2012 Aquatic Management Program - Arlington, MA
Spy Pond, Arlington Mill Reservoir and Hills Pond

Report Prepared by: Aquatic Control Technology
11 John Road
Sutton, MA 01590

AQUATIC CONTROL TECHNOLOGY, INC.
POND AND LAKE MANAGEMENT SPECIALISTS

Report Prepared for: Town of Arlington
c/o Ms. Teresa DeBenedictis, Asst. DPW Director
51 Grove Street
Arlington, MA 02476

INTRODUCTION AND BACKGROUND

The following report details the findings of the survey work performed by Aquatic Control Technology in 2102. All work in 2012 was performed at the request of the Arlington DPW.

The objectives of the Aquatic Management Program in Arlington continue to focus on management of invasive and nuisance aquatic plant and algae species for the preservation of water quality, enhancement of fish and wildlife habitat and improved recreational access at Arlington Mill Reservoir, HIlls Pond (a.k.a Menotomy Rocks Park Pond) and Spy Pond. Survey work performed at each of these waterbodies in 2012 was performed to:

A) Document the density and distribution of non-native invasive and nuisance native aquatic plant species

B) Evaluate the management needs and options for each of the Arlington waterbodies

C) Document the efficacy and impact of native plant management strategies employed in 2013.

D) Provide data and recommendations to aide in the decision for the future management of the three waterbodies

MATERIALS AND METHODS:

All surveys were preformed by boat and estimates of aquatic plant cover and density were made using a combination of visual observation, collection with a throw-rake and the use of an underwater camera. Plants were identified to genus and species level where possible.

Water temperature/dissolved oxygen profiles and Secchi disk clarity measurements were collected in the field. Additionally, surface water quality samples were collected from each waterbody (table 1). An additional June sampling round was also collected from Spy Pond. All samples were analyzed for pH, turbidity, true color, apparent color, total phosphorous, nitrate nitrogen, ammonia nitrogen, kjeldahal nitrogen and e coli bacteria.

Algae samples were also collected and analyzed from each waterbody.

Table 1: Water Quality Sample Locations

Site	Latitude	Longitude
Spy Pond - Site 1	42° 24' 34.64" N	71° 9' 10.85" W
Spy Pond - Site 2	42° 24' 21.39" N	71° 9' 30.28" W
Arlington Reservoir	42° 25' 41.04" N	71° 11' 19.35" W
Hills Pond	42° 24' 39.66" N	71° 9' 54.71" W

More extensive, periodic sampling occurred at Spy Pond due to increasing concerns regarding blue-green algae blooms in this waterbody. Water quality samples for chlorophyll-a were also collected at Spy Pond in the fall following turn-over, when nutrient levels and algae should be elevated. A composite sediment sample was also collected for testing of copper concentrations. A chronology of the tasks performed in 2012 follows:

2012 Management Program:

- DEP annual License to Apply Chemicals issued (# 12244) 07/09/12
- June survey...6/27/12
- Sediment sample collection for copper analysis...6/27/12
- August survey...08/16/12
- Chlorophyll Sample Collection 10/01/12

SURVEY FINDINGS:

Arlington Reservoir:

Arlington Reservoir was surveyed on 8/16/12. The day of the survey was sunny with little wind, providing good conditions for subsurface observation.

The water clarity at the reservoir was poor, averaging 4.75 feet. The water appeared murky with suspended sediment and microscopic algae. Dissolved oxygen levels were lower in 2012 than those observed in 2007 (table: 2). The 2007 values averaged nearly 110% oxygen saturation through the first through the first five feet of water where as in 2012 the values for oxygen saturation averaged at only approximately 58%. These lower oxygen levels have impacts on the rate of conversion from ammonia to nitrate nitrogen (see water quality section below)

Table 2 : 2012 dissolved oxygen and temperature profile for Arlington Reservoir

Depth (feet)	Temperature (°C)	Dissolved Oxygen (mg/L)	Approximate Saturation
Surface	26.9	6.09	74%
1	26.5	5.55	68%
2	26.2	5.43	65%
3	26.0	4.52	55%
4	25.7	3.64	43%
5	25.2	3.92	45%
6	24.7	3.74	43%
7	24.4	1.04	12%
8	21.6	0.52	4%

Eleven aquatic plant species were documented during the 2012 August survey including: coontail (*Ceratophyllum demersum*), spiny naiad (*Najas minor*), Eurasian watermilfoil (*Myriophyllum spicatum*), thin-leaf pondweed (*Potamogeton pusillus*), waterweed (*Elodea canadensis*), water chestnut (*Trapa natans*), cattail (*Typha latifolia*), pickerelweed (*Pontedaria cordata*), water willow (*Decodon verticillatus*), watershield (*Brasenia schreberi*) and white waterlily (*Nuphar odorata*).

The overall biomass at the vegetated sites was high which was due in large part to the large expanse of topped-out coontail growth throughout much of the reservoir's southern shoreline. Other smaller areas of topped-out spiny naiad, thinleaf pondweed and Eurasian watermilfoil were also encountered.

Topped out coontail in the southern end of Arlington Reservoir

Growth of floating leaf plants including: white waterlily (*Nymphaea odorata*), watershield (*Brasenia schreberi*) and water chestnut (*Trapa natans*) was also documented during the survey. Variegated water clover (*Marsilea mutica*) was observed in 2007 but was not observed during the 2012 survey.

The area covered by floating leafed plants was much reduced in 2012 as compared to 2007, primarily due to the harvesting of the water chestnut performed in 2011 and 2012. Scattered regrowth of chestnut plants were observed in the northern 1/3 of the reservoir. The observed chestnut regrowth was too immature to produce seeds in 2012, therefore no additional hand-pulling was necessary. The majority of the water chestnut rosettes had been removed. Smaller patches of watershield and waterlily were observed along the shoreline.

While Eurasian watermilfoil and spiny naiad are notoriously invasive, non-native plants, they are secondary in abundance to coontail, which was the dominant submersed aquatic species throughout most of the reservoir.

A mid-pond water sample was collected and packed on ice for delivery to MicoBac Laboratories in Worcester. A second sample was collected and preserved with glutaraldehyde for analysis of algae.

The preserved sample was analyzed by ACT Biologist Pete Beisler for algae species identification and count by enumeration.

The overall cell count (14,504 cells/ml) was desirably low. The low cell count may indicate that the moderate to low clarity observed may be more attributable to suspended particulate matter rather than algal densities. Chlorophytes (green alga) and Chryptophytes were the dominant taxa for in the sample collected. No blue-green algae species were observed in the sample. The full data sheet for the algal count is attached.

Table 3: Arlington Reservoir Water Quality

		Dates	
Parameter	**Unit**	**2007 Average**	**2012 (8/16/12)**
pH	S.U.	8.71	6.94
Alkalinity	CaCO3/L	46	43
Turbidity	NTU	2.48	2.4
Total Kjeldal Nitrogen	mg/L	0.58	0.600
Ammonia Nitrogen	mg/L	<0.05	0.160
Nitrate	mg/L	0.46	0.108
Total Phosphorus	mg/L	0.035	0.0400
Dissolved Phosphorus	mg/L	0.012*	NT
True Color	Pt-Co	30	35
Apparent Color	Pt-Co	41.5	45.0
E.coli	CFU/100ml	<10	20
*one or more results below laboratory limits NT = Not Tested			

pH: pH is a measurement of the concentration of hydrogen ions (H^+) in solution, which reflects the acidity or alkalinity of the measured solution. The pH measurement scale ranges from 0-14, where zero is extremely acidic, seven is neutral, and 14 is the most basic. A pH measurement within the range of 5.5-8.5 S.U. is typical for the northeastern United States and is desired for maintaining a healthy fishery. Maintaining a stable pH ($\pm$ 1 S.U.) is also important, as frequent fluctuations can have adverse effects on water chemistry and fisheries. There appears to have been a decline in pH since 2007. It should be noted that with the few number of data points definitive conclusions about the changes in pH would be challenging. The pH level recorded in 2012 at Arlington Reservoir was near neutral, well within the desired range and indicates that the pond should be quite favorable for fish and other aquatic wildlife.

