Caring for Our Lakes

Watershed and In-Lake Management for Connecticut Lakes

CONNECTICUT DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATER MANAGEMENT
Revised 1996

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FOREWORD

Caring for our lakes is important to the preservation of natural resources, stimulation of economic growth, and elevation of the quality of life in our state. Lakes and ponds enhance our landscape and are used extensively for swimming, fishing, boating, and other forms of recreation. Money spent on recreation is important to local and state economies, and the high property values of lakefront homes augment tax revenues of surrounding communities. These benefits deteriorate with a decline in lake *water quality*.

How should you care for your lake? First, you must understand the external factors that impact water quality. You must answer questions such as — Where does the water that flows into the lake come from? What pollutants does that water carry? Identifying pollutant sources in the *watershed* and halting or controlling that pollution so it does not enter the lake is called watershed management.

Second you must learn about the physical, chemical, and biological features of your lake. These characteristics make your lake unique. At the same time you should identify real and potential problems that are causing concern for lake residents and users. These may include an overgrowth of aquatic plants, algae blooms, or excessive *sedimentation*. Dealing with these internal problems is called in-lake management. In many instances, the lack of watershed management has given rise to the need for in-lake management.

This booklet is designed to give you an overview of

watershed and in-lake management methods. Some of these methods can be used by local individuals, businesses, lake associations, town officials, and other interested parties. Other tasks may require the services of professional experts such as *limnologists*, environmental engineers, or resource managers. The Lakes Management Program of the Connecticut Department of Environmental Protection (CT DEP) is a good place to start if you have questions or need advice about management options. The program maintains a list of professional firms that can conduct diagnostic studies and implement management measures for your lake and watershed.

INTRODUCTION

The booklet has three chapters. **Chapter 1** provides a general background of lake *ecology* and describes typical problems faced by lake users and residents. This section encourages you to set community goals and to develop a management plan. **Chapter 2** focuses on watershed management activities that protect lake water quality from *nutrients*, *sediment*, and other pollution. *Best Management Practices* (BMPs) for residential, urban and agricultural watershed protection are discussed. **Chapter 3** describes in-lake management methods that relieve aquatic weed and algae growth problems.

Technical terms are *italicized* when they first appear in this booklet, and are found in the glossary in APPENDIX A. APPENDIX B lists organizations and agencies to contact for additional information. Connecticut lakes are classified in APPENDIX C.

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BACKGROUND: HOW A LAKE CHANGES

1.1 Taking Responsibility for Your Lake

Taking responsibility for the lake you use or live near is the first step toward effective lake care. If it is a private lake, you and your neighbors are directly responsible for making management decisions concerning its well-being. If the lake has public access, your responsibilities are shared with one or more tax-supported public agencies. As a member of the public, your responsibility and input are important. In many cases it is crucial that you get involved because public agencies do not have the resources to manage each lake to the degree necessary for effective protection. It is your passion for your lake that will ensure clean water for swimming, fishing, boating, and other uses.

Learning about your lake and watershed is crucial to lake care. All lakes are essentially collectors of water from the surrounding watershed. Thus the quality of a lake is defined largely by the quality of the water that flows into it. If the watershed is farmed, the lake may be impacted by agricultural fertilizers, *pesticides*, and sediments. If the watershed has urban or suburban areas, water runoff may contain septic leachate, oil and gas, road sand, salt, and lawn fertilizers. Land development and forest cutting also can cause *erosion* and movement of sand, silt, and *organic matter* to the lake.

Knowing how the land in your watershed is used and the pathways of water into the lake provides valuable information for designing protection strategies. You also need to know physical factors such as lake depth, shoreline characteristics, inlets, and outlets. Finally, you need to be aware of a process that occurs in all lakes and ponds —*eutrophication*. Eutrophication is a natural increase of nutrients and sediments over time that can stimulate excessive aquatic weed and/or algae growth.

It is crucial that the people responsible for a lake develop watershed and lake management plans to meet their goals. For lakes with eutrophication problems, goals include controlling aquatic weeds or reducing algal blooms. Other goals may include developing recreational opportunities, improving fishing, and enhancing aesthetic appeal.

The plan development process includes defining and ranking problems, setting a timetable, securing funds, implementing solutions, and evaluating progress. Several lake groups in Connecticut have successfully implemented lake and watershed management plans and are reaping the benefits of quality lakes. The primary purpose of this booklet is to help you plan the future of your lake.

1.2 Eutrophication—The Crux of Lake Management

Eutrophication is a natural aging process that increases aquatic weed and algae growth. Ultimately, in the last stage of eutrophication, the waterbody evolves into a wetland — a swamp, marsh, or bog. The rate at which a lake receives nutrients and sediments from its watershed determines the rate of eutrophication. Under natural conditions eutrophication occurs over a long period. A forested watershed contributes minimal amounts of nutrients and sediments, and takes centuries to change a lake's appearance. The aging process speeds up considerably, however, when the amount of plant nutrients and sediments that drain into a lake increases due to development, farming, and other human activities. The term commonly used when eutrophication is accelerated by these man-made conditions is *cultural eutrophication.*

Effects of cultural eutrophication can occur in a short period of time, a few decades or less. *Dissolved nutrients*, including phosphorus and nitrogen, fertilize the water environment and stimulate algae and weed growth. Sediment particles also carry nutrients that eventually become available to aquatic plants in the lake. In addition, sediments settling on the bottom make the lake shallower. This makes the bottom closer to the surface, exposing more area to sunlight, thus expanding growing areas for rooted plants.

