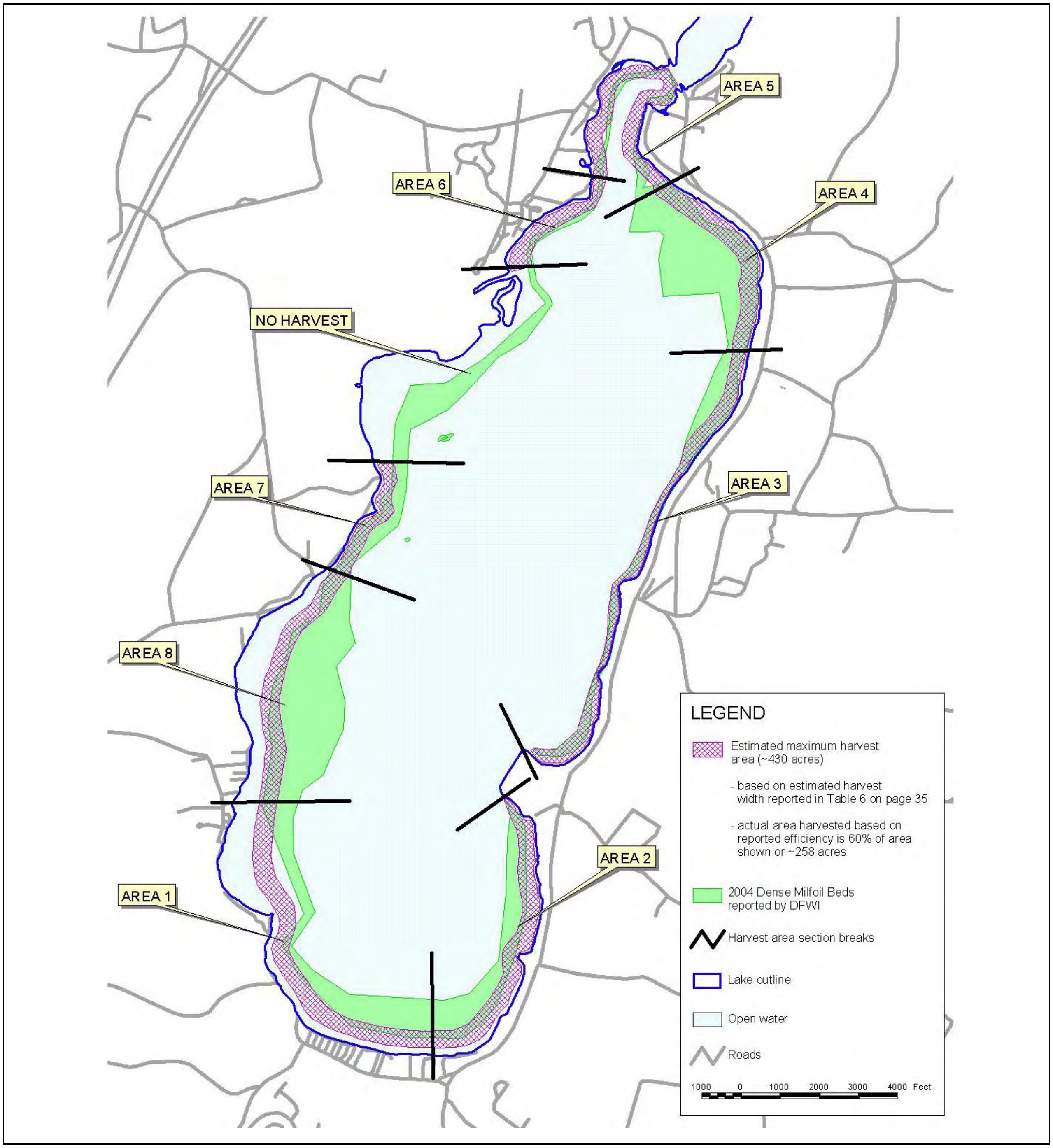
During the winter months, one harvester is stored at the South Shore Marina and the remainder of the equipment is stored at the Malta Town Garage.

The operating staff usually consists of three people, two harvester operators and one person that both drives the pickup truck and operates the shore conveyor. Operations usually run weekdays between 7:00 a.m. and 3:00 p.m. plus an additional 30-45 minutes for daily maintenance. During periods of peak lake usage and particularly problematic weed growth the daily operation is extended to a 10 hour workday and some Saturday operations occur.

The harvesters start near Stony Point in the southeast corner of the lake and work around the lake in a clockwise direction. It reportedly takes approximately six weeks for the harvesting operations to travel around the entire lake. This varies depending on plant density, equipment breakdowns, weather and other complicating factors. The harvesting operation typically travels around the lake at least two times and occasionally three times per summer. Harvesting operations reportedly concentrate on the weed growth found within a couple hundred yards of shore. In areas where dense milfoil beds extend out more than 1500 feet from shore, boating lanes are cut to provide access to open-water. Where weed growth only extends out a couple hundred yards from shore, the operators attempt to clear-cut the area.

There are currently five shoreline off-loading points around the lake being utilized. Three are found along the southwest shoreline, one is at Fitch Road in the northeast corner, and one is just south of Snake Hill in the southeast shoreline. The shore conveyor is moved to the different shoreline off-loading points as the harvesters' progress around the lake. It reportedly takes 4-5 hours to move the shore conveyor to a different shoreline off-loading site. The harvested weeds are hauled to several different dump sites for use as compost. The greatest over the road travel distance to dump sites are 7 and 14 miles, when the operation is working out of the Fitch Road shoreline off-loading site.

Figure 5 – Harvest Areas



4.2.2 Current Harvesting Efficiency

SLPID annually tracks the efficiency of the harvesting operation by recording the number of truckloads of harvested weeds removed from eight designated harvesting areas on the lake. On average approximately 1000 loads are removed from the lake each year. Each truckload holds one full harvester load from the smaller 460 cu. ft. machine or less than half of a load from the new 1000 cu. ft. machine.

The number of truckloads removed from each area is reported each year. Table 7 provides the number of truckloads removed from each area in 2004 and the average number of truckloads removed over the three-year period between 2002 and 2004. It also shows estimates for the total acreage being harvested in each area based on the reported distance from shore the harvesters are operating. Greater distances were used for Areas 1, 2, 5 and 8 where the largest milfoil beds are found to account for the additional cutting of boating lanes that occurs in these areas.

Using these assumptions, a total area of 430 acres is targeted for harvesting each year. However, this appears to be considerably higher than what is actually harvested. In order for two harvesters to clear 430 acres at Saratoga Lake, using a 90 day (18 week) work period, each machine would need to be harvesting one-acre in approximately 3.4 hours. This is in-line with harvester manufacturer specifications that typically suggest 3-4 operating hours are needed to clear one-acre of moderately dense weed growth. This is an unreasonable assumption at Saratoga Lake, due to the size the lake, the relatively long in-lake travel distances to the shoreline off-loading locations, and the high plant density. SLPID's Harvesting Operators estimate that it takes 5-6 operating hours for one harvester to clear a one-acre area on Saratoga Lake. Using an average of 5.5 hours per acre, the harvesting removal rate would be reduced by approximately 40 percent. This reduced efficiency is projected in the "Adjusted Acreage Harvested" column in Table 7 below.

Table 6 – Estimated Harvest Removal Rate

Harvest Area	Linear Feet (along shoreline)	Harvest Width (estimated feet from shore)	Estimated Harvest Area (acres)	Adjusted Acreage Harvested (acres)	2004 Truckloads Removed	2002-2004 Average Truckloads Removed	2004 loads/ac	2002-2004 loads/ac
1	9800	400	90	54	83	88	1.5	1.6
2	7750	400	71	43	278	200	6.5	4.7
3	12150	200	56	33	197	162	5.9	4.8
4	5250	400	48	29	294	331	10.2	11.4
5	8150	300	56	34	108	108	3.2	3.2
6	3500	300	24	14	101	61	7.0	4.2
7	3200	300	22	13	148	51	11.2	3.9
8	6850	400	63	38	62	56	1.6	1.5
Total	56650	337.5 (avg.)	430	258	1271	1057	4.9	4.1

Totaling the adjusted acreage harvested column yields a lake-wide total harvest of 258 acres per year. Again, this is based on a 90-day operating season and a harvester removal efficiency of 5.5 hours to clear a one-acre area for each machine. These assumptions appear to be more realistic to what is being accomplished at Saratoga Lake. The total acreage harvested of 258 acres is nearly identical to the 100 hectare (247 acres) efficiency estimated in the 1983 D/F Study for a 90 day harvesting effort for two harvesters.

The Adjusted Acreage Harvested numbers can be used to calculate the loads per acre removed for each Harvest Area. Higher load per acre numbers likely represent higher plant density. Area 4, which is the northeast corner, consistently yields more loads per acre than any other portion of the lake. The dense milfoil beds in Area 4 start within 100 feet of shore and extend out 1500 feet or more in some locations. A considerable amount of high density milfoil growth is included in the 30 acres that are estimated to be harvested from this Area each year. Contrast this with Areas 1 and 8 in the southwest corner of the lake, where the dense milfoil beds are located more than 300 feet away from shore. Lower density native plant growth is primarily being harvested from these areas, which lowers the harvesting yield to only 1.5 loads per acre. Lake-wide averages in 2004 and for the three-year period between 2002 and 2004 were 4.9 loads per acre and 4.1 loads per acre, respectively.

Where most of the harvesting is performed within 500 feet of shore, only twenty percent of the dense milfoil beds are being harvested each year. This has been noted by the harvester operators who report that on average a maximum of 50 percent of the total weeds being removed is comprised of milfoil.

4.2.3 Increased Harvesting Efficiency

Harvesting is a relatively slow, equipment intensive management strategy. Potential means of increasing harvesting efficiency at Saratoga Lake that were identified in the 2002 Watershed Management Plan (LA Group 2002) included:

- Increase size of harvester.
- Increase transport speed.
- Increase size of truck
- Increase number of off-loading sites.

SLPID took the first step towards increasing the harvesting efficiency by purchasing a new larger harvester before the start of the 2004 season. The new harvester was manufactured by Alpha-Boats and it cuts an 11.8 foot swath and has a storage capacity of 1,000 cubic feet. It is considerably larger than the other two UMI harvesters owned by SLPID that cut a 7 foot swath and have load capacities of 460 cubic feet. The new harvester was used for the entire 2004 season and reportedly provided increased cutting speed. The increased efficiency was somewhat limited by the fact that it still using the same shore conveyor and truck for the off-loading and disposal operations. The shore conveyor was modified to accommodate the new harvester, but one load of the new harvester fills the truck more than two times. The harvester sits idle for 20 minutes or longer waiting to be off-loaded. Despite the off-loading limitations, the new harvester has improved the efficiency of the operation.

Another important step taken by SLPID to improve harvesting efficiency was establishing a harvesting schedule. Setting a defined schedule of work and keeping the machines working in one direction (typically clockwise around the lake) helps by limiting travel time to and from the multiple shoreline off-loading locations.

Other strategies to increase the harvesting efficiency have not yet been instituted for various reasons. Increased transport speed by utilizing either auxiliary propeller units or a separate high-speed transport barge would get the harvested loads to the shoreline off-loading locations faster, but the operation would still be limited by the fact that there is only one truck being used for disposal. The current system with one shore conveyor and one truck servicing two harvesters is probably already operating near its capacity. Increasing the size of the disposal truck to a 6-wheel dump truck would likely require operators with a commercial drivers' license (CDL). This may increase labor and insurance costs. There is also some concern that larger trucks would have trouble accessing some of the smaller disposal locations (LA Group, 2002). Adding another one-ton pick-up truck with a grain dump would require the capital investment in a new or used truck and will require the addition of another driver, but this may be a more realistic alternative for SLPID. Increasing the number of off-loading sites would certainly help, but it will also likely be limited by the fact that currently there is only one shore conveyor and one truck. If more equipment were being utilized for the harvesting operation, then additional off-loading sites would be crucial to the success of the project.

4.2.4 Potential for Harvesting as Primary Milfoil Management Strategy

The current harvesting operation at Saratoga Lake focuses on clearing the immediate shoreline of the lake and cutting boating lanes or channels through the dense milfoil beds. Based on the descriptions of the current operation, it was calculated that approximately 250 acres of the lake are cleared each year. Most of the harvesting is performed within a couple hundred yards of shore, while most of the dense milfoil beds are not found within 300 feet of shore, especially along the southern and western shorelines. The harvester operators also report that only 50 percent of the harvested weeds are milfoil. Taking all this into consideration, it is probably safe to assume that less than 25 percent of the dense milfoil beds are being harvested each year.

Assuming that 25 percent of the 738 acres of dense milfoil beds were harvested during the 2004 operation, more than 550 acres of dense milfoil growth remained in the lake. At a minimum, six harvesters would need to operate during the season to completely harvest all of the milfoil beds on the lake. There would need to be at least one more shore conveyor and two more trucks to handle the off-loading and disposal requirements of six harvesters.

Table 7 – Estimated Harvesting Costs for larger Harvesting Operation

Cost to purchase new equipment	
4 large harvesters	$500,000
1 shore conveyor	$30,000
2 trucks	$80,000
TOTAL EQUIPMENT COST	$610,000
Divided over 20 year useful life of equipment	$30,500
Current annual operating expenses times 2.5	$225,000
TOTAL ANNUAL COST	$255,500
20 YEAR COST	$5,110,000

The capital expenditures are gross estimates based on 2005 prices of medium to large sized harvesting equipment. The cost breakdown does not factor in interest charges on capital purchases. There should be some cost savings on annual operating expenses in a larger harvesting operation, which is why a 2.5 times multiple of the current annual operating expense budget was used. The total estimated annual budget for a harvesting program that targets a complete milfoil harvest at Saratoga Lake would likely be on the order of $250,000-$300,000.

There are some potential complications of a larger scale harvesting effort. Tripling the harvesting operation may have adverse impacts on the fishery. DEC currently does not regulate harvesting, except in designated Freshwater Wetlands, but this level of harvesting may trigger involvement from DEC due to the potential impacts to fisheries or freshwater wetlands. Arrangements would also need to be made for winter storage of the equipment. Presently, one harvester is kept at the South Shore Marina and the rest of the equipment is hauled to the Malta Town Garage. Storage requirements for six harvesters, two shore conveyors and three or four trucks would be considerable.

4.3 HERBICIDE TREATMENT

The use of chemicals to control nuisance aquatic plant and algae growth is probably the most widely used and recommended management strategy for lakes with submersed aquatic plant infestations that are beyond effective control with non-chemical techniques like hand-pulling, suction harvesting or bottom barriers. Registered herbicides must meet strict federal guidelines and demonstrate that there is not an "unreasonable risk" to humans and the environment when applied in accordance with their product label. According to Madsen (Madsen 2000), "currently no product can be labeled for aquatic use if it poses more than a one in a million chance of causing significant damage to human health, the environment, or wildlife resources. In addition, it may not show evidence of biomagnification, bioavailability or persistence in the environment".

Aquatic herbicides and algaecides are also subject to periodic re-registration with the Environmental Protection Agency (EPA) where the latest technology and scientific studies are used to evaluate the potential impacts of these products. Most of the commonly used products have recently completed EPA's more stringent re-registration process. Aquatic herbicides and algaecides must also be registered for use in New York ponds and lakes by the Department of Environmental Conservation (DEC). New York State strictly regulates pesticide registration. Most aquatic herbicides that are registered for use in New York have Special Local Needs (SLN) Labels that have greater limitations and more temporary water use restrictions than the general EPA label. In addition, chemical treatments in New York must obtain a site-specific Aquatic Pesticide Permit from the Regional DEC Bureau of Pesticide Management Office. Furthermore, most applications must be performed under the direct supervision of an Aquatic Applicator that is Commercially Certified and licensed in New York.

When properly used, aquatic herbicides are capable of providing area and, to some extent, species selective plant control, often with less temporary disturbance than comparative mechanical or other non-chemical techniques. Herbicides are generally described as having either "contact action", meaning that only the actively growing portions of the plants that the chemical comes into contact with are controlled; or "systemic action", where the herbicide is internally translocated throughout the plant effectively killing the stem, foliage and root structures. Systemic herbicides are usually preferred for control of perennial nuisance weeds like Eurasian watermilfoil, since multiple year plant control can be achieved. This reduces the frequency of amount of chemicals that are applied. Systemic herbicides do not have the same benefits for control of curlyleaf pondweed or other annual plants that propagate from seed each year. These types of plants can be just as effectively controlled with contact herbicides. Several consecutive years of treatment with contact herbicides before turions (seed structures) are produced are usually needed to achieve appreciable reductions in the amount of curlyleaf pondweed regrowth.

Species-selective control is also desired when targeting non-native and invasive species like Eurasian watermilfoil. Treatment programs can be tailored to limit impacts to non-target native species through treatment timing, treatment location, use of different herbicide formulations, and manipulation of the herbicide concentration or dose rate. Achieving species-selectivity is often challenging considering the limitations of the available herbicide formulations and the variability of response seen from lake to lake. Water chemistry, lake morphology, bottom sediment type and plant composition all potentially influence herbicidal activity and the results are often not completely predictable.

Summaries of aquatic herbicides that could potentially be used for nuisance plant control at Saratoga Lake are provided below. The mode of action and anticipated efficacy for each herbicide is provided, along with highlights on toxicity and non-target impacts. More detailed summaries of each herbicide are provided in Appendix D. The potential limitations and restrictions of current State Regulations are also discussed for each project.

The principal contact-acting herbicides include diquat (Reward), endothall (Aquathol) and copper (various forms of copper-carbonate and copper-ethylenediamine complexes). These products target and disrupt different pathways, but are similar in that they only control portions of the plant that are directly contacted. Contact-acting herbicides are relatively fast acting, with most plant uptake usually occurring over a 1-3 day period. Susceptible plants generally die-back within 1-2 weeks of exposure. Contact-acting herbicides will usually provide summer long control of target species. Since the root structures are not controlled, regrowth usually occurs the following year. Systemic herbicides include 2,4-D (Aqua-Kleen/Navigate), fluridone (Sonar) and Triclopyr (Renovate). These herbicides are absorbed and translocated within the plant, effectively controlling the entire plant including the roots. Typically multiple years of control is attained with systemic herbicides.

4.3.1 Reward (diquat)

Reward is probably the most commonly used contact herbicide for milfoil control in the Northeast, except in New York State where current state regulations limit its use. It is a rapid acting contact herbicide that disrupts the leaf cuticle of plants and acts by interfering with photosynthesis. Some selectivity for Eurasian watermilfoil control has been seen in large lake systems in the Northeast. The Twin Lakes in Northwest Connecticut have had shoreline treatments with Reward in 2003 and 2004. Seasonal control of Eurasian watermilfoil has been achieved, while most pondweeds (*Potamogeton spp.*) and other native species have largely been preserved.

The concentration of Reward in treated water after application at the maximum allowable 2 gallon/surface acre use rate is approximately 0.37 ppm ion immediately after application. Residual levels of Reward in water decline very rapidly, and their reduction is due to the uptake by the weeds and adsorption to suspended soil particles in the water or to the bottom sediment. Reward is practically immobile in sediment and does not pose a significant risk for contamination of wells or ground water. Photochemical degradation accounts for some loss under conditions of high sunlight and clear water. Usually residues decline to 0.01 ppm or below with 3-14 days after treatment.

Application Rate – Reward is usually applied at 1-2 gallons per acre depending on water depth, plant density, water clarity and treatment area configuration. The maximum application rate in water less than two feet deep is one gallon per acre.

Efficacy on Eurasian Watermilfoil – Eurasian watermilfoil and curlyleaf pondweed are controlled by Reward. Treatment typically occurs when the plants are in their most active phase of growth, but before peak biomass is reached. This usually falls between late May and early July. Plants die-back completely within 2-3 weeks of treatment and are usually controlled for the remainder of the summer season. Regrowth of Eurasian watermilfoil in the year following treatment with Reward can range from no regrowth up to 100 percent regrowth with no discernible pattern among the treated lakes. The amount of regrowth is likely determined by several factors including plant density, bottom sediment type, water clarity, and abundance of non-target plant growth that is not impacted by the treatment. A typical level of Eurasian watermilfoil regrowth seen the year after treatment in the northeast is 75 percent.

Water Use Restrictions – Reward went through the Re-registration Eligibility Determination process with EPA in the mid 1990's. Following that review the temporary water use restrictions were lowered considerably. The current EPA label lists the following restrictions on using treated water:

- Drinking – 3 days
- Livestock Consumption – 1 day
- Irrigation for Turf and Ornamentals – 3 days
- Irrigation for Food Crops – 5 days
- Swimming and Fishing – no restriction

Reward has a more restrictive SLN in New York State. The water use restrictions were written into the State Regulations (Section 327.6) several decades ago and read "treated waters shall not be used for irrigation, bathing, fishing, or by man or animals for drinking or food processing for a period of 14 days after treatment."

Advantages – The principal benefits of Reward are its rapid action, effectiveness for partial lake or shoreline applications, and its low cost as compared to other available aquatic herbicides.

Disadvantages – Its contact action and inability to provide multiple years of nuisance plant control are the primary limitations of Reward. It has reduced efficacy in highly colored or turbid water, but this is rarely encountered on large lake systems in the Northeast. Reward is considered a broad-spectrum herbicide and it will impact some non-target, native plants.

New York Use Considerations – The extended water use restriction period of 14 days for all uses is the major factor limiting the use of Reward in New York. Current regulations also limit the application of Reward to within 200 feet from shore or to a maximum depth of six feet, whichever is furthest from shore. This would greatly limit its use at Saratoga Lake where most of the dense milfoil beds are found in water depths between six feet and 12 feet and extend well beyond 200 feet from shore.

4.3.2 Aquathol (endothall)

Aquathol K is probably more widely used for submersed plant control in New York than in the other Northeastern states. This is largely due to the fact that it does not have the extended water use restriction periods that are seen with Reward. In addition, DEC has not expressed undue concerns over toxicity to juvenile fish with Aquathol K, which has been an issue with Reward. Aquathol K has been used for partial lake treatment work at Chautauqua Lake. The manufacturer reports that recent treatment work performed by the U.S. Corps of Engineers Waterways Experiment Station in the Midwest has shown that early season treatments with Aquathol K can provide effective season-long control of curlyleaf pondweed and Eurasian watermilfoil (Adrian pers. comm.).

Endothall, the active ingredient in Aquathol K, reacts with the cell structure to inhibit protein synthesis. The chemical is absorbed into the plant within 12-24 hours after application. Chemical that is not absorbed by the plants is either broken down very quickly or chemically bound up in the sediment where it undergoes further degradation. Endothall is biodegradable, and It normally disappears from water in 1-10 days after application and from the soil in one to three weeks.

Application Rate – Aquathol is available in two formulations – Aquathol K is a concentrated liquid and Aquathol Super K is a granular formulation. Dose calculations for both formulations are determined on a volumetric basis. Application rates of 2.0-3.0 ppm are recommended for whole lake or large treatment areas, while rates of 3.0-4.0 are recommended for spot or lake margin treatments targeting milfoil.

Efficacy on Eurasian Watermilfoil – Again, both Eurasian watermilfoil and curlyleaf pondweed are controlled by Aquathol K. Treatment typically occurs when the plants are in their most active phase of growth, but before peak biomass is reached. This usually falls between late May and early July. Plants die-back completely within 2-3 weeks of treatment and are usually controlled for the remainder of the summer season. Variable levels of Eurasian watermilfoil regrowth are reported in the year following treatment. Limited reduction in regrowth is anticipated the year after treatment.

Water Use Restrictions – The current EPA label lists the following restrictions on using water treated with Aquathol formulations:

- Fish Consumption – 3 days
- Livestock Watering, Agricultural Food Sprays, Irrigation, or Domestic Purposes – 7-25 days (depending on concentration applied)
- Swimming and Fishing – no restriction

The only additional water use restriction listed on the New York SLN is no swimming until the day after treatment.

Advantages – Its rapid action, effectiveness for partial lake or shoreline applications, and less restrictive label in New York State are its primary attributes.

Disadvantages – Again, being a contact herbicide the potential for multiple years of control is limited. The broad-spectrum activity of Aquathol will also impact some non-target, native plants.

New York Use Considerations – There are no specific State regulations that limit the use of Aquathol products beyond the EPA label directions. For that reason, it is probably the only contact herbicide that can be considered for use at Saratoga Lake.

Current Treatment Potential for Saratoga Lake – Aquathol is the only contact herbicides currently registered in New York that could be effectively used for large scale treatment work on Saratoga Lake. Recommended labeled application rates for large area treatments targeting milfoil control are between 2.0-3.0 ppm. Treatments at these concentrations will likely impact many of the native pondweed (Potamogeton spp.) species, coontail and water stargrass, all of which are found in Saratoga Lake.

Cerexagri, the manufacturer of Aquathol, claims that recent early season treatment work being performed in the Midwest by the U.S. Army Corps of Engineers targeting curlyleaf pondweed control is also showing good efficacy on Eurasian watermilfoil. Treatments are being performed early in the growing season when the water temperatures reach 50° F and the plants are only a few feet tall. Treatment protocol has been to treat the lower four feet of the water column at a dose of 1.5 ppm. Aquathol K liquid is being applied using weighted hoses or Aquathol Super K granular is being used. These lower dose rates have provided effective, season-long control of curlyleaf pondweed and Eurasian watermilfoil. Applying a lower concentration provides significant cost savings over higher dose rates. The early season applications have the added benefit of reducing impact to non-target species that have not entered active growth phases so early in the season. (Adrian pers. comm.)

At this point, it is not known whether or not lower dose, early season Aquathol treatments would be permitted in New York under the current regulations, as this would be below the recommended labeled application rate. The potential for this treatment scenario will need to be explored with DEC.

4.3.3 Copper-Based Herbicides (Komeen/Nautique)

Several copper complexes (various forms of copper-carbonate and copper-ethylenediamine) are marketed as contact herbicides. Used alone, these compounds provide typically seasonal control of vascular plants, at best. When used in combination with other herbicides like Fluridone (Sonar) or Reward, they can sometimes enhance their effectiveness. Copper compounds tank-mixed with other herbicides often improve treatment efficacy where the target plants are heavily coated with filamentous algae. Tank mixes are not permitted in New York under the current regulations. Due to their limited effectiveness, copper-based herbicides are not applicable for the current aquatic vegetation problem at Saratoga Lake. These copper compounds typically have no temporary water use restrictions post-treatment when applied to ponds, lakes and even drinking water reservoirs.

4.3.4 Aqua-Kleen and Navigate (2,4-D granular)

Having been used for well over four decades 2,4-D is the oldest and most extensively researched systemic herbicide in the aquatics industry. Granular formulations of 2,4-D ester (Aqua-Kleen & Navigate) are used almost exclusively in the northeast. The granules sink to the bottom where the active ingredient is released over a period of hours to a few days. Plant uptake occurs at the leaves, shoots and root structures. It mimics plant auxins, promoting cell elongation without new cell production. Essentially plants grow themselves to death. Epinasty or the bending and twisting of leaves and stems are the visible signs associated with 2,4-D exposure. 2,4-D is highly selective since it is most effective on dicot, or broad-leafed, species. Commonly managed aquatic dicots include watermilfoils, water chestnut and occasionally water lilies. Most monocot or narrow-leafed species, are only marginally impacted or tolerant of 2,4-D applications. This allows for larger-scale applications to be performed that are fairly species selective. Selective control of Eurasian watermilfoil (M. spicatum) can be achieved with application rates between 75-100 pounds per surface acre, which is less than half the maximum permissible label rate of 200 pounds per acre. The granular formulation also facilitates fairly successful partial lake or shoreline applications.