Alkalinity: Alkalinity is a measure of the buffering capacity of a waterbody against acid additions such as acid rain and pollution, which can be detrimental to fish and wildlife populations. Total alkalinity measures the presence of carbonates, bicarbonates and hydroxides and is mostly a function of the surrounding soils and geology. Values below 20 mg/l typically illustrate that the pond may be susceptible to adverse fluctuations in pH. The alkalinity measurement for the sample collected at Arlington Reservoir in 2012 was consistent with the 2007 measurements. Given that the values were above 40 the reservoir should be protected against significant changes in pH, though minor fluctuations may occur.

Turbidity: Turbidity is a relative measurement of the amount of suspended particles in the water. Turbidity values can range from less than one to thousands of units, however, values in most ponds and lakes rarely rise above 5 NTU and typically <1 NTU in waterbodies used for swimming. The turbidity value from the 2012 sample was 2.4 NTU, which is consistent with the values observed in

2007. These values indicate low to moderate levels of suspended material in the water column.

Ammonia nitrogen: is an inorganic, dissolved form of nitrogen that can be found in water and is the preferred form for algae and plant growth. Ammonia is the most reduced form of nitrogen and is found in water where dissolved oxygen is lacking. Depending on temperature and pH (a measurement of “acidity”), high levels of ammonia can be toxic to aquatic life. High ammonia concentrations can stimulate excessive aquatic production and indicate pollution. Important sources of ammonia to waterbodies include: fertilizers, human and animal wastes, and by-products from industrial manufacturing processes. In general, acceptable ammonia concentrations should range between 0 and 0.05 mg/L depending upon temperature and pH. Nitrogen is an essential element for plant growth. Ammonia is a by product of the decomposition of organic material. In the presence of oxygen, ammonia is readily converted to nitrate nitrogen. The ammonia level is in the sample collected in 2012 was higher than that of the 2007 samples. These moderately high ammonia nitrogen concentrations may indicate low oxygen levels or the rapid decomposition of organic material.

Nitrate nitrogen: Nitrate nitrogen is the end product of the nitrogen cycle under aerobic conditions. Nitrate nitrogen is the form of nitrogen that is most readily available to plants as a nutrient source. High levels of nitrate nitrogen indicate an imbalance between the amount of nitrogen entering a system and the amount being utilized by organisms and may also indicate fertilizer or septic system inputs. Excess nutrients may stimulate nuisance plant and algae growth. Generally speaking nitrate concentrations higher than 0.3 mg/l are sufficient to support such nuisance plant and algae growth. The 2012 Nitrate nitrogen level for Arlington Reservoir was reduced from that observed in 2007. That coupled with the increase in ammonia indicates some break in the nitrogen cycle either due to low oxygen levels or rapid decomposition.

Kjeldahl nitrogen: Kjeldahl nitrogen results signify the amounts of organic or biomass nitrogen and ammonium in a sample. Since this form of nitrogen is not as readily utilized by plants as nitrate nitrogen, concentrations generally need to be greater that 1.0 mg/l to support nuisance algae and plant growth. Levels of Kjeldahl nitrogen in Arlington Reservoir were relatively low in 2007 and in 2012.

Total Phosphorous: Although excess nitrogen can contribute to nuisance plant growth, the ratio of nitrogen to phosphorous in a system is equally important. This ratio will determine which nutrient is the most limiting (i.e.; which nutrient is found in least supply relative to the growth requirements of the plants). Phosphorus is usually the limiting nutrient for plant and algae growth in freshwater systems. Total phosphorus is a reading of particulate and dissolved phosphorus in the water column. Concentrations of 0.03 mg/l or greater are considered sufficient to stimulate nuisance algae blooms. The total phosphorous measurement in 2012 was again above 0.03 mg/l, indicating sufficient nutrients to support algal blooms and nuisance weed densities. It is important to understand that each sample is representative of a mere “snap-shot” of conditions at a moment in time. As a result, it would be necessary to perform more frequent sampling to establish a more meaningful baseline/mean value for the continually fluctuating phosphorus levels.

True Color/Apparent Color: Apparent color is the color of the unfiltered water that is caused by both suspended and dissolved matter. True color is measured after the water has been filtered to remove the suspended matter and is therefore the color due to dissolved constituents only. Water color can effect light penetration and, as a result, can limit rooted plant and algae growth. The disparity between true and apparent color can indirectly indicate the amount of suspended material in the water and lead to conclusions about the influence of stormwater on incoming water quality. The results from Arlington Reservoir indicate that the color of the water is the result of both suspended and dissolved particles but is more influenced by dissolved particles.

Escherichia coliform: *E. coli*. is one of many naturally occurring bacteria found within the intestine of humans and animals. The presence of *E. coli* in pond and/or lake water is indicative of some level of recent sewage or animal waste contamination. The current swimming standard for freshwater is no single sample shall exceed 235 colonies per 100 ml. The bacterial sample collected at in Arlington Reservoir was above the 2007 results but still well below 235 colonies per 100 ml.

Hills Pond:

Hills Pond is a roughly 2.3 acre waterbody located in Menotomy Rocks Park in Arlington. The pond was dredged in 1996 and is deep for a waterbody of its size with an average depth of about 6 feet and a maximum recorded depth of approximately 13 feet.

The water clarity during the 2012 survey was good at 9.6 feet. This value was slightly reduced compared to the average clarity in 2007 of approximately 11.5 feet, however more frequent treating is need to make meaningful conclusions. Likely the decrease in clarity was due to an increase in algal density.

Although the dissolved oxygen values were lower than the 2007 values the water column appears to still be reasonably well oxygenated throughout the water column.

Table 4: 2012 Dissolved Oxygen and Temperature Profile for Hills Pond

Depth (feet)	Temperature (°C)	Dissolved Oxygen (mg/L)	Approximate Saturation
Surface	27.2	7.22	88%
1	27.0	7.15	86%
2	26.6	6.89	85%
3	26.6	6.77	82%
4	26.1	6.75	81%
5	25.7	6.71	80%
6	25.6	6.15	75%
7	24.8	4.36	55%
8	24.6	1.63	18%

HIlls Pond was treated with diquat (Reward) herbicide and copper (Captain) algaecide on May 28^{th} 2012 for the control of invasive non-native curlyleaf pondweed and nuisance filamentous algae. Despite the herbicide treatment, growth of native clasping-leaf pondweed (*Potamogeton perfoliatus*) flourished and was found at varying densities throughout the pond during the August survey (Figure 3). Stonewort (*Nitella sp*.) growth was also extensive, and consistent with previous years, formed a low-growing blanket along the pond bottom. Scattered growth of thin-leaf pondweed (*Potamogeton pusillus*) and naiad (*Najas flexilis*) was also observed mid-pond. Filamentous algae had returned to the pond by the time of the August survey and moderate densities were observed covering the stonewort in the southern end and few floating mats were observed along the northern and southern shorelines.