An important concept to keep in mind is the role of the limiting nutrient, that nutrient in the shortest supply relative to the needs of an organism. When the limiting nutrient is depleted, growth stops, even though other nutrients remain available. Any increase in the supply of the limiting nutrient results in a corresponding increase in growth, as any decrease in the supply results in a decrease in growth. The supply of the limiting nutrient controls the growth of algae and aquatic weeds in a lake. Phosphorus is the principal limiting nutrient for the growth of algae. Phosphorus or nitrogen typically functions as the limiting nutrient for larger aquatic plants.

1.3 Problems Associated with Eutrophication

Cultural eutrophication can interfere with the use and enjoyment of a lake and greatly impact the lake ecosystem. Typical problems associated with eutrophication are discussed below.

Algae blooms

Algae are microscopic plants that are vital components of the lake ecosystem. Algae serve as sources of food and energy for fish and other lake organisms. Excessive algae growths, however, occur as "blooms" that have a pea soup appearance and can form scums and mats on a lake's surface. Algae blooms interfere with the enjoyment of a lake, and can affect both the taste and odor of water. When blooms die, the plant matter decomposes, depleting oxygen in lake waters. Such oxygen depletion can cause a fish kill. The presence of frequent algae blooms usually indicates that phosphorus levels in the water are high.

Aquatic weed beds

Macrophytes are large aquatic plants that, like algae, are vital components of a lake ecosystem. They provide cover for fish and food for wildlife. However, shallow water and too many nutrients can cause large, dense weed beds to grow. These can be a nuisance, interfering with swimming, fishing, and boating. Decomposition of the plant matter may deplete oxygen levels, causing fish kills.

Loss of water depth

Sediments can come from the watershed and from decaying algae and weeds in a lake. The buildup of sediments in a lake causes a loss of water depth. Shallower water encourages excessive macrophyte growth.

Dissolved oxygen depletion

Fish and other aquatic animals depend on *dissolved oxygen* for respiration. Bacteria and other microorganisms use oxygen while decomposing organic materials. In lakes with excessive amounts of organic materials, such as plant matter or waterfowl droppings, oxygen may decline. A reduction of oxygen in deep, cold lake waters can impair the health of trout and salmon, especially in the summer. Severe dissolved oxygen depletion can result in a fish kill. Loss of oxygen can cause *internal nutrient loading* by allowing phosphorus in the sediments to be released to the water.

Special problems in artificial lakes and ponds

Many lakes and ponds in Connecticut are man-made, formed during the construction of dams across streams or wetlands or with the excavation of basins in wetlands. Connecticut also has natural lakes and ponds that have been artificially deepened and enlarged by damming existing outlets. Both man-made and artificially deepened lakes and ponds have water covering fertile wetland soils or terrestrial soils that had previously supported productive vegetation.

Although artificial lakes undergo eutrophication in the same manner as natural lakes, they have a different starting point. Most artificial lakes do not start out with low nutrient levels; they are often enriched due to the fertility of flooded wetland and upland areas. Improving conditions in these lakes can be very difficult because restoration may attempt to create conditions that never existed.

1.4 Acidification

Acidification of lakes is not currently an urgent concern for Connecticut lakes. While there are sources of acidification, such as natural watershed soil and wetland acidification processes, soil acidification associated with watershed reforestation, and acid precipitation, most lakes are well buffered and acids are neutralized. Presently, no lakes in Connecticut are classified by the CT DEP as impaired by acid precipitation.

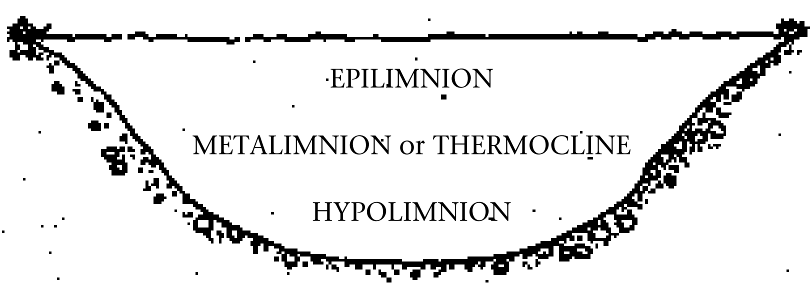
1.5 Seasonal Stratification of Lake Water

Most lakes in Connecticut with depths of twenty feet or more stratify into temperature-defined layers during the summer and winter. This seasonal *stratification* is important in determining movement of nutrients and oxygen in the water column.

Summer stratification

During the summer, surface water becomes less dense as it warms, separating it from colder, denser, bottom waters. Deep lakes stratify into three distinct thermal zones:

- Epilimnion
- Metalimnion or Thermocline
- Hypolimnion



Typical summer stratification of a deep lake.

