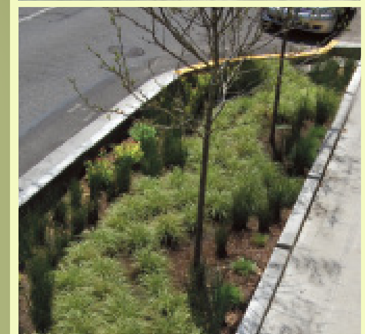
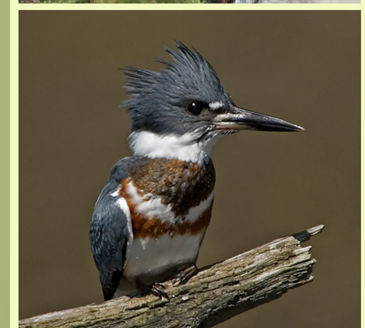
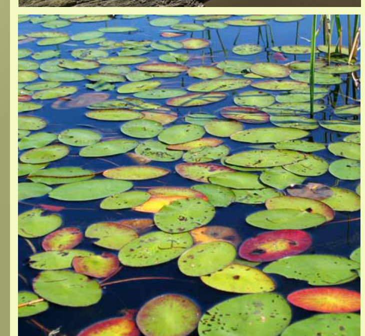
Planning for Effective Pond Management in the Salem Sound Watershed







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Tufts University and Salem Sound Coastwatch

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Abstract

This report articulates common problems of pond management in the Salem Sound Watershed or other urban and suburban environments. Accordingly, it recommends solutions to the non-profit watershed organization Salem Sound Coastwatch (SSCW), conservation commissions, and interested citizens. The analyses and recommendations are based on findings from a case study, interviews, and a review of applicable technical manuals and of local and state regulations. Because controlling non-point sources of pollution is vital to the long-term health of ponds, the research team advocates for a whole watershed approach to pond management. This requires collaboration between municipalities and groups such as SSCW to develop detailed plans for pond management and watershed protection. Essential elements of the planning process include gathering scientific data, evaluating short-term treatment options, developing implementation and evaluation strategies, and selecting long-term regulatory and non-regulatory solutions. To avoid controversy or conflicts, SSCW can facilitate a productive dialogue between different groups. Thus, SSCW should continue to provide unbiased technical assistance, and may expand their role as an educator and liaison among various municipalities, state agencies, and citizens.

Executive Summary

In competing for the finite attention and resources of decision-makers, small ponds often play second fiddle to other natural resources. This report examines the role of small urban and suburban ponds—both unto themselves and in their watershed contexts. We review typical problems that arise, and appraise both short-term and long-term pond maintenance strategies. Our focus is on the Salem Sound Watershed and the non-profit organization that serves it, Salem Sound Coastwatch. For this organization, for conservation commissions, and for interested citizens, we make recommendations about pond management, long-term watershed planning, the coordination of local and regional efforts, the design of streamlined strategies, and effective opportunities for public participation.

Our methodology in producing this report began with an investigation into the heated controversy over the management of Black Joe's Pond, a small urban pond in Marblehead, Massachusetts. For this case study, we looked at all of the various documents that pertain to the case, such as letters and legal notices, in the Marblehead Conservation Commission's archives. We also interviewed the various stakeholders. Then, to broaden our understanding of local pond management efforts and issues, we spoke with members of conservation commissions in the Salem Sound Watershed, as well as with other watershed protection groups in Eastern Massachusetts. Through our research, we discovered that conservation commissions face a number of challenges in protecting the long-term health of public ponds, including:

- A lack of scientific and technical expertise to effectively weigh treatment options;
- Severe time, resource, and budget constraints;

- Reliance on treatments with only short-term effectiveness;
- Differing opinions or lack of interest within communities;
- The lack of a clearly articulated vision or plan for how their ponds should be managed; and
- State-level legislation in Massachusetts that undermines communities' ability to develop comprehensive plans that make sense.

Rather than attempting to tackle these problems on their own, we recommend that municipalities collaborate with local and regional entities to develop management plans for ponds under their jurisdiction. Municipalities should seek to create policies that provide guidance for and disclosure of management practices. To identify potential management strategies, we conducted a thorough review of relevant state and local regulations and consulted technical manuals, including the existing local guides about water resource management. Based on this information, we offer a set of general criteria for crafting an effective management plan, providing specific guidance for:

- Establishing volunteer monitoring programs for collecting data and increasing public participation;
- Selecting and implementing appropriate management practices to remedy pond problems in the short term;
- Identifying and implementing holistic solutions for long-term watershed health; and
- Applying regulatory and non-regulatory tools to better protect wetland resources.

Throughout our report, we consider how Salem Sound Coastwatch might expand its role in the conservation of inland waters by coordinating watershed management planning and providing technical expertise.

Introduction

Consider the small urban pond. It provides ecological, recreational, and aesthetic value, just as any large pond, lake, or river does, though it rarely achieves the same prestige. Like these larger bodies, it is susceptible to the ills of built-up environments, and, because of its small size, is often even more vulnerable. Because a small pond is typically not widely known or used, its management is sometimes at the mercy of the few community members who wish to manage it for a specific use, disregarding its connection to the watershed and surrounding ecosystem. Yet, ponds are not proverbial islands—they feed into broader systems. In this report, we shine a light on the unsung urban pond and consider its role in the wider watershed.

The seed of this project was a heated debate over the management of one particular small pond, Black Joe's Pond in Marblehead. Residents became concerned when Black Joe's began to show signs of eutrophication, a process by which an excess of nutrients causes algae and aquatic plants to proliferate, reducing the amount of oxygen in the water. In April 2006, Marblehead resident Craig Campbell filed a Notice of Intent with the town's Conservation Commission to apply herbicides and algaecides to Black Joe's Pond. Mr. Campbell and some of the private abutters, forming a group called Preservation and Restoration of Marblehead Ponds Today (PROMPT), urgently feared that the pond's eutrophication would cause it to become a wet meadow if it were not treated immediately with chemicals. In June 2006, the Conservation Commission gave them permission to apply herbicides and algaecides to the pond. Yet, four years later, Black Joe's had not been touched, and a debate over its management had snowballed into such controversy that it had been kicked upstairs to the Massachusetts Department of Environmental Protection.

Introduction

Why did a simple request to treat a small pond in Marblehead end up in a state-level hearing? An examination of the Black Joe's Pond conflict reveals its complications and nuances. At Black Joe's, almost no step the process went unchallenged. The most formidable challenger to Mr. Campbell's campaign was a group of residents who opposed the use of chemicals on the pond and emphasized the need for water quality monitoring. In Part I of this report, after a survey of general pond characteristics and uses, we study the Black Joe's controversy in greater detail and consider its lessons for pond and watershed management planning.

We also review other specific and potential pond management issues faced by conservation commissions in the Salem Sound Watershed. Salem Sound, a relatively shallow and well-flushed embayment in the north shore of Massachusetts, is fed by the freshwater inputs of six communities, as shown in Figure A.1.

Throughout this report, we identify ways in which Salem Sound Coastwatch (SSCW), a watershed organization, can reinforce and expand its role among these communities, such as by continuing to support scientific data gathering and facilitating a regional dialogue about watershed management. To be most effective, a small non-profit such as SSCW requires the cooperation and participation of different agencies and the public. In Part II of this report, we provide guidance on collecting pond data, on various short- and long-term management schemes, and steps to developing a management plan—all of which may engage decision-makers and interested citizens. Finally, we consider the regulatory climate in which SSCW and municipalities must operate, and suggest tools for overcoming its obstacles in order to promote comprehensive pond and watershed planning.

Figure A.1: Map of Salem Sound Watershed Hydrography (Data from MassGiS and Salem Sound Coastwatch)

Part I:

The Pond Situation in Salem Sound Watershed

Part I of this report introduces the physical, chemical, ecological, and social aspects of ponds in general. We then focus on a specific pond, Black Joe's in Marblehead, and parse the four-year controversy over its management. Finally, we use our conversations with conservation commission members in Salem Sound Watershed and two watershed organizations to understand the current state of pond management in the region.

Chapter One:

Ponds: Characteristics, Threats, Values, and Uses

To optimize a pond's management, it is vital to understand the pond's physical and chemical attributes, its importance both to the ecosystem and to its human users, and any potential threats to its current value.

Characteristics of Urban Ponds

Physical Characteristics

The majority of the lakes and ponds in Massachusetts were glacially formed between 10,000 and 20,000 years ago. Glacially deposited mounds called moraines dammed rivers and streams to create lakes, while the retreating glaciers also carved gouges in the landscape. Kettle ponds formed when large chunks of ice broke free from the glaciers and melted, forming deep depressions in the earth. Humans have also played a role in creating ponds by damming streams and rivers. In Massachusetts alone, there are over 2,900 private and public dams (Fischer and Yoder 2010). Many ponds in Massachusetts are primarily fed by groundwater and supplemented by precipitation and surface water overflow.

Pond depths are categorized into different zones. The open water area is called the pelagic zone. The inshore area where light is able to penetrate to the bottom, and where large rooted plants thrive, is the littoral zone. The bottommost layer of the pond, usually overlain with fine sediments, is called the benthic zone (Fischer and Yoder 2010).

Chemical Characteristics

Chemical features such as light, temperature, acidity, and nutrient content are significant to both the health and character of a pond. Physical, biological, and geological processes control the internal chemistry of a pond. Geologic inputs, such as the type of bedrock and surrounding soils influence the acidity of the water body. For example, many ponds in New England, including many in the Salem Sound Watershed are underlain with granite, which can increase the water's acidity (Mottana et al. 1978, 442-444). Chemical reactions, such as the decay of biological material in the pond, affect the amount of dissolved oxygen in the water column, affecting the growth of aquatic plants and the life cycle of other species.

Use and Values of Urban Ponds

Ponds, especially those in urban environments, are a limited natural resource and deeply important to people for a variety of reasons. Urban ponds—a term which, for the purposes of this report, also includes ponds in suburban environments—provide a welcome natural environment within a built-up area. Ponds in the Salem Sound Watershed are used for many recreational pursuits such as fishing, swimming, bird watching, and model boat racing. Even a pond as small as the one-acre Black Joe's Pond offers the opportunity for recreational use—Marblehead's Director of Public Health, Wayne Attridge, joked that "the biggest things you'll harvest out of Black Joe's are hockey pucks" (Attridge 2010).

Despite their small size, ponds provide the habitat for a wide variety of species. The value of preserving such a diverse ecosystem cannot be ignored; Massachusetts' lakes and ponds are home to hundreds or organisms including over 170 vertebrate and invertebrate, and 250 plant species that are endangered, threatened, or of special concern (MassWildlife 2009). A pond's value is increased by the ecological benefits it provides, including the purification of air and water, decomposition of waste, maintenance of biodiversity, and regeneration of soil fertility (Daily et al. 1997, 3-16).

Property values may help to approximate the economic value of a pond. A recent study estimates that ponds can increase the value of real estate anywhere between three and thirty-five percent, based on the size of the pond, its proximity to the house, and its health and physical appearance (Pond Owner Magazine 2010). Likewise, a pond suffering from severe biological problems may cause a decline in property values. Presenting this economic valuation could be a useful strategy to garner support for a pond management plan.

Threats to Health and Longevity

Invasive or Unwanted Species

Within the diverse collection of species in pond ecosystems, both native and non-native species may be present. Native species are those that are indigenous to that ecosystem. Non-native species are not indigenous to the ecosystem in which they are located, but have been introduced or have spread outside their normal range (Watershed Academy Web 2008). An invasive species is a non-native species "whose presence in the environment causes economic or environmental harm or harm to human health" (Watershed Academy Web 2008). Invasives species can reduce biodiversity and diminish or even eliminate other species or a particular ecological service in an ecosystem (Watershed Academy Web 2008). The introduction of a non-native species, to which the ecosystem is not adapted, can have dramatic effects on the biological interactions within a pond ecosystem. The survival of a non-native species is not guaranteed, but when these species do succeed in a new environment, they can often outperform native species and establish dominance. Reducing or eradicating unwanted species, both native and non-native, is often a primary goal of pond management plans.

Urban Runoff

Watersheds in urban or suburban settings face a special set of challenges due to their altered hydrology, habitat fragmentation, and especially high impervious area. Rooftops on houses and buildings, roads, parking lots, and driveways all contribute to the total impervious area of a region. Thus, total runoff is considerably greater in built environments than rural environments, putting nearby ponds at particular risk for contamination and eutrophication.

The natural hydrology of a watershed is altered when impervious surfaces intercept precipitation in urban environments. Figure 1.1 compares the hydrology of developed areas with that of undeveloped areas and shows that runoff is significantly increased post-development. The Massachusetts Water Resources Commission (WRC) categorizes the majority of water basins in Massachusetts as stressed, meaning that "the quantity of streamflow has been significantly reduced, or the quality of the flow is degraded, or the key habitat factors are impaired" (Water Resources Commission 2001). Increased impervious area reduces infiltration, reduces groundwater recharge, and reduces streamflow. Increased sources and transport of pollution, as well as decreased treatment, are also associated with post-development increases in impervious surface cover.

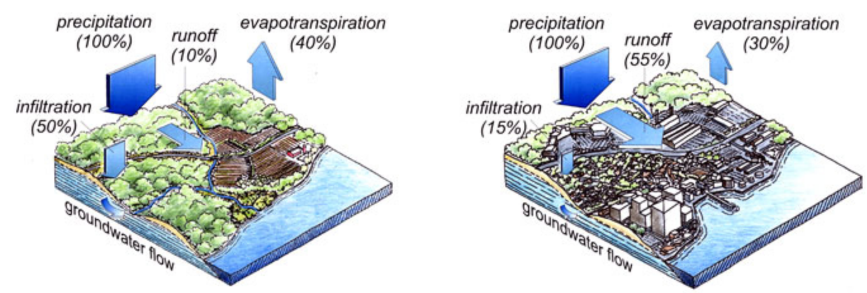

Figure 1.1: A comparison of natural state and post-development hydrologic conditions. (Source: Smart Growth / Smart Energy Toolkit 2007 http://www.mass.gov/envir/smart_growth_toolkit/pages/mod-lid.html)

The most significant damage to ponds occurs in the early stages of stormwater runoff. The first half-inch to inch of runoff that flows over land and enters the pond system is termed the "first flush" and carries approximately ninety percent of the total pollutant load during a storm event (Environmental and Conservation Services Department 1990, 3). The process of infiltration through a vegetated medium provides both physical and biological treatment to stormwater, especially the first flush, removing and treating the runoff water. Not only do impervious surfaces take away these treatment opportunities, they facilitate the direct flow of polluted waters into surface water bodies. Impervious surfaces can increase the velocity at which runoff flows into surface waters and paved surfaces can heat the water. The increased turbidity and heat of the runoff can have detrimental effects in a pond environment, primarily fish habitat degradation.

Eutrophication

Both phosphorus and nitrogen are naturally occurring and crucial to the survival of the ecosystem as they are necessary for plant growth, but in excessive amounts they become pollutants. As explained in the Introduction and depicted in Figure 1.2, eutrophication is a common process, by which an excess of these nutrients—especially phosphorus—causes aquatic plants and algae to proliferate, depleting oxygen levels in a pond. Though eutrophication is a natural process, it may be considered anthropogenic when it is accelerated by urban development or other human activities. Typically, eutrophication is observable as algal blooms and excessive plant growth.

When the algae and plants decompose—an oxygen-dependent process that decreases the amount of dissolved oxygen present in the water column—the habitat is degraded, organisms living in the pond are harmed, and the release of internal phosphorus in the pond is accelerated. Eutrophic ponds are weedy and susceptible to frequent and pervasive algal blooms as well as winterkill, which reduces the amount and diversity of species (Scholten et al. 2005, 1). Conditions often considered undesirable by humans, such as odor, anoxic (oxygen-deprived) conditions, and high turbidity, are associated with eutrophic waters. Stopping eutrophication and reversing its effects are often the main goals of pond management plans. However, restoring a pond to a completely non-eutrophic state is not a realistic goal. Controlling the sources of eutrophication, on the other hand, and eliminating other threats to pond health are viable and worthwhile goals.

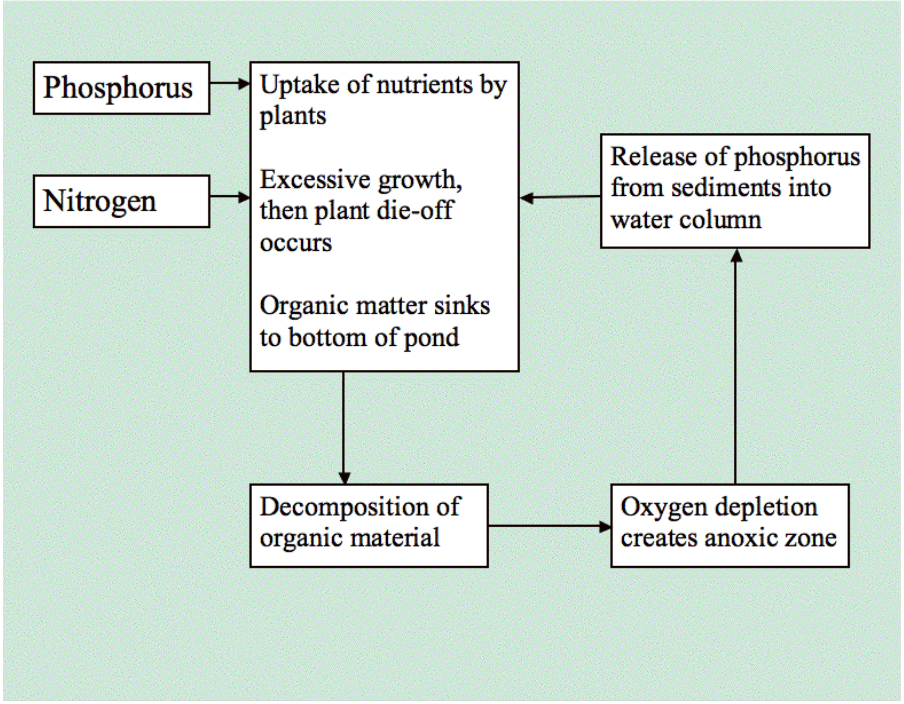

Figure 1.2: Simple model of eutrophication.

Chapter Two:

Black Joe's Pond: A Case Study in Urban Pond Management

In this chapter, we examine the controversy over Black Joe's Pond[1] in closer detail. We find that the bitter disagreement between different groups about a pond management strategy led to a delay in both short-term treatment and actions that might benefit the long term health of the pond. However, the conflict provides insight into a decision-making process that is relevant for any urban pond and can be used to circumvent similar disputes in the future.

Location, Condition, and Uses

Black Joe's Pond is located in the Gingerbread Hill neighborhood of Marblehead, less than a half-mile from the coast. The pond is one acre in size and has an average depth of two feet. It is fed mainly by groundwater, surface runoff and, though there is apparently no continuous inflow, a drain coming from a graveled dead-end road. It has one outlet with a small dam located on an abutting property. This outlet controls outflow into Doliber's Cove to the east via a culvert (B. Warren, pers. comm.).

The ecological condition of Black Joe's Pond is not unusual, considering its size and depth. It shows signs of eutrophication and is becoming shallower. Algae and watershield, a native plant, have covered as much as seventy to ninety percent of the pond in the summer months. (B. Warren, pers. comm.).

1 The pond's name comes from Joseph Brown, an African-American Revolutionary War veteran and resident of Marblehead, who owned and operated a popular tavern in the late 18th early 19th centuries (Wellinger 2010). His wife, Lucretia Brown, was a professional baker whose "Joe Frogger" cookies are still a beloved tradition in Marblehead (Klein 2010). The historic Black Joe's Tavern building exists today as a residence (B. Warren, pers. comm.).

Figure 2.1: Aerial Photograph of Black Joe's Pond, showing inflow and outflow points (Images from MassGIS)

Residents are also concerned about the pond losing depth from sediment build-up. Some attribute this to excessive "weed" and algae growth, and at least one person has pointed out that leaf litter may contribute to the build-up (Attachment A, Notice of Intent; Field 2010).

