WILDLIFE, HABITAT AND VEGETATIVE ASSESSMENT OF BARE HILL POND, WITH MANAGEMENT IMPLICATIONS

Prepared for

Bare Hill Pond Committee

Harvard, Massachusetts

Harvard, Massachusetts

Prepared by

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Introduction

This report is based on a field survey performed by ENSR biologists at Bare Hill Pond in Harvard, Massachusetts, on October 4 (in-lake vegetative assessment) and November 14, 2001 (wildlife, habitat, and vegetative assessment of riparian wetlands). The survey was performed to assess potential impacts on in-lake and riparian vegetation due to a projected increased lowering of the water level. The vegetation characterization at selected sampling stations may also serve as a reference for any future update, and is itself an update of the assessment carried out as part of a diagnostic study for the Town of Harvard in 1998 (ENSR, 1998). Assessment of in-lake vegetation followed the methods adopted for the 1998 survey, including location of observation points. Potential impact to wildlife habitat and wetland functions were assessed. Visual Encounter Surveys (VES) were performed to document wildlife use in the riparian wetland community associated with Bowers Brook and the emergent wetland community at Bare Hill Pond. Surveys were performed along random transects in the emergent and scrub-shrub wetland habitats. Additional surveys were performed in the upland forest habitat bordering the lake. Vegetative sample plots were established in the scrub-shrub wetland north of the dam and the emergent wetland community northeast of the town beach to inventory species composition and to collect plant cover estimates.

Site Description

The project site consists of Bare Hill Pond and surrounding upland and wetland plant communities in Harvard, Massachusetts (Figure 1). Bare Hill Pond is a ~321 acre lake (~129 ha, excluding island surface area) fed by Bowers Brook and several small streams. The water level in Bare Hill Pond is regulated by adding or removing wooden boards in the concrete weir set in an earthen dam on the northern shore of the lake below Camp Green Eyrie. Bowers Brook flows to the north from Bare Hill Pond into a scrub-shrub/emergent wetland community, where beavers have altered the water level.

Methods

In-Lake Vegetation Survey

The 2001 aquatic vegetation survey closely followed the methods adopted in 1998. The survey focused on macroscopic fully submerged, floating-leaved (e.g., waterlilies), and/or floating plants (e.g., duckweed). Plant cover, biovolume, and taxonomic composition of the aquatic vegetation were recorded at 66 points, 52 of which were along the five transects originally outlined in the 1998 survey (Figure 2). The in-lake vegetation survey was carried out on October 4, with partly sunny weather conditions, mild temperature (~55ºF or ~13ºC), and light southwesterly breeze.

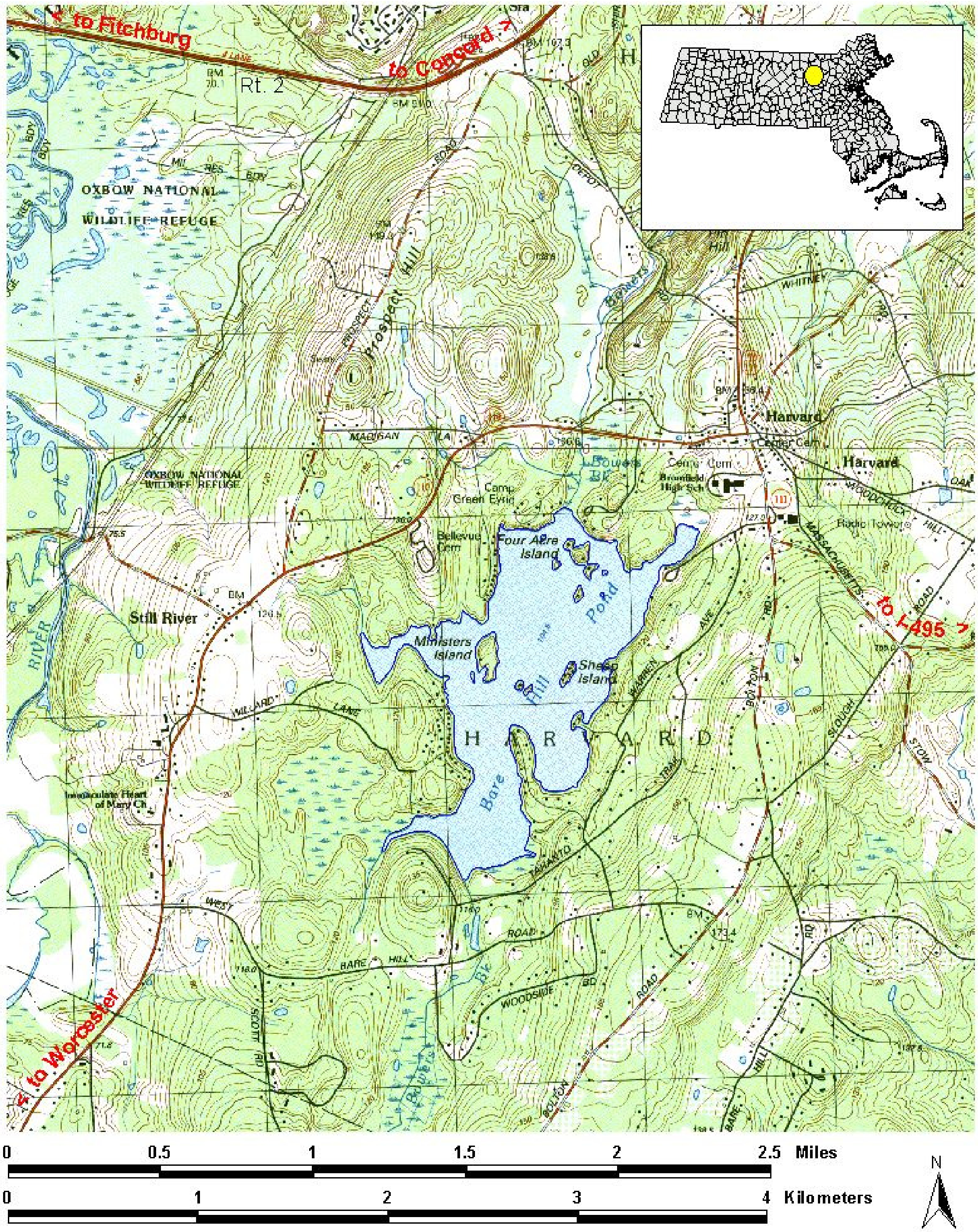

Figure 1. Location of Bare Hill Pond and its surroundings.

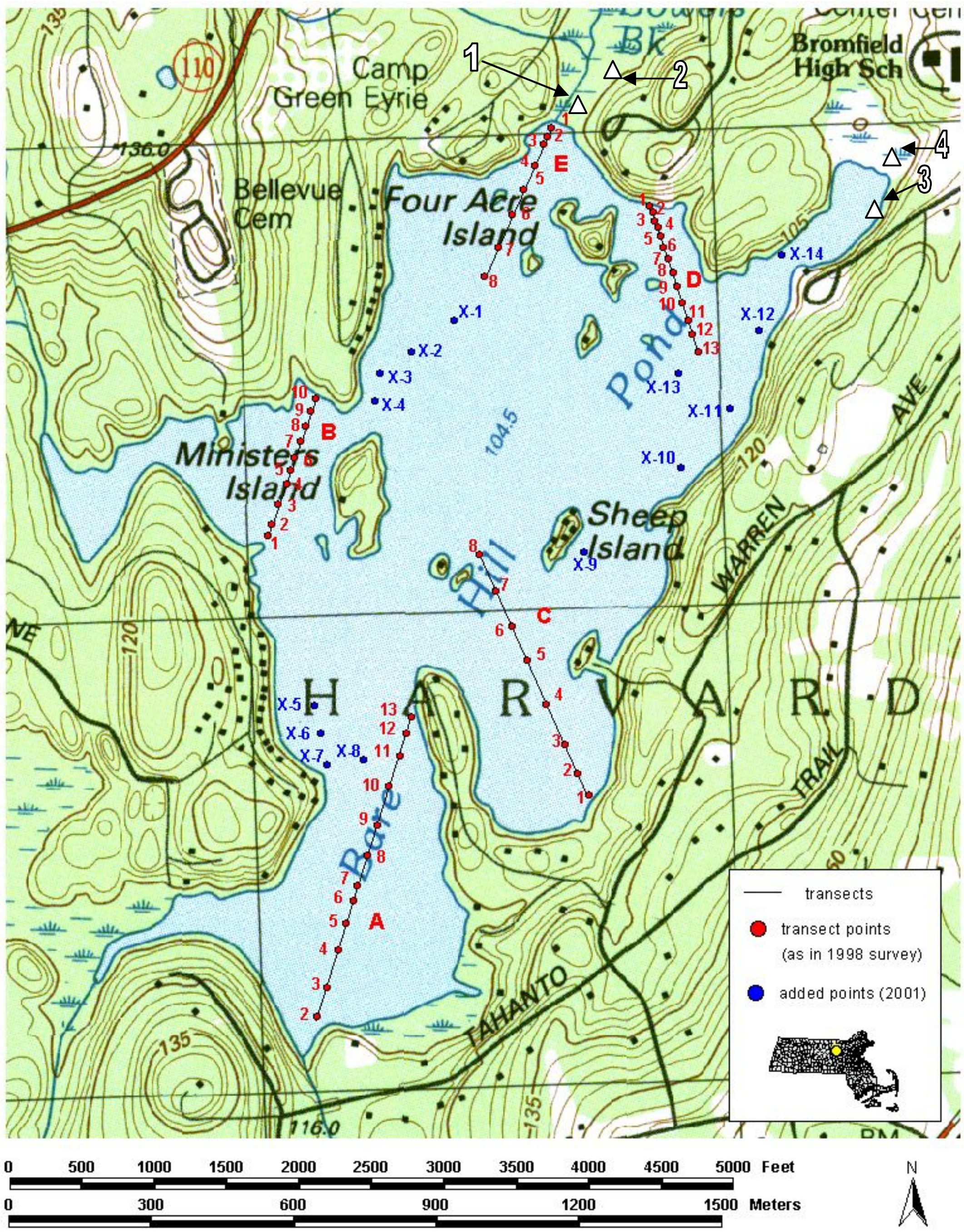

Figure 2. Location of transects and observation points. Location and denomination of transects A through E and relative points as in ENSR (1998); observation points added in 2001 are identifed with an "X". "Permanent" wetland plots are represented by numbered white triangles at north end of the lake.

Observations were made from a boat, viewing an area covering ~3 ft (~1 m) around each transect point. An AquaView submergible video display was used in the 2001 survey, with a camera lens lowered down to the lake bottom at each point. Observations were made by a single investigator, minimizing subjective bias (Cherril & McClean, 1999). Plant taxa were identified *in situ*, upon visual inspection. Taxa were identified to the genus or species level, as in 1998. Benthic mats of filamentous algae were not further defined; they included green algae (Chlorophyta) and/or cyanobacteria. Plant species of difficult identification, such as narrow-leaved pondweeds, were lumped in larger taxa (e.g., *Potamogeton* spp.).

Plant cover was expressed as the proportion of the view area covered by living plant material. As in 1998, a semi-quantitative 0-5 scale was used in 2001, with zero expressing absence of vegetation and 5 expressing 100% cover (i.e., sediments not visible in the view area). Values of 1-4 represent 25% cover increments. Likewise, a 0-5 scale was used to express plant biovolume, defined as living plant material filling the water column above the view area (5 = 100% = entire water column filled with living plants). Intermediate scale values for cover and biovolume are described in the corresponding vegetation maps. As in 1998, percent relative abundance of each taxon was assessed at each point. Percent relative abundance was based on total biovolume (i.e., each taxon comprising a percent of the total biovolume at each transect point). Water depth and sediment type (boulders, rocks, muck, etc.) also were recorded at each transect point.

Wildlife, Habitat, and Vegetation of Riparian Wetlands and Forests

ENSR assessed the vegetative community at Bare Hill Pond at representative sampling stations on November 14, 2001. The weather was cloudy to partially sunny with a light wind and moderate temperatures (55-60ºF or ~13-16ºC). ENSR collected vegetative measurements according to the sampling methodology outlined in the MADEP Handbook: *Delineating Bordering Vegetated Wetlands Under the Massachusetts Wetlands Protection Act* (MA DEP, 1995). Meander surveys were performed to document wildlife use and signs of wildlife activity. Wildlife signs, such as tracks, scat, nests, rubs, and ground burrows were recorded during the surveys. Surveys were performed in the scrub-shrub and forested wetland adjacent to Bowers Brook, the emergent wetland in the northeast corner of Bare Hill Pond, and in the forest community adjacent to Bare Hill Pond. Standing deadwood and snags in the wetland and upland communities were inspected for cavity nests and evidence of woodpecker activity. Reptiles and amphibians were searched for under fallen branches and small logs and rocks.