The top layer, *epilimnion*, is the warmest layer of water. Aquatic weeds and most summer algae blooms occur in this zone. *Atmospheric diffusion* and *photosynthesis* continually supply oxygen to the epilimnion. The *metalimnion*, or *thermocline*, is a transition zone that separates the epilimnion from the *hypolimnion*. The hypolimnion, bottom layer, contains the coldest water and is often void of oxygen.

Water temperature, biological activity, and weather conditions influence the distribution of dissolved oxygen. During the summer, the cold bottom waters of low nutrient (*oligotrophic*) lakes generally contain oxygen and little plant growth. Whereas, in nutrient rich (*eutrophic*) lakes, removal of dissolved oxygen occurs in the hypolimnion as a result of the decay of organic material, such as algae that has died and settled on the bottom. This oxygen cannot be replaced from the atmosphere in the summer when a lake is thermally stratified. Fish habitat is then lost and only organisms that can tolerate anaerobic, or oxygen-free, conditions live in the hypolimnion. If all oxygen is removed, phosphorus and ammonia nitrogen from the sediments are released into the hypolimnion. These nutrients can reach the epilimnion and stimulate an algae bloom if wind mixes the water or during fall overturn (refer to the "Fall overturn" section).

Lakes that flush quickly, such as ponds, shallow lakes, and those created by damming rivers termed impoundments, offer exceptions to the typical stratification pattern. Within such water bodies, surface waters may be only slightly warmer than bottom waters or temperatures may be uniform throughout the water column.

Fall overturn

In the late summer, the epilimnion cools, thereby becoming denser, and the lake mixes from the surface to the bottom. During fall overturn, the temperature and nutrient levels become uniformly mixed throughout the water column and dissolved oxygen is replenished.

Winter stratification

Winter stratification differs from summer stratification in that the coldest waters are found at a lake's surface rather than at the bottom. Although cold water holds more oxygen, it often becomes depleted when ice blocks access to air and reduces light penetration needed for photosynthesis. In shallow eutrophic lakes, this can result in winter fish kills under the ice.

Spring turnover

When ice melts, wind mixes the surface and bottom waters, resulting in spring turnover. The lake remains physically and chemically uniform until the surface waters begin to warm at the onset of summer stratification.

1.6 Lake Classification

Two lake classification systems are used by the CT DEP: the trophic state classification and the *water quality classification*. The trophic state classification system is based on the biological productivity of a lake and its relation to lake uses. The water quality classification system is based on the historical and *designated use* of a waterbody.

Trophic state classification

Scientists have developed a classification system to describe phases of eutrophication: oligotrophic, mesotrophic, and eutrophic. These phases are subdivided into six states used to evaluate water quality:

- Oligotrophic
- Early Mesotrophic
- Mesotrophic

- Late Mesotrophic
- Eutrophic
- Highly Eutrophic

Oligotrophic lakes are in the early phases of eutrophication. They are deep, clear, infertile lakes with little algae and few rooted aquatic plants. Bottom waters are well oxygenated and sediment accumulation is low. Oligotrophic lakes therefore are prime recreational lakes. Mesotrophic lakes are also good recreational lakes, but usually exhibit some water quality degradation and use impairment. Eutrophic lakes are usually relatively shallow with fertile, turbid waters. They have poorly oxygenated bottom waters, substantial sediment accumulations, and dense blooms of algae and aquatic plant beds. These attributes can seriously limit recreational uses.

These classifications can be used to compare the water quality of lakes and to establish benchmarks for short and long-term trends. A list of Connecticut lakes classified according to trophic state by the Connecticut Department of Environmental Protection is in Appendix C. **A lake classified as eutrophic is not undesirable for all types of recreation, and efforts to manage the lake should not be discouraged. Similarly, the classification of a lake as oligotrophic should not engender complacency.**

Additional Information on Trophic State Classifications

Two reports produced by the CT DEP on lake trophic state classifications, "Trophic Classification of Forty-nine Connecticut Lakes" and "Trophic Classification of Seventy Connecticut Lakes," can be obtained from the CT DEP, Maps and Publications Sales Office (860) 424-3555.

Water quality classification

The CT DEP also uses another classification system for water quality. This system is separate from and serves a different function than trophic state classification. These water quality classifications are based on historical and designated uses and identify the *criteria* necessary to support those uses. Most recreational lakes in Connecticut are categorized as either Class A or Class B waters. Class A waters are recreational waters suitable for fishing and swimming that may not receive treated wastewater discharges. Class B waters are recreational waters suitable for fishing and swimming that may receive treated wastewater discharges. A dual classification, such as B/A describes the existing condition (first letter) and the adopted goal (second letter). A few recreational lakes in Connecticut are Class AA waters, indicating tributaries to drinking water supplies.

Additional information on water quality classifications

Lake water quality classifications can be obtained from the CT DEP water quality classification maps. CT DEP leachate and wastewater discharge source maps, available from the CT DEP, Maps and Publications Sales Office (860) 424-3555, provide additional information on current and historical pollution sources.