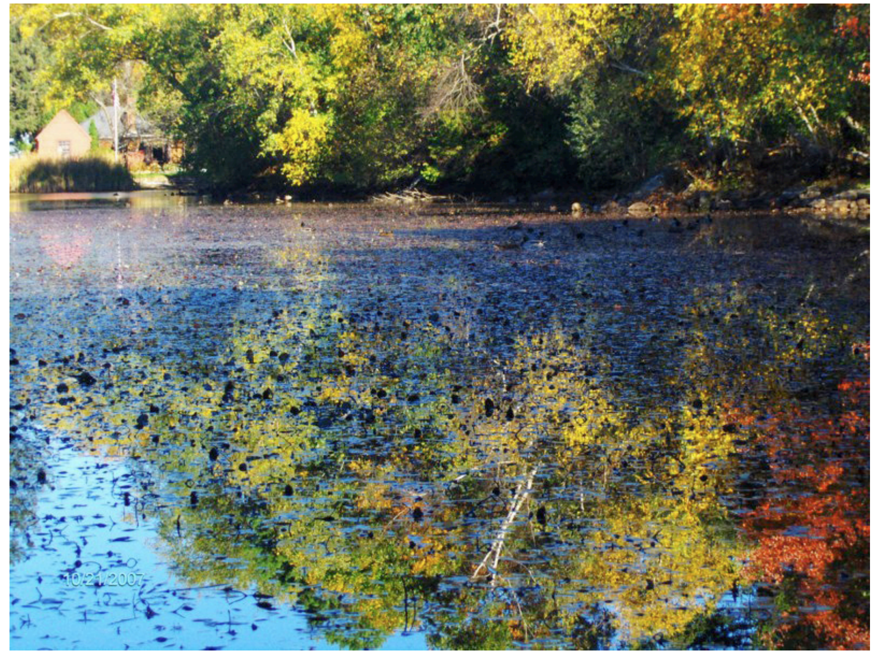

Figure 2.2: Photograph of Black Joe's Pond. (Source: Mary Claire Wellinger)

Abutters and residents of the neighborhood use the pond year-round for skating, fishing, rowboating, wildlife viewing and nature walks. Historic preservation, aesthetics, maintenance of property values, and ecological services are also part of the pond's value.

The Dispute

A complete account of the four-year dispute over Black Joe's Pond is not possible in this space, but a basic version of the story is necessary. A chronology of the major events can be found in Appendix A.

On April 12, 2006, lawyer and Marblehead resident Craig Campbell filed a Notice of Intent (NOI) for a treatment plan of Black Joe's Pond. The NOI cited eutrophication as a risk to the long-term health of the pond and recommended the chemical treatments diquat dibrombide, glyphosate, liquid copper algaecide and buffered alum (Notice of Intent 2006).

At first, Mr. Campbell's request generated confusion over who actually owns Black Joe's Pond, which, given Marblehead regulations, is germane to its management. Town-owned property is subject to Marblehead's Organic Pest Management (OPM) regulation, which requires an organic management plan unless a waiver is obtained from the Board of Health.

In June 2006, after resolving whether or not Black Joe's was subject to the OPM regulation, the Conservation Commission issued an Order of Conditions (OOC) granting Mr. Campbell permission to use chemicals on the pond but with special conditions. Among these conditions was the requirement that all of the pond's owners—that is, the five private abutters and the town—consent to Mr. Campbell's plan to use herbicides and algaecides (Order of Conditions 2006).

Mr. Campbell, who is not an abutter to the pond but lives nearby, was initially unable to obtain consent from all five of the private abutters. He formed a pro-chemical treatment group called Preservation and Restoration of Marblehead Ponds Today (PROMPT), comprising some of the abutters and other residents. Meanwhile, resident Maryclaire Wellinger, on behalf of herself and fifty-four others, petitioned the Massachusetts Department of Environmental Protection (MassDEP) to overturn the OOC and prohibit any chemical treatment. Ms. Wellinger's appeal cited concerns about introducing toxins into the juvenile lobster nursery in Doliber's Cove, and the potential for glyphosate, a proposed treatment, to be an endocrine disruptor (Wellinger 2006).

Another resident likewise petitioned against the use of chemicals on Black Joe's Pond (Bohnert 2006). Mr. Campbell also appealed the OOC to have the special condition of full owner consent removed (Campbell 2006).

With the fate of the OOC in the hands of MassDEP, the Conservation Commission attempted to move forward on pond assessment and evaluation. They formed a pond committee, had Salem Sound Coastwatch modify a Quality Assurance Project Plan (QAPP)—a water quality monitoring protocol—for Black Joe's Pond, and enlisted the help of Salem State College professors (B. Warren, pers. comm.).

Monitoring began in April 2007 and was scheduled to conclude that fall. In May, Salem State College professors with students were conducting water quality tests at the pond when they were confronted by a couple of abutters. The abutters were reportedly so hostile and intimidating that the professors, concerned about the security of their equipment, removed it from the pond (B. Warren, pers. comm.; J. Hubeny pers. comm.).

Shortly thereafter, MassDEP issued a Superseding Order of Conditions (SOC) approving the OOC's one-year chemical treatment of the pond. Still, PROMPT had to obtain consent from all five private abutters, as per the OOC's special requirement. In July of 2007, after a year had gone by without full approval from the abutters, the Conservation Commission rescinded its approval for an herbicide application (Conservation Commission 2007; Bingham 2008).

Eventually, all five abutters agreed to the chemical treatment plan, and the Conservation Commission then reinstated its approval, at last satisfying the OOC's special condition of full owner consent. However, the legal battle between Craig Campbell, on behalf of PROMPT, and the petitioners, delayed any treatment to the pond. In February 2010, the MassDEP's Office of Appeals and Dispute Resolution finally held a hearing to settle the dispute.

The hearing concluded in late March, and on April 2, the MassDEP issued a Recommended Final Decision "dismissing the petitioners' appeal and affirming the SOC" (Recommended Final Decision 2010, 31). Though the SOC grants permission to selectively use herbicide treatments, it also requires a long-term management plan that incorporates data from scientific pond studies, includes public input, considers alternatives to herbicide treatments, and utilizes existing local management guides (Recommended Final Decision 2010, 28-29).

Discussion

Over time, three questions dominated the discourse about the management of Black Joe's Pond:

- Who owns the pond and thus decides what its management scheme should be?
- Does its eutrophication actually represent an ecological emergency?
- What strategies should be used to manage the pond's ecological problems and desired uses?

Several elements of the story conspired to make these questions difficult to answer, drawing out the case and confusing many of the people involved.

The petitioners argued that the pond is of consequence not only to the abutters, but to the many Marblehead residents who use the neighboring conservation land, as well as to a larger ecological system that would be endangered by the introduction of chemicals. PROMPT, on the other hand, asserted that the pond's ecological system and its very existence as a pond were threatened instead by its eutrophication. The urgency of the situation, they argued, warranted the swift and aggressive action of at least one chemical treatment. Mr. Campbell reduced the petitioners' argument this way: "Their whole argument rests on whether there'd be a greater risk to lobsters than benefit to wildlife in the pond. Is the risk great enough to outweigh the benefits of treatment? I think we'll be able to show the likelihood of discharge is extremely small" (Zolot 2010).

The petitioners identified several alternatives to chemical treatments, but none gained any ground with PROMPT, who were committed to using herbicides and algaecides. PROMPT benefited from having this single conventional agenda, as well as a steadfast leader. Meanwhile, the petitioners never rallied behind any single alternative, but they strongly agreed that scientific monitoring should precede any treatment decisions. Thus, the ostensible abandonment of monitoring efforts was destabilizing to the petitioners' campaign.

At its heart, the Black Joe's conflict had a substantive disagreement about pond management practices. In a way, however, the situation may have been most corrupted by the ill will on both sides. Meeting minutes, email exchanges, our interviews, and a series of letters published in the Marblehead Reporter reveal just how acrimonious the conflict quickly became. Some interactions, such as the interception of Salem State's scientific monitoring efforts, evinced a deep distrust on the part of some. The distrust and the lack of a constructive dialogue between different groups made both short-term and long-term pond management planning very difficult.

MassDEP's affirmation of its original Superseding Order of Conditions clearly benefits PROMPT, though the requirements for scientific data collection, monitoring and long-term planning may give those in the anti-chemical camp a foothold in the long run. In any case, we expect that the establishment of a long-term management plan will be less contentious than the selection of a short-term strategy has been. And though the four-year story of this conflict is complicated, the causes and amplifiers of the conflict can be easily distilled:

- Differing perceptions about how a particular treatment, or lack thereof, affect the pond's ecological value or recreational uses;
- Differing ideologies about pond management;
- Despite wide agreement that eutrophication was a problem, a disagreement about the extent of the problem and what it threatened;
- A lack of constructive dialogue between the groups;
- A complex and lengthy appeals process.

Understanding these causes may be generally instructive for other pond management disputes. Additionally, we believe that a group like Salem Sound Coastwatch can offer valuable field support and guidance to promote successful management solutions which would be broadly accepted. In the next chapter, we describe other pond and watershed management issues in the Salem Sound Watershed. In Part II of this report, we offer guidelines for developing a management plan.

Chapter Three:

Management throughout the Salem Sound Watershed

Understanding conservation commissions' perspectives about pond management is useful for Salem Sound Coastwatch in assisting and advising these groups. We spoke with members of four of the conservation commissions in the Salem Sound Watershed, as well as two local watershed associations, about their experiences with pond management. From these interviews we identified certain themes, such as time and funding limitations and a desire for expert assistance. In this chapter, we discuss these findings.

Conservation Commissions

In Massachusetts, the primary function of local conservation commissions is to administer the state's Wetlands Protection Act (WPA). They must approve of any development in or near wetlands, floodplains, riverbanks, beaches and surface waters (Massachusetts Association for Conservation Commissions). They also enforce any additional wetlands protection regulations and bylaws specific to municipalities. The WPA and other local wetlands legislation within the Salem Sound Watershed are discussed in greater detail in Chapter Seven of this report.

We interviewed an administrator from each of the conservation commissions of Peabody, Salem, and Beverly. We also interviewed a former Chair of the Marblehead Conservation Commission who was involved with the Black Joe's Pond controversy.

Pond Problems in Salem Sound Watershed

All of the conservation commissions reported eutrophication, sedimentation, and/or invasive species in ponds within their borders. Some members specifically identified nutrient loading from stormwater runoff as a contributor to eutrophication (Callahan 2010; Maxner 2010).

For example, in addition to Black Joe's Pond, both Redd's Pond and Whittier's Pond in Marblehead are eutrophic (Haug 2010). In Salem, town-owned ponds located in the Greeland Cemetery are eutrophic, while two privately owned ponds, Mills and Rosie's, have stands of phragmites, an invasive grass (Duques, 2010). Citizens in Salem have also expressed concern about potential eutrophication in Anderson's Pond, prompting the Salem Conservation Commission to explore options for assessment and treatment of the pond, however the commission lacks the funding for either of these actions. (Duques, 2010).

In Peabody, the Conservation Commission has focused on long-term stormwater management and education about landscaping and lawn care practices for private property owners. However, an initiative to address the eutrophication at Crystal Lake via stormwater management and Low Impact Development (LID) projects was not sustained (Callahan 2010).

Community Responses to Pond Treatment Decisions

Chemical treatments have been used on numerous ponds in the region. In general, we found that pond treatment decisions have not been widely known or controversial. The controversy over Black Joe's Pond was clearly exceptional. The members we interviewed mentioned only a handful of cases in which the public responded negatively to a treatment. For example, in Salem's Greeland Cemetery ponds, a heavy dose of chemicals one year resulted in a fish kill that caused cemetery visitors to complain. Since then, the chemical applications have been more carefully administered, and there haven't been any other complaints (Duques 2010). In Beverly, a resident concerned about using chemicals was appeased by the Conservation Commission's condition that abutters stop using chemicals on their lawns (Maxner 2010). Finally, after the dredging and stormwater management proposals for Peabody's Crystal Lake failed to gain ground, chemical treatments were considered. Though there was some disagreement about this option, a management plan that includes chemical treatments was eventually approved without much friction (Callahan, 2010).

Some disagreements, as we saw in our case study of Black Joe's Pond, may have to do with different aesthetic expectations of pond, and whether or not a particular management strategy can meet those expectations. For example, the Peabody Water Department oversaw the restoration of Spring Pond after sludge from the city's water treatment plant had been dumped there for several years. Even though MassDEP declared the restoration project complete, commenters on the Peabody Roundtable blog disagreed about this, and about what the pond should look like in its "natural" state (Peabody Roundtable Blog 2009).

Outside Assistance

The tenure of conservation commission members is fairly short, which can add to difficulty and inconsistency in making pond management decisions. They also have a heavy workload for a volunteer board. Permitting takes up most of the commission members' time, making it difficult to devote time to pond management. In Beverly, the commission attempted to address this problem by hiring a consultant to assess Norwood Pond, the largest of its ponds (Maxner 2010). Derosa Environmental of Ipswich, MA has consulted on other pond management projects in the Salem Sound Watershed, and is known for being sensitive to ecological issues (Duques 2010). However because of the expense, this strategy seems to be reserved for large recreational ponds.

Watershed Associations

Watershed associations often focus on the watershed surrounding a specific river, and have little involvement with ponds. In some cases, a pond association for a specific pond is formed under the auspices of a watershed association. We spoke with members of the Neponset River Watershed Association and the Charles River Watershed Association for their perspectives.

The Neponset River Watershed Association (NRWA), based in Canton, is primarily concerned with the Neponset River. However, the association owns Willett Pond, a 250-acre pond bordering Walpole, Norwood, and Westwood (Cooke, 2010). The pond was artificially created by a dam, and maintenance of the dam has been the most costly management task for NRWA. Though the environmental health of the pond is generally good, managing the use of the buffer strip by approximately ninety abutters surrounding the pond has been challenging. Executive Director Ian Cooke explains that having a dedicated staff to reach out to the abutters "so they know the rules" is essential (Cooke, 2010).

Generally, in managing Willett Pond, the NRWA faces many of the same difficulties that conservation commissions face. For this reason, the NRWA has debated, internally, the value of owning the pond. Mr. Cooke explained that they don't see pond management activities as "terribly distinct from other watershed management activities," and are more inclined to focus on the sources of the problems, which typically means refocusing on the pond's watershed context. (Cooke, 2010)

The Charles River Watershed Association (CRWA), based in Weston, does not typically get involved in the management of ponds. Julie Dyer, a watershed scientist with CRWA, believes that the best use of the association's limited resources is to focus on the stormwater management and sewage problems that the Charles River Watershed suffers from. Much of their resources are dedicated to data collection and water quality monitoring, using Quality Assurance Project Plan (QAPP) guidelines. They also rely heavily on volunteer assistance. The CRWA has been successful in building a reputation of collecting sound scientific data that contributes to waterhsed management decisions and policies. They are also an advocacy organization, but they are known for using science to inform their positions, rather than vice versa (Dyer 2010).

Key Observations

From our conversations with conservation commission members, we have made these observations:

- Black Joe's Pond is the exception, not the rule—We were unable to identify any pond treatment that was as contentious or litigious as that of Black Joe's Pond.
- Lack of resources—Conservation commissions generally lack the resources, such as staff, time, and funding, needed to effectively manage ponds. This can make it difficult to assess the ecological problems, engage concerned citizens, identify a treatment, and carry out a management plan.
- Larger ponds are given priority—Resources tended to be allocated to larger ponds, especially those that are used recreationally by the public.
- Seeking of technical expertise—When funding is available, conservation commissions often seek technical advice from private pond treatment companies.
- Interest in additional technical support—All conservation commission members with whom we spoke welcomed the prospect of outside support in assessing technical problems in ponds, identifying both long- and short-term management solutions, engaging the public, and locating sources of funding.

Watershed associations have a whole systems approach to management, rather than a myopic focus on a single pond's problems. Nonetheless, we recognize a clear need for the expertise of watershed associations when pond problems arise. As the former Chair of the Marblehead Conservation Commission explains, "Whenever we make a decision, we have to be able to defend it" (Haug 2010). Given its scientific expertise and experience with community outreach and education, a watershed association like Salem Sound Coastwatch is well positioned to help conservation commissions make defensible decisions.

Part II:

Developing and Implementing an Effective Pond Management Plan

The best way for municipalities to deal with difficult pond management questions is to plan ahead. This is easier said than done. For local conservation commissions that are understaffed and overworked—however dedicated they may be—the prospect of developing a community-wide pond management plan many seem daunting.

Nevertheless, we cannot overstate the utility and importance of having a consistent, predictable, and fact-based approach to local pond management decisions. Due to the short timelines mandated by the Wetlands Protection Act, for example, conservation commissions are forced to make quick decisions about pond treatment proposals. Without a plan, these decisions may not account for important environmental or ecological sensitivities or long-term costs. Municipalities must anticipate problems that could arise in ponds under their jurisdiction and have a framework in place for making treatment decisions. In addition to setting standards for such decisions, a pond management plan may also forge a shared vision among a diverse set of stakeholders in the community, such as municipal departments, pond abutters, and environmentally concerned residents. Involving all stakeholders in the planning process gives them a sense of ownership and may garner support for future decisions.

In Part II of this report, we discuss the major components of a pond management plan, including:

- Gathering and analyzing information.
- Seeking assistance from outside organizations.
- Weighing costs and benefits of various treatment options.

- Developing effective implementation strategies.
- Designing evaluation methods, and long-term watershed planning options.

We argue that pond management planning should be seen in its watershed context and align with land use goals and regulations at the local, regional, and state level. We hope that the following chapters will help to eliminate some of the guesswork in making treatment decisions and guide SSCW, citizens, and conservation commissions that seek to proactively protect their community's ponds.

Chapter Four:
Data Collection and Analysis

The case of Black Joe's Pond illustrates the complexities of pond management decisions even for a small pond in a small town. While some Marblehead residents expressed outright opposition to the use of chemicals, perhaps the greater point of contention in this debate was the prospect of applying chemical treatments without first implementing a pond monitoring program. Here, we prescribe a proactive approach to pond monitoring, in which data is gathered before conditions become extreme. This way, when concerns do arise, stakeholders can immediately apply collected data towards an informed discussion over potential treatments.

Although anthropogenic eutrophication is a common problem among ponds throughout the Salem Sound watershed, the precise symptoms and causes vary based on the characteristics of each location. The amount and quality of information available for each pond and its watershed will largely determine the extent to which solutions can be specifically tailored to address its unique management challenges. Therefore, gathering a robust body of data is the crucial first step in the process of developing an effective pond management plan. A solid foundation of baseline data allows decision makers to prioritize areas for pollution reduction, establish specific management goals, and broaden consensus by providing rational and even legally defensible underpinnings for recommended management actions.

A comprehensive study should assess cultural significance and legal considerations, as well as physical, chemical, and biological characteristics of the pond and its watershed. Despite the broad scope of information to be gathered, a thorough and informative pond study need not require years of monitoring, outpourings of money, and highly technical analyses. Generally, the amount and accuracy of data required will increase with the cost of potential treatments (Wagner 2004, 18).

Involving Volunteers

With most of the available funding allocated to lake, reservoir, and river preservation projects, small ponds in the Salem Sound watershed are typically managed on shoestring budgets, if at all. Additionally, the significant expertise, resources, and coordination required to initiate a monitoring program may seem daunting to conservation commissions or citizen groups unfamiliar with the process. Municipalities may therefore be inclined to explore collaborative and volunteer-based research opportunities. More commonly, however—as we saw with the Beverly Conservation Commission in Chapter Three—they hire private consultants to perform tests and provide recommendations, which towns may or may not choose to implement. While we do not discourage the latter option, especially in situations that require professional engineering or site planning, we emphasize the importance of community participation. Involving the community in data gathering activities presents an opportunity to educate the public about pond health and watershed issues, and may encourage other stewardship activities. Additionally, involving multiple parties in a study reduces the potential for bias towards a particular solution.

We recommend that municipalities, in collaboration with expert individuals and organizations, establish volunteer monitoring programs to broaden participation, and maximize limited resources. Volunteer monitoring provides a cost-effective means of gathering information on ponds that would otherwise go unstudied due to a lack of funding. SSCW and other watershed associations with experience in monitoring and data analysis could assist conservation commissions in designing and implementing these programs.

Chapter Four

In the following section, we provide general guidance for establishing a monitoring program and identify some specific parameters for study.

Designing a Monitoring Program

Rather than designing a study from scratch, municipalities can save substantial time and effort by following pre-existing research templates. Following standard protocols increases the comparability of study results by contributing to the compendium of data from similar studies. From the range of potential templates that exist, we recommend that a Quality Assurance Project Plan (QAPP) be used as the "blueprint" for pond studies due to its widespread acceptance and use by organizations in the watershed.

The QAPP concept was developed by the U.S. Environmental Protection Agency (EPA) to ensure the quality of all environmental data collected with federal funding. In 2008, the Massachusetts Executive Office of Energy & Environmental Affairs (EEA) developed a QAPP specific to inland waters[1] in order to guide communities in designing, implementing, and evaluating their own volunteer monitoring programs (Schoen 2008). A series of supporting documents detail the Standard Operating Procedures for field sampling and laboratory analyses found in the QAPP.