Range maps and habitat requirements for resident and migratory wildlife species were reviewed in regional texts and references, including DeGraaf & Rudis (1983), DeGraaf & Yamasaki (2001), Godin (1977), and Veit & Petersen (1993). The list of Endangered, Threatened and Special Concern species prepared by the Massachusetts Division of Fisheries and Wildlife was reviewed prior to the site inspection. Plant nomenclature follows Sorrie & Somers (1999).

Results

In-Lake Vegetation Survey

Maps summarizing the submerged vegetation of Bare Hill Pond in October 2001 are reported in Figures 3 through 5. The complete list of submerged vegetation, water depth, and sediment type observations at each transect point, from which maps were derived, is in Appendix A.

Approximately 75% of Bear Hill pond surface area was covered by submerged vegetation in October 2001 (Figure 3). Percent cover was especially high (>75%, or classes 4 and 5) at the northeastern tip of the lake, in the dam area. Protected coves and/or shallow areas also had relatively high vegetation cover. Most of the vegetation in deep waters (> 8 ft or ~2.5 m) was in the form of low-light tolerant, benthic algal mats or bushy bladderwort/*Nitella* beds that grew only a few inches off the substrate. Potential nuisance species such as waterlilies, watershield, or tall-stem pondweeds are unlikely to develop at such depths, mainly due to naturally attenuated light (from the colored water).

Areas of perceived or potential impaired use roughly correspond to the areas of highest biovolume (Figure 4). Total plant biovolume in October 2001 did not exceed 50%, except in the pondweed-milfoil area west of Ministers Island. However, waterlilies may grow at nuisance levels even if biovolume remains relatively low, since little biomass typically grows beneath the sunlight-blocking floating leaves. Overall, cover was not greatly altered from 1998 levels, but biovolume was reduced, indicating some success by drawdown in reducing plant biomass without eliminating all plants.

High biovolume (>75%) at the northeastern lake tip (dam area) was clearly reduced from 1998, but biovolume increased somewhat just south of the narrow dam area (comparison of Figure 8 in ENSR 1998 and Figure 4 in this report). As is 1998, this area was dominated by tall-stem plants such as milfoil, with an understory of shorter forms (*Potamogeton robbinsii* and benthic algal mats) (Appendix A). However, waterlily presence and/or density appeared to have decreased in this area since 1998, probably related to drawdowns conducted since that time. The waterlily:other plant ratio in other areas of dense vegetation appeared unchanged since 1998.

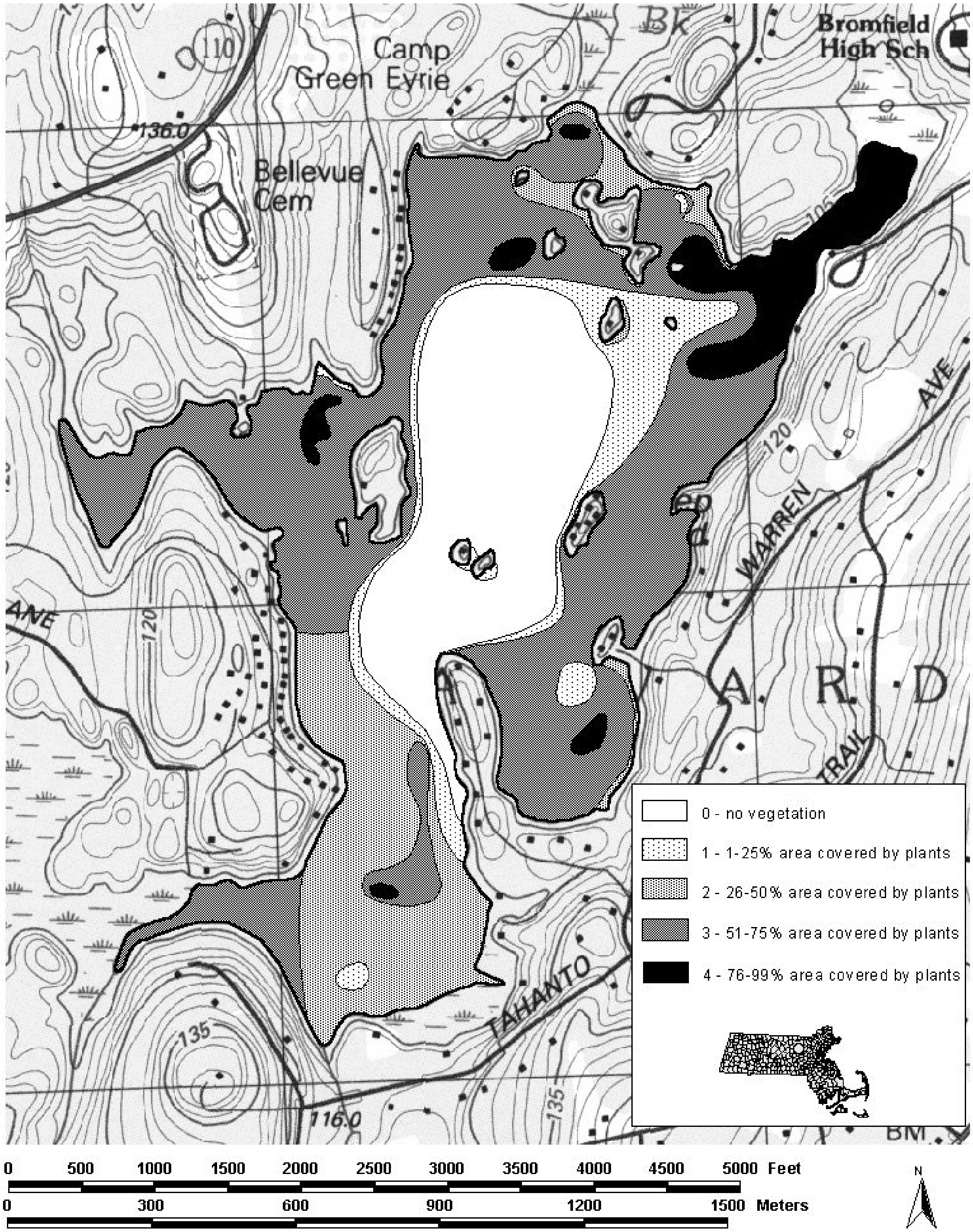

Figure 3. Total plant percent cover in Bare Hill Pond in October 2001.

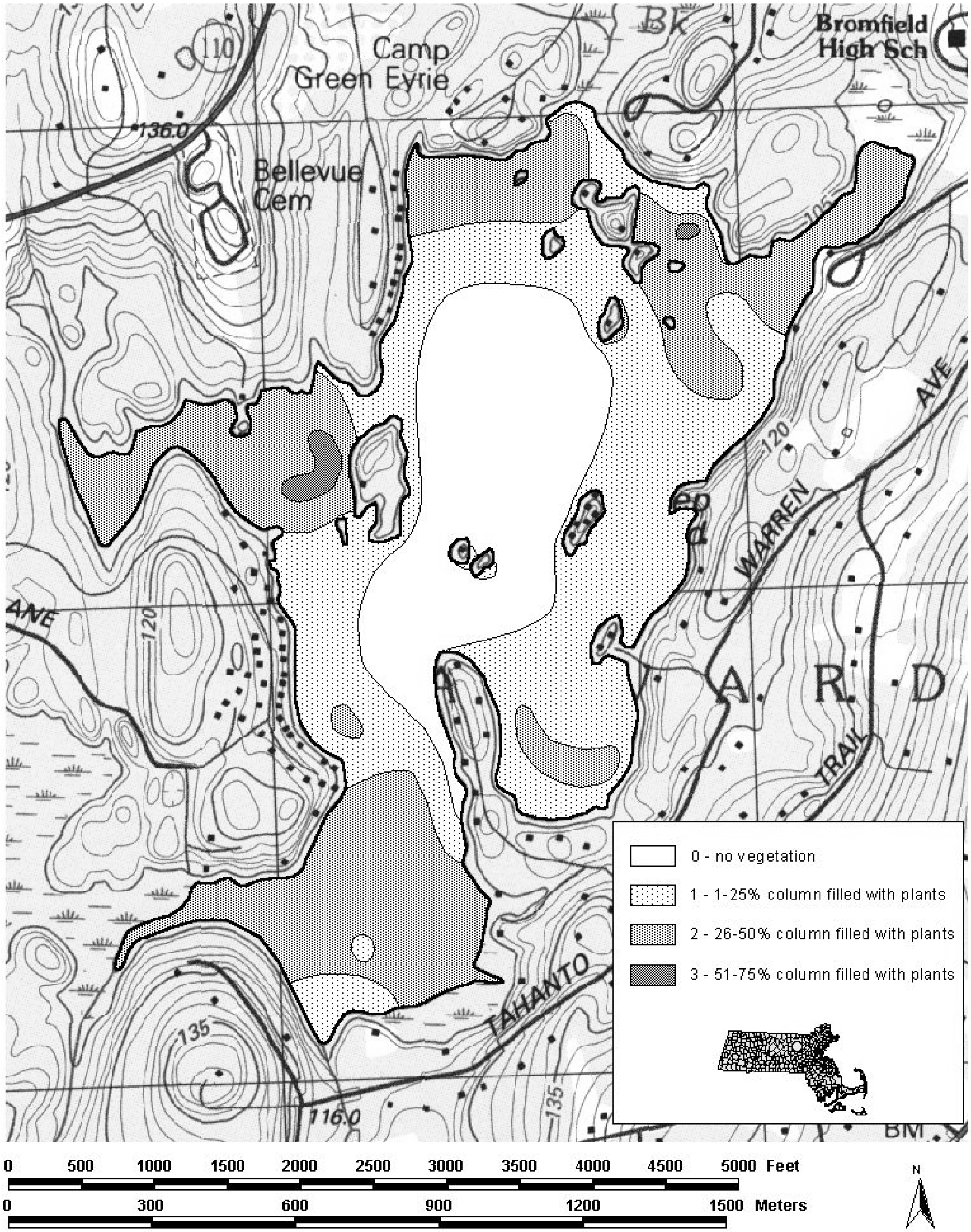

Figure 4. Total plant percent biovolume in Bare Hill Pond in October 2001.

Most taxa found in 2001 were observed also in 1998. Exceptions were *Lemna minor* (duckweed) and *Wolffia columbiana* (watermeal), *Polygonum* sp. (smartweed), *Eleocharis acicularis* (spike rush), *Isoetes* spp. (quillwort), and *Ceratophyllum demersum* (coontail), which were not observed in 2001. All these taxa were found in low to very low abundance in 1998. The minute floating plants *L. minor* and *W. columbiana*, and *E. acicularis* and *Polygonum* sp. were observed only at a few near-shore sites in 1998, although the latter was quite dense. Such taxa may have escaped observation in 2001, because of the focus on submerged vegetation rather than near-shore or wetland areas, and their absence in the 2001 survey does not necessarily mean absence from Bare Hill Pond.

Potamogeton crispus (curly-leaf pondweed) was the only taxon observed in 2001 that was not found in 1998. *P. crispus* was observed only in a protected small cove near Ministers Island (point B10 in Figure 2), but at a relatively high abundance (Appendix A). As for the above plant taxa, absence of *P. crispus* in the 1998 survey does not necessarily mean absence in Bare Hill Pond, since the 1998 survey was carried out in August, at a time when this coldwater species is present only as dormant turions (Les & Mehrhoff, 1999) that may easily escape observation. Turions germinate in the fall and develop into plants that remain green through the winter.

Of the eleven plant taxa found in Bare Hill Pond in 2001 (excluding algal mats), three were non-native. *Potamogeton crispus* (curly-leaf pondweed) is from Eurasia, while *Cabomba caroliniana* (fanwort) and *Myriophyllum heterophyllum* (variable-leaf milfoil) are native to North America but non-indigenous in New England (Les & Mehrhoff, 1999). The non-native, highly invasive water chestnut (*Trapa natans*), was reported in 1998 at trace density in isolated spots outside the transects, and was not observed in 2001.

The non-native *Cabomba caroliniana* (fanwort) was of special concern in Bare Hill Pond. It was reported at non-dominant densities in 1998 (ENSR 1998), but this acidophilic species has potential for rapid growth up to nuisance levels in the slightly acidic waters of Bare Hill Pond. Attention to fanwort growth patterns was recommended in 1998.

C. caroliniana distribution did not appear to change substantially from the 1998 survey, and remained at relatively low, non-dominant density in 2001 (Figure 5). The small fanwort beds observed at points C8 and E4 in 1998 were also observed in 2001. Relative abundance also remained unchanged (<25%). The small area at the northern tip of the lake where fanwort small plants were observed in 2001 appears to be the site of a very recent colonization, probably by plant fragments transported by winds or currents. *C. caroliniana* was present in the narrow cove at the dam area, and it formed a relatively dense bed just south of the narrow cove, where it tended to co-dominate with variable-leaf milfoil (*M. heterophyllum*) and bladderwort (*Utricularia* spp.). Reports of expanded fanwort distribution in Bare Hill Pond have been received, however, and this survey did not cover the entire pond area, so continued vigilance is warranted.

