Ashuelot Pond
Washington, New Hampshire




Drawdown Study

Prepared By:

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

DRAFT Final Report
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DRAFT
Ashuelot Pond, Washington, New Hampshire
Drawdown Study
2002-2005

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CHAPTER 1
INTRODUCTION

Deep fall/winter drawdowns have been used since the mid-1980s by the Ashuelot Pond Dam owner to attempt to control native aquatic vegetation in Ashuelot Pond. Per an Order issued by the Department of Environmental Services (DES) in 1991, annual drawdowns of Ashuelot Pond were limited to a total depth of 3.5 feet below the elevation of the two overflow spillways. Drawdowns were to begin no earlier than Columbus Day. The only exception to this is that every fifth year (1996, 2001, etc.), the dam owners may conduct a deep drawdown, greater than 3.5 ft below the two overflow spillways, at a time designated by the DES Dam Bureau for dam inspection and repairs, shoreline improvements, and for aquatic weed control. A copy of the 1991 Order can be found in Appendix A.

A deep drawdown was accomplished in 1992 to repair the dam and to install new operating gates. This deep drawdown was actually scheduled and attempted the previous year, but was unsuccessful because the amount of inflow in 1991 was too high to allow Ashuelot Pond to drain. DES authorized deep drawdowns in 1996 and 2000 pursuant to the provisions of the 1991 Order. Another deep drawdown was conducted in the fall/winter of 2004 as part of this study.

The purpose of the Ashuelot Pond Drawdown Study was to determine the effects of these drawdowns on pond ecology, and the impacts that drawdowns may have on nearshore and watershed residents surrounding Ashuelot Pond. As part of the study, the pond was monitored for a period of four years from the summer of 2002 through the summer of 2005. Normal 3.5 foot drawdowns were conducted in the fall of 2002 and 2003, and then a deep drawdown was conducted in the fall of 2004. The pond was monitored for another summer (2005) after the fall 2004 deep drawdown for comparison to previous years.

A work plan for this project was prepared by DES in March of 2002 that detailed the scope of the study (see Appendix B). In the plan, DES proposed to perform an assessment of the chemical, biological, and ecological conditions of Ashuelot Pond through a deep drawdown cycle to determine if any statistically significant changes could be observed from these conditions.

Each chapter of this report provides the evaluation of an element of the pond system that was monitored as part of this study to determine changes that may have resulted from the deep drawdown in fall/winter 2004. In Chapter 7, Conclusions and Recommendations, the data are assimilated and recommendations are provided for plant management and drawdown cycles.

EXECUTIVE SUMMARY

Deep fall/winter drawdowns have been used since the mid-1980s by the Ashuelot Pond Dam owner to attempt to control native aquatic vegetation in Ashuelot Pond in Washington, New Hampshire. Per an Order issued by the Department of Environmental Services (DES) in 1991, annual drawdowns of Ashuelot Pond were limited to a total depth of 3.5 feet below the elevation of the two overflow spillways. The only exception to this is that every fifth year (1996, 2001, etc.), the dam owners may conduct a deep drawdown, greater than 3.5 ft below the two overflow spillways, at a time designated by the DES Dam Bureau for dam inspection and repairs, shoreline improvements, and for aquatic weed control.

The purpose of the Ashuelot Pond Drawdown Study was to determine the possible benefits of deep drawdown for aquatic plant control, and the effects of deep drawdowns on pond ecology and on nearshore and watershed residents surrounding Ashuelot Pond. As part of the study, the pond was monitored for a period of four years from the summer of 2002 through the summer of 2005. Normal 3.5 foot drawdowns for flood control purposes were conducted in the fall of 2002 and 2003, and then a deep drawdown (6 feet) was conducted in the fall of 2004. The pond was monitored for another summer (2005) after this deep drawdown of fall 2004 for comparison to previous years.

Water Quality

Ashuelot Pond water quality is monitored by two DES programs: the DES Lake Assessment Program and the Volunteer Lake Assessment Program. According to data from these two programs, Ashuelot Pond can be classified as a moderately acidic waterbody, with no buffering capacity against acid inputs (such as from acid precipitation). The waters are slightly tea colored, yielding a brownish/reddish appearance to the pond, likely attributable to the decomposition of aquatic vegetation derived from the river, associated wetlands, and the pond itself. Specific conductivity is in the low range, and much lower than the state mean. Total phosphorus is within the mid-range, but acceptable for mesotrophic waterbodies. Concentrations of various forms of nitrogen are low, which is not uncommon for lakes and ponds in New Hampshire where phosphorus tends to be the limiting nutrient for growth. Algal biomass, measured by chlorophyll-a concentration, falls within the moderate category. The clarity, measured by Secchi disk, was 12.9 feet, which is slightly above the state average. Dissolved oxygen was extremely low at the pond bottom (0.02 mg/L), causing near anoxic conditions at 21.5 feet.

With the exception of possible and subtle changes in acid neutralizing capacity (ANC) values immediately following drawdown, there do not appear to be any marked changes in water quality as a result of deep drawdowns in Ashuelot Pond. The data from the ANC analyses do suggest that there may be a slight increase in alkalinity following deep drawdowns, as compared to the year immediately preceeding the drawdown event. In general, water quality in Ashuelot Pond seems unaffected by deep drawdowns.

Aquatic Macrophytes

Ashuelot Pond is moderately shallow (mean depth=6.6 feet, maximum depth=29 feet). The nearshore area of Ashuelot Pond is quite extensive, providing shallow shelves that are ideal for plant growth. One native aquatic plant, whorled bladderwort (*Utricularia purpurea*) has been a particular nuisance to some shoreline residents. No exotic aquatic plants have been identified in Ashuelot Pond at this time.

Data that were collected from the pond in summer 2005 were analyzed for statistically significant differences from the data set of non-deep drawdown years (2002-2004). Most of the plant genera represented in the pond showed no change, a few showed weakly significant changes (decreases or increases), and only one (pondweed) showed a definitive statistical decrease in the pond. On a lakewide basis, the overall percent plant cover, for all plants combined, within Ashuelot Pond did not show a statistically significant change as a result of the deep drawdown in fall 2004.

In the river, there was a small but statistically significant increase in plant cover in 2005 as compared with data sets from 2002-2004. The data indicate that plant percent cover increased overall: arrowhead showed strong statistical increases in the river and subtle increases in other species likely also accounted for some of this change.

Aquatic Organisms

Several types of aquatic organisms were also monitored as part of the Ashuelot Pond Drawdown Study. Specifically, DES examined macroinvertebrate, frog, and fish community composition in Ashuelot Pond.

Overall there were no statistically significant differences in the overall number of macroinvertebrates found between the non deep drawdown years, and the deep drawdown year. While deep drawdown did not appear to affect the total number of macroinvertebrates, it did have an apparent impact on species diversity in the total population of the macroinvertebrates. In years before the deep drawdown, Dipterans were the dominant specie, whereas after the deep drawdown in 2005, Dipterans declined to only 18% of the organisms present, and Amphipods increased to 72% of the overall population, suggesting that Amphipods were positively impacted by the deep drawdowns.

Based on observations during this study, frog populations were fairly stable in Ashuelot Pond. Adult frogs were present and egg masses were observed throughout the system each year. Based on both side-by-side comparisons and statistical analyses of the data, frog populations were not negatively impacted by deep drawdowns in Ashuelot Pond.

Ashuelot Pond has a varied warmwater fishery, with common species observed each year of the study. The age class of largemouth bass hatched during years of deep drawdowns (2000 and 2004) was either not captured in the following year's sample or was captured in low numbers. No significant differences in relative weight were found for largemouth bass before and after deep drawdown, suggesting that drawdowns were not directly impacting largemouth bass mass. However, negative relationships between bass total length and relative weight were found for all years and were significant in 1999 and 2003, according to NH Fish and Game Department data. Significant differences were also found for relative abundance of all sizes of largemouth bass combined, and for bass less than stock size. Overall, mean relative abundance values for largemouth bass in Ashuelot Pond from all years sampled were at least 32% lower than statewide values calculated for 1997-2005. No significant differences in relative abundance for non-bass species among years were found.

Largemouth bass growth was categorized as "fast" (2005 data representing age classes from 1999-2004) when compared to statewide values, and mean relative weight values were generally higher than statewide values. It is likely that fast largemouth bass growth and high relative weights in Ashuelot Pond was due to limited competition as a result of relatively low numbers of bass.

The user perception survey that was conducted of Ashuelot Pond shoreline owners and watershed residents included questions on a number of categories relative to Ashuelot Pond. Most of the questions were asked to gauge the overall perception of the pond in the eyes of the nearshore residents. In general, more than half of the survey respondents indicated that Ashuelot Pond was in good condition (53%). Of the problems they did perceive, 'aquatic plants' was a common reply, with 57% of the respondents citing this as the primary problem. Many residents indicated that they noted that plants wash upon the shoreline on a daily basis (55%), and most noted that the most problematic area was in the river segment of the study area. Forty-eight percent of the respondents indicated that plants pose an impact to their recreational use of the pond. Changes to the fishery or wildlife over time do not appear to be a problem to survey respondents, as most respondents indicated that there was no change in the number of fish caught in the pond (75%).

Overall Summary

No overall negative impacts to water quality or amphibians were observed between times of no deep drawdown and the year immediately following deep drawdown. Some negative impacts to macroinvertebrates and fish were observed as a result of deep drawdowns. No statistically significant benefit was observed from the deep drawdown in terms of overall plant reduction or in the reduction of the target bladderwort species. On the basis of these conclusions, a deep drawdown for plant control is not scientifically warranted for Ashuelot Pond.

An alternative control strategy for the target bladderwort species could include diver-assisted suction harvesting to remove abundant growths of the plant, with little to no impact to non-target species.

CHAPTER 2
ASHUELOT POND AND WATERSHED DESCRIPTION

2.1 Ashuelot Pond Morphology and Trophic State

Ashuelot Pond, located in Washington, New Hampshire, is classified as a moderately shallow (mean depth=6.6 feet, maximum depth=29 feet), mesotrophic pond. Figure 2-1 provides a map of the pond and its watershed. The watershed drainage area to the pond outlet is 25.3 square miles, with the pond itself covering an area of approximately 0.6 square miles (375 acres).

The Ashuelot Pond watershed is primarily forested, with rural residential development sparsely scattered through the watershed. The shoreline of the pond and river is moderately developed with seasonal cottages along the southern and western shorelines, and more year-round dwellings on the northeastern shorelines.

Figure 2-2 provides a bathymetric map showing the bottom contours of Ashuelot Pond. Roughly 74 percent of the pond is 10 feet deep or less. Approximately 24 percent of the pond is between 10 feet and 20 feet deep and about 2 percent of the pond is between 20 feet and 23 feet deep. The average depth of the pond is 6 feet. The littoral zone (the nearshore areas of a waterbody where sunlight penetrates to the bottom sediments) of Ashuelot Pond is quite extensive, providing shallow shelves that are ideal for plant growth. The littoral zone is typically the zone of rooted macrophyte growth in a waterbody. With an average depth of only 6 feet, sunlight can easily penetrate the bottom of much of the pond, providing conditions that are quite suitable for plant growth. The mean transparency for the summer of 2002, when this study began, was over 9 feet (VLAP, 2002); therefore, 74% of the pond (those areas with depths less than 10 feet) receives adequate sunlight for plant growth.

The pond bathymetry also reveals that approximately 60% of the lake bottom area is exposed during deep drawdown conditions when the lake level is lowered 6 feet.

2.2 Ashuelot Pond Dam

The Ashuelot Pond Dam (Dam #245.05) controls the outlet of Ashuelot Pond. At the start of the study the dam was owned by the Lake Ashuelot Estates Association, but ownership has since been transferred to the Ashuelot Village District. The 190-foot long, thirteen-foot high dam was first built in 1872, and was most recently repaired during a deep drawdown in 1992. The water level is maintained through the manipulation of an upper and lower gate in the gatehouse (constructed in 1992).

Figure 2-1
Ashuelot Pond Watershed

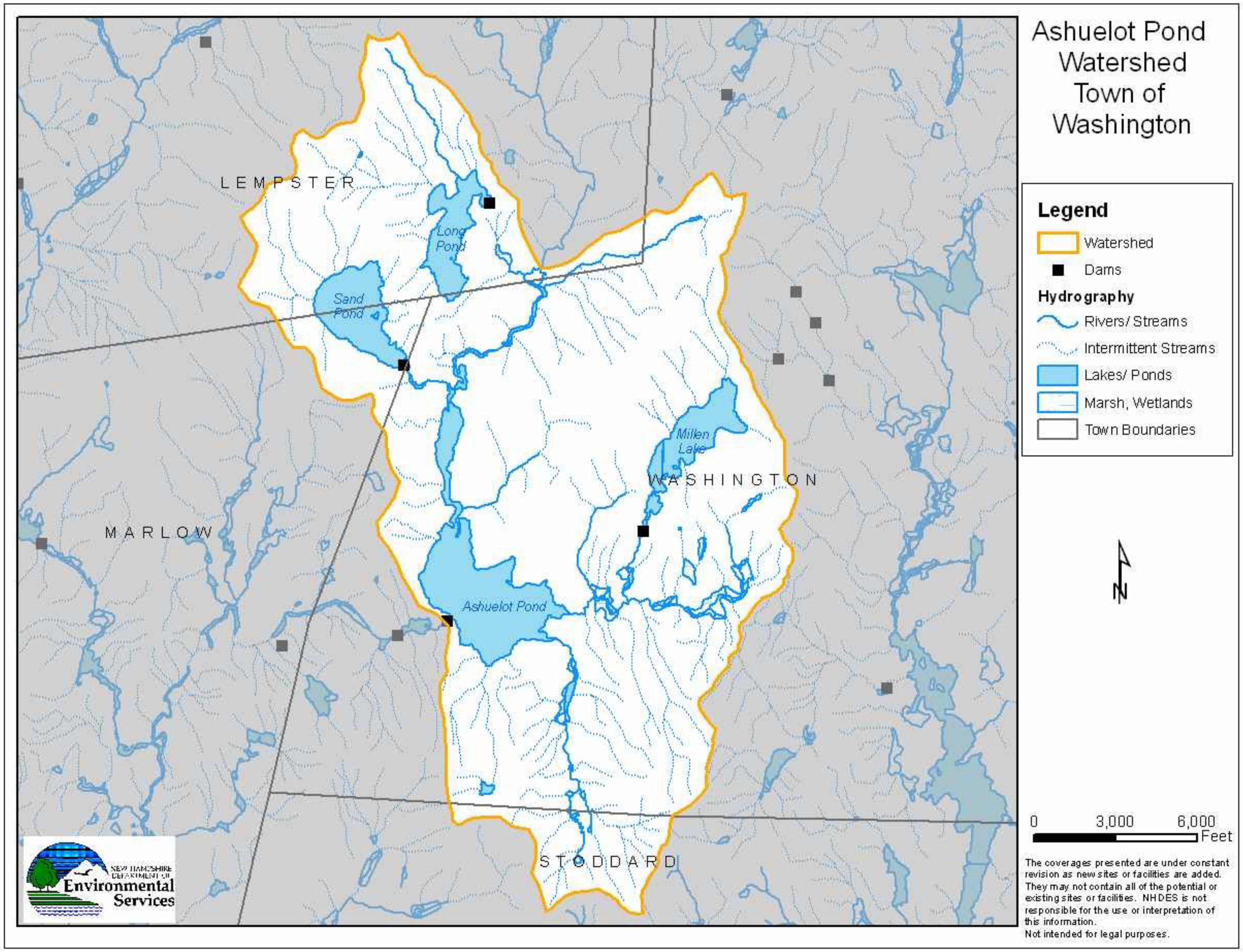
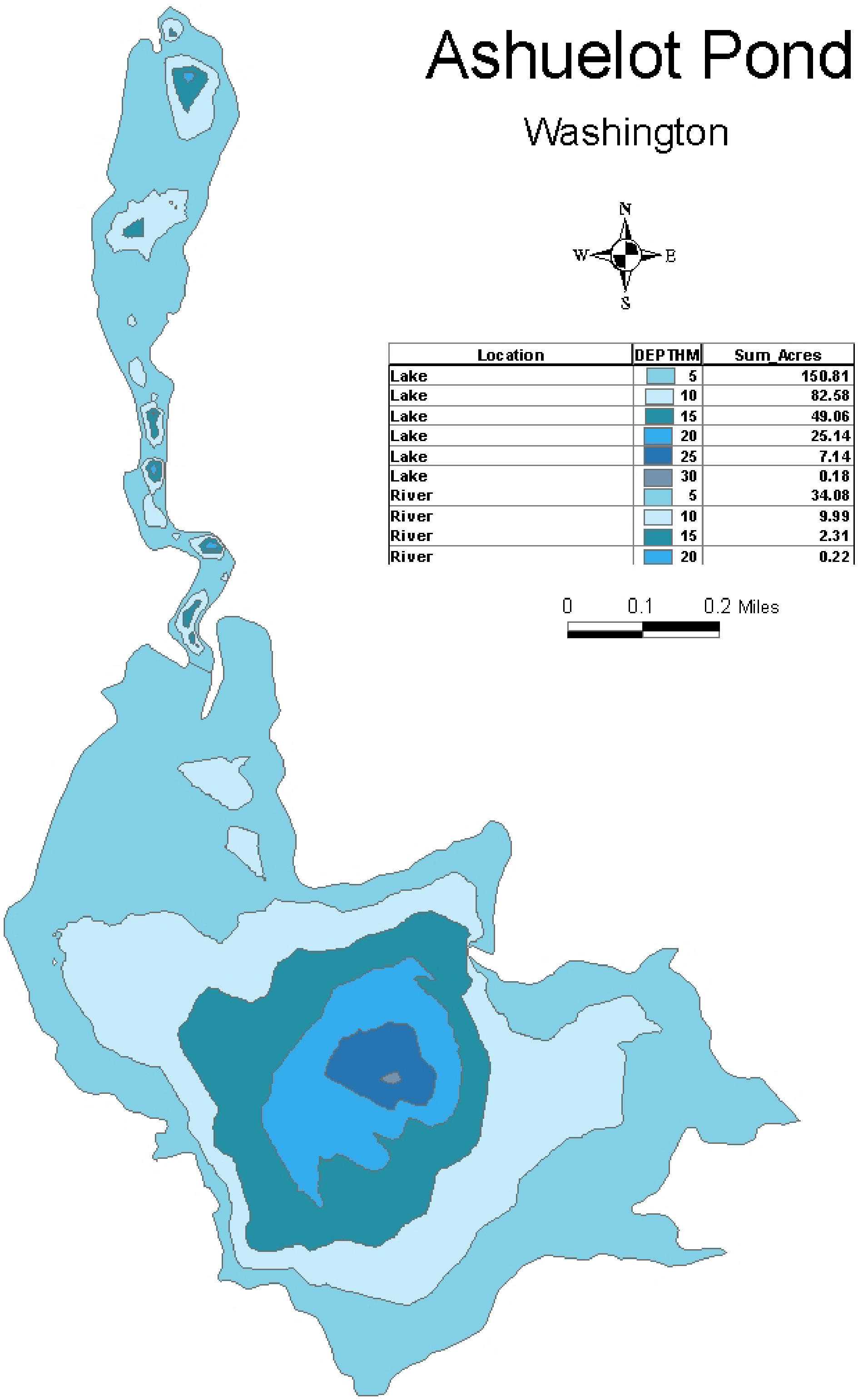


Figure 2-2
Ashuelot Pond Bathymetric Map



Location	DEPTHM	Sum_Acres
Lake	5	150.81
Lake	10	82.58
Lake	15	49.06
Lake	20	25.14
Lake	25	7.14
Lake	30	0.18
River	5	34.08
River	10	9.99
River	15	2.31
River	20	0.22

CHAPTER 3
WATER QUALITY

3.1 Introduction

This chapter discusses the ambient water quality of Ashuelot Pond and evaluates water quality trends over time. Special emphasis is placed on evaluating lake quality trends that develop between years of deep drawdown and those present immediately after deep drawdown conditions.

3.2 Water Quality Monitoring on Ashuelot Pond

Ashuelot Pond is sampled by two separate programs: the DES Lake Assessment Program and the Volunteer Lake Assessment Program.

3.2.1 Lake Assessment Data - General Limnological Information

Based on the DES Lake Assessment Program data from the summer of 2004, Ashuelot Pond is classified as mesotrophic. This classification has not changed since DES first surveyed the pond in 1977. Trophic classification is a standard ranking system for lakes tailored specifically for New Hampshire lakes and ponds. The classification system uses a combination of bottom dissolved oxygen concentration, Secchi disk depth (clarity), overall macrophyte abundance, and chlorophyll-a (a measure of algal biomass in the water column) to establish the trophic status of a lake or pond. Mesotrophic is the intermediate classification. Oligotrophic lakes are the least nutrient rich and productive, and eutrophic lakes are the most nutrient enriched and productive lakes. Oligotrophic lakes are typically quite clear, and eutrophic lakes are those that are nutrient rich and frequently experience algal blooms.

During the lake assessment, many parameters were examined during both the summer and the winter season. The data from the summer 2004 lake assessment are summarized in Table 3-1.

Ashuelot Pond can be classified as a moderately acidic waterbody, with no buffering capacity against acid inputs (such as from acid precipitation). The waters are slightly tea colored, yielding a brownish/reddish appearance to the pond, likely attributable to the decomposition of aquatic vegetation derived from the river, associated wetlands, and the pond itself. Specific conductivity is in the low range, and much lower than the state mean (59.4

umhos/cm). Total phosphorus is within the mid-range, but acceptable for mesotrophic waterbodies. Concentrations of various forms of nitrogen are low, which is not uncommon for lakes and ponds in New Hampshire where phosphorus tends to be the limiting nutrient for growth. Algal biomass, measured by chlorophyll-a concentration, falls within the moderate category. The clarity, measured by Secchi disk, was 12.9 feet. Dissolved oxygen was extremely low at the pond bottom (0.02 mg/L) causing near anoxic conditions at 21.5 feet.

Table 3-1
Summary of Water Quality Analyses from a July 21, 2004 Lake Assessment

Parameter/units	Epilimnion (6.6 foot Depth)	Hypolimnion (16.5 foot Depth)	New Hampshire Means
pH Units	5.48	5.41	6.5
Alkalinity (mg/L $CaCO_3$)	-0.3	0.1	6.6
Apparent Color (CPU)	30	35	28 (median)
Specific Conductance (us/cm)	30.15	31.08	59.4
Total Phosphorus (mg/L P)	0.02	0.026	0.012 (median)
Total Kjeldahl-N (mg/L N)	0.5	0.7	0.35 (median)
Nitrate- NO_2/NO_3 (mg/L)	<0.05	<0.05	<0.05 (median)
Chlorophyll-a (mg/m^3)	5.29 for 16.5 ft. Tube		7.16
Secchi Depth (m)	12.9 ft.		12.1
Bottom DO (mg/L)	0.02 mg/L at 21.5 ft		n/a

3.2.2 Volunteer Lake Assessment Data (VLAP) and Trend Evaluation

The Volunteer Lake Assessment Program (VLAP) provides more frequent sampling than the DES Lake Assessment Program through the assistance of lake residents that collect monthly samples during the summer. Ashuelot Pond has been involved with VLAP since 1989, and lake residents have collected data annually since joining the program.

3.3 Water Quality Trends

The following water quality discussion evaluates data from both the VLAP and Lake Assessment programs. VLAP data are used to evaluate changes in water quality from 2002 through 2004, which are considered the pre-deep drawdown years for this study, and the 2005 data are used to show conditions during the growing season immediately following a deep drawdown in fall/winter 2004/2005. All available pond data will be used to evaluate water quality trends over time.

3.3.1 pH

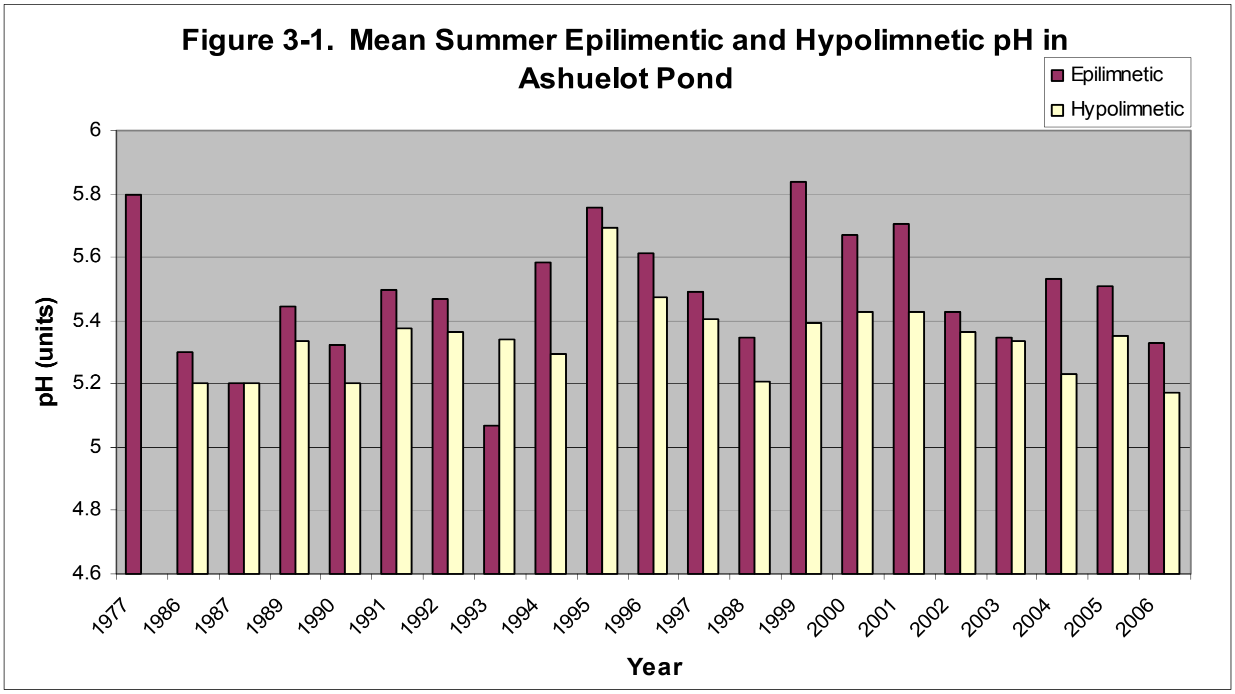
pH is the measure of how acid or basic a substance is. The pH scale is logarithmic, and covers a range of 0-14 units. Substances with a pH of 0 to 6 are considered acidic, those with a pH of 8 to 14 are considered basic or alkaline, while a pH of 7 is neutral. Surface waters in New Hampshire have a median pH of 6.0 and are generally acidic.

The pH level in Ashuelot Pond, and in surrounding ponds of the region, is low compared to the state mean (6.5 units). Throughout the pond's VLAP history, the eplimnetic (upper layer) pH values have ranged from a low of 4.80 units to a high of 5.81 units. The hypolimnetic (lower layer) pH has ranged from 5.14 units to 5.65 units. Using the DES classification system, a lake with a pH range between 5.5-6.0 units is classified as 'Endangered', between 5.0 and 5.4 units the lake is in a 'Critical' condition, and below a pH of 5 units the lake is considered "Acidified." As the pH decreases to between 5 and 6 units, many fish and other aquatic organisms become stressed and some disappear. Little or no fish life may occur when the pH falls below 5 units. The acidity of a system can also be affected as an indirect result of drawdowns. According to Norton (1989), dissolved organic matter from the decay of vegetation contributes to the acidity of lakes, but it is particularly important in lakes with short residence times (i.e., lakes that flush quickly), such as Ashuelot Pond.

Figure 3-1 illustrates the trends in epilimnetic and hypolimnetic pH in Ashuelot Pond as far back as 1977, when the pond was first surveyed by the DES Lake Assessment Program. Even though the Ashuelot Pond field data collection was completed in 2005, we have included 2006 data that were available from the volunteer monitoring program.

When examining these graphs, it should be noted that deep drawdowns occurred in the fall of 1986, 1991 (failed, as explained in Chapter 1), 1992, 1996, 2000, and 2004.

