CHAPTER 7: LAKE & POND MANAGEMENT

Massachusetts Nonpoint Source
Pollution Management Manual

Introduction:

In Massachusetts, many lakes and ponds are impacted by what is known as "cultural eutrophication". All lakes undergo a natural aging process know as "succession" as they gradually become more biologically productive and slowly fill in with sediment and organic matter over time. In a completely undeveloped "natural" setting, this aging process typically takes place over thousands or tens of thousands of years. However, in developed landscapes, increased loading of **sediments** and nutrients (such as **phosphorus** and **nitrogen**) from nonpoint watershed sources can accelerate the lake aging process, leading to nuisance growth of both vascular aquatic plants (**macrophytes**) and **algae**.

Nonpoint Source Pollution Management For Lakes And Ponds

Primary NPS Pollutants and Issues
- Nutrients
- Sediment
- Pathogens
- Nuisance Plants / Algae

Who Typically Gets Involved?
- Conservation Commission (permitting)
- Lake/Pond Associations
- MA-DCR (funding/technical assistance)
- MA-DEP (funding/technical assistance)

Cultural eutrophication can result in excessive aquatic plant and algae growth, loss of open water habitat, and decreased recreational values.

In Massachusetts, the density of residential development in many lake watersheds has increased dramatically in the past fifty years. Many lakefront properties that received only seasonal use as summer cottages have been converted to year-round residences, resulting in increased nutrient loading to lakes from failing or sub-standard **septic system**s, application of lawn fertilizers, and other related sources. Heavy recreational boating use in Massachusetts lakes has also been a primary means of spread for invasive **aquatic** plants, which can be transported from lake to lake when plant fragments get caught on boat propellers and trailers.

Natural Succession vs. Cultural Eutrophication: A **eutrophic** lake is one that has high biological productivity, including abundant primary productivity (e.g. growth of plants and algae). All lakes undergo a natural "aging" process (known as **"succession"**) as they gradually become increasingly productive and lose depth due to the build-up of sediment and decomposed organic matter. However, this natural aging process is **significantly accelerated** for most Massachusetts lakes. This accelerated aging process (known as **"cultural eutrophication"**) is the result of **land uses** that increase the loading rate of **nutrients** and sediment. Highly eutrophic lakes experience decreased **habitat**, recreational, and aesthetic values, and may experience other impacts such as low oxygen levels, **algal blooms**, noxious odors and fish kills.

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Common symptoms associated with accelerated eutrophication include the loss of open water habitat, loss of lake depth, decreased water **clarity**, and decreased recreational values (e.g. swimming, boating). Seasonal oxygen depletion (**anoxia**) in the deep zone of the lake (the hypolimnion) is another common symptom of eutrophication. In the summer, decomposition of aquatic plants and algae consumes oxygen from the bottom waters of deeper lakes, which are thermally separated from the well-oxygenated surface waters. This condition can stress fish populations, particularly cold-water species such as trout. Oxygen depletion in the hypolimnion can also lead to the release of phosphorus from lake sediments back into the water column, fueling fall algae blooms.

The spread of non-native, invasive plants is another significant threat to Massachusetts lakes and ponds. Non-native plants such as Eurasian milfoil, Fanwort and Water Chestnut can spread aggressively once introduced to a lake, threatening the ecological balance and biological diversity of the water body. **Invasive species** tend to outcompete beneficial native plants which provide valuable food sources and protective cover to fish and other aquatic biota.

To aid Massachusetts communities and lake associations with the complicated task of managing nuisance aquatic plants in eutrophic lakes, the Massachusetts Executive Office of Environmental Affairs has prepared a **Generic Environmental Impact Report (GEIR) on Eutrophication and Aquatic Plant Management in Massachusetts** (2004). This document provides a comprehensive review of techniques for the control of nutrients and aquatic plants "in order to support the Commonwealth's Policy on Lake and Pond Management." The GEIR is intended as "a resource that documents existing lake management practices and determines the conditions under which their use is acceptable in Massachusetts". A companion document, **"The Practical Guide Lake Management in Massachusetts"** is also available to the public as a lake management resource document. Web links to the GEIR and "The Practical Guide" are provided on the following page.

Accelerated eutrophication and invasive plant species are not the only water quality problem impacting Massachusetts's lakes and ponds. Other water quality problems include **pathogens** (e.g. **bacteria**, viruses and parasitic protozoa) that may pose health risks, toxic chemicals, and high salinity in coastal areas.