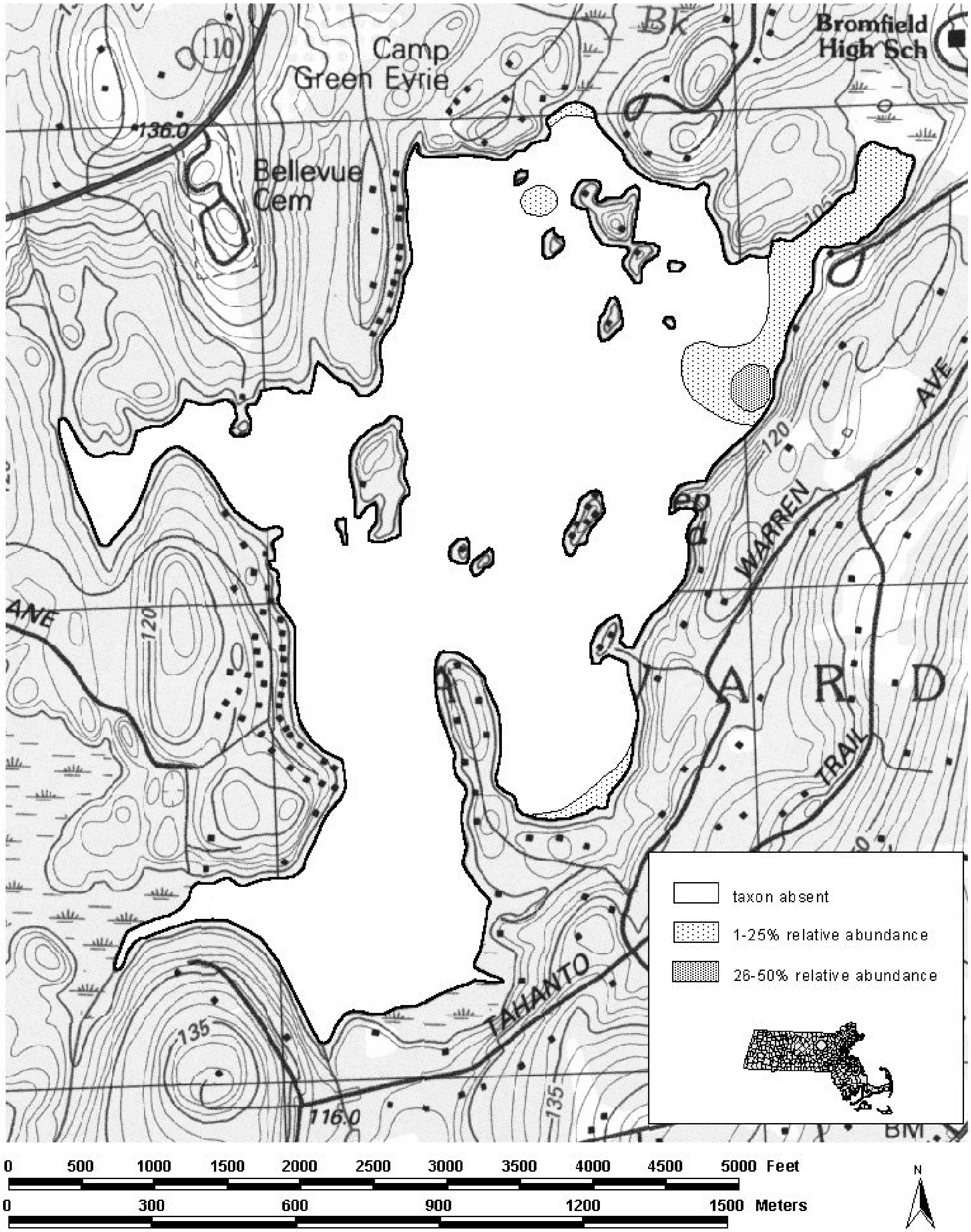

Figure 5. Distribution and relative abundance of fanwort (*Cabomba caroliniana*) in Bare Hill Pond in October 2001, from data in Appendix A.

Vegetative Assessment of Riparian Wetlands and Forests

The majority of the lakeshore does not support emergent vegetation due to exposure to wave action and absence of suitable habitat. Coves and shallow water environments along the lake margin support stands of emergent vegetation. Emergent wetland habitat is best represented in the southern section of the lake at the end of Bowers Road, in the shallow cove west of Minister's Island, and in the shallow water habitat north of the town beach (Figure 2). Aquatic macrophytes were common to abundant in shallow water habitat observed from the lakeshore. Aquatic macrophytes recorded in the field surveys performed by ENSR included such species as variable-leaf milfoil (*Myriophyllum heterophyllum*), yellow water-lily (*Nuphar variegata*), white water-lily (*Nymphaea odorata*), bladderworts (*Utricularia* spp.), pondweeds (*Potamogeton* spp.), and grass-leaf arrowhead (*Sagittaria graminea*). Results of a comprehensive survey on the distribution of aquatic macrophytes in Bare Hill Pond are in Appendix A.

The representative vegetative sample plots set by ENSR (Figure 2) include two plots in the emergent wetland community north of the town beach (Figure 6), contiguous with the lake. Plant cover estimates recorded in the lake sample plots are presented in Appendix B. Dominant species recorded in the vegetation sample plots established in the emergent wetland community include cattail (*Typha latifolia* and *T. angustifolia*), purple loosestrife (*Lythrum salicaria*), Canada bluejoint (*Calamagrostis canadensis*), and wool-grass (*Scirpus cyperinus*). Dominant species in the emergent communities are tolerant of water level fluctuations and extended periods of exposure. The recorded emergent species will not be adversely impacted by the increased water level adjustments proposed to control nuisance vegetation in the lake.

A second set of vegetation sample plots was located in the broad scrub-shrub/emergent wetland community adjacent to Bowers Brook north of (downstream of) the dam (Figures 7 and 8). Dominant plants recorded in the downstream vegetation sample plots include shrubs, such as sweet pepperbush (*Clethra alnifolia*), black alder (*Ilex verticillata*), arrowwood (*Viburnum dentatum*), swamp azalea (*Rhododendron viscosum*), swamp rose (*Rosa palustris*), and highbush blueberry (*Vaccinium corymbosum*). Canopy cover in the scrub-shrub wetland is relatively light. Canopy dominants recorded in the field survey include red maple (*Acer rubrum*), black gum (*Nyssa sylvatica*), white ash (*Fraxinus americana*), and white pine (*Pinus strobus*) along the transitional borders. Standing deadwood and windfalls are common in the scrub-shrub wetland. Herbaceous dominants include burreed (*Sparganium* sp.), tussock sedge (*Carex stricta*), wool-grass, Canada bluejoint, cattail, marsh fern (*Thelypteris palustris*), cinnamon fern (*Osmunda cinnamomea*), and royal fern (*Osmunda regalis*). Plant cover estimates recorded in the downstream sample plots established in scrub-shrub wetland habitat are in Appendix B.

Figure 6. Vegetation sample plots No. 3 (top) and 4 (bottom) in the emergent wetland north of town beach, sampled on November 14, 2001.

Figure 7. Vegetation sample plot No. 1 in the scrub / shrub emergent wetland below the dam, sampled on November 14, 2001.

Figure 8. Vegetation sample plot No. 2 in the scrub / shrub emergent wetland below the dam, sampled on November 14, 2001.

Dominant species in the nearby upland forest community are eastern hemlock (*Tsuga canadensis*), white pine, black birch (*Betula lenta*), red maple, and a variety of oaks (*Quercus* spp.). Shrub cover was light within the forest interior and moderately dense along the pond shore. Shrub species are primarily sweet pepperbush, maleberry (*Lyonia ligustrina*), highbush blueberry, black chokeberry (*Aronia melanocarpa*), alder (*Alnus* sp.), and sheep-laurel (*Kalmia angustifolia*). Pennsylvania sedge (*Carex pensylvanica*) and partridge-berry (*Mitchella repens*) were common in the ground cover. Ground cover consists of loose leaf litter, twigs, branches, rotting logs, and occasional windfallen trees. Large rocks and bounders were common.

According to the Soil Survey of Middlesex County, Massachusetts (June 1989), the upland soil on the site consists of sandy loam, often covered with black organic muck, especially in wetland areas. Shallow muck predominates in the wetland areas adjacent to the lake, including an area of recently filled marshes on the western shore. Much of the soil adjacent to the eastern and northern lakeshore is sandy in nature, but natural layers are no longer recognizable in many areas due to human activities (e.g., development). Field observations support the soil classification referenced by the Soil Conservation Service.

Wildlife Habitat and Wildlife Observations

Wildlife species recorded in the recent field survey were resident species due to the season. Potential and confirmed wildlife species recorded by ENSR are listed in Appendix C. No Massachusetts state-listed rare plants or animals were recorded in the survey performed by ENSR, and no estimated or priority habitats for protected species are shown on the maps available from the Natural Heritage and Endangered Species Program (1999-2001).

Fifteen (15) bird species were recorded in the survey. Black-capped chickadee, tufted titmouse, northern cardinal, and blue jay were recorded in the upland forest adjacent to Bare Hill Pond. Species recorded in the upland forest adjacent to the riparian community were white-breasted nuthatch, American robin, American crow, and downy woodpecker. Standing snags and deadwood in the forest and scrub-shrub wetland below the dam and adjacent to Bowers Brook provide feeding stations and nest cavities for insect-eating birds recorded in the field survey, such as white-breasted nuthatch, black-capped chickadee, and tufted titmouse. Cavity nests and potential den sites for small mammals may occur in the snags and standing deadwood in the scrub-shrub wetland. The seasonal flooding cycle limits habitat availability for small terrestrial mammals in the scrub-shrub wetland.

Great blue heron, mallard, and Canada goose were recorded on Bare Hill Pond. The great blue heron was hunting for fish in shallow water off the town beach. Belted kingfishers and turkey vultures were recorded during the aquatic plant survey in October. Bird activity in the emergent wetland plots was low at the time of the site inspection, but the vegetative cover provides shelter habitat, resting areas, and potential nesting sites for several species. Black-capped chickadees were recorded most often in the shrub community adjacent to the in-lake plots. Migratory species common to scrub woodlands and flood plain forest habitat, such as yellow warbler, common yellowthroat, song sparrow, and gray catbird probably occur on the site during the summer with other migratory bird species common to the region.

Wildlife species recorded during the field survey are presented in Table 1.

The majority of the resident bird species recorded during the field survey are recognized as ecological generalists that are tolerant to moderately tolerant species possessing the ability to adapt to habitat alterations (Stauffer & Best, 1980). ENSR believes that the bird species recorded in the field survey will adapt to the increased water level drawdown proposed at Bare Hill Pond. The increased drawdown will not impact the upland forest habitat or the scrub-shrub/emergent wetland community adjacent to Bowers Brook. The increased drawdown will not significantly impact the emergent wetland communities in Bare Hill Pond, since the drawdown occurs during the late fall and winter months when the vegetative communities are dormant and reptiles and amphibians are hibernating. Exposing the upper layer of the lake muck to freezing temperatures will not impact the dormant vegetative community.

Direct observations and wildlife signs confirmed the presence of six (6) mammal species. Short-tailed shrew, white-footed mouse, red and gray squirrel, beaver, and white-tailed deer. White-tailed deer tracks were observed in soft sediments along the edge of the emergent marsh community and exposed shoreline. A gray squirrel nest was observed in the canopy cover in the upland forest with signs of small mammal runways and tunnels under fallen logs. Signs of beaver were observed in the scrub-shrub wetland and in the emergent wetland community near the town landing. Fresh beaver signs were present near vegetation sample plot no. 1 and near Route 110. Standing deadwood due to backwater flooding was evident in the scrub shrub wetland adjacent to Bowers Brook.

The forest cover provides important habitat for other mammals common to the region, such as opossum, masked shrew, eastern cottontail, eastern chipmunk, striped skunk, red fox, and coyote (Godin, 1997). Larger wetland dependent mammals such as mink, fisher, and river otter may also be present. Water level fluctuations will not have a significant impact on the larger mammals present on the site.

Table 1. Wildlife Species Recorded at the Bare Hill Pond Site (Harvard, Massachusetts).