Healthy growth of native clasping leaf pondweed along the shore of Hills Pond

In 2007 the pond was primarily devoid of vascular plant growth. The increases in native plant growth observed in 2012 represent a positive shift in the plant composition away from the previously dominant non-native curlyleaf pondweed and Eurasian watermilfoil (*Myriophyllum spicatum*) toward a more healthy ecologically balanced plant community. This shift is undoubtedly due in part to the ongoing invasive plant management efforts performed at the pond.

A mid-pond water sample was collected and packed on ice for delivery to MicoBac Laboratories in Worcester. A second sample was collected and preserved with glutaraldehyde for analysis of algae.

Chlorophytes (green alga) and Cyanophytes (blue-green alga) were the dominant taxa for in the sample collected. Overall the cell count was low to moderate and did not indicate severe bloom conditions. Blue-green observed algae in Hills Pond consisted solely of Microcystis. While Microcystis can produce toxins the densities were not high enough to warrant concern regarding toxin production. The presence of Microcystis does, however, indicate that the algae HIlls Pond should be observed more closely in future years. The full data sheet for the algal count is attached.

Table 5: Hills Pond Water Quality

		Dates	
Parameter	**Unit**	**2007 Average**	**2012 (8/16/12)**
pH	S.U.	7.62	7.74
Alkalinity	CaCO3/L	54.5	51.0
Turbidity	NTU	0.66	2.00
Total Kjeldal Nitrogen	mg/L	0.59	NT
Ammonia Nitrogen	mg/L	<0.05	NT
Nitrate	mg/L	0.42	0.11
Total Phosphorus	mg/L	0.022	NT
Dissolved Phosphorus	mg/L	0.010*	NT
True Color	Pt-Co	11.5	15
Apparent Color	Pt-Co	17.5	25
E.coli	CFU/100ml	<10	190

*one or more results below laboratory limits
NT = Not Tested

pH: The pH level recorded in 2012 at Hills Pond was well within the desired range and indicates that the pond should be quite favorable for fish and other aquatic wildlife.

Alkalinity: The alkalinity measurement for the sample collected at Hills Pond in 2012 was consistent with the 2007 measurements and indicates that the pond should be well protected against significant changes in pH.

Turbidity: The turbidity value from the 2012 sample was 2.00 NTU, which is higher than the values observed in 2007. This increase in turbidity may be due in part to the moderate algal densities observed.

Ammonia nitrogen, Kjeldahl nitrogen, total phosphorous: These parameters were not tested in 2012 due to an error in communication with the laboratory. The city was not charged for these parameters.

Nitrate nitrogen: Nitrate nitrogen levels reported in 2012 were reduced from that reported in 2007.

True Color/Apparent Color: The results from 2012 are slightly higher than those of 2007 and indicate that the color of the water is the result of both suspended and dissolved particles but is slightly more influenced by dissolved particles.

Escherichia coliform: The E. coli. levels in Hills Pond were elevated in 2012 but still below the 235 colonies per 100 ml.

Spy Pond:

Spy Pond has a surface area of approximately 103 acres. The pond is comprised of two distinct basins that are separated by a large island directly south of the intersection of Chapman Street and Devereaux Street.

Water clarity has slowly declined following the Alum treatment in 2004. Secchi disk readings averaged 7.2 feet between the June and August surveys performed in 2012. This average is a reduction from the 8.8 foot average reported in 2007. It is important to remember however that these readings will fluctuate over the course of a summer and trends in clarity are more telling with more frequent sampling.

To increase the frequency of water quality sampling and create more meaningful water clarity data for Spy Pond, Aquatic Control Technology worked with the Boys and Girls Club on Spy Pond to establish a weekly volunteer monitoring program in 2012. Volunteers were trained to collect accurate water clarity readings utilizing a Secchi Disk. These readings were recorded in a Google Document so both volunteers and Aquatic Control could access the data instantly. Access to more frequent water clarity readings will help Aquatic Control to time algal treatments, if necessary, such that severe bloom conditions are avoided in the future. While the program took time to establish in 2012, it will hopefully continue in the years to come in order to establish a more meaningful database of season long clarity readings. Below are the water clarity readings from the 2012 program.

Table 6: 2012 Water Clarity Measurements at Spy Pond

Date	**Monitor**	**Basin**	**Secchi Disk Reading (ft)**
6/27/12	ACT	Southwest	9.0
6/27/12	ACT	Northeast	5.4
8/3/12	ACT	Southwest	9.4
8/3/12	ACT	Northeast	7.3
8/3/12	Volunteer	Northeast	9.3
8/7/12	Volunteer	Northeast	8.4
8/8/12	Volunteer	Southwest	7.2
8/14/12	Volunteer	Northeast	6.8
8/16/12	ACT	Southwest	6.3
8/16/12	ACT	Northeast	8.0

Dissolved oxygen levels were comparable to 2007 values throughout the 2012 season (table 7). Spy Pond stratification had developed by the June 27th survey. Oxygen levels depleted in the hypolimnion and metalimnion throughout the season.

Algae counts were moderate in Spy Pond and were primarily dominated by the golden algae *Synura* which accounted for nearly 90% (11,248 of 12,654) of the cells counted. We understand that the Spy Pond Association monitored water clarity and water chemistry on a more frequent basis so their data likely provide a more "fair" representation of summer-long conditions at Spy Pond.

Submersed plant growth in Spy Pond is typically not observed in depths greater than 17 feet. During the June survey Sago pondweed (*Stuckenia pectinatus*), thinleaf pondweed (*Potamogeton pusillus*), and non-native Eurasian watermilfoil (*Myriophyllum spicatum*) were the dominant submersed plant species. Sago pondweed, Eurasian watermilfoil and thinleaf pondweed growth were dense and topped-out or nearly topped out through approximately 45 acres of the pond. Cover of sago pondweed has been increasing in since 2007 and has become the one of the dominant species in the lake occupying an estimated 17 acres to the west of Elizabeth Island. Sago pondweed is a native aquatic plant species but as demonstrated in Spy Pond can grow aggressively reaching nuisance densities and requiring management.

Areas of dense milfoil and pondweed growth were treated with diquat (Reward) herbicide on July 17, 2012. A chelated copper algaecide was tank-mixed with the diquat herbicide to aid in cuticle penetration and help control some of the shoreline growth of filamentous algae. A total of 45 acres was targeted for treatment.

Invasive Eurasian watermilfoil toppe- out in the Northeastern basin of Spy Pond

Other common species observed during the June 2012 survey included filamentous algae, coontail (*Ceratophyllum demersum*), bushy pondweed (*Najas flexilis*), stonewort (*Nitella sp*) and common reed (*Phragmites australis*) (figure 4). Common reed, a highly invasive emergent plant species, has been managed on Spy Pond since 2009. This management has resulted in a vast reduction of the growth along the shoreline of the pond. We would recommend continued annual management of this species.

A small patch of non-native invasive spiny naiad (*Najas minor*) was observed during the June survey. This patch was targeted and controlled with the July diquat treatment.

During the August survey only limited regrowth of Eurasian watermilfoil was observed, primarily to the south of the Elizabeth Island. Sago pondweed had recovered in several locations but did not appear to be negatively impacting recreation. Other common native species observed included coontail, snail-seed pondweed (*Potamogeton bicupulatus*), clasping-leaf pondweed (*Potamogeton perfoliatus*), stonewort, filamentous algae and watermeal (*Lemna sp.*). Invasive purple loosestrife (*Lythrum salicaria*) and common reed (*Phragmites australis*) we observed along the shoreline (figure 5).

In Spy Pond four rounds (6/27/12, 7/11/12, 8/3/12, 8/16/12) of algae samples were collected. Samples were taken from two locations during each sample round: Site 1 (located in the middle of the northeastern basin) and at Site 2 (located in the middle of the southwestern basin).