In general, there are no consistent discernable trends in pH data that can be tied to the deep drawdown years. The pH of Ashuelot Pond ranged from a low of near 5.0 units in some years, to a high of nearly 6.0 in other years. The variability of the mean annual pH values of the waters of Ashuelot Pond appears to be random, and not related to deep drawdowns.

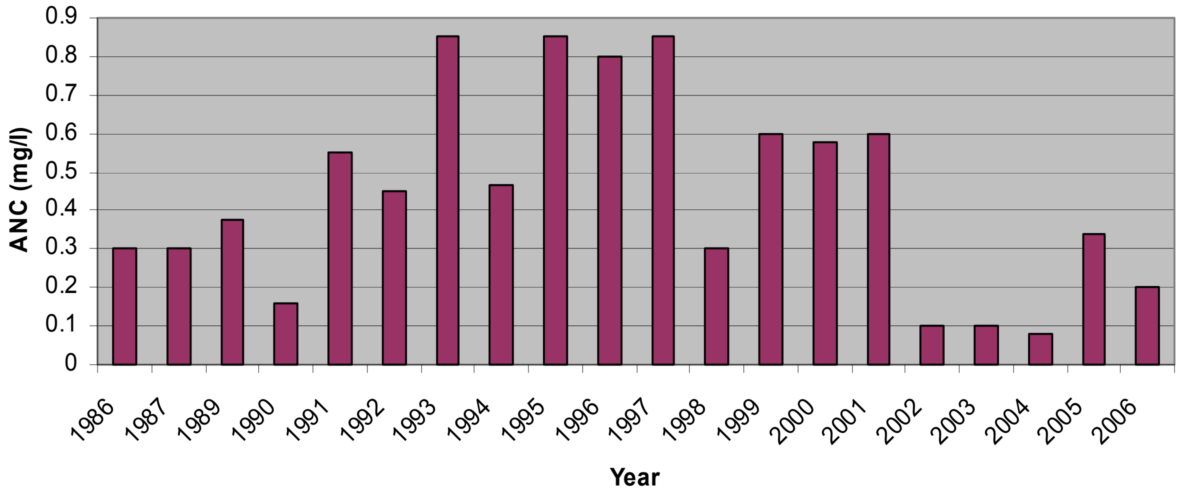


3.3.2 Acid Neutralizing Capacity (ANC)

Acid Neutralizing Capacity or alkalinity measures the capacity of surface waters to absorb or dissipate acid inputs. Typically, New Hampshire waters have very low buffering capacity because of the state's geologic morphology. Granitic bedrock has a low basic mineral content with little calcium, resulting in a short supply of ANC erosion remnants to our waters. The median ANC for New Hampshire lakes is 4.9 mg/L, so the ANC values for Ashuelot Pond are far below the median. Figure 3-2 shows the trend in mean annual epilimnetic ANC for Ashuelot Pond over time.

Examination of ANC data derived from years immediately following deep drawdown shows that mean annual epilimnetic ANC increases from that observed in the year preceding a deep drawdown, then slowly decreases until the next deep drawdown. The data are still variable however, and individual ANC values range from negative numbers to highs of 1.49 mg/L within the data sets for each individual year.

Figure 3-2. Mean Annual Epilimnetic Acid Neutralizing Capacity for Ashuelot Pond



3.3.3 Total Phosphorus

Total phosphorus includes all phosphorus forms present in the water, including both inorganic and organic forms. Phosphorus is considered the limiting nutrient in New Hampshire lakes, meaning that this is the nutrient that controls plant and algae growth. The amount of phosphorus also dictates trophic state and the types and amount of plant life capable of surviving in that lake or pond. Excessive total phosphorous (TP) in a system may impair the aesthetics and recreational uses of a waterbody by causing increased plant and algae growth. According to Fabre (1988), the periodic drawdown of aquatic systems affects the phosphorus cycle in those systems. In the case of shallow lakes, drawdowns can lead to the release of orthophosphate in high enough concentration to influence water quality. Fabre's study demonstrates that sediments, subjected to considerable drawdown every year, can release orthophosphate when brought back into contact with water at full pond.

Total phosphorus concentrations within the Ashuelot Pond water column are within the moderate range. Figure 3-3 shows the Ashuelot Pond mean annual TP trends in both the epilimnion and the hypolimnion.

Generally, Ashuelot Pond TP has fluctuated between approximately 0.008 and 0.015 mg/L over time. There do not appear to be any discernable trends that can be attributed to deep drawdowns.

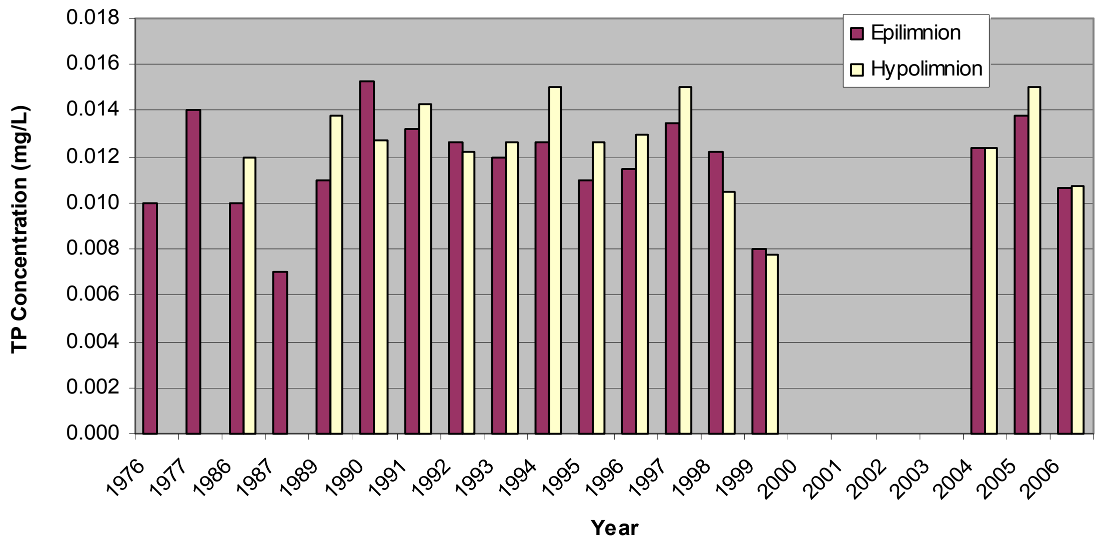
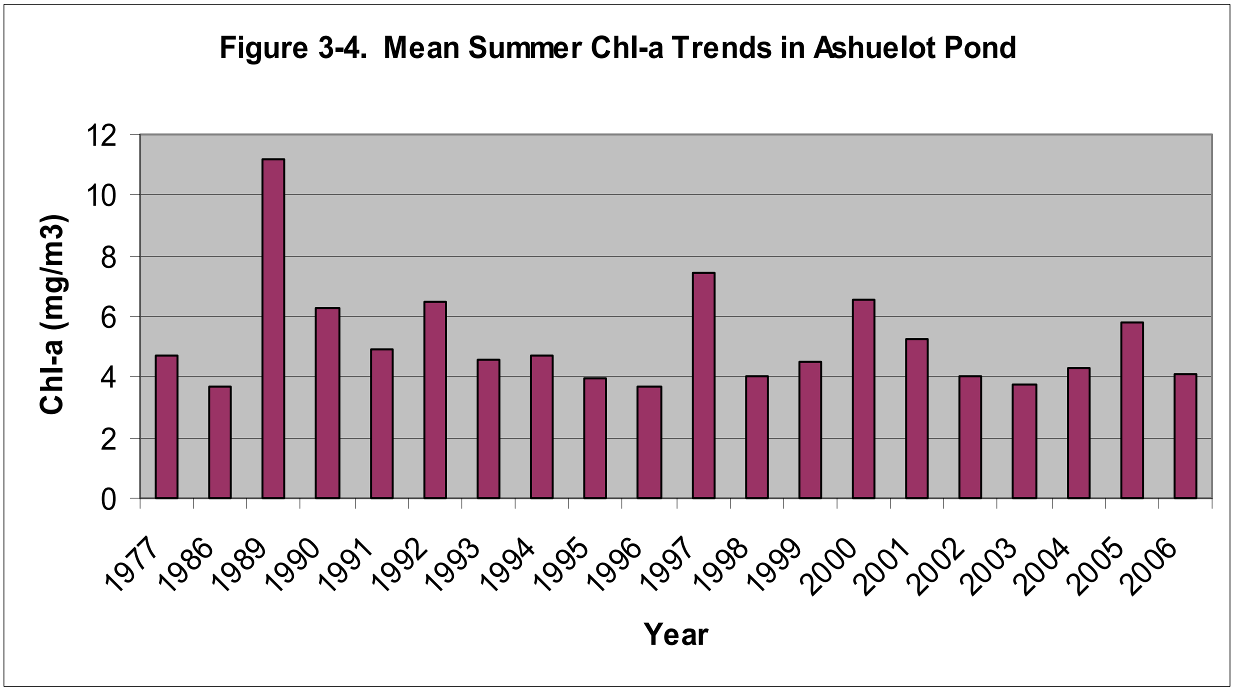


Figure 3-3. Mean Annual Total Phosphorus in the Epilimnion and Hyoplimnion of Ashuelot Pond

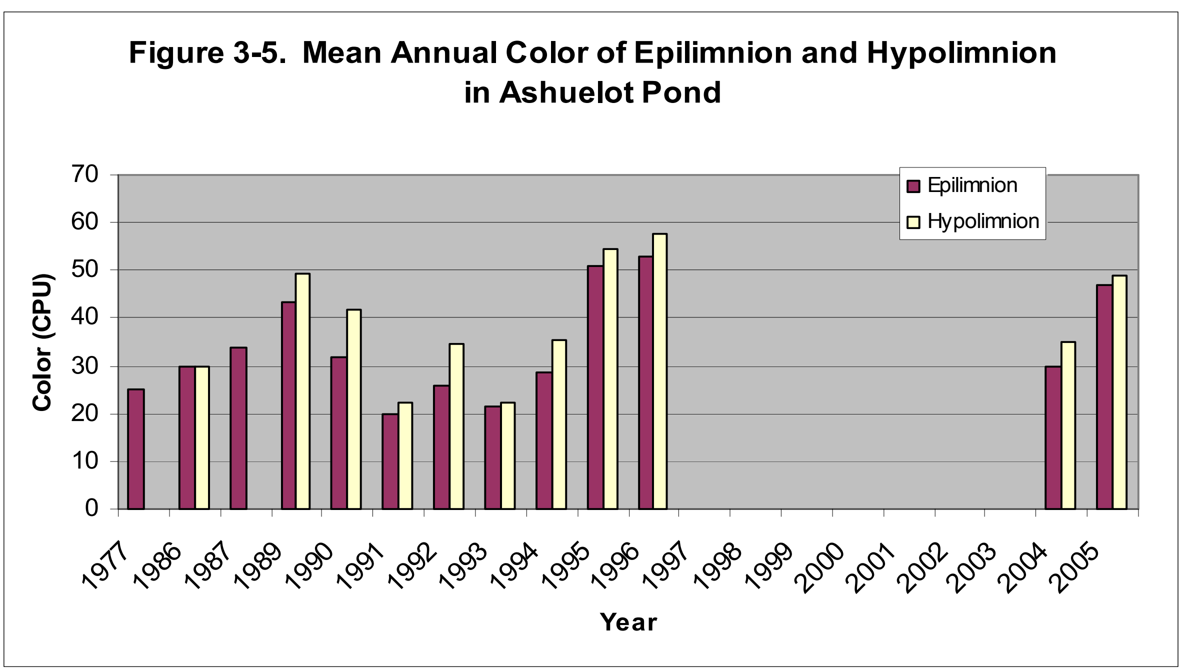
3.3.4 Chlorophyll-a

Chlorophyll-a is a measure of algal biomass in a waterbody. Figure 3-4 illustrates the Ashuelot Pond mean annual summer chlorophyll-a trends. Ashuelot Pond algal densities are within the acceptable limits for chlorophyll-a for New Hampshire lakes and ponds. Chlorophyll-a was considered elevated in 1989, but never reached bloom conditions. Though minor year-to-year fluctuations were measured, there does not appear to be any distinguishable trend in chlorophyll-a that can be attributed to the deep drawdowns.



3.3.5 Color

Color analyses are a visual determination of the water color. Water color can be influenced by many things, including soil metal and mineral content and the presence of watershed wetland systems and their associated decaying organic material. Figure 3-5 shows the Ashuelot Pond annual mean color trends for the epilimnion and the hypolimnion.

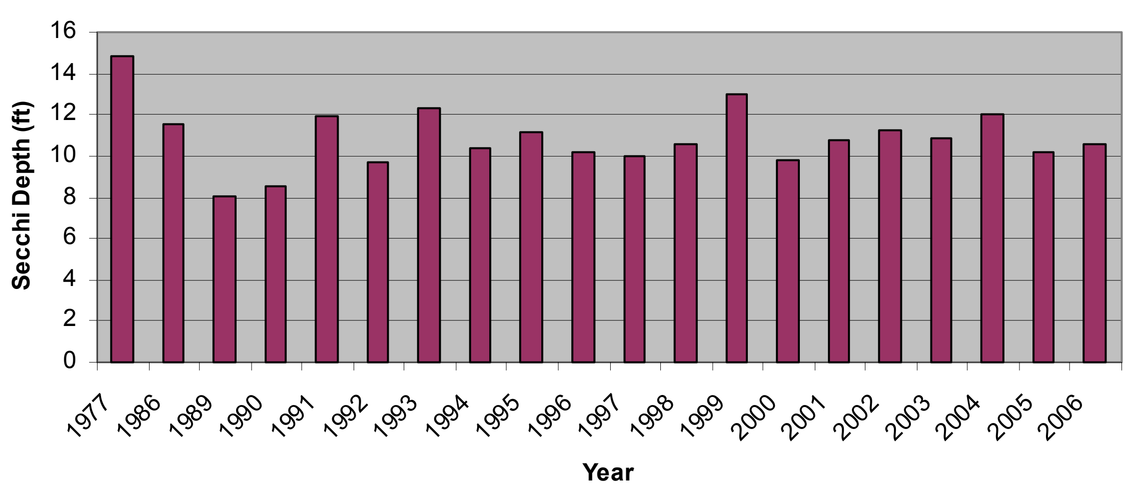


Color was regularly measured by VLAP through 1996, and later discontinued and replaced by turbidity analyses. Therefore, color data are not presented between 1996 and 2003, but this parameter was measured in 2004 as part of the lake assessment sampling. Available data do not reveal a consistent increase or decrease in mean color in the years immediately preceding deep drawdown, nor do they depict a consistent trend in the years after deep drawdowns.

3.3.6 Secchi Depth

This simple test measures water clarity, or a measure of the depth one can see into the water. This depth can vary with weather conditions, suspended matter in the water column, and the eyesight of the observer. A 20 centimeter alternating black and white disk (Secchi disk) is lowered into the water on a calibrated chain to measure this parameter. Figure 3-6 shows mean annual Secchi depth trends over time. Mean Secchi depth ranged between 8.3 and 14.8 feet in Ashuelot Pond over a 20 year period of annual readings.

Figure 3-6. Mean Annual Secchi Depth for Ashuelot Pond

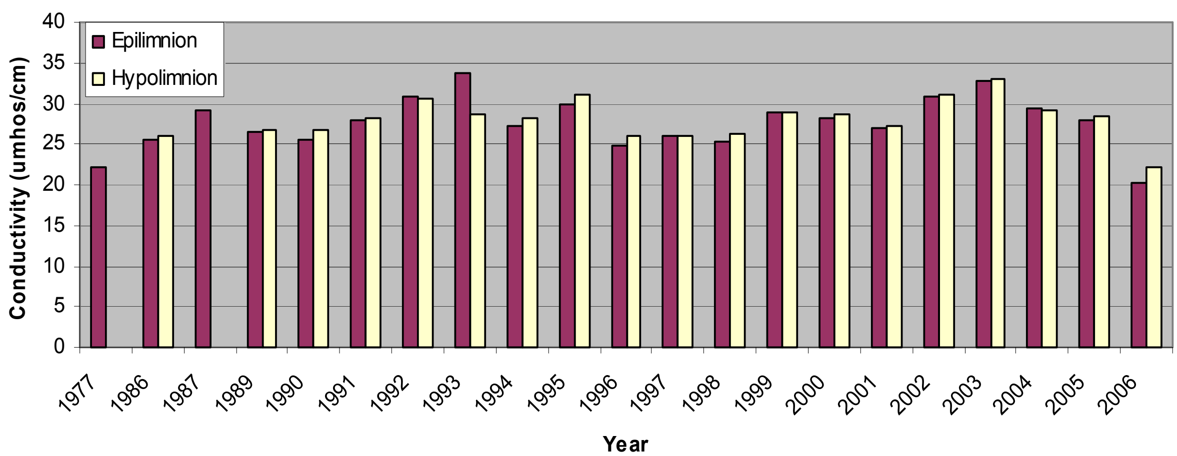


Generally it is expected that clarities will decrease with frequent deep drawdown, partly due to sediment resuspension and algal growth from nutrients liberated by decaying vegetation. This was not observed in Ashuelot Pond. Mean water transparency remained fairly stable, with only normal year to year fluctuations. No specific increasing or decreasing transparency trends were observed immediately following deep drawdown years, and it does not appear that clarity is greatly impacted by deep drawdowns in Ashuelot Pond.

3.3.7 Conductivity

Conductivity is a measure of electrical conductance of a water and is proportional to the ionic concentration in the water. Conductivity can vary as a result of many factors, including watershed geology and other natural occurrences. Human activities, such as fertilizing, chemical application, leaking septic systems, road salting, and other similar activities can lead to increased water conductivity. Generally, conductivity measurements in excess of 100 µmhos/cm in New Hampshire waters indicate human induced impacts from the watershed. Figure 3-7 summarizes mean annual conductivity trends in the two water layers of Ashuelot Pond.

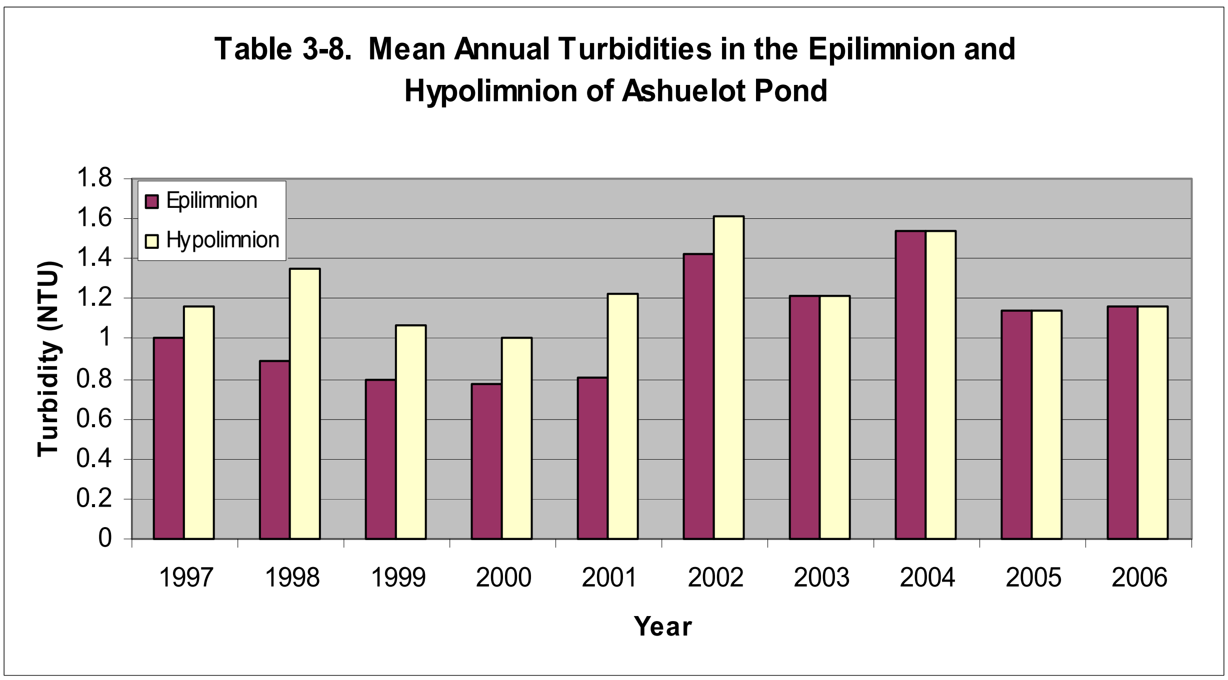
Figure 3-7. Mean Annual Conductivity in the Epilimnion and Hypolimnion of Ashuelot Pond



Mean annual conductivity in both the epilimnion and the hypolimnion have remained relatively stable over time, with only slight fluctuations that range between 22 umhos/cm and 33 umhos/cm. Similar to other water quality parameters discussed above, Ashuelot Pond does not appear to follow predictable patterns in conductivity fluctuations that can be attributed to deep drawdowns.

3.3.8 Turbidity

Turbidity is a measure of the suspended particles in the water column. Turbidity may be caused by bottom sediment resuspension, shoreline erosion, stormwater runoff that flushes in suspended particles, and many other processes. One study conducted with short-term drawdowns showed that they can greatly enhance erosion of fine littoral sediments. This re-suspension of fine sediments may cause high turbidity and enhanced sediment oxygen demand (Gottens, 1994). Increased turbidity in the water column may indicate an increase of organic material and nutrients. Figure 3-8 shows the trend in epilimnetic and hypolimnetic mean turbidity in Ashuelot Pond over time.



Turbidity declined slightly from 1997 to 2001, then between 2001 to 2004 mean in-lake turbidity was slightly higher than normal, and was more variable than in previous years. Following the fall drawdown of 2004, mean annual turbidity decreased slightly in 2005 and 2006, and was more stable. There were no obvious differences observed between the years immediately prior to deep drawdown and those immediately following deep drawdowns that suggest a pattern attributed to drawdowns.

3.4 Water Quality Summary

With the exception of possible and subtle changes in ANC values immediately following drawdown, there do not appear to be any marked changes in water quality as a result of deep drawdowns in Ashuelot Pond. The data from the ANC analyses do suggest that there may be a slight increase in alkalinity following deep drawdowns, as compared to the year immediately preceeding the drawdown event, but they were not large. In general, water quality in Ashuelot Pond seems unaffected by deep drawdowns.

CHAPTER 4
AQUATIC MACROPHYTES

4.1 Introduction

Water level fluctuations, with a specific goal to influence macrophyte distributions, have been documented by some researchers (Kautsky, 1988 and Murphy, 1990) to be a useful technique in managing nuisance growths of aquatic plants in lakes. Drawdowns are generally easy to conduct (provided there is a dam or other mechanism that can be manipulated to lower water levels) and generally low in cost to perform. The ease of this technique is a benefit, but the precise outcomes of drawdowns are often a challenge to predict because of variability in seasonal weather patterns that affects its success in reducing aquatic plant growth. Additionally, drawdown is not target specific and all plants within the system are affected to some degree.

The process of fall/winter deep drawdown is dependent on lowered water levels to expose plants to desiccation and freezing, which ultimately affects plant vascular structure and renders the plant incapable of nutrient transport. This can temporarily reduce plant density for an undetermined period of time depending on species.

4.2 Historical Macrophyte Surveys on Ashuelot Pond

Plant abundance data are available for Ashuelot Pond dating back nearly 70 years. A survey conducted in 1939 by the New Hampshire Fish and Game Department classified emergent vegetation in Ashuelot Pond as common, and submergent vegetation as abundant (no specific plant lists are on record, however).

Detailed macrophyte surveys were completed in both 1977 and 1986 by DES biologists as part of routine lake assessments. These routine surveys involve traveling at slow speeds around the shallows of waterbodies and noting the type and relative abundance of each plant in the lake. A rating for each species, as well as a lakewide relative abundance for all species, is estimated. This method is more qualitative than quantitative in its measurements.

The 1986 survey rated the overall abundance of macrophytes in Ashuelot Pond as common. Rooted plants were rated as abundant in the northern end of the pond near the inlet, as well as in several coves around the pond. DES biologists noted that the macrophytes in this pond were "not a problem in most locations." Three plant species and bottom growth were documented as common, while the remaining aquatic vegetation was rated as either scattered or sparse.

In the earlier evaluation of the pond (1977), a plant survey rated three aquatic macrophyte species as abundant, and bottom growth as very abundant. A comparison between 1977 and 1986 survey data (Table 4-1) shows that many aquatic macrophytes decreased in abundance from the 1977 survey to the 1986 survey.

Table 4-1
A Comparison of 1977 and 1986 Summer Plant Survey Data

Plant	Change in Abundance from 1977 Survey and 1986 Survey
Bladderwort (*Utricularia*)	Decreased from *abundant* to *common*
Yellow water-lily (*Nuphar*)	Decreased from *common* to *scattered*
White water-lily (*Nymphea*)	Decreased from *scattered* to *sparse*
Watershield (*Brasenia*)	Decreased from *common* to *scattered*
Pickerelweed (*Pontedaria*)	Decreased from *abundant* to *common*
Tape-grass (*Vallisneria*)	Decreased from *abundant* to *absent*
Rushes (*Juncus*)	Decreased from *sparse* to *absent*
Bottom growth	Decreased from *very abundant* to *common*
Bur-reed (*Sparganium*)	No change
Native milfoil (*Myriophyllum humile*)	No change
Grass sp. (*Graminea*)	Increased from sparse to scattered
Pondweed (*Potamogeton*)	Not documented in 1977, present in 1986
Bulrush (*Scirpus*)	Not documented in 1977, present in 1986
Spike rush (*Eleocharis*)	Not documented
Arrowhead (*Sagittaria*)	Not documented in 1977, present in 1986
Three-way sedge (*Dulichium arundinaceum*)	Not documented in 1977, present in 1986
Water lobelia (*Lobelia dortmanna*)	Not documented in 1977, present in 1986

Two plant species that did not change in abundance were bur-reed and native water-milfoil. The only plant that increased from 1977 to 1986 was a grass species that changed from sparse to scattered. Pondweed, bulrush, spike rush, arrowhead, and three-way sedge were absent from the 1977 survey report but all appeared in the 1986 survey.

During the 1986 survey, 15 plant genera were documented. During this survey, species of *Juncus* were not documented, but white water-lilies and water lobelia were observed. Biologists that conducted the 1986 survey noted that plants were dense at the northern end of the pond, but were less dense in the main body of the pond.

DES biologists also conducted a macrophyte survey of Ashuelot Pond on September 7, 2000. The purpose of this survey was to determine the type and extent of plant growth in the pond. During this survey, 13 plant genera were identified. Two plants, white water-lilies and water lobelia, documented as sparse in 1986, were not observed in the 2000 survey.

Overall plant abundance throughout the pond was rated as common in 2000. Field notes from the survey indicate that though plant growth in shallow areas was considered to be abundant to very abundant, a large area of open water in the main body of the lake (where no vegetation was documented) brought the overall macrophyte rating for the pond as a whole down to common. During this survey, biologists noted that bright sun and wave activity made viewing beneath the lake surface difficult.

Comparing 2000 data with 1986 data, changes in the abundance of individual taxa were noted, and are listed in Table 4-2 below. Six of the plants showed no difference between these two study years (bladderwort, yellow water-lily, watershield, bottom growth, pondweeds, and three-way sedge), five plants observed in 1986 were not observed in 2000 (spike rush, arrowhead, water lobelia, white water-lily, tapegrass), four plants decreased from 1986 to 2000 (pickerelweed, native watermilfoil, bulrush, spike rush), and three increased (rushes, bur-reed, and grasses). The changes in plant abundance observed between 1986 and 2000 are not considered to be dramatic, given the 14-year time span between surveys. Aquatic macrophyte abundance and percent cover can vary from year to year in a lake or pond depending on winter conditions, water level, macrophyte competition and grazing rates by animals and birds.