Application Rate – 2,4-D is available as a granular ester formulation and as a liquid amine formulation. The granular ester is primarily used in the Northeast. The labeled application rate is 100-200 pounds per surface acre. Eurasian watermilfoil is usually highly susceptible to 2,4-D granular and application rates between 75-100 pounds per acre usually provide sufficient control.

Efficacy on Eurasian Watermilfoil – Eurasian watermilfoil is effectively controlled by 2,4-D. It primarily targets dicot plants, so less effective control of curlyleaf pondweed is anticipated following treatment. Treatment typically occurs when the plants are in their most active phase of growth, but before peak biomass is reached. This usually falls between late May and early July. Plants die-back completely within 2-3 weeks of treatment. The systemic action of 2,4-D usually provides multiple years of effective Eurasian watermilfoil control. Two or three years of nuisance level milfoil control is typical for whole lake or large area treatments.

Water Use Restrictions – The current EPA label lists the following restrictions on using water treated with 2,4-D granular formulations:

- Do not drink treated water until the in-lake concentration drops below 70 ppb
- Do not use treated water for irrigation until the in-lake concentration drops below 100 ppb
- Swimming and Fishing – no restriction

It typically takes 3-4 weeks for 2,4-D concentrations to drop below the reuse thresholds. Additional water use restrictions in New York call for treated water not to be used for any purpose for at least 24 hours after treatment.

Advantages – Selectivity for dicot plants, effectiveness for partial lake or shoreline applications, and systemic action that provides multiple years of effective control make 2,4-D especially effective for Eurasian watermilfoil control.

Disadvantages – Extended water use restrictions limit where 2,4-D can be used. It also carries a negative public perception for use in water, despite being one of the most widely used terrestrial herbicides.

New York Use Considerations – Similar to Reward, 2,4-D cannot be applied beyond 200 feet from shore or in water depths greater than six feet (whichever provides the greater distance from shore). This greatly limits is usefulness at Saratoga Lake. In addition, the water use restrictions may be untenable for lake users.

4.3.5 Sonar (fluridone)

Sonar has often become the herbicide of choice for managing lake-wide infestations Eurasian watermilfoil. It has demonstrated the ability to provide fairly selective control of Eurasian watermilfoil at low doses and its systemic action typically yields multiple years of effective control. Sonar also has a favorable toxicology profile with regulators and the general public. It is even labeled for use directly in potable (drinking) water reservoirs at low doses (<20 ppb) with no restrictions on using the treated lake water for drinking or domestic purposes.

Application Rate – Available Sonar formulations include the liquid Sonar AS (Aqueous Suspension) and two pellets Sonar PR (Precision Release) and Sonar Q (Quick Release). All formulations are labeled for a maximum application rate of 150 ppb. Effective control of Eurasian watermilfoil has been achieved with doses as low as 5 ppb, but doses in the 8-10 ppb are generally preferred for increased duration of control. Pellets are usually applied at higher application rates, due to the time delayed release of fluridone off of the pellets.

Efficacy on Eurasian Watermilfoil – Eurasian watermilfoil and curlyleaf pondweed are highly susceptible to low dose (5-10 ppb) concentrations of Sonar. Provided that adequate contact time can be maintained for 60-90 days, the systemic action of fluridone typically provided multiple year control of Eurasian watermilfoil.

Water Use Restrictions – The current EPA label lists the following restrictions on using water treated with Sonar:

- Do not use treated water for irrigation for 7-30 days following treatment or until the in-lake concentration drops below 10 ppb or 5 ppb for known sensitive species.
- Do not apply Sonar within ¼ mile of an active potable water intake.
- Swimming and Fishing – no restriction

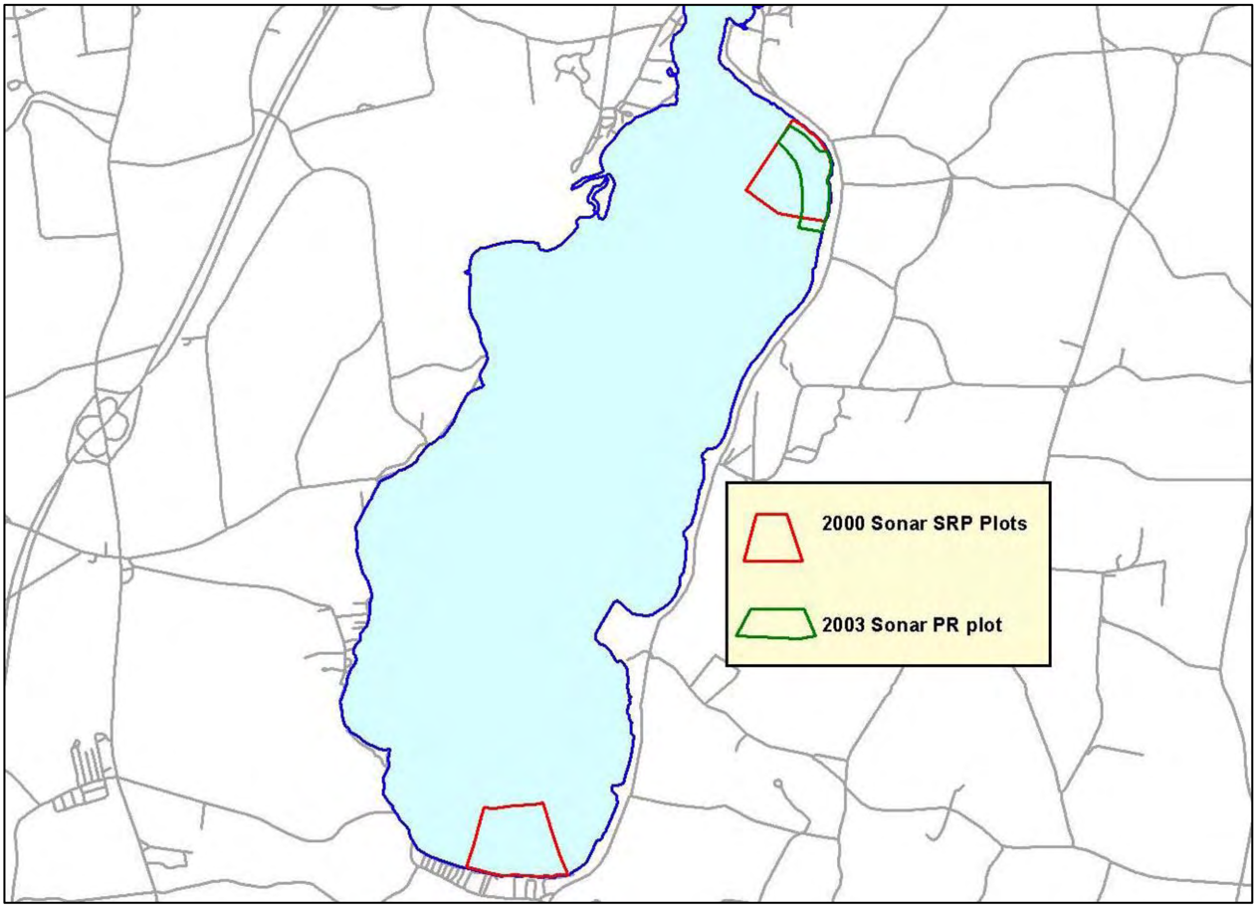
Advantages – Major advantages include potential selectivity for sensitive species with low dose (<10 ppb) applications, systemic action that provides multiple years of effective Eurasian watermilfoil control, and a favorable toxicology profile.

Disadvantages – The high solubility of Sonar makes it difficult to achieve effective control with spot or shoreline applications. Even low dose applications can have adverse impacts non-target, native species.

New York Use Considerations – Based on recommendations of the 1995 EIS for fluridone, current regulations call for Sonar treatments for Eurasian watermilfoil to be performed prior to May 15th. This can be problematic for treatment of large deep lakes, where treatments are usually delayed until after thermal stratification has occurred.

Recent Demonstration Sonar Treatments at Saratoga Lake – Sonar has been the only herbicide used at Saratoga Lake in recent years. Pilot or demonstration treatments were attempted with pellet formulations of Sonar during the 2000 and 2003 seasons. These treatments were performed to evaluate the potential use of herbicides for control of Eurasian watermilfoil in Saratoga Lake.

Figure 6 – Sonar Plot Map



The 2000 treatment program involved the treatment of two 100-acre plots with Sonar SRP (Slow Release Pellet) formulation. The South Plot was located along the southern shoreline between Brown's Beach and South Shore Marina. The North Plot was located on the northeast shoreline, beginning just north of Fitch Road and ending south of Neilson Road. Both plots ran approximately 3000 feet along the shoreline and extended out 1500 feet from shore. The treatment protocol called for a total of approximately 45 ppb (2000 pounds) of Sonar SRP to be applied to each plot. Two applications were performed with half of the Sonar total applied during each application. The applications were performed on May 10, 2000 and June 1, 2000. Monitoring of fluridone residues following the treatments detected very low (< 2 ppb) fluridone concentrations in the water column. There was also little response seen on the milfoil plants in the treatment plots. By early July, it was decided that fluridone concentrations and contact time had been insufficient to be lethal to the targeted milfoil. To bolster the effectiveness of the treatment and achieve the desired milfoil control a series of four booster applications with the liquid Sonar AS (Aqueous Suspension) formulation were performed at one-week intervals beginning in late July. The respective doses of Sonar applied during each treatment were 8 ppb, 7ppb, 5 ppb and 5 ppb for a total of 25 ppb. This treatment regime maintained suitable concentrations of fluridone in the treatment plots and by the end of September milfoil coverage was reduced by an estimated 60 percent in the North Plot and by more than 85 percent in the South Plot. Comprehensive monitoring of the treatment plots in 2001 revealed that there had been reasonable carryover milfoil control achieved in the South Plot, but milfoil rapidly re-infested the North Plot reaching nuisance densities by mid summer.

The failure of the 2000 Sonar SRP treatment was due to insufficient fluridone concentrations and contact-time with the targeted milfoil. In 2001, SePRO the manufacturer Sonar products, reported development of new pellet formulations of Sonar that would have higher fluridone release rates. The first formulation released was called Sonar PR (Precision Release). It was registered for use in New York during the 2002 season. Planning was then initiated for another demonstration treatment in Saratoga Lake during the 2003 season. Because reasonable carryover milfoil control had been achieved in the South Plot following the 2000 treatment program, a decision was made to focus the 2003 treatment in the North Plot. This area is plagued by some of the heaviest milfoil growth. Treatment of the North Plot is complicated by the fact that it receives heavy wind and wave action from the prevailing southwest winds, it is closer to the deepest section of the lake so there is more water volume to dilute the treatment, and it is directly across from Kayderosseras Creek which is the primary surface water tributary for the lake's large watershed (approximately 250 square miles). It was felt that if Sonar PR could be used effectively in the North Plot than the results could be duplicated in other sections of the lake.

Figure 7 – Sonar Release Curves Reported by SePRO

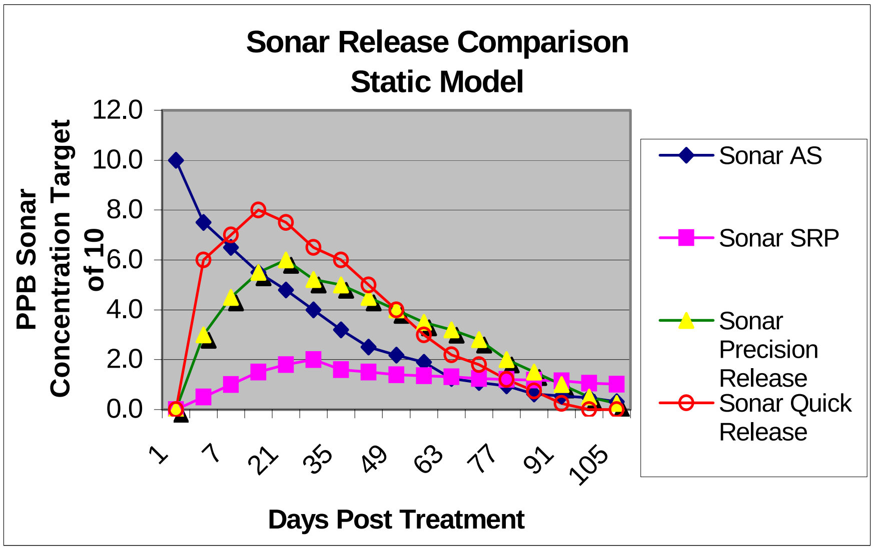


Figure 8 – North Treatment Plot – 2003 Pre Treatment, 2003 Post Treatment & 2004 1-Year Post Treatment

(From left to right) North Plot – 2003 Pre Treatment, 2003 Post Treatment, 2004 1-Year Post Treatment.
See Appendix A for detailed descriptions. The lighter hatching represents lower milfoil densities post-treatment 2003

Treatment in 2003 was limited to a 60-acre area within the same North Plot that was treated in 2000. A single application of Sonar PR was performed on May 15, 2003. The applied concentration was 60 ppb and it was assumed that a maximum of 25 percent of the applied concentration would be present in the water column at any one time. Again, post-treatment monitoring revealed lower than anticipated fluridone concentrations in the water column, but response of the milfoil plants was more noticeable. By the end of the summer, effective milfoil control had been achieved in approximately 40 acres out of the 60 acre total plot size. Plants were not controlled around the edges of the plot, which is indicative of excessive dilution with untreated water. Carryover milfoil control was observed through mid summer of 2004, but milfoil began to aggressively recolonize the plot by the end of summer.

Current Treatment Potential for Saratoga Lake – The 2000 and 2003 Sonar pellet treatments demonstrated that Sonar can used to effectively control Eurasian watermilfoil on Saratoga Lake. The results clearly indicate that larger treatment areas are needed to realize the multiple years of effective control that Sonar is capable of providing. It is also being realized that extended fluridone contact time Another pellet formulation, Sonar Q (Quick Release), is now available that can allow for better management fluridone concentrations the 60 to 90 day period needed for effective milfoil control. Finally, the location Sonar pellet applications will factor into the treatment effectiveness. The North Plot location is not favorable due to wave and current action from the prevailing winds, the proximity of the Kayderosseras Creek inlet, and the large volume of untreated water nearby in the deep hole location. Treatment of the southern third or southern half of the lake would be preferred for future Sonar pellet applications at Saratoga Lake. Larger treatment areas will likely be more effective and provide longer a longer duration of control. Still, untreated milfoil will remain a potential source of reinfestation for treated portions of the lake.

The major advantage of a whole lake treatment with Sonar is that all of the milfoil growth in the lake would be controlled simultaneously. This should provide an extended duration of milfoil control. A whole-lake Sonar treatment performed at the 465 acre Congamond Lakes in Massachusetts in 2001 has, to date, provided nearly complete control of Eurasian watermilfoil over a four year period. Prior to treatment this lake had complete littoral zone infestation of milfoil that was being managed by an annual harvesting program. Native plants continue to recolonize the littoral zone and have increased in abundance each year since the treatment. Other whole lake treatments performed across the country have yielded similar results. Year of treatment impacts to native plants should be anticipated. Following the whole lake treatment of Waneta Lake in New York performed in 2003, DEC expressed concern over greater impacts to non-target plants than were originally anticipated. While year of treatment impacts to non-target, native plants have been documented at several of the whole-lake Sonar treatments performed in the Northeast in recent years, recolonization of native species has occurred in subsequent years. Native plant recolonization was documented following the 2000 whole-lake Sonar treatment on the 480-acre Lake Hortonia in Vermont. Monitoring showed nearly complete recovery of all native plant species that were impacted during the year of treatment (DFWI Hortonia 2004). In fact, Vermont DEC permitted another whole-lake Sonar application at Lake Hortonia during the 2004 season. The target treatment dose was increased from 6 ppb in 2000 to 8 ppb in 2004. It is hoped that this higher dose and longer contact time will result in longer term milfoil control. A similar whole-lake Sonar treatment was performed on the 1100 Lake St. Catherine system in Vermont during the 2004 season. Several native species were documented in the lake at the end of the treatment program in late September 2004. Observations made during a preliminary inspection of Lake St. Catherine in May 2005, showed good taxonomic richness in areas that supported the greatest species diversity prior to treatment. Comprehensive monitoring will continue for the next several years at both Lake Hortonia and Lake St. Catherine.

Aside from the temporary impacts to non-target species, there are other potentially complicating factors for a whole-lake Sonar treatment at Saratoga Lake. First, the lake's large size and rapid flushing rate will require higher quantities of Sonar to be applied to maintain adequate concentrations for the required 60-90 day contact time. The potential that the lake may not thermally stratify until late June will also influence treatment by potentially delaying the application, or will allow Sonar to mix with water below the photic zone and require higher chemical quantities to be applied to reach the targeted concentration. On a 4000 acre lake this could have significant implications on the cost of the treatment program. Still the long-term benefit of whole-lake Sonar treatment must be carefully considered.

4.3.6 Renovate 3 (triclopyr)

EPA granted full aquatic registration for Triclopyr (trade name Renovate 3) in the fall of 2002. New York registration is still pending. Triclopyr has been used in the turf, forestry and right-of-way industries to control terrestrial plants for many years under the trade name Garlon 3A. Triclopyr is an auxin mimic systemic herbicide that targets dicot or broad-leafed plants, with a mode of action similar to that of phenoxy herbicides like 2,4-D. It is translocated throughout the entire plant killing the stem, foliage and roots. It only requires a short contact time with targeted plants, so it should be effective for partial lake treatments. Presently, it is formulated as a concentrated liquid. Dosing is based on the volume of water being treated. Demonstration treatments performed under an Experimental Use Permit (EUP) issued by the EPA showed that species-selective control of submersed Eurasian watermilfoil and emergent purple loosestrife could be achieved. While Renovate cannot be currently used at Saratoga Lake, it could prove to be an potential management tool for partial lake treatments of milfoil in future years.

Application Rate – Renovate is available as a liquid amine formulation. The labeled application rate is based on water volume, target species and anticipated contact time. The dose rate ranges from 0.75-2.5 ppm. Anticipated recommended application rates for large area treatments are between 1.5-2.0 ppm.

Efficacy on Eurasian Watermilfoil – Eurasian watermilfoil is effectively controlled by Renovate. Like 2,4-D, it primarily targets dicot plants, so less effective control of curlyleaf pondweed is anticipated following treatment. Treatment typically occurs when the plants are in their most active phase of growth, but before peak biomass is reached. This usually falls between late May and early July. Plants should die-back completely within 2-3 weeks of treatment. The systemic action of Renovate promises to provide multiple years of effective Eurasian watermilfoil control. Two or three years of nuisance level milfoil control is expected for whole lake or large area treatments.

Water Use Restrictions – The current EPA label lists the following restrictions on using water treated with Renovate:

- Do not use treated water for irrigation for 120 days or until the in-lake concentration drops below detectable limits.

Advantages – Anticipated benefits include selectivity for dicot plants, effectiveness for partial lake or shoreline applications, and systemic action that provides multiple years of effective Eurasian watermilfoil control.

Disadvantages – The extended irrigation restriction period and higher product cost than other herbicides used for partial lake applications are the obvious drawbacks to treating with Renovate.

New York Use Considerations – Renovate is not yet registered for use in New York.

4.3.7 General Herbicide Restrictions

Water Use Restriction Comparsion – Table 9 summarizes the water use restrictions that are likely to be imposed following treatment with the herbicides described above. New York regulations extend the water use restriction periods beyond what is required in the EPA label in many cases and the most restrictive time periods are listed.

Table 8 – Water Use Restrictions

Herbicide	Swimming Restrictions	Domestic Use Restrictions	Irrigation Restrictions	Livestock Watering Restrictions	Fishing Restrictions	Potable Water Restrictions
Sonar AS (Fluridone)	24 hours	24 hours	14-30 days	14-30 days	none	1/4 mile from intake
Sonar PR/Q (Fluridone)	24 hours	24 hours	7-30 days	7-30 days	none	1/4 mile from intake
Reward (Diquat)	14 days	14 days	14 days	14 days	14 days	14 days
Aqua-Kleen/Navigate (2,4-D)	24 hours	by assay	by assay	none	none	by assay
Aquathol K (Endothall)	24 hours	7-25 days	7-25 days	7-25 days	3 days	7-25 days
Aquathol Super K-Granular (Endothall)	24 hours	7 days	7 days	7 days	3 days	7 days
Renovate (Triclopyr) not yet registered	not yet determined	unknown	120 days (label)	unknown	unknown	1/4-1/2 mile from intake dependant on acerage treated (label)

Impacts of Herbicides on Target and Non-Target Plants – Predicting potential impacts to non-target species will be paramount to obtaining successful permit approval for the use of herbicides for large scale treatment work at Saratoga Lake. Anticipated response of all documented plant species in Saratoga Lake to the various herbicides is summarized in Table 10.

Table 9 – Herbicide Impacts on Aquatic Plants

Species	Common Name	1994	2004	Sonar AS (Fluridone)	Sonar PR/Q (Fluridone)	Reward (Diquat)	Aqua-Kleen/Navigate (2,4-D)	Aquathol K (Endothall)	Renovate (Triclopyr)
Bidens beckii Torr. (currently Megalodonta beckii)	water marigold	x	x	S	S	S	S/I	U	S/I
Ceratophyllum demersum L.	coontail	x	x	S/I	S/I	S/I	S/I	S	S/I
Chara/Nitella sp.	muskgrass, chara	x	x	T	T	T	T	T	T
Eleocharis acicularis (L.) Roemer & Schultes	needle spike-rush	x		T	T	U	U	U	U
Elodea canadensis Michx.	elodea	x	x	S	S	S	I	T	I
Eriocaulon septangulare With.	pipewort	x		T	T	T	T	T	T
Heteranthera dubia Jacq. (currently Zosterella dubia)	water stargrass	x	x	T	T	T	S/I	S	S/I
Lemna minor L.	duckweed	x	x	S/I	I/T	I/T	T	T	T
Myriophyllum spicatum L.	Eurasian watermilfoil	x	x	S	S	S	S	S	S
Najas flexilis (Willd.) Rostk. & Schmidt.	bushy pondweed	x	x	S	S	S	I/T	S	I/T
Najas guadalupensis (Spreng.) Magnus	Southern naiad	x	x	S	S	S	I/T	S	I/T
Nuphar luteum (Ait.) Ait. f.	yellow pondlily	x	x	S/I	S/I	T	S/I	T	S/I
Potamogeton amplifolius Tuckerm.	largeleaf pondweed	x	x	I	I	I	I/T	S	I/T
Potamogeton crispus L.	curlyleaf pondweed	x	x	S	S	S	I	S	I
Potamogeton epihydrus Raf.	ribbon-leaf pondweed	x		S	S	S	I	S	I
Potamogeton gramineus L.	variable-leaf pondweed	x	x	I	I	I	T	S	T
Potamogeton illinoensis L.	Illinois pondweed		x	I	I	I	I/T		I/T
Potamogeton pectinatus L. (currently Stuckenia pectinata L.)	sago pondweed	x	x	I	I	S/I	T	S	T
Potamogeton perfoliatus L	Clasping-leaved Pondweed	x	x	I	I	I	T	S/I	T
Potamogeton praelongus Wulfen	white-stem pondweed	x	x	I	I				
Potamogeton pusillus L.	small pondweed	x	x	I	I	I	I/T	S	I/T
Potamogeton richardsonii (Ar. Benn.) Rydb.	Richardsons' pondweed		x	I	I	I	I/T	S	I/T
Potamogeton robbinsii Oakes	Robbins' pondweed	x		T	T	I/T	T	I/T	T

Species	Common Name	1994	2004	Sonar AS (Fluridone)	Sonar PR/Q (Fluridone)	Reward (Diquat)	Aqua-Kleen/Navigate (2,4-D)	Aquathol K (Endothall)	Renovate (Triclopyr)
Potamogeton zosteriformis Fern.	flat-stem pondweed	x	x	S/I	S/I	I	T	S	T
Ranunculus longirostris Godron	white watercrowfoot	x	x	I/T	I/T	S	U	U	U
Sagittaria graminea Michx.	arrowhead	x	x	T	T	I	T	I	T
Sparganium sp.	burreed	x		T	T	T	T	T	T
Spirodela polyrhiza (L.) Schlieden	great duckweed	x		U	U	U	U	U	U
Trapa natans L.	waterchestnut	x	x	T	T	T	S/I	T	S/I
Typha sp.	cattail	x	x	T	T	T	T	T	T
Utricularia vulgaris L.	great bladderwort	x		I	S/I	S	I	T	I
Vallisneria americana L.	wild celery	x	x	S/I	S/I	I/T	I/T	I/T	I/T

Key
Susceptible - S
Intermediate -I
Tolerant - T
Unknown –U
* Susceptibility ratings based on manufacturer literature, Massachusetts GEIR (2004), and treatment experience of Aquatic Control Technology Inc.

<u>Permit Requirements</u> – Currently, the regulations for aquatic herbicide use in New York State are being reviewed and updated by DEC. This process was initiated over a year ago. The major change to date is that Aquatic Pesticide permits for waterbodies over 2.5 hectares (6.4 acres) are now reviewed by the Regional Division of Environmental Permits Office in addition to the Bureau of Pesticide Management. This triggers the State Environmental Quality Review Act (SEQR) process. In addition to the Aquatic Pesticide Permit Application (AQV), an application for herbicide use at Saratoga Lake would now require a Supplemental Aquatic Vegetation Management Project Information (SAV) form and Long Environmental Assessment Form (EAF). Saratoga Lake's size would likely trigger review at the central DEC offices in Albany. DEC would determine if a separate Environmental Impact Statement (EIS) would be needed for treatment work at Saratoga.

5. AQUATIC VEGETATION MANAGEMENT RECOMMENDATIONS

The most challenging aspect of preparing any long-term vegetation management plan is formulating realistic and attainable objectives. Saratoga Lake is a large multiple use waterbody that serves as an important freshwater resource to the Region. Current vegetation management efforts focus on maintaining shoreline access through the use of a limited drawdown and harvesting. While temporary improvements in shoreline access are achieved, the current program is insufficient to provide suitable vegetation control throughout the entire shoreline littoral zone and it does not provide significant reductions of the dense beds of Eurasian watermilfoil. This illustrates the need to identify specific vegetation management objectives at Saratoga Lake.

5.1 LONG-TERM MANAGEMENT NEEDS AND OBJECTIVES

BACKGROUND

In the 1980's access to deep water areas of the lake was becoming problematic primarily due to the expansion of Eurasian water milfoil in the Lake. As a result, in 1986, a plan to harvest navigation cannels through the problematic weed beds was implemented. Since 1986, the amount of harvesting has increased to include both access harvesting and large-scale removal of EWM from the lake. This large-scale harvesting of wide areas over the last sixteen years has contributed to a recovery of the native plant community and improved accessibility to the open water areas.