Scientific Name	**Common Name**	**Primary Habitat**
Mammals:		
Blarina brevicaudata	Short-tailed Shrew	Upland Forest
Sciurus carolinensis	Gray Squirrel	Hardwood and Mixed Forest
Tamiasciurus hudsonicus	Red Squirrel	Coniferous Forest
Peromyscus leucopus	White-footed Mouse	Forest and Brush Habitat
Castor canadensis	Beaver	River and Brook
Odocoileus virginianus	White-tailed Deer	Forest and Scrub Habitat
Reptiles:		
	No Observations	
Amphibians:		
	No Observations	
Birds:		
Ardea herodias	Great Blue Heron	Pond, Brook, and Marsh
Branta canadensis	Canada Goose	Pond and Marsh
Anas platyrhynchos	Mallard	Pond, Brook, and Marsh
Cathartes aura	Turkey Vulture	Soaring over Pond
Megaceryle alcyon	Belted Kingfisher	River and Brook Habitat
Zenaida macroura	Mourning Dove	Open Areas and Mixed Forest
Parus atricapillus	Black-capped chickadee	Coniferous and Mixed Forest
Parus bicolor	Tufted Titmouse	Coniferous and Mixed Forest
Picoides pubescens	Downy Woodpecker	Mixed Forest
Sitta carolinensis	White-breasted Nuthatch	Mixed Forest
Turdus migratorius	American Robin	Open areas and Mixed Forest
Cyanocitta cristata	Blue Jay	Open Areas and Mixed Forest
Corvus brachyrhynchos	American Crow	Open Areas and Mixed Forest
Cardinalis cardinalis	Northern Cardinal	Open Areas and Mixed Forest
Carduelis tristis	American Goldfinch	Open Areas and Scrub Forest

No reptiles or amphibians were recorded in the field survey due to the season. Reptiles such as eastern garter snake, ringneck snake, water snake, northern black racer, and eastern painted turtle probably occur on the site. Wood frog, pickerel frog, and green frog may use the scrub-shrub wetland adjacent to Bowers Brook for cover habitat and feeding areas, while bullfrogs probably occur in the pond. Redback salamander, American toad, and Fowler's toad are other common amphibians that probably occur on the site. Summer surveys are necessary to document the presence of reptiles and amphibians on the site. Lists of documented and potential wildlife species on the site are included in Appendix C.

Wetland Functions

The wetlands identified on the site provide significant wetland functions and benefits. The primary wetland functions and benefits are listed below with comments on specific relationships at Bare Hill Pond and related wetlands.

Flood Storage and Flood Control

Depressed areas that normally harbor wetlands provide temporary storage capacity for runoff that might otherwise cause flooding. Activities that reduce this function are considered deleterious, while activities that increase this function are beneficial. At Bare Hill Pond, the entire lake is a flood storage facility, with additional capacity available in contiguous wetlands upgradient of the lake and in the downstream wetland through which the outlet (Bowers Brook) flows.

Ground Water and Water Quality

Wetlands can act as treatment cells for water passing through them, and may help recharge groundwater beneath the system if soil permeability is adequate. Emergent wetlands with a variety of habitat types can provide excellent treatment of runoff if detention time is sufficient. Activities that enhance habitat types (and associated treatment potential) or detention are therefore considered beneficial. A range of habitat types is present at Bare Hill Pond, and treatment of runoff in adjacent wetlands may be significant. Recharge appears limited, based on muck accumulations and resultant low permeability.

Fish and Shellfish Habitat

Wetlands provide fish habitat, with benefits depending upon the species of fish. With few exceptions, open water is more important to fish habitat quality than emergent wetlands. Land Under Water (LUW) is usually considered open water, but when submergent vegetation grows especially thick, habitat value for most fish species declines. An exact threshold or even a target range for desirable plant cover or biovolume does not exist, as different species have different requirements. In general, biovolume values of 20-40% are considered optimal, but smallmouth bass prefer less cover, pickerel prefer more, and largemouth bass seem to do well over a wide range of plant densities. Densities in Bare Hill Pond are elevated by most fish habitat guidelines, but not to the maximum degree possible.

Shellfish habitat value also varies by species, vegetation type, and vegetation density. It is also highly dependent on water quality, especially pH. Shellfish habitat appears limited in Bare Hill Pond, mainly as a consequence of low pH.

Erosion and Sediment Control

Wetland vegetation can stabilize soils and trap sediments moving through the wetland with runoff. Maximum cover in emergent wetlands benefits this function. In Land Under Water, settling is more important than vegetation in holding sediments, although dense vegetation will limit wind mixing and resuspension. Beneficial cover can be low growing, however, and need not occupy a majority of the water column or lake surface.

Wildlife Habitat

The value of wetlands to wildlife is extremely variable, and any action to increase habitat value for one form of wildlife is likely to have negative impacts on certain other species. A balance of wetland types, each with adequate area, will provide habitat for a wide range of wildlife species, including reptiles, amphibians, birds and mammals. Invertebrates other than shellfish might be included here as well. Certainly the wetlands associated with Bare Hill Pond provide substantial habitat, and lake management actions should consider habitat changes that could result.

Threatened or Endangered Species

Many protected species are associated with wetlands. However, according to the *2000-2001 Massachusetts Natural Heritage Atlas*, Bare Hill Pond does not contain an Estimated Habitat for any state-listed rare wetland species. No rare plants or animals were documented on the site during the field surveys performed by ENSR. Bare Hill Pond is also not identified as a Priority Habitat for Rare Species.

Educational and Scientific Value

Bare Hill Pond offers excellent opportunity for educational outreach and scientific study. Wetlands are an important part of this system, and use of the area by classes or researchers should be encouraged. Management actions offer an opportunity for education and study that is both needed and likely to be required under the current permitting system.

Uniqueness and Heritage

The uniqueness of a habitat or its cultural significance in the history of an area should be considered. Bare Hill Pond is partly man-made, with a smaller pond and wetland system enlarged by construction of a dam. It provides recreation and outdoor activities to many people, and has for a long time. It is not an especially unique habitat among the lakes of Massachusetts, but it has more undeveloped shoreline than most, and represents a highly valued local resource.

Open Space and Aesthetic Quality

Wetlands provide open space and can be aesthetically pleasing to the educated eye. Under current regulations, this open space will be preserved. Activities that enhance this open space are considered beneficial. Bare Hill Pond is a major open space in Harvard, but is suffering from overly dense floating and submergent aquatic vegetation that alters open space use and aesthetic quality.

Potential Drawdown Impacts

Potential impacts of drawdown include a wide range of possible issues (Table 2), many of which are highly site specific and many more of which have not been well studied. A literature review of drawdown reveals the following:

General Information

Historically, water level drawdown has been used in waterfowl impoundments and wetlands for periods of a year or more, including the growing season, to improve the quality of wetlands for waterfowl breeding and feeding habitat (Kadlek 1962, Harris and Marshall 1963). More recently lake drawdown has been successfully used to control submerged aquatic macrophytes, considered nuisance weeds in the littoral zone (Mitchell and Titlow 1989). Although drawdown is known to be a potentially effective tool for lake management, potential conflicts with other lake uses and functions are of concern.

For a lake, water depth is critical to aspects of the fish, benthic invertebrate and macrophyte communities and to water quality (Cooke et al. 1986). Water level is an important determinant of recreation through maintenance of depth of bathing areas, limiting the activity or size of boats, and affecting shoreline facilities (e.g., docks and retaining walls). Water level may also be critical at industrial intakes for processing or cooling water supply purposes. Water level in a lake is related to flood storage capacity and regulation of downstream flow variation. Outside of the lake, changing lake water level may affect water levels in nearby supply wells and the hydrology of hydraulically connected wetlands.

Table 2. Key Factors and Potential Impacts of Drawdown

Reasons for Drawdown
Access to structures for maintenance or construction
Access to sediments for removal (dredging)
Flood control
Prevention of ice damage to shoreline and structures
Sediment compaction
Rooted plant control
Fish reclamation

Drawdown Information
Target level of drawdown
Pond bathymetry
Area to be exposed
Volume to remain
Timing and frequency of drawdown
Outlet control features
Climatological data
Normal range of outflow
Outflow during drawdown and refill
Time to drawdown or refill

Water Quality
Effects on nutrient levels
Effects on oxygen levels
Effects on pH levels
Other water quality impacts

Water Supply
Use of lake water as a supply
Presence of wells in zone of influence
Depth of wells within zone of influence
Total supply needs
Downstream flow restrictions
Alternative water supplies
Emergency response system

Sediments
Particle size distribution
Solids and organic content
Potential for sloughing
Potential for shoreline erosion
Potential for dewatering and compaction
Potential for odors
Access and safety considerations

Flood Control
Anticipated storage needs
Flood storage gained
Effects on peak flows

Protected Species
Presence of protected species
Potential for impact
Possible mitigative measures

In-lake Vegetation
Composition of plant community
Areal distribution of plants
Plant density
Seed-bearing vs. vegetative propagation
Impacts to target and non-target species

Vegetation of Connected Wetlands
Composition of plant community
Areal distribution of plants
Plant density
Temporal dormancy of key species
Anticipated impacts to target and non-target species

Macroinvertebrates and Fish
Composition of fauna
Association with areas to be exposed
Breeding and feeding considerations
Impacts to target and non-target species

Other Wildlife
Composition of fauna
Association with areas to be exposed
Breeding and feeding considerations
Impacts to target/non-target species

Access to the Pond
Alteration of normal accessibility
Possible mitigation measures

Downstream Resources
Erosion or flooding potential
Possible habitat alterations
Water quality impacts

Applicable Regulatory Processes
General review (NEPA or State equivalent)
Discharge permits
Water diversion or flow management statutes
Dam safety statutes
Wetlands protection statutes
Fish and Wildlife agency notification or approval

Associated Costs
Structural alteration to facilitate drawdown
Pumping or alternative technology
Monitoring program

Other Mitigating Factors
Monitoring program elements
Watershed management needs
Political setting
Sociological setting
Economic setting
Ancillary project plans (dredging, shoreline stabilization)

Water level in a lake may be kept relatively constant, fluctuate seasonally or vary in a rapid or seasonally unsynchronized fashion. Respective examples of these types of water level fluctuations would be: (1) an impoundment where the level is determined by the elevation of a large capacity control structure, (2) a natural lake where the level rises with the spring floods but eventually falls with declining summer water table, and (3) a hydroelectric reservoir where release rates are dictated by economic supply and demand. Conflicts with wetlands occur when water level is manipulated principally to the benefit of one purpose without regard to competing uses (O'Neil and Witmer 1988). Management conflicts between lake recreation and wetland protection are most likely to arise in the first category above, since the water level can be regulated for specific purposes. Disagreement over water use priorities or lack of a unified lake management plan (Wagner and Oglesby 1984) can easily result in such conflicts.

In-lake Considerations

One of the common problems of recreational lakes is the overabundance of submerged macrophytes impacting recreational uses such as swimming, fishing and boating. Many lakes are pre-disposed to plant nuisances, but human activities have resulted in excess sedimentation and overfertilization which promote such growths. In the many cases these problems have been exacerbated by invasions of exotic species. To treat the problem, lake managers may resort to a water level drawdown. While this technique is not effective on all submerged species, it does decrease abundance of some of the chief nuisance species, particularly those which rely on vegetative propagules for expansion (Cooke et al. 1986). If there is an existing drawdown capability, lowering the water level provides an inexpensive means to control macrophytes. Additional benefits may include opportunities for shoreline maintenance and oxidation or removal of nutrient-rich sediments.

The desired depth of drawdown should be determined by lake morphometry and the location of target nuisance species, although many other factors will enter into determining the allowable or achievable depth of drawdown. From experiences with several Massachusetts Lakes, suggested drawdowns were generally restricted to less than six feet. More often than not, it is the elevation of the outlet structure, such as a spillway or bottom drain, which determines the practical limits of drawdown. The duration of drawdown should be determined by the time necessary to sufficiently desiccate or freeze vegetation to the point of the desired density reduction. As this cannot usually be determined during the drawdown, several years of experimentation in a given system are often needed. The actual period of drawdown is often determined by watershed size (tributary inflows), weather (storms) and size of the dam opening (maximum outflow).

The typically intended effects of a drawdown are to reduce the density of rooted aquatic plants in the exposed area and to provide an opportunity for clean-up and repairs by shoreline property owners. If the water level declines, there is little that will interfere with maintenance efforts, but several factors may affect the success of drawdown with respect to plant control. The presence of high levels of groundwater seepage into the lake may mitigate or negate destructive effects on both target submergents and adjoining emergents by keeping the area moist and unfrozen. The presence of extensive seed beds may result in rapid re-establishment of previously occurring or new and equally undesirable plant species. Recolonization from nearby areas may be rapid, and the response of some macrophyte species to drawdown is quite variable (Cooke et al. 1986, EPA 1988, Table 3).

Drawdowns of many lakes have controlled macrophyte growths to the satisfaction of users and managers, and have been employed for longer than most other lake management techniques (Dunst et al. 1974). Winter drawdowns of Candlewood Lake in Connecticut (Siver et al. 1986) reduced nuisance species by as much as 90% after initial drawdown. Reductions in plant biomass of 44 to 57% were observed in Blue Lake in Oregon (Geiger 1983) following drawdown. Certain species have been reduced or eliminated from shallow water in Richmond Pond in Massachusetts by annual winter drawdown (Enser, pers. comm.). Drawdown of Lake Bomoseen in Vermont (VANR 1990) caused a major reduction in many species, many of which were not targeted for biomass reductions. About a decade of experience with drawdown at Lake Lashaway in Massachusetts has resulted in the elimination of nuisance conditions without eliminating any species of plants (Munyon, pers. comm.). Drawdowns in Wisconsin lakes have resulted in from 40 to 92% reductions in plant coverage/biomass in targeted areas (Dunst et al. 1974). Reviewing drawdown effectiveness in a variety of lakes, Nichols and Shaw (1983) noted the species-specific effects of drawdown, with a number of possible benefits and drawbacks. A system-specific review is highly advisable prior to conducting a drawdown (Cooke et al. 1986, WDNR 1989).