While the QAPP provides a basis for developing a monitoring program, the formal submission and approval process is unnecessary for most small pond applications and may be an uneconomical undertaking for conservation commissions with severe resource limitations. SSCW can therefore assist conservation commissions in selecting elements of the QAPP that would be most valuable to a specific pond study, much like they did at Black Joe's Pond.

1 The "inland waters" category includes rivers, streams, lakes, ponds and wetlands. Here, we discuss the aspects pertaining to ponds.

Building the Foundation

The key to a successful monitoring program is establishing a sound organizational framework. This section draws on basic QAPP protocols (Schoen 2008) to outline tasks that should be completed prior to monitoring. Here, we address conservation commissions, watershed associations, and concerned citizens about how to use this framework and build the foundation of a monitoring program.

Take Inventory

Locate all potential study areas by taking an inventory of all ponds within the town's boundaries having at least partial public ownership. Given the dynamic nature of ponds and the potential for rapidly changing conditions, keep records on all ponds, even those not in obvious distress. For low-priority ponds where a full-fledged monitoring program may not be feasible, even conducting simple visual surveys and taking photographs a few times each year can be of great value.

Establish Ownership

Compile a list of all parcels abutting the pond. Local regulations typically require the permission of some or all of the abutting landowners in order to obtain a permit for in-pond treatments.

Identify Applicable Laws/Regulations

Pond and watershed management projects must be carried out in accordance with all applicable regulations. Wetlands are regulated under the federal Clean Water Act and the Massachusetts Wetlands Protection Act (M.G.L. Chapter 131 Section 40) and Regulations (310 CMR 10.00 et seq.). In addition, all six towns within the Salem Sound Watershed have local wetland bylaws. Projects may also be subject to additional criteria specified by health codes, stormwater bylaws or zoning overlay districts (see Table 7.2). Refer to Chapter Seven of this report for a more in depth discussion of the regulations governing pond management.

Assess Visitor Demographics/Uses

Determine who visits the pond and what they use it for. For example, do most users live within walking distance or do some travel from farther away, perhaps from neighboring towns? What activities do these users value the pond for? This information could be obtained by administering questionnaires at parking lots, trailheads or other points of public access. For ponds with limited public access, abutting residents may be the primary users. As regular visitors are more likely to participate in the dialogue about a pond's management, knowing their habits and preferences is critical.

Define the Problem

Characterize and document the existing and potential threats to the communities desired uses as specifically as possible, even before a study is initiated.

Establish Goals

What recreational uses should the pond management program strive to maintain? Preservation and restoration strategies should be targeted to meet explicit ecological, recreational, aesthetic, and water quality goals. Goals should be realistically attainable, accounting for the pond's natural aging process, rather than seek to restore it to a nutrient-poor, post-glacial state.

Organize and Coordinate

In order to attain the high degree of coordination required to carry out a monitoring program, an organizational scheme must be established early on. This will involve assigning roles to project managers, coordinators, and volunteers, and establishing clear line of communication between them. The organizers should also create a timeline for the completion of project tasks. Conservation commissions could enlist the help of SSCW in identifying volunteers, organizations or academic institutions that would be interested in participating in the study and connect them to resources around the watershed. Once key roles have been established, SSCW can assist in managing and analyzing data, and act as a liaison between lab and field coordinators (Figure 4.1).

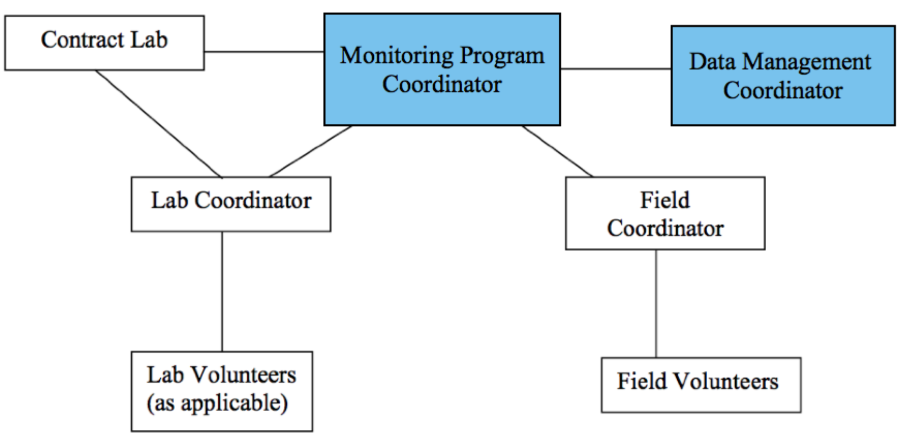

Figure 4.1 Typical project roles and lines of communication for a monitoring program. Blue boxes indicate potential roles for SSCW or other watershed organizations. (Adapted from Schoen 2008.)

Train Volunteers

In order to ensure the quality of data collected, volunteer monitors should attend training workshops to become familiar with Standard Operating Procedures for the research tasks they will perform. The Massachusetts Water Watch Partnership hosts workshops on a variety of topics including, study design, field techniques, lab analyses, data management and interpretation, stream surveying, weed identification, watershed surveying, and a general QAPP workshop. In addition, the Massachusetts Congress of Lake and Pond Associations offers a one-day workshop on how to start a monitoring program. A complete listing of workshops is available on the Massachusetts Water Watch partnership website. [2]

2 http://www.umass.edu/tei/mwwp/wkshdes.html.

Select Study Parameters and Methods

Since large ponds and lakes are usually the first to receive management attention, most guides have been created with these in mind. In general, the methodology for collecting data on small ponds can simply be borrowed from these guides; however, ponds do warrant some special consideration.

The next two sections discuss the core parameters to investigate when studying a small pond and its watershed. Please note that this list is neither exhaustive nor universally applicable, as exact criteria will vary for different ponds. Conservation commissions should consult expert individuals or organizations, such as SSCW, to select appropriate sampling parameters and analysis methods most appropriate to the pond of interest.

Pond Analysis

This section describes some of the fundamental parameters of interest for the in-pond portion of the study. The parameters and methods listed here correspond with those recommended for lakes and ponds in the Inland Waters QAPP (Schoen 2008). A complete table can be found in Appendix B.

Morphometry / Structural Features

A pond's morphometry, or physical form, is a major determinant of habitat type and productivity. After gathering bathymetric data on variations in the depth of the pond basin, one can derive a host of other morphometric characteristics, including surface area, maximum depth, shoreline length, shoreline development, fetch, and littoral area. Together, these factors determine important characteristics, such as the pond's rate of mixing, and are vital to assessing the suitability of any in-pond management technique.

While sampling the bathymetric profile of the pond's true bottom, data can be simultaneously collected on sediment depth. A pond's life span is largely determined by the rate at which this sediment deposition occurs.

Finally, it is also useful to assess the capacity of any outlet structures and their control mechanisms to restrict or increase flow to determine their suitability for management options such as drawdown.

Water Testing

Actual parameters to be tested will vary based on the specific characteristics of each pond, however, some fundamental tests of water quality that are applicable to most studies include: water clarity, dissolved oxygen (DO), total suspended solids (TSS), pH, alkalinity, conductivity, total phosphorus (TP), chlorophyll a, total nitrogen (TN) and total Kjeldahl nitrogen (TKN), and algal toxins. Of these, total phosphorus, water clarity, and chlorophyll a are three of the most widely used methods to gauge a pond's overall productivity, or trophic state. For tests that require laboratory work, the analyst should follow the Standard Operating Procedures published in Standard Methods for the Examination of Waste and Wastewater, 21st Edition (Eaton et al. 2005) or the Clean Water Act Analytical Methods on the EPA website.[3] SSCW should provide assistance in determining appropriate study parameters and explore the potential for collaboration with nearby academic institutions that may be able to offer monitoring assistance or use of their laboratories.

Biological Assessment

The health of a pond ecosystem can be inferred by the abundance and diversity of living organisms it supports. Since organisms exhibit variable sensitivity to changes in

3 http://www.epa.gov/waterscience/methods/method/

water quality, the presence of certain plant and animal species can indicate overall habitat quality. Surveys of macroinvertebrates, aquatic plants, and algal populations should be conducted at least once per year during the sampling season.

Algal blooms provide one of the most visible and immediate signs of eutrophication. The formation of dense algal mats on the pond surface decreases light penetration and causes oxygen levels to plummet. The subsequent decay of algae and plant matter on the pond floor causes further oxygen depletion, creating a positive feedback cycle. Therefore, algal growth is both a symptom and a cause of pond eutrophication.

High nutrient levels also make ponds more susceptible to infestation by invasive aquatic plants, which colonize rapidly and can quickly overwhelm native vegetation. The resulting loss of habitat and biodiversity can substantially reduce the ponds' ecological value. Early detection is the key to effectively managing invasive species. Thus, macrophyte populations should be routinely monitored for the appearance of any exotic plants (Figure 4.2).

Figure 4.2 Volunteers surveying for invasive plants (Source: Maine Volunteer Lake Monitoring Program, as pictured in The National Newsletter of Volunteer Monitoring, Spring 2009).

Watershed Analysis[4]

Whereas the in-pond portion of the study requires a substantial amount of data to be collected in the field, the watershed assessment primarily involves compiling and analyzing existing data. Here, we present a simple model to estimate the hydrologic flow and nutrient loading properties of the watershed. Since this model has demonstrated its ability to predict actual values with reasonable accuracy throughout the region, it is a valid alternative to costly and laborious field studies for most common applications.

For ponds with larger watersheds, Geographic Information Systems (GIS) can be an invaluable tool for watershed delineation and analysis, greatly expediting the process. However, the results of a GIS analysis will only be as accurate and complete as its underlying data. SSCW may be able to assist in performing and interpreting the results of spatial analyses. Watershed surveys need only be performed every few years except when significant disturbances or land use changes have occurred. Appendix C contains a table summarizing the components we recommend for a basic watershed analysis.

Watershed Delineation

While some contaminants enter a pond directly via atmospheric deposition and illicit dumping, most enter indirectly via runoff and groundwater flows. In order to identify all possible sources of contaminants, therefore, one must delineate the entire contributing area, or watershed, from which these flows originate.

Watersheds comprise surface and subsurface drainage basins that are functions of a region's topography, soil type, and surficial geology. Since groundwater flow data is expensive

4 The information in this section comes from Horsley 2009 unless otherwise noted.

to obtain and is highly correlated with surface topography in this region, in most cases it can be safely assumed that the direction of groundwater flow closely mimics that of the surface watershed.

Watercourse Assessment

After mapping the watershed, determine how the pond fits into the surrounding hydrologic network. Unlike larger bodies of water, the inlets and outlets of small ponds are usually far less conspicuous. In highly urbanized watersheds, flows may be altered from their natural courses or channeled into underground drainage systems. Ponds with no apparent inflows or outflows may be fed by or discharge into groundwater. The downstream destination of water exiting the pond must also be considered. For instance, the petitioners in the Black Joe's Pond debate were able to build a sympathetic case around the downstream juvenile lobster nursery in Doliber's Cove (Sullivan 2010). Projects involving ponds that drain into areas subject to protective regulations, such as coastal zones or rare species habitat, require increased scrutiny. In large watersheds with multiple contributing streams, the study area may be divided into sub-basins to assess spatial variations in pollutant loading and prioritize areas for management action.

Hydrologic Budgets

A hydrologic budget calculates the total volume of water entering and leaving the pond and its watershed. These figures are commonly expressed in terms of annual rates, or flow. The calculation takes into account evapotranspiration rates, wastewater imports/exports, and withdraws. When reasonably accurate estimates can be made, incorporating consumptive uses, such as lawn watering, into the calculation is ideal.

Soil or Surficial Geology Analysis

Soil type, surficial geology, and land slope are interrelated factors that determine whether precipitation will runoff or infiltrate into the soil. While soil and surficial geology are closely correlated, we recommend primarily using soil data for the analysis because it includes measures of both slope and permeability, allowing for greater accuracy. Comprehensive soil data is available through National Resources Conservation Service (NRCS) and surficial geology information through the United States Geological Survey (USGS).[5]

After categorizing land areas in the watershed by hydrologic soil type (see Figure 4.3), slope, and impervious cover, each grouping should be matched to an appropriate runoff coefficient to estimate their relative contributions to runoff and groundwater recharge. One possible model, which provides runoff coefficients based on the estimated impervious surface coverage of various land uses, is shown in Table 4.1. Using total flow figures calculated in the previous step, estimate the infiltration to runoff ratio for each surface type and cumulatively for the watershed as a whole. Watersheds with high runoff rates are more susceptible to stormwater pollution.

5 Soils and surficial geology data layers are available through MassGIS

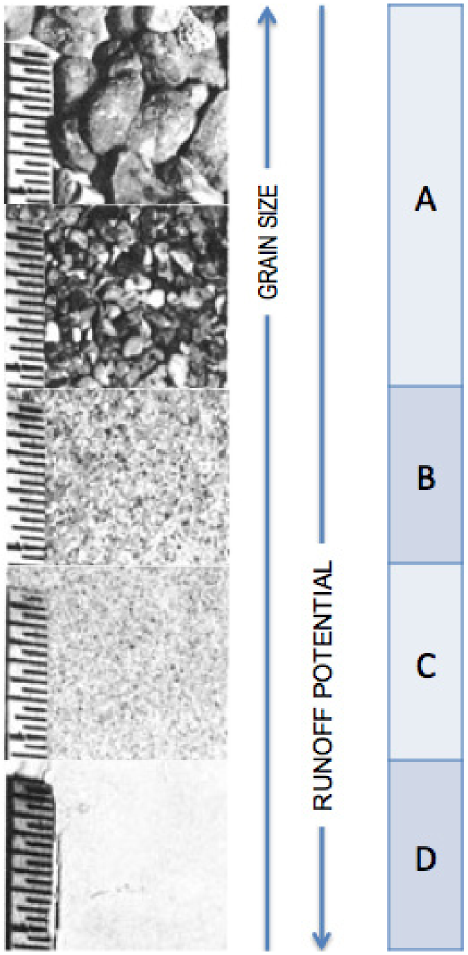

Figure 4.3 Soil groups are classified into hydrologic groups A,B,C and D based on infiltration rates. Small grain size and a slow infiltration rate increases the soil's runoff potential (Adapted from http://nesoil.com/hydrologic.html).

Land Use	Percent Impervious Area	Hydrologic Soil Group											
		A			B			C			D		
		Slope Range Percent			Slope Range Percent			Slope Range Percent			Slope Range Percent		
		0-2	2-6	6 & over	0-2	2-6	6 & over	0-2	2-6	6 & over	0-2	2-6	6 & over
Industrial	90	0.67 0.85	0.68 0.85	0.68 0.86	0.68 0.85	0.68 0.86	0.69 0.86	0.68 0.86	0.69 0.86	0.69 0.87	0.69 0.86	0.69 0.86	0.70 0.88
Commercial	95	0.71 0.88	0.71 0.89	0.72 0.89	0.71 0.89	0.72 0.89	0.72 0.89	0.72 0.89	0.72 0.89	0.72 0.90	0.72 0.89	0.72 0.89	0.72 0.90
High Density Residential	60	0.47 0.58	0.49 0.60	0.50 0.61	0.48 0.59	0.50 0.61	0.52 0.64	0.49 0.60	0.51 0.62	0.54 0.66	0.51 0.62	0.53 0.64	0.56 0.69
Med. Density Residential	30	0.25 0.33	0.28 0.37	0.31 0.40	0.27 0.35	0.30 0.39	0.35 0.44	0.30 0.38	0.33 0.42	0.38 0.49	0.33 0.41	0.36 0.45	0.42 0.54
Low Density Residential	15	0.14 0.22	0.19 0.26	0.22 0.29	0.17 0.24	0.21 0.28	0.26 0.34	0.20 0.28	0.25 0.32	0.31 0.40	0.24 0.31	0.28 0.35	0.35 0.46
Agriculture	5	0.08 0.14	0.13 0.18	0.16 0.22	0.11 0.16	0.15 0.21	0.21 0.28	0.14 0.20	0.19 0.25	0.26 0.34	0.18 0.24	0.23 0.29	0.31 0.41
Open Space	2	0.05 0.11	0.10 0.16	0.14 0.20	0.08 0.14	0.13 0.19	0.19 0.26	0.12 0.18	0.17 0.23	0.24 0.32	0.16 0.22	0.21 0.27	0.28 0.39
Freeways & Expressways	70	0.57 0.70	0.59 0.71	0.60 0.72	0.58 0.71	0.60 0.72	0.61 0.74	0.59 0.72	0.61 0.73	0.63 0.76	0.60 0.73	0.62 0.75	0.64 0.78

Table 4.4 A table of runoff coefficients based on land use, impervious area, hydrologic soil group, and slope (Source: Wisconsin Department of TrTansportation 1997).

Land Use/ Loading Analysis

Pollutants may be released into the pond or its watershed through point or non-point sources. Point source pollution emanates from a specific, identifiable release point, such as wastewater or industrial discharges. Most point sources are now closely regulated under the National Pollutant Discharge Elimination System (NPDES) program. However, in more urbanized areas, combined sewer overflows (CSOs) may be present and should be prioritized for remedial action.

Non-point source pollution, on the other hand, emanates from more dispersed and inconspicuous sources, making mitigation difficult. For example, single applications of fertilizers and herbicides on lawns may seem fairly innocuous, but in the aggregate they can damage local ecosystems, perhaps by accelerating eutrophication in small ponds or by directly poisoning organisms. Thus, the polluted runoff from lawn chemicals in urban and suburban settings exemplify what economist Alfred Kahn called the "tyranny of small decisions". Controlling the release of nutrients from non-point pollution sources is unequivocally the greatest factor in determining the long-term health of a pond. A land use study should analyze historic and present non-point pollution sources, as well as potential increases in nutrient loading due to future development in the watershed. Since phosphorus is typically the limiting nutrient in freshwater systems, most analyses will focus on phosphorus loading. Although some phosphorus is released by natural sources, the relative contributions from fertilizers, pet waste, septic inputs, and wastewater discharges are far greater.

Historic land use data should be gathered from a variety of sources including old land use maps, orthographic images, wastewater/septic systems, and hazardous waste disposal sites.[6] Long disused septic systems should be identified,

6 Chapter 21E Sites under MassDEP Tier Classified Oil and/or Hazardous Material Sites

as they can continue to transfer nutrients to the pond via groundwater flow for decades. Nutrient contributions from the various land uses in the watershed can be estimated by loading coefficients specific to each use.[7] In unsewered areas, the estimate should also account for nutrient loading from septic inputs. This information can then be used to prioritize areas for load reduction.

In the final step of the land use analysis, predict the potential increase in nutrient loading if all available land were developed to its buildout potential, or the maximum extent allowable under existing regulations and codes. While many towns within the Salem Sound watershed may be at or approaching full buildout, remaining growth potential is often surprising. The predictions of the buildout analysis can be effective in cultivating a sense of urgency for management actions that will protect wetland resources from further deterioration. The Massachusetts Executive Office of Environmental Affairs provides a model for conducting buildout analyses on their website.[8]

Biological Analysis

To assess the pond's ecological value, conduct periodic wildlife and habitat surveys along the shoreline. Experienced observers should identify plant species, as well as birds, reptiles, amphibians, and mammals. Gaining insight into the web of organismal relationships that surrounds the pond will help to reconcile recreational and aesthetic goals with ecological requirements.

The condition of the riparian zone, or the area of interface between the pond and the surrounding land, strongly influences water quality. When adequately vegetated, the

7 One widely used source of in this area is Mattson and Isaac's Calibration of Phosphorus Export coefficients for Total Maximum Daily Loads of Massachusetts Lakes (1999).

8 http://commpres.env.state.ma.us/content/buildout.asp

riparian zone provides a buffer against the inflow of sediment, nutrients, and other pollutants transferred by stormwater runoff. In addition, plant roots help to stabilize the soil on the banks, reducing shoreline erosion.

Chapter Four

Chapter Five:
Choosing a Management Practice

After gathering data and analyzing a pond's ecological condition, the next step is to identify an appropriate solution.[1] We categorize these solutions into short-term methods and long-term methods, based on the timeline of their outcomes. Short-term methods may be necessary to treat pressing problems in ponds, while long-term methods are broadly applicable and help to diminish future maintenance costs.