Watershed Management

2.1 A Lake and Its Watershed
2.2 Pollution Prevention (BMPs)
2.3 Pollution Recovery (BMPs)

2.1 A Lake and Its Watershed

A lake's watershed consists of all land areas that drain directly into the lake and those watercourses that flow to the lake. Water entering the lake, especially after a storm, typically carries a load of nutrients, sediments, and other pollutants. Nutrients are important in the eutrophication process because they fertilize the water and stimulate growth of aquatic weeds and algae. Sediments settle to the lake bottom, creating shoals and decreasing lake depth. Other pollutants, such as *pathogens*, *heavy metals*,

and *hydrocarbons* can also cause problems with aquatic life and water use.

The health of a lake depends greatly on the quality of the incoming water. Watershed topography, soil fertility, soil erosion, vegetation, and human activity all affect this quality, and, therefore, the lake itself. The goal of watershed management is to prevent pollution from moving off the land and into the lake. Effective watershed management is the foundation for all lake preservation and restoration efforts.

Sources of pollution: point and nonpoint

Sources of lake pollution are divided into two broad categories — *point* and *nonpoint*. Point sources are concentrated discharges that enter a watercourse at a single point, most commonly a pipe. An example of a point source is a discharge from a wastewater treatment plant. Point sources affect only a few lakes in Connecticut, impoundments on rivers that receive discharges of treated wastewater. The strict standards of state and federal water pollution laws regulate these sources to prevent pollution.

Nonpoint sources are diffuse, occurring primarily as stormwater discharges from land areas within the watershed. Every lake and pond in Connecticut is affected by nonpoint pollution sources. Although a single nonpoint pollution source may not noticeably affect a lake, the cumulative effect of many nonpoint sources in the watershed can be great. In Connecticut most nonpoint pollution sources are tied to human activity and development. They may include septic systems, agriculture, lawns and gardens, stormwater drainage systems, and development that exposes land to erosion. Other sources may include waterfowl, household pets, recreational beaches and poorly managed timber harvesting operations.

Typical nonpoint pollutants include the following:

- NUTRIENTS—Most important are phosphorus and nitrogen because they stimulate aquatic weed and algae growth. Sources include septic systems, agricultural runoff, and urban/suburban landscape runoff, waterfowl, and pets.
- SOLIDS—These include both sediments and floatable wastes. Sources can include eroding construction sites, stream banks, roadway runoff, and agricultural lands. Sediments from eroding land in the watershed increase nutrient and organic matter in a lake. When deposited, solids make the lake shallower and destroy the natural bottom habitat. Suspended solids cloud the water and interfere with organism respiration and digestion.
- PATHOGENS—Bacteria and viruses from animal wastes, failing septic systems, and other sources pose health risks.
- HEAVY METALS—Lead, copper, cadmium, zinc, mercury, and chromium can come from marinas, automobiles, industrial waste and atmospheric pollution. Deposits in a lake can be toxic to aquatic species.
- HYDROCARBONS—Petroleum based substances, including oil and grease, are toxic to sensitive aquatic organisms. Runoff from parking lots, roadways, and marinas is a typical source of these pollutants in a watershed.
- PESTICIDES—This category includes lawn, garden, household, and commercial pest control chemicals. These pollutants can be toxic to many organisms in a lake.
- HUMIC SUBSTANCES—Grass clippings, leaves, and other plant material deposited in a lake from landscaping practices results in problems when they decompose. Dissolved oxygen is lowered, which affects the respiration of aquatic organisms and

allows nutrients to be released from the sediments. And, these organic materials break down forming muck on the lake bottom.

Managing nonpoint source pollution

There are two primary approaches to managing nonpoint pollution sources in the watershed: pollution prevention and pollution recovery. The best, most economical approach is pollution prevention. That is, preventing pollutants such as those listed in Section 2.11 from moving off upland sites and into streams or groundwater that drains into the lake. Pollution recovery is the interception of runoff and reclamation of pollutants before they reach the lake.

Best Management Practices (BMPs) are methods found to be the most effective, practical means for reducing pollution. Implementation of BMPs occurs primarily at the local level by private property owners and the local government according to a watershed management plan. The size of a watershed will determine the scope of the plan. In large watersheds management is complex because a number of different towns or even states may be involved. Some BMPs may be implemented on a voluntary basis, such as the proper application of lawn fertilizers by a homeowner. Other BMPs may be implemented on a regulatory basis, such as erosion controls required for construction sites by town permits in accordance with state laws. Whatever the situation, BMPs are the primary methods used to implement a watershed management plan.

Members of lake associations should become knowledgeable about BMPs, and communicate this information to property owners and town officials. Many lake associations in Connecticut use newsletters, workshops, and handbooks for this purpose. In addition, lake associations can promote the use of BMPs by participating in local public meetings and by commenting on permit applications under review by town commissions.

Additional information on nonpoint source management

The 1994 CT DEP report "Connecticut's Nonpoint Source Assessment and Management Plan" provides an overview of the statewide nonpoint source management program. It is a general guide to pollutants, their sources, impacted resources, management goals, strategies and practices. To obtain a copy of this report call the CT DEP Bureau of Water Management, Planning Division (860) 424-3020.