Desirable side effects associated with drawdowns include the opportunity to clean up the shoreline, repair previous erosion damage, repair docks and retaining walls, search for septic system breakout, and physically improve fish spawning areas (Nichols and Shaw 1983, Cooke et al. 1986, WDNR 1989). The attendant concentration of forage fish and game fish in the same areas is viewed (Cooke et al. 1986) as a benefit of most drawdowns. Since emergent shoreline vegetation tends to be favored by drawdowns, populations of furbearers are expected to benefit (WDNR 1989). The consolidation of loose sediments and sloughing of soft sediment deposits into deeper water is perceived as a benefit in many cases, at least by shoreline homeowners (Cooke et al. 1986, WDNR 1989).

Undesirable possible side effects of drawdown include loss or reduction of desirable plant species, facilitation of invasion by drawdown-resistant undesirable plants, reduced attractiveness to waterfowl (considered an advantage by some), possible fishkills if oxygen demand exceeds re-aeration during a prolonged drawdown, shoreline erosion during drawdown, loss of aesthetic appeal during drawdown, more frequent algal

TABLE 3
ANTICIPATED RESPONSES OF SOME WETLAND PLANTS TO WINTER WATER LEVEL DRAWDOWN

	Change in Relative Abundance		
	Increase	**No Change**	**Decrease**
Acorus calamus (sweet flag)	E		
Alternanthera philoxeroides (alligator weed)	E		
Asclepias incarnata (swamp milkweed)			E
Brasenia schreberi (watershield)			S
Cabomba caroliniana (fanwort)			S
Cephalanthus occidentalis (buttonbush)	E		
Ceratophyllum demersum (coontail)			S
Egeria densa (Brazilian Elodea)			S
Eichhornia crassipes (water hyacinth)		E/S	
Eleocharis acicularis (needle spikerush)	S	S	S
Elodea canadensis (waterweed)	S	S	S
Glyceria borealis (mannagrass)	E		
Hydrilla verticllata (hydrilla)	S		
Leersia oryzoides (rice cutgrass)	E		
Myrica gale (sweetgale)		E	
Myriophyllum spp. (milfoil)			S
Najas flexilis (bushy pondweed)	S		
Najas guadalupensis (southern naiad)			S
Nuphar spp. (yellow water lily)			E/S
Nymphaea odorata (water lily)			S
Polygonum amphibium (water smartweed)		E/S	
Polygonum coccineum (smartweed)	E		
Potamogeton epihydrus (leafy pondweed)	S		
Potamogeton robbinsii (Robbins' pondweed)			S
Potentilla palustris (marsh cinquefoil)			E/S
Scirpus americanus (three square rush)	E		
Scirpus cyperinus (wooly grass)	E		
Scirpus validus (great bulrush)	E		
Sium suave (water parsnip)	E		
Typha latifolia (common cattail)	E	E	
Zizania aquatic (wild rice)		E	

E=emergent growth form; S=submergent growth form; E/S=emergent and submergent growth forms

After Cooke et al., 1986

blooms after reflooding, reduction in water supply and impairment of recreational access during the drawdown (Nichols and Shaw 1983, Cooke et al. 1986). Inability to rapidly refill a drawn down lake is a standard concern in evaluating the efficacy of a drawdown. Winter drawdown can often avoid many of these negative side effects, but managers should be aware of the potential consequences of any management action (WDNR 1989).

Recolonization by resistant vegetation is sometimes a function of seed beds and sometimes the result of expansion of the shoreline vegetation fringe. *Najas* recolonized areas previously overgrown with *Myriophyllum* after the drawdown of Candlewood Lake in Connecticut (Siver et al. 1986), apparently from seeds that had been in those areas prior to milfoil dominance. Cattails and rushes are the most commonly expanding fringe species (Nichols and Shaw, WDNR 1989).

Effects of drawdown on amphibians and reptiles have not been well studied, but burrowing species might be expected to be below the zone of freezing or desiccation. The nature of the sediment and the dewatering potential of the drawdown will be key factors in determining impacts. The drawdown of Lake Bomoseen in Vermont was believed to have reduced the bullfrog population through desiccation and freezing of its burrowing areas (VANR 1990), although the evidence is scant.

Unintended effects within the littoral zone of a lake include loss of fish spawning areas and reduction of benthic invertebrate abundance and diversity. Few fish species spawn during winter in temperate climates (Scott and Crossman 1979), and spawning habitat improvement is more common than detrimental impacts (Cooke et al. 1986). Recolonization by invertebrates is usually rapid, although changes in species composition and diversity may occur and recolonization may be slow in large scale drawdowns (Cooke et al. 1986, WDNR 1989, VANR 1990).

Drawdown may affect water quality, particularly the parameters of clarity and dissolved oxygen concentration. Clarity will be a function of algal production and suspension of non-living particles. Algal production is most often related to phosphorus availability. By oxidizing exposed sediments, later release of phosphorus may be reduced through binding under oxic conditions, although post-drawdown algal blooms suggest that this mechanism may not be effective for all lakes. Some researchers have suggested that decomposition during drawdown makes nutrients more available for release, but there is little experimental evidence to support this mechanism (Cooke et al. 1986). It is likely that binding of iron and phosphorus influences phosphorus availability after drawdown, and the interplay between oxygen and levels of iron, sulfur and phosphorus is likely to vary among aquatic systems, resulting in variable nutrient availability.

Interaction between unexposed sediments and the lesser volume of water in the lake during drawdown can lead to depressed oxygen levels if oxygen demand exceeds aeration and sources of inflow are slight (Cooke et al. 1986, WDNR 1989). Compaction of sediment during drawdown varies with sediment type and dewatering potential, but any resulting compaction tends to last after refilling, reducing resuspension potential and post-drawdown turbidity (Kadlec 1962, Bay 1966, Cooke et al. 1986).

Recreational facilities and pursuits may be adversely impacted during a drawdown. Swimming areas will shrink and beach areas will enlarge during a drawdown. Boating may be restricted both by available lake area and by access to the lake. Again, winter drawdown will avoid most of these disadvantages, although lack of control over winter water levels can make ice conditions unsafe for fishing or skating.

Physical structures associated with the lake may be impacted by a drawdown. Outlet structures, docks and retaining walls may be subject to damage from freeze/thaw processes during overwinter drawdowns, if the water level is not lowered beyond all contact with the structure.

Downstream Considerations

Desirable flood storage capacity will increase during a drawdown, but associated alteration of the downstream flow regime may have some negative impacts. Once the target drawdown level is achieved, there should be little alteration of downstream flow. However, downstream flows must necessarily be greater during the actual drawdown than they would be if no drawdown was conducted. The key to managing downstream impacts is to minimize erosion and keep flows within an acceptable natural range.

Water Supply Considerations

Impairment of water supply during a drawdown is a primary concern of groups served by that supply. Processing or cooling water intakes may be exposed, reducing or eliminating intake capacity. The water level in wells with hydraulic connections to the lake will decline, with the potential for reduced yield, altered water quality and pumping difficulties. Drawdowns of Cedar Lake in Sturbridge, MA and Forge Pond in Westford, MA resulted in impairment of well water supplies, but there is little mention of impairment of well production in the reviewed literature.

Considerations for Hydraulically Connected Wetlands

The impact of drawdowns on wetlands which are hydraulically connected to the lake is often a major concern of environmental agencies. Hydrology is generally considered the master variable of wetland ecosystems (Carter 1986), controlling recruitment, growth and succession of wetland species (Conner et al. 1984). It is apparent that the depth, timing, duration and frequency of water level fluctuations are critical with regard to severity of impacts to adjacent wetlands (Kusler and Brooks 1988). It is also apparent that the specific composition of a wetland plant community prior to drawdown plays an important role in determining impacts.

The naturally-occurring hydrologic regime is probably the single most important determinant for the establishment and maintenance of specific types of wetlands and wetland processes. Hydroperiod is the seasonal pattern of water levels in a wetland and is like a hydrologic signature of each wetland type. It is unique to each type of wetland and its constancy from year to year ensures reasonable stability for that wetland (Mitsch and Gosselink 1986).

The hydrologic regime of a specific wetland system can be permanently altered by a variety of techniques including: (1) constructing or removing berms or other containment devices, (2) water supply augmentation by wells or surface water diversion, (3) diffusing streamflow through the use of mechanical "spreaders" or by physically altering (e.g., braiding) the existing streamflow, and (4) by diverting surface or groundwater flow from the wetland. Significant changes in hydroperiod can produce rapid changes in vegetative species zonation in non-forested wetlands (Brinson et al. 1981). Most drawdowns for lake management purposes constitute only a temporary influence on hydrologic regime, however, and will not necessarily have a detectable, widespread effect.

Duration and timing of the drawdown are important factors in limiting impacts to associated wetlands. The duration of the drawdown must be at least several weeks (and preferably longer), if previously submergent vegetation is to be impacted (EPA 1988). Drawdown of the water level in summer, if more than a week or two in duration, leads to desiccation and stress of wetland species in most cases. In contrast, a similar drawdown practiced during late fall or early winter is expected to have little impact on dormant emergent plants, but should have a destructive effect on exposed littoral zone submergents and their rootstocks.

The frequency of drawdown can be as important as its duration or timing. Annual summer lake drawdowns provide a level of disturbance that often leads to a wetland interface which, while productive, is devoid of all but the most hardy vegetation (aquatic grasses) and lacking in a smooth transition into the littoral zone (Burt 1988). In some cases, annual drawdowns are conducted specifically to prevent emergent wetland encroachment into the lake. The rationale is that if emergent wetlands encroachment into the lake. The rationale is that if emergent wetlands are permitted to extend further into the lake, their ensuing protected legal status would dictate lake management policy.

Management drawdowns to control nuisance submergent vegetation are usually recommended for alternate years (Cooke et al. 1986), although they may be practiced at a higher frequency initially. The "every other year" approach tends to prevent domination by resistant submergent plants. This level of disturbance should also promote a degree of rejuvenation and diversity of the emergent wetland community, and should increase the area of ecotonal overlap between the fringing marshlands and the open water.

Although drawdowns may prevent expansion of emergent vegetation, the absence of water level fluctuations alone probably does not promote intrusion of emergent wetland plants. While emergent wetland species may expand in conjunction with other factors (e.g., increased sedimentation, eutrophication), a stable water level would normally be more encouraging to the expansion of the submergent plant population. However, just as with the emergent vegetation, an expansion of submergents cannot take place without accompanying favorable light, substrate and nutrient conditions.

Most wetland plants are very well adapted for existence during conditions of fluctuating water level. In fact, a prolonged stable water level is known to lead towards dominance by single species in emergent wetland communities; nearly pure stands of common cattail or sedges/grasses are the most common manifestations of this phenomenon (Van der Valk and Davis 1980). Some water level fluctuation is required for elevated species diversity.

The nature of the wetland soils will influence wetland response to a drawdown. Generally the water table in a peat or muck soil is within one or two feet of the average ground surface (Bay 1966). The upper layer of a peat soil has been termed the active layer, the layer in which plant roots exist and the layer with the greatest water level fluctuation (Romanov 1968). The total porosity of the undecomposed raw peat moss horizon exceeds 95%, but the porosity of decomposed peat is only 83%. While this may not seem to be a major difference, lowering the water table in loose, porous, undecomposed peat removes 60 to 80% of the water in a given horizon, but an equal lowering in a decomposed peat removes only approximately 10% of the water (Bay 1966).

The loss of nutrients from wetland organic soils may have an adverse affect on wetland plant growth, especially after repeated annual or biannual drawdowns, but this potential impact is not well understood at this point and needs additional research. Where replacement of lost nutrients is possible, nutrient losses from exposed soils may not have any detectable effect on wetland communities.

Although often viewed as separate entities, wetlands and lakes really constitute a continuum of hydrologic resources, habitat values and recreational opportunities. The interaction between lake and wetland is complex, and any attempt at co-management must accommodate the subtleties of the relationship. The need for integrated watershed management is clear, but a set of goals with corresponding priorities is needed to reach decisions where conflicts occur (Wagner and Oglesby 1984).