Short-term: In-pond Methods

Methods to Control Nutrients

The goal of in-pond treatments is to limit the availability of nutrients, phosphorus and nitrogen, to algae, thereby curbing the uncontrolled growth that leads to algal blooms. There are two main sources of nutrients that need to be addressed, internal and external. Here, we describe the short-term methods to control the internal recycling of nutrients within a pond system. There are a number of approaches to control nutrients using in-pond techniques:

- Hydraulic controls are implemented to manipulate the water that enters the pond, or to control the content and volume of water in the pond.
- Aeration and circulation techniques can also be used to increase the flow of dissolved oxygen in the pond to reduce the anoxic, low oxygen, zone that contributes to and characterizes the state of eutrophy in ponds.
- Phosphorus precipitation and inactivation, as well as bacterial additives, involve adding chemicals or bacteria to the pond to retard the eutrophication process.
- Biomanipulation involves the control of the food web in

1 The term Best Management Practices (BMPs) is commonly used by government agencies to describe these practices.

such a way that bottom browsing, an action that releases phosphorus from the benthic sediment into the water column, is reduced.

- Dredging, the removal of bottom sediments and restructuring of the pond floor can be an effective in-pond nutrient control.

For a detailed description of the various short-term methods, see Appendix D. For tables comparing in-pond nutrient control methods in more detail, see Appendices E-G.

Methods to Control Aquatic Plants

Aquatic plants are an integral component of a healthy pond ecosystem, but in excess they can be problematic. Methods to control aquatic plants mainly entail physically removing plants, causing plant death through water or sunlight deprivation, or applying chemicals. The most desirable management option is to prevent the introduction of invasive plant species into a waterway, but here we consider remediation strategies if this fails, or if native plants need to be controlled. For tables comparing macrophyte control methods in more detail, see Appendices H-I.

No-Management Alternative for Nutrient and Aquatic Plant Control

Another option to control nutrients or macrophytes that should be considered is the no-management alternative. As the name suggests, a no-management alternative excludes all active lake and watershed management techniques. However, it may include monitoring and assessment, as well as the operation of sewage treatment facilities and any pollution control activities required by law.

Shallow ponds often experience the effects of eutrophication and sedimentation more quickly than deeper ponds due to increased light penetration and a greater sediment-to-water interface relative to total water volume. For these reasons, smaller shallow ponds should be thoughtfully considered when planning watershed development and management. The uses of ponds should also be taken into account.

Adverse effects on various non-target organisms may occur as a result of the no-management alternative. For example, if eutrophication causes a blue-green algae bloom and there is a depletion of dissolved oxygen, fish and invertebrate kills may occur. Algal blooms also limit rooted plant diversity and cover, which impacts fish community stability and invertebrate community composition. Unless there is no major nutrient loading from the watershed, negative water quality effects are expected if a no-management alternative is selected as the management plan.

We believe that a no-management plan warrants consideration of pond and watershed conditions, just like any other management plan, as not intervening in the pond's processes might be considered preferable in some cases.

Costs of Short-Term Treatments

Many of the short-term options for both nutrient and macrophyte control require infrastructure to house machinery necessary for the success of the practice, multiple applications in the case of chemical treatments, and occasionally extensive construction or diversion techniques that require pumping and water or sediment storage contribute to the high cost of these methods. Furthermore, these treatments typically do not target the source of the problem, making problems more likely to reoccur. We therefore recommend that long-term measures are taken to prevent the need for short-term solutions in the future. Estimated costs for various short term treatments can be found in Appendices E-I.

Long-term: The Whole Watershed Approach

Here, we consider long-term strategies for targeting the sources of the external nutrient inputs that can accelerate eutrophication. The major external sources of nutrients include pet and human waste, lawn fertilizers, and stormwater runoff. Techniques to reduce the flow of these nutrients into bodies of water are advantageous for several reasons. Not only are they long-term solutions that address the roots of the biological problems in ponds, but they are also inexpensive and many can be performed by members of the community.

Wastewater Treatment

Wastewater treatment facilities and private septic systems are a major source of nitrogen and phosphorus. The water that enters wastewater treatment facilities undergoes a number of treatments. Most treatments facilities are only required to implement primary and secondary treatment processes, which remove suspended and non-settleable solids (Massachusetts Water Resources Authority 2010). Very few wastewater treatment facilities are required to use tertiary treatments that reduce nitrogen and phosphorus content in wastewater through biological and chemical processes (Siemens 2010). Domestic on-site wastewater treatment, or septic systems, utilizes passive treatment, which depends on bacteria to break down organic materials. Both public and private wastewater treatment facilities do little to reduce nutrients in discharged wastewater and, therefore, contribute greatly to the nitrogen content in many urban ponds. In order to reduce the nutrients entering water systems from these wastewater treatment facilities, tanks should be upgraded when needed (Mattson et al. 2004, 2-4). Several studies have also suggested that adding alum to wastewater treatment may help to reduce the nutrient loading of nearby ponds (Brandes 1977).

Picking Up Pet Waste

While it may seem inconsequential, pet waste contributes to problems in ponds and other bodies of water. Pet waste left on the streets, private yards, and public open spaces can be washed into nearby streams and standing water bodies, directly adding to the excessive influx of nitrogen and phosphorus in a pond. Waste from domesticated pets can be reduced by having owners picking up their pets' waste and disposing of it into the trash. Providing plastic or biodegradable bags and trash receptacles, installing signs to encourage owners to clean up after their pets, and issuing fines could all help to reduce the inflow of nutrients from pet waste into ponds.

Reducing the Use of Fertilizers and Other Landscaping Chemicals

Synthetic fertilizers used in landscaping contain high concentrations of nitrogen, phosphate (a salt form of phosphorus), along with other nutrients such as potassium and magnesium (International Fertilizer Industry Association 2010). These nutrients wash into surface waters during storm events, increasing the external nutrient loading of a pond and contributing to eutrophication. Limiting the use of synthetic fertilizers and prohibiting products with certain ingredients would mitigate nutrient loading in ponds. Though organic fertilizers are less concentrated, less water-soluble and do not leach out of the soil as quickly as synthetic fertilizers, and release nutrients more slowly, they still contribute to nutrient loading problems. Greenscapes Massachusetts, an organization that provides outreach and education about landscaping, makes a number of recommendations to reduce reliance on fertilizer:

- Professionally test soils to identify specific problems and make targeted treatment decisions.
- Add lime to acidic soil to reduce its acidity, which fosters

weed growth, and enhance desirable plant growth.

- Leave grass clippings on the lawn after mowing. The nitrogen and organic matter from the clippings "provides the equivalent of one fertilizer application" over the course of a growing season.
- Add a thin layer of compost, which provides nutrients that enhance growth and helps the soil retain moisture.
- Aerate by mechanically perforating lawns to allow the entry of oxygen, water, and nutrients to reach grass roots and aid growth.
- Plant Dutch white clover—among other benefits, it prevents erosion, smothers weeds, and retains soil moisture (Greenscapes Massachusetts 2009).

Controlling Stormwater Runoff

Perhaps the most critical external source of nutrient loading is stormwater runoff, which comes from precipitation that flows over the ground, often picking up nutrients and contaminants, before flowing into waterways or drainage systems. As described in Chapter One, impervious surfaces increase stormwater runoff (Watersheds 2003). Low-Impact Development (LID) techniques can be used to lessen the amount of stormwater runoff flowing into streams and ponds. These strategies can be structural or non-structural. Non-structural approaches include zoning amendments to allow for the conservation of open space, or land use restrictions in critical areas near surface water bodies including streams, wetlands, and ponds. For example, new developments may be required to have narrower streets and driveways, and use permeable pavement. We discuss the regulatory framework for non-structural watershed planning in Chapter Seven.

The conservation of open space, in conjunction with the reduction of impervious surfaces is a key element to low impact development, yet not always possible in urban areas that are already well developed. Several of the following structural practices offer the opportunity for the capture and treatment of stormwater runoff and can be easily integrated into urban development. First, infiltration structures including catch basins, trenches, and leaching chambers, often consisting of simple detention basins and buried chambers that allow temporary storage and gradual release of stormwater runoff can be very effective in capturing the first flush (see Threats to Health and Longevity in Chapter One for further explanation). Vegetated structures like swales, buffer strips, bioretention facilities, and rain gardens not only provide physical detention and treatment, but also biologically treat organic materials and absorb water and nutrients. These structures are easily incorporated into the existing landscape, in lawns, median strips, parks and other open spaces. During the landscape design process, choosing appropriate vegetation species can reduce maintenance expenses and effectively absorb excess nutrients. In Massachusetts, plants should be chosen for their ability to survive both drought and high water, and native-plants are always preferred.

Green roofs or rooftop gardens are very effective ways to capture rooftop runoff. They may also provide many other benefits including increased insulation, improved air quality, habitat preservation, and even food or cut flowers (LID Urban Design Tools 2007). Green roofs can be intensive, designed with pedestrian access and deep soil layers, or extensive, which have shallow soil layers and are more realistic for implementation on homes (Claytor and Horsley 2007).
In cases where rooftop gardens or green roofs are not feasible, there are other less expensive rooftop strategies available that require less maintenance, such as installing cisterns or rain barrels to collect runoff for irrigation and other uses that require non-potable water. Simple diversion techniques, such as gutter downspout extensions, can redirect runoff into gardens or other vegetated areas.

LID practices not only reduce stormwater runoff into surface waters, but also increase groundwater recharge, an especially important benefit in Massachusetts where most surface waters are classified as impaired due to lack of recharge (Water Resources Commission 2001). A more detailed explanation of low impact development practices that can be implemented in urban areas can be found in Appendix J.

Benefits of a Watershed Approach

We emphatically recommend a whole watershed approach for long-term effectiveness in pond management. Watershed approaches to pond management save both time and money. Simplification and streamlining of monitoring, modeling, issuing permits, and reporting can account for some of these savings (Watershed Academy Web 1996). Thus, proper watershed management begs collaboration between different groups such as local advocacy groups, regional watershed organizations and local, state, and federal government agencies (Watershed Academy Web 1996). The Clean Water Act permitting process favors watershed plans over individual pond treatment plans. Local, state, and federal permitting can also be processed in together to avoid unnecessary overlap (Watershed Academy Web 1996). A holistic watershed plan has several very important benefits, including:

- Cost-effectiveness—Source control methods may entail capital costs for construction or planting, but do not have high maintenance costs.
- Time effectiveness—Cooperation among different organizations and agencies will help to implement both short-term and long-term watershed solutions quickly.
- The possibility of qualifying a municipality or organization for government grants and funding, some of which are detailed below.
- The potential to involve the community in the care of rain gardens and other landscape design features.

- The potential to raise awareness and garner public support by education about actions everyone can take to help reduce external nutrient loading in ponds.

Financial Assistance

Funding is required to develop and implement a pond or watershed management program, yet, as we discovered in our interviews with conservation commission members, it can be hard to come by. However, both the EPA and the Massachusetts Department of Conservation and Recreation (DCR) offer funding opportunities for pond and watershed management. The EPA's Clean Water Act, Section 319 Non-point Source Management, offers funds to states for "technical assistance, financial assistance, education, training, technology transfer, demonstration projects and monitoring to assess to success of specific nonpoint source implementation projects" (Polluted Runoff (Nonpoint Source Pollution) 2010).[2] In addition, the DCR's Lakes and Ponds Grant Program works with municipalities and community organizations to "protect, manage and restore…valuable aquatic resources" through technical assistance, monitoring efforts, and education (Department of Conservation and Recreation 2010).

Communities can also choose to enact the Community Preservation Act (CPA), a state-level program that provides funding to "preserve open space and historic sites, and create affordable housing and recreational facilities" (Community Preservation Coalition). The program, which must first be approved by local voters, raises money through an increase in local property taxes and state matching funds. It can be an effective method to acquire new land or conservation easements, which can help restore wetlands to a healthy

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2 More information about this program can be found on the EPA's website: www.epa.gov/nps/cwact.html.

state. Within the Salem Sound Watershed, only Peabody and Manchester-by-the-Sea have passed the CPA, although Marblehead, Salem, and Beverly attempted to enact the program and did not receive voter approval (Community Preservation Coalition).

Community Involvement

Community involvement in pond management planning mainly takes the forms of public education and community outreach. Watershed organizations and other environmental groups are well suited to educate the public about some of the complex and technical aspects of pond and watershed management. Education is especially important for conveying complicated concepts and information, establishing common goals, and facilitating a positive dialogue. As we observed in our case study of Black Joe's Pond, unproductive communication can delay productive treatments and cultivate ill will. Public meetings can serve as forums for education, feedback, and communication between all groups. Releasing technical documents for public review is another form of outreach that adds transparency to the decision-making process and may be educational (Water 2006).

Chapter Six:
Project Implementation and Evaluation

In this section we direct conservation commission members and other interested organizations or residents on how to implement a project plan and evaluate its progress.

Creating an Action Plan

After selecting an appropriate management practice, create a plan outlining intended steps over the next three to five years. This long-range management plan should distill the results of the pond study so that they are concise and easily digestible by the public, the town legislature, and other agencies not directly involved in the program. For each prescribed treatment, include the specific problem being addressed, the party responsible for oversight of the orogram, and a general timeline for implementation.

In the time leading up to the request for treatment, notify residents and visitors through various means such as newspaper or electronic announcements, informational meetings, and posted bulletins. Give all involved parties, including construction teams and chemical applicators, explicit instructions on when and how the treatment should be administered.

The procedure for implementation will vary depending on the management practices selected. Expected timeframes may range anywhere from herbicide applications or harvesting that take a few hours, to structures that require days to install, to non-structural techniques that will be implemented over the next few years. Treatments that provide only short-term solutions often require repeated implementation.

Gaining Approval

After creating an action plan, any proposed treatments with the potential to "alter"[1] a wetland environment must pass a thorough screening process. Following the proper regulatory protocols ensures that wetland management efforts are consistent with the goals set forth in the Massachusetts Wetlands Protection Act (M.G.L. Chapter 131 Section 40). For each project, applicants are required to submit a Notice of Intent (NOI) detailing their proposed course of action to the Conservation Commission, or other issuing authority, for approval. Depending on local regulations, certain treatments may require additional permits from other departments. For instance, Marblehead's Organic Pest Management regulation requires that application of chemical treatments on town-owned property is approved by the Board of Health.

1 Activities subject to regulation under Massachusetts Wetlands Protection Act (M.G.L. Chapter 131 Section 40) are enumerated by 310 CMR 10.02. Local wetlands bylaws may include additional specifications.

All NOIs must evaluate the environmental impacts of the proposed treatment as they relate to the following topics[2] summarized in DEP's Guidance for Aquatic Plant Management In Lakes and Ponds (2004, 3-6):

Control of Target Species

- Investigate how the target species became established.
- Create an implementation plan that maximizes the effectiveness of the treatment, while limiting impacts on non-target species.
- Evaluate the effectiveness of the treatment through continued monitoring efforts.
- Devise a strategy to replace treatments with temporary effectiveness with those that provide long-term solutions.

2 Some projects, including drawdown, herbicide/algaecide applications, harvesting, dredging, and managing pioneer infestations, require the submission of additional criteria. Additionally, aquatic weed control projects where anticipated impacts are deemed minimal may qualify for a "limited review." (DEP 2004)

Protection of Resource Areas

Consider whether the project will significantly affect wetland resource areas,[3] groundwater, or public and private water supplies. Are there alternatives strategies that may lessen these effects?

Work Description

Submit a detailed, site-specific work plan describing treatment methodology, environmental impacts, construction/implementation plan, and a project timeline.

Rare Species and Other Critical Resources

Determine whether the treatment area is located within National Heritage and Endangered Species Program (NHESP) Estimated Habitat[4] or Outstanding Resource Waters (ORW)[5].

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3 Delineated resource areas from DEP Wetland Maps.

4 NHESP defined by 310 CMR 10.59

5 ORW defined by 314 CMR 9.00

Fisheries

Survey the pond for fish species and habitat characteristics. Strive to minimize habitat alterations and negative effects on the fishery, especially during spawning and stocking periods.

Wildlife Habitat

Related to the previous conditions, but more general in scope, 310 CMR 10.56 (4)(a) asserts that the project may not "impair [the pond's] capacity to provide wildlife habitat functions."

Upon reviewing the NOI, the conservation commission or other issuing authority may approve the project on the terms specified by an Order of Conditions. Provided that the applicant has adequately addressed the project's potential impacts, permits are generally granted, especially for minor, routine, and well-documented practices. When seeking to implement more aggressive or unconventional treatments, however, perhaps in accordance with a long-term pond management plan, applicants should anticipate heightened scrutiny of their proposal.

In cases where a private contractor has been hired to administer the treatment, they will often assist the applicant in preparing the NOI. NOIs drafted by contractors with extensive experience navigating the regulatory framework and a good rapport with previous clients may be more readily approved. Aquatic Control Technology, Inc. (ACT) whose lake and pond management services are commonly used throughout the Salem Sound Watershed, have been successful in this. Should SSCW become active in pond management, they can develop a similar reputation by lending technical assistance and credibility to applicants developing NOIs, especially when the proposed treatments are consistent with the goals of a long-term pond management plan. In taking on this role, SSCW should emphasize their unique position in the watershed as an independent research organization.

Though NOI hearings are adjudicative, they are not invulnerable to external political, economic, and social influences. For example, conservation commissions will have broad discretion to approve or deny proposals when regulations are vague, oversight is limited and the risk of appeal is minimal. Additionally, our interviews with conservation commission members from Salem Sound Watershed revealed little consistency in the criteria used to evaluate pond management decisions. In light of this uncertainty, we stress the importance of empirical justifications and public support as the best guarantees that a project will be approved. Public participation throughout the monitoring process not only contributes to a vital body of data, but also fosters consensus and tempers opposition.

Evaluation

Project evaluation is a vital and often overlooked step in managing lakes and ponds. Unless monitoring, surveying and public outreach activities continue during and after management practices are implemented, there will be no empirical measures of their success. Treatments based on speculative evidence, rather than collected data, will be less likely to attract funding and public support.

For each element of the management program, evaluate:

- To what extent initial goals were met;
- Obstacles to implementation;
- Prospects for continuation.

Evaluations will provide the basis for revisions to subsequent management plans. Since the results of many treatments will not be immediately observable, plans need only be updated every three to five years, or in response to changing circumstances. Once the initial management plan has been created, subsequent plans may require only minor revisions.

A continued management program also benefits from a growing compendium of data to inform decisions and a sustained reduction of nutrient inputs to the pond.

We encourage municipalities, perhaps with assistance from SSCW, to periodically release reports or pamphlets informing the public, media, nearby towns and other interested parties about recent management endeavors. These may take the form of a yearly summary of monitoring and management activities, or provide an account of a specific project.
The report should provide a brief description of recent management actions, the rationale behind them and a candid evaluation of their success to date.

Chapter Six

Chapter Seven:

Long Term Planning for Watershed Protection

A great challenge facing municipal governments is how to influence and abate the private decisions that can permanently harm sensitive environmental resources. In this chapter, we describe the role of local government in the long-term protection of wetland resources and discuss the value of several land use planning techniques. We furthermore consider state-level land use legislation and how it affects the success of local and regional planning efforts. By providing an overview of the current regulatory framework related to land use planning, we hope to encourage Salem Sound Coastwatch and similar organizations to advocate for state-level reforms that would promote local comprehensive plans and, therefore, rational land use decisions. While previous chapters of this report focused primarily on the management of individual ponds, here we take a step back to show how municipalities can fit pond management into the contexts of both the entire watershed and other planning objectives.

Local Government Power

Under the Commonwealth of Massachusetts' "home rule" Amendment, municipalities have the authority by their police power to enact local legislation for the protection of the health, safety, and welfare of the public (Massachusetts State Constitution). The rationale behind the home rule Ammendment is that local governments are best situated to understand the needs of their communities, more so than state or federal government.

Any approach that a municipality takes to protect its wetlands should be based on a comprehensive plan, sometimes called a master plan. This plan articulates the community's long-term vision and planning goals and provides a rational basis for the specific land use regulations that it seeks to enact in relation to these goals (Russell 2004). The protection of ponds, lakes, rivers, streams, and other wetland resources should be embedded in the comprehensive plan. According to American Planning Association, "Land use regulation should enhance the predictability for residents, investors and builders. Ad hoc decisions by communities, made outside of effective comprehensive planning processes, undermine that predictability" (American Planning Association 2002). Communities in the Salem Sound Watershed could benefit from the comprehensive planning process, as it would allow for greater foresight in dealing with pond and other resource management issues. This would be a vast improvement over the current paradigm of reactionary management.