Cell counts were high during the June and July sampling rounds and reduced to low to moderate levels in the two August sampling rounds. In general Chlorophytes (green alga) and Cyanophytes (blue-green alga) were the dominant taxa for in the samples collected. Blue-green species observed algae included: *Microcystis, Anabaena* and *Aphanizomenon* as well as other species. *Microcystis, Anabaena* and *Aphanizomenon* can all produce toxins.

The city of Arlington closes the pond to direct contact when the DPH reports cell counts above 70,000 cells/ml, which is the state standard for closure. While closing the pond will protect the public from harm, steps should be taken to reduce the cell densities present, so that these precautionary measures are not necessary. Data sheets for the 2012 Spy Pond algal counts are attached.

Table 7: 2012 Dissolved Oxygen and Temperature Profiles for Spy Pond

Depth (meters)	Site 1						Site 2					
	6/27/12			8/16/12			6/27/12			8/16/12		
	Temp (°C)	D.O. (mg/L)	Approx. Sat.	Temp (°C)	D.O. (mg/L)	Approx. Sat.	Temp (°C)	D.O. (mg/L)	Approx. Sat.	Temp (°C)	D.O. (mg/L)	Approx. Sat.
Surface	24.5	10.93	130%	27.3	9.19	115%	24.2	7.81	92%	27.3	7.85	98%
1	24.4	10.92	130%	27.3	9.03	112%	24.2	7.81	92%	27.2	7.74	95%
2	24.3	10.81	128%	27.2	8.81	110%	24.2	7.81	92%	27.1	7.42	90%
3	21.1	7.47	81%	26.9	8.44	103%	22.9	5.71	65%	26.4	4.26	50%
4	18.7	4.42	45%	22.8	6.79	75%	20.6	5.71	63%	25.6	1.92	22%
5	15.6	2.70	26%	19.6	1.45	14%	17.3	0.27	< 5%	22.4	0.24	< 5%
6	13.8	1.40	13%	13.8	0.61	< 5%	14.0	0.21	< 5%	17.4	0.20	< 5%
7	11.6	0.26	< 5%	10.9	0.28	< 5%						
8	10.3	0.20	< 5%	9.9	0.20	< 5%						
9	9.4	0.16	< 5%	9.9	0.14	< 5%						

Temp = Temperature ; D.O. = Dissolved Oxygen; Approx. Sat. = Approximate Percent Oxygen Saturation

Table 8: Spy Pond Water Quality

			Site 1 - Surface		Site 1 – 10M		Site 2 - Surface		Site 2 – 5M	
Parameter	***Unit***	**2007 Average**	**6/27**	**8/16**	**6/27**	**8/16**	**6/27**	**8/16**	**6/27**	**8/16**
pH	**S.U.**	**8.07**	9.28	7.54	6.68	6.60	7.75	7.32	7.27	6.58
Alkalinity	**CaCO3/L**	**41.6**	36.0	37.0	48.0	60.0	37.0	46.0	41.0	69.0
Turbidity	**NTU**	**1.31**	1.90	0.690	3.20	5.50	1.90	1.60	4.00	7.25
Total Kjeldal Nitrogen	**mg/L**	**0.81**	0.500	0.400	1.60	2.00	0.900	0.70	1.10	3.20
Ammonia Nitrogen	**mg/L**	**0.28***	0.110	<0.100	0.740	1.50	0.110	<0.100	0.140	2.00
Nitrate	**mg/L**	**0.63**	<0.0300	<0.100	<0.0300	0.124	0.110	<0.100	0.0500	0.106
Total Phosphorus	**mg/L**	**0.03**	<0.0100	0.0180	0.0820	0.0900	0.0100	0.03	<0.0100	0.320
Dissolved Phosphorus	**mg/L**	**0.011***	NT	NT	NT	NT	NT	NT	NT	NT
True Color	**Pt-Co**	**5.63**	5	5	10	20	5	10	5	35
Apparent Color	**Pt-Co**	**13.13**	20	10	15	50	5	10	5	90
E.coli	**CFU/100 ml**	**<10.0**	<10.0	<10.0	NT	<10.0	<10.0	140	NT	190

pH:, The June 2012 result at Site 1 at the surface was elevated. PH increases can be resultant of a number of factors including stormwater inputs, pollution and increases in algal densities. The pH reduced back to background levels by the August sampling round. The pH was near neutral for the remainder of the 2012 results

Alkalinity: The alkalinity values indicate that Spy Pond should be protected against significant changes in pH, though minor fluctuations may occur.

Turbidity: These values indicate low to moderate levels of suspended material at the Surface and higher turbidity levels nearer to the pond bottom. As one would expect, as the year progresses and anoxia increases in the hypolimnion an increase in turbidity at the pond bottom is observed.

Ammonia nitrogen: Ammonia levels were somewhat elevated in the surface samples and more significantly elevated in the samples collected at depth. As expected, as the oxygen depleted in the hypolimnion as the summer progressed, ammonia was less rapidly converted to nitrate and the ammonia levels increased.

Nitrate nitrogen: The 2012 Nitrate nitrogen levels in Spy Pond were lower than the 2007 results and were within the desired range.

Kjeldahl nitrogen: Kjeldahl nitrogen levels at the surface of Spy Pond were relatively low and were elevated in the samples collected at depth in 2012. These results were consistent with the 2007 results.

Total Phosphorous: The surface total phosphorous values were relatively low and consistent with 2007 values. The samples collected at depth were highly elevated compared to 2007 results and increased as the summer progressed. These results may indicate that the internal cycling of phosphorous in the pond may again be playing a key role in the nutrient content in the pond. If these is in fact the case another buffered alum treatment may be beneficial in the coming years. More sampling would be necessary to make definitive conclusions regarding necessary alum dosing.

True Color/Apparent Color: Color values observed were consistent with 2007 results. The high turbidity and apparent color in the August site 2 sample collected at depth are indicative of heavier levels of suspended materials.

Escherichia coliform: E.coli. levels in the majority of the Spy Pond samples collected in 2012 were below detectable levels, as they were in 2007. The bacterial samples collected at Site 2 in August were both elevated but still well below the MA DPH swimming maximum (235 colonies per 100 ml).

Chlorophyll –a Results:

Table 9: Spy Pond chlorophyll-a results

Parameter	Site 1 - Surface	Site 1 – 10 M	Site 2 – Surface	Site 2 – 5M
Chlorophyll-a (mg/m^3)	0.300	<0.100	5.70	3.20

Chlorophyll-a is the primary light-harvesting pigment found in algae and a measure of the algal productivity and water quality in a system. As previously mentioned these samples were collected in the fall of 2012 on October first in an effort to capture the higher algal density which is commonly resultant of lake-wide turn-over. The results from the Spy Pond analysis indicate low to moderate levels of primary production consistent with mesotrophic waters. Chlorophyll-a results can vary both spatially and temporally in a water body. Were funding to allow, more frequent analysis of chlorophyll-a might provide a better insight into the variation in primary production over the course of the summer season in response to changes in phosphorous.

Sediment Sampling

Table 10: Spy Pond sediment copper concentrations

Sediment Sample	Total Copper Concentration (mg/kg)	Percent Solids (% by weight)
Composite Sediment Sample - Site 1	170	8.13
Composite Sediment Sample - Site 2	200	10.55

The results of the 2012 sediment analysis indicate moderate concentrations of copper in the sediment. These results are near average for Massachusetts. Sampling of 94 state waterbodies performed by MA DEP during the 1980's indicated a mean copper concentration of 267.5 mg/kg dry weight. A study conducted by the NY Department of Environmental Conservation in 2001, looked at the potential toxicity of accumulated copper in copper sulfate treated lakes as compared to untreated lakes. Despite the fact that all the treated lakes in their study had copper concentrations (mean of 304 mg/l) much higher than Spy Pond, none of the sediments proved to be toxic to representative benthic invertebrates (*Hyallela azteca* and *Chironomus tentans*) during their sediment toxicity testing. They also noted considerable variablility within the results from individual sample collection sites within a single lake (factor of 1.5) [1].