Dudley Pond – Wayland, MA


Forge Pond – Littleton, MA


Mauserts Pond – Clarksburg, MA

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Massachusetts Lake and Pond Management Resources:

Massachusetts Department of Conservation and Recreation (DCR) Lakes and Ponds Program: The Lakes and Ponds Program works with local groups and municipalities to protect, manage and restore lakes and ponds. It provides technical assistance (and grant funds when available) to communities and citizen groups, conducts monitoring at lakes within the State Forests and Parks system, and provides public eduction materials about various lake issues. Web link: **http://www.mass.gov/dcr/waterSupply/lakepond/geir.htm**

Massachusetts Department of Environmental Protection (DEP) Division of Watershed Management (DWM): The DEP-DWM is responsible under Massachusetts General Law (MGL) Chapter 21 for monitoring the **waters of the Commonwealth,** identifying those waters that are impaired, and developing a plan to bring them back into compliance with the Massachusetts Surface **Water Quality Standards.** DEP-DWM produces the Massachusetts Integrated List of Waters (**http://www.mass.gov/dep/water/resources/2002-il1.pdf**), which identifies impaired river, lake, and coastal waters and the reasons for **impairment**. DEP-DWM also awards funding for lake projects through the Section 319 Nonpoint Source Pollution grant program (**http://www.mass.gov/dep/water/resources/nonpoint.htm**).

Policy on Lake and Pond Management for the Commonwealth of Massachusetts
http://www.mass.gov/envir/mwrc/pdf/Lake_Pond_Policy.pdf

Generic Environmental Impact Report (GEIR) on Eutrophication and Aquatic Plant Management in Massachusetts **http://www.mass.gov/dcr/waterSupply/lakepond/geir.htm**

The Practical Guide to Lake Management in Massachusetts (A Companion to the Generic Environmental Impact Report (GEIR) on Eutrophication and Aquatic Plant Management in Massachusetts)
http://www.mass.gov/dcr/waterSupply/lakepond/geir.htm

The Massachusetts Lake and Pond Guide: A full-color guide on lake basics, creating a lake-friendly home, lake management issues, agency contact information and more.
http://www.mass.gov/dcr/waterSupply/lakepond/lakeBook.htm

Invasive Species Information: The Massachusetts Department of Conservation and Recreation (DCR)-Lakes and Ponds Program has a variety of information on invasive species, including a field guide, plant fact sheets, an educational brochure, and boat ramp signage. These information sources can be accessed at the DRC website at: **http://www.mass.gov/dcr/waterSupply/lakepond/publications.htm**

Massachusetts Aquatic Invasive Species Management Plan (Massachusetts Office of Coastal Zone Management) **http://www.mass.gov/czm/invasivemanagementplan.htm**

Permitting and Regulatory Information:

- All in-lake projects are subject to permitting under the Massachusetts **Wetlands Protection Act** (WPA). General information on the WPA and related permits can be found at the DEP website at **http://www.mass.gov/dep/water/laws/regulati.htm#wl**
- Specific guidance on in-lake projects is provided in the Massachusetts DEP Guidance for Aquatic Plant Management in Lakes and Ponds as it Relates to the Wetlands Protection Act: **http://www.mass.gov/dep/brp/ww/files/alkguide.pdf**
- For more information on environmental permitting for in-lake management activities, please refer back to Chapter 2 of this document (**CHAPTER 2**).

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The Pollution Problem: Lakes and Ponds

Managing lakes can be very complicated, and it is important to fully understand a lake and its watershed characteristics when determining a management strategy. Data collection and analysis is also an important component of any water quality management project, and water quality monitoring programs should be designed to document pre- and post-project conditions whenever possible.

Lakes and ponds that are included in Category 5 of the Massachusetts Integrated List of Waters (under Section 303(d) and 305(b) of the Clean Water Act) should be targeted for development and implementation of a Total Maximum Daily Load (TMDL) for the **pollutant** of concern. Once a waterbody is identified as impaired for a designated use, DEP is required by the Federal Clean Water Act to essentially develop a "pollution budget" designed to restore the health of the impaired waterbody. The process of developing this budget, generally referred to as a TMDL, includes identifying the causes (types of pollutant) and source(s) (where the pollutants come from) of the pollutant from direct discharges (point sources) and indirect discharges (non-point sources), determining the maximum amount of the pollutant that can be discharged to a specific water body to meet water quality standards, and developing a plan to meet that goal. A link to the Massachusetts Integrated List of Waters and additional information about TMDLs is provided below.

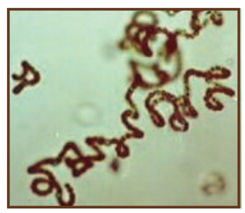
Final Massachusetts Year 2002 Integrated List of Waters
http://www.mass.gov/dep/water/resources/2002-il1.pdf

Some of the symptoms of impaired water quality in lakes and the pollutants that contribute to these symptoms are discussed below:

Problem: Algae

Responsible Pollutants: nutrients

Algae are microscopic photosynthetic plants that are a natural part of lake ecosystems. However, excess nutrients can lead to nuisance algal blooms that impair lake uses and aesthetics. Some types of algae contain toxins that can be harmful to humans and animals when present in high concentrations. Algal blooms reduce water clarity by blocking sunlight penetration through the water, thereby inhibiting the growth of rooted aquatic plants. Decomposition of algae can also contribute to summer oxygen depletion in deep lakes, which can induce fish kills.