The planning approaches used to protect ponds and other wetlands may support or conflict with other community goals, such as business development, affordable housing, or transportation improvements. Thus, bringing together various local officials from different departments (e.g. conservation, health, water, recreation, traffic) and residents to participate in the planning process can help to both ensure that the plan is horizontally consistent—that is, elements of the plan are not contradictory—and build community "buy in" for future regulations that align with the plan.

State Level Policy Relating to Local Land Use Planning

Some planners point to the Massachusetts Zoning Act, which grants municipalities certain regulatory powers related to land use, as a formidable barrier to local planning efforts because it limits cities' and towns' ability to make zoning changes, develop smart growth controls, and protect vacant lands (Krass 2003). Due to these limitations, the Act impedes the protection of wetland resources by "encouraging sprawl" and making it difficult for communities to use their Home

Rule authority to focus growth away from environmentally sensitive areas (Krass 2003). In reviewing Massachusetts' land use policies, the American Planning Association recently reported that "although technically a 'home rule' state, the statutes that govern planning and land use regulation are so restrictive to local authority as to make home rule more an illusion than a reality in Massachusetts" (Barron, Fung, and Su 2004). Because there is no state-level requirement that municipal land use regulations be based on a comprehensive plan, Massachusetts is considered an "unplanned" state (Witten 2010). Without the aid of a master plan, land use decisions are made on an ad hoc basis and often lack the horizontal consistency, described above, and vertical consistency, or uniformity with state-level regulations.

Potential Role for Salem Sound Coastwatch

We see a potential role for Salem Sound Coastwatch (SSCW) as an advocate for important state-level legislation, such as the passage of the Community Planning Act (CPA-II), which would reform state-level statues related to local land use planning. The CPA-II would, among other things, require that municipalities enact zoning and subdivision plans consistent with a master plan, remove loopholes which undermine local planning, and provide more effective planning tools to cities and towns (Zoning Reform Working Group). Due to the small staff at SSCW, the non-profit may, however, prefer to continue its focus on providing technical support to the region's cities and towns. Nonetheless, it behooves SSCW to understand the applicable regulatory restrictions, as well as any changes on the horizon.

SSCW should be well versed in commonly used regulatory methods of watershed protection. As municipalities seek to update their existing wetlands and land use regulations, SSCW is in a position to make policy recommendations in the best interest of the Salem Sound Watershed. The remainder of this chapter describes common regulatory techniques to protect wetland resources as well as details about which protections have already been enacted by municipalities in the Salem Sound Watershed. The descriptions are meant to provide an overview of regulatory approaches for SSCW and identify which communities in the region could strengthen their wetlands protections. Additional research would be required to make specific policy recommendations for each community within the watershed.

Municipal Wetlands Bylaws and Ordinances

As discussed in Chapter Three, the primary responsibility of local conservation commissions in Massachusetts is to administer the Wetlands Protection Act (WPA), which is a state-level legislation that regulates the use of land in and around wetlands. The WPA identifies the types of resource areas that must be protected and for what reasons. All proposed projects on wetlands, or within their buffer zones, will have various levels of review, called performance standards, based on the type of resources areas and protection interests that are affected (MassDEP). These are the most basic protections that every municipality in Massachusetts is required to enforce.

The WPA also lays out a detailed project review process that all proposed projects taking place within a wetland buffer zone must be followed. See Appendix J for a flowchart illustrating the appeals process under the WPA. Although the WPA does provide significant protections for wetlands resources, cities and towns in Massachusetts may enact regulations that are stricter than the Wetlands Protection Act. Municipal wetlands ordinances can expand the State's wetlands protections in var ious ways, including:

- To regulate vernal pools that are not certified by the state and therefore not protected by the WPA.

- To extend buffer zones around vernal pools, isolated vegetated wetlands, and land subject to flooding beyond the requirements of the WPA.
- To expand the WPA's definition of "areas subject to inundation and flooding."
- To enforce "no build zones" within a wetlands buffer zone.
- To give the conservation commission permission to delay the certification of wetlands during the dry season until the spring, when wetland boundaries are more easily identifiable (Pioneer Institute).

A recent study analyzed the effects of municipal wetlands bylaws and ordinances on the conversion of open space to residential use. Interestingly, the study found that communities with wetlands regulations have a lower open space conservation rate than those that do not have regulations (Sims and Schuetz June 2007). These findings support the argument that local wetlands ordinances may be an effective mechanism to protect sensitive environmental resources, such as ponds.

All six municipalities within the Salem Sound watershed have adopted wetlands ordinances that give the local conservation commission the authority to adopt stricter wetlands regulations than those within the WPA. Of the six conservation commissions, all except Salem have actually used this authority.[1] Table 7.1 indicates how each community in the Salem Sound Watershed have strengthened their wetlands protections (Pioneer Institute).

1 According to the Pioneer Institute, Salem has adopted a wetlands bylaw that extends the buffer zone around rivers to 200 feet. However, the Salem Conservation Commission has not enacted any additional wetlands regulations despite having the authority to do so (Pioneer Institute).

		Marblehead	Manchester-by-the-Sea	Salem	Beverly	Danvers	Peabody
Vernal Pools	Does the municipality have jurisdiction to regulate vernal pools that are not certified by the state?	Yes	Yes	No	Yes	No	Yes
	Does the municipality's jurisdiction extend to buffer zones around vernal pools beyond what the jurisdiction granted in the state Wetlands Protection Act would cover?	Yes	Yes	No	Yes	No	Yes
	If so, what is the width of jurisdiction from the mean annual water-line of the vernal pool?	200 ft	200 ft	N/A	100 ft	N/A	200 ft
Isolated Wetlands	Does the municipality regulate buffer zones around isolated vegetated wetlands?	Yes	Yes	No	Yes	Yes	Yes
	If yes, what is the size of the buffer?	100 ft	(100 ft) - isolated wetland must be a minimum 5,000 sq ft	N/A	100 ft	100 ft	100 ft

Table 7.1 – Local Wetlands Regulations of Municipalities in the Salem Sound Watershed (Adapted from a joint initiative of the Pioneer Institute for Public Policy Research and Harvard's Rappaport Institute for Greater Boston, 2004).

Table 7.1 (cont.)

		Marblehead	Manchester-by-the-Sea	Salem	Beverly	Danvers	Peabody
Land Subject to Flooding	Does the municipality regulate buffer zones around "land subject to flooding"?	Yes	Yes	No	No	No	Yes
	Does the municipality define "areas subject to inundation and flooding" to cover greater potential area than the jurisdiction granted in the state Wetlands Protection Act would cover?	Yes	Yes	No	No	Yes	Yes
Setback Regulations	Does the municipality enforce "no build zones" within the buffer zone around wetlands? If yes, what is the setback requirement?	Yes	Yes	No	Yes	Yes	Yes
	If so, what is the specific setback requirement?	* 25 ft no disturbance, * 50 ft no build, * 100 ft no disturbance (vernal pool)	*50 ft no disturbance	N/A	* 25 foot no disturbance * 100 foot no disturbance (vernal pools)	* 25 foot no disturbance * 35 foot no build	100 ft no disturbance
Wetlands Certification Delay	Does the wetlands bylaw/ordinance give the Conservation Commission the right to delay certification of wetlands during dry seasons or winter months or for another reason?	Yes	Yes	No	Yes	Yes	Yes

Municipal Pesticide Restrictions

From our case study we find that the Marblehead Board of Health's Organic Pest Management (OPM) regulation conjures a larger question about the role of local government in regulating the use of herbicides and pesticides. In Massachusetts, at the state level, the Department of Food and Agriculture's Pesticide Bureau is responsible for carrying out the Massachusetts's Pesticide Control Act, by overseeing the registration of new pesticide products and the licensing of commercial applicators, including aquatic herbicide products (Massachusetts Department of Agricultural Resources).

So, how does this state law affect local pesticide regulations, such as the one in Marblehead? Though the act makes it illegal for a municipality to regulate the use of pesticides on private land, it does not prevent it from regulating the use of pesticides on town-owned property (Wellesley Natural Resources Commission May 2002).[2] Thus, Marblehead's OPM regulation can only apply to town-owned property, such as public recreational fields, but not on private property, such as the lawns abutting Black Joe's Pond. If cities and towns wish to protect a watershed by reducing non-point source pollution from private properties, they must use non-regulatory strategies, such as education and outreach. We support SSCW's endorsement of programs like Greenscapes Massachusetts, which educates homeowners about pesticide-free yard care.

Low-Impact Development / Stormwater Regulations

As discussed in Chapter Five of this report, Low-Impact Development (LID) is a site design technique that encourages

2 In this context, the term "pesticide" is meant to include both herbicides and algaecides.

the use of stormwater best management practices. Municipalities can enact LID or stormwater regulations that create standards for the control of stormwater for development, establish design criteria, and provide developers with incentives for using of LID techniques (Metropolitan Area Planning Council).

Overlay Zoning

An overlay zone is an additional layer of zoning placed on top of existing zoning to impose greater restrictions on land uses and future development. An overlay district could be used for wetlands protection by including limitations on impervious surface cover, setback requirements, buffers, restriction on hazardous material storage, septic systems requirements, and erosion control measures (Russell 2004). Although overlay zoning can be a powerful tool to protect the land around vital wetland resources, we do not recommend it for communities in the Salem Sound Watershed. Enacting new zoning bylaws require an act of the legislative branch of local government and therefore cannot easily be adapted when the conditions or boundaries of wetlands change (Witten 2010). This can be especially problematic in communities where the legislature meets infrequently, such as towns where community-wide voting at a public meeting is required for zoning changes. Instead, we recommend that local governments continue to strengthen the provisions within their local wetlands regulations, as described above, which is a more achievable method to protect important water resources.

Flexible Zoning

Cluster development, open space residential design (OSRD), conservation subdivision, and planned unit development (PUD), are all types of flexible zoning that allow a developer to subdivide land so that structures are clustered together more densely than under existing zoning. By clustering housing units together, more of the remaining land within their lot can be set aside for open space (Pioneer Institute). Using data from the Frontier Institutes Housing Regulations Database and local government bylaws and ordinances, Table 7.2 shows the types of regulations and land use planning approaches employed by cities and towns in the Salem Sound Watershed.

	Manchester-by-the-Sea	Salem	Peabody	Marblehead	Beverly	Danvers
Wetlands Ordinances (Stricter than Mass WPA) (Pioneer Institute)	x	x	x	x	x	x
Stormwater Management Ordinance (From Local Bylaw or Ordinance)	x			x		
Wetlands Overlay District (From Local Bylaw or Ordinance)		x	x			
Groundwater / Surfacewater Protection Overlay District (From Local Bylaw or Ordinance)	x		x			x
Flood Plain (Control) Overlay District (From Local Bylaw or Ordinance)	x	x	x		x	x
Watershed Protection Overlay District (From Local Bylaw or Ordinance)					x	
Cluster Development, by right (Pioneer Institute)						
Cluster Development, by special permit (Pioneer Institute)	x	x	x		x	x
Has cluster development been used? How many times? (Pioneer Institute)	No	Yes (1-8)	Yes (1-8)		Yes (1-8)	?

Table 7.2: Salem Sound Watershed Land Use Regulations

Conclusion

A successful pond management program is a multifarious set of solutions. It addresses pressing problems with in-pond techniques, and pre-empts future problems by targeting their sources. It also requires the collaboration of several different groups, such as conservation commissions, watershed organizations, town planners, and the public.

We emphasize the need to first gather data about pond conditions as a foundation for treatment and planning decisions. Given the strain on their time and resources, conservation commissions and watershed organizations may harness volunteer assistance for data gathering efforts. Once data has been collected and analyzed, the involved groups can assemble a management plan, which may include an in-pond treatment and must include watershed protection measures. In this report, we have provided an introductory guide both to in-pond treatments and to long-term watershed-saving strategies. Furthermore, municipalities can take advantage of certain regulatory tools to strengthen these pond and watershed protection efforts.

The need for pond management and watershed planning is heightened in urban or suburban areas such as the Salem Sound Watershed, where long-term pond management planning is scarce. Thus, we have articulated a potential role for Salem Sound Coastwatch that would further engage the organization as a regional liaison, educator, scientific resource, and environmental advocate. We hope to have shown how SSCW is uniquely poised to facilitate integrated pond management, whole watershed goals, and a productive regional dialogue about future steps.

Acknowledgments

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Finally, we are particularly grateful to our professors, Rusty Russell and Rachel Bratt, and their teaching assistants, Jack Melcher and Jeremy Robitaille, for their thoughtfulness, enthusiasm, and assistance throughout the semester.

List of Acronyms

ACT	Aquatic Control Technology
CPA	Community Preservation Act
CPA-II	Community Planning Act
CRWA	Charles River Watershed Association
CSO	Combined sewer overflow
CWA	Clean Water Act
DCR	Department of Conservation and Recreation
DEP	Massachusetts Department of Environmental Protection
DO	Dissolved oxygen
EEA	Massachusetts Executive Office of Energy & Environmental Affairs
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
GEIR	Generic Environmental Impact Report
GIS	Geographic Information Systems
LID	Low impact development
MassDEP	Massachusetts Department of Environmental Protection
NHESP	National Heritage & Endangered Species Program
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resources Conservation Service
NRWA	Neponset River Watershed Association
OOC	Order of Conditions

List of Acronyms

OPM	Organic Pest Management
ORW	Outstanding Resource Waters
OSRD	Open space residential design
PROMPT	Preservation and Restoration of Marblehead Ponds Today
PUD	Planned unit development
QAPP	Quality Assurance Project Plan
SOC	Superseding Order of Conditions
SSCW	Salem Sound Coastwatch
TKN	Total Kjeldahl nitrogen
TN	Total nitrogen
TP	Total phosphorus
TSS	Total suspended solids

USGS	United States Geological Survey
WPA	Wetlands Protection Act
WRC	Water Resources Commission

Glossary

algae: Photosynthetic and usually autotrophic organisms found in most habitats, ranging from single- to multi-cellular.

alkalinity: A measure (mg/L) of a solution's ability to neutralize acid.

anoxia: The state of being low in oxygen—in the case of a pond, low dissolved oxygen content.

anoxic water: The area of a pond in which there is low dissolved oxygen.

anthropogenic: Caused or produced by human activity or because of human influence.

Aquatic Control Technology (ACT): A private lake and pond management service based out of Sutton, MA.

bathymetry: Measurement of the depth of a pond basin.

benthic zone: The lowest level of water in a pond, includes the sediment surface.

bioretention: An engineered stormwater management technique designed to capture stormwater runoff before it is infiltrated or discharged. Bioretention treats stormwater runoff through physical and biological mechanisms during infiltration.

buffer zone: Any area that keeps two entities separate from each other: as it pertains to environmental issues, a buffer zone refers to the area between any development activity and a natural resource area including a wetland.

buildout: An area's maximum development potential.

Charles River Watershed Association (CRWA): A watershed organization dedicated to the use of science, advocacy, and the law for the protection, preservation, and enhancement of the Charles River and the surrounding watershed.

chlorophyll a: Green pigment found in most plants, used to measure water quality with a high level indicating poor water quality (high algal growth and excessive nutrient content).

Clean Water Act (CWA): Passed in 1972, the CWA uses regulatory and non-regulatory tools to reduce pollutant discharges into surface receiving waters.

combined sewer overflow (CSO): A wastewater discharge occurring when the volume of water in sewers designed to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipe exceeds the capacity of the sewer system or treatment plant.

Community Planning Act (CPA-II): Proposed state-level legislation that would reform statutes related to local land use planning by providing municipalities with new planning tools such as impact fees, ensuring that new zoning is consistent with a master plan, and removing loopholes that weaken local planning.

Community Preservation Act (CPA): Legislation enacted in Massachusetts in 2000 to help communities preserve open space and historic sites, create affordable housing, and recreational facilities.

conductivity: The ability to transmit electricity, sound, or heat.

conservation commission: A department of municipal government responsible for the preservation and protection of natural resources.

Department of Conservation and Recreation (DCR): An agency charged with protecting, promoting, and enhancing natural, cultural, and recreational resources.

dissolved oxygen: The amount of gaseous oxygen dissolved in water.

drawdown: A management technique whereby a pond's water level is lowered to expose unwanted aquatic vegetation

eutrophication: A process whereby water bodies receive excess nutrients that stimulate excessive plant and algae growth.

environmental impact statement (EIS): A document required under US environmental law that describes the positive and negative environmental effects of a proposed action and outlines alternative actions.

Environmental Protection Agency (EPA): Agency of the federal government charged with protecting human health and the environment by developing and enforcing regulations, studying environmental issues, education, and grants and sponsorships.

fetch: A measurement of the two most distant points on the pond's shoreline. A longer fetch allows greater interaction between wind and the water surface, thus promoting mixing.

first flush: The initial surface runoff from a storm event, typically the first ½ to 1 inch.

Generic Environmental Impact Report (GEIR): A report that aims to support the Commonwealth's 1994 Policy on Lake and Pond Management and details management options for the control of aquatic plants and algae.

Geographic Information Systems (GIS): System that integrates hardware, software, and data for analyzing and displaying geographically indexed information.

green roof: A roof that is partially or totally covered in vegetation designed to intercept and manage stormwater runoff, provide insulation, and/or create habitat.

groundtruthing: On-site verification of spatial or structural features.

groundwater: Water that is below the soil surface, in soil pore spaces, or contained in fractures in the rock often withdrawn for agricultural, industrial, or municipal use.

home rule: The power of municipality by the authority to enact local legislation for the protection of the health, safety, and welfare of the public.

horizontal consistency: The concept that adjoining jurisdictions and departments within one level of government agree with each other.

hydrologic budget: Accounting for the inflow, outflow, and detention of water in a given area.

hydrologic soil group: a classification system developed by the Natural Resource Conservation Service indicating a soil's moisture absorption properties

impervious surface: Any surface that is impenetrable and does not allow the infiltration of water, typically man-made surfaces such as roads, sidewalks, driveways, and parking lots.

invasive species: A species whose presence in an ecosystem is characterized by uncontrolled growth, potential to cause environmental and economic harm, or harm to human health.

littoral area: Area of the pond basin extending from the shoreline to the limit of rooted aquatic plants.

Low impact development (LID): An alternative approach to land development or redevelopment to manage stormwater through the conservation and use of natural features to protect water quality and conserve or restore natural hydrologic conditions.

macrophytes: Aquatic plants that are emergent, submergent, or floating that are growing in or near water.

Massachusetts Department of Environmental Protection (MassDEP or DEP): A state agency responsible for environmental protection and administering environmental laws.

Massachusetts Executive Office of Energy & Environmental Affairs (EEA): A multi-department state agency that deals with environmental and energy issues.

Massachusetts Zoning Act: Enacted in 1975, allows municipalities under their police power to create and enact zoning ordinances to protect the health, safety, and welfare of the public.

moraine: A glacial feature made up of unconsolidated glacial till.

morphometry: The pond's physical form.

National Heritage & Endangered Species Program (NHESP): Part of the Massachusetts Division of Fisheries and Wildlife, responsible for the conservation and protection of species that are not commercially trapped, hunted, harvested or fished in the state.

National Pollutant Discharge Elimination System (NPDES): A permit program that controls water pollution by regulating point sources that discharge pollutants into US waters, authorized by section 402 of the Clean Water Act.

National Resources Conservation Service (NRCS): Federal agency committed to conserving natural resources on private lands.

native plant species: Plant species that inhabit an area and are considered indigenous to that ecosystem.

Neponset River Watershed Association (NRWA): A grassroots 501c3 organization dedicated to the protection and restoration of the Neponset River, its tributaries, and the surrounding watershed.

non-native plant species: Any species that is found to be living outside of its natural range, most commonly introduced to an ecosystem by human activity.

non-point source pollution: Contamination from diffuse sources, often transferred by stormwater runoff.

Notice of Intent (NOI): A notice in the federal register that an environmental impact statement for a proposed action will be prepared.

nutrient loading: Nutrients entering an ecological system.

Open space residential design (ORSD): Method of residential development that conserves open space.

Order of Conditions (OOC): A legal document describing the ability of a development or treatment plan to meet applicable performance standards per the Wetlands Protection Act.

Organic Pest Management (OPM): A regulation passed by the Marblehead Board of Health in 2001 prohibiting the use of peticides on town-owned land unless a waiver is obtained.

