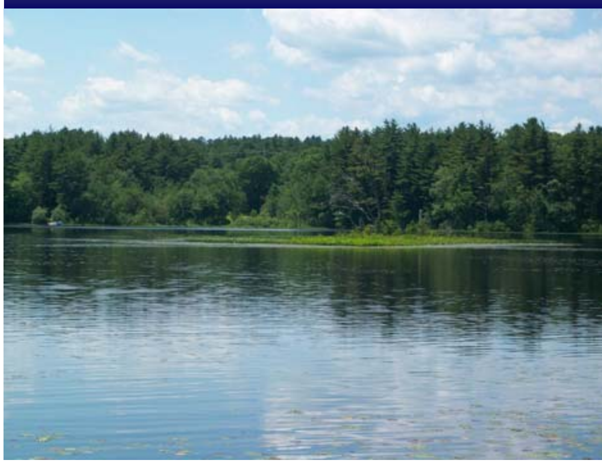
Baddacook Pond

Baseline Assessment Survey Report
July 2011



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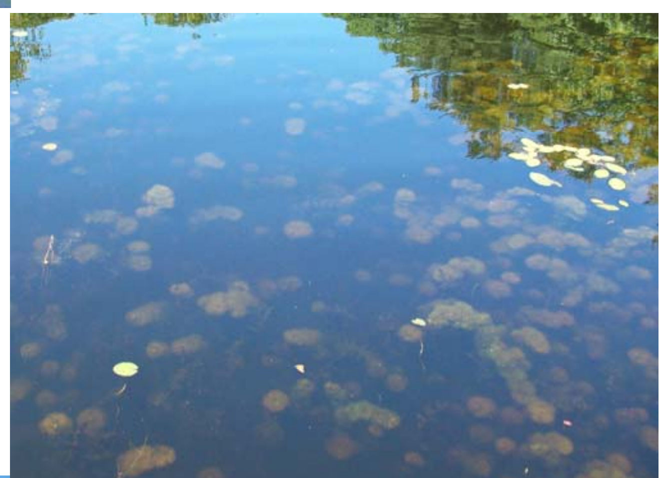

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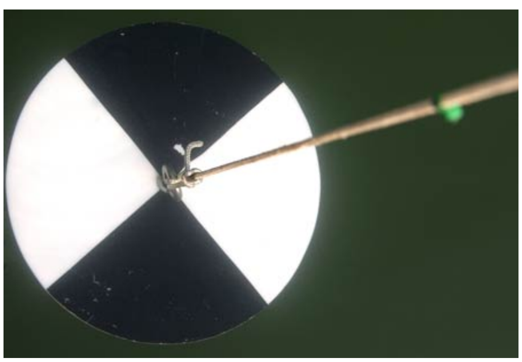
Introduction:

Baddacook Pond is an approximately 78 acre Pond located in Groton Massachusetts. The Pond reportedly has three small unnamed intermittently flowing tributaries along the western shoreline. Based on the topographical maps, water primarily enters the pond by filtering in through the wetland areas located to the north and south of the pond. The northern wetland likely flows in and out of the pond at different times of the year. Water exits the pond from a cove on the eastern shore flows through a forested wetland and enters Baddacook Brook where it flows in a south-easterly direction eventually reaching Whitney Pond. This wetland may back flow into the pond at times but appears to primarily flow away from the pond.

A Biologist from Aquatic Control conducted a baseline biological survey of Baddacook Pond on June 20th, 2011. The objective of this survey was to document current vegetation growth and water quality conditions in the Pond and to provide management recommendations. Tasks included in this field inspection consisted of a vegetation survey, spot measurements of sediment depth and type, spot measurements of water depth, water quality sampling and water clarity measurement. The day of the survey was sunny with little wind, allowing for good visualization of the pond below the water's surface.

Water Clarity, Water Depth and Sediment Depth Measurements



Water Clarity was measured using a Secchi disk in the deeper section of the Pond. A Secchi disk is a black and white colored disk attached to a calibrated measuring tape. The disk is lowered below the water surface and the depth at which the disk becomes no longer visible is recorded. This method is used throughout the scientific community to measure and compare water clarity. The water clarity at Baddacook Pond was 9ft 10in on the day of the survey. This clarity is typical for a Pond of this size located in this region.

Sixteen water depth measurements, utilizing a calibrated pole, were taken at predetermined locations throughout the littoral zone of the Pond. The average water depth in the littoral zone observed at Baddacook Pond was ~4.91 feet with a maximum observed depth of ~14 feet (table 1). Reportedly water depths reach ~45 feet in the deepest portion of the Pond.

Sediment is characterized as muck, sand, gravel or peat. The average unconsolidated sediment depth was determined by pushing a calibrated pole into the soft sediment until a firm refusal layer is reached. The unconsolidated sediment in Baddacook Pond varied in characterization (see table 1). The average sediment depth in the littoral zone observed was approximately 3.6 feet with a minimum observed unconsolidated sediment depth of 0 feet and a maximum observed depth of 10 feet (table 1).

Vegetation and Algae Survey Methods and Results

Fanwort and whitestem pondweed in Baddacook Lake

The vegetation survey was conducted utilizing a variety of techniques including a throw rake, underwater camera system, and visual observations (figure 2). The most abundant species observed on the day of the survey was fanwort (*Cabomba caroliniana*). Moderate to dense fanwort was observed throughout the littoral zone covering a total of approximately 29 acres of Baddacook Pond.

Other dominant in-Pond species observed included variable milfoil (*Myriophyllum heterophyllum*), coontail (*Ceratophyllum demersum*), bladderwort (*Utricularia sp*.), quillwort (*Isoetes sp.*), curly-leaf pondweed (*Potamogeton crispus*), ribbonleaf pondweed (*Potamogeton epihydrus*), thinleaf pondweed (*Potamogeton pussilis*), robbin's pondweed (*Potamogeton robbinsii*), floating leaf pondweed (*Potamogeton natans*), white stem pondweed (*Potamogeton praelongus*), white waterlily (*Nymphaea odorata*), yellow waterlily (*Nuphar variegatum*), watershield (*Brassenia schreberi*), Floating heart (*Nymphoides cordata*), duckweed (*Lemna sp.*), watermeal (*wolfia sp.*), Pickerel weed (*Pontederia cordata*), hedge-hissop (*Gratiola aurea*), arrowhead (*Peltandra virginica*) cattails (*Typha sp.*) (figure 2, table 1). Of these species variable milfoil, fanwort and curlyleaf pondweed are non-native invasive species. These species will out-compete native species, reduce open water habitat and make poor quality fish habitat.