Anabaena

Problem: Nuisance Aquatic Vegetation

Responsible Pollutants: nutrients, non-native infestations

Macrophytes are vascular aquatic plants large enough to see with the naked eye. Although most rooted aquatic plants get the majority of their nutrient requirements from lake sediments, high nutrient levels in the water column can contribute to excessive growth among both native and non-native species of plants. Nuisance macrophyte populations reduce the recreational opportunities in a lake and can contribute to summer oxygen depletion in deep lakes as plants decompose.

Eurasian milfoil

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Increased populations of non-native invasive species can dramatically impact the populations of beneficial native species. For example, infestations of Eurasian Milfoil are common in Massachusetts and this plant has nearly eliminated the native species of milfoil in many local lakes (Holdren 2001). However, it is important to remember that some non-native species such as Eurasian milfoil can proliferate to nuisance levels even in lakes with relatively low nutrient levels. As such, the best way to control non-native species is to (1) prevent their spread to new lakes and (2) identify and aggressively control new pioneer infestations as soon as they are found. A non-native plant infestation is generally not considered to be an impairment requiring development of a TMDL as described above.

Problem: Turbidity

Responsible Pollutants: sediment, nutrients

Turbid (cloudy) water can be a symptom of abundant microscopic algae or suspended sediment in a lake. This may result from excess nutrients which spark algal blooms (see above), or from soil erosion and stormwater sources of sediment.

Problem: Human Health Risks

Responsible Pollutants: pathogens, toxic substances

Waterborne pathogens that can cause human health problems include bacteria, viruses and parasitic protozoa. Specific examples include Salmonella, Norwalk virus, and Cryptosporidium, respectively. These pathogenic organisms can be discharged directly to waterbodies or can be transported with **surface runoff**. Bacteria and viruses contaminate both surface and **groundwater**, whereas parasitic protozoa appear predominantly in surface water. Possible sources of pathogens include septic system failures, **combined sewer** overflows, pet waste (including livestock) (Holdren 2001), or droppings from waterfowl.

Other threats to human health include toxins such as mercury or PCBs (caused by point or non-point sources and atmospheric deposition), and salinity (due to irrigation water or road deicing) (Holdren 2001).

Best Management Practices for Lakes and Ponds

There are a variety of Best Management Practices (**BMPs**) that can be applied to help restore lakes and ponds. The in-lake Best Management Practices (BMPs) described in this chapter are directly applied to lakes after they have been impacted by **nonpoint source pollution** or invasive plants. Watershed management BMPs may also be implemented to prevent pollutants from reaching the lake in the first place. For example, upgrading failing or sub-standard septic systems can help to prevent algae blooms, high turbidity, and excessive growth of aquatic vegetation. Watershed management practices act as **source controls** and are often a critical component of long-term water quality management. Many of these watershed management BMPs are discussed elsewhere in this Manual, including the chapters on **Urban** Stormwater, Onsite **Wastewater** Treatment and Waste Disposal, Agriculture, and **Erosion** and Sediment Control. For information on choosing the best watershed-based BMPs, refer to this manual's Interactive BMP Selection Menu.

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As discussed above, the **GEIR on Eutrophication and Aquatic Plant Management in Massachusetts** provides a comprehensive technical review of lake management techniques, including a discussion of the following for each technique:

- Effectiveness
- Impacts to non-target organisms
- Impacts to water quality
- Costs
- Regulations
- Case Study

Massachusetts Case Studies

A variety of Massachusetts lake management case studies are presented in the GEIR on Aquatic Plant Management in Massachusetts. These case studies include the following:

- Nonpoint Source Pollution – Best Management Practices (Pontoosuc Lake, Pittsfield)
- Point Source Control – Advanced Wastewater Treatment (Forge Pond, Granby)
- Hydrologic Controls (Long Pond, Dracut)
- Wetland Treatment (Sevenmile River, North Attleboro)
- Phosphorus Inactivation/Precipitation-Alum Treatment (Dug Pond, Natick)
- Artificial Circulation (Lake Cochituate, Natick)
- Dredging (Nutting Lake, Billerica)
- Drawdown (Lake Lashaway, East and North Brookfield)
- Mechanical Harvesting (Big Bearhole Pond, Taunton)
- Biological Control (Goose Pond, Lee/Tyringham and Lake Mansfield, Great Barrington)
- Benthic Barriers (Great Pond, Eastham)
- Herbicide Treatment (Todd Pond, Lincoln)

* Web link to GEIR: **http://www.mass.gov/dcr/waterSupply/lakepond/geir.htm**

In-lake Management Techniques:

Brief overview descriptions of in-lake management techniques listed in the table below and links to fact sheets with additional information are provided on the following pages.