In recent years, improved water clarity, associated with both improved water quality and zebra mussel introduction in 1996 (Saratoga Watershed Study 2002) has expanded the littoral zone and now the EWM is moving into depths that are impractical to harvest. In addition, the conversion of the lake properties from second homes to primary year round residences and growth in Saratoga County has increased the pressures on the lake. On a typical summer weekend, there may be as many as 300 boats on the lake. The increased weed beds are reducing navigation areas, and thus creating safety concerns. It should also be recognized that recreation spending associated with Saratoga Lake is over

$7,300,000 annually, and this figure does not include the weekend rowing regattas that, on their own, bring in over a $1,000,000 of spending to the region. These revenues are an important source of income to many small businesses in the region.

It is now necessary to expand and refine the control program for EWM on Saratoga Lake. This program seeks to improve access for the boating public and expand the area of the lake that is readily accessible to the boating public. As a result of a number of experimental treatments between 2000 and 2004, the practical limitation of systemic slow acting aquatic herbicides are now well understood on Saratoga Lake. A multi-year program of systemic and contact herbicides along with harvesting is now being pursued.

MANAGEMENT GOALS

The Saratoga Lake Protection Improvement District (SLPID) was formed by the NYS Legislature to ensure the preservation of real property values within the proposed district, improve the water quality of Saratoga Lake thereby enhancing the opportunities for the public water-related recreational act at this waterbody, and conserve the fish and wildlife of the lake, this purpose is the basis of the management plan for nuisance species in the lake.

"The management goals are to maintain the fish and wildlife habitat and recreational uses of the lake. The lake currently supports over 736 acres of abundant Eurasian watermilfoil growth (20% coverage) and approximately 1300 acres of total plant growth. The management goal is to annually manage between 50 to 75% of the total plant cover, most of which is dominated by non-native and invasive Eurasian watermilfoil growth. Under the expanded program, milfoil will be removed where possible, but when milfoil cannot be removed, its growth will be managed. Harvesting will be focused in areas where approved systemic herbicides are believed to be less effective.

SLPID taxes on the land owners in the Lake District currently provide 95% of the annual budget for the Lake maintenance. The Lake District envisions securing the additional funding for the expanded management program by inviting the City of Saratoga to participate at a level comparable to the other neighboring municipalities, increasing the taxes on the Lake District and implementing a permitting system to collect user fees from non-District residents who also use the Lake.

Tax dollars will be used first to insure that the public use areas are managed, but can be used elsewhere on the lake when available. Funds not used in a specific year, will be placed in an aquatic plant management fund and used as needed in subsequent years.

MANAGEMENT PRINCIPALS

Evaluating the current conditions at Saratoga Lake, it would appear to be reasonable to adopt the following principals in a long-term vegetation management plan. The challenge will be to develop a program that adequately addresses all of these stated needs.

1. Improve and maintain shoreline access by controlling excessive vegetation growth
2. Target control of the dense Eurasian watermilfoil beds
3. Prevent the establishment of other non-native and potentially invasive species
4. Preserve a diverse native plant assemblage for fish and wildlife habitat
5. Avoid any adverse impacts on water quality
6. Improve recreation for the multiple user groups, including: fishing, rowing, sailing, power boating and swimming.

No Action Alternative – Considering the current commitment to vegetation management to support recreational use of the lake, it is unreasonable to assume that the no-action alternative would be acceptable to the constituent lake user groups. Limited drawdowns would inevitably be continued under routine operation of the Fish Creek Dam which is dictated by the Federal Energy Regulatory Commission. However, this would only provide noticeable plant control in areas less than one meter deep. Suspending all vegetation management efforts beyond the zone of drawdown would immediately result in increased weed densities in the lake. The total area of nuisance weed growth would rapidly increase to 1000 acres, by combining the 250 acres that are currently being harvested to the roughly 750 acres of dense milfoil beds found in the lake. Expansion of the milfoil beds would be expected to occur in the shallow water areas as the canopy growth of milfoil would out compete native species. Slight expansion of the total milfoil coverage may occur, but it would be a gradual process since most areas within the littoral zone that do not presently support milfoil growth have bottom substates that do not support rooted vegetation. Assuming that milfoil does not expand into deeper water, the maximum expansion potential of milfoil is expected to be approximately 10 percent above the current total vegetated area of 1000 acres. Dense vegetation growth throughout 1100 acres of Saratoga Lake would cover approximately 30 percent of the main body of the lake.

Harvesting – Tripling the size of the current harvesting operation does appear to have the potential to maintain shoreline access throughout the lake. It is unlikely, however, that even a harvesting operation of this magnitude would be able to completely remove all of the dense beds of milfoil in the lake and provide summer long control. On the other hand, herbicide treatments would likely be able to provide more cost effective control of the dense milfoil beds, but may not maintain adequate control of abundant native plant growth that is found close to shore. In addition, it is unlikely that permits would be issued for herbicides to be used to control native plants over large expanses of the shoreline, because non-selective plant control would drastically alter habitat for fish and wildlife and may negatively impact water quality.

Integrated Approach – An integrated management approach is recommended to best mitigate the potential advantages and limitations of different strategies. Utilization of drawdown, harvesting and herbicide treatments will be needed to accomplish the stated management objectives. Drawdown is already being utilized to the maximum extent practicable. Harvesting and herbicide treatments will be the principal strategies used to increase the level of weed control at the lake. The level to which each technique can be utilized will be dictated by permitting constraints, public acceptance and the availability of funds.

Large scale or whole lake herbicide treatments may draw regulatory scrutiny over the potential for adverse impacts to the native plant community. On the other hand, it is apparent that small scale spot-treatments are incapable of providing significant benefits at Saratoga Lake given the expanse of the milfoil infestation. Moderate to large-scale treatments of areas 100 acres or larger should be considered. Treatments should focus on areas where treatment efficacy will be maximized. Considering the current State regulations and limitations on which herbicides could be used for large-scale treatments at Saratoga Lake, there appears to be a greater potential for success from large-scale treatments in the southern half of the lake. This will enable the harvesting program to focus most of its effort at the northern end of the lake where some of the highest nuisance weed densities are found. Possible future changes to regulations on aquatic herbicide use in New York State may allow for other herbicides to be considered for use and may warrant changes in what sections of the lake can be effectively treated. This necessitates the need to keep the vegetation management plan fluid, so that adjustments can be made in the best interest of the resource.

5.1 RECOMMENDED MANAGEMENT ALTERNATIVES

As previously stated, it is unlikely that a management program that solely utilizes either harvesting or herbicide treatment will meet all of the desired management objectives. Harvesting might maintain suitable shoreline access, but is unlikely to provide complete control of the dense Eurasian watermilfoil beds that extend out more than 1000 feet from shore in many locations. Whole lake herbicide treatments might effectively control milfoil, but are unlikely to control dense native plants found in the shallow water lake margins without unacceptable adverse impacts. Ultimately, a program integrating these two techniques should be considered.

Eradication of Eurasian watermilfoil or other nuisance weeds is also not attainable given current technologies. Therefore, management efforts will be ongoing for the foreseeable future. More effective management of nuisance weed growth at Saratoga Lake will require a considerable annual expenditure. Cost will ultimately be a determinant of which management strategies are employed at Saratoga Lake. Because the duration of nuisance plant control varies by technique, it is important to consider both the annual expenditures and the anticipated expenditure over an extended period of time. Harvesting will likely require a similar expenditure each year, while systemic herbicides may provide multiple years of effective plant control and will necessitate large expenditures every three to four years.

It was previously determined that tripling the size of the current harvesting operation would require an annual budget of approximately $250,000. Herbicide treatment costs could vary considerably based on which product is being used and how large an area is being treated. Despite the fact that current State regulations would only permit Aquathol or Sonar to be used at Saratoga Lake, cost comparisons for all products currently registered with EPA with known efficacy for Eurasian watermilfoil were considered. The following summary tables consider three different treatment scenarios for Saratoga Lake.

- Treatment of the southern third of the lake
- Treatment of the southern half of the lake
- Treatment of the whole lake

Aside from Sonar, all of the other products could be considered for smaller treatments, but given the scope of the milfoil infestation at Saratoga Lake, treating less than one-third of the lake may provide limited benefit. These treatment scenarios allow for a fair cost comparison between all products. Estimated treatment costs projected over a 20 year period are illustrated in Table 11.

Figure 9 – Recommended Treatment Options

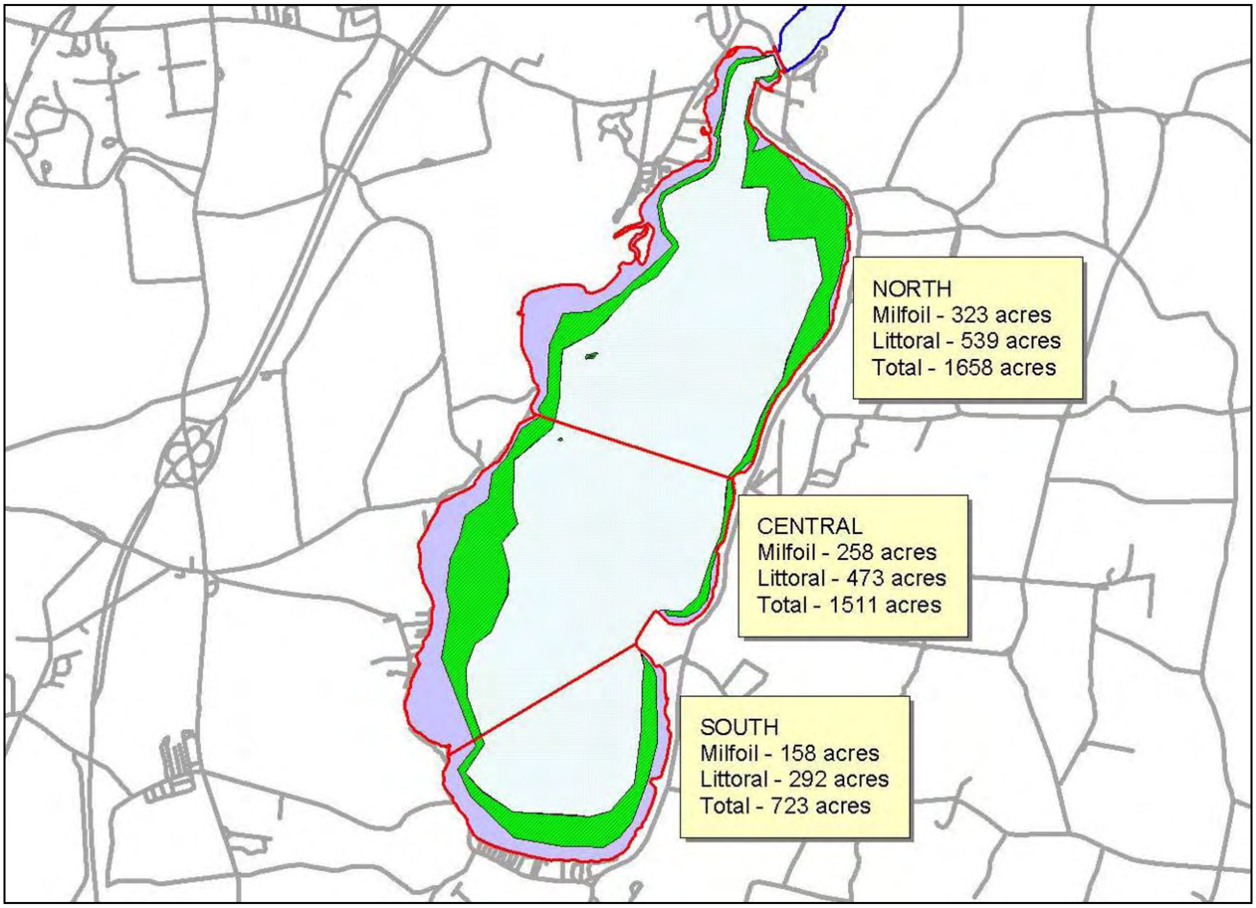


Table 10 – Twenty-Year Cost Comparison for Chemical Treatment

	Acres of Milfoil	Treatment Cost	# times treated in 20 year period	Cost in 2005 $
Sonar AS - Whole Lake				
Whole Lake	736	$1,230,000.00	5	$6,150,000.00
Sonar Pellets				
South	158	$205,000.00	7	$1,435,000.00
South & Central	415	$497,000.00	6	$2,982,000.00
Aquathol K (2 ppm)				
South	158	$131,800.00	20	$2,636,000.00
South & Central	415	$300,300.00	20	$6,006,000.00
Whole Lake	736	$518,600.00	20	$10,372,000.00
Aquathol K & Super K (1.5 ppm)				
South	158	$92,500.00	20	$1,850,000.00
South & Central	415	$189,500.00	20	$3,790,000.00
Whole Lake	736	$312,300.00	20	$6,246,000.00
Reward				
South	158	$65,000.00	20	$1,300,000.00
South & Central	415	$131,400.00	20	$2,628,000.00
Whole Lake	736	$210,200.00	20	$4,204,000.00
Aqua-Kleen				
South	158	$81,300.00	8	$650,400.00
South & Central	415	$158,000.00	7	$1,106,000.00
Whole Lake	736	$259,700.00	6	$1,558,200.00
Renovate				
South	158	$184,400.00	8	$1,475,200.00
South & Central	415	$435,800.00	7	$3,050,600.00
Whole Lake	736	$815,600.00	6	$4,893,600.00

Detailed tables that breakdown the herbicide treatment cost estimates by task are provided in Appendix B. These estimated 20-year projections are provided to simply illustrate the differences in cost if one technique was solely used at the lake. They do not factor in the likelihood that a combination of techniques would likely be used to achieve the desired level of control. For instance, following a whole lake Sonar treatment it would neither be recommended nor anticipated that milfoil would be allowed to rebound to pre-treatment densities. Smaller scale treatments or other strategies would inevitably be used to keep milfoil growth in check. The same would likely hold true even if smaller portions of the lake were being treated.

Based solely on cost, Aqua-Kleen or Navigate (2,4-D granular) would be the most desirable herbicide for use at Saratoga Lake. Its systemic action provides multiple years of effective Eurasian watermilfoil control and its selectivity for dicot (broad leafed) plants would limit impacts to desired non-target, native species. However, current State regulations prohibit its use beyond 200 feet from shore for the six foot depth contour, whichever is further. In addition, 2,4-D usually draws concern over toxicity issues, particularly with the potential contamination to groundwater. Recent field tests performed at Oneida Lake showed that Aqua-Kleen had no significant effect on walleyes and fathead minnows in caged fish studies (Johnson, et. al., NEAPMS 2005). Additional tests on invertebrates are planned. 2,4-D is currently undergoing the Re-Registration Eligibility Decision review at EPA. Changes in use restrictions of 2,4-D in New York may occur if a new EIS is submitted by the manufacturer, which is expected to occur in the next couple of years.

Renovate is reported to have efficacy and selectivity similar to 2,4-D. It would be another systemic herbicide capable of providing multiple year milfoil control, with greater flexibility for treatment of smaller areas. It is not yet registered for use in New York, but is currently under review. Its registration could be delayed if there new requirements for an EIS.

Again, current State regulations effectively preclude herbicides other than Aquathol or Sonar at Saratoga Lake. It is unlikely that whole-lake treatments will be approved in the near future. Therefore, it becomes a decision between using Sonar pellets that should provide multiple years of milfoil control, but carry a higher year of treatment cost; or performing annual treatments with Aquathol at a lower year of treatment costs. It is unknown whether or not there would be any carryover control into a second season following treatment with Aquathol. It is a contact herbicide that does not kill the root structures of the plants, but several years of consecutive treatments may exhaust the starch reserves in the root structures and reductions in milfoil regrowth might be realized. It is also uncertain whether or not the State would permit a low dose (below recommended label rate) application of Aquathol, which would significantly lower the treatment program cost. The potential advantage of using Aquathol is that if it proves to be effective, its rapid mode of action may facilitate treatment of the north end of the lake, where the efficacy of Sonar is questionable.

5.1.1 Treatment of Southern Third of the Lake

Selection of the southern third of the lake was dictated by the fact that this appears to be the smallest portion of the lake that could be effectively treated with Sonar pellets and still provide more than one season of effective milfoil control. At least two and possibly a third year of effective milfoil control should be achieved following a Sonar pellet treatment of this area. This section of the lake has maximum water depths of just over 30 feet, which would help limit the dilution of Sonar into untreated water. SePRO (the manufacturer of Sonar) would recommend that both the PR and Q pellet formulations of Sonar be used to maintain the required 60-90 days of fluridone contact time. A treatment dose of approximately 70 ppb was calculated for the entire littoral zone of the area to be treated. This includes the estimated 158 acres of dense milfoil beds and approximately 150 acres of shallow water between the milfoil beds and shore. The Aquathol treatment costs were calculated based on treatment of the milfoil beds only.

Table 11 – Treatment Costs for Southern Third of Lake

	Acres of Milfoil	Treatment Cost	# times treated in 20 year period	20 Year Cost in 2005 $
Sonar Pellets				
South	158	$205,000.00	7	$1,435,000.00
Aquathol K (2 ppm)				
South	158	$131,800.00	20	$2,636,000.00
Aquathol K & Super K (1.5 ppm)				
South	158	$92,500.00	20	$1,850,000.00

Treating the southern third of the lake between Snake Hill and Stony Point should provide acceptable control of nuisance weeds for this area. Native plant growth is not as robust along these shorelines as it is at the northern end of the lake. SLPID's harvesting logs between 2002 and 2004 indicate that less than 25 percent of the total harvesting effort is expended in this portion of the lake. It is expected that if the milfoil beds are completely controlled in this area, harvesting needs to control native plant growth will be reduced considerably.

If the southern third of the lake were successfully treated, then the 25 percent of harvesting effort could be allocated to the central and northern sections of the lake. Proportionally distributing it to the central and north Harvest Areas would increase the removal efficiency in these areas by an estimated 20 percent (Appendix C). Approximately 80 percent of the total shoreline littoral area in the north and central sections could be harvested, compared to the 60 percent harvest that is currently being achieved on the whole lake. This assumes no changes in the existing operation of two harvesters, one shore conveyor and one truck. It still would not allow for any appreciable removal of the dense milfoil beds in the northern and central portions of the lake, but the management of the shoreline access areas should be much more easily accomplished.

Treatment of the southern third of the lake with Sonar pellets would likely be the most economically feasible way of making an initial foray into larger scale treatment work and an integrated aquatic vegetation management program at Saratoga Lake. Perhaps three years of effective milfoil control could be realized in the treatment area. At the same time, the increased harvesting work in the remaining portions of the lake should provide more satisfactory results. In practice, on-going milfoil control efforts at a reduced scale would be a preferred follow-up to letting the area become completely reinfested with milfoil, requiring complete retreatment. For budgeting purposes we assumed follow-up spot-treatment of 100 acres with Aquathol K in Year 4 or Year 5 of the following five-year budget projection.

Table 12 – Estimated Management Expenses for a 5 Year Integrated Program Following Treatment of the Southern Third of the Lake

Years	Management Technique	Cost
1	Sonar pellet treatment of southern third of lake	$205,000
1-5	Harvesting operations (north & central sections) – assume $90,000 per year to continue existing operation	$450,000
1-5	Annual monitoring and reporting – assume $20,000 per year	$100,000
4 or 5	Aquathol treatment of 100 acre area	$100,000
TOTAL		**$825,000**
Annual expenditure over 5-year period		$171,000
Estimated percent of potential harvest area cleared in north & central sections – complete milfoil removal is not anticipated		79%

5.1.2 Treatment of the Southern Half of the Lake

Treating the southern half of the lake with Sonar pellets would likely provide even more effective and longer lasting control of milfoil. Higher chemical concentrations would be maintained in the southern half of the lake and removing additional milfoil growth would reduce the rate of reinfestation from untreated portions of the lake. The same herbicide dose calculations used in the "Treatment of the Southern Third of the Lake" scenario (section 5.1.1) were used for the Southern Half of the Lake, as shown in Table 12 below.

Table 13 – Treatment Costs for the Southern Half of Lake

	Acres of Milfoil	Treatment Cost	# times treated in 20 year period	20 Year Cost in 2005 $
Sonar Pellets				
South & Central	415	$497,000.00	6	$2,982,000.00
Aquathol K (2 ppm)				
South & Central	415	$300,300.00	20	$6,006,000.00
Aquathol K & Super K (1.5 ppm)				
South & Central	415	$189,500.00	20	$3,790,000.00

The cost table illustrates how larger treatment areas favor the use of systemic herbicides, especially when considering costs over a 20 year period. The difference in cost between the two Aquathol treatment options is more evident in the half lake treatment scenario. Aquathol would probably not be recommended for regular management of such a large area of milfoil growth, unless the lower dose, early season treatment protocol could be utilized, or if significant carryover milfoil control were being obtained.

Significant increases in harvesting efficiency would be realized by moving the harvesting effort from the southern half of the lake to the northern half. Average values between 2002 and 2004 suggest that 42 percent of the harvesting effort is expended in the southern half of the lake. Proportionally distributing this to the remaining harvest areas in the northern half should facilitate a nearly 100 percent harvest of the shoreline littoral area. Again, it is unlikely that complete removal of the milfoil beds in the northern end of the lake could be achieved, but harvesting effort could be reallocated to focus on more milfoil bed removal, if desired. The improvement in shoreline access should be significant.

Table 14 – Estimated Management Expenses for a 5 Year Integrated Program Following Treatment of the Southern Half of the Lake

Years	Management Technique	Cost
1	Sonar pellet treatment of southern half of lake	$497,000
1-5	Harvesting operations (north section) – assume $90,000 per year to continue existing operation	$450,000
1-5	Annual monitoring and reporting – assume $22,500 per year	$112,500
4 or 5	Aquathol treatment of 200 acre area	$160,000
TOTAL		**$825,000**
Annual expenditure over 5-year period		$244,000
Estimated percent of potential harvest area cleared in north & central sections – complete milfoil removal is not anticipated		98%

5.1.3 Whole Lake Treatment

A whole lake treatment program would unquestionably provide the greatest immediate improvement at Saratoga Lake. The duration of effective milfoil control should also be greatest following a whole lake treatment. Harvesting requirements should also be greatly reduced following a whole lake treatment. Limited harvesting of dense native plant growth at access points and along developed shorelines should be all that is required for a several year period following treatment. However, as previously discussed, there are several complicating factors (i.e. rapid flushing rate, delayed thermal stratification, potential impacts to non-target plants and fish and wildlife habitat, and potential permitting constraints) to a whole lake treatment program at Saratoga Lake that will require further evaluation. Still, the potential benefit of lake-wide milfoil control warrants the consideration of the whole-lake treatment option.

Based on available information, SePRO suggests the use of Sonar AS (Aqueous Suspenion) liquid formulation rather than the pellet formulations for a whole lake treatment. The liquid formulation allows for better dose manipulation in order to maintain suitable fluridone concentrations over the required 60-90 day contact time needed to control milfoil. The cost projections provided below assume an initial application at 8-10 ppb and two or three follow-up booster applications. The Aquathol treatment protocol would be the same as the Third and Half lake treatment scenarios.

Table 15 – Treatment Costs for Whole Lake

	Acres of Milfoil	Treatment Cost	# times treated in 20 year period	20 Year Cost in 2005 $
Sonar Pellets				
South & Central	736	$1,230.000.00	5	$6,150.000.00
Aquathol K (2 ppm)				
South & Central	736	$518,600.00	20	$10,372,000.00
Aquathol K & Super K (1.5 ppm)				
South & Central	736	$312,300.00	20	$6,246,000.00

The benefits of using a systemic herbicide like Sonar are even more apparent when considering whole-lake treatments. While the lower dose Aquathol treatment (1.5 ppm) option may be close to the cost of Sonar over a 20-year period, the requirement for annual treatments and potential impact to non-target species would likely complicate permit approval.

A significant benefit of a whole-lake treatment would be the dramatic reduction in the harvesting requirements on the lake. Some shoreline harvesting of native plants would undoubtedly be required, but the harvesting program might be reduced from its current level.

Table 16 – Estimated Management Expenses for a 5 Year Integrated Program Following Treatment of the Southern Half of the Lake

Years	Management Technique	Cost
1	Sonar liquid whole-lake treatment	$1,230,000
1-5	Harvesting operations (native plants along developed shorelines) – assume $30,000 per year to continue existing operation	$150,000
1-5	Annual monitoring and reporting – assume $30,000 per year	$150,000
4 or 5	Aquathol treatment of 300 acre area	$230,000
TOTAL		**$1,760,000**
Annual expenditure over 5-year period		$352,000

REFERENCES

Chautauqua County Department of Planning and Development. Supplemental Environmental Impact Statement to the New York State Aquatic Vegetation Control Program: Plan for Future Use of Aquatic Herbicides in Chautaqua Lake, February 1990.

Dick, J. III and Z. Hayden. August 31, 1994. Lake Dunmore Nuisance Aquatic Plant Control Program, 1994 Summary of Events. Lake Dunmore Fern Lake Association, Salisbury, Vermont.

Martin, Michael. The Use of Hand-Harvesting to Control Eurasian Milfoil in Upper Saranac Lake, NY. Cedar Eden Environmental, Saranac, NY. Paper presented at: Northeast Aquatic Plant Management Society 2005 Conference, Saratoga Springs, NY.

Eichler, Lawrence, and Charles Boyen. Saratoga Lake Aquatic Plant Survey – 2004. New York: Darrin Fresh water Institute, 2004.

Fugro East, Inc. and Aquatic Control Technology, Inc. December 1995. Draft Lake George Milfoil Control Evaluation. The Lake George Park Commission.

Hardt, Frederick W., George Hodgson, and Gerald F. Mikol. Saratoga Lake Phase I Diagnostic Feasibility Study and Management Plan. New York, 1983.

Martin, Michael. The Use of Hand-Harvesting to Control Eurasian Milfoil in Upper Saranac Lake, NY. Cedar Eden Environmental, Saranac, NY. Paper presented at: Northeast Aquatic Plant Management Society 2005 Conference, Saratoga Springs, NY.

Mattson, M.D., P.J. Godfrey., R.A. Barletta and A. Aiello. 2004. Eutrophication and Aquatic Plant Management in Massachusetts. Final Generic Environmental Impact Report. Edited by Kenneth J. Wagner. Department of Environmental Protection and Department of Conservation and Recreation, EOEA, Commonwealth of Massachusetts.

Reinhardt, Glenn. Pesticide Control Specialist II, New York State Department of Environmental Conservation, Division of Solid and Hazardous Materials, Region 9. Personal Communication.