Dense waterlily growth in the shallow waters of Baddacook Lake

During the June survey a few small clumps of algae, which looked like they could be blue-green algae were observed. A sample was collected and brought back to Aquatic Control for preservation and identification. *Closterium*, which is a green algae taxa, *Oscillatoria,* which is a blue-green algae taxa and several different diatoms were identified as the dominant taxa. The presence of a blue-green algae species which can produce toxins is cause for some concern; however given the densities observed no immediate action is necessary. It is important to keep in mind that algae densities and distribution changes throughout the summer. If blue-green algae appear to be a problem in the Pond at any time please contact Aquatic Control. Information on what to watch out for in terms of blue-green algae blooms is attached to this report.

Water Quality Sampling and Results:

Two surface water quality sample sets were collected in the pond. The first sample was collected mid-pond and the second was meant to be collected at a primary inlet. Looking at the watershed and sediment build-up we determined that water likely primarily filters into the pond through the two wetlands located on the northern and southern sides of the pond. A second water quality sample was collected at the southern end where a slow moving but relatively wide inlet enters the pond from the southern wetland.

To collect the samples, sterile 1 liter sample bottles were submersed elbow deep and filled. Careful attention was taken not to touch any surface inside the bottles or caps. The samples were sent to Microbac Laboratories to test for pH, alkalinity, turbidity, nitrate nitrogen, ammonia nitrogen, total Kjeldal nitrogen, total phosphorous, true color, apparent color and E. coli. The results are summarized below in table 1.

Table 1: A Summary of Water Quality Sample Results for 2011

Parameter	Units	Inlet	Mid-Pond
pH	S.U.	7.25	7.34
Alkalinity	$CaCO_3$/L	21.9	22.6
Turbidity	NTU	0.660	0.36
Total Kjeldahl Nitrogen	mg/L	1.10	0.7
Ammonia Nitrogen	mg/L	<0.100	<0.100
Nitrate nitrogen	mg/L	<0.400	<0.400
Total Phosphorous	mg/L	0.0198	0.0142
True Color	Pt-Co	42	38
Apparent Color	Pt-Co	45	42
E. coli	CFU/100ml	50	ND

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. The pH was recorded in Baddacook Pond was relatively consistent between the mid-Pond sample and the sample collected at the southern inlet. Both values were within the desired range.

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 (i.e. acid rain). The alkalinity measurements for the samples collected in Baddacook Pond both indicate that the Pond should be well buffered against pH fluctuations.

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 healthy ponds and Ponds rarely rise above 5 NTU and typically <1 NTU in waterbodies used for swimming. The turbidity measurement in the inlet was somewhat higher than the mid-Pond value. This is to be expected due to the fact that when water flows into the pond from the inlet its initial high velocity does not allow for suspended solids to settle out. When the water reaches the deeper portions of the pond it slows to the point where solids are able to settle out. Both values were desirably low and indicate good conditions for swimming.

Ammonia nitrogen: Nitrogen is an essential element for plant growth. Nitrogen is found in the environment in several forms. High levels of nitrogen can indicate poor water quality. In particular high concentrations of ammonia nitrogen can be toxic to fish. Ammonia is also important due to the fact that it is a by product of the decomposition of organic material. In the presence of oxygen, ammonia is readily converted to nitrate nitrogen. Therefore high ammonia nitrogen concentrations may indicate low oxygen levels to anoxic conditions. Levels of ammonia nitrogen observed in the samples collected at Baddacook Pond were all desirably below laboratory detection limits (0.100 mg/L).

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. Nitrate nitrogen levels were below detectable levels (0.400 mg/L) both the inlet sample and the mid-Pond sample. While this is not very concerning it is a bit unusual and we would recommend further testing of the Pond throughout a summer season to observe if the levels fluctuate considerably.

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. The results from Baddacook Pond indicate moderate amounts of organic nitrogen and ammonia. Given the three nitrogen results it is possible that the level of nitrogen break-down by microbial processes is low and that as nitrogen is converted to the forms that are more easily utilized it is being utilized by plants and algae. It is important to understand that each sample is representative of a mere “snap-shot” or 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 nitrogen levels.

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. Phosphorous levels in the inlet and mid-Pond samples were both below this threshold. These results are consistent with the secchi disk reading of 9ft 10in. Both observations indicate low levels of microscopic algae. 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. The results from Baddacook Pond indicate that the color of the water is primarily the result of dissolved particles such as tannic acid. Tannic acid imparts a somewhat darker “tea color” to the water but it is largely of natural origin and not a pollutant. The color content typically increases throughout the course of the summer as the water temperature warms and the release of tannic acid from bottom sediments is accelerated.

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 Pond 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 samples taken in Baddacook Pond both showed low levels of E coli indicating acceptable conditions for swimming and other contact recreation. The slightly elevated levels near the southern inlet were likely due to water fowl or other wildlife inputs in the adjacent wetland.

Temperature dissolved oxygen:

Depth (meters)	Temperature (°C)	Dissolved Oxygen (mg/L)
Surface	27.1	9.06
1	24.2	8.87
2	22.1	9.20
3	18.2	9.66
4	12.5	6.48
5	8.7	2.48
6	7.3	1.15
7	6.1	1.14
8	5.5	1.25
9	5.0	0.81
10	4.9	0.71
11	4.8	0.68
12	4.8	0.65
13 (off bottom)	4.8	0.64

During the June survey a temperature and dissolved oxygen profile was recorded for Baddacook Pond mid-Pond. The results indicate that the Pond is strongly stratified; the thermocline was located between 4 and 5 meters below the surface on the day of the survey. Good oxygenation was observed through the epilimnion of the Pond and relatively low oxygen levels through the hypolimnion of the Pond. This is relatively common mid-summer in strongly stratified Ponds.