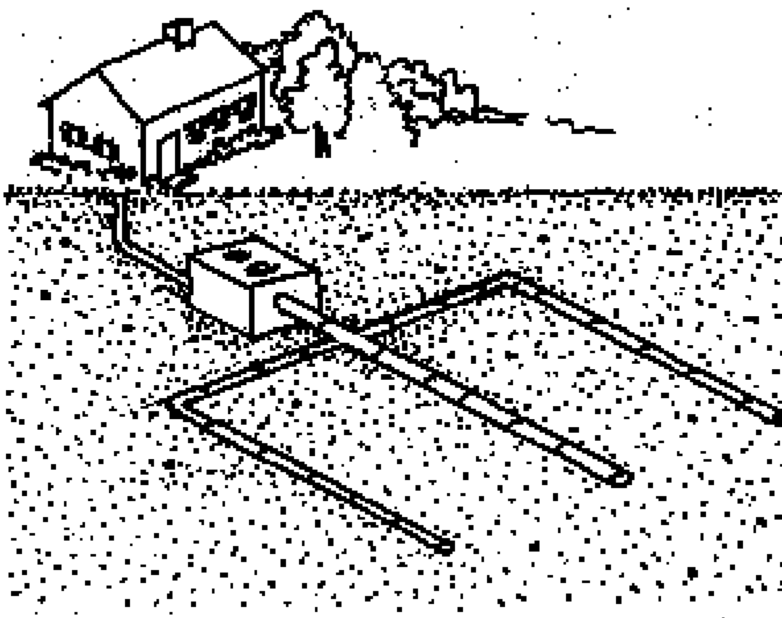
2.2 Pollution Prevention

BMPs are a key aspect of pollution prevention. Common nonpoint pollution sources in lake watersheds can be septic systems, soil erosion, agricultural areas without BMPs, residential landscaping, urban runoff, car washing, waterfowl, recreational beaches, and poorly managed timber harvesting operations. The following sections discuss BMPs for dealing with these pollution sources.

Septic systems

Individual septic systems are often used for sanitary wastewater treatment for homes around Connecticut lakes. A septic system includes a house sewer, a septic tank, a distribution system, and a leaching field. Sewage is delivered to the septic tank via the house sewer. In the septic tank, solids separate from liquids. Heavy solids settle to form a sludge blanket; light solids float to form a scum layer. The liquid from the septic tank flows to the leaching system where soil bacteria decompose waste matter. After treatment in the leaching system, wastewater effluents flow into the soils below the surface.

BMPs for septic systems include proper siting, design, installation, operation, and maintenance. Septic systems must provide for the sanitary degradation of wastewaters into simple chemical substances, including soluble phosphorus and nitrogen compounds. If not managed properly, a septic system can fail, resulting in the backflow of wastewaters into the house, or the breakout of wastewaters on the ground. A septic system failure is a public health hazard that demands immediate correction. Eliminating the health threat eliminates a possible source of nutrients to a nearby lake.



Local health officials are responsible for seeing that homeowners correct failing septic systems. Single and scattered failures can often be repaired on-site. However, widespread failures may require a community wastewater management plan. A lake association should notify local health officials about suspected septic system failures, and monitor the results of investigations.

When seasonal cottages around a lake are converted to permanent homes, local public health officials are responsible for evaluating septic system upgrades to assure conformity with the state Public Health Code. Cottage conversions are usually subject to local building permits and zoning approval, providing a means for local authorities to require septic system upgrades.

The following septic system BMPs should be followed by property owners in a lake watershed:

- Pump out septic tank solids on a regular basis. Sludge levels in the septic tank should be checked annually and pumped when sludge fills half the tank, usually every two to three years for permanent homes, five to six years for seasonal cottages. If solids are not removed from the tank, they will wash into and clog the leachfield.
- Do not use the septic system for disposal of kitchen wastes. Ground-up garbage from a kitchen garbage disposal can overburden a septic tank.
- Do not flush strong cleaning agents such as drain cleaner, bleach, paint, or other household chemicals into a septic system. These chemicals may kill the beneficial microorganisms needed to break down wastes.
- Use nonphosphate laundry detergents. This can reduce the amount of phosphorus passing through the septic system and into the environment 30 to 40 percent.
- Conserve water and give the septic system time to "rest" after heavy use.

Additional information on septic systems

"Septic Systems Manual: A Guide to On-Site Subsurface Sewage Disposal for Local Land-Use Officials," published by the CT DEP in 1985, is available at the CT DEP Maps and Publications Sales Office (860) 424-3555. This guide explains the legal and technical aspects of on-site septic system design and installation. The manual provides a brief explanation of the process of sewage treatment in a septic tank, leachfield, and surrounding soils. This manual should be consulted by local commissions when reviewing applications for planning, zoning, and wetland permits that involve the installation of new septic systems within the lake watershed.