Dredging	Benthic Barriers
Lake Level Drawdown	Dilution and Flushing
Artificial Circulation and Aeration	Herbicides and Algaecides
Harvesting	Phosphorus Precipitation and Inactivation
Biological Control	

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Dredging

can be an effective technique to deepen a shallow lake or for the control of excessive algae and invasive macrophytes. Dredging can be accomplished by a variety of methods grouped into the following five categories: **(FACT SHEET LINK)**

- Dry Excavation
- Wet Excavation
- Hydraulic Dredging
- Pneumatic Dredging
- Reverse Layering

Lake Level Drawdown

involves lowering a lake's water level, most often during fall and winter, to expose nuisance vegetation infestations. Exposing plants to the elements for a sustained periods (i.e. >6-8 weeks) during the winter facilitates desiccation and freezing of plants and their root systems.
(FACT SHEET LINK)

Artificial Circulation and Aeration

are applied in unstratified as well as thermally stratified lakes to mitigate oxygen depletion in the hypolimnion (deep water zone). Oxygen depletion can stress fish populations and result in the release of phosphorus from lake bottom sediments into the water column. The re-released phosphorus is usually concentrated in the hypolimnion until fall turnover, when it may result in an autumnal algae bloom.
(FACT SHEET LINK)

Harvesting

of nuisance aquatic plants includes a suite of techniques that vary in sophistication and cost from simply hand pulling weeds to large-scale mechanical cutting and collection of plants using specialized equipment. This technique can be an effective short-term treatment to seasonally remove vegetation that limits lake uses such as boating and swimming. Specific harvesting techniques include mechanical harvesting, hydro-raking, hand harvesting and suction harvesting.
(FACT SHEET LINK)

Biological Control

Biological control involves the introduction or removal of organisms such as fish, insects, pathogens and plants to control a population of nuisance aquatic plants or algae. Biological control offers the potential to effectively reduce algae or vascular plants, but can also have the potential for adverse impacts to non-target organisms. For this reason, the safest biocontrol techniques involve augmenting populations of native and naturally occurring biocontrol agents. **(FACT SHEET LINK)**

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Benthic Barriers

for plant control are based on the concept that rooted plants require light and can not grow through physical barriers. A variety of artificial sediment covering materials include solid and porous forms of polyethylene, polypropylene, fiberglass and nylon. **Benthic** barriers are usually in sheet form and applied on top of plants (or before they begin growing) to limit light, physically disrupt growth, and allow unfavorable chemical reactions to interfere with further plant development. **(FACT SHEET LINK)**

Dilution and Flushing (Hydraulic Control)

Lakes with low nutrient concentrations are unlikely to exhibit algal blooms. While it is preferable to lower nutrient loads to a lake, it is possible to lower (dilute) the concentration of nutrients by adding low-nutrient water from an external source. Large quantities of water can also be used to flush algae out of a lake faster than they can reproduce. Small, linear **impoundments** are the best candidates for such treatment. **(FACT SHEET LINK)**

Herbicides and Algaecides

contain ingredients that are toxic to target plants and are classified as "contact" or "systemic" based on the action mode of the active ingredient. Contact **herbicides** are toxic to plants in the immediate vicinity of external contact and are more effective against annuals than perennials because they may not kill the roots, allowing perennials to grow back. Systemic herbicides work more slowly because they are translocated throughout the entire plant. Systemic herbicides provide more effective control of perennials because they can kill the entire plant. Another way to classify herbicides is by whether the active ingredients are selective (more effective at killing certain plants than others) or broad spectrum (kill a wide variety of plants). **(FACT SHEET LINK)**

Phosphorus Precipitation and Inactivation

are used to control algae by reducing the availability of phosphorus that fuels the growth of algae. Chemical complexes are applied to bind with soluble phosphorus and make it unavailable for biological uptake by algae. Aluminum sulfate (alum) is frequently used because it is effective over a relatively wide range of environmental conditions. Phosphorus precipitation can provide temporary control of algae until the phosphorus supply is replenished. Phosphorus inactivation aims to achieve long-term control of phosphorus release from lake sediments by adding as much phosphorus binder to the lake as possible within the limits dictated by environmental safety. It is essentially an application of "anti-fertilizer" to the lake. **(FACT SHEET LINK)**

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For information on additional BMPs, jump to the Interactive BMP Selection Menu

References:

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