Watershed Information:

Land Use Type	Area
Water	79.5
Non-forested Wetland	23.5
Forested wetland	65.1
Forest	242.1
Pasture	15.3
Power line/ Utility	19.5
Very Low Density Residential	17.6
Low Density Residential	23.3
Multi-Family Residential	2.3
Total	**488.4**

The watershed of Baddacook Pond was estimated using a USDA topographical map. The watershed is depicted on Figure 3 and encompasses an area of 488.4 acres. A watershed is defined as the land area from which surface water drains into a given Pond or pond. Land uses and activities within the watershed can affect water quality and quantity. Figure 3 shows the reported land uses based on 2005 data compiled from the MA DEP and the table (left) summarizes the proportions of the different land use types in the watershed. Reviewing this information is a good place to begin addressing watershed management techniques and can form a basis for further investigations and monitoring (see watershed management section below).

Management Options and Recommendations:

The condition of Baddacook Pond is similar to many other waterbodies in the region. Commonly referred to as "eutrophic", the Pond is characterized by high biological productivity, excessive aquatic plant growth, increased sedimentation, and a nutrient-rich mucky bottom. Eutrophication (or "aging") of a pond is a natural process but can be accelerated due to pollution, development and wildlife activity.

The most obvious symptom of eutrophication in Baddacook Pond is the excessive growth of aquatic plants, dominated by fanwort and to a lesser extent by variable milfoil and waterlily species. As a result the focus of our management plan is the management of nuisance aquatic plant species.

In broad terms, Pond management can be broken down into in-Pond and watershed management techniques. In addition to active management, it is also recommended to conduct on-going monitoring of vegetation and water quality.

In-Pond Management Techniques:

In-Pond management techniques are typically broken down into mechanical, physical, chemical and biological methods. The following is a discussion on the applicability of each technique to Baddacook Pond.

Mechanical Techniques

Mechanical techniques include mechanical cutting/harvesting and hydro-raking. Harvesting involves cutting the nuisance weed growth below the water's surface and collecting the cut plants for removal from the pond. In most cases, harvesting provides only short term control of the target plants and multiple cuttings over the course of a season may be required to maintain desirable conditions. Repetitive annual harvesting of some annual (seed producing) plants such as water chestnut or certain pondweed species, however, may can result in long-term control.

In the case of Baddacook Pond the Association is limited by the NHESP permit to only using the harvester in the fall after the water temperature drops below 50°F. The only major concern for re-rooting of fragmented materials during harvesting would be the possibility of downstream infestation. The spread of fanwort downstream due to fragmentation during harvesting could be hindered by stretching a fragment barrier across the outlet portion of the pond. It should be noted that the barrier would likely have to stretch further than just along the main area of the outlet as it appears that water filters out through a larger portion of the wetland area located on the southeastern side of the northeastern cove and also flows out of the northern wetland at times.

Due to the time constraints imposed on harvesting at Baddacook Pond we are not sure much, if any, carry-over control will be seen in the year following harvesting. In addition to this little recreational benefit will be experienced in the year of management, due to the fact that management must occur after the majority of in-Pond of recreational activities have subsided for the year. That said, harvesting will help to reduce the amount of biomass accumulating on the bottom of the Pond

Aquatic Control operates several harvesting machines which cut the weeds 5-7 feet below the water's surface and collects the cut material for off-site disposal. We understand Baddacook Pond has access to a harvester of their own and has harvested in the past. In general, as compared to other vegetation control techniques like herbicide treatment, harvesting will be more expensive per unit area (unless you are able to borrow a machine and can run it yourself) and will provide shorter term control. As previously mentioned harvesting does have the advantage of removing the plant biomass from the system.

Harvesting is not the recommended approach for Baddacook Pond, but would provide temporary relief from nuisance vegetation in the event that herbicide treatment is not approved by the Association or the State Regulators.

Another mechanical technique, Hydro-Raking, is performed with a "floating backhoe" type machine and involves the removal of plants, root systems and associated hydrosoils. The Hydro-Rake is powered by hydraulic paddle-wheels and is capable of working in as little as 1.5-feet of water. Hydro-raking is typically not recommended for control of submersed plants especially those species that can reproduce through vegetative fragmentation such as fanwort or milfoil, but rather for emergent plants, like cattails, and floating leaf plants, like waterlilies. Control of submersed plants is seasonal at best, while control of plants with significant root-systems can be 2-3 years or more. Hydro-Raking would not be the method of choice for widespread control of submersed plants, but could be effective on areas of emergent vegetation and waterlilies and would be a valuable tool to clean individual shorefronts of leaf litter and other debris.

Hydro-raking is contracted on an hourly basis ($190/hour), generally with a 16-hour minimum and a lump sum mobilization/demobilization charge of $1,200. In general, it takes about 1-2 hours to adequately rake a 50’ x 100’ area, however this estimate can change depending on the density of vegetation, frequency of underwater hazards and distance to offloading areas. Plants with significant root systems, like waterlilies, are likely to take more work to remove. Since the Hydro-Rake has no onboard storage, and must deposit each rake-full on the shoreline, it is most advantageous to have a nearby off-loading location, ideally within ~200 feet of the work area. If this is not practical, we can utilize a harvester/transporter, at an additional cost of $185/hour, to move the raked material to a more distant offloading location without significantly decreasing the efficiency of the raking process.

It is the responsibility of the Association to handle the loading, trucking and disposal of the raked (or harvested) material through a separate, local contractor. Upland disposal of the material at least 100-feet away from the water may be required by the wetland regulations. The Association can expect the cost of this work to be an additional 33-50% of the mechanical budget.

A permit will need to be filed with the Conservation Commission for any mechanical work proposed in the Pond. The cost for Aquatic Control to prepare and file this type of permit and attend one meeting of the wetland agency generally ranges from $1,500-$2,000 plus expenses (i.e. filing fees, postage, copying, etc.). As each Town’s requirements vary, we or you may want to touch base with the Commission to determine how the permitting will be handled for any proposed work.