Soil erosion

Soil erosion is the wearing away of land by wind, water, ice, and gravity. In lake watersheds, soil erosion caused by water running off the land and by wave action on the shore are important concerns. Natural erosion occurs at a slow and generally uniform rate. However, disturbance of land surface by human activity eliminates the protection provided by natural vegetation, exposing the soils to excessive erosion. The exposed soil can become hard, reducing its infiltration capacity and resulting in greater runoff.

The severity of erosion is influenced by soil type, slope of land, type of vegetative cover, rain, snow, and proximity to a watercourse. Severe natural erosion can occur on land with steep slopes and along stream banks and lake shorelines. Common man-made sites of erosion include construction sites, roadway embankments, roadway drainage ditches, and cultivated fields. Construction site erosion can be particularly severe; research has shown that soil erosion from construction sites may be ten to 100 times greater than erosion from agricultural land of the same size, slope, and soil type. Because the demand to develop lake properties is high, construction site erosion can play a major role in lake eutrophication.

The effectiveness of erosion controls for construction sites in the watershed should be closely monitored. Any incidents of water turbidity, siltation, or sediment obstruction in the lake or its tributary watercourses should be reported to the town zoning enforcement officer or wetlands enforcement officer for inspection and corrective action.

Stream bank erosion has an immediate and often severe impact on lake water quality. Activities that disturb land surfaces should be avoided in these areas. Bank sloping, riprap, vegetation, jetties, fencing, and removal of obstructions to stream flow are examples of appropriate preventive measures.

Buffer strips, a universal BMP, control stream bank erosion by keeping strips of natural vegetation along stream corridors. Vegetated buffer strips protect the soil and also intercept runoff, thereby removing sediment and phosphorus. A lake association should support the use of BMPs on stream bank properties in their lake's watershed.

Wave action can also erode shorelines. Lakefront properties with vulnerable shorelines should consider the following BMPs:

- maintain vegetated buffer strips
- leave rocks and boulders undisturbed in order to diffuse wave action
- employ strict erosion and sediment controls for construction activities

Legal requirements on erosion controls

The Soil Erosion and Sediment Control Act, Sections 22a-325 through 22a-329 of the Connecticut General Statutes requires towns to adopt erosion and sediment control plan regulations for disturbed areas greater than one-half acre. The town regulations must provide for certification of the technical adequacy of the plans and provide for inspection of the measures installed pursuant to the plan.

The town may consult a County Soil and Water Conservation District (see Appendix B) for technical review of plans. Single family dwellings that are not part of a subdivision are exempt from town erosion and sediment control regulations by state statute, and cannot be controlled by the town under the authority of state erosion and sediment control laws. However, construction of single family homes within the town's regulated wetland and watercourse zone may require installation of sedimentation and erosion controls under local wetland regulations.

Erosion from construction activities may also regulated by DEP's Bureau of Water Management. Construction sites of five acres or more must have plans for controlling stormwater and dewatering wastewaters generated from the site approved by DEP before construction can commence.

Additional information on soil erosion

Erosion from construction sites can be controlled by using BMPs found in "Guidelines for Soil Erosion and Sediment Control," prepared by the Connecticut Council on Soil and Water Conservation. This technical manual assists government officials, developers, engineers, contractors, and others in selecting measures to prevent erosion and sedimentation. Measures discussed in detail include site planning; vegetative controls, such as seeding, sodding, and tree planting; nonstructural controls such as hay bale checks, mulching, land grading, and traffic control; and structural controls such as diversions, riprap, and sediment basins. These guidelines should be used by government officials, developers, engineers, contractors, and others in designing structural measures for erosion and sediment control. This manual may be obtained through the CT DEP Maps and Publications Sales Office, (860) 424-3555.

Agriculture

In many lake watersheds, agricultural lands such as croplands, grazing lands, feedlots, and tree nurseries can be potential nonpoint pollution sources of sediments and nutrients. Generally, nonpoint source pollution is managed by the individual farm owner/operator working with state and federal technical and financial assistance programs. The following are BMPs for each of these common nonpoint pollution sources.

BMPs for croplands include:

- conservation tillage
- contour farming
- contour strip-cropping
- no-till seeding
- terracing
- vegetative buffers
- winter cover crops
- nutrient management
- riparian area protection
- integrated pest management

Feedlot BMPs include:

- paving
- stormwater management
- runoff treatment

Grazing land BMPs include:

- terracing
- fencing to protect wetlands and watercourses
- rotation grazing

Animal waste BMPs include:

- diversion and treatment of stormwater
- manure management

Nursery BMPs include:

- contour planting
- cover crops
- nutrient management
- integrated pest management

Additional information on agriculture

In 1993, the CT DEP published "Manual of Best Management Practices for Agriculture" for Connecticut's Aquifer Protection Program. This manual contains detailed information on agricultural BMPs needed to protect the quality of groundwaters used as public drinking water supplies and is applicable to lake watershed management programs. Copies of this manual are available at the CT DEP Maps and Publications Sales Office, (860) 424-3555. Several government agencies have programs to assist in the implementation of agricultural BMPs (See Appendix B):

- The U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS), a federal agency, provides technical assistance to farmers on planning and implementing agricultural BMPs and developing farm resource management plans for individual farms.
- The USDA Farm Services Agency, also a federal agency, assists in funding BMP projects undertaken by individual farmers.
- The University of Connecticut (UCONN) Cooperative Extension Service, a state agency, provides information and education to farmers.
- The Connecticut Agricultural Experiment Station, also a state agency, performs BMP research and demonstration projects.
- The county Soil and Water Conservation Districts (S&WCD) are an important communication link

between government programs and the agricultural community.