Table 4-2

A Comparison of 1986 and 2000 Summer Plant Survey Data

Plant	Change in Abundance from 1986 Survey and 2000 Survey
Bladderwort (*Utricularia*)	No change
Yellow water-lily (*Nuphar*)	No change
White water-lily (*Nymphea*)	Declined from *sparse* to *absent*
Watershield (*Brasenia*)	No change
Pickerelweed (*Pontedaria*)	Decreased from *common* to *scattered*
Tape-grass (*Vallisneria*)	Not observed
Rushes (*Juncus*)	Increased from *absent* to *common*
Bottom growth	No change
Bur-reed (*Sparganium*)	Increased from *scattered* to *scattered/common*
Native milfoil (*Myriophyllum humile*)	Decreased from *scattered* to *sparse*
Grass sp. (*Graminea*)	Increased from *scattered* to *common*
Pondweed (*Potamogeton*)	No change
Bulrush (*Scirpus*)	Decreased from *scattered* to *sparse*
Spike rush (*Eleocharis*)	Not observed
Arrowhead (*Sagittaria*)	Not observed
Three-way sedge (*Dulichium arundinaceum*)	No change
Water lobelia (*Lobelia dortmanna*)	Documented as *sparse* in 1986, not observed in 2000

4.3 Expected Degree of Macrophyte Control from Drawdown

In a study that evaluated a series of lake drawdown projects, Cooke (1980), found that various aquatic plants responded differently to drawdown. Table 4-3 summarizes Cooke's findings.

Table 4-3
Summary of Winter Drawdown Study Findings (Cooke, 1980)

Decrease in Abundance	Increase in Abundance	No Change
Watershield (*Brasenia*)	Bulrush (*Scirpus*)	Bladderwort (*Utricularia*)
Pondweed (*Potamogeton*)	Arrowhead (*Sagittaria*)	Bur-reed (*Sparganium*)
Yellow water-lily (*Nuphar*)	Three-way sedge (*Dulichium*)	Tape grass (*Vallisneria*)
White water-lily (*Nymphea*)		
Spike rush (*Eleocharis*)		
Water milfoil (*Myriophyllum spp*)		
Pickerelweed (*Pontedaria*)		

Plants that tend to increase due to drawdown, such as rushes and sedges, are generally categorized as sparse in Ashuelot Pond. Specifically, plants that have rhizomes (trailing root systems) do not appear to be well-controlled by drawdown. An increase or expansion of vegetation in the near-shore areas where these types of plants are typically found may be expected with drawdowns.

Cooke's study revealed that plants that were not expected to change in abundance include the bladderworts and the bur-reeds, which tend to be more common in Ashuelot Pond. Bladderwort (*Utricularia purpurea*) is found throughout the pond in floating masses near the bottom, but this growth is denser in the river. Bladderwort is not rooted and forms winter buds of modified leaves that settle to the sediments where they are protected throughout the winter. Though the literature does not suggest a strong correlation between drawdowns and bladderwort biomass reductions, anecdotal and personal observations made by some lake residents indicated that some level of control is achieved through lake drawdown. One of the main goals of this study was to quantify these changes, if any, associated with a deep drawdown. Overall, a number of aquatic plants species can be expected to show some degree of decline following drawdown; however, species that are the most ubiquitous in Ashuelot Pond may not change at all in abundance, according to the literature.

4.4 Methods Used for Macrophyte Evaluation

For a more rigorous and quantitative assessment of the plant population, a specialized study was conducted at ten stations around the pond, and in seven stations throughout the Ashuelot River leading into the pond (Figure 4-1). Overall percent plant cover of various species present in the pond was estimated annually at each of these stations.

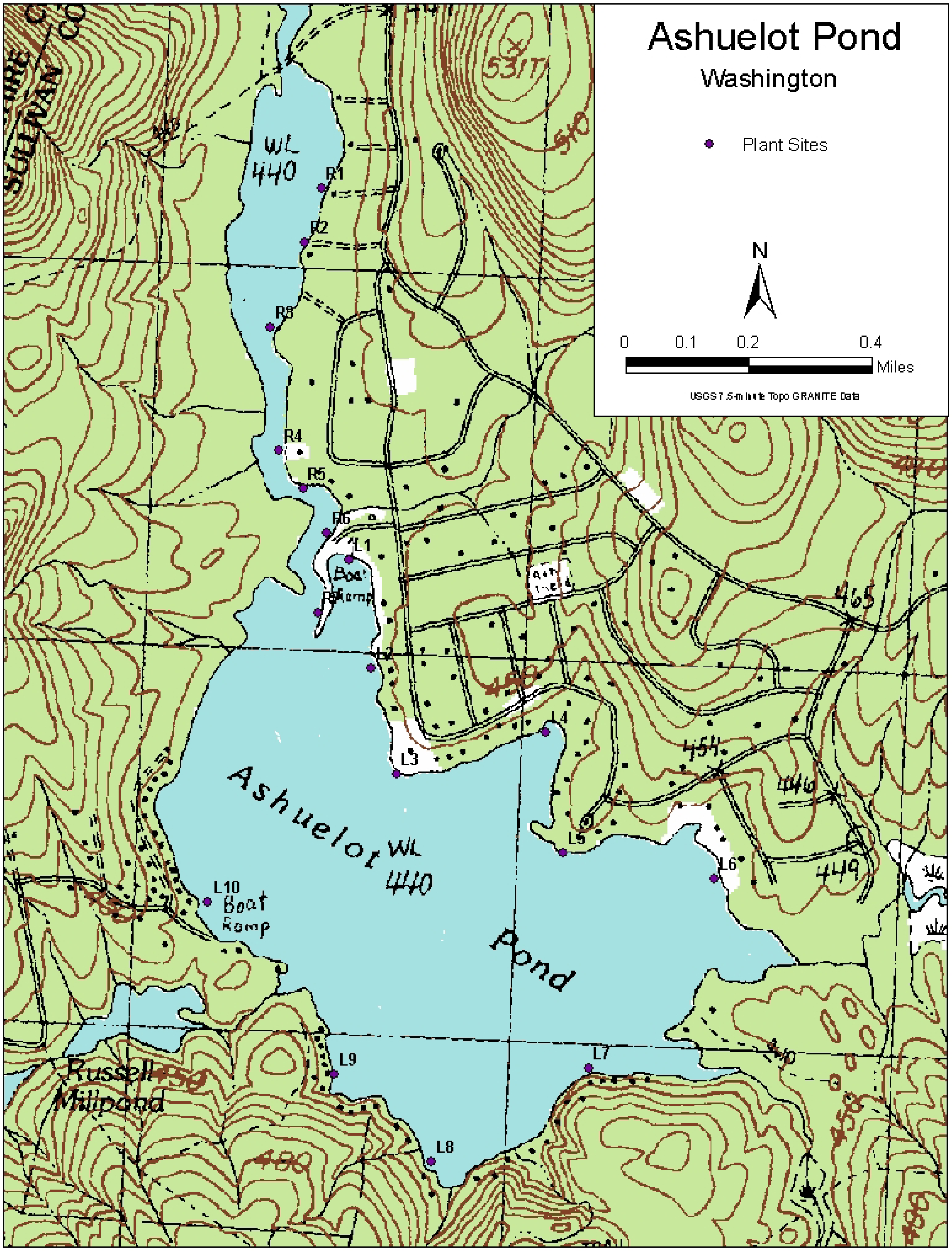
Figure 4-2- PVC quadrat for macrophyte sampling

At each station, three to four plots were permanently established at five meter intervals starting at shore by staking one-meter squared PVC quadrats to the lake bottom (Figure 4-2). On each field macrophyte sampling event, the project biologist used a view scope to look below the surface of the water and analyze the plant cover within each quadrat. The biologist identified each plant within the quadrat, and made a notation on a field data sheet as to the overall percent cover of each plant type within the quadrat. This was done for each species within each quadrat. Some locations had either bare sand or rocky bottom and were included in the total percent cover of the plot. Percent cover was based on 100% total area within each quadrat.

This method was performed at each quadrat in the lake and in the river, one time at approximately the same time each summer. The data from each transect were averaged to yield one percent cover estimate for each sampling location.

Data from the field sampling dates were compiled into spreadsheets and were analyzed on a lakewide and a river-wide basis using the Kruskal-Wallis Test Statistic to determine any statistically significant changes in plants or bottom cover from three consecutive years without deep drawdown (2002 thru 2004) to the growing season immediately following deep drawdown (2005).

Figure 4-1
Ashuelot Pond Plant Sampling Plot Locations



4.5 Aquatic Macrophyte Coverage Pre- and Post Deep Drawdown

Table 4-4 summarizes the findings of the statistical analyses that were performed on the aquatic macrophyte data set from Ashuelot Pond. For clarity, there are separate lines in the table for each genus based on their location in the system (pond or river).

For many of the growth types present in the pond and the river, there were no statistically significant changes in overall percent cover to indicate a change between the years of no deep drawdown, and the summer data set from 2005 which immediately followed a deep drawdown in fall 2004. Only a few growth types showed possible or definitive changes that occurred from non-deep drawdown years and the post deep drawdown year.

4.5.1 Ashuelot Pond Macrophytes- Pond Segment Analysis

A majority of the plants observed within the sample plots around the lake showed no substantive changes in the percent cover between drawdown regimes. Filamentous green algae, bur-reed, water naiad, quillwort, emergent spike rush, arrowhead, sedges, tapegrass, watershield, yellow water-lily, sandy bottom cover, and rocky bottom cover each remained fairly consistent without statistically significant changes to their percent cover.

Some of the changes that were observed are considered statistically significant but 'weak,' meaning that the power of the test statistic was low. These are considered 'possible' changes. Possible changes were observed in both bladderwort and native milfoil growth in the pond in 2005 as compared to other sample years. Bladderwort is not a rooted plant and tends to drift with wind and currents in the water column. Bladderwort is not a stationary species within the pond system and has the capacity to easily drift out of the sample quadrat. This fact, coupled with the weakness of the statistical result, makes this apparent decrease somewhat speculative. Native milfoil is a rooted plant, and could have been scoured from the pond and sample quadrats during deep drawdown. Possible changes were also observed with grassy spike rush, which showed a statistically weak increase in the pond following deep drawdown.

Some of the changes that were observed, however, fell within the category of statistically significant with 'strong' correlation to drawdown. These strong correlations generally indicate definitive changes in macrophyte cover. Definitive changes were observed for pondweed species in the pond, which showed a decline in the summer following deep drawdown. It is not unusual to see declines in seed-bearing plants such as these as a result of a drawdown (Peverly, 1991).

Table 4-4
Statistical Analysis Results for Ashuelot Pond Macrophytes for Non Deep Drawdown Years (average of 2002-2004 data) and for Post Deep Drawdown Year (2005)

Growth Type	Station	Correlation to Drawdown	Probability[1]	Type of Change[2]
Filamentous green algae growths	Pond	No	p=0.360	None
Filamentous green algae growths	River	No	p=0.342	None
Bladderwort	Pond	Possible	p =0.106	Decrease
Bladderwort	River	No	p =0.332	None
Grassy Spike Rush	Pond	Yes	p=0.013	Increase
Grassy Spike Rush	River	No	p =1.000	None
Bur-reed	Pond	No	p =0.210	None
Bur-reed	River	Yes	p =0.008	Decrease
Native milfoil	Pond	Possible	p =0.112	Decrease
Native milfoil	River	No	p =0.686	None
Water naiad	Pond	No	p =0.218	None
Water naiad	River	No	p =1.000	None
Pondweed	Pond	Yes	p =0.003	Decrease
Pondweed	River	Possible	p =0.101	None
Quillwort	Pond	No	p =0.277	None
Quillwort	River	No	p =0.226	None
Emergent Spike Rush	Pond	No	p =1.000	None
Emergent Spike Rush	River	Possible	p =0.128	None
Arrowhead	Pond	No	p =0.460	None
Arrowhead	River	Yes	p =0.051	Increase
Sedge	Pond	No	p =0.415	None
Sedge	River	No	p =0.426	None
Tapegrass	Pond	No	p =0.415	None
Tapegrass	River	No	p =0.426	None
Watershield	Pond	No	p =0.210	None
Watershield	River	No	p =0.175	None
Yellow water-lily	Pond	No	p =0.599	None
Yellow water-lily	River	No	p =1.000	None
Pipewort	Pond	Not present in pond		
Pipewort	River	Yes	p =0.008	Decrease
Visible sandy bottom	Pond	No	p =0.394	None
Visible sandy bottom	River	Yes	p =0.008	Decrease
Visible rocky bottom	Pond	Possible	p =0.121	None
Visible rocky bottom	River	No	p =0.310	None

[1] P values less than 0.100 were indicative of an impact related to deep drawdown. P values between 0.100 and 0.150 were considered to be indicative of a possible impact as a result of deep drawdown. P values greater than 0.150 are not significant, and do not indicate any change at all as a result of deep drawdown.
[2] Comparing no drawdown years to deep drawdown years. Notation indicates if plant/category increased, decreased, or stayed the same following the deep drawdown in 2004.

4.5.2 Ashuelot Pond Macrophytes- River Segment Analysis

No statistically significant differences were noted from the period of 2002-2004 and the summer of 2005 (post deep drawdown) for filamentous green algae growths, bladderwort, grassy spike rush, water naiad, quillwort, emergent spike rush, sedges, tapegrass, watershield, or yellow water-lily.

Definitive changes were observed for percent cover of bur-reed, arrowhead, and pipewort. Bur-reed and pipewort decreased at a statistically significant level, whereas the arrowhead increased slightly following the deep drawdown.

Sample plots that had portions comprised of rock bottom that were free from plant growth showed no statistically significant changes as would be expected; however, sample plots that had portions comprised of sandy bottom showed statistically significant decreases in the overall percent cover of sandy areas, meaning that sandy areas free from plant growth were fewer following deep drawdown (possibly suggesting an overall expansion of plant growth to sandy areas).

4.5.3 Ashuelot Pond Macrophytes- Overall Percent Cover

Averaging the percent cover from all in-lake and in-river plots per year allows for the evaluation of the overall percent cover and overall changes for each portion of the system. Table 4-5 summarizes the results from this statistical evaluation.

Table 4-5
Statistical Analysis Results for Overall Percent Plant Cover in Ashuelot Pond and River for Non Deep Drawdown Years (2002-2004) and for Post Deep Drawdown Year (2005)

Measurement	Station	Correlation to Drawdown	Probability[1]	Type of Change[2]
Overall Percent Plant Cover	Pond	No	p =0.276	None
Overall Percent Plant Cover	River	Yes	p =0.041	Increase

[1] P values less than 0.100 were indicative of an impact related to deep drawdown. P values between 0.100 and 0.150 were considered to be indicative of a possible impact as a result of deep drawdown. P values greater than 0.150 are not significant, and do not indicate any change at all as a result of deep drawdown.
[2] Comparing no drawdown years to deep drawdown years. Notation indicates if plant/category increased, decreased, or stayed the same following the deep drawdown in 2004.

Overall, there was no statistically significant change in percent cover across the pond data set between the 2002-2004 seasons and 2005 (post deep drawdown). In general, many of the plants in the pond showed no change when analyzed individually by growth type. Only three plant types (bladderwort, native milfoil, and pondweed) showed small decreases following deep drawdown, while one (grassy spike rush) showed increases following the deep drawdown. Generally, on a lakewide scale of overall plant cover in the pond, the percent plant cover did not statistically change as a result of the deep drawdown.

The river plots, however, showed a statistically significant increase in overall plant cover. Some of the previously un-vegetated visible sandy bottom areas prior to the deep drawdowns had apparently declined. Plant analysis by individual genus showed that arrowhead increased slightly following deep drawdown. In reality, it is not likely that this is the only plant that colonized the sandy substrates enough to cause a statistically significant difference. The most likely scenario is that other plants increased on a very small scale to a level to encroach on what sandy substrate is left, but not to a level that would result in a statistically significant change in their overall percent cover on the genus level.

4.6 Aquatic Macrophyte Summary

On a lakewide basis, the overall percent plant cover within Ashuelot Pond did not show a statistically significant change as a result of the deep drawdown in fall 2004. Data that were collected from the pond in summer 2005 were analyzed for statistically significant differences from the data set of non-deep drawdown years (2002-2004). On a plant by plant basis, most of the genera represented in the pond showed no change, while only a few showed weakly significant changes (decreases or increases) as a result of deep drawdown, and only one showed a definitive statistical decrease (pondweed) in the pond.

In the river, there was a small but overall statistically significant increase in plant cover in 2005 as compared with data sets from 2002-2004. The data indicate that plant percent cover increased overall, with arrowhead showing strong statistical increases in the river, though subtle increases in other species were likely to account for this change.

CHAPTER 5
AQUATIC ORGANISMS

5.1 Introduction

To evaluate the effects of the deep drawdowns on the aquatic ecology of Ashuelot Pond, DES selected three categories of organisms on which to focus: aquatic macroinvertebrates (insects), amphibians (specifically, frogs), and the fishery. Following is a discussion of the findings for each category.

5.2 Macroinvertebrate Assessment

5.2.1 Introduction

Macroinvertebrates are an essential food source for other larger invertebrates, amphibians, and fish, and their place in the food web make them an obvious choice as a focus group for an evaluation of the effects of deep drawdown.

The littoral habitat of lakes and ponds is generally occupied by a diverse assemblage of macroinvertebrates, with representatives of most aquatic Orders (Merritt and Cummins, 1984). Because many insects begin their lifecycle in the water, developing from larval stages through several instars, their vigor and survival is dependent upon the presence and the quality of the water. During drawdown conditions, many macroinvertebrates may be left stranded in the sediment, and may not retreat with the receding water levels. In fact, in their study of a reservoir in Wisconsin, Kaster and Jacobi (1978) noted that benthic fauna did not follow the path of receding waters, and generally stayed in situ. Kaster and Jacobi (1978) also noted that recolonization of zones disturbed by fluctuating water levels, and subsequent exposure to air and ice, required approximately 3 months (mid-March to mid-June) for macroinvertebrates to achieve pre-drawdown numbers and biomass. Further, they noted that the benthos recolonized more rapidly and had a greater density in areas that had greater amounts of organics and detritus.

5.2.2 Study Methods

5.2.2.1 Macroinvertebrate Sampling Methods

The kick and sweep method of invertebrate collection was used at ten stations around the pond, in a water depth of approximately three to four feet. At each station, a staff member walked back and forth over the designated area kicking up the substrate to re-suspend the invertebrates. An aquatic kick net was swept over the disturbed area to catch insects that were disturbed and re-suspended. The sampling area was swept several times to capture any invertebrates in the five-minute time allotted for each site. After the five-minute sampling period the net contents were rinsed into a white enamel pan for field inspection, and identifiable Orders were noted on a field data sheet.

The sample contents were poured through a U.S. No. 60 sieve to remove the water, transferred into a labeled jar, and preserved with a 70% alcohol solution. The sample was returned to the DES Limnology Center where the alcohol was drained from the container using a U.S. No. 60 sieve. The sieved contents were then spread evenly in a white enamel pan, and a small amount of sample was randomly removed for further analysis (approx 1.2 in^3).

For analysis, the sub-sample was placed into a petri dish and examined under a dissecting microscope. A small spatula and forceps were used to sort the sample from one side of the petri dish to the other, and those invertebrates passing through the viewing area were extracted. Extracted invertebrates were stored in 70% alcohol in small glass vials labeled with their site and taxonomic Order, and identified to family level (where feasible).

5.2.2.2 Sediment Sampling and Characterization

Sediment samples were extracted at each sample site in July 2002 to determine the substrate composition and notable vegetation present. Sediment samples were collected with a Peterson grab sampler lowered from the boat. Samples were stored in labeled jars for laboratory analysis. The jar contents were transported to the Limnology Center and sieved through a U.S. No. 60 sieve to remove water. Each sample was dried in a labeled crucible for 96 hours inside a drying oven at 100^{o}C. The dried samples were removed and put through a Keck Sandshaker Mechanical Field Analyzer to sieve the sample particles. A U.S. No. 10 sieve (1.9mm or 0.08 in. opening) was used to separate *gravel*. A U.S. No. 35 sieve (0.54mm or 0.02in opening) was used to separate *sand*. A U.S. No. 200 sieve (0.07mm or 0.003 in opening) was used to separate *silt*. A U.S. No. 270 sieve (0.05 mm or 0.002 in opening) was used to separate *clay*. Each sample was weighed before being sieved, and each portion was weighed after separation to determine the percent composition. Figure 5-1 shows a map of the macroinvertebrate and sediment sample sites, and Table 5-1 lists the sample sites, coordinates and a brief description of the composition of the sediment. Figure 5-2 illustrates the sediment composition at each site.

Figure 5-1
Map of Ashuelot Pond Sediment and Macroinvertebrate Sample Sites

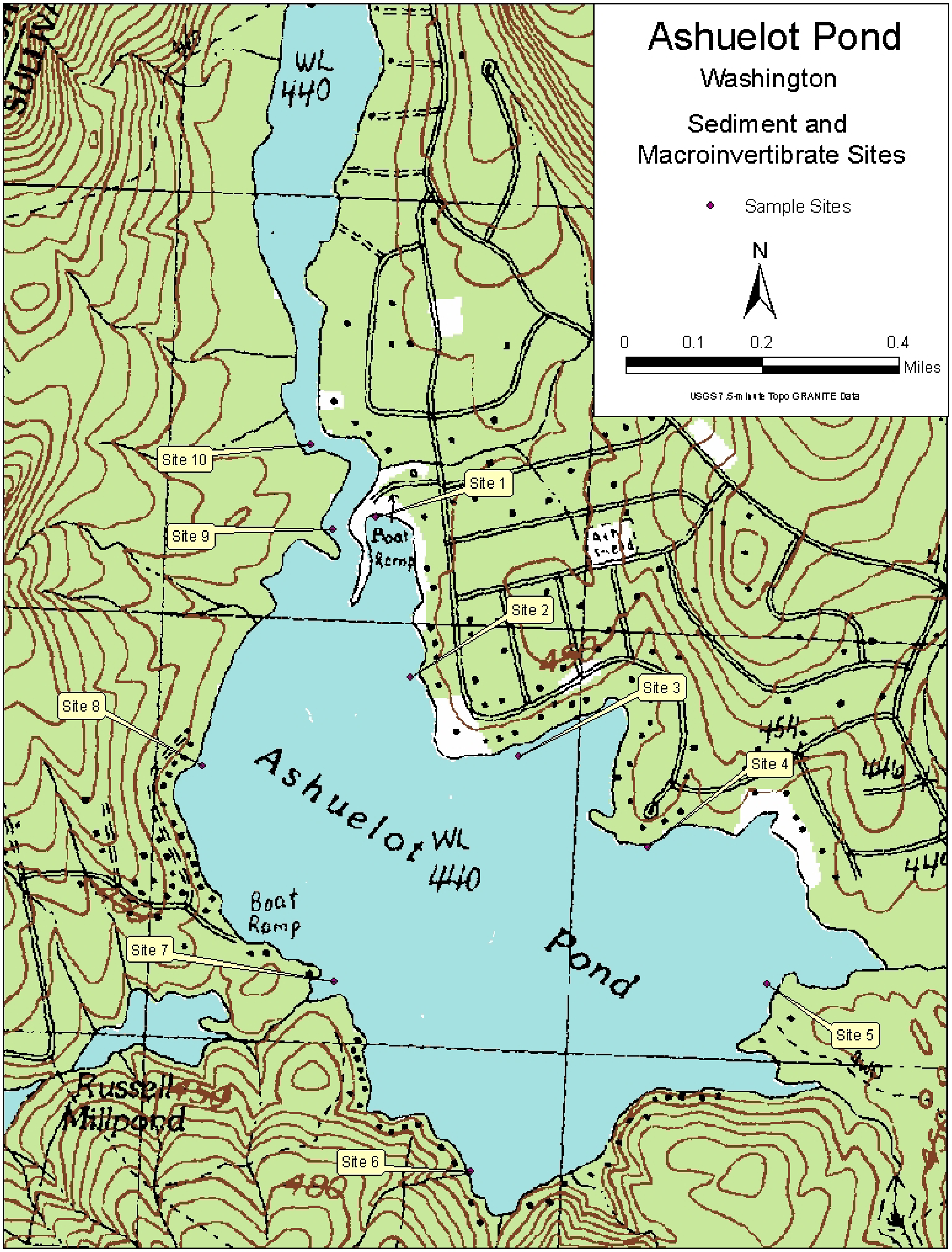
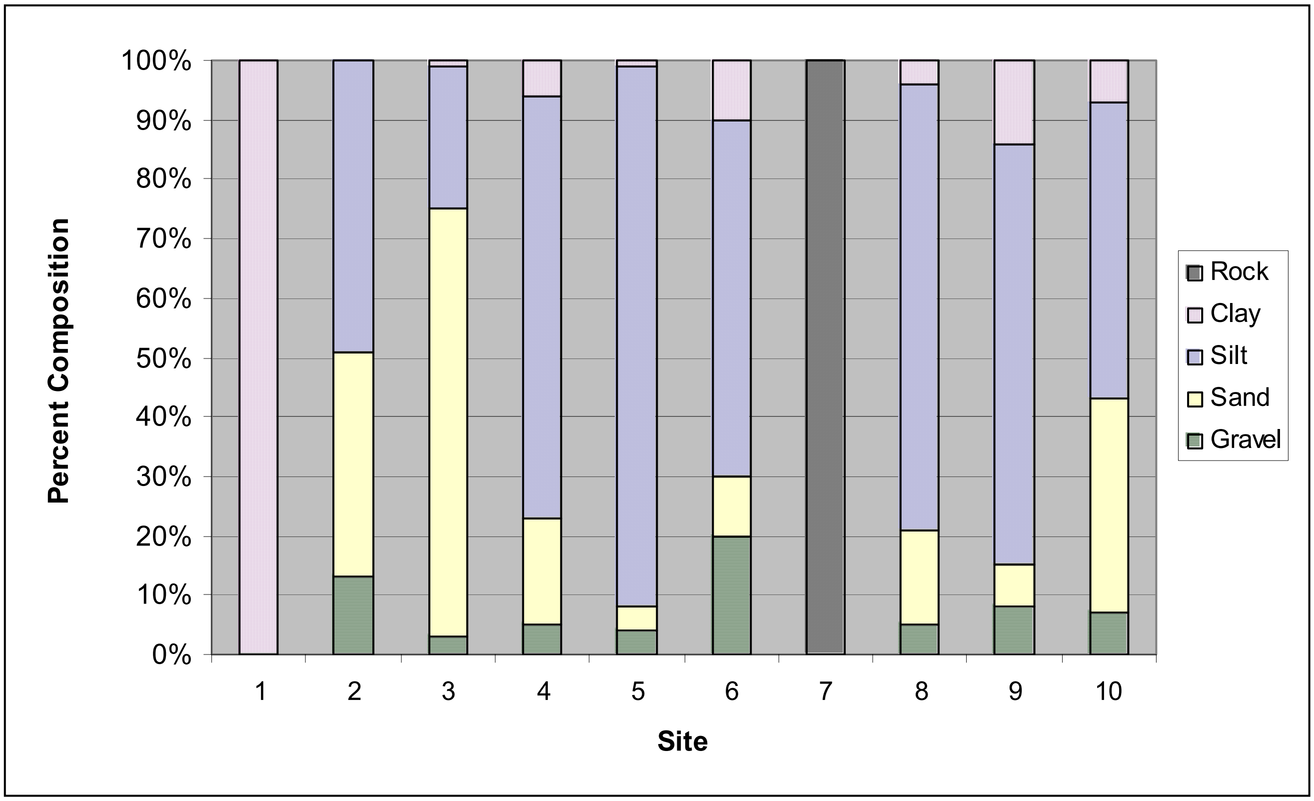


Table 5-1
Macroinvertebrate Sample Site Locations

Site #	Description
1	North end of the cove near the peninsula by the river channel (approximate GPS coordinates: N 43^{o}9’34.57” W 72^{o}9’7.72” tax lot 148). The bottom substrate was 100% clay.
2	Half way between Site 1 and the Lake Ashuelot Estates (LAE) beach at tax lot 160 (approximate GPS coordinates: N 43^{o}9’ 22.32” W 72^{o}9’4.08”). The bottom substrate was 14% gravel, 38% sand and 49% silt.
3	East of the LAE beach near tax lot 172 (approximate GPS coordinates: N 43^{o}9’16.33” W 72^{o}8’52.60”). The bottom substrate was 3% gravel, 72% sand, 24% silt and 1% clay.
4	Around the peninsula near the Van Buren Circle near tax lot 190 (approximate GPS coordinates: N 43^{o}9’9.41” W 72^{o}8’39.11”). The bottom substrate was 6% gravel 18% sand, 71% silt and 6% clay.
5	Located south of the inlet near the sandy shore by tax lot 18 (approximate GPS coordinates N 43^{o}8’57.56” W 72^{o}8’ 57.56”) The bottom substrate was 5% gravel, 4% sand, 91 % silt and 1% clay.
6	Located near tax lot 452, south of the dam (approximate GPS coordinates N 43^{o}8’44.16” W 72^{o}8’59.00”). The bottom substrate was 20% gravel, 10 % sand, 60% silt and 10% clay with a few rocks.
7	Located on the rocky point near the outlet to Russell Mill Pond at tax lot 443 (approximate GPS coordinates: N 43^{o}8’59.33” W 72^{o}9’27.03”). The bottom substrate was rubble and large rocks.
8	Western edge of the pond near tax lot 403 (approximate GPS coordinates: N 43^{o}9’16.01” W 72^{o}9’27.03”). The bottom substrate was 5% gravel, 16% sand, 75% silt and 4% clay.
9	Western side of the peninsula in the channel near tax lot 148 (approximate GPS coordinates N 43^{o}9’33.65” W 72^{o}9’12.20”). The bottom substrate was 8% gravel, 7% sand, 71% silt and 14% clay.
10	In the channel, north of the small island across from tax lot 21/22 (approximate GPS coordinates: N 43^{o}9’34.49” W 72^{o}9’14.42”). The bottom substrate was 7% gravel, 36% sand, 50% silt and 7% clay.