Chemical Treatment

Chemical treatment is the recommended approach for control of nuisance submersed weeds in Baddacook Pond. Treatment with USEPA / State registered aquatic herbicides and algaecides does not pose an unreasonable risk to the environment or human health when used by licensed applicators in accordance with the product label.

The herbicide of choice for the initial control of nuisance plant growth in Baddacook Pond would be Clipper (flumioxazin). While Clipper is not yet approved for use in Massachusetts, we are currently working with the herbicide in many other states. This herbicide, while it is a contact herbicide, would likely provide season long control of the variable milfoil and fanwort. Because it is a contact herbicide it works quickly compared to other herbicides and can be used in a partial Pond treatment. As with any type of herbicide treatment, some re-growth will eventually occur, especially with the less sensitive species. While we expect conditions will continue to be much improved in the year after treatment, the Association will want to budget for maintenance treatment.

Another option for chemical treatment of the species present in Baddacook Pond is Sonar (fluridone). Sonar works slowly and requires a 45-60 day contact time with the plants to work effectively. The toxicity of Sonar is considered to be very low and it can even be used in drinking water reservoirs in some situations with little or no water use restrictions. Sonar can be applied as either a liquid (which provides an instantaneous concentration) or as a pellet (which provides a release of the herbicide over a period of time). For Baddacook Pond, both the liquid and the time-release action of the pellets would be vital to achieving the desired contact time. To further prolong the contact time, multiple applications of the herbicide would be necessary over the course of the summer. Even with the use of pellets and multiple applications due to the size and depth of the Baddacook Pond and the inability to control outflow, maintaining the necessary contact time at the required dose (12-15 ppb) would be challenging and costly. A whole Pond treatment would likely be required in order to combat the effects of dilution and as a result the use of Sonar would likely be cost prohibitive.

Waterlily growth could be targeted in specific areas to open up swim areas or boating channels if desired with Aquapro® (glyphosate) herbicide. We would work with the Association to determine specific treatment areas if desired and leave other areas of fish/wildlife habitat.

Prior to any treatment, the Pond's shoreline will be posted with signs warning of the temporary water use restrictions in effect. These restrictions include closing the Pond to all uses, including boating, fishing and swimming on the day(s) of treatment. If Clipper were utilized there would be a five day irrigation restriction. If Sonar were used, there would be a 60-90 day irrigation restriction, depending on the timing of split applications.

Algae Control & Nutrient Precipitation/Inactivation

While rooted aquatic plant growth derives its nutrients primarily from the Pond's sediments, algae growth (both filamentous & microscopic) depend on nutrients in the water column. The concentration of nutrients in the water column can vary throughout the year and when present in sufficient quantities, may stimulate excessive growth of algae.

If algae become problematic, typical symptoms are heavy mats of filamentous species, surface scums and/or reduced water clarity from microscopic species. Severe algae blooms are not only unsightly but can also reduce dissolved oxygen levels, produce odors and be a potential health hazard. The most common method of controlling algae is treatment with copper-based algaecides like copper sulfate or liquid copper chelates (Captain, Cutrine, etc.). There are some new products such as peroxide agents, copper/polymer mixes and devices that use sounds waves to disrupt algae cells, however their effectiveness is questionable at this time.

In the event that either filamentous or microscopic algae becomes problematic at Baddacook Pond, copper based algaecides could be used. Typically, copper sulfate is used for applications targeting microscopic algae or to treat large sections of the Pond. Given their higher cost, liquid copper algaecides would be used to treat smaller sections of the Pond. It's somewhat unusual for filamentous algae to be a major problem in a waterbody the size of Baddacook Pond, however topped out plant growth can trap and exacerbate is growth when present. As previously mentioned blue-green algae species were observed in the Pond though not at concerning densities. Were a bloom to form we would recommend treatment with a copper algaecide prior to the bloom reaching problematic densities. Treatment would be low dose and split into multiple applications in the presence of trout which can be sensitive to copper algaecides. Residents should keep vigilant for green or blue-green surface scums and notify Aquatic Control if they have concerns (see attached information)

Nutrient precipitation/inactivation treatments are designed to make phosphorus (the primary nutrient that feeds algae growth) biologically unavailable. This type of treatment involves applying a metal salt, usually aluminum sulfate (alum) to sequester the phosphorus and settle it to the bottom of the Pond. Depending on pH and alkalinity, a buffering compound may also need to be applied. Alum treatments can be performed with a low dose to remove only the phosphorus from the water column (precipitation) or with a higher dose to also inactivate the top layer of sediment which can release phosphorus to the water under anoxic conditions.

Alum treatments are not appropriate for all waterbodies and further study would be needed including sediment/water testing, phosphorus/hydraulic budgets and bioassays. Given the low levels of phosphorous observed in our first round of water quality tests, we do not anticipate that phosphorous inactivation will be necessary.

Physical Control Techniques

Benthic weed barriers are used to cover the bottom of the Pond and control weed growth by shading and compressing the plants. Benthic weed barriers are typically used in small beach or dock areas and are not economical for control of large infestations. Barrier costs are in the range of $1.00-$1.50/ft^2 installed. Barriers would not be appropriate for widespread control of plants in Baddacook Ponddue to the lack of selectivity of this technique for plant control and the potential for the widespread hindering of access to the sediments by macro-invertebrates. However they would a good tool to clear small areas for swimming or to allow for boat access to the deeper portions of the Pond where fanwort and milfoil are not currently growing.

Pond dyes are intended to color the water and reduce the amount of sunlight that is available to feed weed and algae growth. These dyes are only marginally effective and not generally recommended for natural ponds with a flowing outlet.

Aeration of the water provides many good benefits, including oxygenation and circulation, but properly designed systems for large Ponds can be prohibitively expensive and will not control rooted plant growth. Large Ponds are also usually naturally well-oxygenated unless severely polluted and/or very deep. Aeration could provide limited benefits at Baddacook Pond; however these benefits are not likely to justify the cost.