Spy Pond Sediment Sample

[1] Paul, E.A., Siminon, H.A., Symula, J., Neuderfer, G., Bauer, R. "Technical Report: Impacts of Long Term Copper Sulfate Use on the Sediment of Treated Lakes" January 2001. New York State Department of Environmental Conservation – Division of Fish, Wildlife and Marine Resources – Bureau of Habitat

SUMMARY AND ONGOING MANAGEMENT RECCOMENDATIONS:

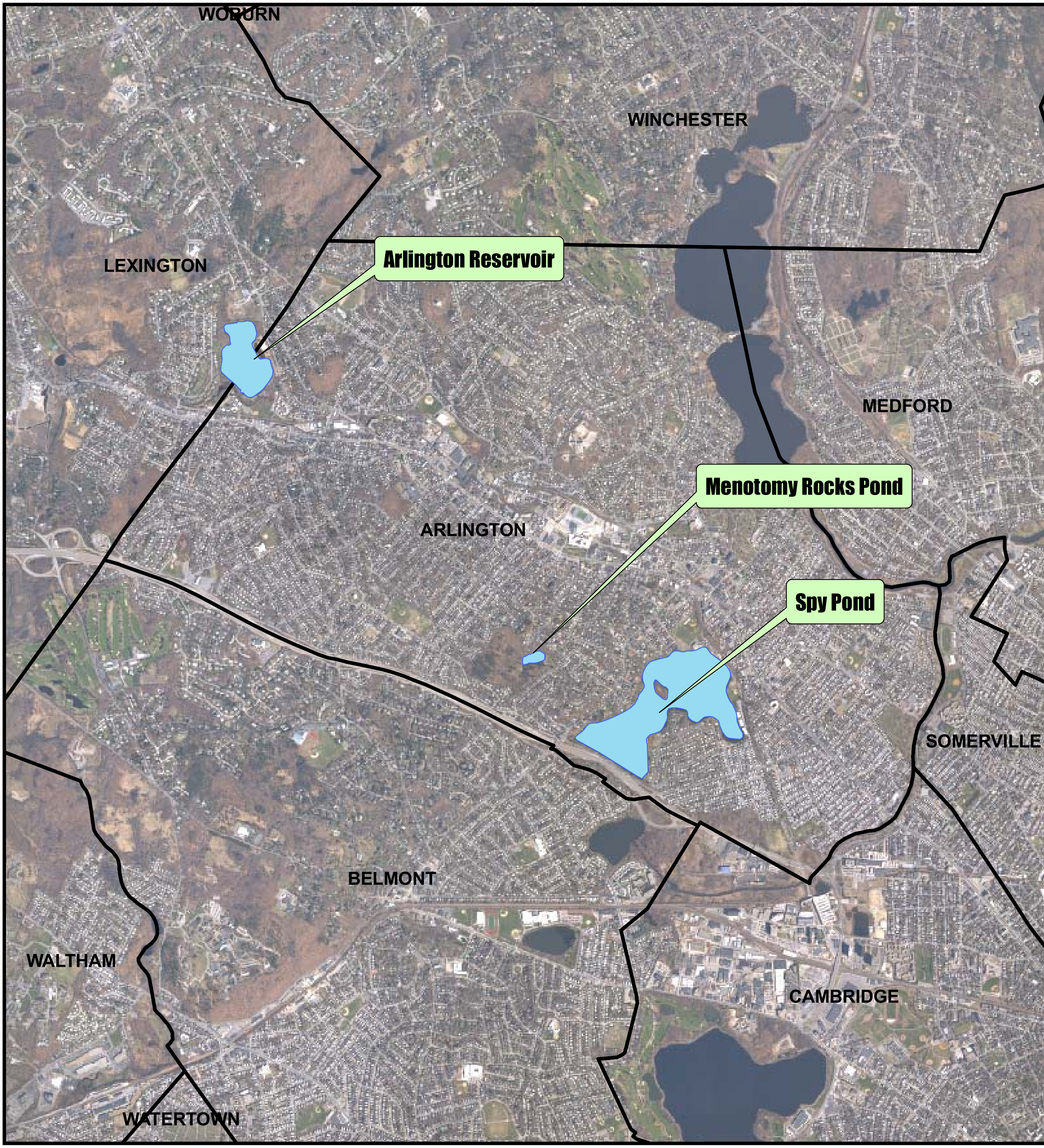
The following is a summary of ongoing recommendations for the management of the Arlington Ponds:

- All Waterbodies
    - Monitoring - Continued annual pre and post-treatment monitoring of vegetation and algae in all waterbodies
    - Permitting – file for Annual DEP License to Apply Chemicals

- Arlington Reservoir
    - Annual mechanical harvesting of water chestnut until the seed bank is reduced to such densities that smaller scale management options, such as hand-pulling, can successfully control the invasive plant population.
    - Herbicide and algaecide treatments as necessary to allow for safe and enjoyable recreational use of the pond.
- Menotomy Rocks Pond (Hills Pond)
    - Complete the installation of new aeration system provided that power has been restored to the park
    - Partial pond diquat treatment during the late spring/early summer to maintain control over invasive curlyleaf pondweed
    - One to two algaecide treatments as necessary to maintain control over filamentous algae mats
- Spy Pond
    - Whole-lake fluridone (trade name: Sonar) treatment or partial-lake diquat (Trade name: Reward) treatment to control nuisance submersed weeds
    - Precipitation dose of buffered Alum treatment
    - Copper algaecide treatments as necessary guided by volunteer Secchi disk water clarity monitoring and DPH cell counts.
    - Shoreline treatment of common reed re-growth

ATTACHMENT A

Figures



Arlington Ponds

Site Locus Map

FIGURE:	SURVEY DATE:	MAP DATE:
1	--	02/08/13

Legend:

N

0 0.25 0.5 1 1.5 Miles

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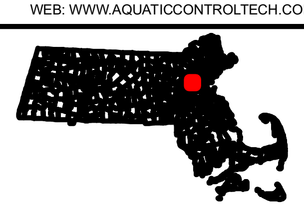
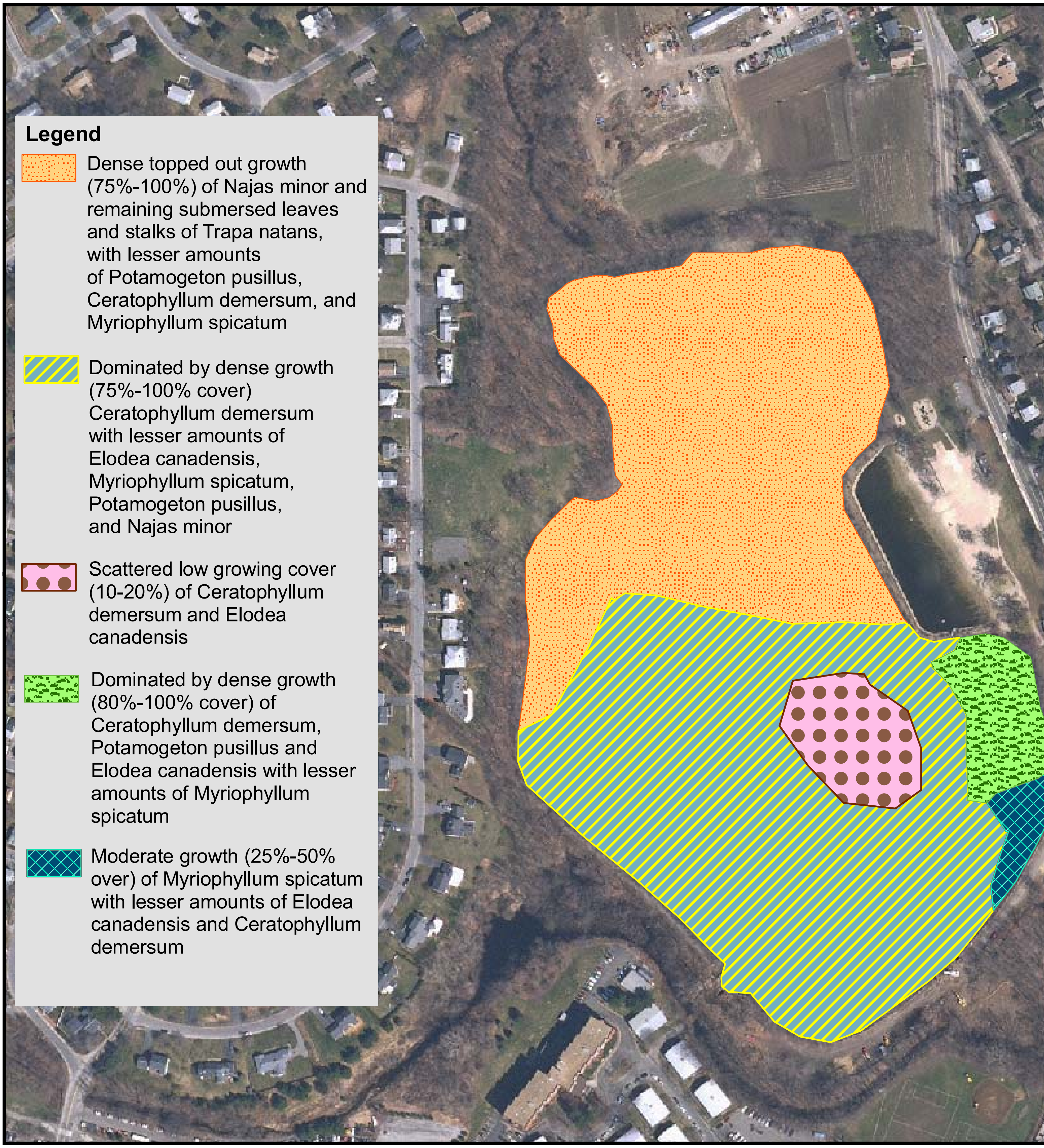
11 JOHN ROAD
SUTTON, MASSACHUSETTS 01590
PHONE: (508) 865-1000
FAX: (508) 865-1220
WEB: WWW.AQUATICCONTROLTECH.COM





Arlington Reservoir

Arlington & Lexington, MA

2012 Vegetation Assembly Map

FIGURE:	SURVEY DATE:	MAP DATE:
2	8/16/12	2/8/13

N

0 85 170 340 510 680 Feet

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11 JOHN ROAD
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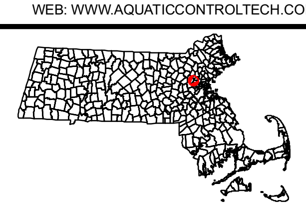

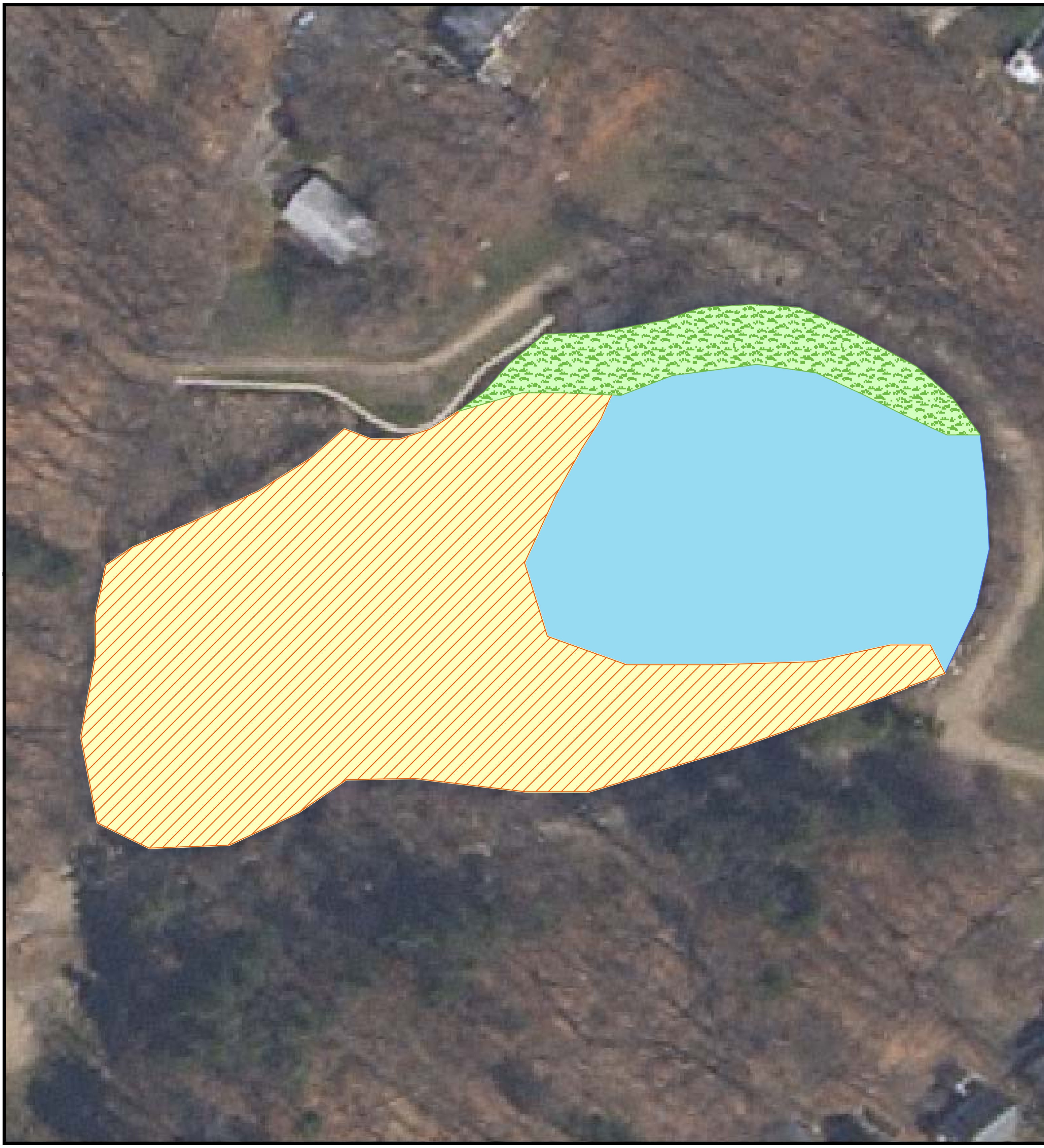

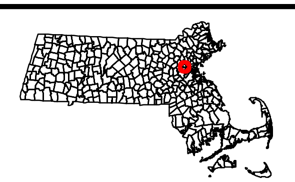

Menotomy Rocks Pond

Arlington, MA

2012 Vegetation Assembly Map

FIGURE:	SURVEY DATE:	MAP DATE:
3	08/16/12	02/08/13

Legend:

- Moderate (50%-75% cover) Nitella sp. and filamentous algae with low density growth of Potamogeton pusillus, Potamogeton perfoliatus and Najas flexilis
- Dense (75% cover) Potamogeton perfoliatus with lesser amounts of filamentous algae, nitella sp. and Najas flexilis

N

0 25 50 100 150 200 Feet

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

Spy Pond

Arlington, MA
Vegetation June 2012

FIGURE:	SURVEY DATE:	MAP DATE:
4	06-27-12	07-02-12

Legend

- Low to moderate density Eurasian mifoil and light cover of filamentous algae and scattered sago pondweed (5-40% cover)
- Eurasian milfoil dominant and dense with lesser amounts of sago pondweed (75-100%)
- Dense sago pondweed with lesser amounts of thin-leaf pondweed and naiad (75-100% cover)
- Open water

N

0 250 500 Meters

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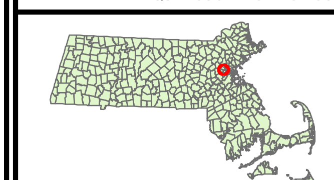
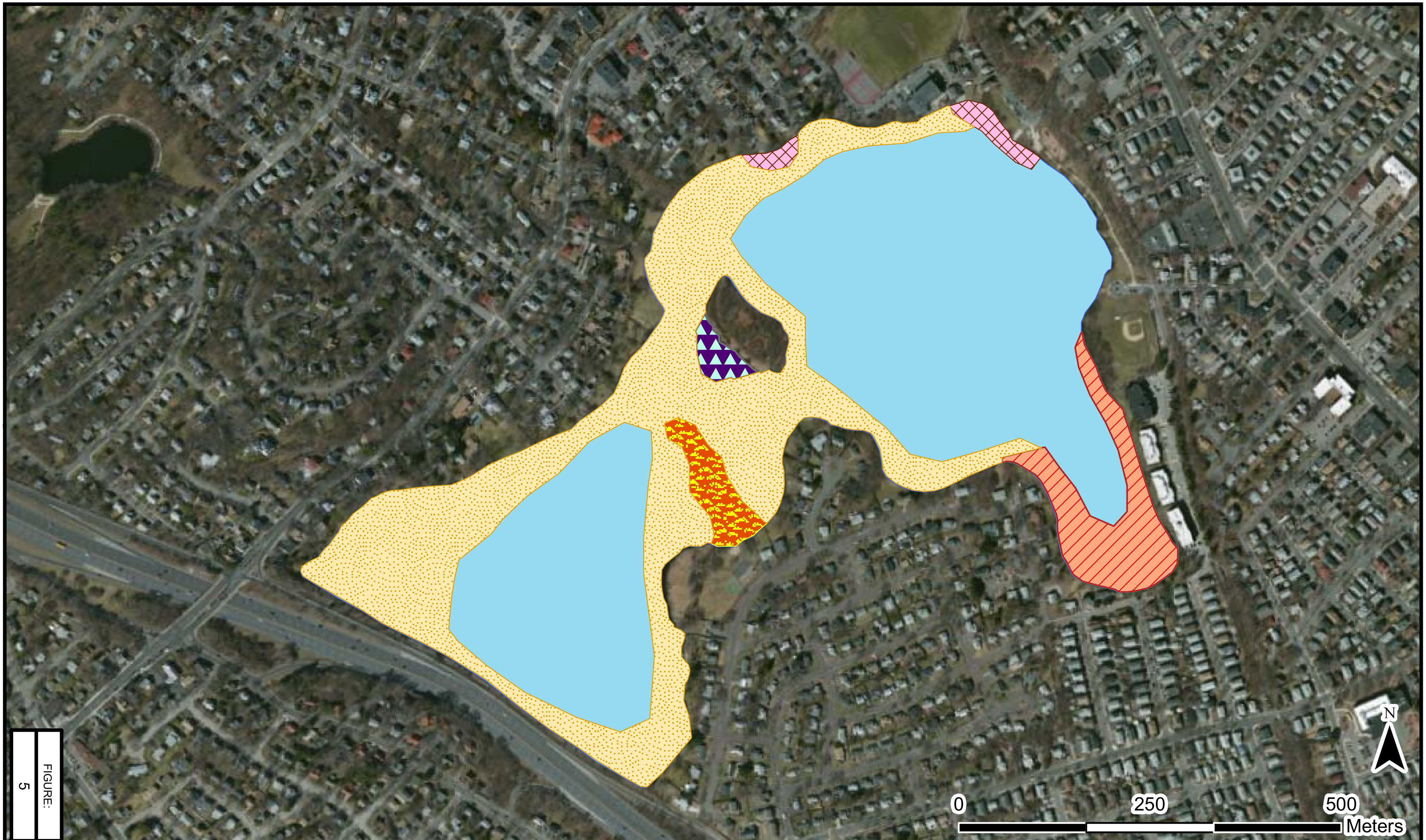
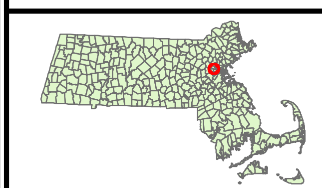
PHONE: (508) 865-1000
FAX: (508) 865-1220
WEB: WWW.AQUATICCONTROLTECH.COM







Spy Pond

Arlington, MA
Vegetation August 2012

FIGURE:	SURVEY DATE:	MAP DATE:
5	08-16-12	02-08-13

- Low density growth of nitella, sago pondweed, and filamentous algae (10-25% cover)
- Low to moderate density Eurasian milfoil regrowth (15-30% cover)
- Low density growth of snailseed pondweed, coontail, and filamentous algae (10-25% cover)
- Moderate regrowth of sago pondweed and Eurasian milfoil (50% cover)
- Low to moderate growth of clasping leaf pondweed with lesser amounts of nitella (25-50% cover)
- Open water

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

ATTACHMENT B

Algal Count Datasheets

Counted by: PAB	Date:02-07-13	Project & Sample Date	Project & Sample Date	Project & Sample Date	Project & Sample Date
ALGAL DIVISION	**Algal Taxa**	Spy Pond - Site 1 6/27/12	Spy Pond - Site 2 6/27/12	Spy Pond - Site 1 7/11/12	Spy Pond - Site 2 7/11/12
Bacillariophytes:	Acanthoceras				
(DIATOMS)	Achnanthes				
	Asterionella				
	Cocconeis	444	296	444	
	Cyclotella				
	Fragilaria				
	Navicula				148
	Nitzschia				148
	Pinnularia			148	
	Stauroneis			296	
	Stephanodiscus				
	Synedra	148		444	
	Tabellaria		148		148
	Actinastrum				888
	Totals:	592	444	1332	1332
Chlorophytes:	Ankistrodesmus		148	148	148
(GREENS)	Arthrodesmus				
	Botryococcus				
	Chlamydomonas			296	
	Chlorella	2220	1332	2220	5772
	Chlorococcum	13320		2960	2960
	Chlorogonium		1480		148
	Closterium			592	
	Coelastrum				
	Cosmarium				
	Dictyosphaerium	5920	3552	7104	4736
	Elakatothrix	148			
	Gleocystis	23680		2960	4440
	Golenkinia		148	148	
	Micractinium				
	Microspora				
	Crucigenia				
	Pediastrum				
	Scenedesmus		888	888	296
	Schroederia		148		
	Sphaerocystis	11840			
	Ulothrix				5920
	Pandorina	8880			
	Stigeoclonium		5920		11840
	Selenastrum		296		1184
	Totals:	66008	13912	17316	37444