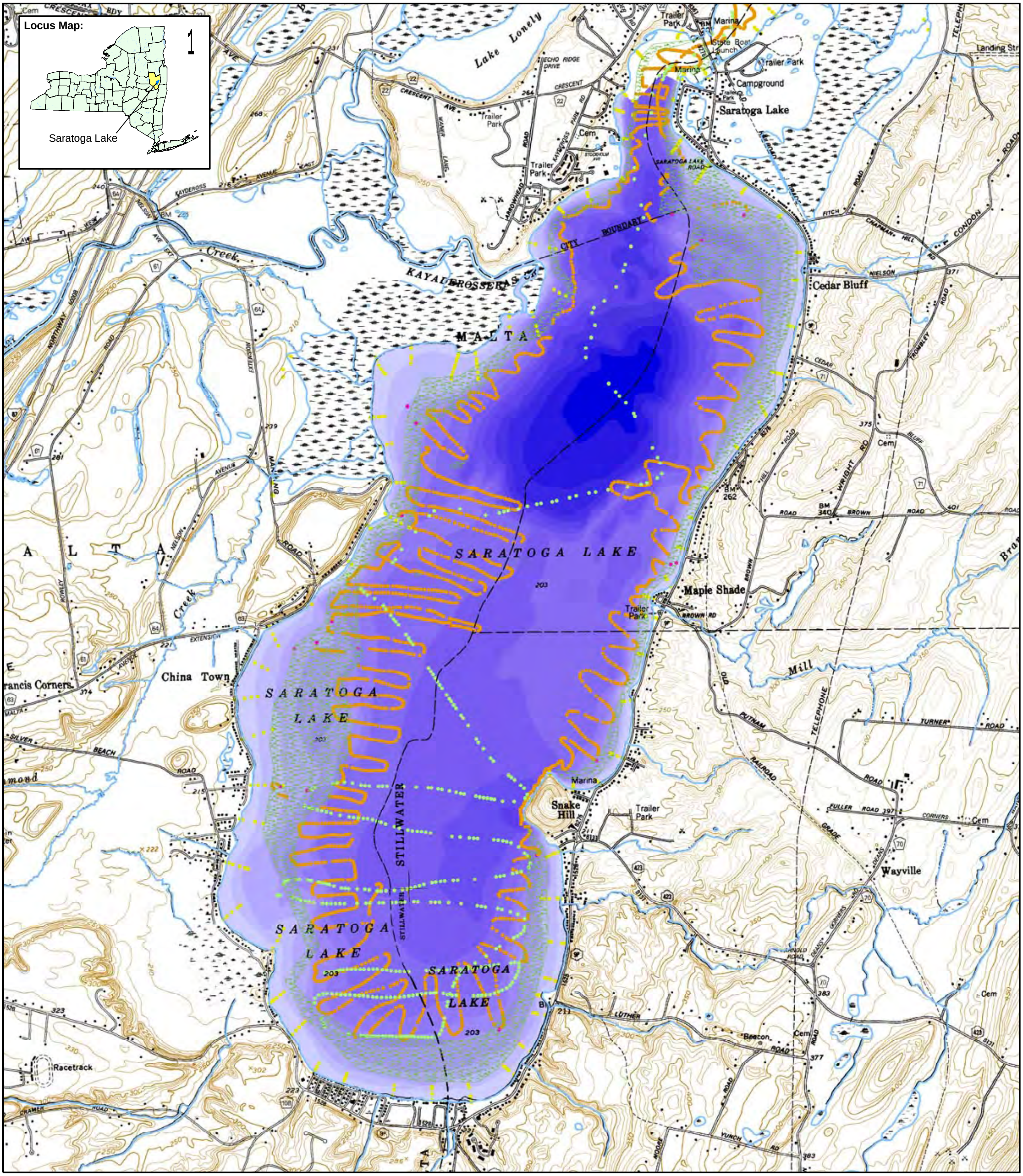
The LA Group, P.C. Land to Lake Perspectives: A Watershed Management Plan for Saratoga Lake.Saratoga Springs: New York, 2002.

Wagner, K.J. December 2003. The Practical Guide to Lake Management in Massachusetts: A Companion to the Final Generic Environmental Impact Report on Eutrophication and Aquatic Plant Management in Massachusetts. Department of Environmental Protection and Department of Conservation and Recreation, EOEA, Commonwealth of Massachusetts.

APPENDICIES:

A – Maps
B – Saratoga Lake Aquatic Plant Survey – 2004, Darrin Fresh Water Institute
C – Harvesting Efficiency Calculations
D – Herbicide Toxicology Summaries
E – Herbicide Treatment Cost Comparisons
F – 2005 Milfoil Inspection Report

APPENDIX A - Maps



Saratoga Lake

Bathymetric Survey Data
Figure 1

SCALE:	DATE:	PROJECT:
1 : 18,000	Dec 2004	ACT Saratoga

Legend:

Bathymetry (CT Male 1981)

- 0.0 - 3.0
- 3.1 - 6.0
- 6.1 - 9.0
- 9.1 - 12.0
- 12.1 - 15.0
- 15.1 - 18.0
- 18.1 - 28.0
- 28.1 - 38.0
- 38.1 - 47.0
- 47.1 - 57.0
- 57.1 - 63.0
- 63.1 - 75.0
- 75.1 - 85.0
- 85.1 - 95.0

Bathymetry Source Data

- C.T. MALE (02-02)
- ACT Sonar (11-18-04)
- ACT Sonar (10-21-04)
- ACT Manual (11-18-04)

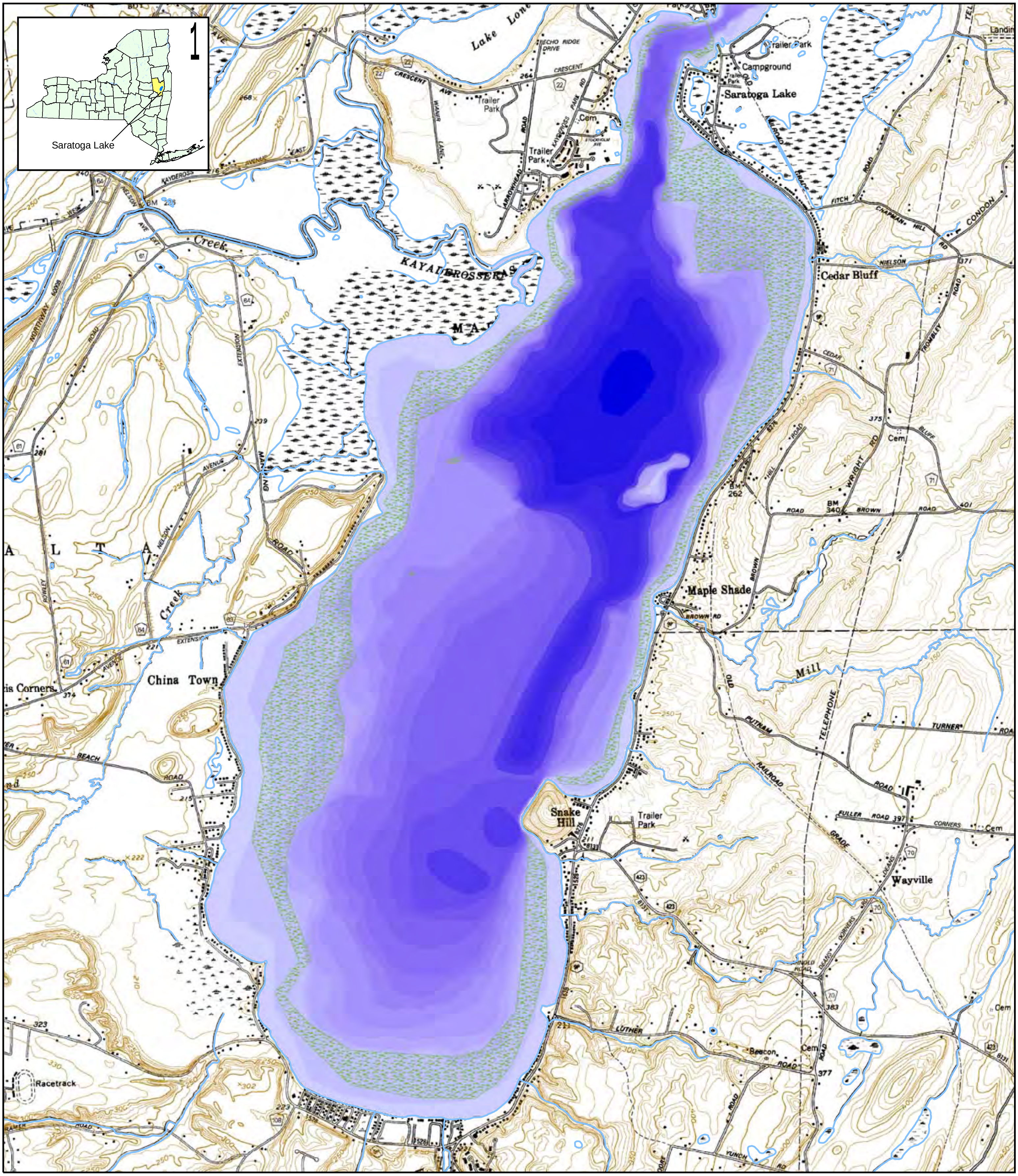
Eurasian watermilfoil beds mapped by DFWI Aug. 2004

Universal Transverse Mercator Coordinate system
Zone 18 North, North American Datum 1927

2,000 1,000 0 2,000 Feet

AQUATIC CONTROL TECHNOLOGY, INC.
POND AND LAKE MANAGEMENT SPECIALISTS
11 JOHN ROAD
SUTTON, MASSACHUSETTS 01590
PHONE: (508) 865-1000
FAX: (508) 865-1220
WEB: WWW.AQUATICCONTROLTECH.COM

animasgeographictechnology
WWW.ANIMASGEOTECH.COM



Saratoga Lake

Updated Bathymetric Contours
Figure 2

SCALE:	DATE:	PROJECT:
1 : 18,000	March 2005	ACT Saratoga

Legend:

Bathymetry (2004)

0 - 3
4 - 6
7 - 9
10 - 12
13 - 15
16 - 18
19 - 21
22 - 24
25 - 27
28 - 30
31 - 33
34 - 36
37 - 39
40 - 43
44 - 53
54 - 63
64 - 73
74 - 83
84 - 93

Eurasian watermilfoil beds mapped by DFWI Aug. 2004

Universal Transverse Mercator Coordinate system
Zone 18 North, North American Datum 1927

2,200 1,100 0 2,200 Feet

AQUATIC CONTROL TECHNOLOGY, INC.
POND AND LAKE MANAGEMENT SPECIALISTS
11 JOHN ROAD
SUTTON, MASSACHUSETTS 01590
PHONE: (508) 865-1000
FAX: (508) 865-1220
WEB: WWW.AQUATICCONTROLTECH.COM

animasgeographictechnology
WWW.ANIMASGEOTECH.COM

APPENDIX B - Saratoga Lake Aquatic Plant Survey – 2004, Darrin Fresh Water Institute

DARRIN
Fresh Water Institute

Lake George, New York
Adirondack Field Station at Bolton Landing

Saratoga Lake Aquatic Plant Survey – 2004

Prepared By

Lawrence Eichler
Research Scientist

&

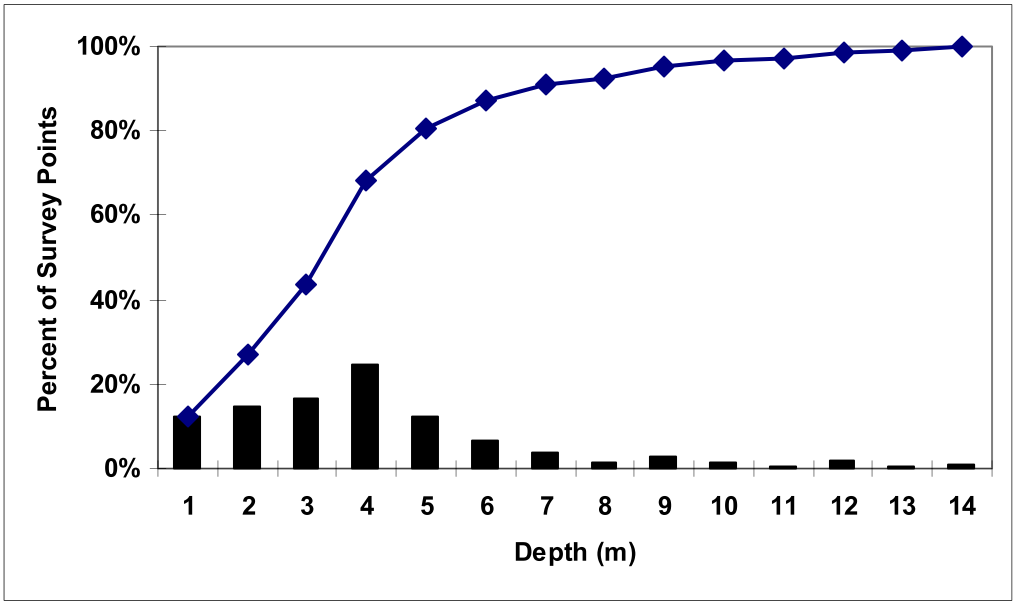
Charles Boylen
Associate Director

Darrin Fresh Water Institute
5060 Lakeshore Drive
Bolton Landing, NY 12814
(518) 644-3541 (voice) (518) 644-3640 (fax)
eichll@rpi.edu

December 2004

meters. This weakly rooted species may have drifted to this location and may not be able to survive. *Ceratophyllum demersum* and *Najas guadalupensis* were commonly found between 5 and 6 meters depth, with occasional *Myriophyllum spicatum* specimens also encountered. These observations indicate that the littoral zone extends to 6 m, an increase of approximately 1 m in depth from the 1994 estimates (Eichler and Boylen, 1995).

Figure 3. Depth Distribution of Saratoga Lake sampling points in 1 meter depth classes.



Saratoga Lake Point Intercept Survey Results

Species Lists

Maps of the distribution of aquatic plant species and groups of species (i.e. Broad-leaf Pondweeds) for Saratoga Lake are included in Appendix A. *Myriophyllum spicatum* was the most abundant species, present in 54% of all samples collected. *Ceratophyllum demersum* was the second most abundant aquatic plant species occurring in Saratoga Lake, reported in 38% of samples collected. Common native species for Saratoga Lake included *Zosterella dubia* (29%), *Vallisneria americana* (23%), *Najas guadalupensis* (11%), *Elodea canadensis* (7%), *Chara/Nitella* (7%), *Potamogeton zosteriformis* (6%) and *Najas flexilis* (6%). With this diversity and distribution of native species, the test for selectivity should be sensitive to a number of species, and the probability of native plant restoration in areas formerly inhabited by Eurasian watermilfoil should be high following management efforts.

A total of 21 species were recorded in open lake surveys of Saratoga Lake in 2004 (Table 1). These results are comparable to previous surveys in 1994 (22 species, Eichler & Boylen, 1995),

TABLE OF CONTENTS

List of Tables

List of Figures

Background

Quantitative aquatic plant surveys were undertaken in 2004 for Saratoga Lake, New York as part of a cooperative effort between Aquatic Control Technologies (ACT) and the Darrin Fresh Water Institute, and supported by the Saratoga Lake Protection and Improvement District (SLPID). The project was designed to obtain data to evaluate current aquatic plant management efforts and review potential new strategies. The project consisted of three components: 1) collection of herbarium specimens throughout the lake for compilation of a species list, 2) point-intercept frequency and depth data for points distributed throughout the lake, and 3) line-intercept transect data for selected areas of the lake.

Introduction

Survey Site

Saratoga Lake is located in Saratoga County, New York in the towns of Saratoga, Stillwater, Round Lake, and Malta. The lake has a surface area of approximately 3765 acres and a surface elevation of 203 ft amsl. Saratoga Lake has a single outlet, Fish Creek draining to the Hudson River. Average water depth is reported to be 25 ft, with a maximum depth of 95 ft (Mikol & Polsinelli, 1985). Hydraulic retention time is reported to be 0.4 years and lake volume is 381,000,000 m^3. Transparency via secchi disk in 2003 was reported to be 4.1 m (SLPID, 2003).

An aquatic plant survey of Saratoga Lake in 1932 (NYS DEC, 1932) indicated that the lake was quite free of "weeds" except in a few protected bays, primarily along the south and west shores. Common species included *Ceratophyllum demersum, Elodea canadensis, Vallisneria americana* and the pondweeds; *Potamogeton amplifolius, P. praelongus, P. nodosus*, and *P. compressus*. One exotic species, *Potamogeton crispus* was reported. In 1969, the NYS DEC pesticides unit did a more extensive mapping of aquatic plants in Saratoga Lake. They reported a healthy native plant community with 13 submersed species, 2 native rooted floating-leaf species, 3 native emergent species and 3 free floating species (Dean, 1969). Additional data collections by the US EPA Clean Lake Program reported 14 submersed species, 2 floating-leaved species, 2 emergent species and 3 free floating species in 1981-82 (Hardt et al., 1983). Both *Myriophyllum spicatum* and *Potamogeton crispus* were reported as occurring as dense growth. *Myriophyllum spicatum* populations were first confirmed in the mid-1970's and reported to be the dominant aquatic plant species in the lake by the early-1980's (Hardt et al., 1983). In 1994, the Saratoga Lake aquatic plant community contained 23 submersed species, 3 native rooted floating-leaf species, 2 native emergent species and 1 free floating species (Eichler and Boylen, 1995). *Myriophyllum spicatum* was the most common plant species, present in 68 percent of survey points. Two other exotic aquatic plant species were reported, *Potamogeton crispus* and *Trapa natans*.

Nuisance aquatic plant growth has posed problems for Saratoga Lake for the past two decades.

Excessive aquatic plant growth is reported to impact water-based recreation, aesthetic quality, environmental issues related to loss of habitat diversity, exclusion of native plant and animal species, and hydrodynamics. Nuisance growth of aquatic plants in Saratoga Lake is mainly attributable to three non-native species:

- Eurasian watermilfoil – *Myriophyllum spicatum*
- Curly leaf Pondweed – *Potamogeton crispus*
- Waterchestnut – *Trapa natans*

with the majority of effort devoted to the management of Eurasian watermilfoil.

In 1994, an aquatic plant survey of Saratoga Lake was conducted by the Darrin Fresh Water Institute to evaluate the ongoing aquatic plant harvesting and lake level drawdown program for the control of *Myriophyllum spicatum* and *Potamogeton crispus*. Volunteer efforts were also underway to hand harvest an infestation by *Trapa natans*. Results of that survey indicated a diverse population of native aquatic plants (Table 1) dominated by the exotic invasive *Myriophyllum spicatum*. While mechanical harvesting provided access to the open waters of the lake for recreational use, this technology was not having an appreciable long-term effect on the density of growth of *Myriophyllum spicatum*. Winter draw-down and the resultant ice scour in the shallow waters (depth less than 1 meter) was determined to be negatively effecting the growth of *Myriophyllum spicatum*. In order to control *Myriophyllum spicatum*, a long-term aquatic plant management program, keyed to effective use of all appropriate technologies is a worthwhile programmatic goal. The current survey is designed to provide aquatic plant population data sufficient to develop a long-term strategy based on current levels of plant growth and to provide a baseline of aquatic plant growth to use to evaluate future control efforts.

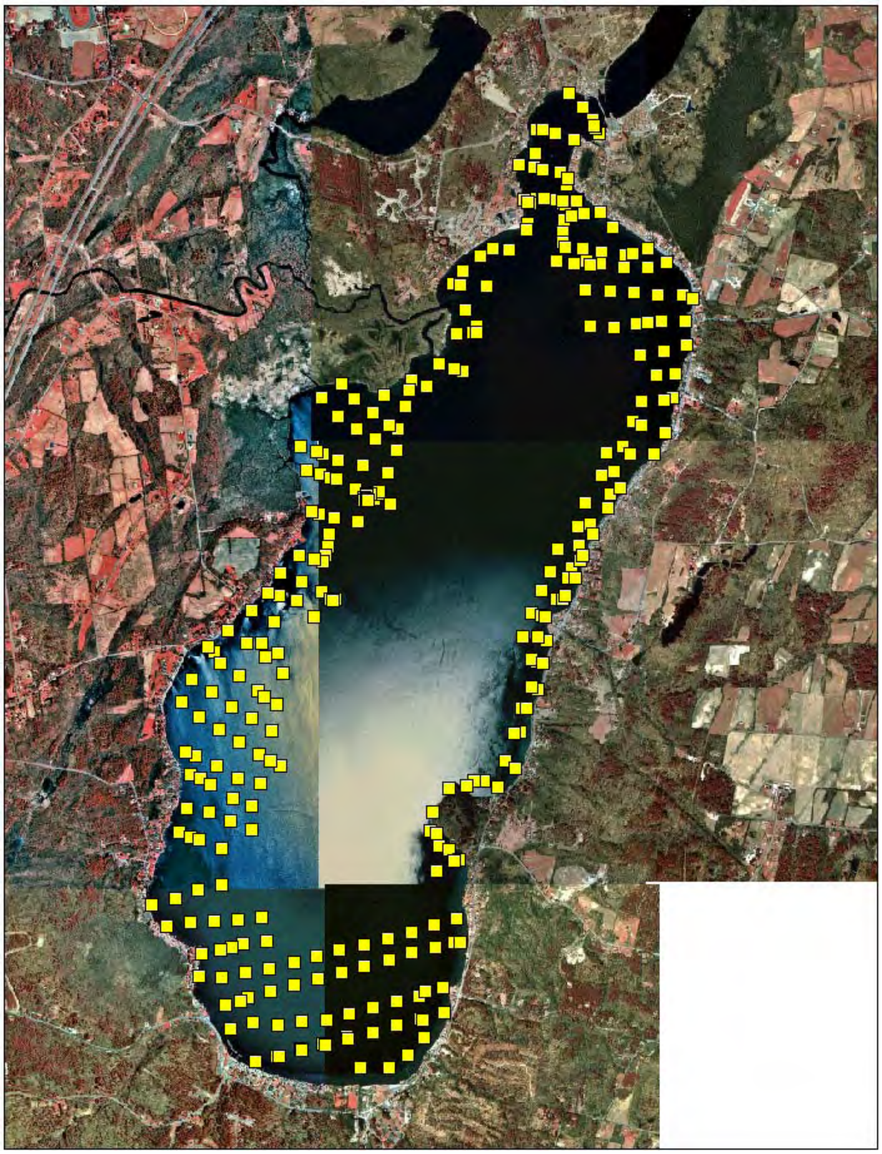
Methods

Species List and Herbarium Specimens. As the lake was surveyed, the occurrence of each aquatic plant species observed was recorded and adequate herbarium specimens collected. The herbarium specimens were pressed, dried, and mounted (Hellquist 1993) at the Darrin Fresh Water Institute Laboratory in Bolton Landing, NY, where they became part of the permanent collection.

Point Intercept Survey. The frequency and diversity of aquatic plant species were evaluated using a point intercept method (Madsen 1999). At each grid point intersection, all species located at that point were recorded, as well as water depth. Species were located by a visual inspection of the point and by deploying a rake to the bottom, and examining the plants retrieved. A differential global positioning system (Garmin GPSmap 168) was used to navigate to each point for the survey observation. Point intercept plant frequencies were surveyed in August and September of 2004. A total of 325 points were surveyed for Saratoga Lake (Figure 1).

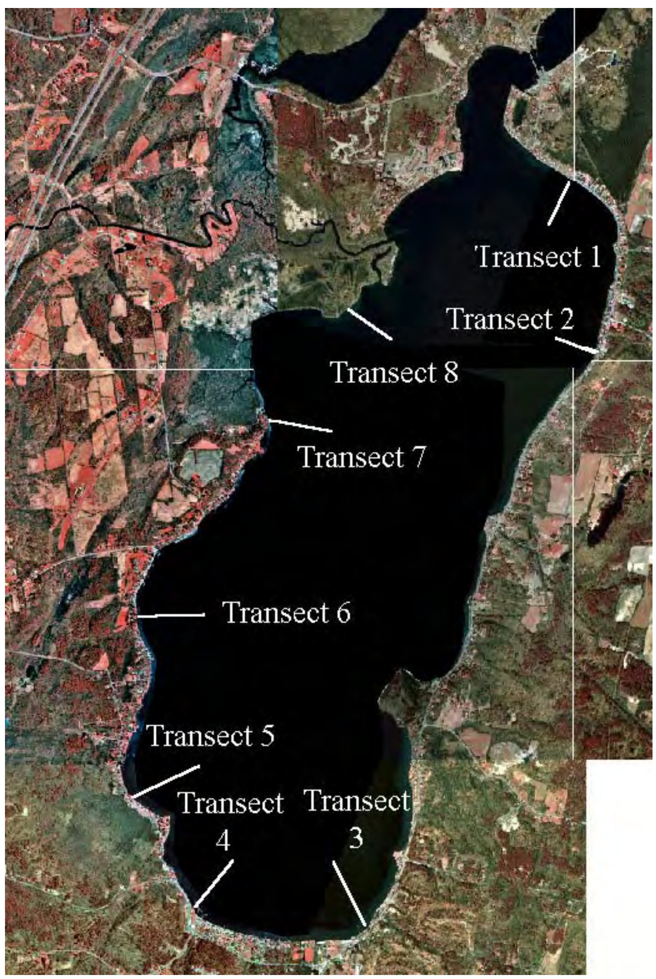
The point intercept method allows a large number of discrete observations in a short period of time facilitating statistical analysis and comparisons. Point intercept methods also allow for production of distribution maps for all species listed. The line intercept surveys provide a more complete listing of all aquatic plant species present; however, the limited number of discrete observations are somewhat more difficult to quantify statistically.

Figure 1. Distribution of point intercept survey points for Saratoga Lake aquatic plant survey.



Line Intercept Transects. A total of 8 transects were placed to duplicate the survey of 1994 (Eichler and Boylen, 1995, see Figure 2). These transects were inspected between 25 and 27 August 2004. Transect locations were selected to represent the maximum number of different habitat types; slope, sediment type, orientation, and fetch were all considerations. Transects were placed perpendicular to the shoreline. Each transect was 100 meters long, divided into 1-meter segments, and extended perpendicularly from the shoreline. At each 1-meter interval or stop point, a 0.1 m^2 quadrat was placed. Percent cover of each species within the quadrat was recorded, based on a Daubenmire scale by SCUBA divers knowledgeable in aquatic plant identification (Daubenmire, 1959; 1968). In addition, surficial sediments were visually characterized into four physical classes (rock, gravel, sand and silt).

Figure 2. Location of transects for Saratoga Lake aquatic plant survey.



Results and Discussion

Saratoga Lake Survey Results

In August of 2004, the aquatic plant community of Saratoga Lake included 21 submersed species, 3 floating-leaved species, 1 floating species and 3 emergent species. A total of 21 species were collected in the point intercept portion of the survey and 23 species recorded in the line intercept survey. Three exotic species, *Myriophyllum spicatum, Potamogeton crispus* and *Trapa natans* were reported, however both *Potamogeton crispus* and *Trapa natans* were limited to only a few specimens. *Myriophyllum spicatum* dominated the aquatic plant community. Species richness was quite high, with a large number of species occurring in more than 10% of survey points (Table 2). While Eurasian watermilfoil was by far the most widely distributed plant (54% of point intercept and 35% of line intercept survey points), a number of native species were also commonly observed. A list of species observed for Saratoga Lake is provided in Table 1.

Table 1. Aquatic plant species present in Saratoga Lake in 2004.