Dredging is usually a very costly technique and planning/permitting alone can often cost in the range of $20,000 or more. Since there is a moderate amount of sediment collected in the Pond, it would probably benefit somewhat from dredging, however the cost of such a project would likely be very high, with no guarantees that additional vegetation management would not be required. Based on an approximate unit cost of $20-$40 per cubic yard, dredging just 2-feet of sediment over a 2-acre area would cost in the range of $125,000-$250,000. A dredging feasibility study would be required to provide more details about a possible dredging project.

Drawdown is a commonly used and typically low-cost technique that can provide control of rooted plants in some Ponds. The principal mechanism through which water level drawdown controls aquatic plants is exposure to unfavorable climates for an extended period of time. This is accomplished by lowering the water level of the waterbody and exposing the target plants to the open air, essentially killing the plants and certain reproductive structures, due to the combined effects of sustained freezing and/or drying. Water level drawdown can be performed during the summer or winter months, but due to several factors, including environmental impacts, waterbody usage, ability to refill and the added benefit of freezing temperatures, drawdowns are usually performed throughout the fall and winter months, at least in northern waterbodies. Baddacook Pond does not have the structures in place to control the water level and as such drawdown is not likely to be a viable option.

Biological Control Techniques

There are no legal plant specific biological agents known to be effective on the nuisance aquatic species present in Baddacook Pond.

Watershed Management

Only limited water quality data (chemistry, temperature, dissolved oxygen and clarity) was collected as part of this survey and a more detailed investigation will be necessary to identify watershed nutrient sources and assess the potential methods for mitigation.

Watershed management involves identifying and mediating or eliminating sources of nutrients and/or pollution in the watershed. The process of identification involves a thorough survey of the watershed area and further water testing, including sampling upstream tributaries and waterbodies. Samples are taken throughout the year to reflect both base flow and storm flow conditions. Calculation of the potential nutrient load can be made from land-use data using accepted coefficients. "Nearby" watershed areas must also be evaluated and include the residential lots around the ponds and direct runoff from the surrounding streets and other impervious areas.

Such a study is normally referred to as a "diagnostic/feasibility" study and can cost upwards of $20,000 or more. The ultimate goal of such as study is a review and cost vs. benefit analysis of "best management practices" (BMP's) which can be implemented by the Town and pond residents. The following list describes a selection of some common watershed management options broken down into two categories:

Source Control

Limit impervious area – Impervious areas such as parking lots, driveways, buildings and roads interfere with the natural absorption and filtering of storm water through soils. Limiting impervious areas will reduce flow volumes and mitigate plug flow of nutrients into the watercourse.

Minimize contaminant exposure – Regulating the use of potentially hazardous chemicals and other nutrient sources in the watershed area.

Control of fertilization, pet & yard wastes – Educational campaigns or ordinances to increase awareness of proper processing of pet & yard wastes and the control of fertilization practices and other activities which introduce nutrients in the watershed (ex. car washing). Establishing practices to limit nuisance waterfowl, such as signs warning against feeding, can also eliminate a significant source of nutrients.

Land Management – Minimizing introduction of land uses that have potential to negatively impact the ponds and preservation of natural woodland areas through review of the zoning laws in the watershed will prevent increases in nutrient loading. Possible development and adoption of a Town watershed protection by-law will also aid in this endeavor.

Street Cleaning – Frequent cleaning of any paved roadways in the watershed and maintenance of catch basins will promote cleaner storm water runoff.

Transport Mitigation

Where substantial impacts have already been identified, some method of transport mitigation can be employed to minimize the pollution load from these sources.

Buffer Strips – Vegetated buffer strips of grass and/or shrubs can act as a biofilter to mediate nutrients from non-point sources before they enter the waterbody.

Catch Basins/Grease & Grit Traps ,Detention Basins, Infiltration systems – For point source runoff from drainage systems, construction and/or improvement of catch basins, detention basins or infiltration systems can significantly reduce the nutrient load of stormwater inflow.

Constructed Wetlands – For larger areas, simulated wetlands can act as both settling/detention basins and help to process nutrients from runoff.

Watershed management and source control are important to the long-term health of the pond system. While there did not appear to be major nutrient inputs during our survey, it is always a good idea to monitor the watershed for changes in land-use and potential sources of nutrient loading. The simplest techniques can be implemented right away through education, including proper septic system maintenance, proper fertilization procedures, maintenance of buffer strips and minimizing use of potential contaminants/nutrients. With the small watershed at Baddacook Pond, "near shore" BMP's like these are likely to have an effect on water quality.

Even if a watershed management plan is enacted, actual improvement of the pond condition will be a slow process. Nutrient recycling within the system will likely support growth of nuisance plants and algae indefinitely. Eutrophication is a natural process and although we can attempt to slow its progress, some type of in-Pond management is usually necessary.

Water Quality & Vegetation Monitoring

To maintain surveillance of the water quality and vegetation in Baddacook Pond, we recommend initiating an annual monitoring program to include one to two rounds of water quality data a mid-late summer vegetation survey. Samples should be collected late in the season both at the surface and within the hypolimnion for phosphorous to if determine internal nutrient cycling may be an issue. A temperature/dissolved oxygen profile and Secchi Disk transparency measurement will also be taken.

Data will be presented in an annual report along with any management activities that occurred that year. Management recommendations will be re-evaluated annually.

Permitting:

We recommend discussing with NHESP the possibility of filing a MESA form separately from an NOI initially. The project description for this application could discuss a number of management options. As the protected species is not disclosed it is hard to know what will be the lowest impact management options. Perhaps NHESP could shed some light on which program aspects would be allowable given the presence of this protected species prior to the filing of a notice of intent.

Summary of Management Recommendations

In summary, we recommend moving forward with discussions with NHESP on possible management techniques. Following this we would recommend either filing a new NOI or requesting an amendment to the old OOC to include new management techniques. We feel that a partial Pond treatment with the herbicide Clipper will be the best solution for management of the invasive exotic species in Baddacook Pond as soon as the approval process for its use in Massachusetts has been completed. In the interim we recommend the use of bottom barriers for small swim areas, docks or paths to the deeper water.