From a lake management perspective, wetlands do not always act as good neighbors. Among their common, less desirable exports to lakes are organic material, color, turbidity, odors, easily resuspended particulates, nuisance insects, animal wastes, larger floating debris, and floating macrophytes (e.g., *Utricularia, Lemna*). Yet, it is undeniable that wetlands are critical to promoting a healthy lake flora and fauna and maintenance of desirable recreational and aesthetic qualities of most lakes. Furthermore, the Wetlands Protection Act establishes certain priorities and considerations without regard to potentially conflicting management goals. Management activities must therefore be structured around existing regulations.

Carefully planned water level fluctuation can be a useful technique to check nuisance macrophytes and periodically rejuvenate wetland diversity. Planned disturbance is always a threshold phenomenon; a little is beneficial, too much leads to overall ecosystem decline. Therefore; the depth, length, timing and frequency of the disturbance are critical elements in devising the most mutually beneficial program. This type of management is compatible with the idea of a multi-purpose lake, with various recreational and conservation zones (Jones 1988).

Extreme variations in wetland hydrology directly influence wildlife presence and production, and affect habitat quality through modification of the plant substrate, food abundance and variety, and physical elements that modify spatial relationships (Weller 1988). Common parameters of change are water depth, areal extent of flooding, and length of the hydroperiod. Additionally, rate of change is also critical and may be the primary cause of impact on some species. Drawdowns may cause an extreme variation in wetland hydrology, but the timing and duration of drawdown will be the primary determinants of its impact.

Expected Impacts at Bare Hill Pond

Bare Hill Pond has been drawn down for several years now. Reductions in density of vegetation have been noted in the drawdown zone (3-4 ft water depth), and no catastrophic impacts on other components of the system have been reported. Monitoring has been very limited, however, so there are no data to show quantitatively that non-target organisms have been maintained at pre-drawdown levels. Expected impacts from any drawdown, with emphasis on an increased drawdown, can be summarized as follows:

Reasons for Drawdown

Rooted plant control is the primary reason for drawdown at Bare Hill Pond, but benefits accrue for goals of flood control, access to structures for maintenance or construction, and sediment compaction. Prevention of ice damage to shoreline and structures is provided by the current drawdown, and would not be appreciably enhanced by the extended drawdown; this function would be maintained, however.

Drawdown Information

The target level of drawdown would be up to 8 ft, as compared with up to 4 ft currently. Based on pond bathymetry, the area of this 321 acre water body to be exposed would increase from 60 acres (at 4 ft) to 130 acres (at 6 ft) to 185 acres (at 8 ft). Out of a volume of 112 million cubic feet at full level, the water volume to remain would decline from 84 million cubic feet (at 4 ft) to 70 million cubic feet (at 6 ft) to 56 million cubic feet (at 8 ft). Drawdown would be an annual event, although it may be terminated early in years with less suitable conditions and could be skipped in some years after very successful drawdowns. Drawdown would last from about mid-October to sometime in March, depending upon the weather. A worst case refill target of mid-April would be set. The actual period during which the target drawdown depth was achieved need only be a month or two, with November and December as the intended period of maximum drawdown.

Based on climatological data for this area and known relationships between watershed area and inflow, it can be expected that the average spring flow into Bare Hill Pond will be about 12 cfs. During a dry year the flow could be as low as 6 cfs, and during an extreme drought the flow could approach 4 cfs. Based on these inflows, the refill time associated with a 4 ft drawdown will average about 27 days, could be as long as 54 days in a dry year, and might approach 81 days under an extreme drought. For a six foot drawdown, the average refill rate would be 40 days, with low flow and drought refill times of 81 and 121 days. The 8 ft drawdown will require an average refill time of 54 days, with dry and drought refill rates of 108 and 162 days. As an experiment, the 8 ft drawdown is certainly worthwhile, but the depth of drawdown may have to be scaled down under weather conditions that lead to sub-average flow rates. Observation of the refill rate in 2002 will be very helpful in evaluating refill limits.

Outlet control features that currently allow up to a 4 ft drawdown are inadequate for providing an 8 ft drawdown. A pilot pumped drawdown would be attempted, and if successful would initiate an investigation of possible pipe installation or more permanent pumping arrangements to facilitate future drawdowns. What is currently needed is that pilot attempt to draw the pond down farther by pumping.

Pumping during a drawdown of >4 ft will have to exceed inflow by enough water to affect the targeted drawdown over the course of one to two months, then will have to match inflow on a daily to weekly basis to hold the drawdown. For an 8 ft drawdown, this translates into a net of outflow over inflow of 56 million cubic feet of water, or about 11.6 cfs between mid-September and mid-November. Assuming a typical fall inflow of about 6 cfs, the required discharge would be slightly less than 18 cfs during water level reduction, followed by a discharge averaging around 6 cfs during the drawdown period (mid-November to early January). Slight adjustments may be necessary in response to major storms or especially cold or dry conditions, but this is the approximate range of outflows necessary to cause and hold an 8 ft drawdown at Bare Hill Pond.

Water Quality

Effects on nutrient levels are possible. Exposure of organic materials may allow oxidation to release nutrients that may be available the following spring. This does not appear to be an obvious problem from the 4 ft drawdown, as no major algal blooms have been reported. Natural humic substances in the water column may be controlling phosphorus availability. Mitigative means are available (nutrient inactivation) if needed. Monitoring is advised.

Effects on oxygen levels reduced lake volume with continued sediment decomposition, albeit at greatly slowed winter rates, could lower oxygen levels somewhat. Flushing time will also increase, however, and as incoming water is well oxygenated, no severe oxygen depletion appears likely. Again, no problems have been noted with the 4 ft drawdown, and the 8 ft drawdown would be monitored.

Effects on pH levels are not expected, and most other water quality impacts have a very low probability of occurrence, especially in light of no obvious problems with the 4 ft drawdown.

Water Supply

Bare Hill Pond is not a direct water supply. Presence of wells within zone of influence suggests possible impairment of well production, but no such impairment has been noted at the 4 ft drawdown level. Local wells supply local homes, and are generally quite deep in this area. Contingency plans can be adopted to handle any well impairment at lowered water level. No threat to downstream uses is known at this time. Water flow would be increased during water lowering in fall and decreased during spring refill, but downstream flows will not be ceased and will be kept within the natural range for the Bowers Brook system.

Flood Control

Flood storage will be gained in proportion to the volume of lake drained during drawdown. The effect on peak flows downstream will be to reduce them considerably during spring refill and during any major storm during the drawdown period. No impact is expected at other times.

Sediments

Bare Hill Pond sediments are highly organic, with a range of particle sizes representing the range of states of organic decay. The shoreline is mostly sandy and vegetated, with some rocky areas. The increase from 4 ft to 8 ft in the drawdown will not affect shorelines to any greater degree. The exposure of additional organic bottom sediments is not expected to result in additional downstream transport, but could cause movement of those sediments into deeper water. As deep areas are already occupied by a thick organic muck layer, additional muck laid on top will have no additive effect; it is the area of interaction between the water column and the sediment that is important, not the volume of sediment.

There is potential for dewatering and compaction of exposed sediments, and the degree to which this will occur is dependent upon weather and ground water flow. As the muck deposits limit ground water flow and winter is not a period of high evaporation, little change in muck density is expected. Slight compaction, just from pressure of overlying muck in the absence of water, is expected.

There is some potential for odors during drawdown, but not much more than already experienced with the 4 ft drawdown. Likewise, access and safety considerations will not be substantially altered from the situation under a 4 ft drawdown.

Protected Species

No presence of protected species has been documented.

In-lake Vegetation

The composition of the plant community is amenable to density reduction through drawdown. The areal distribution of plants extends to all areas <8 ft deep, and drawdown has the potential to reduce plant densities in this zone by at least 50%. Complete elimination is extremely unlikely, and remaining plant densities are expected to be suitable for fish and wildlife habitat, natural aesthetics, and other wetland functions. Water lilies, variable milfoil, and the relatively new population of fanwort would be the primary target species. Increased densities by native pondweeds, which are mostly annual seed producers, would be expected and is considered beneficial.

Vegetation of Connected Wetlands

The composition and areal distribution of the emergent plant community is amenable to drawdown without significant impacts. Temporal dormancy of key species during the winter is expected to minimize any impacts. The contiguous wetlands have been subjected to drawdown for several years now, and have retained their functions and remained as valuable habitat. The downstream wetland is not subjected to any greater stress, as water passing through the pond must still pass through this wetland.

The greatest threat involves dewatering of sediments associated with wetlands, with possible oxidation and/or slumping causing physical changes that might facilitate vegetative changes. General meander surveys and more detailed permanent plot monitoring can be used to detect any such changes, if they occur at all. High organic content and thick muck deposits suggest no likely impacts, but if they did occur, the result is likely to be increased diversity. The only potentially negative impact easily envisioned would be the introduction of an exotic or nuisance species, such as purple loosestrife, as a function of available space during drawdown-induced disturbance. Again, monitoring can allow early detection of such introductions.

Macroinvertebrates and Fish

Composition of the fauna of Bare Hill Pond indicates not major threat by drawdown. Absence of largely sessile populations (such as molluscs) is an aid here. The main threat will be that by concentrating truly aquatic fauna into a smaller area, predation and competition will become more potent forces, shaping the community accordingly. There have been numerous hypotheses about the benefits or negative impacts of drawdown on aquatic fauna, mostly without rigorous testing. As long as the water quality (especially oxygen) remains suitable over the winter and refill is completed prior to spawning season, no negative impacts are expected. Further study is warranted, but not necessarily as part of this project.

Other Wildlife

Wildlife are not expected to be impacted by an 8 ft drawdown any more than by the 4 ft drawdown, although impacts from either water level are possible. As with fish and macroinvertebrates, many hypotheses have been generated about impacts to reptiles, amphibians, birds and mammals, and few have been rigorously tested. Certainly the potential exists for hibernating species to be subjected to exposure or predation if drawdown is initiated later in the autumn. Failure to refill prior to spring breeding season could have negative impacts as well. Conduct of a drawdown in accordance with properly proscribed procedures should minimize such impacts, however. Area available for overwintering is still substantial in Bare Hill Pond, and extending the drawdown from 4 to 8 ft should not create a space limitation. As with possible fish and invertebrate impacts, further study is warranted, but needs to be undertaken at a research level, not as part of routine monitoring under Orders of Conditions.

Access to the Pond

Alteration of normal access points will not be greater than with the 4 ft drawdown, but wildlife and people will have to travel further, over potentially even deeper muck, to reach open water or ice. During true winter conditions, this should not be an issue, but there could be indirect impacts on access during the late fall period (prior to freezing).

Possible mitigation measures include signage for informing people of the risks and altering the timing of drawdown to minimize risks to wildlife or other users. Birds and most wildlife will not find the extended mud flats a concern, and may in fact be drawn to the lake for feeding purposes, as has been observed elsewhere.

Downstream Resources

Erosion or flooding potential should be reduced overall. The only period of real risk is during the lowering of the water level, when higher than average flows would be discharged. These flows should be kept within the normal range for the downstream system to minimize impacts. No significant changes in water quality are expected.

Applicable Regulatory Processes

General Federal of State review (NEPA or State equivalent) is not needed in this case, and water diversion or flow management statutes do not apply. Dam safety statutes are not an issue as long as pumping is applied, but may come into play in the future if dam alteration is recommended. Discharge permits also do not appear necessary.

The Wetlands Protection Act is the primary regulatory process governing this project, and an Order of Conditions will be needed. It is possible for the existing Order to be amended. Alternatively, a new Order could be issued, as the change in drawdown depth may be considered significant. However, as no additional deleterious impacts are projected, it is not clear that this change constitutes a significant one. Addition of monitoring provisions to any amended or new Order of Conditions is suggested.

Fish and Wildlife agency notification and comment has been conducted for the 4 ft drawdown, and should be repeated for the 8 ft drawdown.

Associated Costs

Structural alteration to facilitate drawdown is not planned at this time. Pumping costs have not been firmly established, but will be substantial. Conducting a greater drawdown as a pilot effort is intended to allow evaluation of benefits, drawbacks and costs. Addition of a more comprehensive monitoring program will carry some cost, but is necessary to evaluate the efficacy of the expanded drawdown.

Other Mitigating Factors

Monitoring program elements would logically include re-survey of the in-lake and emergent wetland plant community, water quality analyses, further wildlife habitat assessment, and possible surveys of targeted indicator populations (e.g., frogs, dragonflies, or other representative populations).

Watershed management needs have been considered previously as part of the ENSR (1998) study and by the DEP in TMDL development. Watershed management actions are highly recommended, but are independent of in-lake effort to control rooted plants.

The political, sociological and economic settings are such that use of herbicides, the logical alternative to drawdown, has been denied. Drawdown is the only other affordable option that can affect pond vegetation on a large scale, and has been applied with some success already. Extension of that drawdown from 4 to 8 ft is intended to determine if this technique can provide sufficient relief from excessive plant growths to function as the primary plant control method in Bare Hill Pond.

There are no current ancillary project plans (e.g., dredging, shoreline stabilization).