Species	**Common Name**	**1994**	**2004**
Bidens beckii Torr. (currently *Megalodonta beckii*)	water marigold	x	x
Ceratophyllum demersum L.	coontail	x	x
Chara/Nitella sp.	muskgrass, chara	x	x
Eleocharis acicularis (L.) Roemer & Schultes	needle spike-rush	x	
Elodea canadensis Michx.	elodea	x	x
Eriocaulon septangulare With.	pipewort	x	
Heteranthera dubia Jacq. (currently *Zosterella dubia*)	water stargrass	x	x
Lemna minor L.	duckweed	x	x
Myriophyllum spicatum L.	Eurasian watermilfoil	x	x
Najas flexilis (Willd.) Rostk. & Schmidt.	bushy pondweed	x	x
Najas guadalupensis (Spreng.) Magnus	Southern naiad	x	x
Nuphar luteum (Ait.) Ait. f.	yellow pondlily	x	x
Potamogeton amplifolius Tuckerm.	largeleaf pondweed	x	x

Species	**Common Name**	**1994**	**2004**
Potamogeton crispus L.	curlyleaf pondweed	x	x
Potamogeton epihydrus Raf.	ribbon-leaf pondweed	x	
Potamogeton gramineus L.	variable-leaf pondweed	x	x
Potamogeton illinoensis L.	Illinois pondweed		x
Potamogeton pectinatus L. (currently *Stuckenia pectinata* L.)	sago pondweed	x	x
Potamogeton perfoliatus L	Clasping-leaved Pondweed	x	x
Potamogeton praelongus Wulfen	white-stem pondweed	x	x
Potamogeton pusillus L.	small pondweed	x	x
Potamogeton richardsonii (Ar. Benn.) Rydb.	Richardsons' pondweed		x
Potamogeton robbinsii Oakes	Robbins' pondweed	x	
Potamogeton zosteriformis Fern.	flat-stem pondweed	x	x
Ranunculus longirostris Godron	white watercrowfoot	x	x
Sagittaria graminea Michx.	arrowhead	x	x
Sparganium sp.	burreed	x	
Spirodela polyrhiza (L.) Schlieden	great duckweed	x	
Trapa natans L.	waterchestnut	x	x
Typha sp.	cattail	x	x
Utricularia vulgaris L.	great bladderwort	x	
Vallisneria americana L.	wild celery	x	x

Maximum Depth of Colonization

Maximum depth of colonization by rooted aquatic plant growth extended to a depth of 6 meters, defining the littoral zone. Depth distribution of sampling points (Figure 3) was equitable throughout the littoral zone. Calculated maximum depth of colonization (MDOC) by aquatic plants ranged from 4.3 to 4.9 m, and was comparable to that reported in 1994 (Eichler and Boylen, 1995). *Ceratophyllum demersum* was reported for a single sample in a depth of 8.8

1982 (21 species, Hardt et al., 1983) and 1969 (20 species, Dean, 1969). One previously unreported

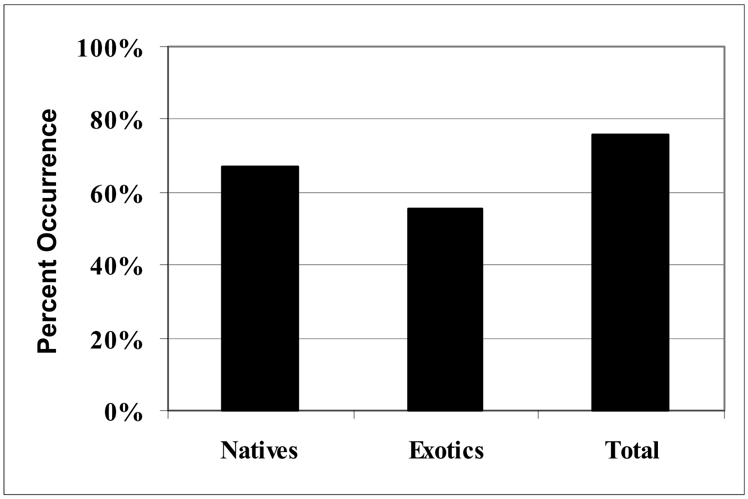
Table 2. Saratoga Lake point intercept percent frequency of occurrence data.

Species	**Percent Frequency**
Myriophyllum spicatum	54.2%
Ceratophyllum demersum	38.2%
Zosterella (Heteranthera) dubia	28.6%
Vallisneria americana	23.4%
Najas guadalupensis	11.4%
Elodea canadensis	7.4%
Chara/Nitella	6.8%
Potamogeton zosteriformes	6.2%
Najas flexilis	5.5%
Potamogeton perfoliatus	2.8%
Lemna trisulca	2.5%
Megalodonta beckii	1.8%
Potamogeton illinoensis	1.8%
Potamogeton praelongus	1.5%
Potamogeton crispus	1.2%
Potamogeton pusillus	0.6%
Potamogeton gramineus	0.3%
Nuphar luteum	0.3%
Potamogeton amplifolius	0.3%
Stuckenia pectinata	0.3%
Trapa natans	0.3%

species, (*Potamogeton illinoensis*), was encountered in 2004. This species is very similar in appearance to another commonly occurring pondweed, *Potamogeton amplifolius,* and easily overlooked or misidentified. The limited occurrence of *Potamogeton crispus* can be attributed to the timing of the current survey (August and September), rather than an actual decline in the abundance of this species. *Potamogeton crispus* generally reaches peak abundance in June and July, and then undergoes senescence. Species absent from the 2004 survey but present in prior surveys were generally either present in only a single survey year or relatively uncommon in prior surveys (<1% of survey points).

Sixty-seven percent of whole lake sampling points were vegetated by at least one native plant species (Figure 4), 79% of survey points with depths less than 6 m (Figure 5) and 89% of survey

Figure 4. Saratoga Lake frequency of occurrence summaries for sampling points of all water depths.



points less than 2 meters depth yielded native aquatic plants. Eurasian watermilfoil was present in 54% of whole lake survey points, and 66% of survey points less than 6 m water depth, representing the littoral zone or zone of aquatic plant growth.

For survey points within the littoral zone, water depth less than 6 m (Figure 5), results similar to whole lake surveys are reported. The expected relationship of greater frequency of occurrence of aquatic plants with shallower water depth is consistent with that reported by Eichler and Boylen

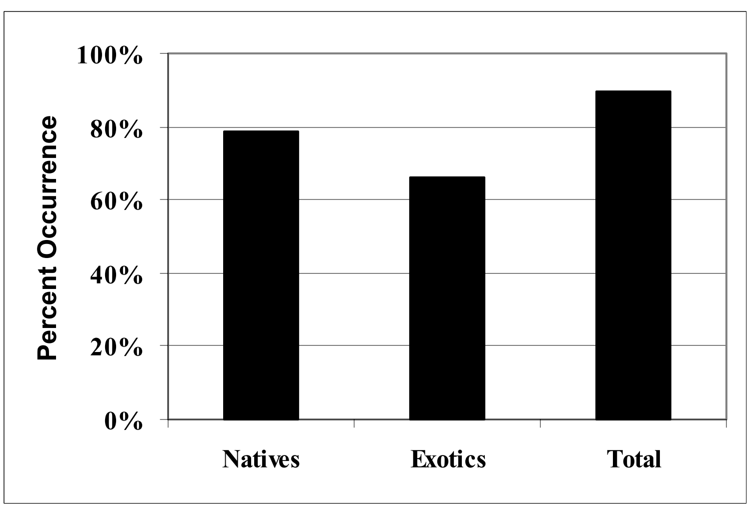


Figure 5. Saratoga Lake frequency of occurrence summaries for sampling points less than 6 meters water depth.

(1995) where frequency of occurrence values in the littoral zone ranged from 78 to 87% of survey points.

Species richness results for the point intercept survey are presented in Table 3 and Figure 6. In 2004 whole lake species richness was 2.00 species per survey point. For survey points exclusively within the littoral zone (depths less than 6 meters) species richness increases to 2.31 species per sample and the shallow end of the littoral zone (depths less than 2 meters) yields 3.04 species per sample point.

Native species richness was 1.65 species per survey point in the entire littoral zone (depths less than 6 meters). Whole lake native species richness was 1.43 species per sample. In the shallow portion of the littoral zone, depths less than 2 meters, species richness was 2.47 native species per sample. As expected, species richness in the littoral zone and its shallow fringe was higher than whole lake species richness. Lack of a Eurasian watermilfoil canopy in water depths less than 2 m may also allow for greater species richness.

Table 3. Saratoga Lake species richness for the point intercept survey.

Plant Grouping	Water Depth Class	Summary Statistic	Point Intercept Survey
Native plant species	Whole Lake (all depths)	Mean	1.43
		N	325
		Std. Error	0.08
	Points with depths <6m	Mean	1.65
		N	274
		Std. Error	0.09
	Points with depths <2m	Mean	2.47
		N	80
		Std. Error	0.18
All plant Species	Whole Lake (all depths)	Mean	2.00
		N	325
		Std. Error	0.10
	Points with depths <6m	Mean	2.31
		N	274
		Std. Error	0.10
	Points with depths <2m	Mean	3.04
		N	80
		Std. Error	0.21

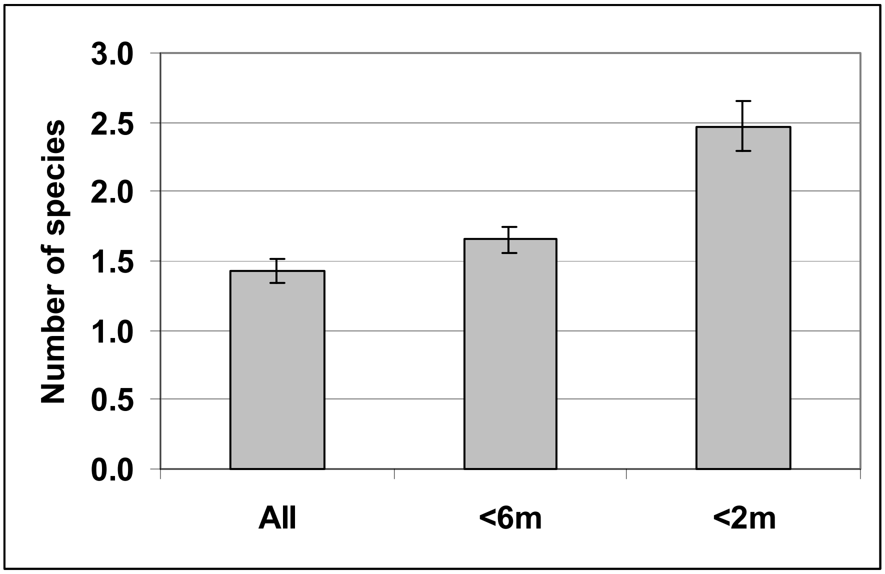


Figure 6. Saratoga Lake species richness for native species. Error bars are standard error of the mean.

Saratoga Lake Line Intercept Transects

Results for line-intercept transects were somewhat different than whole-lake littoral plant communities, although most individual species were represented in both (Table 1). The most common species based on frequency of occurrence were *Zosterella (Heteranthera) dubia* (47%), *Vallisneria americana* (39%), *Myriophyllum spicatum* (35%), *Chara* sp. (24%), *Najas flexilis* (21%), *Najas guadalupensis* (18%), *Elodea canadensis* (11%), and *Ceratophyllum demersum* (7%). Of the 23 species recorded for the line intercept transects in 2004, 14 increased in frequency of occurrence, 5 decreased and 4 were unchanged from the 1994 survey results. Frequency of occurrence of *Myriophyllum spicatum* in the line intercept transects increased between the 1994 and 2004 survey years, from 19% to 35% of survey points. The largest increase in frequency of occurrence was reported for *Zosterella dubia*, from 19% of survey points in 1994 to 47% of survey points in 2004. Species declining in frequency of occurrence were for the most part relatively uncommon (present in <2% of survey points) or reported at a single transect (*Potamogeton pusillus*). No major declines in native species frequency of occurrence were observed. As discussed in previous reports, suppression of canopy formation as a result of mechanical harvesting may account for the increase in frequency of occurrence of native species observed in 2004. Lack of dense Eurasian watermilfoil growth in shallow waters (<1.5m) may also allow for expansion of native plant populations.

Table 4. Frequency of occurrence for all species in the Saratoga Lake line intercept surveys.

	Line Intercept Survey	
Species	**2004**	**1994**
Ceratophyllum demersum	6.9%	3.9%
Chara	24.1%	11.8%
Elodea canadensis	11.4%	4.8%
Lemna trisulca	0.9%	1.5%
Megalodonta beckii	2.6%	1.1%
Myriophyllum spicatum	34.6%	18.5%
Najas flexilis	21.1%	13.9%
Najas guadalupensis	17.6%	13.6%
Nuphar luteum	0.8%	1.1%
Potamogeton amplifolius	1.8%	0.0%
Potamogeton crispus	0.9%	0.0%
Potamogeton gramineus	2.6%	1.4%
Potamogeton illinoensis	6.8%	0.0%
Potamogeton perfoliatus	5.4%	5.1%
Potamogeton praelongus	0.3%	0.1%
Potamogeton pusillus	1.0%	8.9%
Potamogeton richardsonii	0.4%	0.4%
Potamogeton zosteriformes	5.8%	3.0%
Ranunculus longirostris	0.5%	0.6%
Sagittaria graminea	0.1%	0.1%
Stuckenia pectinata	2.3%	3.3%
Vallisneria americana	39.0%	38.0%
Zosterella dubia	47.4%	19.1%

The number of species recorded for the line intercept transects in Saratoga Lake have been relatively constant, ranging from 21 in 1982 (Hardt et al., 1983), to 22 in 1994 (Eichler and Boylen, 1995), and 23 in 2004. Species present however, have been variable from year to year, with a total of 32 species recorded between the 3 surveys. Differences have generally been in the less common species, less than 2% frequency of occurrence, or in species represented in only a single survey year (10 species). One species was reported in the 2004 survey for the first time, *Potamogeton illinoensis*, a native species common to the region.

The number of species per transect in 2004, or species richness, increased at most locations (6 of 8 transects) when compared to prior surveys in 1982 and 1994 (Figure 7). The largest increases were at transects 1, 5, 6 and 8. Transects 1 and 8 were located in areas experimentally treated

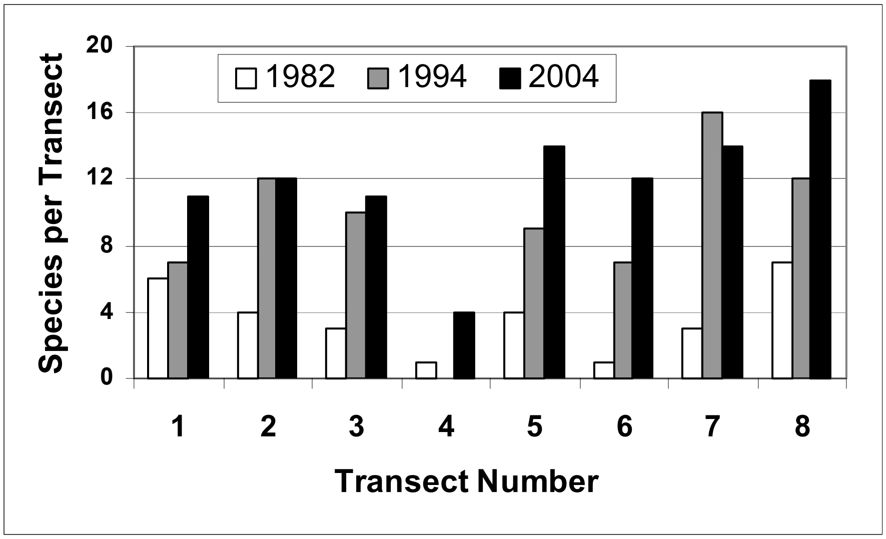


Figure 7. Species recorded per transect in 1982 (Hardt et al., 1983), 1994 (Eichler and Boylen, 1995) and 2004.

with herbicide in 2003. Transects 5 and 6 have extensive areas of shallow water with limited growth of Eurasian watermilfoil.

Species richness for the Saratoga Lake line intercept transects (Figure 8) ranged from a high of 4.1 species per survey point at transect 1 (Franklins Beach) to a low of 0.2 species per survey point at transect 4 (Stony Point). Exposed bedrock greatly limited aquatic plant abundance at the Stony Point transect. At the Franklins Beach site, extensive areas of shallow water (less than

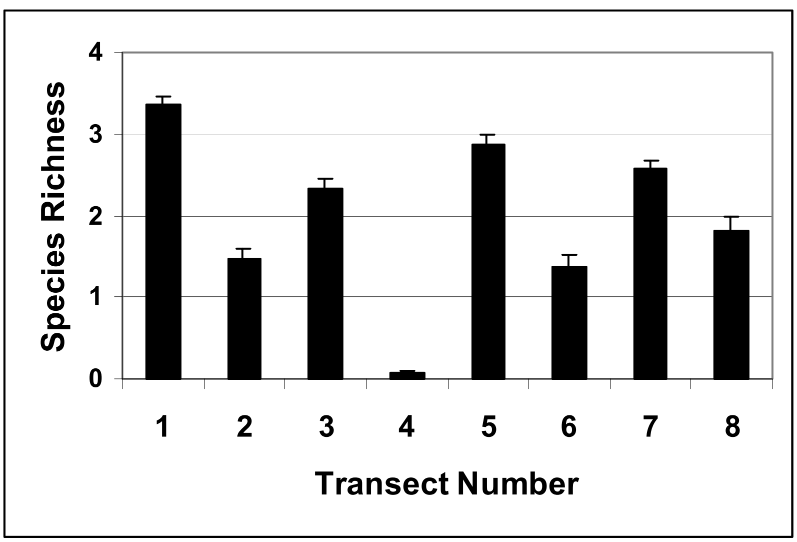


Figure 8. Species richness for the line intercept transects. Error bars are standard error.

1.5m depth) coupled with an experimental herbicide application in 2003, may account for higher than average species richness, as a result of reduced abundance of Eurasian watermilfoil. Declines in native species richness following expansive growth of *Myriophyllum spicatum* have been well documented (Madsen et al. 1989, 1991). Conversely, species richness increases in areas where Eurasian watermilfoil growth is reduced (Boylen et al., 1996).

In 2004, species richness lakewide was 2.3 species per survey point, an increase from 1.5 species per survey point reported in 1994 (Figure 9). Native plant species richness in 2004 was 2.0 species per survey point, an increase from 1.3 species per survey point in 1994 (Figure 9).

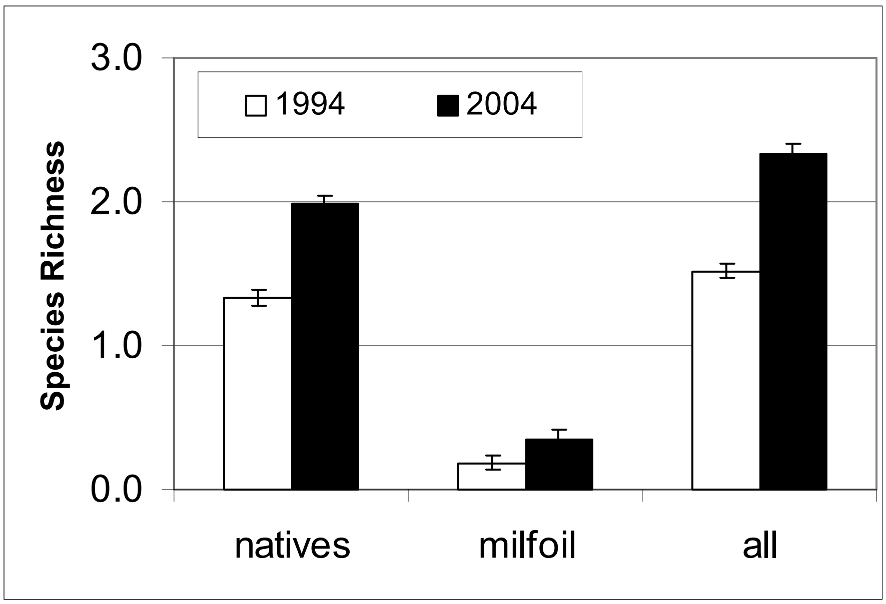


Figure 9. Species richness for the line intercept transects for 1994 and 2004. Error bars are standard error.

While frequency of occurrence increased, Eurasian watermilfoil average percent cover declined between 1994 and 2004 for the line intercept transects. The decline in average percent cover of Eurasian watermilfoil was primarily in water depths less than 2 m, the area of the lake affected by winter drawdown and ice scour.

Summary

Quantitative aquatic plant surveys were undertaken in 2004 for Saratoga Lake, New York as part of a cooperative effort between Aquatic Control Technologies (ACT) and the Darrin Fresh Water Institute, and supported by the Saratoga Lake Protection and Improvement District (SLPID). The project was designed to obtain data to evaluate current aquatic plant management efforts and review potential new strategies. The project consisted of three components: 1) collection of herbarium specimens throughout the lake for compilation of a species list, 2) point-intercept frequency and depth data for points distributed throughout the lake, and 3) line-intercept transect data for selected areas of the lake.

In Saratoga Lake, Eurasian watermilfoil (*Myriophyllum spicatum*) expanded rapidly after an initial invasion in the 1970's. *Myriophyllum spicatum* populations were first confirmed in the mid-1970's and reported to be the dominant aquatic plant species in the lake by the early-1980's (Hardt et al., 1983). In 1994, the Saratoga Lake aquatic plant community contained 23 submersed species, 3 native rooted floating-leaf species, 2 native emergent species and 1 free floating species (Eichler and Boylen, 1995). *Myriophyllum spicatum* was the most common plant species, present in 68 percent of survey points. Two other exotic aquatic plant species were reported, *Potamogeton crispus* and *Trapa natans*. *Potamogeton crispus* is seasonally abundant, forming a dense band at the deep margins of Eurasian watermilfoil growth in the spring and early summer. *Trapa natans* has been reported as scattered individuals on the delta of Kayadeross Creek and in Mannings Cove.

In August of 2004, the aquatic plant community of Saratoga Lake included 21 submersed species, 3 floating-leaved species, 1 floating species and 3 emergent species. A total of 21 species were collected in the point intercept portion of the survey. These results are comparable to previous surveys in 1994 (22 species, Eichler et al., 1994), 1982 (21 species, Hardt et al., 1983) and 1969 (20 species, Dean, 1969). One previously unreported species (*Potamogeton illinoensis*) was encountered in 2004. This species is very similar in appearance to another commonly occurring pondweed, *Potamogeton amplifolius,* and easily overlooked or misidentified. Species absent from the 2004 survey but present in prior surveys were generally either present in only a single survey year (10 species) or relatively uncommon in prior surveys (<1% of survey points). Three exotic species, *Myriophyllum spicatum, Potamogeton crispus* and *Trapa natans* were reported, however both *Potamogeton crispus* and *Trapa natans* were limited to only a few specimens. The timing of the current survey (August) may have lead to under-reporting the relative abundance of *Potamogeton crispus*, since this species generally reaches peak abundance in June and July, and then undergoes senescence. *Myriophyllum spicatum* dominated the aquatic plant community, occurring throughout the littoral zone of Saratoga Lake and present from the waters edge to a depth of 5.7m. Eurasian watermilfoil reached its maximum abundance in waters of 2 to 4 meters depth where is dominated the aquatic plant population. While Eurasian watermilfoil was by far the most widely distributed plant (54% of survey points), a number of native species were also commonly observed. Species richness was

quite high, with a large number of species occurring in more than 10% of survey points. Increased species richness is most likely related to light availability, either through greater water clarity or a reduction in shading due to reduced Eurasian watermilfoil canopy effects. Suppression of canopy formation through mechanical harvesting may allow for light penetration and thus the survival of native plant species in areas of dense Eurasian watermilfoil growth. Changing water clarity may be a byproduct of the invasion of Saratoga Lake by zebra mussels (*Dreissena polymorpha*) in the mid-1990's. Improved water clarity is frequently reported following zebra mussel invasions due to their ability to filter large volumes of phytoplankton from the water column. Reduced Eurasian watermilfoil density in shallow waters as a result of winter draw-down and ice scouring has also provided areas for colonization of native species resistant to winter draw-down.

Lakewide aquatic plants were found to cover 67% of the lake bottom in the littoral zone. The littoral zone or maximum depth of colonization (MDOC) by aquatic plants was calculated to extend to a depth of 4.9m. *Ceratophyllum demersum* and *Najas guadalupensis*, however were commonly found between 5 and 6 meters depth, with occasional *Myriophyllum spicatum* specimens also encountered, suggesting a littoral zone maximum depth of approximately 5.5m, 0.5m greater than reported in 1994.

Estimates of the amount of lake bottom supporting dense growth of Eurasian watermilfoil have been developed since the 1980's. In 1982, Hardt et al. estimated that approximately 870 acres of the bottom of Saratoga Lake supported dense growth of Eurasian watermilfoil (Table 5). Depth distribution indicated dense growth extended from the shoreline to water depths of 4 meters. In 1994, Eichler and Boylen estimated that Eurasian watermilfoil dominated 445 acres of lake bottom. The reduction in Eurasian watermilfoil growth between 1982 and 1994 was primarily in shallow waters, depth less than 1 meter, which was attributed to winter lake level draw-down and resultant ice scour. Dense growth of Eurasian watermilfoil was reported in water depths of 1 to 4 meters in 1994 (Figure 9). In 2004, dense growth of Eurasian watermilfoil was found to cover 736 acres of the bottom of Saratoga Lake (Figures 9 & 10). The shallow margin of dense Eurasian watermilfoil growth is currently reported in water depth of 1.5 m. The deep margin of growth has expanded to water depths of 4.8m, possibly due to greater water transparency.

Table 5. Acreage of Dense Growth of Eurasian watermilfoil in Saratoga Lake.

Survey Year	Acres of Dense Eurasian watermilfoil growth
1982	**870**
1994	**445**
2004	**736**

Principal areas of expansion are in the northeast at Franklins Beach and the southwest in the area of Rileys Cove (Figures 10 & 11).

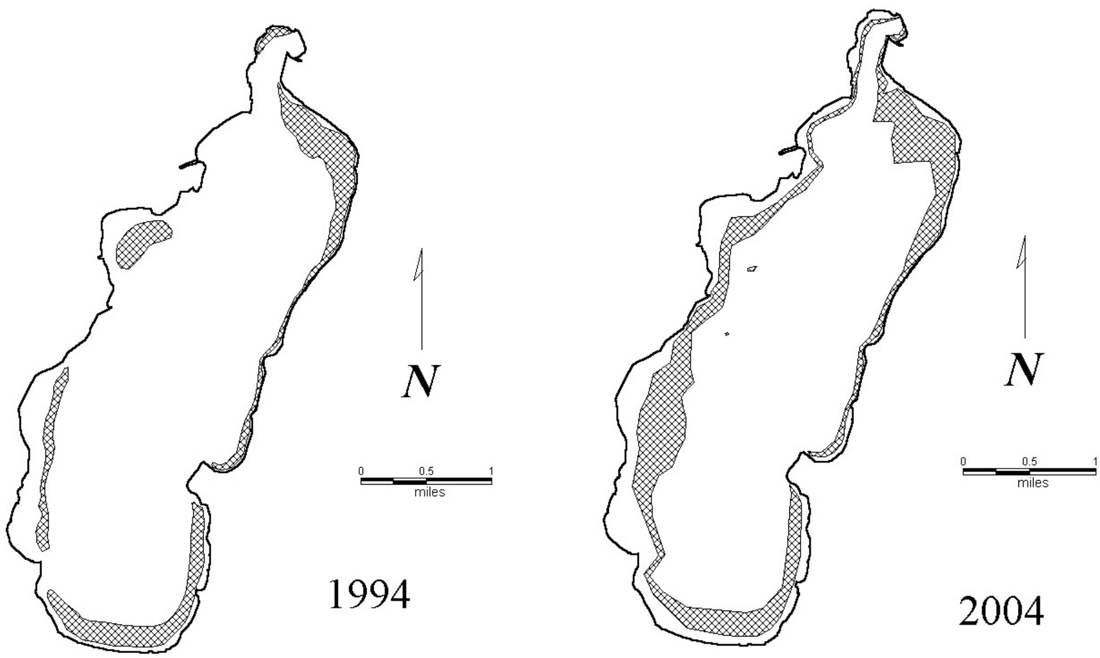


Figure 10. A comparison of the distribution of dense Eurasian watermilfoil (*Myriophyllum spicatum*) growth in Saratoga Lake in 1994 and 2004.