We also recommend conducting some level of annual water quality and vegetation monitoring. As knowledge and experience managing the Pond is built, the Association may want to consider some of the alternative management techniques discussed in this report. Management recommendations should be reviewed on an annual basis.

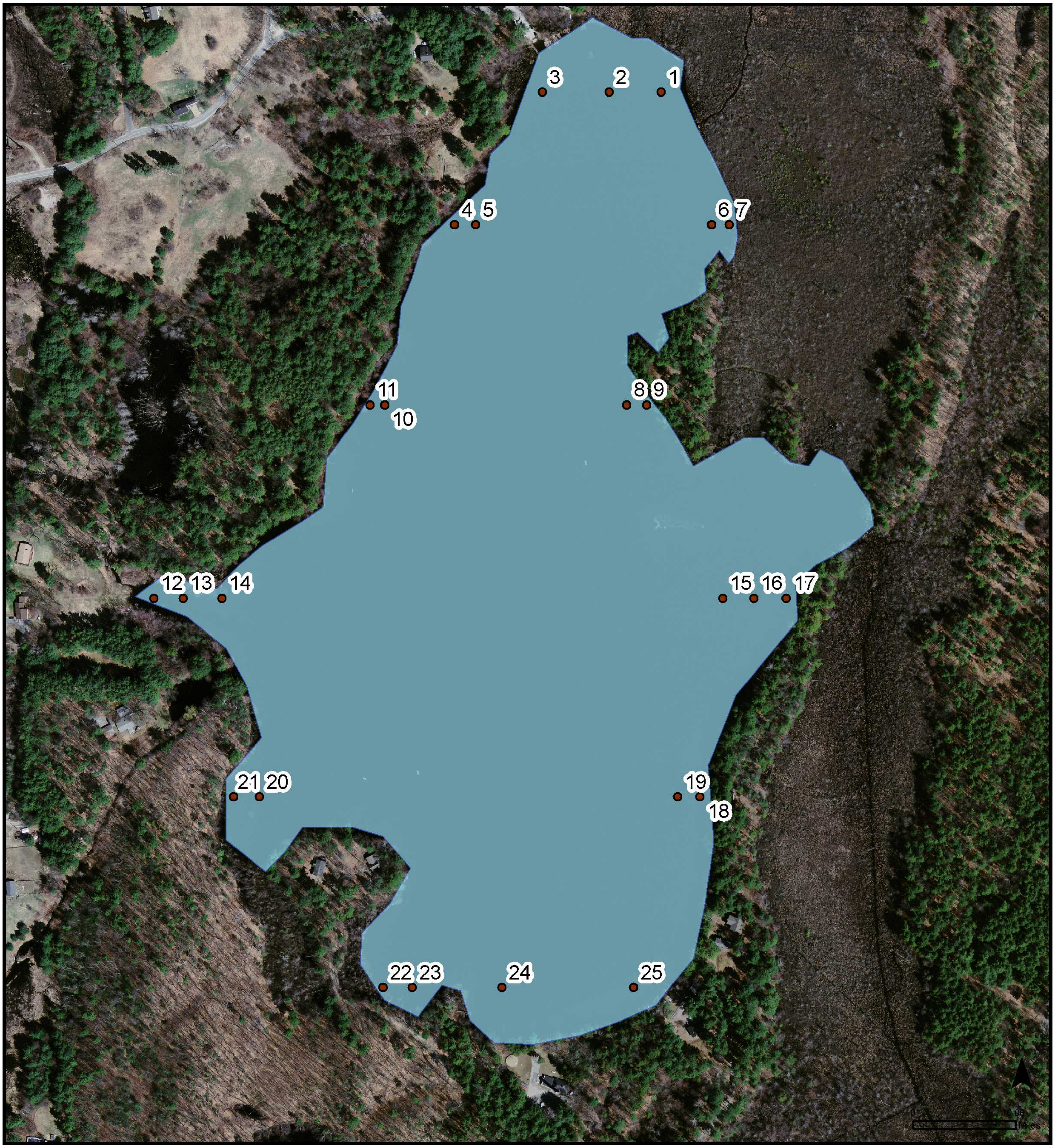
We hope that this information will aid you in future management decisions. If you have any questions or require additional information, please do not hesitate to contact our office.

Sincerely,

Aquatic Control Technology, Inc.

Erika J Haug

Erika Haug
Biologist



Baddacook Pond

Groton, MA
Point Locations

FIGURE:	SURVEY DATE:	MAP DATE:
1	6-21-11	6-20-11

Legend

- Data Point Locations (see table 1)

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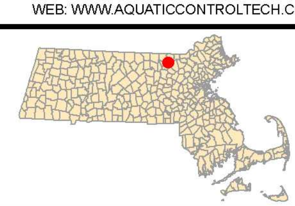