In terms of impacts to specific interests of the Wetlands Protection Act and other permitting processes in Massachusetts, the following summary is offered:

Flood Storage and Flood Control

Increased water level drawdown will increase the capacity of the lake to provide a storage area for storm water runoff during winter storm events. Flood control functions will be benefited.

Ground Water and Water Quality

Increased water level drawdown will not reduce the capacity of the emergent wetlands to protect water quality through the removal of sediments and nutrient removal. The emergent wetland is dormant during the period of water level drawdown. No change in recharge rates is expected.

Fish and Shellfish Habitat

Fish habitat will be temporarily reduced during the period of water level drawdown, but overall habitat improvements are anticipated due to the removal of nuisance aquatic vegetation killed by exposure to winter freezing. Shellfish habitat appears absent, mainly as a consequence of low pH. No shellfish impacts are expected.

Erosion and Sediment Control

The emergent wetland communities occur in shallow water areas and protected coves. The emergent vegetation protects the shoreline from wave action and erosion. The temporary water level drawdown will not reduce this important wetland function and may benefit the overall control of erosion along the lakeshore by lower the water level during periods when winter storms can generate wave action along the exposed shoreline.

Wildlife Habitat

The temporary water level drawdown will not diminish the capacity of the emergent wetland community to provide wildlife habitat. Reptiles and amphibians are hibernating during the withdrawal cycle. Migratory birds are absent during the water level drawdown, but may find the pond more attractive in the fall if migration ovelaps with drawdown, as a function of increased feeding opportunities. Spring use may be somewhat diminished if refill is not complete by the time of migration. Resident birds and mammals may experience some disruption from the existing and proposed water level fluctuation, but no lasting impact is expected.

Threatened or Endangered Species

According to the *2000-2001 Massachusetts Natural Heritage Atlas*, Bare Hill Pond does not contain an Estimated Habitat for a state-listed rare wetland species. No rare plants or animals were documented on the site during the field surveys performed by ENSR. Bare Hill Pond is not identified as a Priority Habitat for Rare Species either.

Educational and Scientific Value

The lake system may still be used for educational purposes during the water level drawdown. Local biology classes could monitor the permanent vegetation sample plots established in the emergent wetland and the scrub-shrub wetland adjacent to Bowers Brook for long-term impacts. Adverse long-term impacts are not anticipated by ENSR.

Uniqueness and Heritage

Bare Hill Pond will continue to be a focal resource with the Town of Harvard. The water level drawdown will contribute to the preservation of related cultural functions.

Open Space and Aesthetic Quality

The proposed water level drawdown will not diminish the open space functions. Aesthetic quality will be temporarily impacted by the exposure of the lake bottom sediments in order to facilitate the winter freezing and removal of nuisance aquatic vegetation. Aesthetic qualities will be enhanced as the lake is allowed to refill in the spring.

Management Implications, Summary and Recommendations

Only drawdown and herbicides provide options for widespread control of nuisance vegetation. Herbicide use is not currently an option for Bare Hill Pond, based on Town reaction to previous proposals to apply herbicides. The application of a 4 ft drawdown several times since 1998 has shown some promise of alleviating the rooted plant problem, as suggested by monitoring in 1998 and 2001. Recreational opportunity has been enhanced. Extension of this drawdown to 8 ft makes sense from a plant control perspective, if technically feasible and if the interests of the Wetlands Protection Act are appropriately served. Additional monitoring of non-target populations has been limited, so the complete impacts of the 4 ft drawdown are not precisely known. However, major changes in water quality, water supply, algae, invertebrate and fish populations, and wildlife use of the pond are not obvious and have not been reported. A monitoring program should be instituted in association with expanded drawdown to track any such changes, and to allow fine tuning of the drawdown as a management technique for this system.

Submerged vegetation provides both substrate and food for fish and their invertebrate prey, but grows to densities considered a nuisance for human activities in Bare Hill Pond and also appears excessive from an overall habitat perspective. Density changes recorded since the 1998 survey suggest that the 4 ft drawdown has had some impact, but is not severe enough to cause major changes over a short period. The projected additional drawdown to 8 ft is expected to expand control and increase the stress on shallow-water species such as waterlilies, watershield, and to some extent variable milfoil and fanwort, reducing their densities by perhaps 50%. Such changes are regarded as desirable, since these species grow to densities impairing human activities and habitat value. In particular, waterlilies and watershield are a poor substrate for fish and invertebrates, so their reduction in Bare Hill Pond is unlikely to cause major disruptions to the lake ecology. Variable milfoil and fanwort are introduced species with high dominance and nuisance potential; control is advised on human use and ecological grounds.

The emergent wetlands established in shallow water environments along the shore of Bare Hill Pond provide important wetland and wildlife habitat benefits. Emergent wetland communities occur in seasonally flooded or shallow water environments. Plant species in the emergent wetlands are adapted to water level fluctuations and are largely dormant during the winter months. Impacts from an expanded drawdown should not be significantly greater than those associated with the present water level management program.

The emergent wetlands associated with Bowers Brook downstream of the pond are also adapted to water level fluctuations and are dormant during the winter, but would not be subject to additional stress under the proposed expanded drawdown. Water would be pumped from the pond into this wetland near the dam, such that the flows and water levels would not be appreciably altered over those experienced under the current water level management program. There is some question as to how well pumping will be able to maintain the drawdown, but impacts on the downstream wetland should be minimal.

Water dependent reptiles and amphibians are hibernating during the period of drawdown, and as long as the drawdown target level has been achieved prior to their period of dormancy, these species should not be adversely impacted by the proposed increase in drawdown. Migratory bird species are absent for most of the water level drawdown, but may find expanded mud flats more attractive in the fall and spring where there is overlap between drawdown and migration. Resident birds are generally not believed to be affected by the present water level fluctuations.

Wetland functions should not be diminished by the proposed increase in the water level drawdown. Protective cover, feeding sources, and breeding and nesting sites for birds and small mammals should be enhanced for the many species that do not thrive in dense vegetation. Bird activity is expected to remain moderate to high in the scrub-shrub wetland community adjacent to Bowers Brook. Wildlife activity in the emergent wetland communities is expected to remain as presently exists.

In order to track results and minimize impact to wildlife species dependent on higher water levels, ENSR recommends several procedural and monitoring actions for inclusion in the vegetative management program at Bare Hill Pond.

- The water level drawdown shall continue to be scheduled for fall and winter months when the plant community is dormant. Reptiles and amphibians will also be inactive at this time of year, and interaction with migratory species will be limited. Resident bird species will be monitored for continued activity at the lake. A simple amphibian survey should be devised and implemented, such as a count of frogs along five 200 ft shoreline segments at the same time on three dates each late spring.
- Water levels should be carefully monitored and documented in response to all drawdown activities, from the time of drawdown initiation to completion of refill. Weekly manual records from an installed staff gauge near the dam should be sufficient, but an electronic monitoring log (by pressure transducer) is suggested.
- Naturally vegetated communities north of the earthen dam along Bowers Brook should remain undisturbed and established sample plots should be monitored annually to document a lack of impact. The scrub-shrub wetland downstream of the dam is not to be impacted by the water level drawdown, and is expected to continue to provide nesting and breeding habitat and travel corridors for birds and small mammals. A repeat of the survey conducted in 2001 is advised, with additional photographic documentation.
- Vegetation sample plots in the emergent wetland in Bare Hill Pond should be monitored annually for impacts due to the proposed water level drawdown. Major changes in vegetation pattern and wetland functions are not expected, but any changes should be documented. A repeat of the survey conducted in 2001 is advised, with additional photographic documentation.
- In-lake vegetation will be surveyed at the same locations by the same methods applied in 1998 and 2001 on an annual basis to document any changes.

- A fish survey should be devised and implemented. To avoid excessive cost, an assessment of fish growth patterns could be conducted using scales acquired from fish caught and released. Monitoring of largemouth bass, pickerel, and a sunfish species is recommended. This survey would be conducted prior to the expanded drawdown and again after three-years.

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Appendix A

In-Lake Vegetation Data

Appendix A. Physical characteristics (water depth, sediment type), total plant percent cover and biovolume, and plant taxa (with relative abundance) recorded at each transect point during the survey (October 4, 2001). Location of transect points is in Fig. 2. Plant taxa are reported from the most abundant to the least abundant for each transect point. Full names of plant taxa, sediment type codes, and total plant percent cover and biovolume codes as footnote at the end of the table.

trans.	water depth		sediment	total plant %		
pt. ID	m	ft	type	cover	biovol.	plant taxa (% relative abundance)
A-1	0.8	2.5	mu	1	1	Nod (40%), Mhe (20%), Bsc (20%), Pol (10%), alg (10%)
A-2	0.7	2.4	mu	2	1	Mhe (40%), Bsc (20%), alg (20%), Utr (20%)
A-3	0.9	3.1	mu	1	1	Bsc (25%), Mhe (25%), alg (25%), Nva (25%)
A-4	0.8	2.5	mu	2	2	Mhe (25%), Nva (25%), Pot (25%), Bsc (25%)
A-5	1.0	3.2	mu	2	1	Utr (40%), Pot (30%), Mhe (15%), Pro (15%)
A-6	0.9	2.9	mu	4	2	Pot (90%), Utr (10%)
A-7	0.9	2.9	mu	3	2	Mhe (85%), Pot (10%), alg (5%)
A-8	1.0	3.2	mu	2	2	Mhe (95%), Sgr (5%)
A-9	1.2	4.1	mu	2	2	Mhe (95%), Sgr (5%)
A-10	1.2	4.1	mu	3	2	Utr (50%), Mhe (45%), alg (5%)
A-11	3.1	10.3	mu	3	1	Utr (50%), alg (50%)
A-12	4.0	13.0	mu	0	0	-
A-13	2.8	9.1	mu, ro	0	0	-
B-1	0.9	2.8	mu	3	2	Mhe (50%), Pro (40%), Utr (10%)
B-2	0.9	3.1	mu	3	2	Mhe (50%), Pro (40%), Sgr (10%)
B-3	1.0	3.3	mu	3	3	Mhe (50%), Utr (45%), Sgr (5%)
B-4	1.1	3.7	mu	3	2	Mhe (40%), Utr (40%), alg (20%)
B-5	1.1	3.5	mu	4	2	Mhe (25%), alg (25%), Nod (25%), Utr (15%), Pro (10%)
B-6	1.0	3.2	mu	3	3	Mhe (25%), alg (25%), Pro (25%), Utr (25%)
B-7	1.2	4.0	mu	4	2	Mhe (45%), Pro (30%), alg (10%), Utr (10%), Sgr (5%)
B-8	1.1	3.5	mu	3	2	Mhe (50%), Pro (30%), alg (20%)
B-9	1.2	3.9	mu	4	2	Mhe (75%), alg (10%), Pro (10%), Utr (5%)
B-10	0.9	2.8	mu, bo	1	1	Pcr (50%), Mhe (50%)
C-1	1.2	3.8	mu	2	1	Mhe (40%), Pro (25%), Cca (15%), Utr (10%), alg (5%), Sgr (5%)
C-2	1.9	6.1	mu	3	2	Utr (70%), Mhe (15%), Pro (15%)
C-3	3.3	10.7	mu, ro	4	1	Utr (80%), alg (20%)
C-4	3.6	11.7	mu	1	1	Utr (80%), alg (20%)
C-5	3.7	12.2	mu	3	1	Utr (90%), alg (10%)
C-6	4.1	13.6	mu	0	0	-
C-7	4.5	14.9	mu	0	0	-
C-8	4.6	15.1	mu	0	0	-

Legend :

bo – boulder
mu – muck
ro – rock

0 – absence of vegetation
1 – 1-25% of sediment area (cover) or water column (biovolume) covered or filled with plants
2 – 26-50% of sediment area (cover) or water column (biovolume) covered or filled with plants
3 – 51-75% of sediment area (cover) or water column (biovolume) covered or filled with plants

4 – 76-99% of sediment area (cover) or water column (biovolume) covered or filled with plants
5 – 100% of sediment area (cover) or water column (biovolume) covered or filled with plants

Appendix A. (continued).