Woodland and timber harvesting

An acre of properly managed woodland in a lake watershed contributes much less phosphorus to the lake than an acre of residential land in the same location. However, poorly managed harvesting of timber and firewood can cause serious erosion and sedimentation.

Legal requirements on timber harvesting

Town governments may regulate timber harvesting through local inland wetlands and watercourses regulations. The statutes that give municipalities this authority allow towns to regulate clear cutting of timber in inland wetlands. CT DEP's Division of Forestry is in the process of developing regulations through the Forest Practices Act. This program will require licensing of forest practitioners and review of commercial timber harvests.

Additional information on timber harvesting

The CT DEP Division of Forestry distributes a 1990 guide, "Timber Harvesting and Water Quality in Connecticut — A Practical Guide for Protecting Water Quality While Harvesting Forest Products." For more information, call the CT DEP Division of Forestry, (860) 424-3630.

Residential nonpoint pollution sources

Fertilizers that are commonly applied to lawns, home gardens, and ornamental shrubs and trees contain the plant nutrients nitrogen, phosphorus, and potassium. In a lake watershed, these nutrients from fertilizers may enter the lake, thereby fertilizing aquatic plant growth.

Residents in lake watersheds should use fertilizers judiciously or not at all. If used, the type of fertilizer should match the specific needs of the soil and the plants being grown. The correct type and amount of fertilizer can be "prescribed" through a soil sample analysis conducted by the UCONN Cooperative Extension Service. Soil testing kits can be obtained for a nominal fee from them at (860)486-2928.

The timing of fertilizer applications is important. Applications should be avoided in the late summer and fall when plant growth has ended. Furthermore, fertilizers should not be applied if heavy rain is forecast. Nutrients not captured by plants are likely to be transported off the property during rainstorms.

Leaves, grass clippings, and other wastes from lawns and gardens are rich in nutrients and organic matter. When washed into a lake, they increase lake sedimentation and release plant nutrients. An important BMP is to compost such wastes and recycle the compost as a soil conditioner and fertilizer. Composting sites should be a safe distance from the lakeshore, tributary watercourses, and stormwater drainage systems. In addition, woody wastes should be chipped and reused as landscaping mulch or disposed of in a municipal brush disposal site.

Excrement from household pets, especially dogs, is another potential source of lake pollution. Pet manure contains organic matter, nutrients, and bacteria that can be easily transported from paved surfaces to lake waters by stormwater runoff. An obvious BMP is to collect and properly dispose of pet droppings. Some Connecticut towns have adopted ordinances requiring such action; leash laws prohibiting pets from unsupervised roaming are also helpful in lake communities.

Urban runoff

Many types of water pollutants accumulate on sidewalks, streets, driveways, parking lots, and other paved areas. Leaves, branches, litter, animal excrement, salt, sand, and fluid leaks from motor vehicles accumulate during periods of dry weather. Wastes such as used motor oil, radiator fluid, grass clippings, animal excrement, and car wash wastewater is sometimes improperly discarded down stormwater drains. Rainfall and melting snow, known as stormwater runoff, transport these materials and contaminate watercourses with nitrogen, phosphorus, sediments, decomposable organic matter, hydrocarbons, heavy metals, pathogenic bacteria, and road salts.

Many BMPs can be implemented to manage urban runoff. Source controls include the following:

- regulatory programs to control litter
- regulatory programs to prevent improper disposal and discharge of wastes in stormwater systems and to require removal of animal excrement from paved surfaces
- maintenance of paved surfaces, including street and parking lot sweeping and repair of eroding pavement areas

A comprehensive urban runoff plan should be developed for a lake watershed with appropriate measures for specific sources of pollutants. Lake associations should implement pollutant controls at their sources as well as through cooperation with local officials and private property owners.

Town regulations requiring stormwater runoff control plans are effective. Stormwater control measures should be incorporated into site development plans so that urban runoff BMPs become an integral component of permitted land use activities.

Legal requirements on stormwater discharges

The state of Connecticut issues three permits concerning stormwater. One covers construction activities disturbing more than five acres; the other two regulate stormwater discharges from industrial or commercial facilities (Section 22a-430b of the Connecticut General Statutes).

Additional information on stormwater BMPs

The U.S. Environmental Protection Agency publication "Urban Targeting and BMP Selection" presents an overview of BMPs for urban stormwater management. BMPs are categorized as source controls, detention basins, infiltration basins, and vegetative controls. For copies of this document, call the U.S. Environmental Protections Office, Washington, D.C. (202) 833-8317.