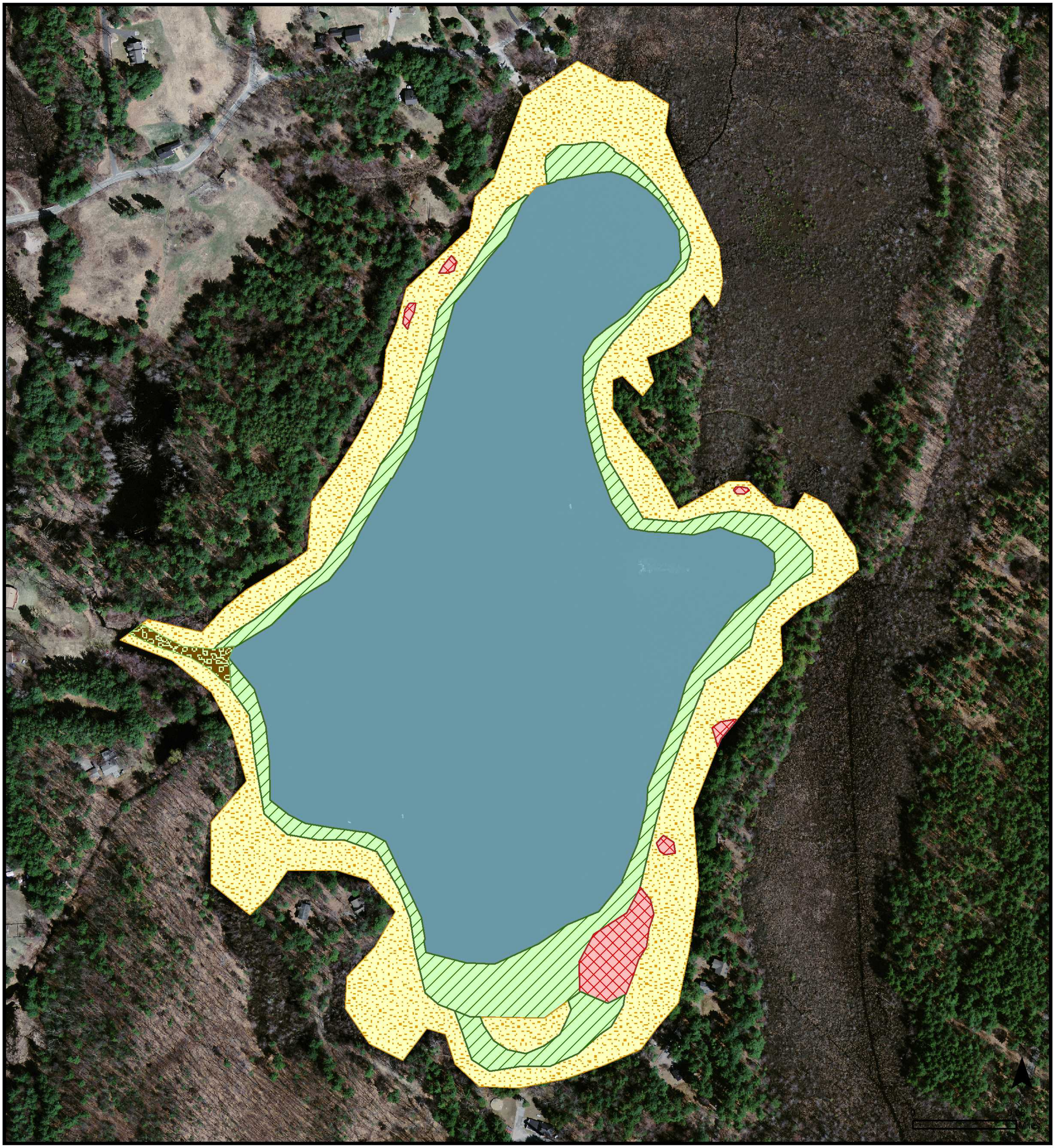

Baddacook Pond

Groton, MA

Vegetation Assemblage

FIGURE:	SURVEY DATE:	MAP DATE:
2	6-21-11	7-13-11

Legend

- Fanwort dominant with lesser amounts of bladderwort, whitestem pondweed and variable milfoil
- Mixed assemblage of coontail, tapegrass, robbin's pondweed, thinleaf pondweed, ribbonleaf pondweed, duckweed, watermeal, hedge hissop, bladderwort, and variable milfoil
- Variable milfoil dominant with lesser amounts of bladderwort and whitestem pondweed
- White waterlily dominant with lesser amounts of bladderwort, watershield, yellow waterlily, fanwort, whitstem pondweed, coontail, and floating-leaf pondweed. Pickerelweed, arrowhead and swamp loostrife near shore.

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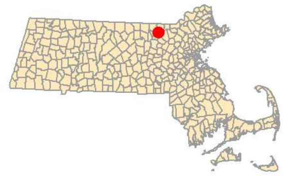