Evidence suggests that a native species, Water Stargrass (*Zosterella dubia*) is replacing Eurasian watermilfoil at the shallow end of its range. The frequency of occurrence of *Zosterella dubia* has increased substantially, reported in 19% of samples in 1994, and currently occurring in 47% of samples. The operators of the mechanical harvesters report that *Zosterella dubia* has become a prevalent species in their harvested materials. Survey results indicate that this species is found growing densely in waters of 1 to 1.5 m depth at the inner margins of dense Eurasian watermilfoil growth. Consideration of the growth habits of this species may be a consideration in future management efforts.

Management of nuisance levels of aquatic plants in Saratoga Lake has been based on winter lake level drawdown and mechanical harvesting. These two practices were instituted in 1984 and continue on an annual basis. As stated in previous reports, mechanical cutting/harvesting is generally considered a short-term (within a growing season) management tool designed to remove plants interfering with recreational access to lake waters. While declines in aquatic vegetation in the long term (more than 1 year) have been reported for this technique, it is generally considered to be effective only in the short term. In evaluations conducted in 1982 in Saratoga Lake, regrowth of Eurasian watermilfoil to pre-harvest levels was generally observed within 30 days. While long-term reductions in Eurasian watermilfoil abundance have not been reported, benefits of mechanical harvesting may include reduced canopy formation of both Curly-leaf pondweed and Eurasian watermilfoil. Lack of canopy formation allows light penetration to the lake bottom, which in turn permits an understory of native aquatic plant species to survive. In 2000 and 2003, two additional aquatic plant management tools were evaluated on an experimental basis, biological control agents (weevils) and herbicide (Sonar) application. Biocontrol agents, while promising, are experimental at the present time. Native species richness in the herbicide treated areas has increased, however Eurasian watermilfoil is still the dominant species.

While differences in the distribution of dense growth of Eurasian watermilfoil were observed, there is no indication of a lake-wide decline in Eurasian watermilfoil in Saratoga Lake. Changes in the distribution of Eurasian watermilfoil can generally be attributed to reduced abundance in the shallow end of its depth range and increased abundance at the deep margins of growth. Shallow water reductions are most likely the result of winter drawdown and resultant ice scouring. The expansion of Eurasian watermilfoil at the deep margin of its growth can be related to increasing water clarity in Saratoga Lake. Mechanical harvesting efforts to date appear to have improved recreational access to the open waters of the lake through reduction of near surface growth of Eurasian watermilfoil.

References

Boylen, C.W., L.W. Eichler and J.W. Sutherland. 1996. Physical control of Eurasian watermilfoil in an oligotrophic lake. Hydrobiologia 340:213-218.

Dean, H. 1969. Aquatic vegetation survey of Saratoga Lake. NYS Dept. of Environmental Conservation, Bureau of Pesticides Report. Albany, NY.

Eichler, L.W. and C.W. Boylen. 1995. An aquatic plant assessment of Saratoga Lake. Darrin Fresh Water Institute Technical Report 95-1. Darrin Fresh Water Institute, Bolton Landing, NY. Prepared for the Saratoga Lake Protection and Improvement District, Ballston Spa, NY.

Hardt, F.W., G. Hodgson and G.F. Mikol. 1983. Saratoga Lake Phase I Diagnostic – Feasibility Study and Management Plan. US EPA Clean Lakes Program. September 1983. 236 pp.

Hellquist, C.B. 1993. Taxonomic considerations in aquatic vegetation assessments. Lake and Reserv. Manage. 7:175-183.

Madsen, J.D., J.W. Sutherland, J.A. Bloomfield, K.M. Roy, L.W. Eichler, and C.W. Boylen. 1989. Lake George aquatic plant survey final report. NYS Department of Environmental Conservation, Albany, NY. 350pp.

Madsen, J.D., J.W. Sutherland, J.A. Bloomfield, L.W. Eichler, and C.W. Boylen. 1991. The decline of native vegetation under dense Eurasian watermilfoil canopies. J. Aquat. Plant Mgmt 29:94-99.

Madsen, J.D. 1993. Biomass techniques for monitoring and assessing control of aquatic vegetation. Lake and Reserv. Manage. 7:141-154.

Madsen, J.D. 1999. Point intercept and line intercept methods for aquatic plant management. US Army Engineer Waterways Experiment Station Aquatic Plant Control Research Program Technical Note CC-02, Vicksburg, MS.

Mikol, G.F. and D.M. Polsinelli. 1985. New York State Lakes – Morphometric Atlas of Selected Lakes, Volume I – Region 5. Bureau of Water Research, New York State Department of Environmental Conservation, Albany, NY. 81pp.

New York State Conservation Department. 1932. A biological survey of the Upper Hudson Watershed. Supplement to the 22nd Annual Report, Albany, NY

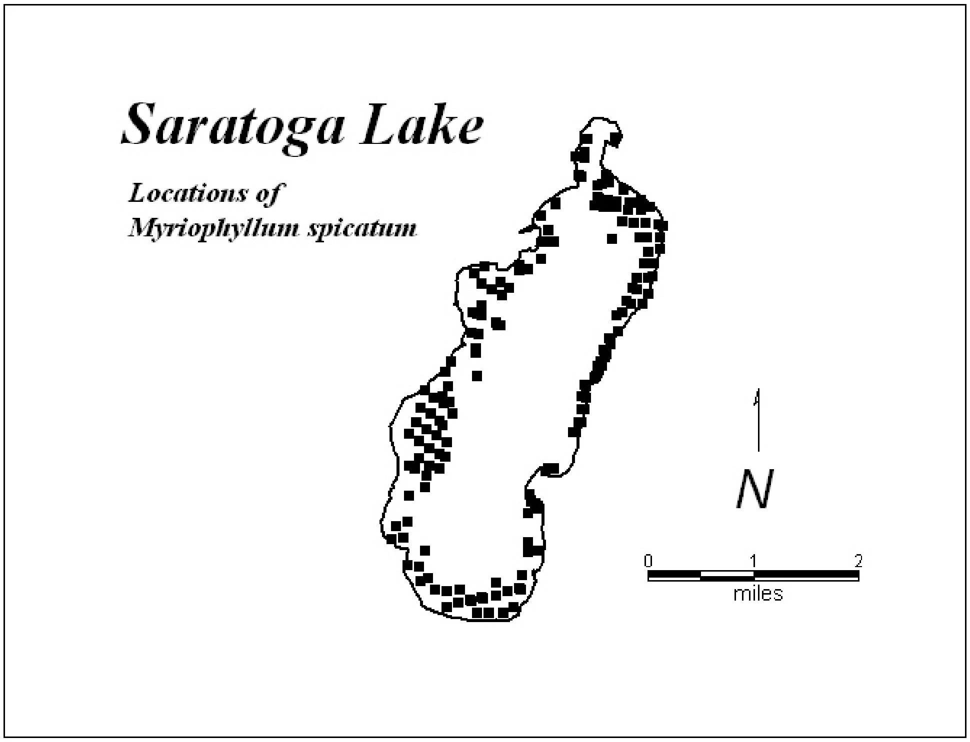
SLIPID. 2003. Interim report on water quality assessments of Saratoga Lake. Prepared by

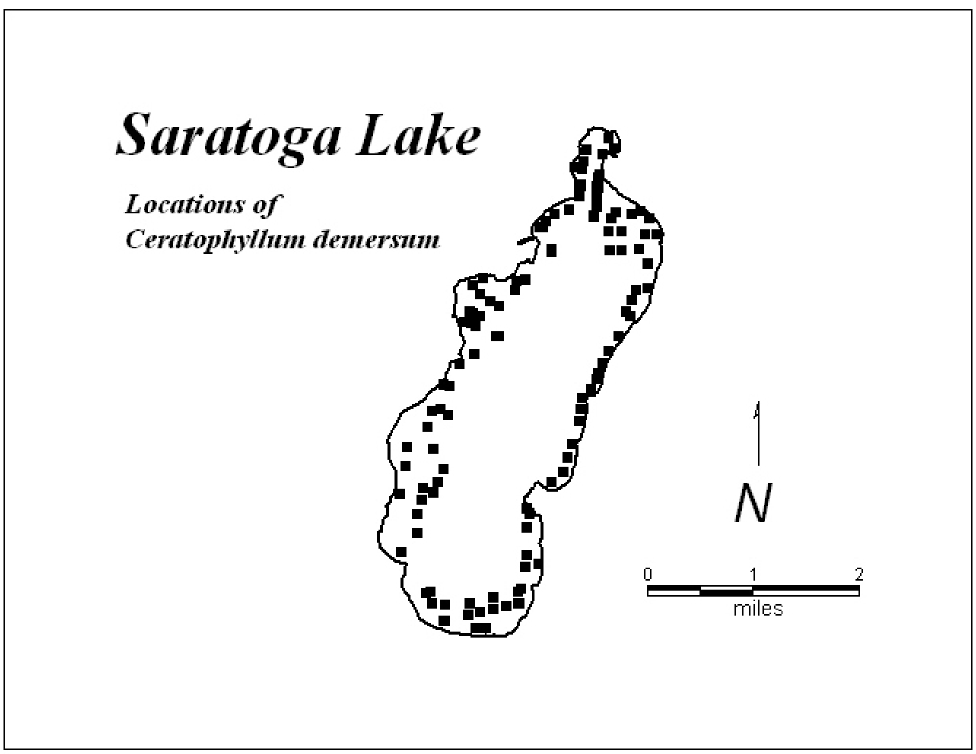
Adirondack Ecologists, Crown Point, NY for the Saratoga Lake Protection and Improvement District (SLPID)

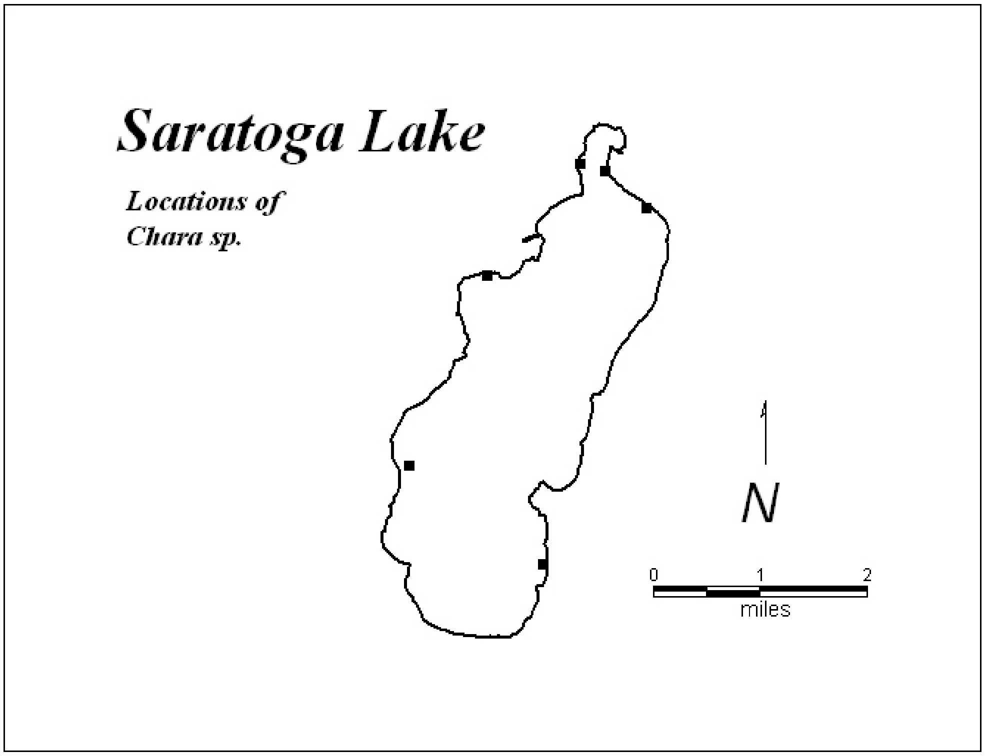
.

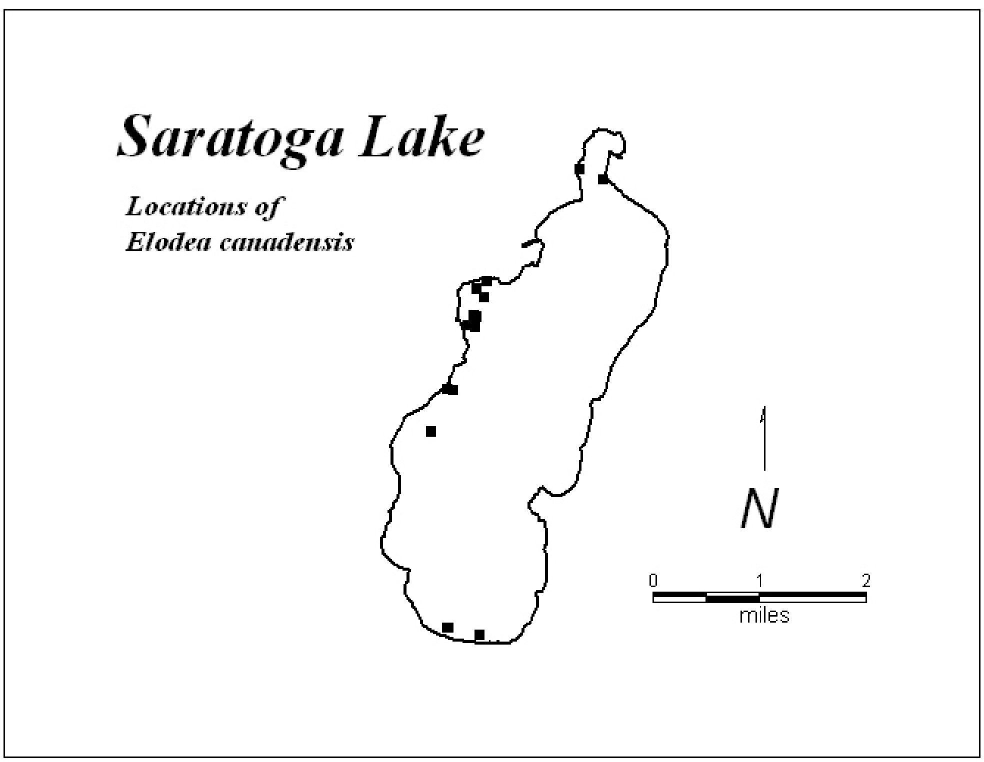
Acknowledgements

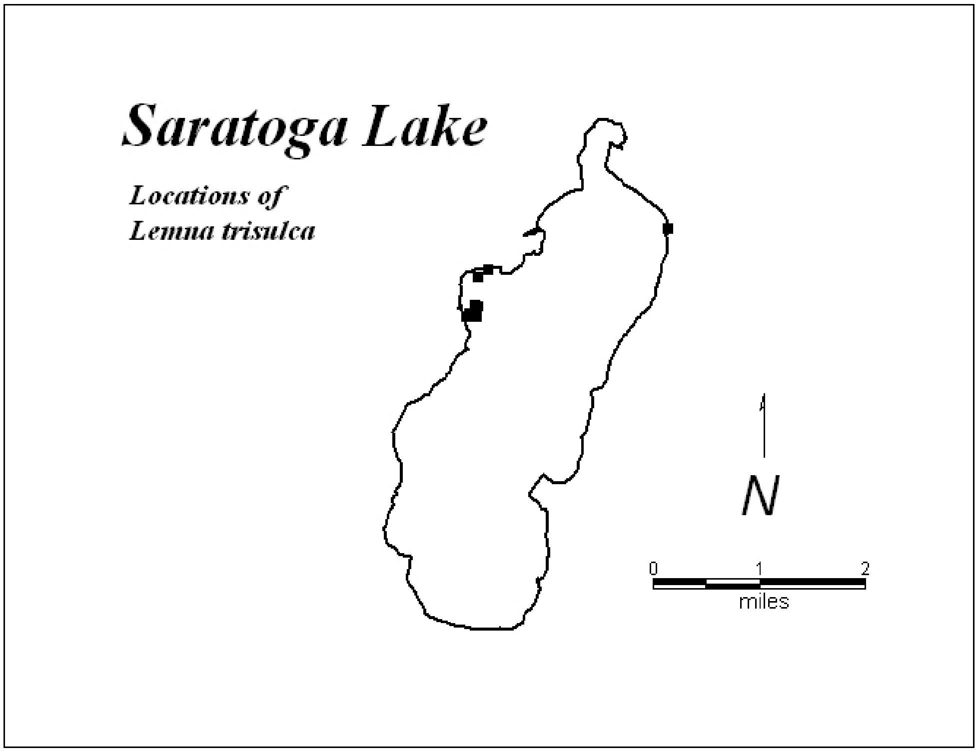
The authors would like to acknowledge Mr. Joseph Finn of the Saratoga Lake Protection and Improvement District for his assistance in coordinating lake access and development of the current survey project. We would like to thank Laurie Ahrens-Franklin and Tiffini Burlingame for their assistance in the field component of the project.