Figure 5-2
Ashuelot Pond Substrate Composition at Various Sample Locations (2002)



5.2.3 Macroinvertebrates in Ashuelot Pond

In general, macroinvertebrates from Orders Diptera, Trichopteria, and Amphipoda were most abundant in samples collected from designated locations within the littoral zone of Ashuelot Pond. Representatives of other Orders, including Ephemeroptera, Coleoptera, Oligochaeta, Acariforme, Odonata, Annelida, Mollusca, Megaloptera, and Hydrocharina were present, though not in high numbers in the samples. Table 5-2 summarizes some key information about each of these Orders, including descriptions, habitat preferences, and ecological attributes of the species within each Order.

Table 5-2
Ashuelot Pond Macroinvertebrate Orders and their Characteristics

Order	Description	Habitat Type	Other
Trichoptera (Caddisflies)	Moth like insects with two pairs of wings held over the body when at rest. Range from 6-40 mm when mature	Are common in all substrate types, can be found in and around vegetation as commonly used for protection	Spring and fall hatches provide food source for fish species.
Ephemeroptera (Mayflies)	Moth like, identifiable by long tails unique to mayflies 3-30mm long at maturity	Shallow waters of any kind, typically in the benthos or where dissolved oxygen is abundant	Both larval and mature stages are food source for fish species, and other insects
Coleoptera (Beetles)	Beetles that thrive underwater, adults can be anywhere from 1-50mm.	Certain species can be found from decaying trees to intertidal zones.	Are predacious and feed on other insects and larva, source of food for some wading birds
Diptera	Larva easily identifiable by lack of limbs, adults 1-100mm	Can be found wherever standing water accumulates	Food for dragonfly larva and adults source of food for carnivorous insects
Amphipoda	Laterally flattened scuds that range from 5-20 mm at maturity.	Shallow waters of any kind, typically in the benthos among vegetation and organic debris. Omnivorous/detritivores.	Very important food source for many fish species.
Oligochaeta (Worms)	Elongated cylindrical worms averaging in size from 1-30mm, some greater then 100mm	May be found in silty substrates among debris and detritus of ponds, lakes, pools, streams, and rivers.	Aquatic oligochaetes are important food for fish and larger invertebrates.
Acariforme (Mites)	Oblong, tiny, mobile, predatory mites, will not exceed 1mm	Can be found in and around any type of aquatic or terrestrial vegetation	Feeds on plants and is a source of food for most larval stages of aquatic bugs.
Odonata (Dragonflies)	Slender body with elongated abdomen. Can be up to 100mm when mature. Largest reaches 720 mm from wing tip to wingtip.	Can be found anywhere there is an abundant source of food, can inhabit any number of freshwater environments.	larvae sometimes have been used to control pest insects
Annelida (Segmented worms)	Elongated cylindrical or flattened worms average size 5-over 400mm, some greater then 500mm	Are common in all substrate types, can be found in and around vegetation as commonly used for protection	Is a source of food for fish.
Mollusca (Mussels)	Two-pieced shelled animals that lack protruding body parts of head, eyes, and tentacles. Can range from 2 – 250mm.	Can be found in many river systems and lakes.	Their soft body parts are eaten by a number of fishes as well as some other animals like the muskrat
Megaloptera (Alderflies, dobsonflies)	Larvae are elongate, moderately flattened have a distinct labrum, and measure 10-90 mm when mature.	Can be found in sediments of lakes and depositional zones of streams as well	Also a source of food for other insects and small fishes.
Hydrocarina (Water mites)	Small mites less then 1mm, feed on algae which grows on rocks and hard underwater surfaces.	Cannot be found in saline lakes or ponds	Is source of food for some larval stages of aquatic insects. Also helps with control of algae growth in lakes and ponds.

5.2.4 Overall Community Composition Over Time

Figure 5-3 shows a comparison of macroinvertebrate community composition in Ashuelot Pond during the month of July for each year of the study (2002-2005). In general, species compositions in years between deep drawdowns show similar characteristics. Organisms within the Order Diptera comprised roughly half of the organisms identified. Species within the Orders Amphipoda, Oligochaeta, and Trichoptera were also among those more commonly measured. Species from the Order Ephemeroptera were observed in lesser numbers each year, but were not observed in 2004.

A comparison between non deep drawdown years to one year post deep drawdown reveals an obvious shift in species composition in 2005. The Dipterans that dominated in years intermediate to deep drawdowns declined greatly to only 18% (where they had generally been at or greater than 50%), and Amphipods increased greatly to comprise nearly three-quarters (72%) of the sample lakewide. There were also, unexpectedly, a few more species identified in the samples post-deep-drawdown than were present in samples in previous years.

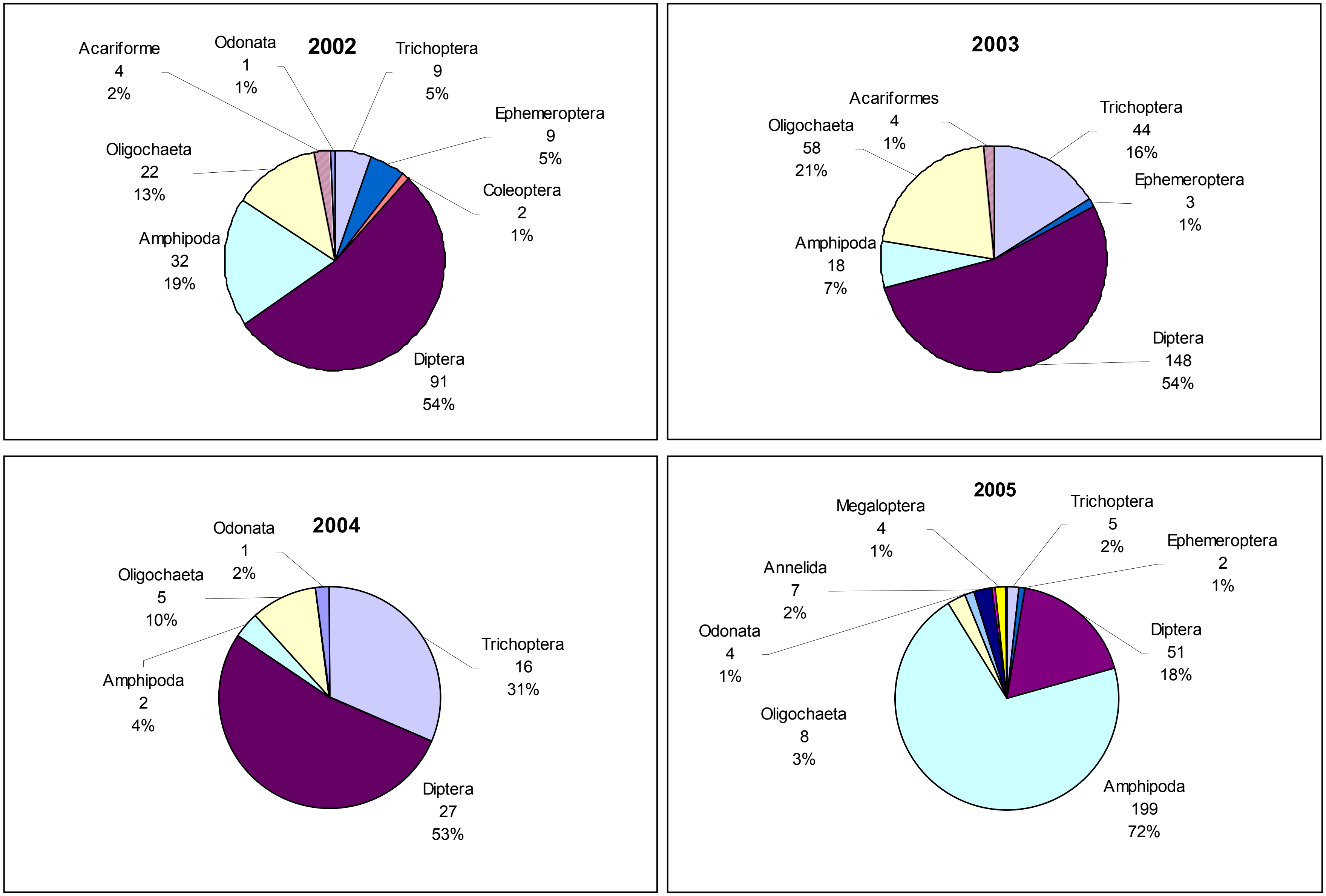
A statistical analysis of the data using the Kruskall-Wallis non-parametric analysis yielded statistically significant differences in the numbers of Amphipods at the 0.05 level for the years where no deep drawdown was done (2002-2004), and for the year immediately following deep drawdown (2005). The statistical analyses also showed that the 2004 Amphipoda population was statistically lower than in 2005 which suggests that the deep drawdown may have had a positive effect upon the organisms in this Order.

Amphipods are wholly aquatic organisms that are more adapted to fluctuating conditions and more resistant to stressors in the aquatic environment than the other macroinvertebrates common in the sediments of Ashuelot Pond. Amphipods are also able to move with receding water, where other macroinvertebrates bury into the sediments and are less mobile. The other macroinvertebrates are generally the larval stages (nymphs) of emergent insects, and drawdowns could affect the larval stage or the metamorphosis to the adult flying insect, thereby reducing their overall number.

Additionally, amphipods are capable of producing multiple generations in a year, whereas most of the other macroinvertebrates present in the samples are capable of only producing few or one generation in a given season, and rely on adults to deposit eggs in the lake sediments during each spring and summer period. Amphipods, being wholly aquatic, do not need to rely on seasonality for reproduction, and can continue to increase their standing population throughout a drawdown period; whereas the nymphs of other aquatic insects may succumb to drawdowns by being stranded and frozen in the exposed sediments, which would slow down or inhibit their regeneration in spring.

Statistical analyses on organisms from other Orders observed in the samples showed no statistically significant differences in the numbers of organisms observed between non deep drawdown years and the deep drawdown years. This suggests that species from these Orders neither increased nor decreased significantly in a way that can be tied to the deep drawdown.

Figure 5-3
Macroinvertebrate Community Composition in the Littoral Zone of Ashuelot Pond: 2002-2005

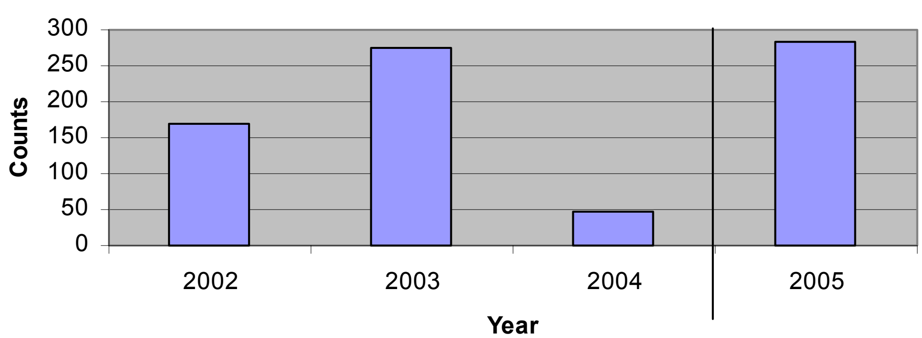


5.2.5 Total Number of Organisms Over Time

In addition to comparing the numbers of organisms within each Order over time, it is also important to compare the total number of organism counts within subsamples per year between non deep drawdown years and the year immediately post deep drawdown. A side-by-side comparison of data over the course of this special study shows that there is variability in the total numbers of organisms found between years, including those years in which no deep drawdowns occurred. Figure 5-4 shows this trend in total counts of macroinvertebrates from 2002 through 2005.

For reference, a deep drawdown occurred in winter 2000, so the 2002 data reflect two years post deep drawdown. A total of 170 organisms were present in subsamples from the 2002 sample year. In 2003, 275 total organisms were counted amongst the subsamples collected that year. The next year (2004), there was a greatly reduced number of organisms found, with only a total of 51 organisms found in subsamples from the ten monitoring sites in the lake. In 2005, the year immediately following a deep drawdown, the total count of organisms reached a high for the study period, with a total of 280 macroinvertebrates counted from all the subsamples across the sample sites.

Figure 5-4. Trend in Total Counts of Macroinvertebrates Collected from Ashuelot Pond 2002-2005



Data from this side-by side comparison suggest there are likely other factors that come into play in determining macroinvertebrate population densities other than drawdown, including weather patterns, type of winter, predation, and water chemistry. In this instance, it appears that macroinvertebrate populations actually increased over those of the previous year after the deep drawdown in the fall of 2004.

5.2.6 Macroinvertebrate Conclusions

Overall there were no statistically significant differences in the overall number of organisms found between the non deep drawdown years, and the deep drawdown year. While deep drawdown did not appear to affect the total number of organisms, it did have an impact on species diversity in the total population of the macroinvertebrates. In years before the deep drawdown, Dipterans were the dominant species; after the deep drawdown in 2005, Dipterans declined to only 18% of the organisms present, and Amphipods increased to 72% of the overall population. Statistical analysis showed that Amphipods were positively impacted by the deep drawdowns, meaning that they increased after the deep drawdown.

5.3 Frog Assessment

5.3.1 Introduction

To evaluate the biological effects of drawdown on amphibians, DES examined the frog species present throughout Ashuelot Pond and the portion of the Ashuelot River system that is considered part of the contiguous waterbody due to the impoundment.

Frogs are closely tied to the aquatic environment, and as such, their lifecycle and physiology make them particularly susceptible to habitat disturbances, making frogs a key indicator species of environmental quality. Eggs are laid during the spring months, and the tadpole phase matures in the water. When mature, frogs continue to live in or adjacent to the water. During the fall months, particularly in October in this region, frogs begin to burrow into the mud to overwinter. These highly aquatic species hibernate under leaves and mud in the littoral zone. Hibernating frogs are highly susceptible to ground-freezing during drawdown conditions resulting in mortality. Other potentially negative effects on frog populations as a result of drawdowns include habitat loss, increased predation, and a reduction of food sources.

Frogs are grazers of periphyton when in the tadpole phase, and they feed on insects or other small frogs as adults; frogs are in turn a food source for fish and birds.

The Ashuelot Pond frog evaluation provides the following information:

- Frog geographic location patterns within the pond.
- The presence of egg masses and and/or adults
- An indication of reproducing populations over time by evidence of egg masses, tadpoles, and immature frogs.

5.3.2 Frogs Expected to be Present in Ashuelot Pond

According to the DES Biomonitoring Section, the frogs expected to be found in Ashuelot Pond were the bullfrog (*Rana catesbeiana*) and the green frog (*Rana clamitans melanota*), as these are the two most common species in the state, with peak breeding periods in late May to July. The pickerel frog (*Rana palustris*) may also be present. These species are relatively easy to collect and identify.

Bullfrogs (*Rana catesbeiana*) are often found near shorelines in emergent vegetation of large waterbodies. This species breeds close to shorelines in areas with dense shrubs and where shoreline vegetation provides shelter. This type of habitat is common along the shoreline of Ashuelot Pond. Bullfrogs feed on a mix of small animals, fish, newts, snakes, crayfish, insects and other frogs. The bullfrog begins to hibernate in the mud or leaves by mid-October, and emerges from hibernation during late February and March.

Green frogs (*Rana clamitans melanota*) live in the shallow freshwaters. The green frog hibernates from October to March, generally underwater or underground. They feed at night on insects that live among shoreline vegetation.

Pickerel frogs (*Rana palustris*) live in colder water lakes with thick shoreline vegetation at the margins. The pickerel frog hibernates in the mud from October to March. Pickerel frogs generally feed on insects, crayfish, and aquatic amphipods and isopods.

5.3.3 Frog Study Methods

All frog surveys were conducted in late June or early July of each year during the study period from 2003 through 2005. Data collected in 2002 were derived using methods that differed from those used for 2003 through 2005 surveys. Sample sites differed as well, therefore the 2002 data are not included in this discussion. Figure 5-5 illustrates the frog sampling locations in the pond and river segments of Ashuelot Pond. Field staff used canoes to paddle to the designated locations along the lake or river for the frog surveys.

Fifteen-minute frog searches were conducted along each designated segment of the shoreline (however far one traveled in fifteen minutes). Field data sheets were completed by noting substrate/vegetation types for each segment and approximate linear distance covered. Tally marks were made for each frog/tadpole/egg mass and/or sightings/auditory counts for each segment that was monitored. Frog species were not identified as part of the study, but counts of adult frogs, tadpoles, and egg sacs were made.

It is important to note that there is an inherent margin of error associated with this particular type of biological monitoring. Variability in field observers from year to year, time of day, weather conditions, and time of year can all contribute to the yield of information from this type of analysis. To reduce the possibility of overall variability of the data set, field sampling for this parameter was conducted at roughly the same time of year and the same time of day, and at least one of the field staff was consistent throughout the study years. Field sampling was usually conducted on days when there was no precipitation, and when conditions were relatively clear.

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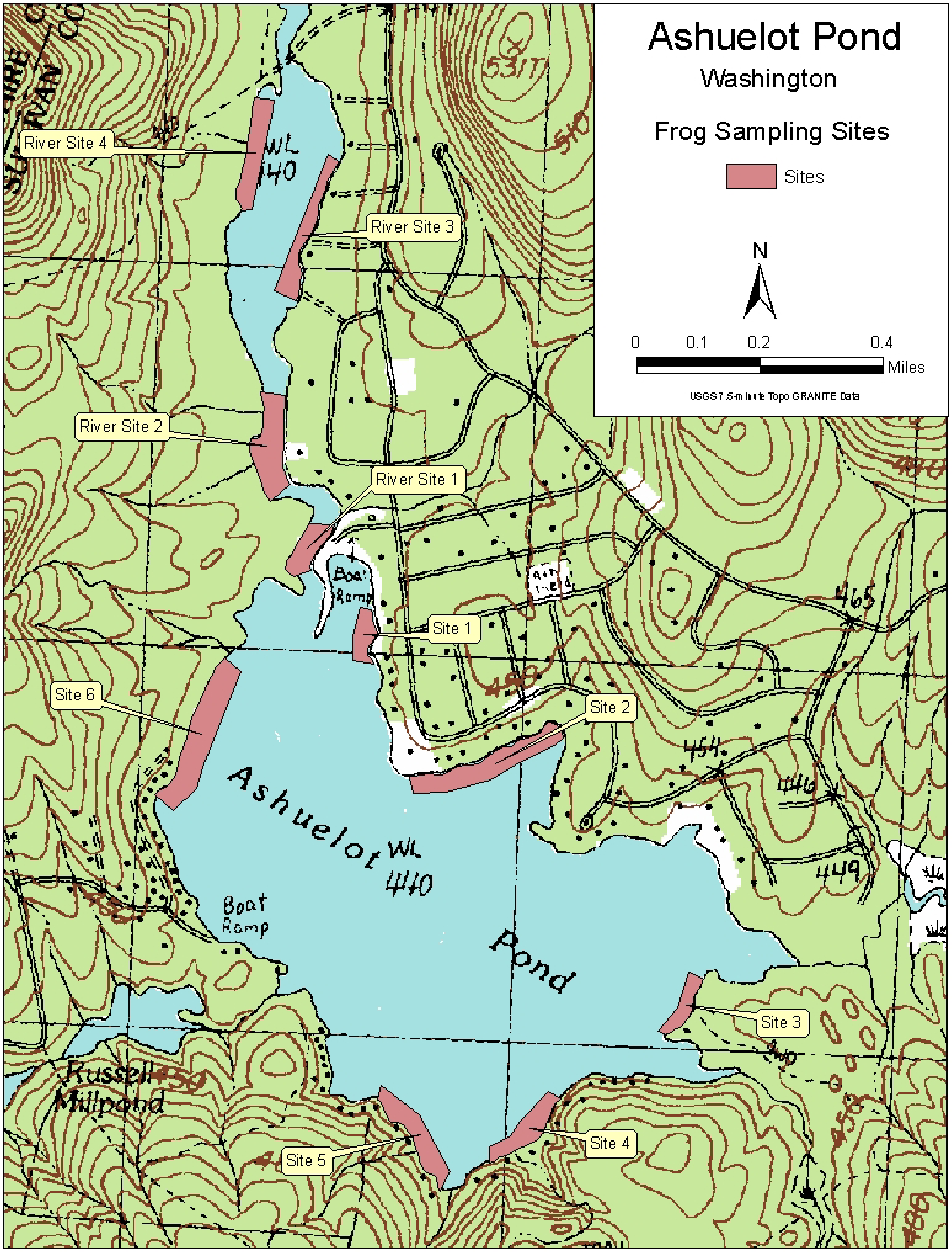
Figure 5-5
Frog Sampling Sites

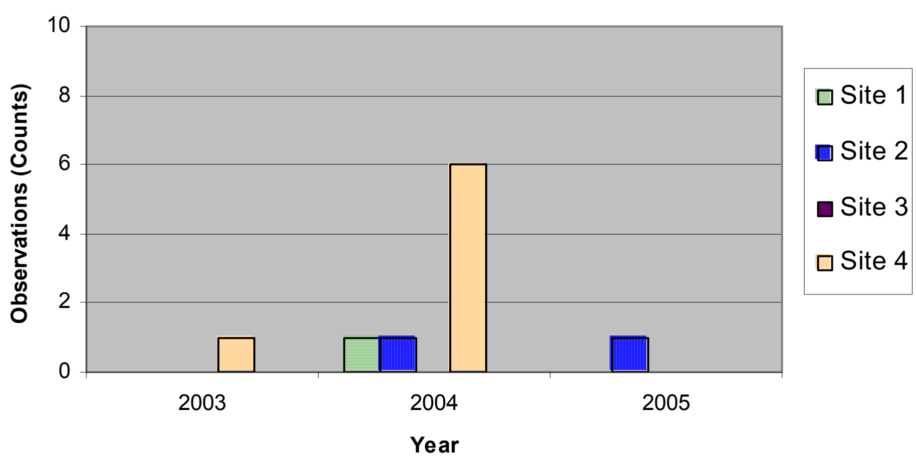


5.3.4 Frog Trend Counts Derived from Visual Frog Observations

Visual observations of frogs during the study were low overall, a possible result of the methods involved in this type of sampling; however, information provided by others experienced with this type of sampling indicate that the numbers are fairly representative of a normal yield during this type of monitoring (Racine, 2008). Frogs are often well camouflaged in the aquatic system, and can easily be overlooked. We reduced the possibility for this by incorporating two to three persons per canoe to cover more area.

Frogs were visually detected in the pond only in 2004 and only at sample sites 4 and 5. Only one frog was documented at each site. In the river, frogs were visually detected each year. As many as six frogs were observed during one day at Site 4 in the river (Figure 5-6). Field data do not indicate which frog species were observed.

Figure 5-6. Frog Counts by Site- Visual Observation in River



5.3.5 Frog Trend Counts Derived from Auditory Frog Observations

As mentioned above, frogs are well camouflaged in aquatic systems. They generally hide in aquatic macrophytes along the shoreline, and are often positioned among emergent vegetation with only a small portion of their head above the water's surface. The auditory monitoring allowed biologists to document the presence of frogs when visual observations were not successful at yielding data.

There were several frogs detected during the auditory sampling in both the pond and in the river. This method is useful in combination with the overall visual documentation of frogs to develop a more accurate data set for frog counts overall. Field staff were cautious to not over-estimate frogs by auditory counts by estimating the location of the frog during the call, and not double counting frogs based on calls from the same general area. There will, of course, be a margin of error associated with this assessment method, however.

Figure 5-7 summarizes the data for the auditory observation in Ashuelot Pond, and Figure 5-8 summarizes the auditory data for Ashuelot River.

Figure 5-7. Frog Counts by Site- Auditory Observation in Pond

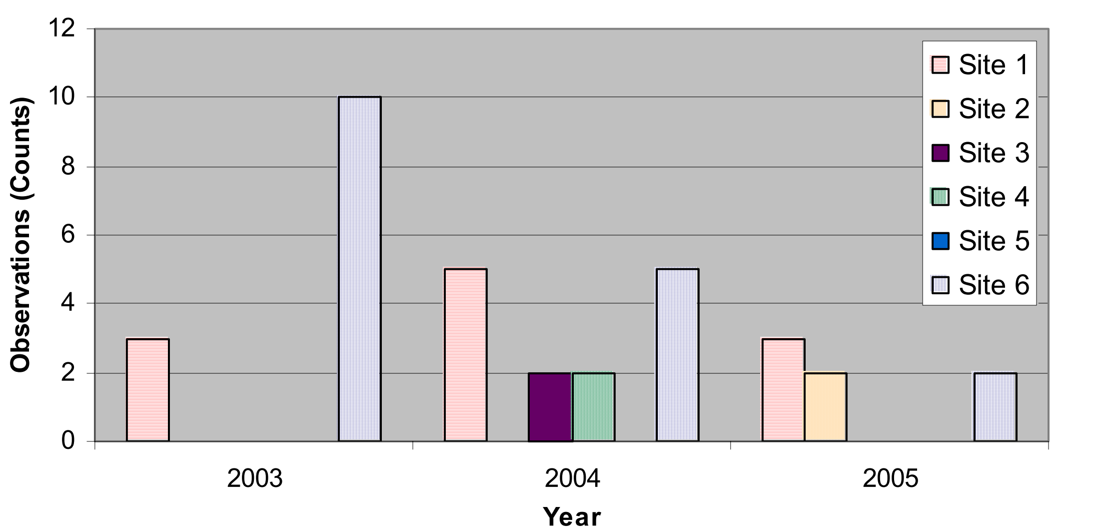
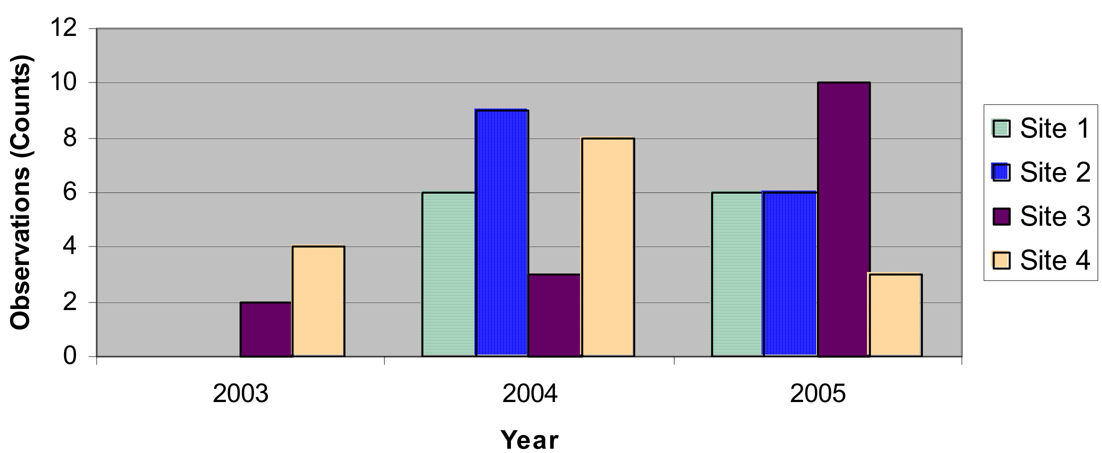


Figure 5-8. Frog Counts by Site- Auditory Observation in River



Pond sampling sites 1 and 6 consistently yielded the presence of frogs throughout the study period, whereas sites 2, 3, and 4 had fewer auditory counts. Site 5 yielded no frog counts as a result of auditory observations throughout the study period.