trans.	water depth		sediment	total plant %		
pt. ID	m	ft	type	cover	biovol.	plant taxa (% relative abundance)
D-1	1.1	3.5	mu	2	1	Mhe (40%), Nod (40%), Pro (10%), Sgr (10%)
D-2	1.0	3.3	mu	1	1	Mhe (50%), Nod (50%)
D-3	0.9	2.8	mu	3	1	Mhe (45%), Nod (45%), Pro (5%), Nfl (5%)
D-4	1.0	3.4	mu	1	1	Mhe (34%), alg (33%), Sgr (33%)
D-5	0.9	2.8	mu	2	2	Mhe (85%), alg (10%), Nva (5%)
D-6	1.2	3.8	mu	3	3	Mhe (85%), alg (10%), Pro (5%)
D-7	1.3	4.3	mu	4	2	Mhe (90%), alg (10%)
D-8	1.1	3.7	mu	4	2	Mhe (100%)
D-9	1.3	4.3	mu	4	2	Mhe (60%), Pro (20%), alg (15%), Sgr (5%)
D-10	1.5	4.9	mu	4	2	Mhe (40%), alg (40%), Pro (20%)
D-11	1.9	6.2	mu	1	1	alg (100%)
D-12	1.6	5.1	mu	1	1	Mhe (90%), alg (10%)
D-13	1.9	6.1	mu	3	1	Mhe (90%), alg (10%)
E-1	1.5	4.9	mu, ro	2	1	Mhe (60%), Pro (20%), Utr (15%), Cca (5%)
E-2	1.4	4.5	mu	3	2	Pro (60%), Mhe (40%)
E-3	1.5	5.0	mu	4	2	Pro (90%), Mhe (5%), alg (5%)
E-4	1.7	5.6	mu	3	2	Mhe (50%), Pro (35%), Nfl (10%), alg (5%)
E-5	1.6	5.2	mu	3	2	Mhe (80%), alg (15%), Pro (5%)
E-6	2.6	8.6	mu	2	2	Mhe (50%), alg (30%), Cca (20%)
E-7	3.1	10.3	mu	3	1	Utr (50%), Mhe (25%), alg (25%)
E-8	3.5	11.6	mu	4	1	Utr (80%), alg (20%)
X-1	4.5	14.9	mu	0	0	-
X-2	4.3	14.0	mu	0	0	-
X-3	1.7	5.6	mu	3	1	Utr (80%), alg (20%)
X-4	2.8	9.3	mu	3	1	Utr (90%), alg (5%), Mhe (5%)
X-5	3.8	12.5	mu	2	1	Utr (100%)
X-6	1.2	3.8	mu	2	2	Mhe (80%), Utr (20%)
X-7	1.1	3.6	mu	2	1	Utr (60%), Sgr (30%), Mhe (10%)
X-8	0.9	2.8	mu	2	1	Nod (80%), Mhe (20%)
X-9	1.9	6.3	mu	3	1	Utr (50%), Mhe (40%), alg (10%)
X-10	3.5	11.4	mu	3	1	Utr (60%), alg (40%)
X-11	1.2	4.1	mu	3	1	Mhe (50%), Cca (50%)
X-12	1.6	5.2	mu	4	2	Utr (30%), Mhe (30%), Cca (30%), alg (10%)
X-13	2.3	7.4	mu	4	2	Mhe (50%), Utr (25%), Cca (15%), alg (10%)
X-13	1.3	4.4	mu	4	2	Pro (50%), Cca (20%), Mhe (15%), Pot (15%)

Legend (continued):

alg – filamentous algal mats
Bsc – *Brasenia schreberi* (watershield)
Cca – *Cabomba caroliniana* (fanwort)
Mhe – *Myriophyllum heterophyllum* (variable-leaf milfoil)
Nfl – *Nitella flexilis* (stonewort)
Nva – *Nuphar variegata* (yellow-flower waterlily)
Pcr – *Potamogeton crispus* (curly-leaf pondweed)
Pot – *Potamogeton* spp. (pondweeds)
Pro – *Potamogeton robbinsii* (Robbins pondweed)
Sgr – *Sagittaria graminea* (arrowhead)

Nod – *Nymphaea odorata* (white-flower waterlily)

Utr – *Utricularia* spp. (bladderwort)

Appendix B

Wetland and Forest Vegetation Sampling Sheets

2001 FIELD REPORT: VEGETATION SAMPLING SHEET

Site Name: Bare Hill Pond
Location: Harvard, Massachusetts
Transect No. One
Community Type: Scrub-Shrub Wetland
Soil Type: Muck and sands and gravel

Weather: Cloudy, Lt. Wind, 55-60 º F
Date: November 14, 2001
Plot Size: 30-ft. radius, Plot 1
Observers: Don Schall
Photographs: Yes (Figure 1)

General Description of the Vegetation Sample Station:

Vegetation sample plot is located in the scrub-shrub wetland community approximately 100 ft. north of the dam at the northern end of the pond. Access to the sample plot is from the service road to the dam off Willow Road. A narrow fringe of flood plain forest occurs along the edge of the sample plot. The estimated plant cover in the sample plot is over 60 percent. The sample plot was photographed during the survey performed on November 14, 2001.

Species List with Estimated Cover and Abundance Rankings for Dominants
Cover Estimates: 1 - 5%; 6-15%; 16-25%; 25-50%' 51-75%; 76-95%; and 96-100%
Frequency of Occurrence Scale: 5 = Abundant; 4 = Frequent; 3 = Occasional; 2 = Infrequent; and 1 = Rare

	Species Name	Abundance	Estimated Cover
Trees:	Red Maple (*Acer rubrum*)	5	16-25%
	White Pine (*Pinus strobus*)	4	6-15%
	Black Gum (*Nyssa sylvatica*)	3	6-15%
Saplings:	Red Maple (*Acer rubrum*)	4	Included in Tree Cover
Shrubs:	Sweet Pepperbush (*Clethra alnifolia*)	5	51-75%
	HB Blueberry (*Vaccinium corymbosum*)	4	6-15%
	Arrowwood (*Viburnum dentatum*)	4	6-15%
	Swamp Azalea (*Rhododendron viscosum*)	3	6-15%
	Black Chokeberry (*Aronia melanocarpa*)	3	1-5%
Vines:	Wild Grape (*Vitis* sp.)	3	1-5%
Herbaceous:			
Wool-grass (*Scirpus cyperinus*)		4	6-15%
Soft Rush (*Juncus effusus*)		4	6-15%
Cinnamon Fern (*Osmunda cinnamomea*)		4	6-15%

Sample plot is subject to spring floods and backwater flooding due to a beaver dam at the culvert under Route 110. Dam material was recently removed from the culvert. Standing deadwood is present in the scrub-shrub wetland due to past flooding. A windfall red maple occurs in the sample plot. Soil consists of approximately 3 inches of black muck over sands and gravel. Soil was saturated with free water recorded 8 inches below the soil surface. Signs of past flooding were evident at the base of standing trees and exposed boulders.

2001 FIELD REPORT: VEGETATION SAMPLING SHEET

Site Name: Bare Hill Pond
Location: Harvard, Massachusetts
Transect No. One
Community Type: Scrub-Shrub Wetland
Soil Type: Muck and sands and gravel

Weather: Cloudy, Lt. Wind, 55-60 º F
Date: November 14, 2001
Plot Size: 30-ft. radius, Plot 2
Observers: Don Schall
Photographs: Yes (Figure 2)

General Description of the Vegetation Sample Station:

Vegetation sample plot is located in the scrub-shrub wetland community approximately 500 ft. north of the dam at the northern end of the pond. Access to the sample plot is from the service road to the dam off Willow Road. A narrow fringe of flood plain forest occurs along the edge of the sample plot. The estimated plant cover in the sample plot is over 60 percent. The sample plot was photographed during the survey performed on November 14, 2001.

Species List with Estimated Cover and Abundance Rankings for Dominants
Cover Estimates: 1 - 5%; 6-15%; 16-25%; 25-50%' 51-75%; 76-95%; and 96-100%
Frequency of Occurrence Scale: 5 = Abundant; 4 = Frequent; 3 = Occasional; 2 = Infrequent; and 1 = Rare

	Species Name	**Abundance**	**Estimated Cover**
Trees:	Red Maple (*Acer rubrum*)	5	16-25%
	White Pine (*Pinus strobus*)	4	6-15%
Saplings:	Absent		
Shrubs:	Sweet Pepperbush (*Clethra alnifolia*)	5	16-25%
	HB Blueberry (*Vaccinium corymbosum*)	4	16-25%
	Black Alder (*Ilex verticillata*)	4	6-15%
	Swamp rose (*Rosa palustris*)	3	1-5%
Vines:	Absent		
Herbaceous:			
Wool-gGrass (*Scirpus cyperinus*)		5	16-25%
Tussock Sedge (*Carex stricta*)		5	26-50%
Sedge (*Carex* sp.)		3	6-15%
Purple Loosestrife (*Lythrum salicaria*)		3	1-5%
Canada Bluejoint Grass (*Calamagrostis canadensis*)		4	1-5%
Burreed (*Sparganium* sp.)		4	6-15%
Water Purslane (*Ludwigia palustris*)		3	1-5%

Sample plot is subject to spring floods and backwater flooding due to a beaver dam at the culvert under Route 110. Standing deadwood is present in the scrub-shrub wetland due to past flooding. Soil consists of approximately 8 inches of black muck over sands and gravel. Soil was saturated with free water recorded 2 inches below the soil surface.

2001 FIELD REPORT: VEGETATION SAMPLING SHEET

Site Name: Bare Hill Pond	Weather: Cloudy, Lt. Wind, 55-60 º F
Location: Harvard, Massachusetts	Date: November 14, 2001
Transect No. Two	Plot Size: 30-ft. radius, Plot 3
Community Type: Emergent Wetland	Observers: Don Schall
Soil Type: Muck over sands and gravel	Photographs: Yes (Figure 3)

General Description of the Vegetation Sample Station:

Vegetation sample plot is located in emergent wetland community approximately 400 ft. north of the town beach parking lot. Access to the sample plot is from the bike trail along Pond Road. A narrow fringe of scrub-shrub wetland occurs along the upper edge of the pond at the sample plot. The estimated plant cover in the sample plot is over 75 percent. The sample plot was photographed during the survey performed on November 14, 2001.

Species List with Estimated Cover and Abundance Rankings for Dominants
Cover Estimates: 1 - 5%; 6-15%; 16-25%; 25-50%' 51-75%; 76-95%; and 96-100%
Frequency of Occurrence Scale: 5 = Abundant; 4 = Frequent; 3 = Occasional; 2 = Infrequent; and 1 = Rare

	Species Name	**Abundance**	**Estimated Cover**
Trees:	Absent		
Saplings:	Absent		
Shrubs:	Sweet Pepperbush (*Clethra alnifolia*)	4	6-15%
	HB Blueberry (*Vaccinium corymbosum*)	4	6-15%
	Swamp Azalea (*Rhododendron viscosum*)	3	1-5%
	Gray Birch (*Betula populifolia*)	3	1-5%
Vines:	Absent		
Herbaceous:			
Cat-tail (*Typha latifolia* and *T. angustifolia*)		5	76-95%
Sedge (*Carex* sp.)		3	6-15%
Purple Loosestrife (*Lythrum salicaria*)		3	1-5%
Blueflag (*Iris versicolor*)		3	1-5%
Water Purslane (*Ludwigia palustris*)		3	1-5%
Royal Fern (*Osmunda regalis*)		3	1-5%

Sample plot is subject to extended periods of exposure due to water drawdown in the fall. Water level is managed to control nuisance aquatic vegetation in Bare Hill Pond. A narrow fringe of scrub-shrub wetland exists along the upper edge of the sample plot. Soil consists of over 16 inches of black muck over sands and gravel. Soil was saturated to the soil surface.

2001 Field Report: Vegetation Sampling Sheet

Site Name: Bare Hill Pond
Location: Harvard, Massachusetts
Transect No. Two
Community Type: Emergent Wetland
Soil Type: Muck over sands and gravel

Weather: Cloudy, Lt. Wind, 55-60 º F
Date: November 14, 2001
Plot Size: 30-ft. radius, Plot 4
Observers: Don Schall
Photographs: Yes (Figure 4)

General Description of the Vegetation Sample Station:

Vegetation sample plot is located in emergent wetland community approximately 900 ft. north of the town beach parking lot. Access to the sample plot is from the bike trail along Pond Road. A narrow fringe of scrub-shrub wetland occurs to the east of the sample plot. The estimated plant cover in the sample plot is over 75 percent. The sample plot was photographed during the survey performed on November 14, 2001.

Species List with Estimated Cover and Abundance Rankings for Dominants
Cover Estimates: 1 - 5%; 6-15%; 16-25%; 25-50%' 51-75%; 76-95%; and 96-100%
Frequency of Occurrence Scale: 5 = Abundant; 4 = Frequent; 3 = Occasional; 2 = Infrequent; and 1 = Rare

	Species Name	Abundance	Estimated Cover
Trees:	Absent		
Saplings:	Absent		
Shrubs:	Absent		
Vines:	Absent		
Herbaceous:			
Cat-tail (*Typha latifolia* and *T. angustifolia*)		5	26-50%
Canada Bluejoint Grass (*Calamagrostis canadensis*)		5	26-50%
Purple Loosestrife (*Lythrum salicaria*)		5	16-25%
Wool-grass (*Scirpus cyperinus*)		4	6-15%

Sample plot is subject to extended periods of exposure due to water drawdown in the fall. Water level is managed to control nuisance aquatic vegetation in Bare Hill Pond. A narrow fringe of scrub-shrub wetland exists just to the east of the sample plot. Soil consists of over 16 inches of black muck over sands and gravel. Soil was saturated to the soil surface.

Appendix C

Documented and Potential Wildlife Species