Counted by: PAB	Date:02-07-13	Project & Sample Date	Project & Sample Date	Project & Sample Date	Project & Sample Date
ALGAL DIVISION	**Algal Taxa**	Spy Pond - Site 1 6/27/12	Spy Pond - Site 2 6/27/12	Spy Pond - Site 1 7/11/12	Spy Pond - Site 2 7/11/12
Chrysophytes:	Dinobryon				
(GOLDEN)	Mallomonas		296	148	148
	Synura				
	Totals:	0	296	148	148
Cryptophytes:	Cryptomonas		148		
	Rhodamonas		148		444
	Chroomonas				
	Chromulina				
	Totals:	0	296	0	444
Cyanophytes:	Anabaena		2960		
(BLUE GREENS)	Aphanizomenon				17760
	Aphanocapsa				4440
	Arthospira				
	Chroococcus				
	Coelosphaerium				
	Gomphosphaeria				
	Lyngbya				
	Merisomopedia			35520	40256
	Microcystis	8880	5920	5920	32560
	Nostoc				
	Oscillatoria				
	Rivularia				
	Totals:	8880	8880	41440	95016
Euglenophytes:	Euglena	444	148	444	296
	Phacus				
	Trachelomonas	148	148	444	592
	Totals:	592	296	888	888
Pyrrhophytes:	Ceratium				
(DINOFLAGELATES)	Gymnodinium				
	Peridinium	148		296	
	Totals:	148	0	296	0
Rhodophytes:	Cyanidium				
	Totals:	0	0	0	0
GRAND TOTALS:		76220	24124	61420	135272

Counted by: PAB	Date:02-07-13	Project & Sample Date	Project & Sample Date	Project & Sample Date	Project & Sample Date
ALGAL DIVISION	**Algal Taxa**	Spy Pond - Site 1 8/03/12	Spy Pond - Site 2 8/03/12		
Bacillariophytes:	Acanthoceras				
(DIATOMS)	Achnanthes				
	Asterionella	148	148		
	Cocconeis	148			
	Cyclotella				
	Fragilaria	148			
	Navicula	148			
	Nitzschia	296	148		
	Pinnularia				
	Stauroneis	148			
	Stephanodiscus				
	Synedra	148	296		
	Tabellaria	148			
	Actinastrum		296		
	Totals:	1332	888		
Chlorophytes:	Ankistrodesmus	148	296		
(GREENS)	Arthrodesmus	296			
	Botryococcus				
	Chlamydomonas	740	1036		
	Chlorella	1776	3552		
	Chlorococcum				
	Chlorogonium				
	Closterium	444			
	Coelastrum				
	Cosmarium	296	296		
	Dictyosphaerium	5328	8880		
	Elakatothrix				
	Gleocystis	740	5920		
	Golenkinia		592		
	Micractinium		888		
	Microspora				
	Crucigenia				
	Pediastrum				
	Scenedesmus	2960	1776		
	Schroederia				
	Kirshnenella	592			
	Meugotia	1480			
	Haematococues	296			
	Monoraphidium		296		
	Selenastrum	148			
	Totals:	15244	23532		

Counted by: PAB	Date:02-07-13	Project & Sample Date	Project & Sample Date	Project & Sample Date	Project & Sample Date
ALGAL DIVISION	**Algal Taxa**	Spy Pond - Site 1 8/03/12	Spy Pond - Site 2 8/03/12		
Chrysophytes:	Dinobryon				
(GOLDEN)	Mallomonas	296	148		
	Synura				
	Totals:	296	148		
Cryptophytes:	Cryptomonas	296	148		
	Rhodamonas				
	Chroomonas				
	Chromulina				
	Totals:	296	148		
Cyanophytes:	Anabaena				
(BLUE GREENS)	Aphanizomenon				
	Aphanocapsa		20720		
	Arthospira				
	Chroococcus		1480		
	Coelosphaerium				
	Gomphosphaeria				
	Lyngbya				
	Merisomopedia	7104	4736		
	Microcystis	4440			
	Nostoc				
	Oscillatoria				
	Rivularia				
	Totals:	11544	26936		
Euglenophytes:	Euglena	148	148		
	Phacus		148		
	Trachelomonas	148	1036		
	Totals:	296	1332		
Pyrrhophytes:	Ceratium				
(DINOFLAGELATES)	Gymnodinium				
	Peridinium		148		
	Totals:	0	148		
Rhodophytes:	Cyanidium				
	Totals:	0	0		
GRAND TOTALS:		29008	53132		

Counted by: PAB	Date: 02-07-13	Project & Sample Date	Project & Sample Date	Project & Sample Date	Project & Sample Date
ALGAL DIVISION	Algal Taxa	Arlington Reservoir 8/16/12	Menotomy Rocks 8/16/12	Spy Pond- Site 1 8/16/12	Spy Pond- Site 2 8/16/12
Bacillariophytes:	Acanthoceras				
(DIATOMS)	Achnanthes				
	Asterionella				
	Cocconeis			148	444
	Cyclotella				
	Fragilaria				
	Navicula		148		148
	Nitzschia		444		296
	Pinnularia				
	Stauroneis				
	Stephanodiscus			888	
	Synedra	296			
	Tabellaria				
	Totals:	296	592	1036	888
Chlorophytes:	Ankistrodesmus				296
(GREENS)	Arthrodesmus	148			
	Botryococcus				
	Chlamydomonas			888	888
	Chlorella	1776	8880	3552	1776
	Chlorococcum				
	Chlorogonium				
	Closterium	148			
	Coelastrum				
	Cosmarium			296	592
	Dictyosphaerium	5920	8288	5328	7104
	Elakatothrix		148		
	Gleocystis	2220	2960	1480	740
	Golenkinia	148	148	444	592
	Micractinium		888	444	444
	Microspora				
	Crucigenia		2960		
	Pediastrum		4144		
	Scenedesmus	1184	1184	592	1776
	Schroederia		148		
	Selenastrum			148	
	Staurastrum				
	Palmella		29,600		
	Kirchnenella	296			296
	Tetraedron	296			
	Totals:	12136	59348	13172	14504

Counted by: PAB	Date:02-07-13	Project & Sample Date	Project & Sample Date	Project & Sample Date	Project & Sample Date
ALGAL DIVISION	**Algal Taxa**	Arlington Reservoir 8/16/12	Mentonmy Rocks 8/16/12	Spy Pond- Site 1 8/16/12	Spy Pond- Site 2 8/16/12
Chrysophytes:	Dinobryon				
(GOLDEN)	Mallomonas	296	296	296	444
	Synura				
	Totals:	296	296	296	444
Cryptophytes:	Cryptomonas			444	296
	Rhodamonas	444		148	296
	Chroomonas	444			
	Chromulina			148	
	Totals:	888	0	740	592
Cyanophytes:	Anabaena				
(BLUE GREENS)	Aphanizomenon				
	Aphanocapsa				
	Arthospira				
	Chroococcus			2220	
	Coelosphaerium				
	Gomphosphaeria				
	Lyngbya				
	Merisomopedia				4440
	Microcystis		2960		
	Nostoc				
	Oscillatoria				
	Rivularia				
	Totals:	0	2960	2220	4440
Euglenophytes:	Euglena				148
	Phacus			296	
	Trachelomonas	592	444	296	148
	Totals:	592	444	592	296
Pyrrhophytes:	Ceratium				
(DINOFLAGELATES)	Gymnodinium				
	Peridinium	296		296	
	Totals:	296	0	296	0
Rhodophytes:	Cyanidium				
	Totals:	0	0	0	0
	GRAND TOTALS:	14504	63640	18352	21164