5.3.6 Frog Trend Counts Derived from Egg Mass Observations

To determine if frogs were reproducing on an annual basis in the Ashuelot pond and river system, counts of frog egg masses were made at each monitoring site at each visit.

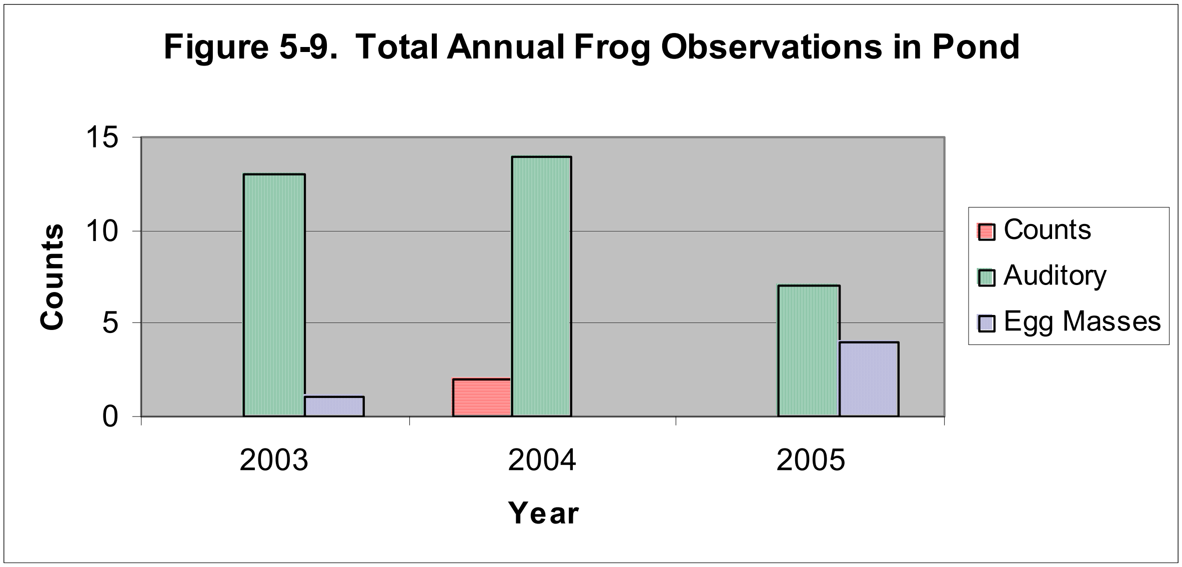
Ashuelot Pond egg masses were observed in 2003 at Site 2, and in 2005 at Sites 1, 2, and 6. It is evident from the presence of egg masses in 2005 that frogs survived the 2004 fall/winter deep drawdown and were reproducing in the pond during the spring/summer of 2005.

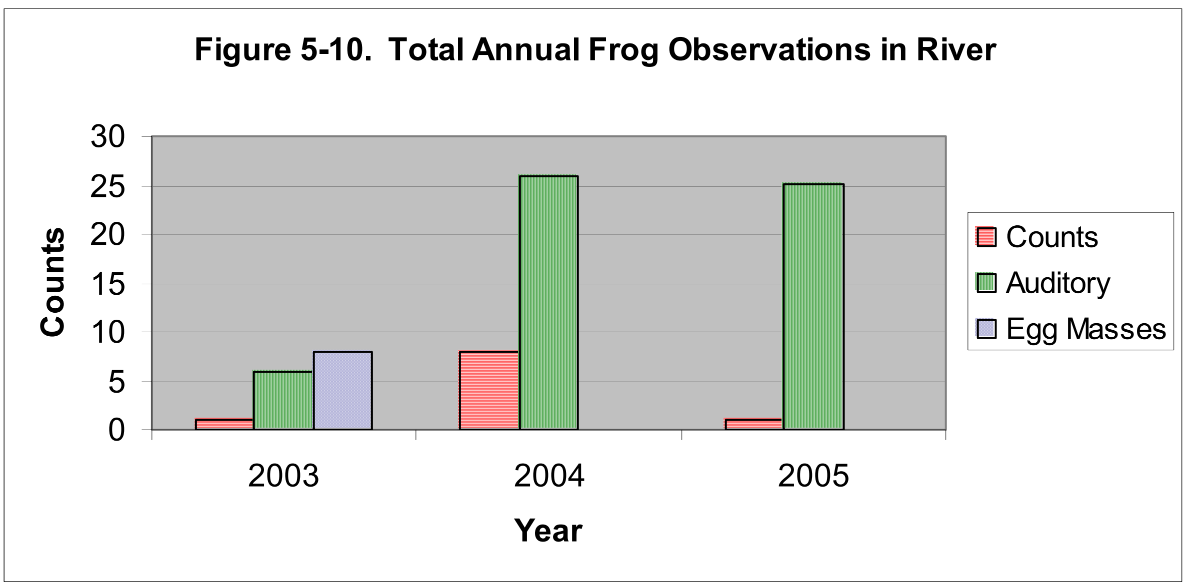
In the Ashuelot River, egg masses were only present at Site 2 in 2003, and were not observed elsewhere in the river that year, or the 2004 and 2005 sample years. Both visual and auditory observations in the river, however, verify that frogs were present in the 2005 post-drawdown sample year.

5.3.7 Total Annual Frog Observations

An evaluation of the overall frog observations in Ashuelot Pond (Figure 5-9) suggests that frog populations varied on an annual basis within Ashuelot Pond. Frogs were visually observed in the pond only in 2004, though the presence of frogs was documented in each of the three years through counts of auditory calls or egg masses. Auditory observations ranged between 13 and 14 counts overall for years not following deep drawdowns (2003 and 2004), and were half that amount in the sampling season immediately following a deep drawdown. Visual observations of egg masses showed the opposite trend. Egg masses were not documented at samples sites two years following a deep drawdown, and were higher the year immediately following the deep drawdown.

In the river portion of the pond, visual counts of frogs were low in 2003, increased in 2004, and then decreased again in 2005, the year following the deep drawdown (Figure 5-10). Auditory counts of frogs were low in 2003 (three years post-deep-drawdown), they increased greatly in 2004, and remained near the same level in 2005, the sampling season post deep drawdown. Frog eggs were more common in the river system than they were in the pond.





5.3.8 Statistical Analysis of Frog Data

A statistical analysis of total frog observations (the sum of both visual frog observations and auditory observations) was done to compare observations from non-deep drawdown data from 2003 with post-deep-drawdown data from 2005. Statistical analyses were also used in this analysis to compare observations from non-deep drawdown data from 2004 with 2005 data. Because of the small size of data sets available, the non-parametric Kruskall-Wallis test was used to determine if differences between a non deep drawdown year and post deep drawdown frog populations were significant at the 0.05 level.

The comparison of 2003 and 2005 observations, and 2004 and 2005 observations of frogs in Ashuelot Pond yielded no statistically significant differences in frog populations between deep drawdown and non-deep-drawdown years. Based on this statistical analysis, it does not seem apparent that the drawdowns altered frog counts in either a positive or negative manner.

The same analysis was conducted on data for frog observations in the Ashuelot River. The individual data points show that there were more frog observations in 2005 following the deep drawdown than there were in 2003, a non deep drawdown year. The statistical analysis of the 2003 and 2005 data indicated that the difference was statistically different. The statistical analysis for the 2004 and 2005 river data indicated that there were no statistically significant differences between a non deep drawdown year and a deep-drawdown year at the 0.05 significance level.

5.3.9 Summary of Frog Assessment

Both side-by-side comparisons and statistical analyses of the data indicate that frog populations were not negatively impacted by deep drawdowns in Ashuelot Pond. However, since no data set exists from the pre-drawdown regime (i.e., before drawdowns ever began) in Ashuelot Pond, no significant baseline exists to compare with current day trends.

Based on the data presented here, we conclude that frog populations are fairly stable in Ashuelot Pond, and that frogs are obviously reproducing as adult frogs are present and egg masses are observed throughout the system each year.

5.4 Fisheries Assessment

5.4.1 Introduction

Fish community structure was analyzed as part of the Ashuelot Drawdown Study to determine if there were any impacts over time to this ecological component as a result of the deep drawdown regime. Because of the generally shallow nature of Ashuelot Pond, and the fact that the pond decreases in surface area by nearly 60% during deep drawdowns, some impacts to fisheries were expected. During deep drawdowns in Ashuelot Pond, the fish are forced into one small deep hole for the winter period or are able to migrate through the river channel.

Some studies, including one by Paller (1997), found that drawdowns resulted in a significant reduction in fish abundance and number of fish species. Changes in the relative abundance and changes in the size structure of fish were also observed. Paller's study showed that an important factor contributing to these changes was the complete loss of the original littoral zone of the waterbody. Based on observations made in the field work associated with this study, the general structure of the littoral zone is still intact in Ashuelot Pond, and remains so. There are mixed assemblages of native plant species including emergent, submergent, and floating vegetation, (macrophyte communities are discussed in detail in Chapter 4 of this report) as well as areas that are naturally sandy and free from plant growth. Thus the littoral zone of Ashuelot Pond, despite repeated deep drawdowns, still offers diverse fish habitat and cover.

5.4.2 Methods

The Ashuelot Pond fish community was sampled in 1999, 2001, 2003 and 2005 by boat electrofishing (Smith-Root SR18) after sunset using two netters. Electrofishing equipment was adjusted according to water conductivity and observed fish behavior relative to their position in the electrode's field.

The study design incorporated timed runs of 400 to 7000 seconds using the equipment on metered time when sampling for fish species in the pond. Fish species were captured during both target and community runs. The timed runs permitted a measure of statistical precision (as Standard Deviation) to be estimated for relative abundance indices, expressed in mean fish per hour (fish/hr) that were further partitioned into discrete length categories.

All fish were placed in a live well upon capture. Fish lengths were measured to the nearest millimeter and weighed to the nearest gram. Fish were processed shortly after capture and then released. Table 5-3 summarizes the dates and the types of runs that were conducted in Ashuelot Pond.

All reported mean values include estimated standard deviations, unless otherwise noted. Linear regression was used to examine the relationship of fish total length to relative weight. The level of significance for all statistical analyses was 0.10.

Figure 5-3
Dates and Types of Ashuelot Pond Fisheries Assessments

Sample Date	Type of Run
August 23, 1999	Six target species runs Two community species runs
October 2, 2001	One community species run
July 30, 2003	Three target species runs Two community species runs
August 8, 2005	Three target species runs Two community species runs

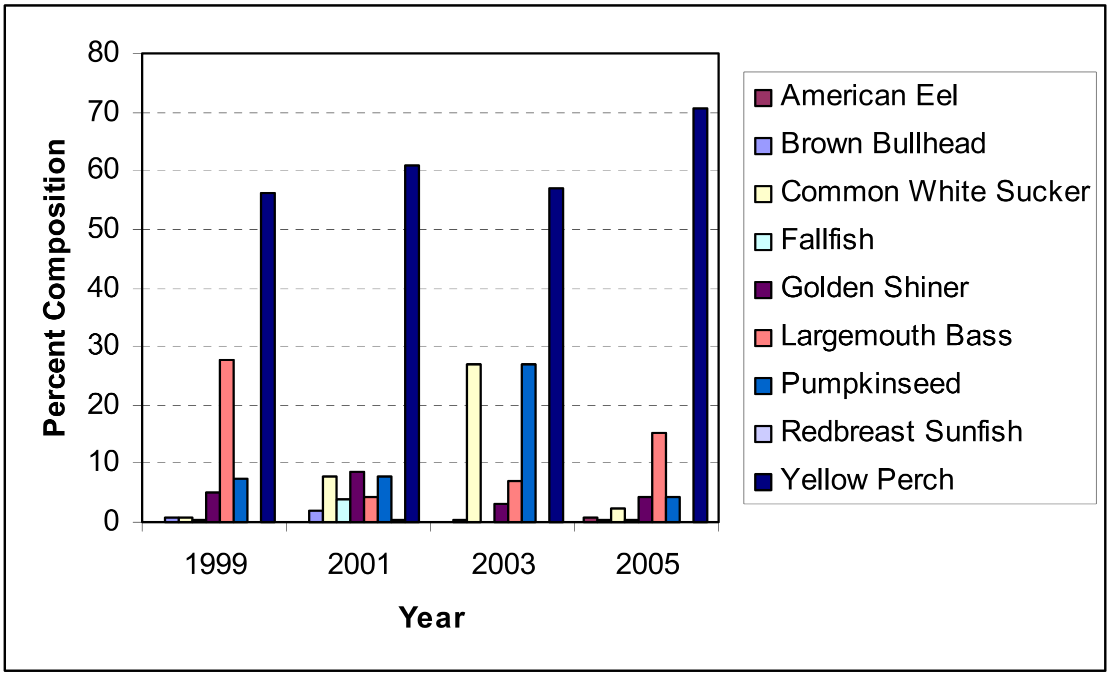
The data were analyzed by the New Hampshire Fish and Game Department, and the following fisheries discussion was provided courtesy of the New Hampshire Fish and Game Department Biologists.

5.4.3 Results

5.4.3.1 Fish Population Percent Composition

Percent composition (by count) of fish species was examined as part of the survey to determine what types and what relative percentages of fish were present in Ashuelot Pond. Figure 5-11 summarizes the relative percent, by year, of fish in Ashuelot Pond. Fish captured during electrofishing samples varied by year, but generally yellow perch, pumpkinseed, and largemouth bass were the most common fish species observed in samples each year that monitoring took place. Golden shiner abundance was also somewhat consistent in samples collected from Ashuelot Pond. The abundance of common white sucker and fallfish varied in the samples taken over this study period. Redbreast sunfish were not commonly found in samples collected from Ashuelot Pond.

Figure 5-11
Percent Composition of Fish Species in Ashuelot Pond by Year



5.4.3.2 Proportional Stock Density for Largemouth Bass in Ashuelot Pond

Proportional Stock Density (PSD) is a value used to numerically describe length-frequency data. The PSD is calculated by dividing the number of largemouth bass greater than or equal to the quality size ($\geq$ 300 mm) by the number of bass greater than or equal to stock size ($\leq$ 200 mm) and multiplying by 100. Confidence intervals were approximated for PSD estimates at the 95% confidence level (CI) (Zar 1984). PSD values between 40–60 indicate a structurally balanced population. Values less than 40 indicate too many small fish and values greater than 60 indicate too many large fish.

Figure 5-12 illustrates the PSDs for largemouth bass in Ashuelot Pond. The PSD for largemouth bass in Ashuelot Pond was 72 in 1999, 50 in 2001, 43 in 2003, and 100 in 2005. In comparison, the mean statewide PSD value from waterbodies sampled by electrofishing during summers from 1997-2005 was 65 (Racine, 2006a).

Although the PSD values in 2001 and 2003 are within the range of a “balanced” bass population, it is unlikely that a population that goes from a PSD of 43 (2003) to a PSD of 100 (2005) over two years is “balanced” or stable; therefore, in Ashuelot Pond, the PSD data over time suggest the bass population’s length frequency distribution is variable.

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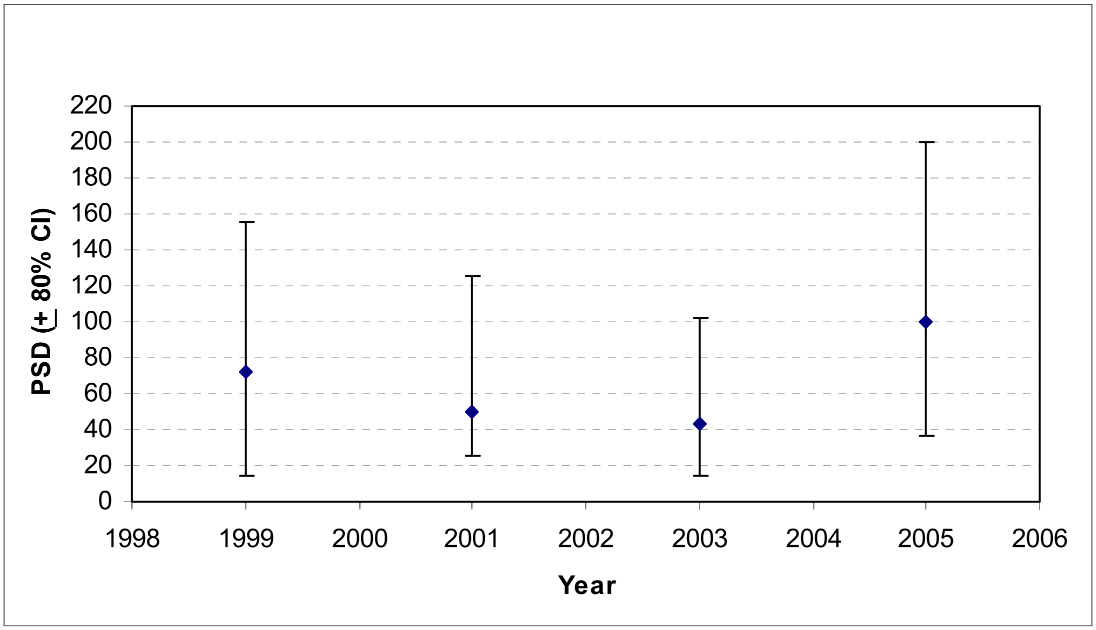
Figure 5-12
Proportional Stocking Density Values for Largemouth Bass (+ 95% CI)



5.4.3.3 Relative Weight

Mean relative weight values were calculated for largemouth bass by year and by length category (Table 5-4). Relative weight (W_r) values were derived as a measure of condition of individual fish. Relative weight values were calculated for black bass greater than 150 mm total length (TL). This index compares the actual weight of an individual (W) with a standard weight (W_s) for a fish of the same length: $W_r = W/W_s * 100$. The equation used for largemouth bass was $\log_{10} W_s$ (g) = -5.316 + 3.191 x $\log_{10}$ TL(mm), proposed by Wege and Anderson (1978). Relative weight values > 90 may be considered good, with values greater than 100 considered excellent.

No significant differences in largemouth bass relative weight values among years were found for stock, quality and preferred size fish (Table 5-4) suggesting that drawdowns were not impacting fish mass within specific size classes. Relative weight values for memorable size bass were not tested due to a lack of fish being captured in more than one year. Mean relative weight values of largemouth bass from Ashuelot Pond were higher than statewide values (1997-2005) with the exception of quality size bass in 2001 and preferred size bass in 2003 and 2005 (Racine 2006a). High mean relative weight values of largemouth bass were likely due to the fact that the largemouth bass population in Ashuelot Pond is below the carrying capacity of the pond, as depicted by the fast growth of the bass and low relative abundance, and adequate food and habitat are available.

Table 5-4. Data Summary for Largemouth Bass Populations in Ashuelot Pond

	Total Length Interval (mm)											
	Stock 200-299			Quality 300-379			Preferred 380-509			Memorable 510-629		
Year	*n*	Wr	SD	*n*	Wr	SD	*n*	Wr	SD	*n*	Wr	SD
1999	7	105.5	7.7	8	97.7	7.9	10	99	7.3	0	-	-
2001	4	118.3	40.0	3	93.1	4.8	1	99.8	-	-	-	-
2003	12	105.1	5.3	6	95.9	8.4	2	90.1	7.4	1	104.2	-
2005	-	-	-	5	93.3	6.2	3	92.8	8.3	-	-	-
Mean Wr		109.6			95.0			95.4			104.2	
Std Dev Wr		7.5			2.2			4.7			-	

5.4.3.4 Relative Abundance

Relative abundance is a surrogate measure of total fish abundance. Relative abundance does not measure the actual number of fish in a waterbody, but can be used to compare fish populations among years, waterbodies, and within or among species. In this report, relative abundance is reported as the number of fish captured per hour of sampling. Mean relative abundance was calculated for largemouth bass in the stock, quality, preferred, and memorable length categories, as well as for the young of year (YOY) length category and a juvenile length category, which was any fish less than stock size and greater than YOY size.

Mean relative abundance estimates for largemouth bass in 1999, 2001, 2003, and 2005 are shown in Table 5-5. Data from 2001 were not used for statistical analyses because only one sampling run was performed.

A significant difference in relative abundance among years was found for all sizes of largemouth bass combined (P = 0.09), and for bass less than stock size (P = 0.03). Relative abundance of all sizes of bass combined was highest in 1999 (post average drawdown), followed by 2005 (post deep draw down), 2003 (no draw down the year before), and for 2001 (post deep drawdown). Relative abundance for bass less than stock size was highest in 1999 (post average drawdown), followed by 2005 (post deep drawdown), 2001 (post deep drawdown), and values were lowest for 2003 (no drawdown the year before). Comparisons of data showed relative abundance of less than stock size bass was significantly higher in 1999 than in other years. A marginally significant difference (P = 0.105) was found for stock size largemouth bass across years with 2003 having the highest value, followed by 1999.

Mean relative abundance values for largemouth bass were lower than statewide values (1997-2005) with the exception of less than stock sized bass in 1999 and 2005, stock sized bass in 2003, preferred sized bass in 1999 (tie), and memorable sized bass in 2003 (Racine 2006a). Overall, mean relative abundance values for largemouth bass in Ashuelot Pond from all years sampled were at least 32% lower than statewide values calculated for 1997-2005.

Mean relative abundance estimates for non-bass species varied by year and species (Table 5-6). Data from 2001 were not used for statistical analyses because only one sampling run was performed. No significant differences in relative abundance estimates of non-bass species among years were found, although pumpkinseed showed decreases in years (2001 and 2005) following deep drawdowns (Table 5-6).

Mean relative abundance estimates for non-bass species that were less than or equal to 100 mm (total length) and greater than 100 mm (total length) varied by year and species (Table 5-7a and Table 5-7b). Data from 2001 were not used for statistical analyses because only one sampling run was performed. No significant differences in relative abundance estimates of non-bass species among years were found.

Table 5-5. Year, sample size, mean relative abundance estimate (fish/hour) and one standard deviation by length category for largemouth bass captured by electrofishing in Ashuelot Pond. *n* = number of electrofishing runs.

	Total Length Interval (mm)																		
	All Lengths				< Stock (YOY & Juvenile)			Stock 200-299			Quality 300-379			Preferred 380-509			Memorable 510-629		
Year	*n*	#fish	f/h	SD	#fish	f/h	SD	#fish	f/h	SD	#fish	f/h	SD	#fish	f/h	SD	#fish	f/h	SD
1999	8	148	82.0	59.6	123	71.2	62.0	7	3.1	4.8	8	3.4	3.1	10	4.3	7.3	0	0.0	0.0
2001	1	16	14.8	-	8	7.4	-	4	3.7	-	3	2.8	-	1	0.9	-	0	0.0	-
2003	5	22	18.6	24.9	1	3.2	223.6	12	10.7	13.4	6	4.3	9.6	2	1.4	3.2	1	0.7	1.6
2005	5	48	38.2	27.1	40	31.7	28.0	0	0.0	0.0	5	4.3	4.7	3	2.2	3.2	0	0.0	0.0
Mean f/h			23.8			14.1			4.8			3.8			1.5			0.2	
CV for f/h			53			109			113			23			42			173	

Table 5-6. Year, mean relative abundance estimates (fish/hour) and one standard deviation for non-bass species captured during community electrofishing runs in Ashuelot Pond. *n* = number of runs.

Year	*n*	American Eel	Brown Bullhead	Common White Sucker	Chain Pickerel	Fallfish	Golden Shiner	Pumpkinseed	Redbreast Sunfish	Yellow Perch
1999	2	0	18±5	11±5	32±5	7±10	100±40	139±116	0	1079±61
2001	1	0	6	19	24	13	30	27	2	211
2003	2	0	4±5	39±5	18±5	0	36±30	293±30	0	625±207
2005	2	7±10	4±5	29±41	18±5	4±5	50±20	50±20	0	810±209
Mean f/hr		2	8	25	23	6	54	127	1	681
Stdev of f/hr		4	7	12	7	5	32	121	1	365

Table 5-7a. Year, mean relative abundance estimates (fish/hour) and one standard deviation for non-bass species ≤ 100 mm (total length) captured during community electrofishing runs in Ashuelot Pond. *n* = number of runs.

Year	*n*	American Eel	Brown Bullhead	Common White Sucker	Chain Pickerel	Fallfish	Golden Shiner	Pumpkinseed	Redbreast Sunfish	Yellow Perch
1999	2	0	0	0	7±10	0	54±15	104±96	0	100±10
2001	1	0	0	1	3	0	6	11	2	154
2003	2	0	0	0	7±10	0	14±20	254±15	0	575±217
2005	2	0	0	7±10	4±5	0	36±30	32±25	0	743±232
Mean f/hr		0	0	2	5	0	28	100	1	393
Stdev of f/hr		-	-	3	2	-	22	110	1	315

Table 5-7b. Year, mean relative abundance estimates (fish/hour) and one standard deviation for non-bass species > 100 mm (total length) captured during community electrofishing runs in Ashuelot Pond. *n* = number of runs.

Year	*n*	American Eel	Brown Bullhead	Common White Sucker	Chain Pickerel	Fallfish	Golden Shiner	Pumpkinseed	Redbreast Sunfish	Yellow Perch
1999	2	0	18±5	11±5	25±15	7±10	46±56	36±20	0	75±45
2001	1	0	6	19	21	13	24	16	0	57
2003	2	0	4±5	39±5	11±15	0	21±10	39±15	0	46±15
2005	2	7±10	4±5	21±30	14±10	4±5	14±10	18±5	0	61±25
Mean f/hr		2	8	23	18	6	26	27	0	60
Stdev of f/hr		4	7	12	6	5	14	12	-	12

5.4.3.5 Length-Frequency Distribution and Relative Weight

In 1999 and 2003, the relationship between largemouth bass total length and relative weight was significant with a negative trend (i.e. relative weight declined as fish increased in length), but the variation was poorly explained (1999: $P < 0.001$, $R^2 = 0.22$, Figure 5-13a+b; 2003: $P = 0.03$, $R^2 = 0.23$, Figure 5-15a+b;). In 2001 and 2005, the relationship between largemouth bass total length and relative weight was not significant (Figure 5-14 and Figure 5-16). The age class of largemouth bass hatched during years of deep drawdowns (2000 and 2004) was either not captured in the following year's sample or was captured in low numbers (2001 and 2005, respectively).

Figure 5-13a
The Length-Frequency Distribution for Largemouth Bass in Ashuelot Pond during August 1999.

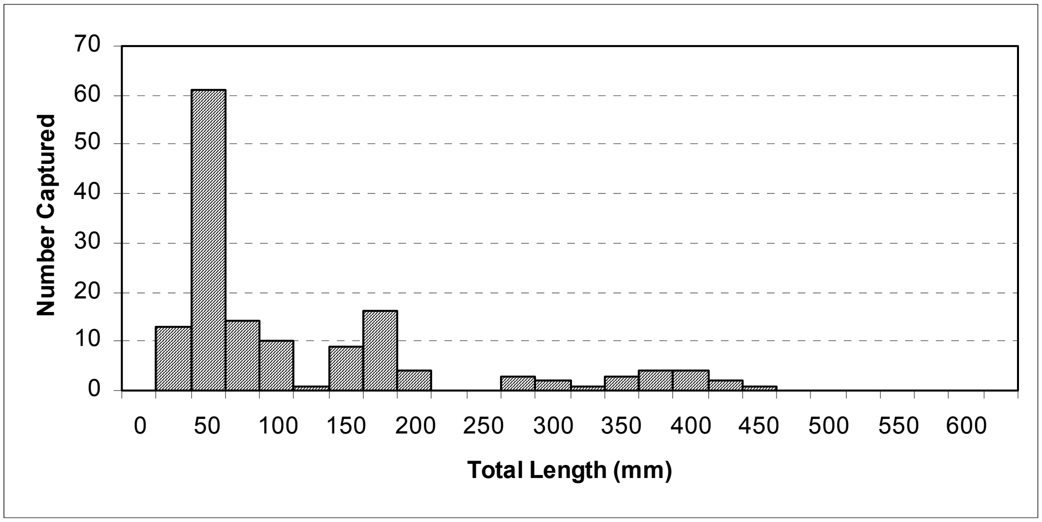


Figure 5-13b
The Relationship of Total Length to Relative Weight for Largemouth Bass in Ashuelot Pond during August 1999.