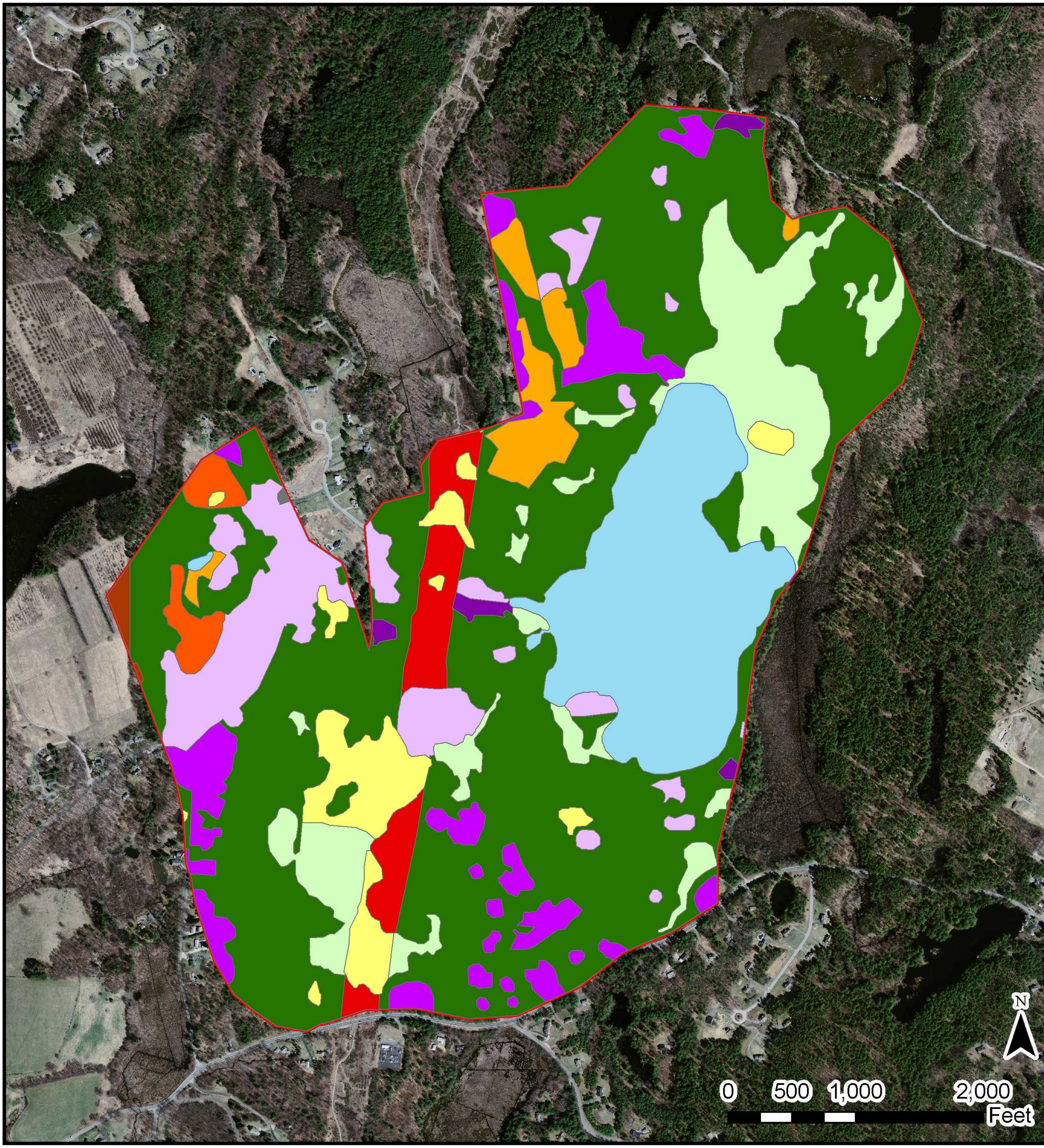

Legend

- Estimated watershed area
- Forest
- Forested Wetland
- Non-Forested Wetland
- Pasture
- Cropland
- Orchard
- Powerline/Utility
- Very Low Density Residential
- Low Density Residential
- Multi-Family Residential
- Open Land
- Lake Baddacook

Baddacook Pond

Groton MA
Land Use within Estimated Watershed

FIGURE:	SURVEY DATE:	MAP DATE:
3	6-20-11	7-12-11

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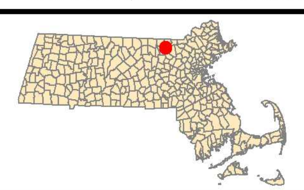


Baddacook Pond
6-21-11

Table 1: sediment , water depth and vegetation data

Point Number	Water depth	Sediment Depth	Sediment Type	Myriophyllum heterophyll	Cabomba caroliniana	Ceratophyllum demersum	Utricularia sp.	Isoetes sp.	Potamogeton crispus	Potamogeton epihydrus	Potamogeton pussilis	Potamogeton robbinsii	Potamogeton natans	Potamogeton praelongus	Nymphaea odorata	Nuphar variegatum	Brassenia schreberi	Floating heart	Pickerel weed	Lemna sp.	Wolfia sp.	Hedge hissop	Arrowhead
1	2.5	8.5	muck		X		X							X	X	X							
2	5	3.5	muck				X	X							X								
3	4	9	muck		X		X																
4	2	0.5	muck over sand		X		X	X	X						X			X					
5	5.5	0	rocky		X		X								X		X						
6	5	3	muck		X		X				X	X			X								
7	3	7	muck		X		X								X								
8	>14	n/a	n/a																				
9	3	0	rocky		X			X		X					X				X				
10	5.6666	4.3334	muck/ clay	X	X		X								X		X						
11	3	0	sand/ rock		X		X					X	X		X			X	X				
12	2.08333	2.166666	muck			X					X									X	X	X	
13	3.5	2.333333	muck	X			X				X	X									X		
14	3	10	muck		X										X		X						
15	11.5	1.5	muck		X																		
16	11	>2	loose muck		X																		
17	8	>5	muck		X																		
18	2.3333	0	sand	X				X															
19	4.25	0	sand	X			X							X									
20	4	>9	muck		X		X								X	X	X						
21	2.1666	2.6666	muck		X		X					X			X	X	X						X
22	2.6666	1.33333	muck				X								X		X						
23	3.6666	3.25	muck		X		X								X								
24	6.5	5.5	muck	X											X								
25	5.58	0.25	muck/sand	X	X		X								X								

Blue-Green Algae

Common Blue-green Algae Species in NH

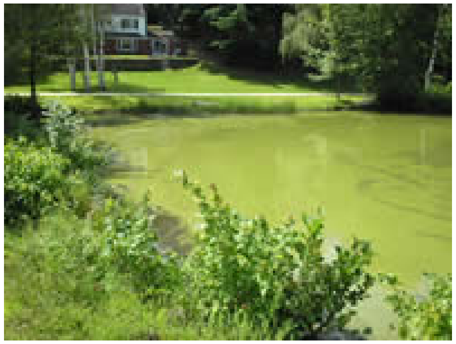
Genus	Common Toxin
Anabaena	Anatoxin Microcystin
Aphanizomenon	Saxitoxin
Microcystis	Microcystin
Oscillatoria	Anatoxin, microcystin aplysiatoxins

- **Possible effects:**
  - Acute: skin and mucous membrane irritation, nausea, vomiting, diarrhea, motor weakness
  - Chronic: Liver, kidney, central nervous system damage, potential link to ALS.

Blue-Green Algae

Monomonac, Rindge

Bow Lake, Northwood



- **How to recognize it:**
  - Pea-green scum on surface
  - Blue-green colored algae (clumps, uniform through water, clouds in the water or scum on surface)

Webster Lake, Franklin

Baboosic Lake, Amherst

Blue-Green Algae

- **What to do:**
  - Call ACT at 508-865-1000
  - Take a picture and collect a sample:
    - Clean glass or plastic bottle
    - Label with specific location (perhaps make a mark on a map to send along as well), date of collection, collector's name and brief (5-10 word) description
    - Keep on ice
    - Wash hands
    - Drop off at ACT for identification
  - Stay out of the water and keep pets out of the water
  - If you think you may have been exposed, take a shower immediately.
  - If you feel ill, visit the doctor and explain that you may have been exposed to Blue-green algae toxins.