Outstanding Resource Waters (ORW): A classification to protect waters of outstanding state or national recreational or ecological significance with high water quality.

pelagic zone: The open water area of a pond, between the benthic (bottom) and littoral (nearest the shore).

permeable pavers: Pervious paving materials that allows the infiltration of water to the soil below by allowing movement of water around the material.

pH: A measure of the acidity or basicity of a solution, measured by the molar concentration of dissolved hydrogen ions (H+)

planned unit development (PUD): A development tool used by municipalities to encourage flexibility in zoning regulations to meet community density or land use goals.

point-source pollution: Contaminated discharges from specific, identifiable sources.

Preservation and Restoration of Marblehead Ponds Today (PROMPT): A Marblehead group comprising Black Joe's Pond abutters and other residents. PROMPT wanted to chemically treat Black Joe's Pond.

Quality Assurance Project Plan (QAPP): A procedure developed by the EPA that documents the planning, implementation, and assessment procedures for a particular project, as well as any specific quality assurance and quality control activities.

rain garden: A depressed garden that intercepts and collects stormwater to facilitate treatment and infiltration of runoff, a form of bioretention.

riparian zone: Vegetated areas alongside a stream or waterbody.

runoff coefficient: A measure of a surface's capacity to absorb precipitation.

Salem Sound Coastwatch (SSCW): A non-profit coastal watershed organization dedicated to the protection and enhancement of the environmental quality of the Salem Sound Watershed through education, stewardship, scientific investigation, and municipal partnering.

sedimentation: The deposition and accumulation of solid particulate matter including debris, sand, and silt (sediments) on the pond bottom therefore reducing the depth of the pond.

shoreline development: A ratio indicating the degree of irregularity of a lake shoreline, given as the length of the shoreline to the circumference of a circle whose area is equal to that of the lake.

stressed water basin: A basin, or sub-basin in which the volume of streamflow has been reduced, or water quality of streamflow or habitat factors have been degraded or impaired.

stormwater runoff: Water flow that occurs from precipitation from rain (storm events) or snowmelt.

Superseding Order of Conditions (SOC): Legal document that either confirms or alters an Order of Conditions for a proposed project in the case of an appeal.

swale: A naturally occurring or man-made low tract of land. Artificial swales are designed for the management of stormwater runoff, to facilitate infiltration, and provide treatment of runoff; typically vegetated.

total Kjeldahl nitrogen: A water quality indicator that measures the total organic nitrogen content.

total nitrogen: A water quality indicator that measures the total nitrogen content including organic, ammonia nitrogen, nitrate, and nitrite; used a water quality indicator.

total phosphorus: A water quality indicator that measures the total phosphorus content including organic and inorganic, dissolved and particulate forms.

total suspended solids: A water quality indicator that measures the total content of suspended particulate matter in water.

turbidity: A water quality indicator that measures the transparency of water, influenced by the presence of suspended particulate matter.

United States Geological Survey (USGS): A multi-disciplinary science organization committed to the study of landscape, natural resources, and natural hazards that focuses on biology, geography, geology, water, and geospatial information.

Glossary

urban pond: A pond in an urbanized context—that is, an area that is populated by humans and contains buildings, roads, mowed lawns, or other structures and infrastructure. For this report, we consider ponds in suburban environments to be urban ponds.

urban runoff: Surface runoff created by impervious surfaces associated with urban development.

vernal pool: A seasonally flooded depressional pond or wetland, termed vernal because they are usually flooded during spring and early summer.

vertical consistency: The concept that local government plans and regulations do not conflict with those of higher government.

water clarity: A measure of how much sunlight can penetrate the water column.

water column: The vertical distance from the bottom sediments to the surface of the pond; the conceptual idea of a vertical column of water.

Water Resources Commission (WRC): The commission responsible for developing and overseeing the water planning activities and policy in Massachusetts.

watershed: An area of land where all water either under or on the land drains to the same place; a bounded hydrologic system.

watershed association: An organization dedicated to the protection of a particular watershed.

watershield: A perennial, floating-leaved aquatic plant

Wetlands Protection Act (WPA): State legislation to protect wetland resources that regulates activities on lands bordering waters. It is administered by conservation commissions and the Massachusetts Department of Environmental Protection.

winterkill: The death of fish during the winter season resulting from extreme cold temperatures or dissolved oxygen depletion.

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Appendix A

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Appendix A:

Chronology of the Black Joe's Pond Conflict

This chronological list of events is more complete than Chapter Two's overview of the conflict, but it still excludes minor events and exchanges.

4/12/2006	Craig Campbell files a Notice of Intent (NOI) to use herbicides and algaecides on Black Joe's Pond (BJP).
6/2/2006	Director of Public Health Wayne Attridge writes to Conservation Commission stating that town owns the pond, and is thus subject to the Board of Health's Organic Pest Management (OPM) regulation.
6/8/2006	Conservation Commission is unable to verify Mr. Attridge's claim that the town owns Black Joe's Pond.
6/22/2006	Conservation Commission issues an Order of Conditions (OOC) with special conditions, including the requirement that all pond owners (five private abutters and the town) consent to the treatment proposed in the NOI.
6/23/2006	Mr. Attridge writes to Mr. Campbell stating at least a portion of pond is owned by town, and therefore no application of chemicals can be made until waiver from OPM regulations is granted from the Board of Health.
6/23/2006	Mr. Campbell requests an OPM waiver from the Board of Health on grounds that the condition of BJP represents an environmental emergency.
6/30/2006	Maryclaire Wellinger requests a Superseding Order of Conditions (SOC) from the Massachusetts Department of Environmental Protection (MassDEP) to disallow the OOC and prohibit chemicals on BJP.

7/7/2006	Mr. Campbell requests a MassDEP SOC that would delete the OOC special condition of full owner consent.
8/8/2006	Site walk at BJP with MassDEP's Gary Bogue.
12/6/2006	SSCW begins work on a Freshwater QAPP (Quality Assurance Project Plan).
2/1/2007	Mr. Bogue notifies Mr. Campbell that the NOI will be sent to the Natural Heritage and Endangered Species Program (NHESP) for their review.
3/27/2007	Mr. Campbell on behalf of PROMPT writes to NHESP stating that they would be willing to comply with any mitigation measures NHESP would deem necessary.
4/4/2007	Mr. Campbell requests that the Board of Health "grant last year's request for a waiver pursuant to the Organic Pest Management Regulations to permit treatment" of BJP.
4/23/2007	NHESP declares that the plan in the NOI "will not adversely affect the actual Resource Area Habitat of state-protected rare wildlife species." Thus, the OOC would be permissible in their opinion.
5/1/2007	SSCW and others conduct the first Lakes and Pond survey using Department of Conservation and Recreation survey data sheet.
5/?/07	Salem State College (SSC) installs sediment traps and a geochemical probe to monitor pond's water chemistry (temperature, pH, conductivity, etc.).
5/29/2007	Two abutters confront SSC professors and students at the pond.
6/8/2007	SSCW and others conduct the second Lakes and Pond survey using DCR survey data sheet.

6/12/2007	MassDEP issues a Superseding Order of Conditions (SOC), upholding the OOC and requesting that a long-term plan also be formed.
6/22/2007	Ms. Wellinger requests a MassDEP adjudicatory hearing in response to the SOC.
7/16/2007	Mr. Campbell's Motion to Dismiss the Request for an Adjudicatory Hearing, claiming that Ms. Wellinger "failed to demonstrate that she is a person authorized to request action" by MassDEP.
7/17/2007	Mr. Campbell writes to the Conservation Commission to say that abutters were not willing to sign a consent agreement with SSC but that the Conservation Commission, on behalf of the town, can proceed with study efforts on the town-owned portion of BJP.
7/17/2007	SSC formally acknowledge their removal of all monitoring equipment and cession of any activities at BJP.
7/23/2007	Conservation Commission member's letter to Chair Walter Haug expressing support for a reversal of the decision to allow chemicals on BJP.
7/25/2007	Ms. Wellinger's Objections to the Motion to Dismiss the Request for and Adjudicatory Hearing.
7/26/2007	The Conservation Commissions, as an abutter and owner of over forty percent of BJP, withdraws their approval for herbicide application at BJP.
8/9/2007	MassDEP Order to Mr. Wellinger and Mr. Campbell to send copies of all filed papers to MassDEP's Office of Appeals and Dispute Resolution.
8/25/2007	MassDEP's Response to Applicant's Motion to Dismiss asking Maryclaire Wellinger to show "cause as to why Ms. Wellinger's claim should not be dismissed for lack of jurisdiction."

8/27/2007	Ms. Wellinger's Clarifications to the Objections to the Motion to Dismiss in response to MassDEP's Response to Applicant's Motion to Dismiss.
11/23/2007	MassDEP's Office of Appeals and Dispute Resolution's Decision on Applicant's Motion to Dismiss and Order to Show Cause and to File Notice of Appearance by Ms. Wellinger.
5/15/2008	Mr. Campbell's Objection to Ms. Wellinger's Motion to Dismiss.
6/27/2008	MassDEP's Final Decision that the SOC cannot be complied with since local bylaw permits have lapsed.
6/10/2009	Mr. Campbell's request a 3-year extension of the OOC.
6/11/2009	MassDEP's Ruling on Motion to Dismiss denies Mr. Campbell's Motion to Dismiss following a Status Conference.
6/12/2009	Conservation Commission denies Mr. Campbell's request for an extension because of a procedural error.
7/27/2009	Mr. Campbell writes to Conservation Commission with signatures of all private, landowning abutters consenting to the chemical treatment of BJP.
8/13/2009	The Conservation Commission votes to reinstate its approval for one time application of chemicals.
2/23/10 & 3/15/2010	MassDEP Hearing.
4/2/2010	Recommended Final Decision upholding the original OOC.

Appendix B:

Recommended Parameters for Pond Analysis

As specified in Inland Waters QAPP (Schoen 2008). Methods are derived from the follwing sources:

[1] Standard Methods for the Examination of Waste and Wastewater, 21st Edition (Eaton et al. 2005)

[2] EPA Clean Water Act Analytical Methods (http://www.epa.gov/waterscience/methods/method/).

[3] USGS Water-Resources Investigations Reports (http://pubs.usgs.gov/wri/)

	Parameter	Method	Importance
Morphometry / Structural Features	Bathymetric Profile	Manual or electronic depth measuring device and GPS unit	Pond depth affects the distribution of aquatic macrophytes and rate of mixing. Used to calculate a number of areal characteristics including surface area, maximum depth, shoreline length, shoreline development, fetch, and littoral area.
	Sediment Depth	Sediment probe	A pond's life span is largely determined by the rate at which sediment accumulates on its bottom.
	Outlet Structure	Visual assessment	Outlet structure type and flow control mechanisms should be assessed to determine their suitability for management options that require the capacity to regulate outflow.
Water Testing	Site Location	Sighting landmarks	To maintain consistency, sampling locations should be carefully recorded so that monitors can find the site on subsequent visits.
		GPS	
	Water Clarity	Secchi Disk with viewscope	Clarity is a simple and effective indicator of water quality and is used to estimate trophic state because of its influence on plankton and algae production, as well as the distribution depth of aquatic macrophytes.
		Transparency Tube	

	Parameter	Method	Importance
Water Testing (cont.)	Temperature	Thermometer and calibrated line	Thermocline depth and temperature differential determine the extent of vertical mixing and the water's capacity to hold dissolved oxygen.
	Dissolved Oxygen (DO)	SM 4500-O[1]	The decomposition of organic matter and higher water temperature deplete DO levels, creating unfavorable and potentially lethal conditions for pond organisms.
	Total Suspended Solids (TSS)	SM 2540D[1] or EPA 160.2[2]	High amounts of suspended particles in the water column can decrease light penetration, thereby decreasing the amount of oxygen released by photosynthesis. Other deleterious effects include reducing habitat suitability for insects and fish, increasing water temperature, and releasing nutrients and other pollutants.
	pH	SM-4500-H[1]	pH levels affect the solubility of chemicals and their availability in the water column. Organisms exhibit varying tolerances to changes in pH.
	Alkalinity	SM 2320-B[1]	Alkalinity is a measure the pond's buffering capacity, or its ability to maintain a constant pH in the presence of acidic inputs.
	Conductivity	SM-2510-B[1]	Dissolved salts introduced to the water through geological processes or pollution increase its conductivity. Values outside of the acceptable range can affect plant and animal physiology.
	Total Phosphorus (TP)	SM 4500-P[1] or EPA 365 (.1, .2 or .3)[2]	Phosphorus is often the limiting nutrient for algae and aquatic plant growth in freshwater systems and is used to estimate trophic state.
	Chlorophyll a	SM 10200 H[1]	Chlorophyll a provides an indirect measure of algae abundance in the pond and can be used to estimate trophic state. High algae levels decrease dissolved oxygen levels, light penetration, and mixing.

	Parameter	Method	Importance
Water Testing (cont.)	Total Nitrogen (TN)	SM 4500-N B[1] SM 4500-N C[1] USGS WRIR 03-4174 (Method I-4650-03)[3]	Nitrogen stimulates the growth of algae and aquatic plants. Since nitrogen is often the limiting nutrient in estuarine ecosystems, ponds that drain into these areas should be closely monitored for nitrogen output.
	Total Kjeldahl Nitrogen (TKN)	EPA 351 (.1, .2, .3 or .4)[2] SM 4500-Norg B[1] SM 4500-Norg C[1]	The sum of organic nitrogen and ammonia nitrogen.
	Algal Toxins	Microscopic identification; Quicktube Microcystin kits can be used to test for microcystin	Algal blooms may release toxins harmful to humans and aquatic organisms.
Biological Assesment	Macroinvertebrates	Kick net sampling	Assess biodiversity and presence of indicator species.
	Invasive Species Identification	Visual, grab	Invasive plants can colonize rapidly and quickly become the dominant species in the pond ecosystem, reducing its ecological and recreational value.
	Aquatic Plant Survey	Visual, grab	The distribution and abundance of aquatic plants in the pond provides an indicator of overall health and habitat quality.
	Algae Identification	Grab or depth integrated	Management techniques vary for different algal species.

Appendix C:

Recommended Components of a Watershed Analysis

The following information was compiled from a variety of sources, most notably, Eutrophication and Aquatic Plant Management in Massachusetts: Final Generic Environmental Impact Report (EOEA, 2004).

	Parameter	Data / Methods	Purpose
Hydrological Analysis	Watershed Delineation	Topographic data and groundtruthing	Determine land area that contributes runoff to the pond.
	Watercourse Assessment	Topographic data and groundtruthing	Identify and characterize sources of inflow and destination of outflow.
	Hydrologic Budget	-Annual precipitation data -Watershed area -Evapotranspiration -Withdraws -Wastewater Imports/Exports	Calculate total annual flow of water entering and leaving the watershed and account for any net gains or losses.
	Soil or Surficial Geology Analysis	-NRCS soil surveys -USGS surficial geology maps -slope data -Runoff coefficients for various surface types	Soil type or surficial geology, in addition to the presence of wetlands and impervious surfaces, determine relative contributions of surface and groundwater flow into the pond.

	Parameter		Data / Methods	Purpose
Nutrient Loading Analysis	Pollutant Point Sources		Field observation / Inquiry	Identify any wastewater or industrial discharges inside the watershed.
Nutrient Loading Analysis (cont)	Land Use	Historic	Historic land use maps and orthographic images Inquiry	Examine potential sources of attenuated nutrient and pollutant release from past land uses, septic systems, hazardous waste disposal sights, and wastewater discharges.
		Present	Loading coefficients for various land uses	Estimate total nutrient input from the watershed and the relative contributions from existing land uses.
		Future Buildout	-Zoning laws and lot size specifications -Loading coefficients for various land uses	Estimate potential increase in nutrient loading if all available land were developed to the maximum extent allowable under existing regulations and codes.
Biological Analysis	Bank/Riparian Zone Assessment		Qualitative description or relative point system	Evaluate the bank's susceptibility to erosion and the condition of the riparian zone.
	Shoreline Species and Habitat Survey		Field observation	Create a record of the organisms that utilize the shoreline ecosystem.

Appendix D:

Methods for the Management of Eutrophication

The following information is paraphrased from Mattson et al.[1] Direct quotations and information from other sources are attributed so. The Eutrophication and Aquatic Plant Management in Massachusetts: Final Generic Environmental Impact Report aims to support the Commonwealth's 1994 Policy on Lake and Pond Management:

Massachusetts advocates a holistic approach to lake and pond management and planning which integrates watershed management, in-lake management, pollution prevention and education. Lake management in Massachusetts will be designed with consideration of the quality of the lake's ecosystem, its designated uses and other desired uses, the ability of the ecosystem to sustain those uses, and the long term costs, benefits and impacts of available management options (Mattson et al 1-1).

The report was last updated in 2004. The information from this source may not reflect changes in treatment practices or alterations in cost estimations since the date of publication.

In-Pond Methods to Control Nutrients

Hydraulic Controls: Diversion

The process of diversion, the rerouting of water away from the pond, is most often used for stormwater runoff.

1 Eutrophication and Aquatic Plant Management in Massachusetts: Final Generic Environmental Impact Report; authored by Mark D. Mattson and Paul J. Godfrey while employed at the Water Resources Research Center at the University of Massachusetts, Regina A. Barletta and Allison Aiello, also of the Water Resources Research Center, and revised by Kenneth J. Wagner of ENSR International, an environmental consulting firm. This document was published by: the Commonwealth of Massachusetts; the Executive Office of Environmental Affairs; the Department of Environmental Protection; and the Department of Conservation and Recreation.

Diversion prevents nutrient-rich water from entering a pond and increasing the overall nutrient load. Smaller volumes of water are easier to redirect because the downstream channel or outlet structure must be able to handle the entire volume. While case studies show that diversion has a good probability of long-term pond recovery, a major disadvantage of this technique is that it reduces the overall hydrologic load in the system. This can be especially harmful in states such as Massachusetts where the majority of water are stressed or impaired; due to this complication, special permits are required for some types of diversion. Costs for implementation depend on transport distance, the volume of water to be diverted, and site characteristics.

Hydraulic Controls: Dilution and flushing

Dilution lowers the concentration of a nutrient by adding nutrient-poor water to the pond, therefore limiting the availability of the nutrient for uptake in plants. Flushing inputs nutrient-poor water into the pond in an effort to flush algae out of the pond faster than they can reproduce; physical removal of algae reduces algal blooms. A high rate of flushing is required to make significant improvements because algae reproduce rapidly. Dilution and flushing are more effective in small ponds because of the large amount of water required. Downstream degradation and increased turbidity may impact non-target organisms. Main cost considerations include the volume and availability of water to be used, and the capital cost for any necessary infrastructure and equipment.

Hypolimnetic or Selective Withdrawal

Withdrawal removes the poorest-quality water, often found in the oxygen-deprived bottommost layers of the pond. Removal of poor-quality water prevents the release of nutrients from the sediment-water interface by preventing anoxic conditions. Proper application of this technique requires “detailed knowledge of system morphometry, thermal structure, chemistry, hydrology and phosphorus loading" (3-44). Its effectiveness depends on the amount of nutrient reduction. Its disadvantages include the technical knowledge it requires, disrupted stratification, and the possibility of degraded downstream conditions. Costs depend on the volume of water removed, but one-time capital costs for withdrawal and treatment of discharged water is high.

Phosphorus Precipitation and Inactivation

Phosphorus binders including aluminum, iron, calcium, and nitrate compounds can be added to the water column to control algal blooms that result from high internal recycling of nutrients. The additives are applied to the surface or subsurface in either liquid or solid form. They form hydroxide precipitates that adhere to phosphorus, removing it from the water column. The precipitate hydroxides inactivate the phosphorus and make it insoluble so that plants and algae cannot use the nutrient. The floc settles to the bottom of the pond and "[t]he resulting nutrient limitation in the surface waters prevent algal blooms from forming" (3-54). This technique creates a clearer water column and reduces algal blooms. Effectiveness is dose dependent and varies highly depending on the method and site characteristics. Both long- and short-term effects must be considered and because once the additives are in the water column they cannot be removed easily. Monitoring should take place after treatment. Costs depend on the compound chosen and dose. A comparison of phosphorus precipitation and inactivation techniques can be found in Appendix F.

Artificial Circulation and Aeration

The main purpose of these related techniques is to increase oxygenation of the pond to reduce the internal recycling of phosphorus and therefore manage algae. Whole pond circulation minimizes stratification and is used to create desired circulation patterns in shallow ponds. This can be accomplished with surface aerators, bottom diffusers, and water pumps. Increased turbidity, changing light regime, and altered water chemistry may produce a shift in algal types from more noxious blue-green cyanobacteria to less dangerous green species.