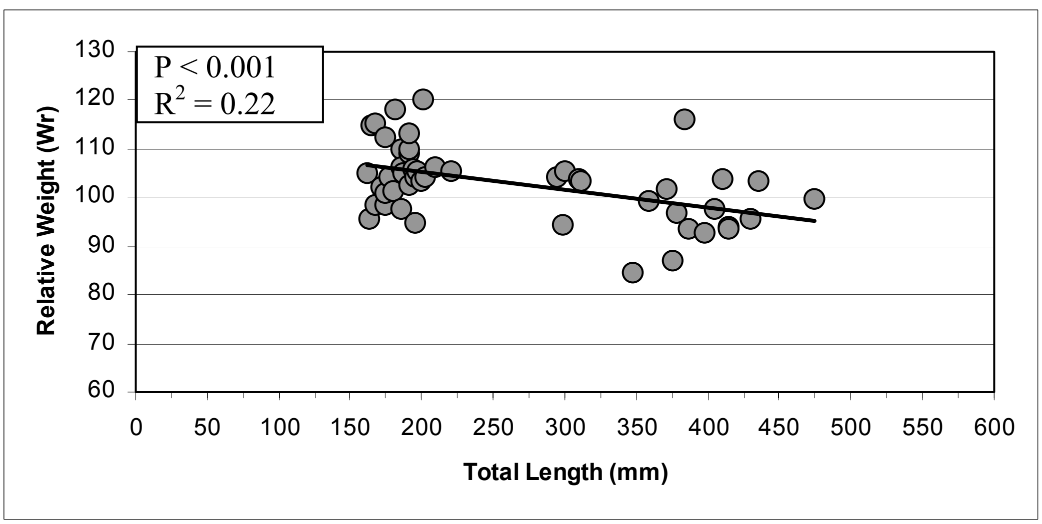


Figure 5-14a
The Length-Frequency Distribution For Largemouth Bass Captured In Ashuelot Pond During October 2001.

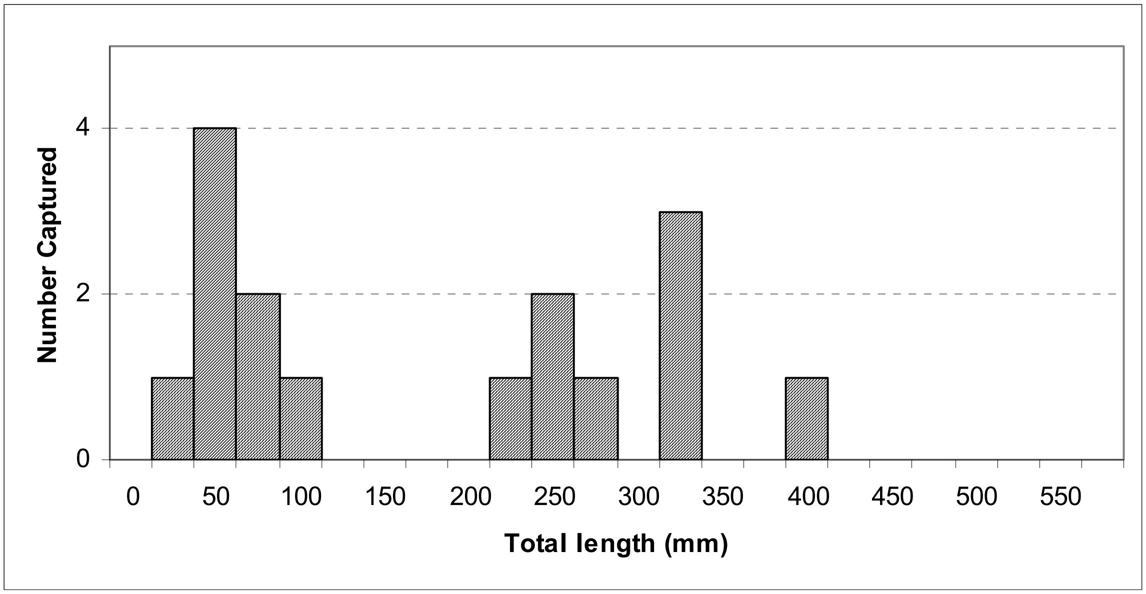


Figure 5-14b. The Relationship of Total Length to Relative Weight for Largemouth Bass Captured in Ashuelot Pond during October 2001.

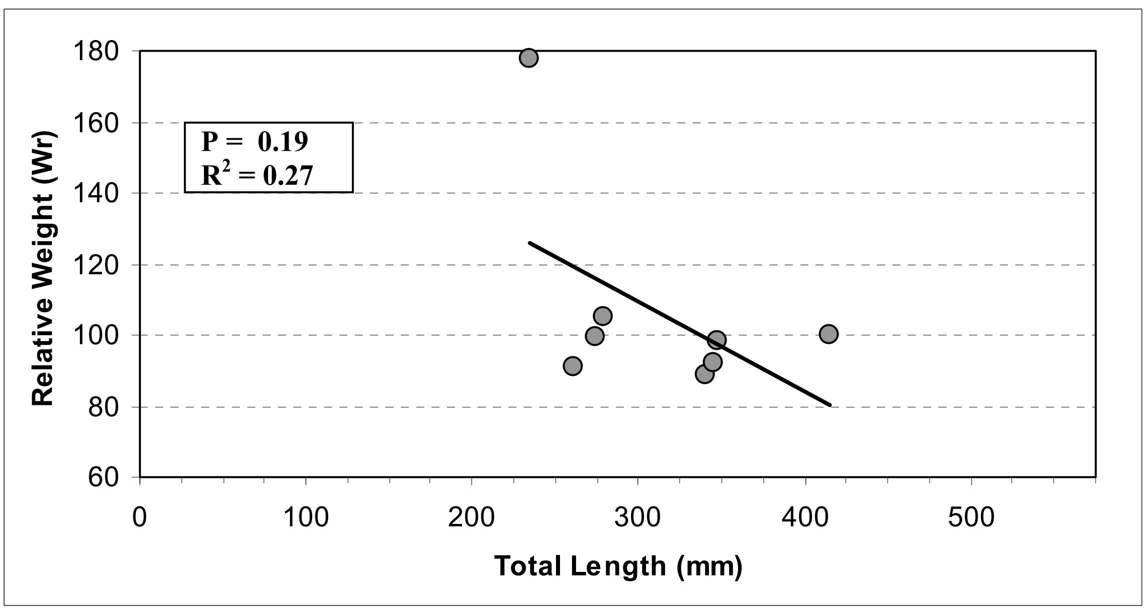


Figure 5-15a
The Length-Frequency Distribution For Largemouth Bass Captured In Ashuelot Pond During July 2003

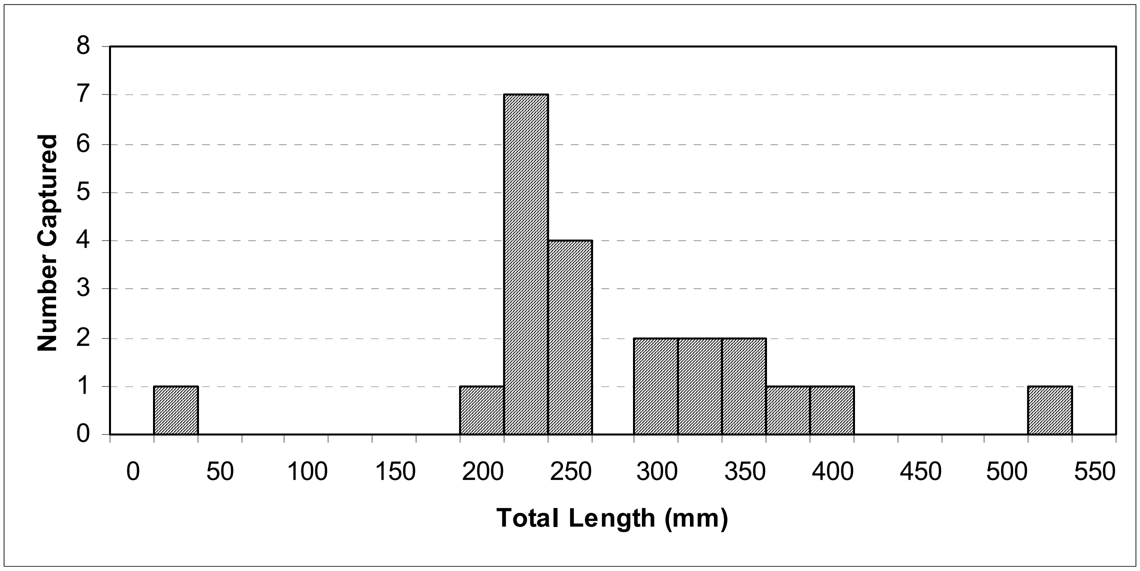


Figure 5-15b
The Relationship of Total Length to Relative Weight for Largemouth Bass Captured in Ashuelot Pond During July 2003.

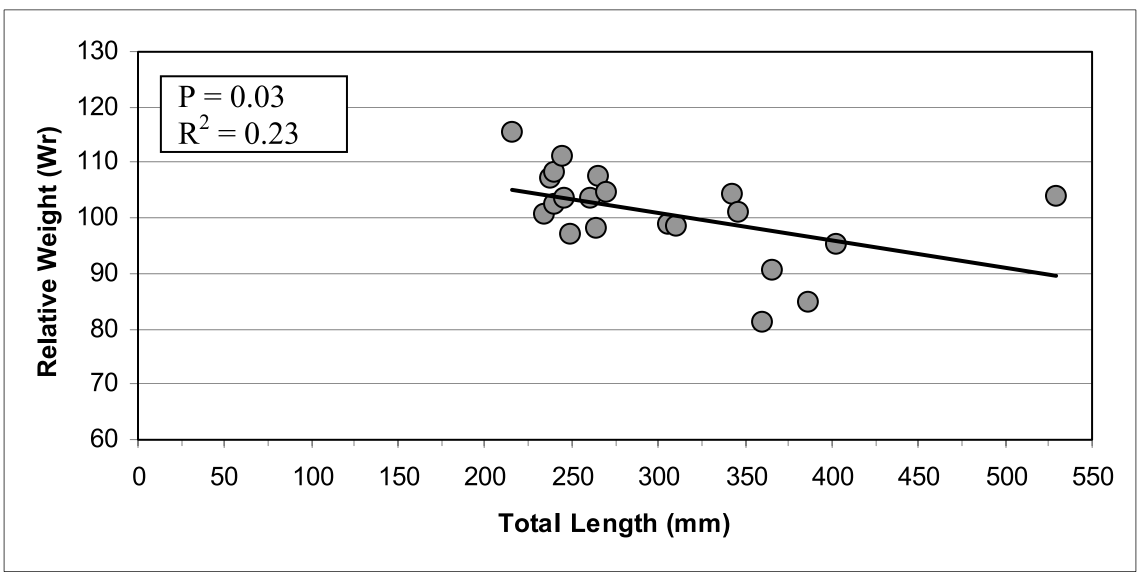


Figure 5-16a
The Length-Frequency Distribution For Largemouth Bass Captured In Ashuelot Pond During August 2005.

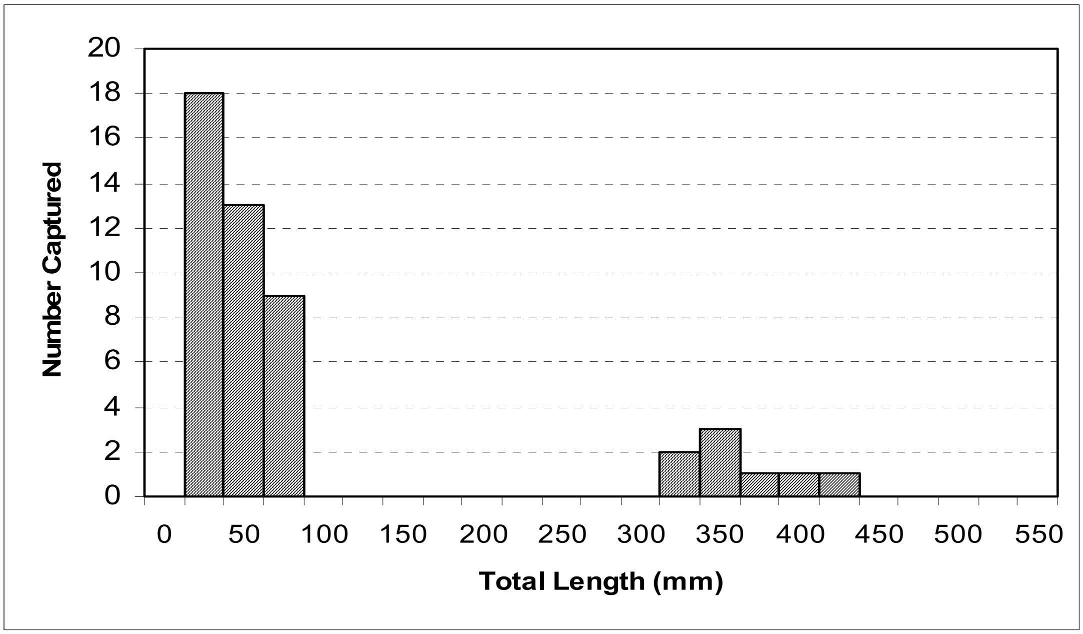
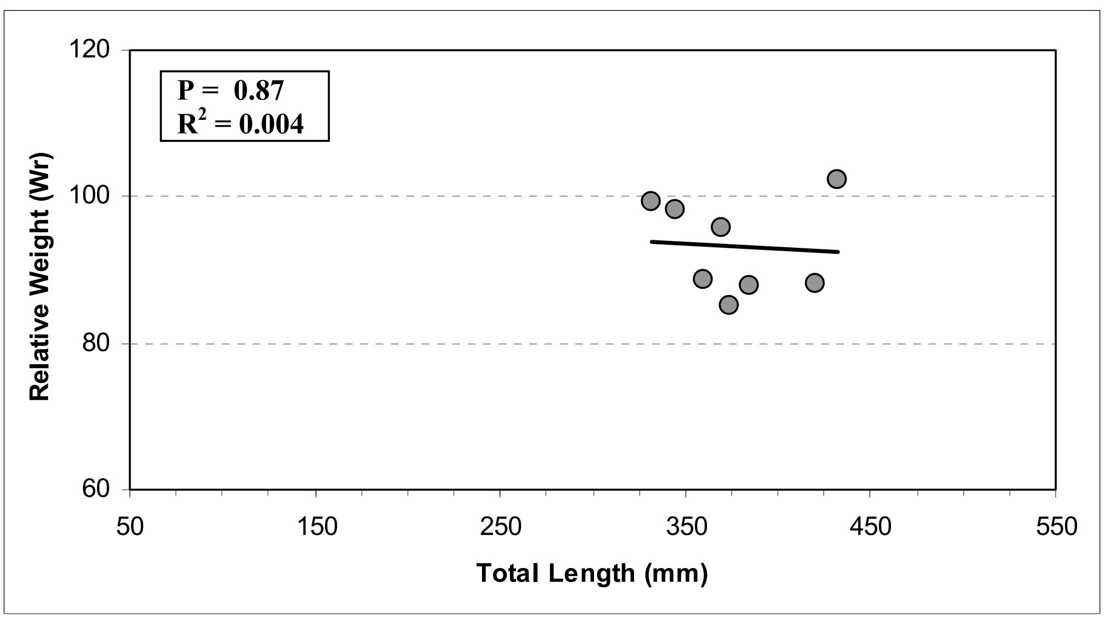


Figure 5-16b
The Relationship Of Total Length To Relative Weight For Largemouth Bass Captured In Ashuelot Pond During August 2005.



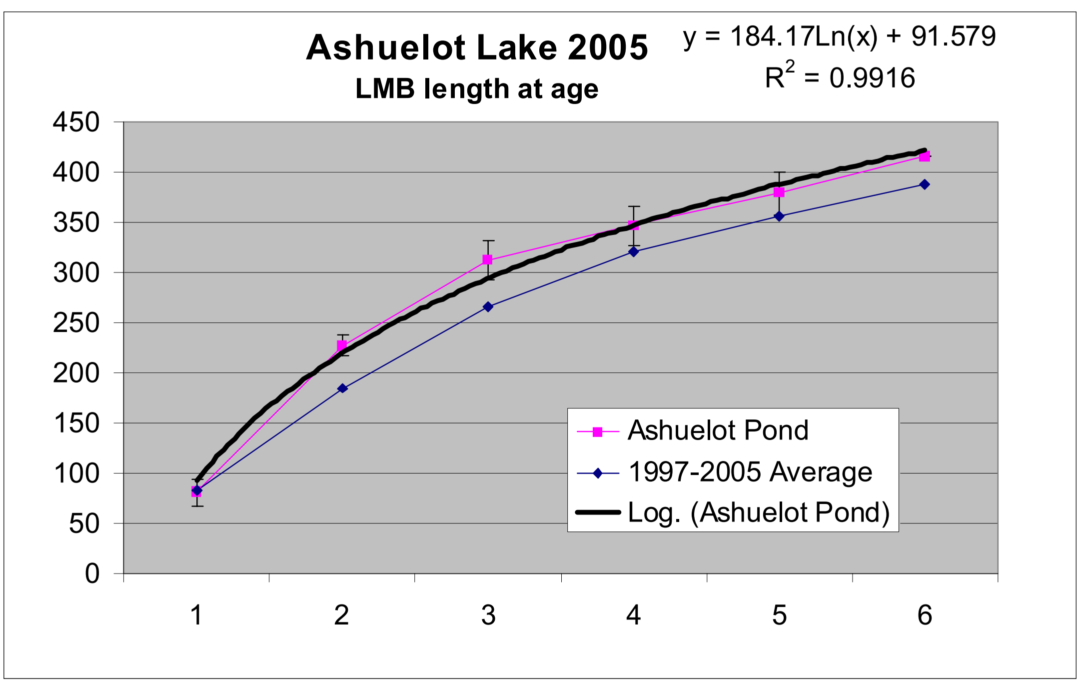
5.4.4 Other Calculations

Largemouth bass growth was calculated from fish sampled in 2005 (the year post deep drawdown) and represented age classes hatched from 1999-2004. Growth was categorized as fast when compared to fish from other New Hampshire waterbodies sampled during 1997-2005. Average length at age was above statewide values (1997-2005) for all ages of largemouth bass from age 1-6 except for age 1 fish (Table 5-8, Figure 5-17). Largemouth bass took an average of 3.10 years to reach quality size (300 mm) compared to the statewide average of 3.74 years (1997-2005) (Racine 2006b).

Table 5-8. Mean back-calculated length at age, total number of fish aged, logarithmic trendline correlation coefficient, age at quality size, and growth categorization for largemouth bass sampled in Ashuelot Pond in 2005.

Maximum Age ≤ 8 with CR < 4[a]	Maximum age used for back-calculations	Mean back-calculated length (mm) at age						Number of fish aged		R^{2b}	Age at quality size 300 mm	Growth Categorization
		1	2	3	4	5	6	≥1	5-6			
7	6	81	229	313	349	383	417	7	3	0.99	3.10	Fast

Figure 5-17
Average back-calculated length at age for largemouth bass from Ashuelot Pond sampled in 2005 (from Racine 2006b).



5.4.5 Summary of Fishery Data

Ashuelot Pond has a varied warmwater fishery, with common species that were present from year to year. The age class of largemouth bass hatched during years of deep drawdowns (2000 and 2004) was either not captured in the following year's sample or was captured in low numbers. The potential loss of these small bass may be related to increased predation pressure during times of lower water due to deep drawdowns when fish are forced into a smaller volume of water at the deep spot of the pond. Although largemouth bass PSD was variable over time and there was no clear PSD pattern as related to deep drawdowns during the study period, a loss or reduction in an age class which could be caused by deep drawdown will lead to changes in PSD over time.

No significant differences in relative weight were found for largemouth bass among years, suggesting that drawdowns were not directly impacting largemouth bass mass. However, negative relationships between bass total length and relative weight were found for all years and were significant in 1999 and 2003.

Significant differences were found for relative abundance of all sizes of largemouth bass combined, and for bass less than stock size. Overall, mean relative abundance values for largemouth bass in Ashuelot Pond from all years sampled were at least 32% lower than statewide values calculated for 1997-2005. No significant differences in relative abundance for non-bass species among years were found.

Largemouth bass growth was categorized as "fast" (2005 data representing age classes from 1999-2004) when compared to statewide values, and mean relative weight values were generally higher than statewide values. It is likely that fast largemouth bass growth and high relative weights in Ashuelot Pond was due to limited competition as a result of relatively low numbers of bass present.

CHAPTER 6
ASHUELOT POND AND WATERSHED USER PERCEPTION SURVEY

6.1 Introduction

DES, with input from both the Ashuelot Pond Association and the Lake Ashuelot Estates Association, developed a user survey which was mailed to residents around the Ashuelot Pond, Ashuelot River and the watershed during the summer of 2004. A total of 250 surveys were mailed out, and a total of 155 completed, or partially completed surveys were returned. The goal of using this survey was to determine if deep drawdowns impacted the landowner's or the visitor's use or perception of the pond.

The survey questions covered a variety of topics (a copy of the survey is included in Appendix C). Specific survey inquiries allowed DES to analyze data on the basis of overall landowner opinion and how landowners located in different lake areas varied in their survey responses. To avoid any discrepancies surrounding biased opinion, the survey was structured and administered by the Survey Center of the University of New Hampshire (UNH), a division of the University's Institute for Policy and Social Science Research.

The questions included in the survey were grouped into seven categories, based on similarity and relevance to specific topics. These categories include general landowner information, docking/boats/pond access, recreational uses, fish/wildlife/plant abundance, water supply, fire safety, and general water quality problems. Data collected that were most useful to the study will be discussed in this chapter.

6.2 Perceptions of Fish and Wildlife

One of the most important topics that survey questions addressed included those that referred to the landowners' observations of fish and wildlife, particularly since there were many concerns voiced at the start of this study about the impacts of deep drawdowns to the aquatic biota of Ashuelot Pond.

When asked what type of fish were usually caught, polled responses indicated that most were bass, followed by pickerel, hornpout, sunfish, others (not specified) and suckers, respectively (Figure 6-1). These resident fishing enthusiasts also indicated that most (75 %) have not noticed a decline in the number of fish caught since the deep drawdown regime began, while 25% say they have noticed a decline (Figure 6-2).

Figure 6-1. What kinds of fish do you catch?

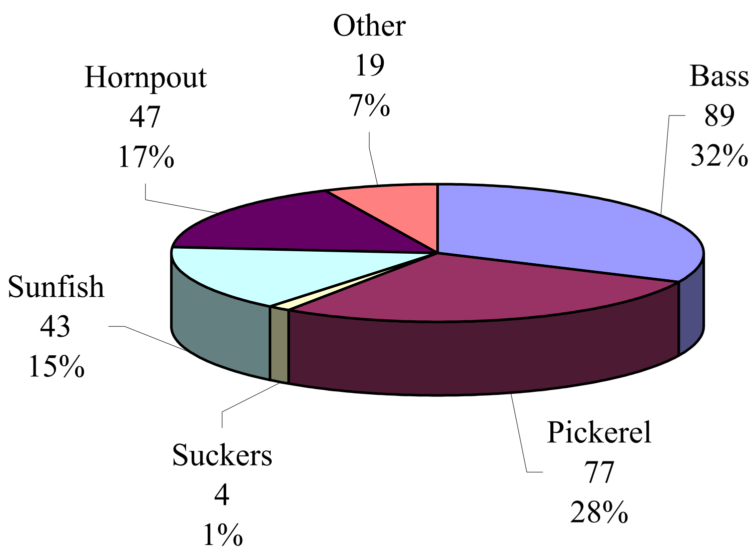
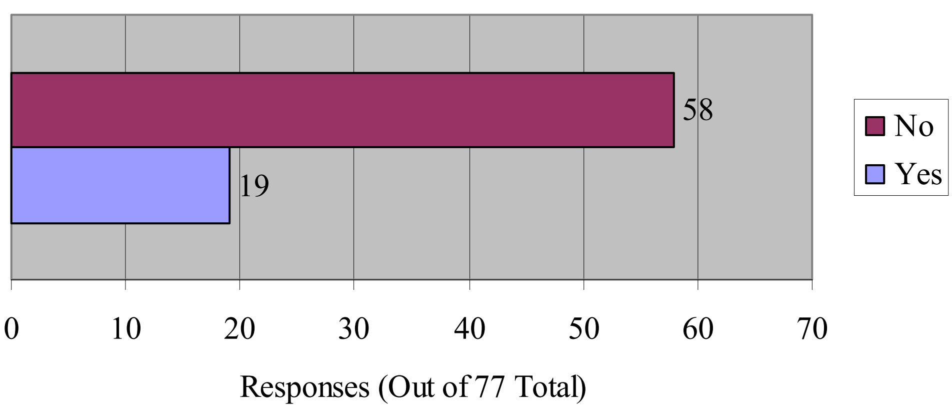


Figure 6-2. Have you noticed a decline in the number of fish caught?

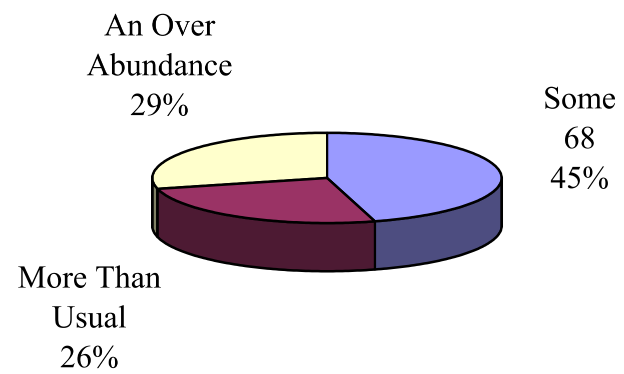


6.3 Perceptions of Aquatic Plant Populations

Another important series of questions in the user survey focused on the aquatic plant populations in Ashuelot Pond. Specifically, with regards to plant life and abundance, 29% of responding landowners indicated that they felt aquatic plants are present in an over-abundance in

Ashuelot Pond, while 26% indicated that plant abundance is simply more than usual. The other 45% indicated that only some aquatic plants are seen in the pond (Figure 6-3).

Figure 6-3. Do you see aquatic plants in the pond?



Landowners also indicated in the survey that 64% of them observed aquatic plants washing up on their shores, while 36% did not (Figure 6-4). For those that responded that plants did wash ashore, 35% indicated that the plants washed up several times per day, followed by 24% indicating the wash-ups occurred about once a week, and a final 20% stating once a day (Figure 6-5).

Figure 6-4. Do you have aquatic plants washing up on your shore?