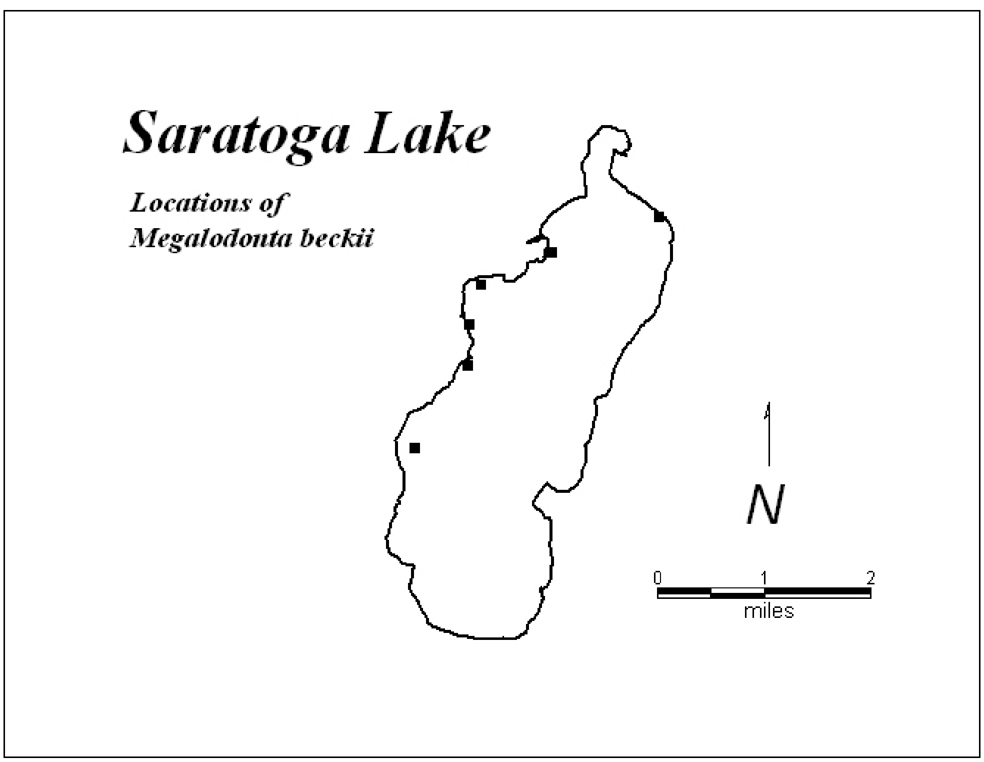

Saratoga Lake
Locations of
Myriophyllum spicatum
N
0
1
2
miles

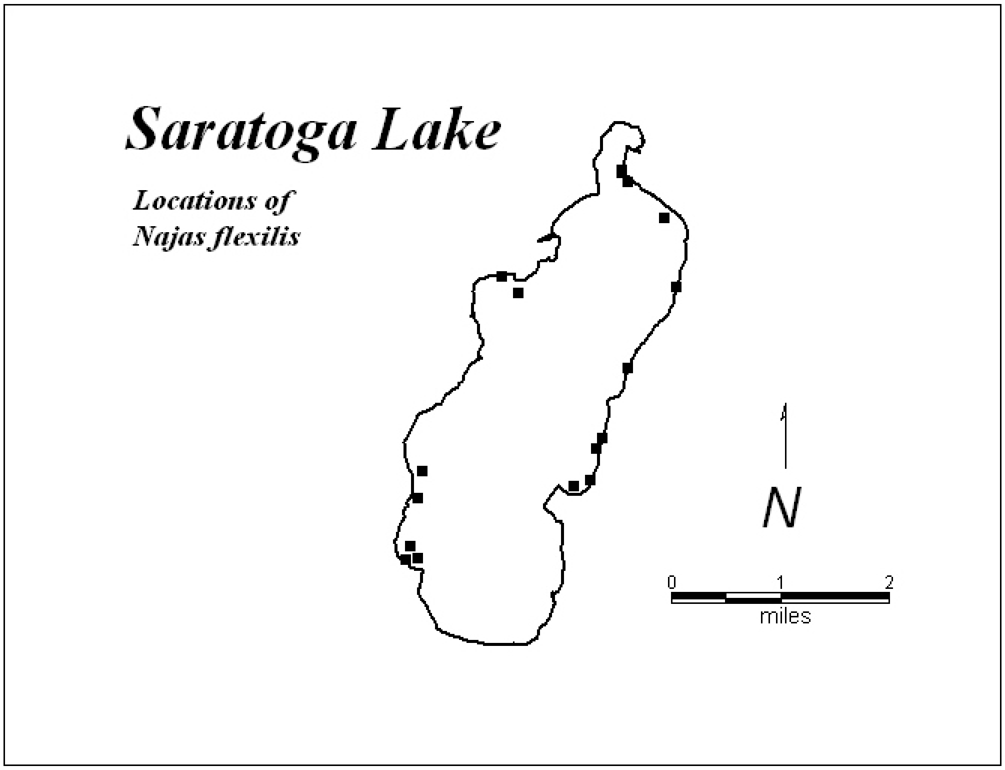

Saratoga Lake
Locations of
Ceratophyllum demersum
N
0
1
2
miles

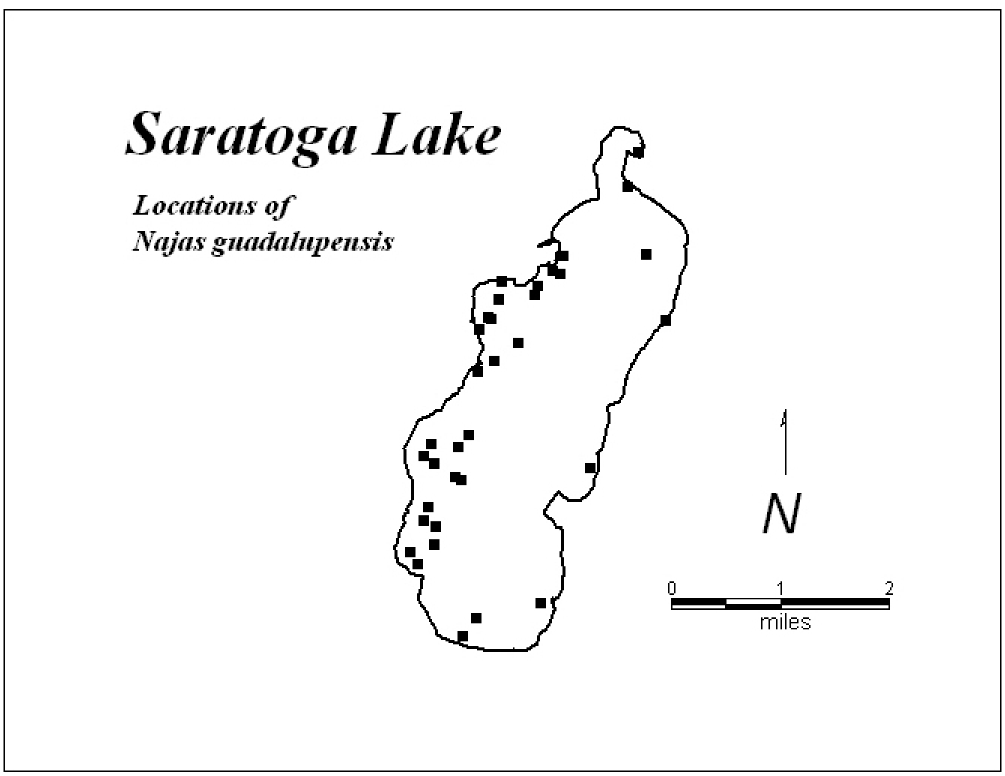

Saratoga Lake
Locations of
Chara sp.
N
0
1
2
miles

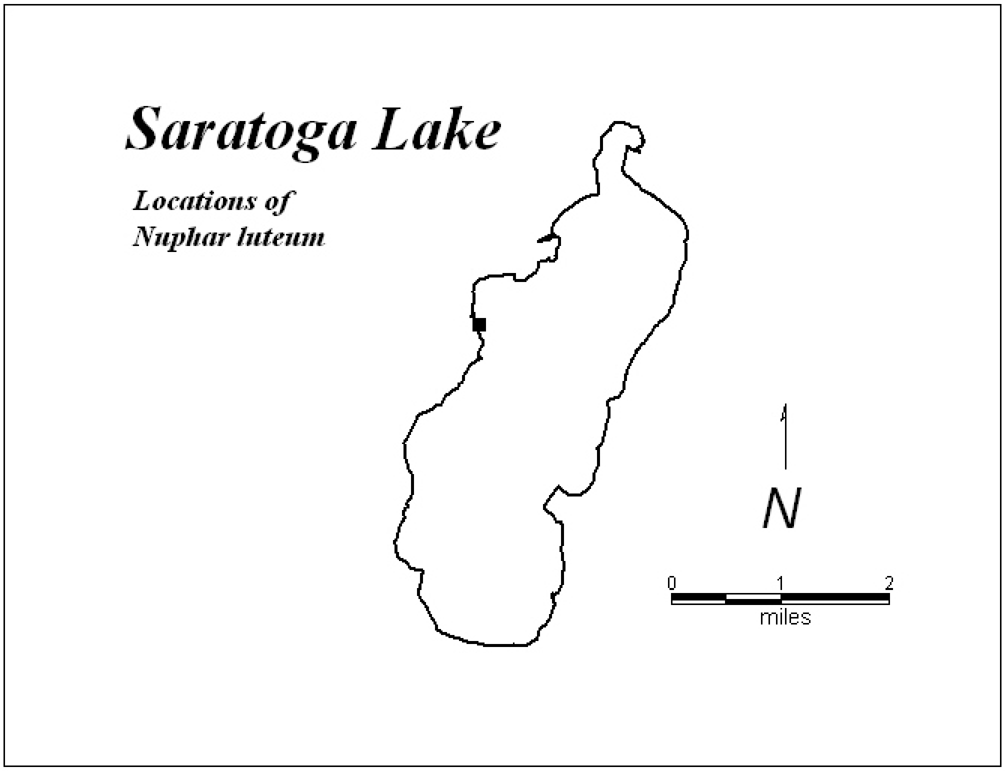

Saratoga Lake
Locations of
Elodea canadensis
N
0
1
2
miles

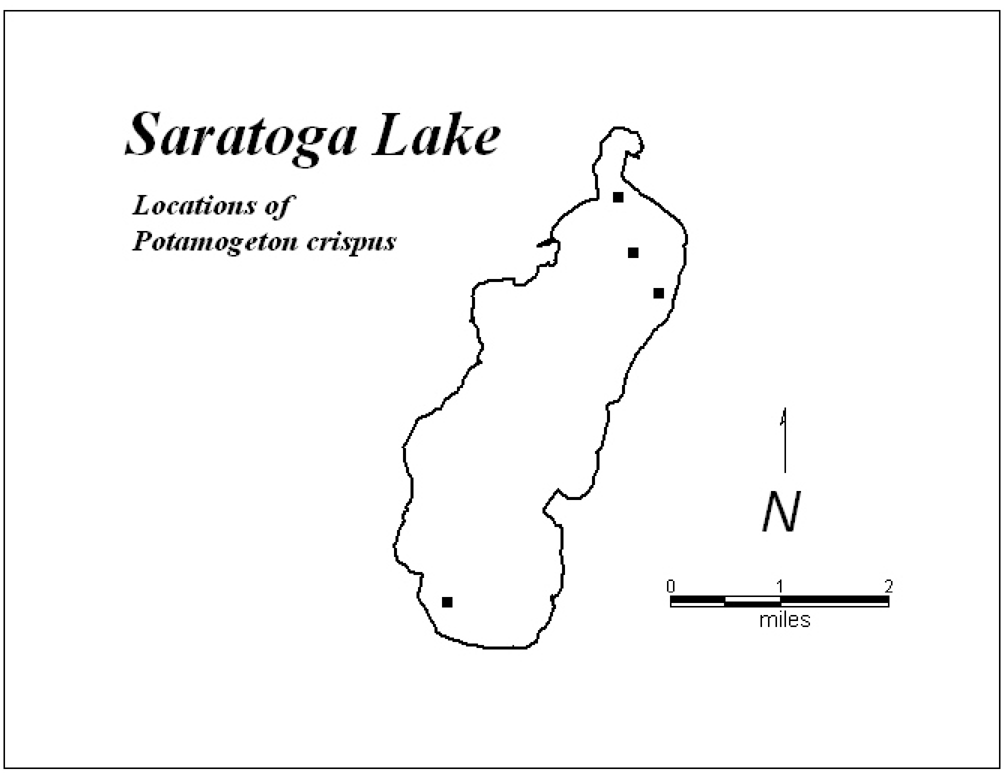

Saratoga Lake
Locations of
Lemna trisulca
N
0
1
2
miles

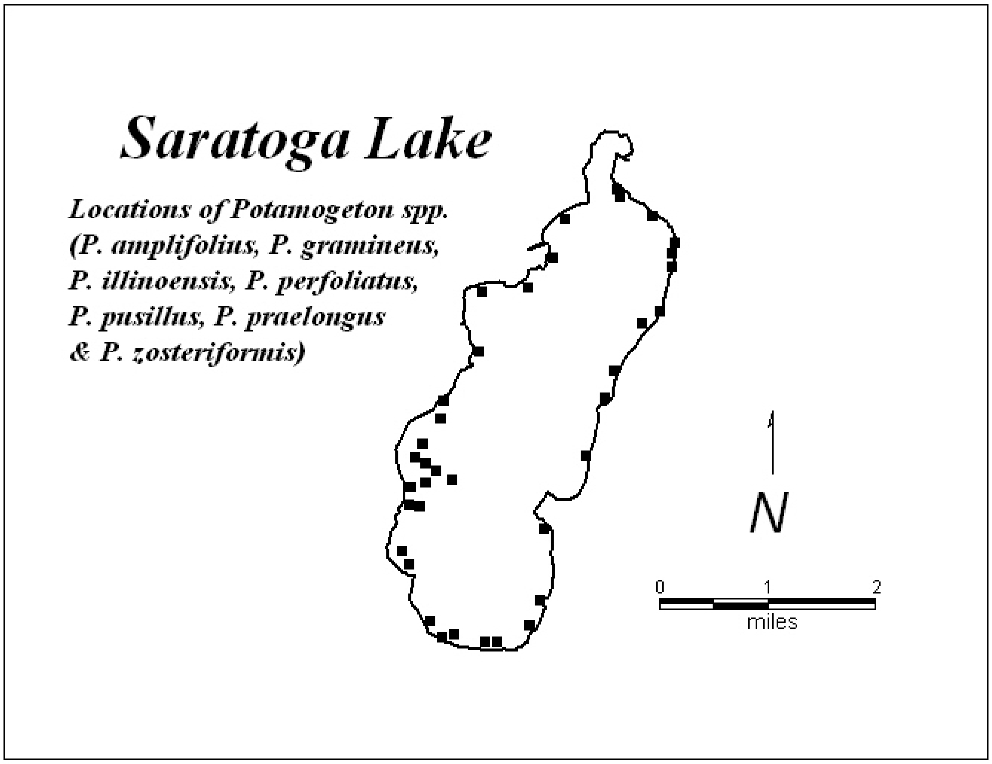

Saratoga Lake
Locations of
Megalodonta beckii
N
0
1
2
miles

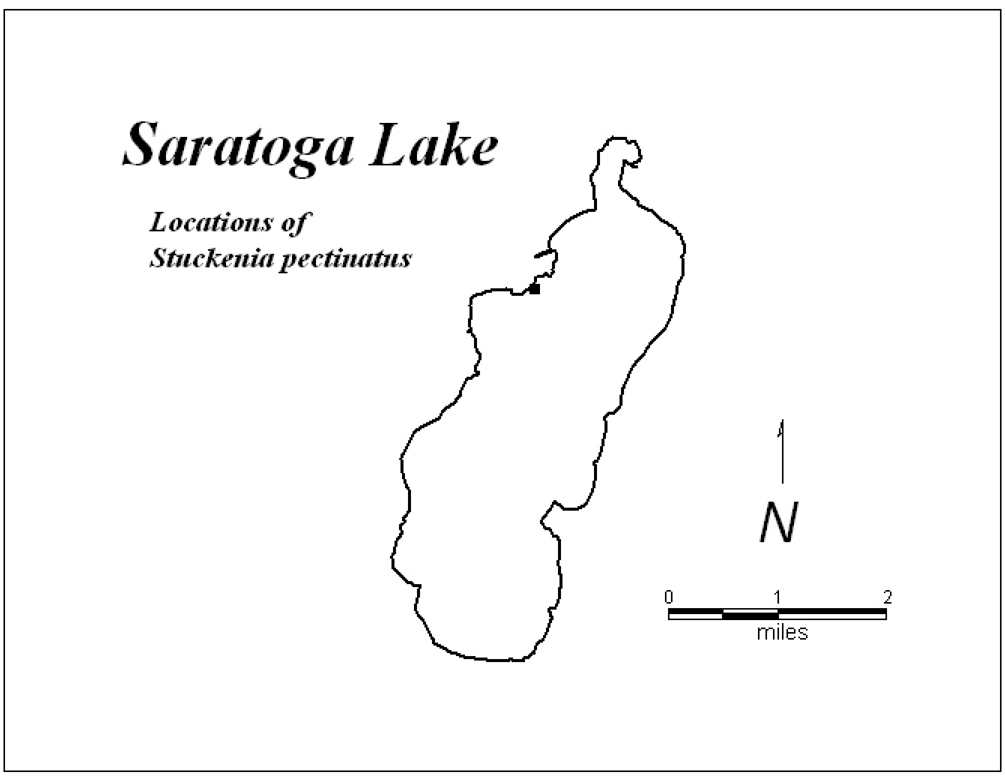

Saratoga Lake
Locations of
Najas flexilis
N
0
1
2
miles

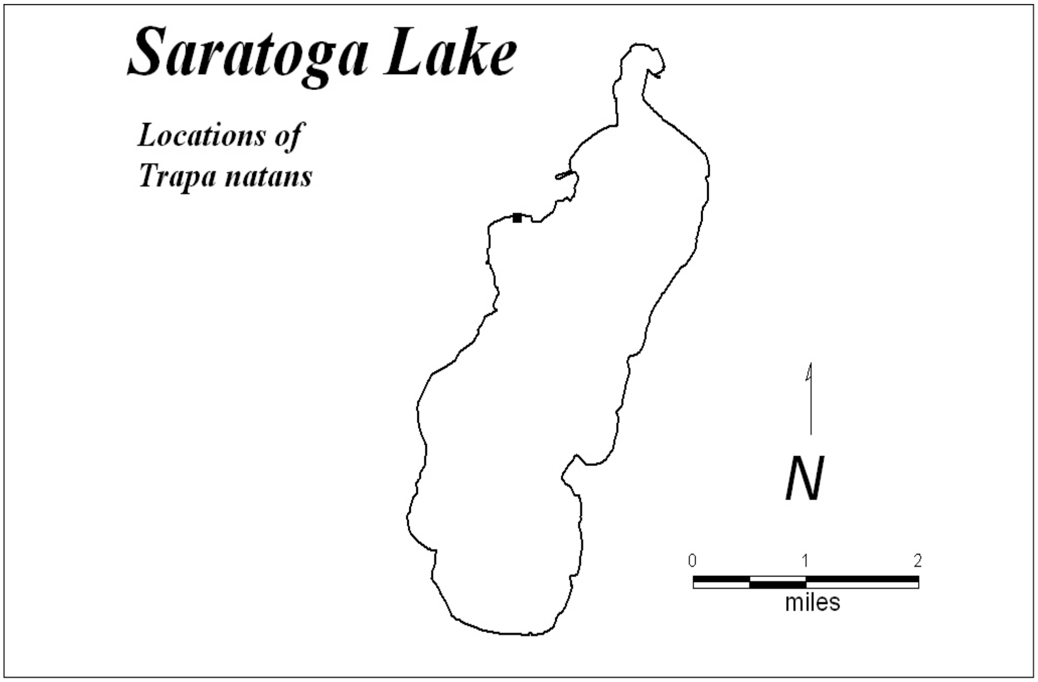

Saratoga Lake
Locations of
Najas guadalupensis
N
0
1
2
miles

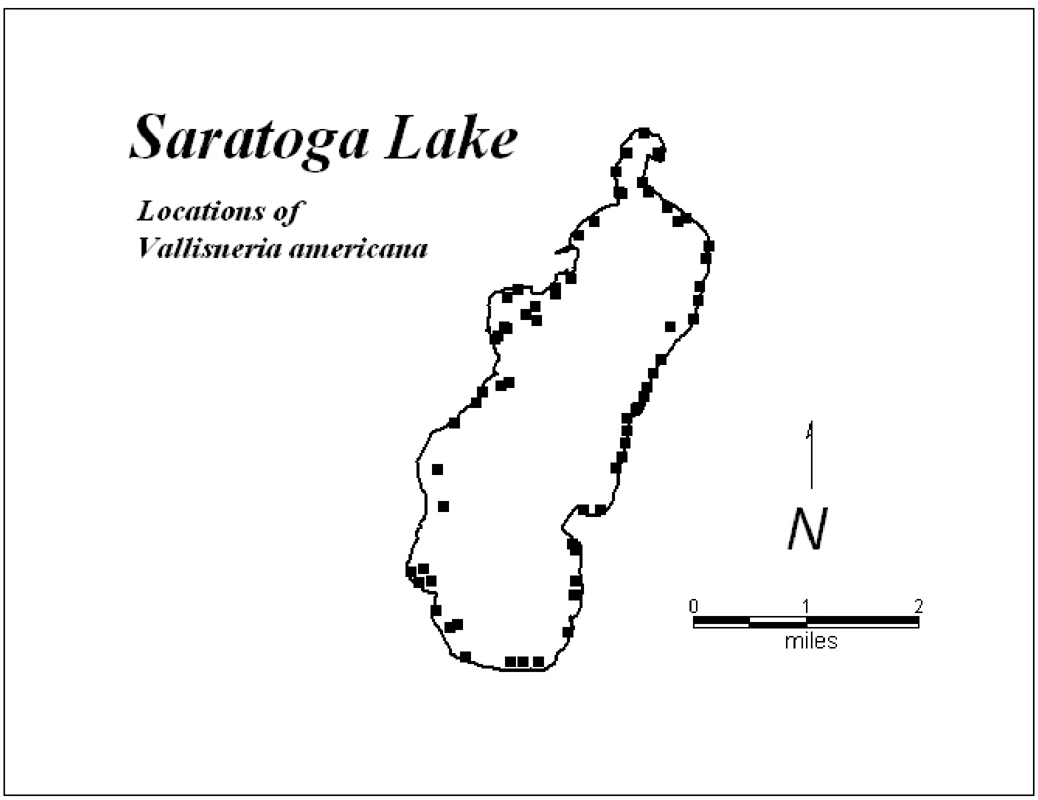

Saratoga Lake
Locations of
Nuphar luteum
N
0
1
2
miles

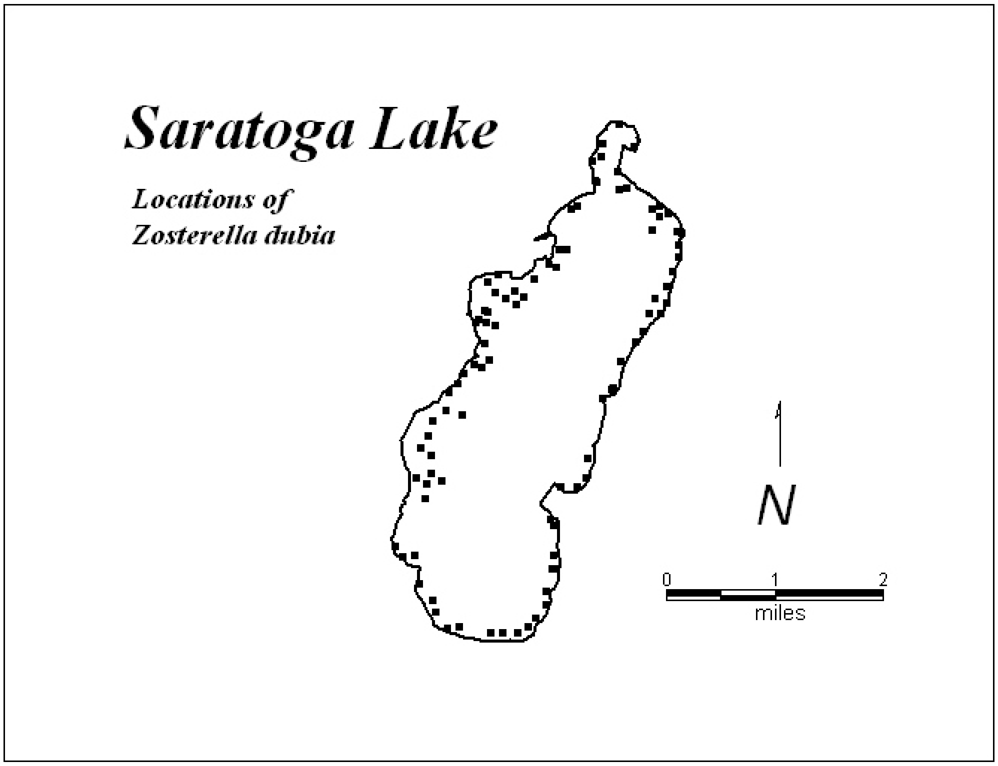

Saratoga Lake
Locations of
Potamogeton crispus
N
0
1
2
miles


Saratoga Lake
Locations of Potamogeton spp.
(P. amplifolius, P. gramineus,
P. illinoensis, P. perfoliatus,
P. pusillus, P. praelongus
& P. zosteriformis)
N
0
1
2
miles


Saratoga Lake
Locations of
Stuckenia pectinatus
N
0
1
2
miles


Saratoga Lake
Locations of
Trapa natans
N
0
1
2
miles


Saratoga Lake
Locations of
Vallisneria americana
N
0
1
2
miles


Saratoga Lake
Locations of
Zosterella dubia
N
0
1
2
miles

APPENDIX C - Harvesting Efficiency Calculations

Harvest Area	Linear Feet (along shoreline)	Harvest Width (estimated feet from shore)	Estimated Acreage Harvested	Acreage of Dense Milfoil Growth in Area	2004 Truckloads Removed	2002-2004 Average Truckloads Removed	2004 loads/ac	2002-2004 loads/ac
1	9800	400	90	99	83	88	0.9	1.0
2	7750	400	71	85	278	200	3.9	2.8
3	12150	200	56	81	197	162	3.5	2.9
4	5250	400	48	152	294	331	6.1	6.9
5	8150	300	56	25	108	108	1.9	1.9
6	3500	300	24	10	101	61	4.2	2.5
7	3200	300	22	36	148	51	6.7	2.3
8	6850	400	63	185	62	56	1.0	0.9
	56650	337.5	430	673	1271	1057	3.0	2.5

60% efficiency (5.5 hours/acre)

Harvest Area	Linear Feet (along shoreline)	Harvest Width (estimated feet from shore)	Estimated Acreage Harvested	Adjusted Acreage Harvested	2004 Truckloads Removed	2002-2004 Average Truckloads Removed	2004 loads/ac	2002-2004 loads/ac
1	9800	400	90	54	83	88	1.5	1.6
2	7750	400	71	43	278	200	6.5	4.7
3	12150	200	56	33	197	162	5.9	4.8
4	5250	400	48	29	294	331	10.2	11.4
5	8150	300	56	34	108	108	3.2	3.2
6	3500	300	24	14	101	61	7.0	4.2
7	3200	300	22	13	148	51	11.2	3.9
8	6850	400	63	38	62	56	1.6	1.5
	56650	337.5	430	258	1271	1057	4.9	4.1

Total shoreline area within 300-400 ft. from shore *430*
% harvested *0.600*

Treatment of southern third of lake

Harvest Area	Linear Feet (along shoreline)	Harvest Width (estimated feet from shore)	Estimated Acreage Harvested	Adjusted Acreage Harvested		2002-2004 Average Truckloads Removed	% of Harvest Effort	Adjusted %of harvest effort	# loads added from 250 loads moved from southern third	2002-2004 loads/ac	Additional Acres Harvested	Total Acres Harvested
1	9800	400	90	54		88	0.08					
2	7750	400	71	43		200	0.19					
3	12150	200	56	33		162	0.15	0.12	30.0	4.8	6.3	39.7
4	5250	400	48	29		331	0.31	0.48	120.0	11.4	10.5	39.5
5	8150	300	56	34		108	0.10	0.15	37.5	3.2	11.7	45.4
6	3500	300	24	14		61	0.06	0.09	22.5	4.2	5.4	19.8
7	3200	300	22	13		51	0.05	0.08	20.0	3.9	5.1	18.4
8	6850	400	63	38		56	0.05	0.08	20.0	1.5	13.3	51.1
	56650	337.5	430	258		1057	1.00	1	250.0			213.8

Total shoreline area within 300-400 ft. from shore *269*

% harvested *0.794*

Treatment of southern half of lake

Harvest Area	Linear Feet (along shoreline)	Harvest Width (estimated feet from shore)	Estimated Acreage Harvested	Adjusted Acreage Harvested	2004 Truckloads Removed	2002-2004 Average Truckloads Removed	% of Harvest Effort	Adjusted %of harvest effort	# loads added from 465 loads moved from southern half	2002-2004 loads/ac	Additional Acres Harvested	Total Acres Harvested
1	9800	400	90	54	83	88	0.08					
2	7750	400	71	43	278	200	0.19					
3	12150	200	56	33	197	162	0.15	0.13	60.5	4.8	12.6	46.1
4	5250	400	48	29	294	331	0.31	0.52	241.8	11.4	21.2	50.1
5	8150	300	56	34	108	108	0.10	0.17	79.1	3.2	24.7	58.4
6	3500	300	24	14	101	61	0.06	0.1	46.5	4.2	11.1	25.5
7	3200	300	22	13	148	51	0.05	0.08	37.2	3.9	9.5	22.8
8	6850	400	63	38	62	56	0.05					
	56650	337.5	430	258	1271	1057	1.00	1		0.0		202.9

Total shoreline area within 300-400 ft. from shore *206*

% harvested *0.984*

Treatment of northern half of lake

Harvest Area	Linear Feet (along shoreline)	Harvest Width (estimated feet from shore)	Estimated Acreage Harvested	Adjusted Acreage Harvested		2002-2004 Average Truckloads Removed	% of Harvest Effort	Adjusted %of harvest effort	# loads added from 580 loads moved from northern half	2002-2004 loads/ac	Additional Acres Harvested	Total Acres Harvested
1	9800	400	90	54		88	0.08	0.19	110.2	1.6	68.9	122.9
2	7750	400	71	43		200	0.19	0.45	261.0	4.7	55.5	98.2
3	12150	200	56	33		162	0.15	0.17	98.6	4.8	20.5	54.0
4	5250	400	48	29		331	0.31					
5	8150	300	56	34		108	0.10					
6	3500	300	24	14		61	0.06					
7	3200	300	22	13		51	0.05	0.06	34.8	3.9	8.9	22.1
8	6850	400	63	38		56	0.05	0.13	75.4	1.5	50.3	88.0
	56650	337.5	430	258		1057	1.00	1				385.3

Total shoreline area within 300-400 ft. from shore *269*

% harvested *1.431*

APPENDIX D - Herbicide Toxicology Summaries

HERBICIDE TOXICOLOGY & ENVIRONMENTAL FATE SUMMARIES

The following toxicology and environmental fate summaries were adapted from Appendix III of "Eutrophication and Aquatic Plant Management in Massashusetts; Final Generic Environmental Impact Report." This section was compiled by the Massachusetts Department of Environmental Protection, Office of Research and Standards.

Reference:

Mattson, M.D., P.J. Godfrey., R.A. Barletta and A. Aiello. 2004. Eutrophication and Aquatic Plant Management in Massachusetts. Final Generic Environmental Impact Report. Edited by Kenneth J. Wagner. Department of Environmental Protection and Department of Conservation and Recreation, EOEA, Commonwealth of Massachusetts.

Diquat (Reward)

Diquat dibromide (6,7 –dihydrodipyridol [1,2-ά:2',-c] pyrazinediium ion)

Distributing Company- Syngenta Group Greensboro, NC
EPA Registration Number- 100-1091
Percent of Active Ingredient- 35.3%
General- a water soluble contact type, nonselective herbicide
Aquatic Uses- used to control both submerged and floating weeds
Submersed Plants Controlled by Diquat- Bladderwort (*Utricularia*), Coontail (*Ceratophyllum demersum*), Elodea (*Elodea spp.*), Naiad (*Najas spp.*), Watermilfoil (*Myriophyllum spp.*), Hydrilla (*Hydrilla verticillata*), Pondweeds (*Potamogeton spp.*)
Mode of Action- Diquat is absorbed readily by foliage through the cuticle of the leaf. Absorption is rapid, resulting in concentrations in plant tissue well above that in surrounding water. Diquat's herbicidal activity is dependant on the diquat cation.
Environmental Fate- Following application dissipation of diquat is very rapid. At the maximum label rate of 4lbs/acre (in four feet of water) yields a concentration of 0.37ppm, falling to 0.10ppm within 24 hours and 0.01ppm within 14 days. Once diquat reaches the sediment it is irreversibly bound and becomes biologically unavailable.
Toxicity- As a result of Diquat's rapid dissipation acute effects on organisms in the field are unlikely at rates used for vegetation control. Studies have found that *Daphnia* and *Hyallella* are the most sensitive invertebrates with 24-hour LD50s of 1-2ppm, and 0.6ppm respectively. Diquat has shown no adverse effect on oysters, shrimp or fish. Toxicity of Diquat varies with the size and type of fish as well as the softness or hardness of water. One study reports LD50 values ranging from 12-90ppm for 24-hour exposures, 6-44ppm for 48-hour exposures and 4-36ppm for 96-hour exposures. The results of 13 experiments conducted with diquat indicate that diquat did not cause any direct mortality to any fish species at 1.0ppm and below. The highest concentration allowed by the manufacturer's label would equal an initial in-water concentration of 1.5ppm. When diquat concentrations diminish in the water, diquat concentrations in fish tissue clear.
Water Use Restrictions (at maximum label rate of 1.5ppm)-

Drinking – 3 days
Fishing and Swimming – 0 days
Livestock Consumption – 1 day
Irrigation for turf and ornamentals – 3 days
Irrigation for food crops – 5 days

Fluridone (Sonar (AS))

(1-methyl-3-phenyl-5-[3-(trifluoromethyl)phenyl]-4(1H)-pyridinone)

Distributing Company- SePRO Corporation, Carmel IN
EPA Registration Number- 67690-4
Percent of Active Ingredient- 41.7%
General- a selective systemic aquatic herbicide
Aquatic Uses- used to control broad-leafed aquatic macrophyte species
Submersed Plants Controlled by Fluridone- American Lotus (*Nelumbo lutea*), Bladderwort (*Utricularia*), Coontail (*Ceratophyllum demersum*), Duckweed (*Lemna minor*), Elodea (*Elodea spp.*), Fanwort (Cabomba caroliniana), Hydrilla (*Hydrilla verticillata*), Naiad (*Najas spp.*), Watermilfoil (*Myriophyllum spp.*), Pondweeds (except Illinois) (*Potamogeton spp.*), Spatterdock (Nuphar luteum), Waterlily (*Nymphaea spp.*), Waterprimrose (including *Waterpurlane*) (*Ludwigia spp.* including *Ludwigia palustris*), Watershield (*Brasenia schreberi*)
Mode of Action- Fluridone produces its toxic effect in plants by inhibiting carotenes (pigments that protect chlorophyll molecules from photodegredation)
Environmental Fate- Following application the major fate process affecting fluridone in aqueous environments is photolysis. Secondary fate processes include microbial degradation, absorption to soil and suspended colloids and plant uptake. Fluridone that has adhered to sediment particles/organics in sediment will eventually desorb and photodegrade.
Toxicity- At maximum label concentrations fluridone has no acute effects on aquatic organisms. At twice the maximum label rate (0.30ppm) fluridone has been shown to cause a reduction in certain zooplankton, however, populations recover quickly. Fish toxicology studies have found that Rainbow Trout are most sensitive to fluridone with 96-hour LD50 values of 11.7ppm, nearly eighty times the maximum label rate.
Water Use Restrictions (at maximum label rate of 150ppb)-
Drinking – 0 days
Fishing and Swimming – 0 days
Livestock Consumption – 1 day
Irrigation – 7-30 days

<u>2,4-D (BEE (butoxyethonol esters)) (Aqua-Kleen/Navigate)</u>

(2,4-dichlorophenoxyacetic acid)