Aeration is often used in deeper ponds and lakes. Bottom diffusers inject columns of air bubbles that disrupt stratification and create mixing, which eliminates temperature differences between layers and oxygenates the water column. Oxygen can also be injected into the bottom layers of the pond to encourage aerobic respiration of organic matter; without anoxic conditions phosphorus will be trapped in the sediments and therefore not available to vegetation. Improper design or installation, or insufficient aeration can lead to increased algal blooms. Other disadvantages are the possibility of thin ice if used in winter and noise from compressors or pumps. Ceasing treatment stops any adverse effects, but it also makes the treatment ineffective. A comparison of layer aeration and hypolimnetic aeration (full- and partial-lift systems) can be found in Appendix E.

Dredging

Dredging removes nutrient-rich soils from the pond bottom that may cause algal blooms or encourage macrophyte growth. Removing these nutrient-rich layers of sediment from the pond, as well as resting algae-deposited cysts, "effectively sets it back in time, to a point prior to significant sedimentation" (3-81). Dredging can reduce benthic mat formation even if external nutrient sources are significant. Rapid recolonization of algae is expected, yet, changes in algal composition may result. Fully understanding the pond and watershed system is necessary for successful dredging, especially the engineering aspects involved with this practice. This method is most appropriate for total pond restoration. Partial dredging projects are possible, but it will be most effective if all of the sediments are removed. If water column-sediment interactions in a specific area are not localized, they can affect the entire body of water. Benefits of dredging, in addition to algal control, include increased water depth and clarity due to decreased water-sediment interactions, and macrophyte control.

A number of performance guidelines should be considered prior to dredging, including a nutrient budget, biological, chemical, and physical surveys, and a feasibility analysis. The cost of dredging is often prohibitively high, though costs vary significantly by size of the project and are dependent on the volume of material removed. See Appendix I for a full comparison of dredging methods.

Bacterial Additives

Bacterial additives, natural or engineered, can be added to the aquatic environment to out-compete the algae for nutrients. The additives can also bind up the supply of phosphorus and nitrogen, therefore reducing concentrations in the pond. This technique has been termed "organic dredging" (3-103) because the bacteria consume the organic material at the bottom of the pond. However, "it is not clear that a bacterial community capable of precluding algal blooms would not itself constitute an impairment of aquatic conditions" (3-103) or that added bacteria will not become undesirable over time.

Removal of Bottom Feeding Fish

This technique is a form of biomanipulation that aims to restructure food chain and organism interactions in a pond or lake. The harvest of nutrient-releasing bottom-feeders like carp and bullheads has led to increased water clarity. However, the removal of these species without sacrificing the entire fish population is difficult and labor-intensive, as bottom-feeders tolerate low levels of dissolved oxygen and high levels of fish poison.

Methods to Control Aquatic Plants

Drawdown

In drawdown, water levels are lowered to the point where susceptible species can be dried or frozen and algal growth potential is limited; drawdown can be an effective multipurpose lake and pond management tool. Pumping, opening a pipe or gate in a dam, or siphoning lowers water levels. This technique is often used for flood control, repair or cleanup, with macrophyte control as an auxiliary benefit. Drawdown is not effective on all submergent species, but is able to decrease the abundance of some chief nuisance species. In order to effectively accomplish a drawdown, more outflow than inflow needs to be maintained for a sustained period, and inflow and outflow are matched again and maintained when the desired water level is reached.

Obstacles to effective implementation include precipitation patterns, system hydrology, outlet structure, lake morphology, and sedimentation of an outlet channel or other obstructions that may affect the maximum drawdown level. Freezing the exposed macrophytes may significantly increase the success of this technique. Short-term results include effective shoreline clean up and plant control. The long-term results of drawdown are also contingent upon the reduction of sediment-released nutrients in the pond as well as effective control of the macrophyte population. Recreational activities and certain fish populations will be affected during drawdown as swimming areas shrink, beaches are enlarged, boating may be restricted, and lowered oxygen levels under ice—if freezing is used—can lead to fish kills. Though typically inexpensive, the costs depend on whether or not an outlet structure exists or if pumping is required.

Harvesting

Harvesting is defined as mechanical plant cutting, with or without removal, as well as algal collection. It can be a very effective short-term treatment to control aquatic plants and, with repeated applications at appropriate intervals, it can also be an effective long-term treatment option by producing long-term shifts in the plant community. It is, however, unlikely to reduce long-term plant density substantially, and is not practical on a large scale. This is an effective short-term tool for controlling macrophyte growth, but not nutrients.

All forms of harvesting (hand-pulling, cutting, hydroraking or rototilling, suction harvesting) cause turbidity from resuspension of organic materials and detritus, though pond-wide effects are minimal, and oxygen-dependent decay increases if the material is not collected during the harvesting process. Special care should be taken to watch out for protected plant species, especially if the harvesting technique is not very selective. Submerged obstacles such as stumps should be assessed for potential problems for the equipment. Harvesting often needs to be implemented more than once a season to achieve desired macrophyte control, with the exception of major hydroraking operations, which rarely occur more than once every three-to-five years. Water quality characteristics should be monitored several times each season, and an annual monitoring program should focus on plant surveys. Non-target species loss should be considered and incorporated into the planning process, such as timing the procedure to avoid spawning fish or eggs. A management plan should include the areas to be harvested, means to dispose of the biomass after harvesting, the timing and pattern of the harvesting, as well as the harvesting method. For a complete explanation and comparison of harvesting techniques please see Appendix H.

Biological Controls

Food web biomanipulation, herbivore stocking, pathogen additives, and plant interactions are all biological controls that alter ecosystem communities to control macrophytes and algae. These techniques are often favored because they are an organic approach to lake and pond management. Although biomanipulation allows for control without the use of machinery or chemicals, it has an ecological drawback that makes its effectiveness hard to predict: the predator rarely eradicates the prey population in predator-prey populations. Biological controls often have many more variables to consider than other control techniques, and usually need a longer span of time to evaluate efficacy.

The potential for long-term effectiveness with little maintenance makes biological control an attractive option. However, there are risks. For example, non-native organisms may be difficult or even impossible to control once introduced. Augmentation of native or naturalized species is preferable to the introduction of foreign species. Cost can vary substantially depending on choice of introduced organism, necessary mitigation measures, monitoring, magnitude of application, as well as labor costs for removing planktivores and the cost of stocking piscivores.

Benthic Barriers

The aim of benthic barriers, based the principle that plants cannot grow through physical barriers or without light, is to impede the growth of macrophytes through the placement of materials on the bottom of the pond, burying existing plants and seed banks. Benthic barriers restrict light, disrupt growth, and prevent chemical reactions from taking place to interfere with the development of plants. Manufactured benthic barriers can be solid or porous, and are negatively buoyant, often made of fiberglass, polyethylene, and nylon. Their need for in-place maintenance limits their physical range, and they have the potential to become structurally compromised by their environments. Thus, pond-wide effects are not expected as this technique is usually applied to small areas. Unless the barrier is permanent, enduring effects on the ecosystem are not usually associated with this technique. Assessment of the physical and biological area to be covered is required before installation and maintenance planning. Maintenance is necessary and the barrier should be removed if there are problems.

Herbicides and Algaecides

Perhaps the most common and the most controversial aquatic plant control technique is the use of biological chemicals to kill macrophytes or algae. Algaecides and herbicides contain both active toxic and inert ingredients (auxiliary compounds) that aid in application or effectiveness. Chemical treatments can be classified as systematic or contact herbicides. Systematic herbicides are taken up by the plant and are translocated throughout the plant, therefore killing the entire plant. Contact herbicides are toxic to plants by uptake in the immediate vicinity of external contact, which may not eradicate the root. The active ingredients in herbicides are either selective or broad spectrum. Selective ingredients are more effective on particular species, but can kill most plants if applied at high rates. Contact herbicides are usually broad spectrum because they kill any plants in the immediate vicinity rather than targeting specific species. Only six active ingredients are approved for use in Massachusetts and often come in terrestrial and aquatic formulations. Herbicides may contain adjuvants—that is, chemical additives to increase the effectiveness, usually by increasing the plant's uptake, distributing the herbicide through the water column, or helping the chemical adhere to the plant. Adjuvants increase the toxicity of the chemical treatment and often have toxic properties themselves.

The short-term effects of herbicide treatments include the rapid reduction of algae or vascular plants for weeks or months. Chemical treatments are typically considered a short-term solution although long-term results are possible. Systematic herbicides provide longer lasting results than contact herbicides that can leave roots that can regrow after treatment. Chemical treatments are often used to get plant and algae growth under control until a long-term alternative treatment can be determined and implemented.

These chemicals can indirectly affect species that use the targeted plants for food or for cover. Permanent changes in the plant community can have dramatic effects. Proper timing, application dosage and location can help reduce impacts on non-target species. Application dosage and rate should be below the amount that would produce harmful effects on non-target fauna species. Factors to consider include the timing of application, water temperature, water hardness (many herbicides have varying toxicity depending on the hardness) and other environmental conditions, as well as the form, granular or liquid, of application. Fish kills are rarely observed if herbicides are used according to their label, though fish kills may result from the lowered oxygen levels during plant die-off. Negative water quality effects are more likely in ponds with the following characteristics: high water temperature; high plant biomass to be controlled; shallow, nutrient-rich water; high percentage of the pond area treated; closed or non-flowing system (4-81).

Accurate plant identification from a biological study along with distributions and densities should be obtained prior to treatment and the treatment area should be clearly indicated. Extensive water quality and use data should be gathered. Costs for monitoring and developing assessments or case studies is significantly greater than is required for most treatments and maintenance, other than reapplication (typically every two years). Because the treatment is irreversible, carefully planned timing and dosage is vital for limiting adverse effects. Adherence to all label warnings is crucial and a licensed professional must perform all herbicide treatments. See Appendix G for a comparison chart.

Dyes and Surface Covers

Dyes and surface covers are coloring agents or sheet materials that inhibit light penetration and reduce growth of vascular plants or algae. Dyes restrict light availability for algal growth, and restrict the depth at which rooted plants grow. These techniques are called selective because they favor species that can tolerate low light or have enough food reserves to support growth until the stem reaches a level where light is available. Generally, dyes and surface covers are non-toxic to all species, including the target species.

Dyes have been effective in small ornamental and golf course ponds, but are not generally used in larger pond or lake systems. They should be applied early in the growing season and in ponds without a flowing outlet. Stratification in shallow ponds that do not typically stratify may result from increased surface water temperatures and shifts in faunal communities, though long-term effects are not expected. Knowledge of lake or pond bathymetry and hydrology is required in order to facilitate the calculation of the amount of dye needed. No maintenance is required, although reapplication may be necessary (4-132).

Surface shading can also be used as a rooted plant control technique, though this technique is often ruled out because of its interference with recreational activities. Surface covers are a useful and inexpensive alternative for aquatic plant control, especially for small areas. Surface shading is a slow growth elimination process that is more likely used to prevent future growths than eliminate existing growths. No significant long-term or pond-wide effects are associated with this treatment. Assessment of biological and physical features of target area, as well as wave effects, presence of protected species, and extensive obstructions should be considered prior to implementation. Installation and anchoring of the covers are the primary logistic considerations resulting in frequent surveillance and adjustments to maintain desired cover. In the case of adverse effects, covers should be removed.

Dredging

Dredging, as explained in the Nutrient Control section, can also be used as an effective aquatic plant control technique.

Flooding

Filling a pond beyond its normal water levels acts to drown aquatic plant stems by inhibiting carbon dioxide uptake. Flooding also causes dilution of nutrients and the increased water depth prohibits light from reaching submergent plants. The combined effects from flooding may reduce biota density, however, this method is not popular because the negative effects often outweigh the benefits, especially where shoreline residents are present.

Filtration

The Safe Drinking Water Act requires filtration of water for consumption. Many technologies exist to meet this need, but most only apply to lake management. The cost of filtration on such a scale necessary to reduce algal biomass in eutrophic lakes is very high. It might be possible to apply some form of filtration in small ponds if water is going to be taken out and treated, but it would probably be more logical to control the sources of eutrophication instead.

Settling Agents

Settling agents can be added to a pond to increase algal particle size to facilitate settling as a way to enhance filtration. In conjunction with phosphorus precipitation and inactivation, settling agents could enhance effectiveness by increasing the occurrence of precipitation.

Sonication

Sonication applies sound to agitate and break up particles for better lab analysis. A floating sonicator that breaks up algae and causes it to sink to the bottom of the lake or pond is available commercially. The sonic waves have no reported effect on fish or zooplankton. Sonication can provide short-term relief and may be a viable option for small ponds, however this technique needs to be further researched.

Appendix D

Appendix E:

Aeration Techniques

This table compares layer and hypolimnetic aeration techniques (Source of information unless otherwise noted: Mattson et al 2004).

Method	Procedure	Advantages	Disadvantages	Cost
Layer Aeration	Oxygen is added to the system at specific depth layers. It acts as a mixing force, preventing hypolimnetic anoxia by making more oxygen available to bacteria during decomposition.	Effectiveness can be increased by adding phosphorus binders. Layer aeration does not disrupt stratification. Effective in recovering cold-water habitat where anoxia is problematic	Treatment becomes ineffective when ceased. Thin ice in winter. Facilities needed to house equipment. Noise. Need for Maintenance.	All-inclusive costs are estimated to be about $500-3000 per acre for circulation systems. Costs include materials (e.g., oxygen and equipment) and operating costs.

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Method		Procedure	Advantages	Disadvantages	Cost
Hypolimnetic Aeration	Full-Lift System	Hypolimnetic water is transported to the surface by compressed air or electric- or wind-powered pumps. The water is aerated then piped back down into the hypolimnion to maintain separation of the newly aerated waters from the epilimnion.	Does not disrupt stratification in the system. Reduces the anoxic zone in the hypolimnion.	Treatment becomes ineffective when ceased. Thin ice in winter. Facilities needed to house equipment. Noise. Need for Maintenance.	All inclusive costs are estimated to be about $500-3000 per acre for circulation systems. Costs include materials (e.g., oxygen and equipment) and operating costs
	Partial-Lift System	Air is pumped into a submerged chamber, which then allows for the transfer of oxygen into deeper waters. The newly oxygenated waters are released back into the hypolimnion.	No interference with pond use or aesthetics because of the submerged chamber system. Does not disrupt stratification in the system. Reduces the anoxic zone in the hypolimnion.	Treatment becomes ineffective when ceased. Thin ice in winter. Facilities needed to house equipment. Noise. Need for Maintenance.	

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Appendix F:

Phosphorus Precipitation and Inactivation Techniques

This table compares phosphorus precipitation and inactivation techniques (Source of information unless otherwise noted: Mattson et al 2004).

Method	Procedure	Advantages	Disadvantages	Cost
Aluminum Compounds	Alum added to the pond forms an aluminum hydroxide precipitate (floc). The floc binds to phosphorus, removing it from the water column and forming an insoluble aluminum phosphate compound that settles out and cannot be consumed by algae. (Fisheries and Habitat 2003).	Binds to phosphorus under a wide range of pH and oxygen levels, including anoxia. The aluminum phosphate compound collects suspended particles from the water column and carries them to the pond floor, leaving the water clearer (Fisheries and Habitat 2003).	Application provides no refuge for organisms in the water column in surface application. Aluminum lowers the pH oh the treated pond. Aluminum can be toxic to fish if not added in the proper amount.	Cost is dependent on the form of alum used, dosage, area treated, and method of application. Costs range from $280-700 per acre (Fisheries and Habitat 2003).

Method	Procedure	Advantages	Disadvantages	Cost
Iron Compounds	Iron compounds form hydroxides that bind phosphorus making the nutrient unavailable for algal intake.	Effective in well aerated systems. No negative long-term impacts. Beneficial impacts on water quality.	Not effective in anoxic conditions, in which unstable floc will dissolve and re-release phosphorus into the water column. Long-term effects on non-target organisms are not known.	Relatively inexpensive, however higher doses are needed. Costs will be greater because iron treatments are recommended in conjunction with aeration systems.
Calcium Compounds	Calcium compounds form carbonates and calcium hydroxides that form floc. The floc precipitates in and sinks to the bottom of the pond, removing phosphorus from the water column.	Calcium is highly soluble.	Only effective in ponds with high pH values.	Average of $200 per acre.
Nitrate Compounds	Nitrates are injected directly into surface sediments. They maintain a high oxidation-reduction potential and enhance the ability for naturally occurring iron to bind phosphorus particles.	Excessive algal growth is not expected in ponds where phosphorus is the main algal growth control factor. Nitrogen to phosphorus ratio is increased.	Not a widely used technique. Can displace oxygen molecules in hemoglobin.	Expensive, largely due to the cost of injecting the chemical into the sediments.

Appendix G:

Chemical Treatments

A comparison of herbicide and algaecide methods (Source of information unless otherwise noted: Mattson et al 2004).

Method	Procedure	Advantages	Disadvantages	Cost
2,4-D	Systematic herbicide: absorbed by roots, leaves, and shoots, disrupts cell division throughout the plant.	Selective. Acts in 5-7 days, to 2 weeks (Madsen 2000). Relatively low application rates. Inexpensive (Madsen 2000).	Public perception (Madsen 2000). Short-term solution.	The cost of herbicide treatments are highly dependent on the chemical used, volume and area of the pond to be treated, application strategy, and distance from the applicator. Costs range from $50-2,000 per acre including costs for monitoring programs.
Flouridone	Systematic herbicide: inhibits carotene synthesis, therefore the plant is unable to produce carbohydrates necessary for life.	Low toxicity to invertebrates, fish, other aquatic life, and humans. Slow plant die off reduces the potential for rapid negative water quality impacts.	Broad spectrum. Long contact period, more effective in slow flowing systems (Madsen 2000). Acts in 30-90 days (Madsen 2000). Most expensive treatment.	Costs range from $50-2,000 per acre including costs for monitoring programs.

Method	Procedure	Advantages	Disadvantages	Cost
Glyphosate	Systematic herbicide: prevents plant from synthesizing protein to produce new plant tissue. It is most effective in controlling emergent and floating vegetation.	Widely used (Madsen 2000). Few label restrictions (Madsen 2000). Acts rapidly, 7-10 days, up to 4 weeks (Madsen 2000).	Broad spectrum. Slow action (Madsen 2000). Short-term solution. Localized decrease in dissolved oxygen and increase in suspended solids as plant matter decays.	Costs range from $50-2,000 per acre including costs for monitoring programs.
Copper Complexes	Contact herbicide.	Least expensive treatment (Madsen 2000). Acts rapidly, 7-10 days, up to 4-6 weeks.	Broad spectrum. Not biologically active in sediments, but does not biodegrade. Several factors influence effectiveness (e.g., alkalinity, dissolved solids content, water temperature, suspended matter). Reapplication necessary.	Costs range from $50-2,000 per acre including costs for monitoring programs.

Method	Procedure	Advantages	Disadvantages	Cost
Diquat dibromide	Contact herbicide: interferes with photosynthesis.	Acts rapidly, 7-10 days (Madsen 2000). Widely used for macrophyte control in Massachusetts.	Broad spectrum. Does not affect underground root systems (Madsen 2000). Not as effective in flowing systems.	Costs range from $50-2,000 per acre including costs for monitoring programs
Endothall	Contact herbicide: inhibits oxygen for respiration.	Acts rapidly, 7-14 days (Madsen 2000).	Broad spectrum. Does not affect underground root systems (Madsen 2000). More effective as a localized treatment. Rapid plant decay negatively affects water quality.	Costs range from $50-2,000 per acre including costs for monitoring programs
Triclopyr	Systematic herbicide: disrupts growth processes by preventing synthesis of plant-specific enzymes.	Selective. Acts in 5-7 days, up to 2 weeks.	Not approved for use in Massachusetts until 2004 (Mitchell 2007). Toxicity depends on formulation.	Costs range from $50-$2,000 per acre including costs for monitoring programs.

Appendix G

Appendix H:

Harvesting Techniques

A comparison of different forms of harvesting to achieve macrophyte control (Source of information unless otherwise noted: Mattson et al 2004).

Method	Procedure	Advantages	Disadvantages	Cost
Hand-pulling	"Weeding the Garden": Snorkeler or diver selectively pulls unwanted plants on an individual basis. The process can be aided by tools or collection devices.	Highly selective technique. Ideal for small patches or assemblages.	Highly labor intensive. Repetition is likely to be needed to ensure complete removal or targeted species. Plant fragments need to be removed to limit regrowth. Short-term turbidity. Not practical for large or dense assemblages.	These efforts are often carried out by volunteers. Cost estimates range from \$150-300 per acre if the target species is sparse and as high as \$500 per acre or more for dense assemblages.