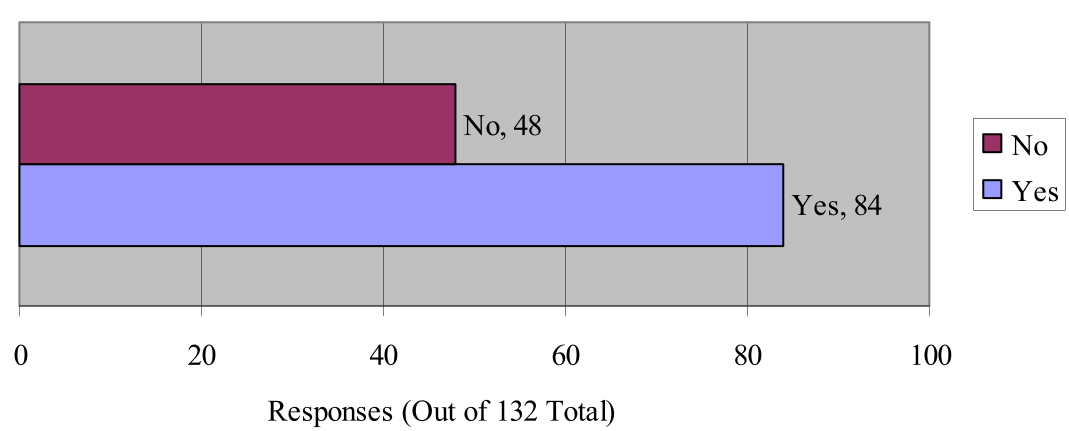
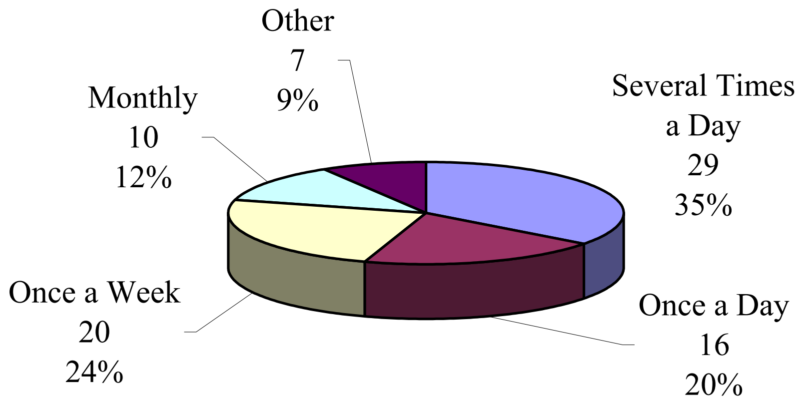


Figure 6-5. If aquatic plants do wash up on shore, how often?



Another goal of the survey was to obtain an understanding of where on the pond aquatic plants tended to be perceived as more of a problem. As a result, a map of the pond was included in the survey for a series of specific questions. The map showed the pond and the river divided into five general areas (Figure 6-6). When asked what areas landowners saw the aquatic weeds 48% responded that most were seen in Area 1, the Ashuelot River portion of the pond impoundment. Area 2 was the next indicated area, which is the eastern shoreline, with 33% of responses. Area 4, Area 5, and Area 3, respectively, were also indicated for areas of aquatic plant observations (Figure 6-7).

Figure 6-6
Ashuelot Pond Area Designations

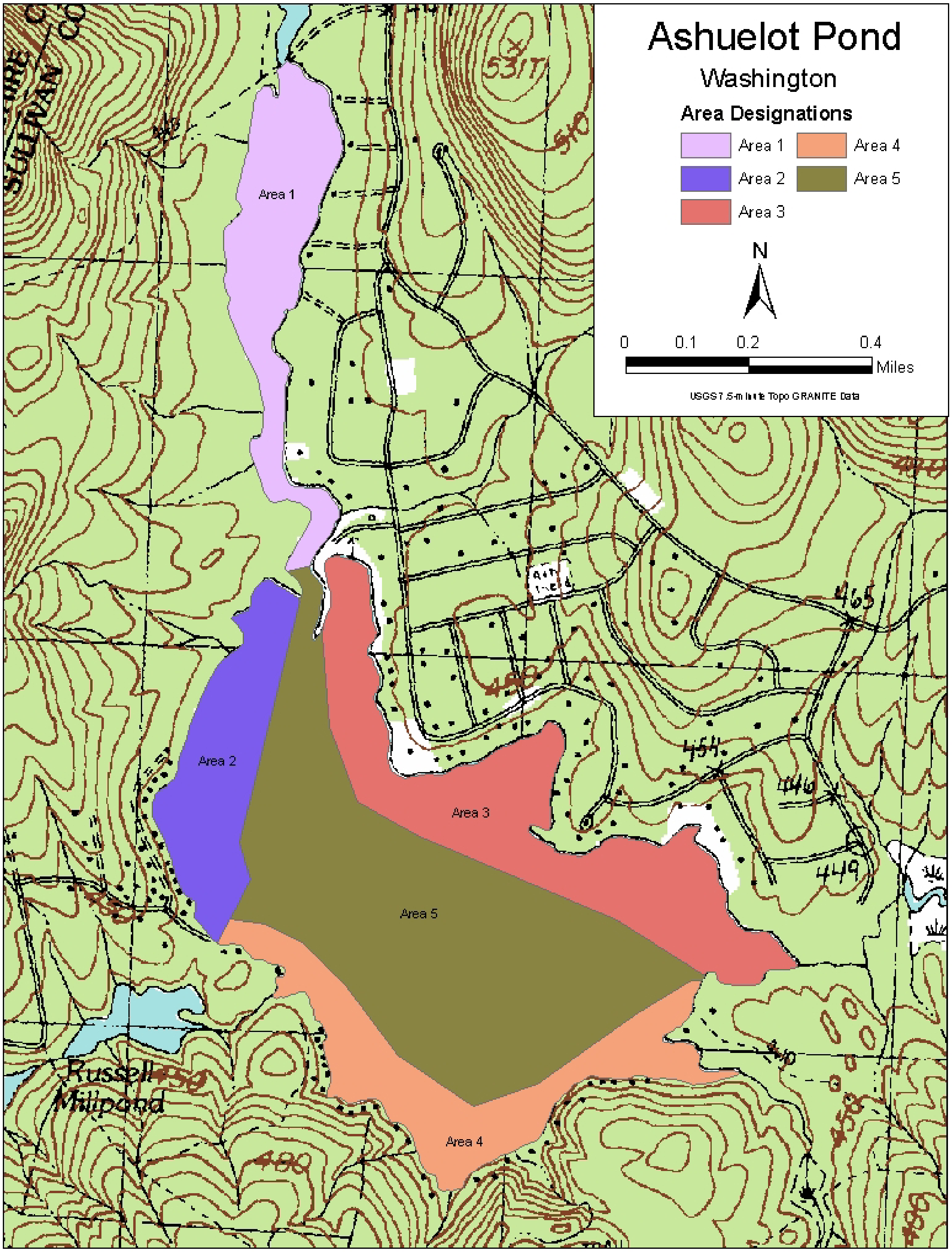
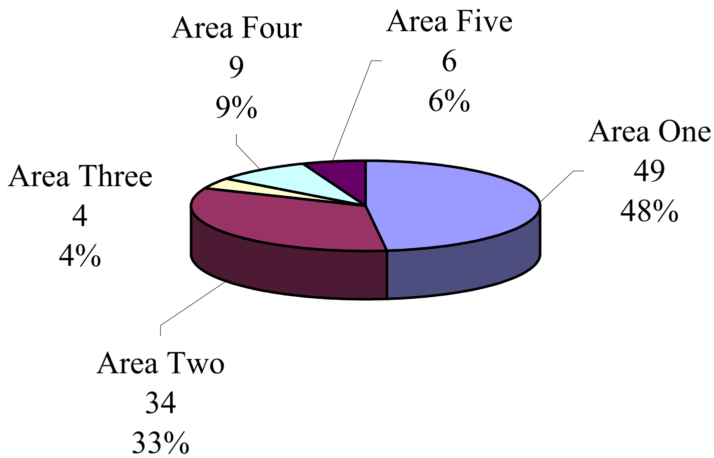
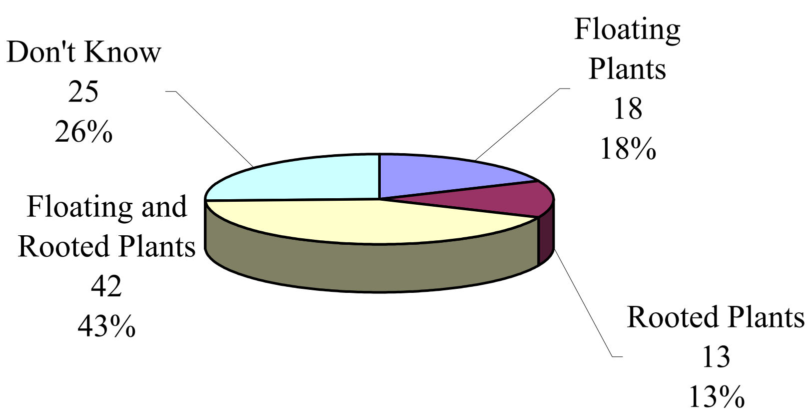


Figure 6-7. If you do see weeds, where do you see them?



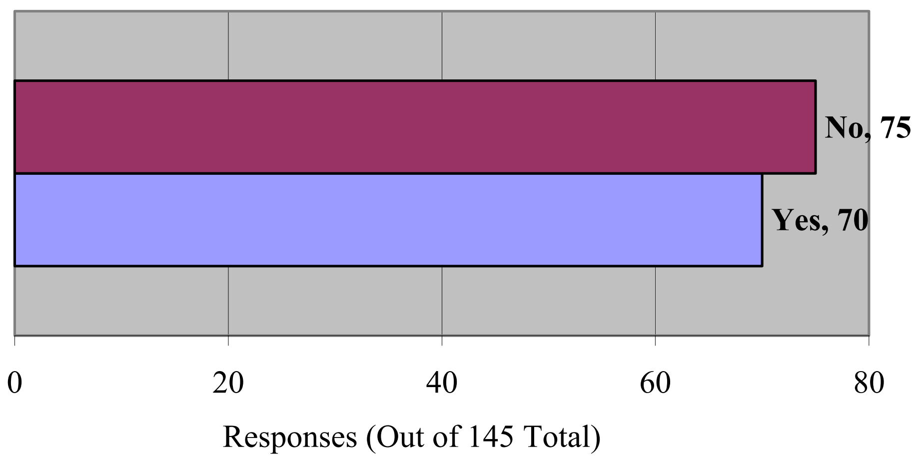
Most landowners (43%) observed plants washing ashore that were a combination of both floating and rooted aquatic plants. Of the remaining responses, 25% were not able to identify whether the plants were floating or rooted, 18% indicated that they were just floating plants, and 13% indicated they were just rooted plants (Figure 6-8).

Figure 6-8. Are these weeds that are washing up on your shore? (Floating and/or Rooted)



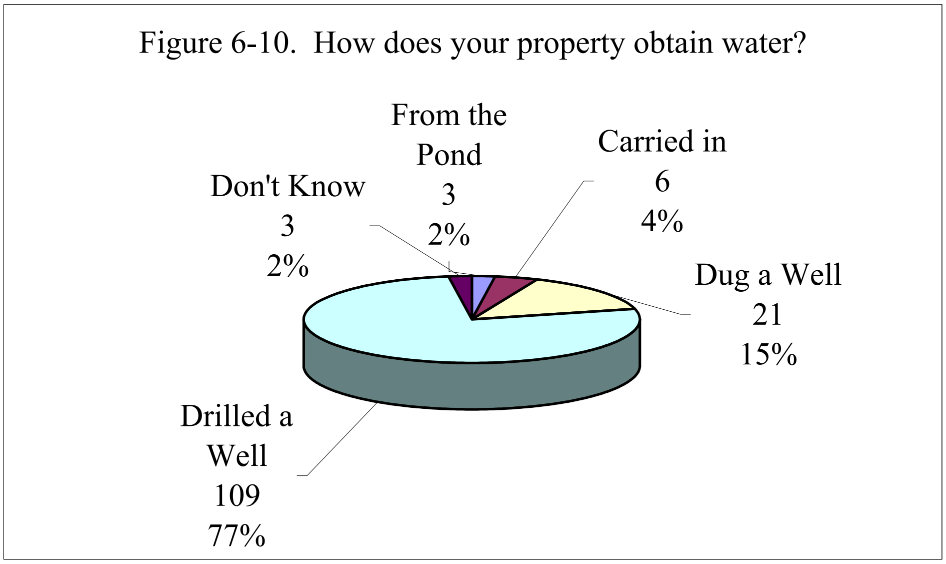
Overall, roughly half of landowners (48%) feel that the presence of aquatic weeds has had an impact on their recreational use of the pond (Figure 6-9), while the other half (52%) feel that weeds have not had an impact on their recreational uses.

Figure 6-9. Has the presence of weeds in the pond had any impact on your ability to use the pond for recreaction?



6.4 Water Source

Also in the user survey was a question relating to the source of water on which lake residents relied for their dwelling. This topic is of significance in that nearshore dug wells and some artesian wells can occasionally go dry during deep and prolonged drawdowns. Landowners were asked how their property obtained water. Most (77%), acquired water through a drilled well. Others indicated obtaining household water by dug wells (15%), carrying in water from outside sources (4%), from the pond (2%) and some were unsure how their property obtained water (2%) (Figure 6-10).



6.5 Fire Safety and Water Supply

Fire safety was also addressed in the survey with respect to landowners and their properties at Ashuelot Pond to determine how significant a source of fire-fighting water the pond provides. Only 7% of landowners at Ashuelot have indicated that there is no road access for fire trucks to reach their property in case of a fire emergency situation, so they would need to rely on lake water to fight a fire. The remaining 93% of landowners have sufficient road access for fire trucks to reach their properties (Figure 6-11). Also, 62% of residents responded that they would use the pond as their primary source of water to extinguish a fire in case of emergency (Figure 6-12).

Overall, 20% of the residents of Ashuelot pond properties indicated that the drawdown of the pond would impact fire safety or their abilities to fight a fire. The other 80% of landowners responded that the drawdown would have no impact on their safety (Figure 6-13).

Figure 6-11. Is there road access for fire trucks to reach your property?

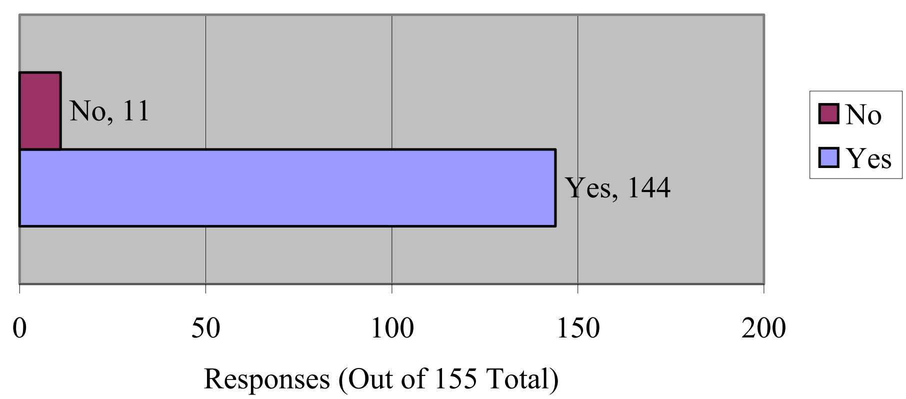


Figure 6-12. If a fire did occur, would the pond be your main source of water to extinguish it?

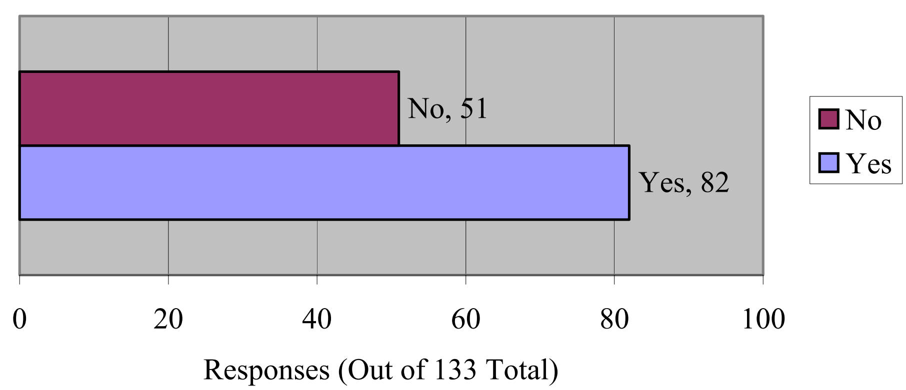
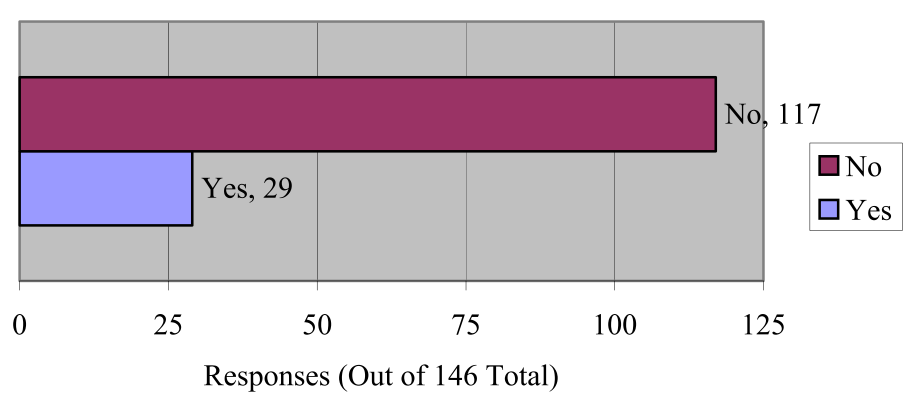


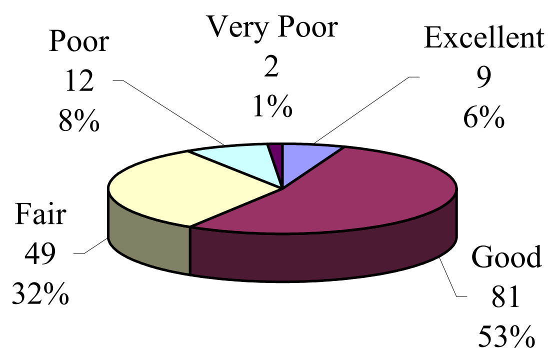
Figure 6-13. Does this drawdown have any impact on firefighting or fire safety for your property?



6.6 Overall Perceptions of Ashuelot Pond

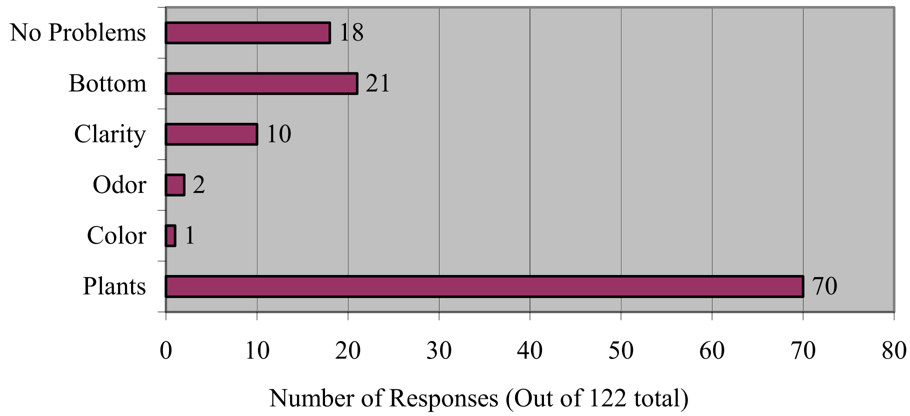
Several important questions with direct correlation to the Ashuelot drawdown were also asked of the landowners of the pond and nearby watershed. When asked what they thought of the overall quality of the pond, most (53%) responded that they thought that Ashuelot Pond was in good condition, followed by other responses that indicated they believed that Ashuelot Pond was in fair (32%), poor (8%), excellent (6%), and very poor (1%) condition, respectively (Figure 6-14).

Figure 6-14. What do you think of the quality of the pond water?



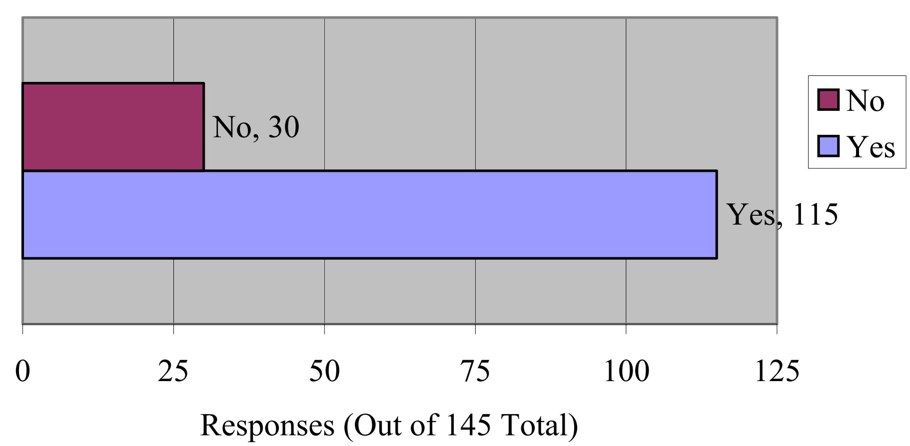
Most residents then indicated that the primary water problem at Ashuelot Pond was plant abundance (57%). Other problems included the quality of the pond's substrate (17%), clarity (8%), odor (2%), and color (1%). About 15% indicated there was no problem with the water at Ashuelot Pond (Figure 6-15).

Figure 6-15. What do you see as the most important water problem?



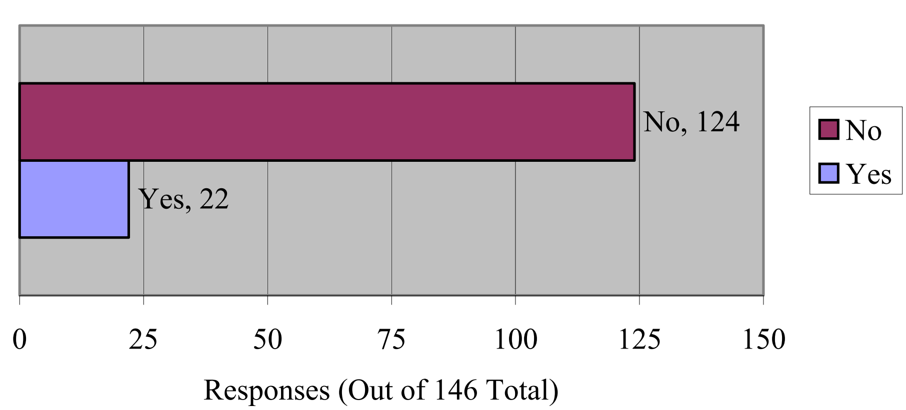
When asked if they felt that a deep drawdown controls the aquatic plants, 79% of residents indicated that they believed it would (Figure 6-16).

Figure 6-16. Do you believe that deep drawdowns help control aquatic plants?



Finally, the survey asked if residents had any objections to the drawdown that had not been addressed in the survey. Most (85%) replied that they had no other objections, while 15% did object to the cycle of deep drawdowns (Figure 6-17).

Figure 6-17. Do you have any objections to the pond drawdown that were not covered by this survey?



CHAPTER 7
CONCLUSIONS AND RECOMMENDATIONS

To determine the benefits and ecological impacts of deep drawdown regimes in Ashuelot Pond to the various lake characteristics (i.e., physical, chemical, ecological, recreational, aesthetic), DES embarked on a four year study of Ashuelot Pond to catalogue changes between non-deep drawdown years (2002-2004) and a post deep drawdown year (2005).

The cycle of a deep drawdown regime has been in place for a number of years, so it is infeasible to go back to gather a baseline data set that reflects what Ashuelot Pond would resemble today if no deep drawdowns had been conducted. However, it is possible to extrapolate from the study data to determine if the goal of aquatic plant management has been achieved in the pond as a result of a deep drawdown, and to generalize the findings from other elements of this study.

The study goal was to determine if deep drawdowns decreased nuisance growths of (native) aquatic vegetation in Ashuelot Pond (specifically *Utricularia purpurea*, commonly referred to as whorled bladderwort). Results from each of the analyses were discussed in greater detail in the preceding chapters of this report. Table 7-1 briefly summarizes the impacts of drawdown to the various characteristics that were analyzed as part of this study:

Table 7-1
Conclusions from Individual Categorical Analyses in Ashuelot Pond

Category/Characteristic	Impact
Water Chemistry	With the exception of possible and subtle changes in ANC values immediately following drawdown, there do not appear to be any marked changes in water quality as a result of deep drawdowns in Ashuelot Pond. The data suggest that there may be a slight increase in ANC following deep drawdowns, as compared to the year immediately preceding the drawdown event. In general, water quality in Ashuelot Pond showed no obvious changes as a result of deep drawdowns.
Macrophytes (Plants)	On a lakewide basis, the overall percent of plant cover within Ashuelot Pond did not show a statistically significant change as a result of the deep drawdown in fall 2004. Data collected during the 2005 summer season were analyzed for statistically significant differences from the data set of non-deep drawdown years (2002-2004). On a plant-by-plant basis, most of the genera represented in the pond showed no change, while only a few showed weakly significant changes (decreases or increases) as a result of deep

	drawdown, and only one showed a definitive statistical decrease (pondweed) in the pond. In the river, there was a small but overall statistically significant increase in plant cover in 2005 as compared with data sets from 2002-2004. The data indicate that plant percent cover increased overall, with arrowhead showing strong statistical increases in the river. Subtle increases in other species were also likely to account for this change.
Macroinvertebrates (Insects)	There were no statistically significant differences in the overall number of organisms found between the non deep drawdown years, and the deep drawdown year. While deep drawdown did not appear to affect the total number of organisms, it did have an impact on the diversity of the macroinvertebrates. In years before the deep drawdown, Dipterans were the dominant organisms; after the deep drawdown in 2005, Dipterans declined to only 18% of the organisms present, and Amphipods showed a statistically significant increase to 72% of the overall population.
Amphibians (Frogs)	It is not evident that frog populations were negatively impacted by deep drawdowns in Ashuelot Pond. Based on the data presented, we speculate that frog populations are fairly stable in Ashuelot Pond, and that frogs are obviously reproducing as adult frogs are present, and egg masses are observed throughout the system each year.
Fish	Data from the fishery analysis in Ashuelot Pond suggest that there is instability in the sportfishery (bass) population in the lake. Mean relative abundance values for largemouth bass in Ashuelot Pond from all years sampled were at least 32% lower than statewide values calculated for 1997-2005. No significant differences in relative abundance estimates of non-bass species among years were found, although pumpkinseed showed decreases in years (2001 and 2005) following deep drawdowns.
Perception Survey	The user perception survey included questions on a number of categories relative to Ashuelot Pond. Most of the questions were asked to gauge the overall perception of the pond in the eyes of the nearshore residents. In general, more than half of the survey respondents indicated that Ashuelot Pond was in good condition (53%). Of the problems they did perceive, 'aquatic plants' was a common reply, with 57% of the respondents citing this as the primary problem. Many residents indicated that they noted that plants wash upon the shoreline on a daily basis (55%), and most noted that the most problematic area was in the river segment of the study area. Forty-eight percent of the respondents indicated that plants pose an impact to their recreational use of the pond.

	Changes to the fishery or wildlife over time do not appear to be a problem to survey respondents, as most respondents indicated that there was no change in the number of fish caught in the pond (75%).

Despite the fluctuations in water level when a deep drawdown occurs, no overall negative impacts to water quality or amphibians were observed between times of no deep drawdown and the year immediately following deep drawdown.

Some categories of organisms did show some impacts as a result of deep drawdown. Macroinvertebrates appeared to suffer impacts to the population, namely in a change in the species diversity within the nearshore areas of Ashuelot Pond. Although the overall number of the organisms did not significantly decrease, there were obvious changes in organism types that made up the benthic macroinvertebrate community, which could have ecological impacts across the food chain.

There are noted instabilities in the bass population in Ashuelot Pond, but it is not known if those instabilities are a result of the deep drawdowns, or a result of other changes. There was also a noted decline in the relative abundance of pumkinseeds in the sample years that followed deep drawdowns.

There were no statistically significant differences in plant cover that can be attributed to the deep drawdown. Some plant genera did show some weak correlations to drawdown (where plant cover decreased to a small degree), but these appeared to be compensated by slight increases in other species. There were clearly no dramatic declines in plant abundance ratings in any of the plant genera represented in the pond to suggest that drawdown is a successful tool in reducing overall plant percent cover in the pond. Though anecdotal information suggests certain plant genera decline as a result of deep drawdown, a scientific and objective study of the pond, followed by a statistical analysis of the data, does not support that claim.