Distributing Company- Cerexagri, Inc. Philadelphia, PA (Aqua-Kleen), Applied Biochemists Milwaukee, WI (Navigate)
EPA Registration Number- 228-378-4581 (Aqua-Kleen), 713668-4-8959 (Navigate)
Percent of Active Ingredient- 27.6%
General- a somewhat selective systemic broadleaf aquatic herbicide
Aquatic Uses- used to control a variety of submersed, emersed and floating aquatic plants
Submersed Plants Controlled by Fluridone- Arrowhead (*Sagittaria spp.*), Bladderwort (*Utricularia*), Bullrush (Scirpus spp.), Burreed (Sparganium spp.), Coontail (*Ceratophyllum demersum*), Creeping Waterprimrose (*Jussiaea repens*), Pickerelweed (*Pontederia spp.*), Spatterdock, Cow Lily, Yellow waterlily (*Nuphar spp.*), Waterweed (*Elodea spp. or Anacharis*), Waterchestnut (*Trapas natans*), Naiad (*Najasflexilis.*), Watermilfoil (*Myriophyllum spp.*), Pondweeds (*Potamogeton spp.*), Waterlily (*Nymphaea spp.*), Water Smartweed (*Polygonum spp.*), Watershield (*Brasenia schreberi*)
Mode of Action- 2,4-D is readily translocated throughout the plant phloem (the food-conducting tissue of vascular plants). It is a somewhat selective, systemic growth regulator with hormone-like activity. 2,4-D inhibits cell division of new tissue and stimulates cell division of some mature plant tissue, resulting in inhibition of growth, necrosis (death of cells) of apical growth and eventual total cell disruption and plant death.
Environmental Fate- The primary fate process of 2,4-D (BEE) in water is microbial biodegeneration and hydrolysis (decomposition of a chemical compound by reaction with water). Degradation of 2,4-D in aquatic sediment is rapid, generally occurring in less than one day through microbial biodegeneration.
Toxicity- 2,4-D (BEE), is toxic to fish with LD50s starting below 1ppm (0.78ppm for Cutthroat fingerlings). In-water concentrations following application of 2,4-D rarely exceed 0.3ppm and are generally much lower around 0.1-0.15ppm. Bioconcentration factors (BCF) values for 2,4-D (BEE) are very low. The ester formulation of 2,4-D is quickly hydrolyzed by organisms to its acid form and rapidly excreted. Applied at maximum label rate, 2,4-D poses little treat to aquatic organisms from either acute or chronic poisoning.
Water Use Restrictions (at maximum label rate of 200lbs/acre)-
Drinking – <0.07ppm*

Irrigation – <0.1ppm*
*concentrations to be determined by approved assay

Endothall (Aquathol K)

Dipotassium salt of endothall (7-oxabicyclo [2.2.1]heptane-2,3-dicarboxylic acid)

Distributing Company- Cerexagri, Inc. Philadelphia, PA
EPA Registration Number- 4581-204
Percent of Active Ingredient- 40.3%
General- a relatively water soluble contact herbicide
Aquatic Uses- used to control submersed aquatic macrophyte species
Submersed Plants Controlled by Endothall- Largeleaf pondweed (Bass Weed) (Potamogeton amplifolius), Burreed (Sparganium spp.), Coontail (*Ceratophyllum demersum*), Watermilfoil (*Myriophyllum spp.*), Bushy pondweed (Najas spp.), Curly-leaf pondweed (*Potamogeton crispus*), Flat-stemmed pondweed (*Potamogeton zosteriformis*), Floating-weed pondweed, (*Potamogeton natans*), Horned pondweed (*Zannichellia spp.*), Sago pondweed (*Potamogeton pectinatus*), *Potamogeton nodosus, Potamogeton diversifolius, Potamogeton filiformis, Potamogeton pusillus,* Water Star Grass (*Heteranthera spp.*)
Mode of Action- Not clear – Knowns: Endothall interferes with plant protein synthesis; affects lipid synthesis and dipeptidase and proteinase activities. Postulations: 1. Endothall produces a number of cell membrane changes that cause drying and wilting of leaf tissue and an increased respiratory rate in plants; 2. endothall acts to inhibit respiration; 3. endothall interferes with metabolism of molecules involved in genetic coding.
Environmental Fate- Following application the major fate process affecting endothall in aqueous environments is biotransformation and biodegeneration via microbial action. In aerobic conditions, endothall has a half-live of a week or less. In anoxic conditions this half-life is increased to about 10 days. Endothall applied to a waterbody at a rate of 0.3-1.4ppm has a half-life between 2.5-12 days. In general endothall usually undergoes compete degradation 30-60 days in aquatic systems depending on application rate and trophic conditions. Endothall does not adsorb to sediments nor does it bioconcentrate in organisms to any appreciable degree.
Toxicity- At maximum label concentrations endothall (in dipotassium salt formulation) has no acute effects on aquatic organisms. The maximum allowable application rate of endothall (as Aquathol K) is 5ppm. Studies have shown that typical 96-hour LC50 values for most aquatic organisms are greater than 150ppm, but rage from 39-740ppm. Toxicology studies have found that mysid shrimp are most sensitive to the Aquathol formulation of endothall with an LC50 value of 39ppm, nearly nine times the maximum label rate.
Water Use Restrictions (at maximum label rate of 5ppm)-
Drinking – 25 days
Fish Consumption – 3 days
Livestock watering – 25 days
Irrigation – 25 days

Triclopyr (Renovate 3)

(3,5,6-trichloro-2pyridinyloxyacetate acid, trithylamine salt)

Distributing Company- SePRO Corporation, Carmel, IN
EPA Registration Number- 62719-37-67690
Percent of Active Ingredient- 44.4%
General- Triclopyr is a systemic herbicide with selective control of woody and broadleaf species.
Aquatic Uses- Renovate 3 is labeled for control of submerged weeds, such as watermilfoil (*Myriophyllum spicatum*) in lakes, reservoirs or ponds, and in non-irrigation canals or ditches that have little or no continuous outflow. Triclopyr the ability to remove milfoil and allow non-invasive native monocots and tolerant dicots to proliferate.
Submersed Plants Controlled by Triclopyr-, Watermilfoil (*Myriophyllum spp.*), Spatterdock (*Nuphar spp.*), American Lotus (*Nelumbo lutea*), American frogbit (*Limnobium spongia)*, Aquatic sodaapple (*Solanum viarum*), Parrotfeather (*Myriophyllum aquaticum*), Pickerelweed (*Pontederia spp.*), Pennywort (*Hydrocotyle leucocephala*), Purple loosestrife (*Lythrum salicaria*), Waterhyacinth (*Eichhornia crassipe ; Mart*), Waterlily (*Nymphaea spp.*), Waterprimrose (*Jussiaea repens*)

Mode of Action- Although not completely understood, the primary action of this compound is thought to be like that of the naturally occurring auxin (Any of several plant hormones that regulate various functions, including cell elongation), Indole Acetic Acid (IAA). The action appears to involve cell plasticity and nucleic acid metabolism. The symptoms typical of auxin-type herbicides include epinastic3 bending and twisting of stems and petioles, stem swelling (particularly at nodes) and elongation, and leaf cupping and curling.

Environmental Fate- Triclopyr triethylamine salt (TEA) is highly soluble in water and dissociates within one minute to the weak acid, triclopyr. Aquatic photolysis and microbial breakdown are significant degradation pathways for triclopyr. Dissipation half lives of triclopyr in water range from 0.5 days to 7.5 days. In sediment, triclopyr dissipation rates ranged from 2.8 to 5.8 days in field studies. Triclopyr is, however, persistent under anaerobic aquatic conditions. It is highly water soluble and is not expected to bind with organic material

Toxicity- Triclopyr acid is practically non-toxic to freshwater invertebrates. Based on the waterflea (*Daphnia magna*) life-cycle toxicity study using triclopyr TEA formulation, the calculated 48-hr LC50 value based on nominal concentrations, was 1,170 ppm and the 21-day chronic toxicity LC50 value, based on analyzed concentrations, was 1,140 ppm. Triclopyr TEA is practically non-toxic to freshwater fish on an acute basis. Triclopyr TEA has fish 96-hr LC5O values of 552 and 891 ppm for rainbow trout and bluegills respectively. The corresponding values for triclopyr acid are 117 and 148 ppm for rainbow trout and bluegill respectively. No toxicological effects were seen at the maximum label rate of 2.5ppm.

Water Use Restrictions (at maximum label rate of 2.5ppm)-

Drinking – Setback distances from potable water intakes determined by size of area treated and herbicide concentration levels. Setback distances are on the herbicide label.
Swimming – 0 days
Fish Consumption – 0 days
Livestock watering – 0 days
Irrigation – 120 days*
*safe irrigation concentrations can be determined before 120 days with an approved ELISA test.

A Review of the Toxicity and Environmental Fate of Triclopyr

Submitted to the Massachusetts Pesticide Board Subcommittee
By Steven E. Antunes-Kenyon and Gerard Kennedy
Massachusetts Department of Agricultural Resources
November 12, 2004
http://www.mass.gov/agr/pesticides/water/Aquatic/triclopyr_final.pdf

APPENDIX E - Herbicide Treatment Cost Comparisons

Treatment Area	Acres of Milfoil	*Chemical Cost*					
Treatment Area	**Acres of Milfoil**	**Sonar AS**	**Sonar PR/Q**	**Aquathol K & Super K**	**Renovate**	**Reward**	**Aqua-Kleen**
South	158.0		$155,000	$47,500	$144,400	$30,000	$36,300
South & Central	415.0		$424,500	$127,000	$378,300	$78,900	$95,500
TOTAL	736.0	$1,100,000		$227,300	$735,600	$140,200	$169,700

Sonar AS (liquid) - Whole Lake

Chemical Cost (18 ppb total)

Treatment Area	Acres of Milfoil	Sonar AS	Chemical Volume	Application Costs	Monitoring		TOTAL
TOTAL	736.0	$1,100,000	721 gals	$100,000	$30,000		$1,230,000

Sonar PR/Q (pellets)

Chemical Cost (100 ppb - 75 PR:25 Q)

Treatment Area	Acres of Milfoil	Sonar PR/Q	Chemical Volume	Application Costs	Monitoring		TOTAL
South	158.0	$155,000	6608 lbs	$30,000	$20,000		$205,000
South & Central	415.0	$424,500	18103 lbs	$50,000	$22,500		$497,000

Aquathol K (liquid)

Chemical Cost (2.0 ppm Aquathol K based on whole treatment volume)

Treatment Area	Acres of Milfoil	Aquathol	Chemical Volume	Application Costs	Monitoring		TOTAL
South	158.0	$86,800	1591 gals	$30,000	$15,000		$131,800
South & Central	415.0	$237,800	4359 gals	$45,000	$17,500		$300,300
TOTAL	736.0	$433,600	7948 gals	$65,000	$20,000		$518,600

Aquathol K (liquid) & Super K (granular)

Chemical Cost (1.5 ppm 50:50 Aquathol K liquid to Super K Granular)

Treatment Area	Acres of Milfoil	Aquathol	Chemical Volume	Application Costs	Monitoring		TOTAL
South	158.0	$47,500	300 gals & 2100 lbs	$30,000	$15,000		$92,500
South & Central	415.0	$127,000	850 gals & 5100 lbs	$45,000	$17,500		$189,500
TOTAL	736.0	$227,300	1525 gals & 9750 lbs	$65,000	$20,000		$312,300

Reward (liquid)

		Chemical Cost (1.5 gals per acre)					
Treatment Area	**Acres of Milfoil**	**Reward**	**Chemical Volume**	**Application Costs**	**Monitoring**		**TOTAL**
South	158.0	$30,000	237 gals	$20,000	$15,000		$65,000
South & Central	415.0	$78,900	623 gals	$35,000	$17,500		$131,400
TOTAL	736.0	$140,200	1107 gals	$50,000	$20,000		$210,200

Aqua-Kleen/Navigate (granular)

		Chemical Cost (100 lbs per acre)					
Treatment Area	**Acres of Milfoil**	**Aqua-Kleen**	**Chemical Volume**	**Application Costs**	**Monitoring**		**TOTAL**
South	158.0	$36,300	15800 lbs	$30,000	$15,000		$81,300
South & Central	415.0	$95,500	41500 lbs	$45,000	$17,500		$158,000
TOTAL	736.0	$169,700	73800 lbs	$70,000	$20,000		$259,700

Renovate (liquid)

		Chemical Cost (1.5 ppm)					
Treatment Area	**Acres of Milfoil**	**Renovate**	**Chemical Volume**	**Application Costs**	**Monitoring - FasTEST**		**TOTAL**
South	158.0	$144,400	1501 gals	$25,000	$15,000		$184,400
South & Central	415.0	$378,300	4000 gals	$40,000	$17,500		$435,800
TOTAL	736.0	$735,600	7700 gals	$60,000	$20,000		$815,600

Notes:

* Sonar costs assume multiple applications (3-4 separate) and FasTEST monitoring of fluridone residues following treatment
* Reward, Aquathol, and Aqua-Kleen/Navigate costs assume a single application that might be performed over several consecutive days for large treatments
* Renovate costs assume split applications spaced several hours apart on the same day, several consecutive days may be needed for large treatments

APPENDIX F – 2005 Milfoil Inspection Report

Aquatic Control Technology, Inc.
Pond and Lake Management Specialists

December 12, 2005

Saratoga Lake Protection and Improvement District
c/o Mr. Joseph Finn, Commissioner
157 Nielson Road
Saratoga Springs, NY 12866

Re: Milfoil Survey of North Plot Treatment Area – August 2005

Dear Joe:

On August 3, 2005 we surveyed the milfoil growth on Saratoga Lake. The primary purpose of the survey was to assess the level of Eurasian watermilfoil regrowth seen in the North Plot treatment area following the 2003 demonstration treatment with Sonar PR (Precision Release) herbicide). The 2005 season represents the second year after treatment. A cursory visual inspection of the milfoil beds in the remainder of the lake was also conducted.

SURVEY METHODS

The survey was completed by Gerald Smith, Principal Biologist, and Marc Bellaud, Senior Biologist, of Aquatic Control Technology, Inc. The survey was conducted from an Airboat which enabled us to access all areas of the lake, including areas with dense, surface mats of milfoil. Milfoil beds were visually inspected to characterize the type and density of aquatic plant cover. GPS coordinates were recorded at the edges of the major plant assemblages seen in the North Plot area to facilitate mapping. The understory plant community was verified through the use of a throw-rake and an Aqua-Vu underwater camera system. These were the same methods that were used in prior years.

NORTH PLOT – FINDINGS

For the most part, milfoil has recolonized the North Plot in coverage and density similar to what was documented prior to the 2003 treatment. Three distinct plant assemblages were noted.

Shallow water assemblage – The shallow water assemblage extended out 50-150 feet from shore throughout the North Plot.

Total Plant Cover 80-100%
Most plant growth 1-2 feet below the surface
Dominant species observed

Scientific Name	Common Name	Percent Cover
Zosterella dubia	Water Stargrass	50%
Vallisneria americana	Wild Celery	30%
Myriophyllum spicatum	Eurasian watermilfoil	10%
Potamogeton richardsonii	Richardson's Pondweed	present
Elodea canadensis	Elodea	present
Chara sp.	Muskgrass	present

This assemblage had considerable plant cover, but the biomass was lower than deeper areas dominated by milfoil. The milfoil densities in this assemblage were lower than anticipated based on our August 2004 survey. There was likely some milfoil control in the shallow water areas from the 2004/2005 winter drawdown.

Mid-depth assemblage – The mid-depth assemblage generally started in water depths of 4-5 feet and extended out to depths of 9-10 feet.

Total Plant Cover 80-100%, mostly milfoil		
Milfoil plants growing to or matted along the surface		
Dominant species observed		
Scientific Name	Common Name	Percent Cover
Myriophyllum spicatum	Eurasian Watermilfoil	80-100%
Potamogeton amplifolius	Largeleaf Pondweed	present
Potamogeton illinoensis	Illinois Pondweed	present
Ceratophyllum demersum	Coontail	present

Milfoil had clearly returned to nuisance densities throughout the majority of the North Plot. Plants were growing to and in some cases were matted along the surface to water depths approaching 10 feet. Only widely scattered cover of a few other species were noted in these dense milfoil beds. There were obvious boat channels that had been cut through the milfoil beds with the SLPID Harvesters.

Deep water assemblage – The deep water assemblage started after the milfoil plants dropped below the surface. This usually occurred in water depths greater than 10 feet. At the northern edge of the plot plants were found growing 1500-2000 feet from shore. At the southern end of the plot, plant growth dropped off 800-1000 feet from shore.

Total Plant Cover 60-100%, mostly milfoil
Milfoil plants growing generally 2-3 feet below the surface
Dominant species observed

Scientific Name	Common Name	Percent Cover
Myriophyllum spicatum	Eurasian Watermilfoil	60-100%
Ceratophyllum demersum	Coontail	10%
Potamogeton amplifolius	Largeleaf Pondweed	present
Potamogeton illinoensis	Illinois Pondweed	Present
Potamogeton zosteriformis	Flatstem Pondweed	Present

The plant cover in this deep water area was similar to what was seen in 2004, one year after treatment. Milfoil cover did appear to be increasing, but the plants remained 2-3 feet or more below the surface and generally did not appear to interfere with boating.

OBSERVATIONS AND RECOMMENDATIONS

During our more cursory inspection of milfoil growth in the remainder of the lake, we observed conditions similar to what was documented in 2004. Similar to the North Plot, there is a shallow water plant assemblage of varying thickness around the entire shoreline of the lake. This area is impacted by the winter drawdown and as a result has more a more diverse and lower density plant assemblage that is more drawdown tolerant. Water stargrass is the dominant plant seen in this shallow water assemblage around the entire shoreline.

Milfoil dominated the mid-depth areas (4-10 feet). Milfoil density was variable and the North Plot appeared to support the highest milfoil densities. For example, the South Plot area that has not been treated since 2000 still has lower milfoil densities than the North Plot with milfoil cover estimated between 40-70%. Milfoil is growing to the surface in many areas, but it does not form the large floating mats that are found in the North Plot. The continuous harvesting effort is undoubtedly one reason for reduced milfoil cover seen in other parts of the lake.

Eurasian watermilfoil continues to dominate the aquatic plant community in Saratoga Lake, with much of the lake supporting nuisance densities of milfoil that undoubtedly interferes with recreational use of the lake. Observations made during our August 2005 survey reinforce our recommendations for large-scale herbicide treatments that were made in the Long-Term Aquatic Vegetation Management Plan. Significant reductions of the milfoil cover and biomass are a necessary first step towards developing an effective, integrated weed management program for the lake. Large-scale milfoil treatments performed in Vermont, Massachusetts and Connecticut in recent years, have demonstrated that selective milfoil control can be achieved and the native plant community shows reduced impact in the year of treatment and strong recovery the year after treatment.

As always, please feel free to contact us if you have any questions. We look forward to assisting with SLPID's efforts to initiate a long-term vegetation management program in the coming months.

Sincerely,
AQUATIC CONTROL TECHNOLOGY, INC.

Marc Bellaud
Senior Biologist

Gerald N. Smith
President/Aquatic Biologist

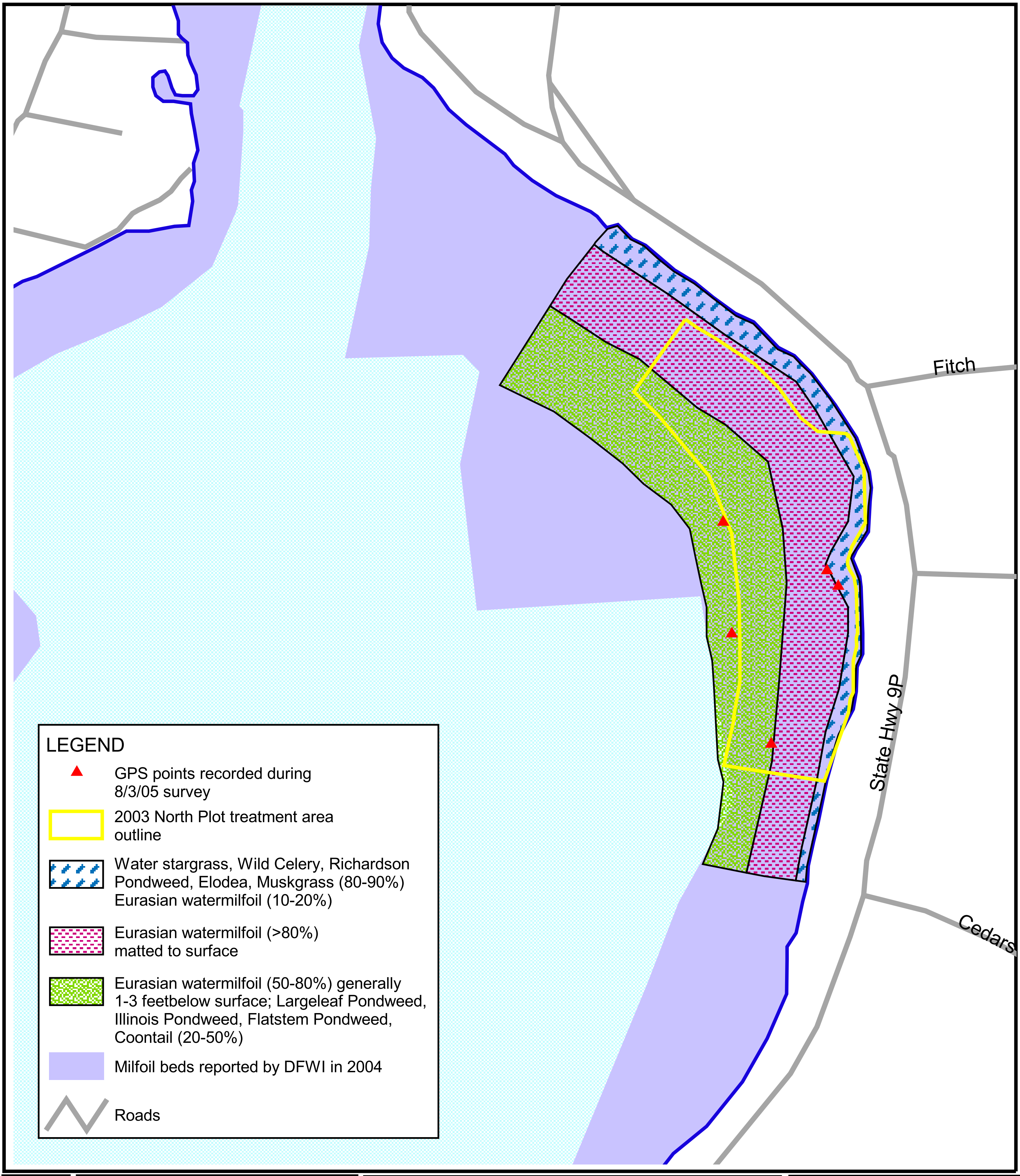


FIGURE NUMBER: 1

Saratoga Lake

2005 Milfoil Survey of North Plot Treatment Area

Legend:

See Above

600 0 600 1200 Feet

AQUATIC CONTROL TECHNOLOGY, INC.

11 JOHN ROAD
SUTTON, MASSACHUSETTS 01590
PHONE: (508) 865-1000
FAX: (508) 865-1220
WEB: WWW.AQUATICCONTROLTECH.COM

NORTH PLOT COMPARISON

AQUATIC CONTROL TECHNOLOGY, INC.

2003 Pre-Treatment

Coontail, curlyleaf pondweed, Eurasian watermilfoil (<5%) Total Plant Cover 50%; Biomass 1

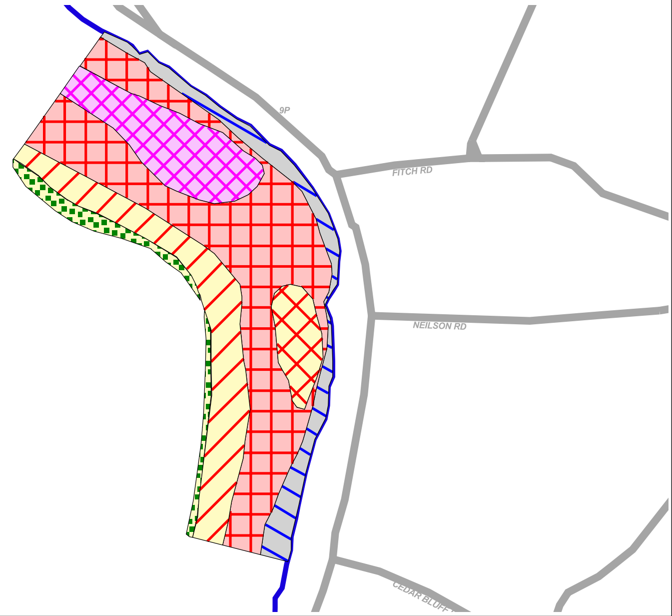
Coontail, Eurasian watermilfoil (<50%), curlyleaf pondweed Total Plant Cover 70%; Biomass 2

Eurasian watermilfoil (>80%), scattered coontail, curlyleaf pondweed Total Plant Cover 90%; Biomass 3

Eurasian watermilfoil (50%), water stargrass, pondweeds Total Plant Cover 90%; Biomass 3

Eurasian watermilfoil (<80%), coontail Total Plant Cover 90%; Biomass 3

Water stargrass, Eurasian watermilfoil (<10%), curlyleaf pondweed, elodea Total Plant Cover 80%; Biomass 3



2003 Post-Treatment

Coontail, curlyleaf pondweed, Eurasian watermilfoil (<5%) Total Plant Cover 50%; Biomass 1

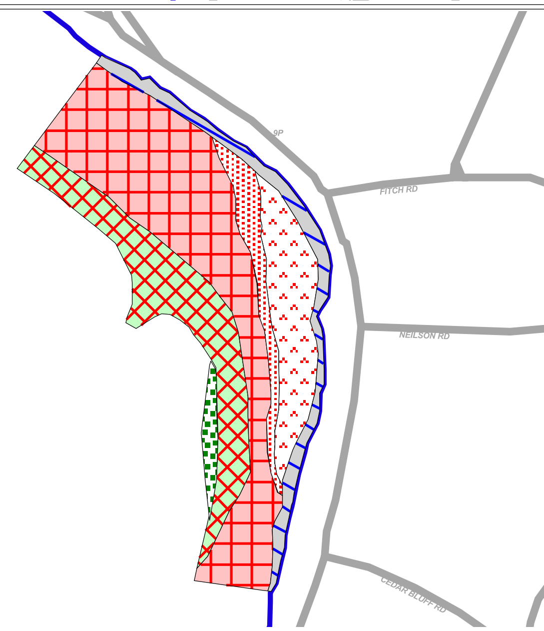
Eurasian watermilfoil (<80%), coontail Total Plant Cover 90%; Biomass 3

Eurasian watermilfoil (>80%), scattered coontail, curlyleaf pondweedTotal Plant Cover 90%; Biomass 3

Eurasian watermilfoil (<50% controlled), coontail, pondweeds: Total Plant Cover >70%; Biomass 2

Eurasian watermilfoil (>80% controlled), Water stargrass, wild celery, pondweeds: Total Plant Cover 70%; Biomass 2

Water stargrass, Eurasian watermilfoil (<10%), Curlyleaf pondweed, elodea Total Plant Cover 80%; Biomass 3



2004 Year AfterTreatment

Water stargrass, Illinois pondweed, Eurasian watermilfoil (0-20%), Coontail, Largeleaf pondweed, Wild Celery
Total Plant Cover ~ 100% ; Biomass 2

Water stargrass, Coontail, Eurasian watermilfoil (20-50%), Naiad, Illinois Pondweed Wild Celery, Richardson pondweed
Total Plant Cover ~ 100% ; Biomass 2.5

Eurasian watermilfoil (50-80%), Water stargrass, Coontail, Largeleaf pondweed, Wild Celery
Total Plant Cover ~100% ; Biomass 3

Eurasian watermilfoil (>80%), Coontail
Total Plant Cover ~100% ; Biomass 3