Method	Procedure	Advantages	Disadvantages	Cost
Suction Harvesting	Provides a conveyance system for plants pulled by divers, therefore allowing for faster hand harvesting. Plants can also be removed directly using suction.	Hand harvesting process can be accelerated. Utility of hand harvesting can be extended for denser assemblages. Can decrease biomass over time. Less intense yearly upkeep than the initial harvest.	Direct plant removal is dependent on skill of operator. Effectiveness is largely a function of the collection system; plant fragments need to be collected to reduce plant grow-back. Short-term turbidity and sediment suspension may occur. Disturbance of non-target species is expected. Timing is crucial; suction harvesting can remove fish eggs or have a negative impact on fish spawning areas.	Cost estimates are in the $7,000-8,000 per acre range and can be higher if equipment is not tested and perfected prior to use.

Method	Procedure	Advantages	Disadvantages	Cost
Cutting	"Mowing the Lawn": A blade of some kind severs the location of growth and the plant from the remaining root portion. Collection in small boats or nets may remove the plant fragments from the water column to reduce potential for regrowth. Plant fragments may be ground to minimize viable fragments after cutting if no collection occurs	Weed disposal is not usually problematic; farmers can use the weeds as mulch or fertilizer and the dry bulk is small. Effective in the short-term by providing relief from invasive plants and removing nutrients and organic matter. Effective way to provide open water for many acres that otherwise would have no recreational value. No significant negative long-term impacts.	Regrowth is expected and can be rapid, negating the benefits of cutting in just a few weeks. Not a very selective technique, non-targeted species may be harmed. Nutrients may be released as plants decay, and the consumption of oxygen during decomposition contributes to an anoxic zone and to eutrophication. Slow process. Spread of invasive species into newly cleared areas is possible.	Costs range from $350-550 per acre, including trucking and disposal. Costs can range to $1,000-5,000 per acre for very high plant densities. Costs of mechanical harvesting projects are inversely proportional to the size of the project, as fixed costs for permitting and mobilization are spread over the total project.

Method	Procedure	Advantages	Disadvantages	Cost
Rototilling/Rotovation	Cultivation equipment, typically a barge-like machine with a hydraulically operated tillage device, tears up roots. It can be lowered to depths of 10-12 feet or can be used after a drawdown.	This technique is appropriate where severe weed infestations exist.	Physical disturbance of bottom sediments, including the removal of plants that provide habitat for benthic organisms, and the resuspension and redistribution of find sediments. Invasive species that are able to recolonize from plant fragments may have a competitive advantage after rotovation.	The density of the macrophyte growth, substrate type, and size of the treatment area are the main factors influencing the cost of this treatment. Costs range from $2,000-4,000 per acre for submergent operations, and $6,000-10,000 for emergent growths, large floating mats, and dense root masses.
Hydroraking	The tines of a rake are pulled through the sediments to rip out thick root masses and associated sediment and debris. The machinery is tillage equipment—the equivalent of a floating backhoe outfitted with a rake.	Can be effective in removing thick root masses (ex: water lily), floating islands, and subsurface obstacle (ex: submerged stumps, logs). Immediate removal, so effective in the short-run; could provide relief from target species for 3-5 years if applied properly	Not very selective; non-target species will be harmed. Not effective for plants that can regrow from fragments. Growth of other plants in the raked areas could cause another invasive situation depending on which species becomes dominant during regrowth phases.	Costs range from $2,000-4,000 per acre, yet are expected to be higher if subsurface obstacles are prevalent and hard to remove.

Appendix I:

Dredging Techniques

This table compares dredging techniques (Source of information unless otherwise noted: Mattson et al 2004).

Method	Procedure	Advantages	Disadvantages	Cost
Dry Excavation	The pond is drained as much as possible and sediments are dewatered by pumping and/or gravity. Sediments are then removed using conventional excavation machinery (e.g., backhoes, draglines, bulldozers).	Thorough sediment removal and complete reconstructing of the pond floor is possible. Lowered nutrient levels. Increased water clarity. More stable dissolved oxygen levels and pH possible after dredging. Very long-term results possible.	Negative impacts to non-mobile and water-dependent species in short-term. Not effective in reducing algal blooms if nutrient sources are primarily external. Sediments need to be properly disposed of after dredging. Significant habitat and ecosystem disruption.	The cost of dredging is dependent on the size of the project and is mainly a function of the volume of material removed. Averages is about $10 per cubic yard of material removed and can run as low as $7 or as high as $20 per cubic yard. The high cost of dredging is often prohibitive.

Method	Procedure	Advantages	Disadvantages	Cost
Wet Excavation	The pond is not drained or there is partial drawdown. Excavation of wet sediments occurs using bucket dredges on cranes or amphibious excavators. Sediment-laden water is stored until dewatering occurs.	Effective in restoring degraded habitats. Lowered nutrient levels. Very long term results.	Variable water quality caused by increased turbidity and sediment resuspension. Inflows must be rerouted and outflow and inflow must be balanced.	see above
Hydraulic	Equipment is used to loosen sediment that is then pumped in the form of a slurry (80-90% water, 10-20% sediment) through a pipeline to a disposal site. At the disposal site, the sediment is allowed to settle out, with or without augmentation and the excess water is released back into the waterway.	Pond habitat is maintained throughout the process, minimizing the impact on non-target organisms. Gradual recolonization is expected and post-dredging biota is often preferred; resultant conditions might be inhospitable to pre-existing biota. Minimal impacts from turbidity, limited nutrient release during transport makes this an effective technique in ponds with highly organic sediments. Effective long-term solution.	Benthic organisms are negatively affected. Improper treatment of removed water can increase nutrient levels when released back into the waterway. Risk to the flora and fauna in the disposal or containment site is high.	see above

Method	Procedure	Advantages	Disadvantages	Cost
Pneumatic	Air pressure is used to pump a sediment-heavy slurry (50-70% solids) out of the pond. The sediments are separated out and treated.	Effective long term solution. Favored when water control in the water body is limited or large subsurface obstructions exist.	Increased turbidity. Nutrients are released into the water column as sediments are removed. Risk to the flora and fauna at the containment or disposal site is high. Failure to properly treat slurry could lead to problems with contamination.	see above

Method	Procedure	Advantages	Disadvantages	Cost
Reverse Layering	Sediments are not removed from the pond. Sandy substrate is pumped up by hydraulic jetting over the top layer of pond muck, therefore burying the nutrient rich layers of sediment and reducing the release of nutrients into the water column. The cavity left by the pumped sediments is filled in as the bottom sediments settle.	Retards eutrophication by reducing the release of nutrients into the water column. Restores the lake bottom to its original sediment type. Allows for a more diverse plant and animal community.	Benthic or non-mobile organisms may be buried under the sandy substrate. Minimal and temporary increase in turbidity. Does not increase pond depth. Does not remove contaminated layers or organic sediment. Long-term effects are not well-known.	see above

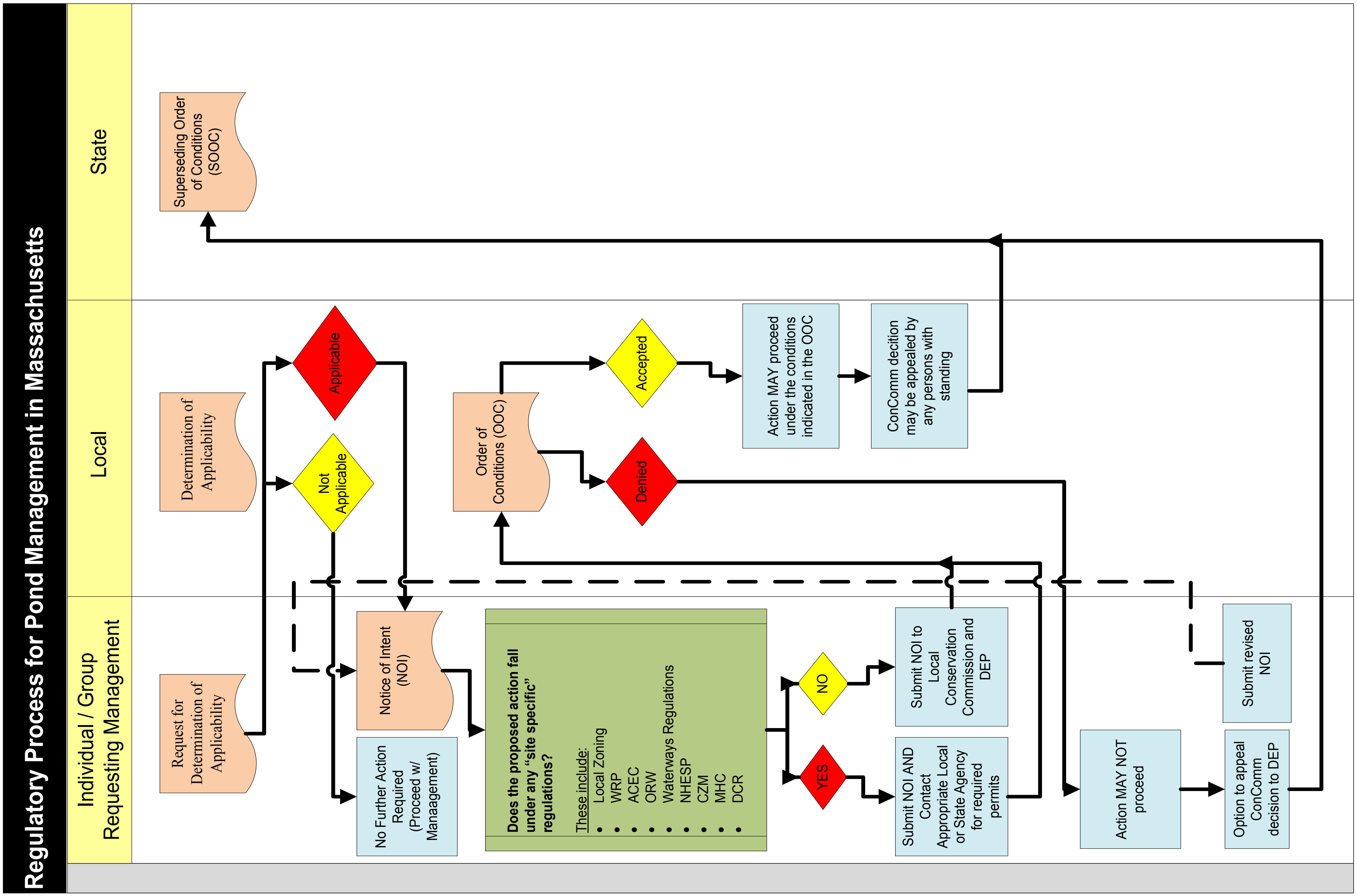
Appendix J:

Low Impact Development Practices

Low Impact Development Practice/Feature	Procedure	Cost Considerations
Buffer strips and swales	Surface overflow passes through vegetated strips of swales, decreasing the velocity of the runoff, and trapping and filtering out some of the pollutants. Water that infiltrates through the strips will get the benefit of physical and biological treatment. Slope and vegetation choices are important in the design, implementation, and effectiveness of these methods (Mattson 2004).	Inexpensive to build and maintain, however may require cleaning and replanting. Approximately a few dollars per square foot of buffer, about $20-50 per linear foot swale (Mattson 2004).
Minimization of impervious surfaces; Permeable pavers	Reducing impervious surface area reduces the amount of pollutants transported into the receiving waters and also reduces the velocity of the runoff, allowing more time for large particulates to settle out (Mattson 2004). Permeable pavers may be used in place of asphalt or concrete.	Cost considerations depend on the paving surface chosen. For example, grass pavers require replanting and maintenance; and paving stones may require material replacement over time. Most permeable pavers will require regular vacuum sweeping or hosing to keep the surface from clogging (Claytor and Horsley 2007).
Bioretention and Rain Gardens	Bioretention areas capture stormwater runoff and facilitate infiltration into the groundwater system with the added benefits of physical and biological treatment. These areas can be incorporated into existing or required landscaping and can be very aesthetically pleasing (Claytor and Horsley 2007).	Cost considerations include vegetation, soil fill, and maintenance depending on the area of the bioretention cell and rain garden (Claytor and Horsley 2007).

Rooftop Runoff Mitigation	The aim of rooftop runoff mitigation is to reduce the amount of stormwater runoff reaching impervious surfaces such as driveways. Methods include landscaping around areas where rooftop runoff is observed (rain gardens), redirecting gutters onto permeable surfaces, Drywells, cisterns, or rain barrels can also be used to capture and temporarily store water (Claytor and Horsley 2007).	Costs include vegetation and fill for a rain garden approach to rooftop runoff mitigation strategy, or costs for gutter extensions to redirect runoff, cistern or rain barrels for storage (Claytor and Horsley 2007).
Tree Planting	Increased tree planting, or conservation of existing trees, increases nutrient uptake, provides shading, provides habitat, and provides bank stabilization (Claytor and Horsley 2007).	Costs include purchasing new trees to be planted, or inventory and planning prior to any construction to preserve existing trees (Claytor and Horsley 2007).
Green Roofs	Rain gardens are "rooftop areas that have been landscaped with grasses, shrubs and, in some cases, trees" (Claytor and Horsley 2007). Green roofs offer insulation benefits, as well as natural habitat and runoff storage until uptake by plants can occur.	Costs for green roofs include vegetation, soil fill, and also depends on climate and the type of roof chosen. Extensive green roofs have a shallow soil foundation and do not generally incorporate pedestrian access, while intensive green roofs are designed for pedestrian access and have "deep soil layers to provide for complex planting schemes" (Claytor and Horsley 2007). Initial costs range from $8-20 per square foot for extensive, and $15-20 per square foot for intensive green roofs. Costs for maintenance and irrigation should also be considered (School of Freshwater Sciences 2010).

Appendix K



Flowchart based on Regulations of Wetlands Protection Act (http://www.mass.gov/dep/service/regulations/310cmr10a.pdf)

Tufts UNIVERSITY

OFFICE OF THE VICE PROVOST

Social, Behavioral, and Educational Research
Institutional Review Board

FWA00002063

Re: IRB Study # 1002014
Title: The Conservation and Politics of Urban Ponds: Charting a Path Through the Swamp of Competing Interests
PI: Corey Cameron
Co-Investigator(s): David Quinn, Daniel Nally, Alexandra Reisman, Bronwyn Cooke
Faculty Advisor: Robert Russell
IRB Review Date: 2/8/2010

February 8, 2010

Dear Corey,

Your *Application for Exempt Status* for the above referenced study has been reviewed. This study qualifies as exempt from review under the following federal guidelines:

Exempt Category 2 as defined in 45 CFR 46.101 (b). For complete details please visit the United States Department of Health and Human Services Office (DHHS) for Human Research Protections (OHRP) website at:
http://www.hhs.gov/ohrp/humansubjects/guidance/45cfr46.htm#46.101

Please know that this exemption does not relieve the investigator of any responsibilities relating to the research subjects; equal care must still be taken to ensure that subjects experience no harm to themselves or to their legitimate interests.

Furthermore research should be conducted in accordance with the ethical principles, (i) Respect for Persons, (ii) Beneficence, and (iii) Justice as outlined in the Belmont Report.

Any changes to the protocol or study materials that might affect the exempt status must be referred to the Office of the IRB for guidance. Depending on the changes, you may be required to apply for either expedited or full review.

If you have any questions, please contact the Office of the IRB at (617) 627-3417.

Sincerely,

Yvonne Wakeford, Ph.D.
IRB Administrator

20 Professors Row, Medford, MA 02155 | TEL: 617.627.3417 | FAX: 617.627.3673 | EMAIL: SBER@tufts.edu

Memorandum of Understanding
between
Tufts University Field Projects Team No. 8
and
Salem Sound Coastwatch

I. Introduction

Project (i.e., team) number: 8
Project title: **The Conservation and Politics of Urban Ponds: Charting a Path through the Swamp of Competing Interests**
Client: Salem Sound Coastwatch [SSCW]

This Memorandum of Understanding (the "MOU") summarizes the scope of work, work product(s) and deliverables, timeline, work processes and methods, and lines of authority, supervision and communication relating to the Field Project identified above (the "Project"), as agreed to between (i) the UEP graduate students enrolled in the Field Projects and Planning course (UEP-255) (the "Course") offered by the Tufts University Department of Urban and Environmental Policy and Planning ("UEP") who are identified in Paragraph II(1) below (the "Field Projects Team"); (ii) SSCW, further identified in Paragraph II(2) below (the "Client"); and (iii) UEP, as represented by a Tufts faculty member directly involved in teaching the Course during the spring 2010 semester.

II. Specific Provisions

(1) The Field Projects Team working on the Project consists of the following individuals:

1. **Corey Cameron** — **email address: camerocc@gmail.com**
2. **Bronwyn Cooke** — **email address: bronwyncooke@gmail.com**
3. **Daniel Nally** — **email address: dmnall@gmail.com**
4. **David Quinn** — **email address: dmquinn05@gmail.com**
5. **Alexandra Reisman** — **email address: arreisman@gmail.com**

(2) The Client's contact information is as follows:

Client name: Salem Sound Coastwatch [SSCW]
Key contact/supervisor: Barbara Warren
Email address: barbara.warren@salemsound.org
Telephone number: (978) 741-7900
FAX number: (978) 741-0458
Address: 201 Washington Street, Suite 9, Salem, MA 01970
Web site: www.salemsound.org

(3) The goal/goals of the Project is/are:

The goals of the Project are to examine strategies for coping with urban pond eutrophication, to analyze the competing interests in the case of Black Joe's Pond, and to advise SSCW on how best to proceed in this particular case and with future urban pond management.

(4) The methods and processes through which the Field Projects Team intends to achieve this goal/these goals is/are:

The Team's methods will include a literature review of the historical, scientific, political, and legal components of the issue; data compilation and synthesis; comparative case studies; interviews with stakeholders; and possibly mapping and geospatial analysis.

(5) The work products and deliverables of the Project are (this includes any additional presentations for the client):

The Project's primary deliverables will be a written report submitted in electronic and paper form, a debriefing for SSCW, and possibly a presentation to groups involved with the Mystic River Watershed.

(6) The anticipated Project timeline (with dates anticipated for key deliverables) is:

- **The main background research and data collection will be completed by February 23rd.**
- **All interviews will be conducted no later than March 19th.**
- **A draft of the Final Report will by submitted by April 10th, on which the Client will provide feedback no later than April 23rd.**

- **The final report submission, debriefing, and any presentations will occur no later than May 13th.**

(7) The lines of authority, supervision and communication between the Client and the Field Projects Team are (or will be determined as follows):

The Field Projects Team will communicate with the Client via phone or email every two weeks to provide updates on the project and intended future steps. The Client will provide feedback within 3 business days. The Team also hopes to meet with the Client in person at least once a month.

(8) The understanding with regard to payment/reimbursement by the client to the Field Projects Team of any Project-related expenses is:

Prior approval from the Client must be obtained before any spending in relation to the Project by the Team.

III. Additional Representations and Understandings

A. The Field Projects Team is undertaking the Course and the Project for academic credit and therefore compensation (other than reimbursement of Project-related expenses) may not be provided to team members.

B. Because the Course and the Project itself are part of an academic program, it is understood that the final work product and deliverables of the Project (the "Work Product") - either in whole or in part - may and most likely will be shared with others inside and beyond the Tufts community. This may include, without limitation, the distribution of the Work Product to other students, faculty and staff, release to community groups or public agencies, general publication, and posting on the Web. Tufts University and the Field Projects Team may seek and secure grant funds or similar payment to defray the cost of any such distribution or publication. It is expected that any issues involving Client confidentiality or proprietary information that may arise in connection with a Project will be narrow ones that can be resolved as early in the semester as possible by discussion among the Client, the Field Projects Team and a Tufts instructor directly responsible for the Course (or his or her designee).

C. The Client will review the Work Product before it is finalized, and may make suggestions and/or edits in relation to the content of the Product. All research data and information will be given to the Client in both paper and electronic forms by the end of the Project for the Client's full use. The

Client will use the data compiled and the final Work Products for both internal and public uses, with credit given to the Field Projects Team. Edits made after the Work Products have been finalized are to be noted in the form of an addendum or a clearly defined subset in the text.

D. It is understood that this Project may require the approval (either through full review or by exemption) of the Tufts University Institutional Review Board (IRB). This process is not expected to interfere with timely completion of the project.

IV. Signatures

Barbara Warren

For SSCW
By: Barbara Warren
Date: February 5, 2010

Representative of the Field Projects Team
By: Daniel Nally
Date: 2/9, 2010

Tufts UEP Faculty Representative
By: Rusty Russell
Date: Feb. 9, 2010