While drawdown does not appear to negatively affect most forms of aquatic life in Ashuelot Pond, there were some shifts in key elements of the aquatic food web (macroinvertebrates and fish), that suggest that deep drawdowns may not be an ecologically sound means to attempt to control aquatic plants in Ashuelot Pond.

Recommendations

Whorled bladderwort (*Utricularia purpurea*) has clearly been cited as the most problematic plant in the pond. Bladderwort is a free-floating aquatic plant that can achieve stem lengths of 1-8 feet. The general habit of bladderwort is to start out the growing season as a turion in the lake sediments. The vegetative material elongates from the turion and floats in the water column with wind and wave activity. Generally, bladderwort forms inter-tangled mats of growth that float to the pond surface. These growths are most often observed drifting in the shallows of Ashuelot Pond, and floating onto the shoreline areas of waterfront properties. Given the nature of this plant, Table 7-2 provides an evaluation of available management options:

Table 7-2
Evaluation of Control Options for Bladderwort in Ashuelot Pond

Control	Recommendation	Explanation
Aquatic Herbicide	Not recommended	The herbicide Reward (active ingredient Diquat) is the most effective herbicide used in control of bladderwort species. Diquat effectiveness is limited by a number of factors, including water color and organic material in the water column. Ashuelot Pond is a tea colored waterbody, and often has fine organic particulates in the water column, which would reduce the effectiveness of the herbicide. For these reasons, Diquat would not likely provide the desired level of control for bladderwort.
Deep Drawdown	Not recommended	Data from this study do not support the idea that deep drawdowns are an effect means of plant control in Ashuelot Pond.
Mechanical Control	Not Recommended	Mechanical harvesting generally involves the use of a hydro-rake or a device with cutter bars to dig out or cut off the vegetation and remove it from the lake. Since bladderwort is not a rooted plant, this technique is not recommended.
Benthic Barrier	Not recommended	Bladderwort is not a rooted plant, and due to its widespread and variable distribution in the pond, and its tendency to drift with water currents and wind, benthic barriers are not the most cost effective, nor would they be appropriate for widescale use.
Diver-Assisted Suction Harvesting	Recommended	Diver assisted suction harvesting can be an effective technique in selectively thinning bladderwort from a system. Divers use a suction device to selectively entrain bladderwort plants and remove them from the lake/pond. The harvested plants are then disposed of away from the waterbody. Over time, bladderwort

		populations may be thinned by this control technique.
Biological Control	Not Recommended	There are no known biological controls for bladderwort.
No Control	Recommended	At this point in time, Ashuelot Pond is not plagued with growths of exotic aquatic plants like variable milfoil or other invasive plants. The native plant community is diverse and the relative abundance of plants is typical of that for a waterbody with the characteristics of Ashuelot Pond, and is not at a level that would warrant radical management practices. A no control option is therefore reasonable for consideration here.

At this point in time, if further control of bladderwort populations is desired, DES recommends that the plants be selectively controlled by experienced divers using a Diver-Assisted Suction Harvesting (DASH) device. This is a labor-intensive strategy, but one that provides the most realistic, selective, longer-term, and environmentally sound management strategy for the waterbody.

It is important to note that bladderwort is not currently posing any ecological harm at its current abundance level. Ashuelot Pond is a relatively shallow waterbody where sunlight can penetrate to nearly three-quarters of the bottom sediments. Given the nutrient levels and the substrate types in the pond, aquatic plants will naturally achieve an expanded coverage on the bottom. It is also understandable that shorefront property owners may be aggrieved by the abundance of those plants, and may chose to pursue control actions to reduce the plant abundance in the lake.

Because the data collected from this study show that there is no statistically significant benefit from the deep drawdown, in terms of overall plant reduction, or even reduction in the target bladderwort species, a deep drawdown is not scientifically warranted for Ashuelot Pond. Deep drawdowns should be conducted when there is a specific need for such a drastic water withdrawal, such as flood control purposes, dock or shoreline repair, or other valid and documented circumstance. The request for such a deep drawdown should be directed to the DES Dam Bureau for their consideration based on their scientific and engineering experience with drawdowns. Based on observations made during this study, it is concluded that there is no biological benefit of deep drawdown for plant control in Ashuelot Pond, and no specific benefit of regularly scheduled deep drawdowns for plant control purposes.

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APPENDIX A

1991 DES ORDER RELATIVE TO DEEP DRAWDOWNS

State of New Hampshire
DEPARTMENT OF ENVIRONMENTAL SERVICES
WATER RESOURCES DIVISION
64 North Main Street
Post Office Box 2008
Concord, NH 03301-2008
603-271-3406

TTY/TDD 225-4033
Relay Service for Deaf/Speech Impaired

ROBERT W. VARNEY
COMMISSIONER
DELBERT F. DOWNING
DIRECTOR

FILE COPY

Lake Ashuelot Estates Association
P.O. Box 105
Washington, NH 03280

Re: Ashuelot Pond Dam
Washington, NH
Dam #245.05

NOTICE OF DECISION
Determination of Lake Level
Date: September 13, 1991

A. INTRODUCTION

This Determination of Lake Level is issued by the Department of Environmental Services, Water Resources Division ("Division") to the Lake Ashuelot Estates Association (Owner), pursuant to authority vested in the Division by RSA 482:79.

B. PARTIES

1. The Department of Environmental Services, Water Resources Division is a duly constituted administrative agency having a mailing address of P.O. Box 2008, 64 North Main Street, Concord, N.H. 03302-2008, and a telephone number of (603) 271-3406.

2. The Lake Ashuelot Estates Association is an association of homeowners and has a mailing address of P.O. Box 105, Washington, N.H. 03280.

C. STATEMENT OF FACTS AND LAW

1. The Lake Ashuelot Estates Association is the owner of the Ashuelot Pond Dam ("the Dam") in Washington, N.H., N.H. Dam #245.05 in the State dam inventory.

2. On October 16, 1990, the Division received a petition for lake level investigation of Ashuelot Pond in the Town of Washington ("the Petition").

3. In response to the Petition, the Division conducted a preliminary investigation of conditions affecting the use and enjoyment of Ashuelot Pond, and determined that a public hearing should be held.

4. The Division gave notice of the hearing as required by NH Code of Admin. Rules Env-Wr 208.03, and conducted the public hearing on July 12, 1991, ("the Hearing").

5. Ashuelot Pond is a "great pond" raised by damming. A great pond is defined as a fresh water waterbody of more than ten acres in its natural condition.

6. The State of New Hampshire claims ownership of the land and flowage rights to a point of 3.5 feet below the elevation of the two overflow spillways associated with the Dam at the pond's outlet.

7. The Lake Ashuelot Estates Association retains the flowage rights from a point 3.5 feet below the elevation of the two overflow spillways to the pin in the large boulder just upstream of the Dam.

8. The annual drawdowns, which have been conducted since the Lake Ashuelot Estates Association obtained ownership of the Dam and flowage rights, have reduced the amount of aquatic vegetation present in the pond.

9. The 1983 repairs to the stone spillways consisted of remortaring the voids between and beneath the stones. The repairs did not act to raise the spillway elevation.

10. Sand Pond in Marlow and Millen Lake in Washington, both located upstream of Ashuelot Pond, have annual fall drawdowns. Sand Pond's 15" drawdown begins the week after Columbus Day. Millen Pond's 30" drawdown begins the week before Columbus Day.

11. The Dam is registered with the Department of Environmental Services Water Resources Division.

12. The flowage rights of the Dam are as follows:

    The upper limit extends to the uppermost pin in the large boulder (historical marker) which is approximately 75 feet upstream of the Dam. This translates to 1.3 feet above the crests of the overflow spillways. The lower limit of the flowage rights extend to a point 3.5 feet below the overflow spillways.

13. At the July 12, 1991, Hearing, the Division received testimony that:

a. Reducing aquatic weed growth and guarding against future submergent and emergent vegetation is generally desired.

b. The three reasons that Lake Ashuelot Estates Association conducts the annual drawdown are weed control, flood control, and Dam repairs.

c. The pH levels were measured at 5.8 in 1977, at 5.3 in 1986, at 5.4 in 1989, at 5.3 in 1990 and at 5.4 in 1991.

d. The pH of the pond is having a negative effect on the pond's aquatic life.

e. The transparency of the pond seems to be decreasing. SECCI disk readings have been 4.5 in 1977, 3.5 in 1986, 2.45 in 1989, and 2.5 in 1990

f. The public boat launch which is adjacent to the right end of the Dam is nearly impossible to use when the pond is very low. This is due to the presence of large boulders and the proximity of the low level outlet intake channel to the Dam.

g. Due to changes in winter water levels of the pond, ice can become unsafe for recreation.

h. There is a historic marker (large boulder) about 80 feet upstream of the Dam. The marker contains a reference point for the water rights.

i. The utility of the two dry hydrants is adversely affected by drawdowns. The hydrants are presently inoperable. Fire department representatives stated that alternate sources of fire fighting water supply are readily available.

j. Repairs made to the two overflow spillways in 1983 resulted in higher pond elevations during low flow conditions due to reduced leakage.

k. Drawdowns of upstream ponds affect the ability to draw down the pond.

l. Lake Ashuelot Estates Association favors a 5 to 7 foot drawdown to be conducted every two years. The Lake Ashuelot Estates Association also stated that the drawdown should begin in mid-September.

m. Ashuelot Pond Association, another association of property owners, favors a drawdown to begin November 1 and which does not exceed three feet. The Ashuelot Pond Association also stated that refilling should begin thirty days after drawdown is reached.

D. DETERMINATIONS

1. Large drawdowns infringe on the ability of those who must use the spillway crests or boats to access their property.

2. The management and control of Ashuelot Pond is lawful and in the public interest, but changes in the manner of the exercise of the right of management and control would be of benefit to others without undue injury to the owner of the outlet.

3. Changes in the management and control of the outlet would not deprive the owner of the outlet or others of rights which they are lawfully entitled.

E. ORDER

Based on the Division's independent investigation and the testimony received at the Hearing, as summarized above, the Lake Ashuelot Estates Association is hereby ordered as follows:

1. The annual drawdown of Ashuelot Pond may begin no earlier than Columbus Day.

2. The drawdown may not exceed two feet below the elevation of the overflow spillways prior to November 1.

3. The total drawdown depth thereafter may not exceed 3.5 feet below the elevation of the overflow spillways.

4. Drawdowns below 3.5 feet may be conducted once every five years for the purpose of Dam repairs, aquatic weed control and maintenance of shorefront improvements. These deep drawdowns may begin prior to Columbus Day provided that notification is given by certified mail, return receipt requested, to the Division and the Town of Washington, and is posted in a place for public viewing no less than 30 days in advance. The first major drawdown shall begin in the Fall of 1991. Deep drawdowns for weed control and shorefront improvements shall be returned to not greater than 3.5 feet by January 1.

5. The boulder upstream of the Dam which is the reference for water rights shall and not be disturbed for any reason including Dam repairs or navigational improvements, (see attached photographs).

6. The pond shall be returned to normal operating level not later than June 1.

7. Notwithstanding Item E.4 above, unplanned drawdowns may be conducted at a greater depth or frequency should an emergency condition exist. The emergency shall be determined by the Department of Environmental Services, Water Resources Division based upon evidence provided by the Dam owner or upon its own investigation.

continued ...

Notice of emergency drawdowns shall be given by the Lake Ashuelot Estates Association as soon as practicable to the Town of Washington and to the public.

8. During periods of drought or flooding the level of Ashuelot Pond may fall below or extend above the limits set forth in this Decision. These conditions are considered to be natural occurrences and shall not be attributed to the Dam owner.

Kenneth Stern, P.E., Chief Engineer
Water Resources Division
Department of Environmental Services

KJS/SND/waf/0322V

cc. Barbara A. Wright
Town of Washington
Public Information Coordinator
Gretchen Rule, DES Enforcement Coordinator

APPENDIX B

DES WORKPLAN FOR ASHUELOT POND

ASHUELOT POND WORK PLAN
PREPARED: MARCH 2002

SAMPLING METHODOLOGIES

The evaluation of the effects of drawdown on the aquatic flora and fauna of Ashuelot Pond will be performed in accordance with the procedures described below. This evaluation will also take into account the recreational values and fire safety issues of Ashuelot Pond.

Sediment/Substrate Sampling

Sediment samples will be collected using an Eckman Dredge at randomly selected locations throughout the littoral zone of Ashuelot Pond during the summer of 2002. The purpose of this sampling will be to determine the sediment composition of the lakebed (muck, sand, gravel, rock, etc.). Plant and animal communities differ between substrate types, so it is important to establish the type and extent of sediments on the lakebed.

A visual examination of the collected samples will be conducted to determine the substrate type.

Plant Surveys

This study will employ two different plant sampling methods in an effort to quantify changes to the plant community that result from the drawdown. All plant sampling will take place during August and September during each year of the study.

General Plant Survey

Using the methodology from the NH Lake Assessment Program, the project coordinator will travel around the pond and river shoreline and map the locations, the relative abundance, and the genus of aquatic macrophytes. These data will be used to determine percent cover of each plant genus in Ashuelot Pond (this method was used to produce the maps that appear in Appendix A of this report).

Permanent Quadrant Sampling Stations

Permanent sampling locations will be established around the lake and river edge in areas that are representative of plant community types. Quadrant sampling will be used to determine plant species and their relative abundance within a 1-meter squared area.

A PVC-frame quadrant will be placed adjacent a buoy anchor during August of each year of the study, and plants within the quadrants will be analyzed to species level, and quantified. Sampling locations will be identified using GPS.

Macroinvertebrate and Crustacean Sampling Plan

Macroinvertebrate surveys will be conducted in the littoral zone to determine qualitative and quantitative information about the benthic fauna. These samples will be collected one time each summer for the duration of the study period. Samples will be collected in early August. The vegetated and open zones of the littoral area of Ashuelot Pond will be surveyed for macroinvertebrates in two ways:

<u>Sweep-netting</u>- Sweep nets will be passed through three permanent and separate beds of mixed emergent vegetation in the littoral zone. These three samples will be composited to represent the fauna present in these habitats. Samples will be rinsed through a #30 sieve and preserved in the field with 75% ETOH. Samples will be analyzed in the Limnology Center (unless funding is available for samples to be sent to a laboratory for sorting, identification, and enumeration).

<u>Shallow Lakebed Sampling</u>- Permanent macroinvertebrate sampling locations will be selected in three areas around Ashuelot Pond. D-nets will be dipped into the pond sediments in an area free of vegetation. Organisms disrupted from the sediments will be collected in the net. This method will be repeated in vegetated sites. The macroinvertebrate samples from the pond will be composited then rinsed through a #30 sieve. Samples will be preserved in the field with 75% ETOH. Samples will be analyzed in the Limnology Center (unless funding is available for samples to be sent to a laboratory for sorting, identification, and enumeration).

Freshwater Mussel and Snail Surveys

Freshwater mussel and snail surveys will take place one time each summer, in areas that will be permanently marked and sampled in early August of each year of the study.

Full-lake Mussel Surveys- Ten sampling locations will be randomly selected in the sandier littoral zone of Ashuelot Pond. During full pond (non-drawdown conditions), biologists will sample these locations using a one-meter squared PVC quadrant. Quadrants will be placed on the lake sediments in the selected locations, and the lake bottom within the quadrant will be examined for mussel and snail populations. Mussels and snails will be enumerated and identified in each quadrant, and results from each quadrant will be averaged to yield an estimated number of mussels and snails per unit area of lakebed.

Drawdown Mussel Survey- During full drawdown conditions, biologists will use the same ten areas of exposed lakebed for mussel sampling. The same methods as described above for full-lake sampling will be employed for drawdown sampling.

Fish Sampling

The New Hampshire Fish and Game Department will conduct an annual summer electro-shocking study at Ashuelot Pond to determine the species and approximate biomass of fish in the pond. The first sampling event will take place in September of 2001 to determine the status of the fish population following the winter 2000 drawdown. Another electro-shocking sampling event is planned for the fall months of alternate years of the study (2001, 2003, 2005) to determine the status to the fish population as a result of the drawdown.

Frog Surveys

NHDES will conduct a frog survey to determine the species and approximate numbers of frogs collected during a specified time period. NHDES will train volunteers around the lake to survey the frog population to determine the species and abundance of frogs. During July of each year of the study period, NHDES biologists and volunteers will conduct a one-day survey of the frog populations at Ashuelot Pond. Random locations will be selected around the pond and one-hour collections in each selected location will be performed. Frogs will be enumerated and identified from each sample location, and data from each location will be averaged to determine the number and type of frogs present during the specified sample timeframe.

Water Chemistry

As previously mentioned, Ashuelot Pond is involved in the VLAP program. Data collected each summer through the VLAP program will be collected and analyzed for changes in water chemistry throughout the study period. These data will be compared with historical data to assess water quality trends. A field biologist or intern will assist in sample collection during the duration of the study.

Lake Level Maintenance

The Dam Bureau will work with the dam owner to assess methods for a slow, regulated drawdown of the water level. The dam owners should maintain the drawdown rate to sustain and minimize the impacts to the aquatic biota. Biologists will try to determine the most beneficial drawdown depth and cycle that will maximize weed bed impacts.

Drawdowns will begin at a time designated by the NHDES Dam Bureau so as to coincide with drawdowns from ponds further up in the Ashuelot Pond watershed. Weather and other lakes in the watershed influence drawdowns. When it is determined that the adequate conditions have existed for plant impacts, the gates will be closed to allow the water to return to about three feet below the normal level of the lake. The top gate will remain open to allow for the release of the spring snowmelt.

Recreational Value Assessment

The Biology Section, along with input from both the APA and the LAE, will develop a survey to be distributed to all shoreline property owners during the summer of 2002. This survey will aim to determine the overall perception of current lake conditions, timing for drawdowns, perspectives on plant abundance, recreational uses, fire safety and an overall rating of the pond by the lake residents.

The survey will also have a section for lake residents to comment on their concerns relevant to lake management issues.

Reporting

Following the completion of the study, the NHDES will prepare a report of the findings. Data will be examined for the following:

- Drawdown impacts on the lake ecosystem
- Impacts to fire safety
- Recommendations on drawdown procedures

- Assessment of the recreational value and use of the lake
- Interim status reports will be provided to involved parties in February of each year

SECTION 7- PROJECT TIMELINE AND ACTIVITIES

Date	Activity
May 2001	DES Dam Bureau to determine discharge capacity of outlet
June 2001	General plant survey Collect water quality samples and oxygen measurements
July 2001	Establish sample locations and transects
August/September 2001	Conduct plant survey with density studies Collect water quality samples and oxygen measurements Biota studies Fish study
June 2002	Collect water quality samples and oxygen measurements
July 2002	Field investigation Mussel/Frog Surveys Collect water quality samples and oxygen measurements
August/September 2002	Conduct thorough plant survey with density studies Conduct biota studies Collect water quality samples and oxygen measurements
February 2003	DES to provide summary of Summer 2002 results
June 2003	Site inspection Water quality sampling
July 2003	Field investigation and plant survey Overall assessment of pond Mussel/Frog Surveys Oxygen levels Water quality sampling
August/September 2003	Thorough plant survey Biota studies Water quality sampling Oxygen levels Fish study
February 2004	DES to provide summary of Summer 2003 results
June 2004	Water quality sampling Site inspection
July 2004	Water quality sampling Mussel/Frog Surveys Oxygen levels
August/September 2004	Thorough plant survey Water quality sampling
September 2004	Deep Drawdown Mussel survey
February 2005	DES to provide summary of Summer 2004 results

Date	Activity
June 2005	Site inspection Water quality sampling
July 2005	Field investigation and plant survey Overall assessment of pond Mussel/Frog Surveys Oxygen levels Water quality sampling
August/September 2005	Thorough plant survey Biota studies Water quality sampling Oxygen levels Fish study

Pending completion of the tasks outlined above, NHDES will evaluate the data to determine if adequate information exists to recommend an appropriate drawdown practice for the pond. The need for the continuation of the data collection phase of this study will be determined at that time.

APPENDIX C

WATERSHED USER PERCEPTION SURVEY

NHDES

ASHUELOT POND SURVEY

Dear Resident of Ashuelot Pond Community and Watershed:

This survey is designed to provide a better understanding of the public awareness level concerning the conditions of Ashuelot Pond and how residents feel about the pond in general. Please take a few minutes to complete our brief survey, and be assured all your answers are strictly confidential. For each question please circle the appropriately numbered answer that best represents your opinion. When completed, please use the enclosed business reply envelope to return the survey. If you have any questions about the survey you may call Amy Smagula, NH Dept of Environmental Services, (603) 271-2248 or University of New Hampshire Survey Center, 1-800-786-9760. Thank you, in advance, for taking the time to complete this survey. The input of Ashuelot Pond residents and visitors such as yourself is vital to the success of this research.

Please complete and return this survey by September 30, 2004.

SECTION A

1. Where on the lake do you live?
(Refer to attached map)
1. Area One 2. Area Two
3. Area Three 4. Area Four
5. Visitor to the lake (not a resident)

2. Do you own or rent your property?
1. Own
2. Rent

3. Are you a:
1. Year round resident –**SKIP TO SECTION B**
2. Seasonal resident

4. If you are a seasonal resident do you spend your summers on the pond and the winters at home somewhere else?
1. Yes
2. No

5. What state is your primary residence in?
1. New Hampshire 5. Connecticut
2. Maine 6. New York
3. Massachusetts 7. Other _______
4. Vermont

6. If you are a seasonal resident, what seasons do you visit the pond?
1. Spring 3. Fall
2. Summer 4. Winter

7. If you are a seasonal resident is your home/cottage a seasonal or weekend retreat?
1. Entire Season(s)
2. Weekends
3. Both

8. How often do you visit your property?
1. Weekly
2. Monthly
3. Occasionally

9. When you visit how long do you usually stay?
1. 1-2 days 4. One month
2. One week 5. More than one month
3. 1-2 weeks

SECTION B

B1. How long have you (or your family) owned the property?

1. 0-5 years
2. 5-10 years
3. 10-20 years
4. over 20 years
5. Do not own
6. Don't know/Not Sure

B2. Is your property…

1. Lakefront
2. Riverfront
3. In the surrounding community

B3. If you do have waterfront access do you have a dock?

1. Yes
2. No

B4. If you do have waterfront access do you have a boat?

1. Yes
2. No

B5. If you do have a dock and/or a boat when do you put them in and out of the water for the season?

	IN	OUT
DOCK		
BOAT		

B6. Briefly describe the maintenance do you do on your dock? ______________________

____

____

B7. If you do not have waterfront access how often would you say you use the pond?

1. Daily
2. 1-2 times a week
3. 3-4 times a week
4. 5-6 times a week
5. Less than once a week

B8. How do you access the pond?

1. Someone else's waterfront property
2. Public Boat Launch
3. Public Right of way
4. Don't use the pond

B9. If you have a boat where do you launch it?

1. Someone else's waterfront property
2. Public Boat Launch
3. Public Right of way
4. Private boat launch
5. Don't use the pond

SECTION C

C1. Do you use the lake for any recreational activities?

1. Yes
2. No – **<u>SKIP TO C4</u>**

C2. What part of the lake do you usually use for recreational purposes? (Refer to attached map)

1. AREA 1
2. AREA 2
3. AREA 3
4. AREA 4
5. AREA 5

C3. From the list of activities below, please mark the appropriate column to indicate how many times you participate in that activity?

Activity	More than once per week	More than once per month	Only a few times per year	Never
Recreational Motor boating				
Paddle/row boating				
Kayak/canoeing				
Sailing				
Fishing/ice fishing				
Swimming				
Observing wildlife/nature				
Pond as a water source				
Pond as a means of transportation				
Hunting (Fowl)				
Cross-country skiing				
Snowmobiling				
Other (please specify)				

C4. Do you ever use the Ashuelot River as it flows into the pond?

1. Yes
2. No

C5. From the list of activities below, please mark the appropriate column to indicate how many times you participate in that activity?

Activity	More than once per week	More than once per month	Only a few times per year	Never
Recreational Motor boating				
Paddle/row boating				
Kayak/canoeing				
Sailing				
Fishing/ice fishing				
Swimming				

Activity	More than once per week	More than once per month	Only a few times per year	Never
Observing wildlife/nature				
Pond as a water source				
Pond as a means of transportation				
Hunting (Fowl)				
Cross-country skiing				
Snowmobiling				
Other (please specify)				

C6. Do you fish on the pond?

1. Yes
2. No

C7. If you do fish what kinds of fish do you catch?

1. Bass
2. Pickerel
3. Suckers
4. Sunfish
5. Hornpout (Catfish)
6. Other ___________________

C8. Have you noticed a decline in the number of fish caught? (If so, since when?)

1. Yes
2. No

Date ______________

C9. Have you seen a decline in wildlife around the pond? In the pond? (If so, since when?)

1. Yes
2. No-**SKIP TO D1**

Date______________

C10. If you answered yes to C9, what type of wildlife have you seen a decline in. (Circle all that apply)

1. Fish
2. Mussels
3. Frogs
4. Salamanders
5. Mammals
6. Other _______________.

SECTION D

D1. How does your property obtain water?

1. From the pond
2. Carried in
3. Dug well
4. Drilled well
5. Don't now/not sure

D2. How does your property dispose of wastewater from sinks and showers?

1. Septic System
2. Cesspool
3. Sealed Holding Tank
4. No Sewer System
5. Other ____________
6. Don't know/Not sure

D3. What type of sewer system does your property have?

1. Septic System
2. Cesspool
3. Outhouse
4. Sealed Holding Tank
5. No Sewer System
6. Other _____________
7. Don't know/Not sure

D4. How old is your sewerage system?

1. 1-5 years
2. 5-10 years
3. 10-20 years
4. Over 20 years
5. Don't know/Not sure

D5. As you may know each fall there is a drawdown of water from the pond. Does this have any impact on your recreational activities?

1. Yes
2. No

D6. Does this drawdown have any impact on firefighting or fire safety for your property?

1. Yes
2. No

If Yes, please explain________________________
____
____

D7. If a fire did occur would the pond be the main source of water to fight the fire on your property?

1. Yes
2. No

D8. Is there road access for fire trucks to reach your property?

1. Yes
2. No

D9. Would a pump boat be necessary to fight a fire on your property?

1. Yes
2. No

D10. Do you have any objections to the pond drawdown that were not covered?

1. Yes
2. No

If Yes, please explain _____________________
____

D11. Do you believe that deep drawdowns help control the amount of aquatic plants in the pond and river ?

1. Yes
2 .No

D12. Do you see aquatic plants in the pond?

1. Some
2. More than usual
3. Over abundance

D13. Do aquatic plants wash up on your shore?

1. Yes
2. No-**Skip to D15**

D14. If aquatic plants do wash up on your shore, how often do you see them?

1. Several times a day
2. Once a day
3. Once a week
4. Monthly
5. Never
6. Other ________________.

D15. If you do see weeds, in what area do you see them? (REFER TO MAP)

1. AREA ONE
2. AREA TWO
3. AREA THREE
4. AREA FOUR
5. AREA FIVE

D16. Are the weeds that are washing up on your shore…

1. Floating plants?
2. Rooted plants?
3. Floating and rooted?
4. Don't Know/Not Sure?

D16. Has the presence of weeds in the pond had any impact on your ability to use the pond for recreation?

1. Yes
2. No – **SKIP TO D18**

D17. If yes, please explain:________________________
____
____

D18. What do you think of the quality of the pond water?

1. Excellent
2. Good
3. Fair
4. Poor
5. Very Poor

D19. What do you see as the most important water problem?

1. Plants
2. Color
3. Odor
4. Clarity
5. Bottom (Mucky)
6. No problems

D20. Do you use fertilizer or other chemicals on your property?

1. Yes
2. No

D21. If yes, please circle what type you use?

1. Herbicides
2. Fertilizers
3. Lime
4. Pesticides
5. Other _____________

Thank you very much for completing the survey. Please return it in the enclosed self addressed stamped envelope, or mail to: The Survey Center

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Durham, NH 03824-9987