The Metropolitan Washington Council of Governments, (202)962-3256, offers "A Current Assessment of Urban Best Management Practice," a valuable source of BMP information. The CT DEP Maps and Publications Sales Office, (860)424-3555, has another helpful publication, "Guidance Document for Assessment of Non-Point Sources of Pollution in Urbanized Watersheds in Connecticut."

Washing vehicles

The direct discharges of soapy wash water from car washing into lakes and their tributaries should be prevented. Wash waters can transport sand, oil, and phosphorus from soaps and detergents that degrade the water quality of a waterbody. Even nonphosphate "biodegradable" soaps should not be allowed to enter surface waters directly, as they can be toxic to aquatic organisms at low concentrations and cause unsightly foaming.

Connecticut law requires the obtaining of a permit for the discharge of wash water from vehicle washing, regardless of volume or location, including charity sponsored car washes. Acceptable disposal options for vehicle wash waters include:

- wash cars in an area where all wash water enters a municipal sanitary sewer for proper treatment
- for individual cars, wash in a grassy area large enough to contain all wash water and then allow it to seep into the soil
- have a commercial car wash operator host the event at a permitted facility

Additional information on washing vehicles

"Guidelines for Disposal of Vehicle Washwater" is available from the CT DEP Bureau of Water Management, Permitting, Enforcement and Remediation Division, (860) 424-3018.

Waterfowl

Excrement from Canada geese can be a troublesome source of enrichment of lake waters with phosphorus, nitrogen, and decomposable organic matter. Since the late 1970s, large flocks of Canada geese have been a problem at several Connecticut lakes. At two lakes with large winter flocks, the phosphorus from the bird droppings was estimated to be equivalent to 50 to 70 percent of the annual phosphorus input from the lake watershed. As organic matter in the droppings decomposed the following summer, these lakes experienced early and intense oxygen depletion setting the stage for additional nutrient releases from lake sediments. Recently, similar concerns have been raised about gulls.

The presence of geese and gulls depends on many factors, including weather patterns, local climate conditions, availability of food supplies, hunting pressure, and flock behavioral patterns. Often habitat preferred by these birds is unknowingly created when wooded areas are converted to residential lawns adjacent to a lake. If large flocks of waterbirds are contributing to eutrophication, government bird control experts should be consulted due to their jurisdiction over these wildlife populations. Techniques to manage birds depend on lake size, type of bird, proximity of human habitation, and feeding areas and may require federal permits before initiating. Techniques include the following:

- construction of fences, walls or buffer strips of shrubs along lake shorelines prohibits easy movement in and out of the water for geese
- hunting in eligible areas
- harassment scarecrows and other foreign objects,

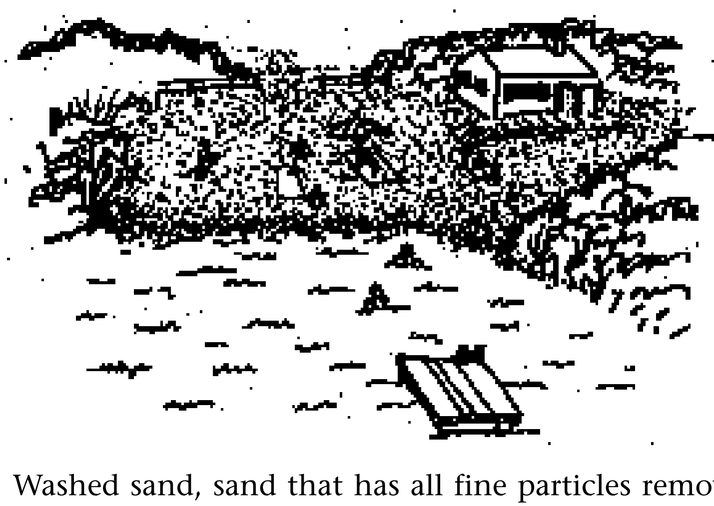
automatic exploders, flashing lights, balloons, and chase dogs

Additional information on waterfowl

The USDA, Animal Damage Control, 463 West Street, Amherst, MA 01022, (413) 253-2403 offers more information.

Recreational beaches

Erosion by wave action and stormwater runoff may wash sand from recreational beaches into lakes. Lost sand is usually replaced with new sand, which is again lost and replaced. As the cycle continues, sand from the beach accelerates the filling-in of the lake. Beaches should be designed to have sand stabilized by vegetation and retaining walls. When feasible, dry dredging can recapture sand washed into the lake.



Washed sand, sand that has all fine particles removed, should be used for beaches. One method to test if sand is suitable for a beach is to place a handful in a jar of water. If the sand leaves the water turbid after shaking the jar, the sand should not be used for beach sand.

2.3 Pollution Recovery

BMPs are important to pollution recovery. Common pollution recovery techniques include designing or utilizing extended detention ponds, wet ponds, natural wetlands, artificial stormwater wetlands, infiltration trenches, infiltration basins, and sand filters. The following sections discuss such pollution recovery techniques.

Extended detention ponds

Extended detention ponds are designed to collect and retain stormwater runoff for a period up to twenty-four hours so that pollutants such as sediments, phosphorus, and organic matter can be removed from runoff before it enters a lake. The ponds are normally dry between storm events. Sometimes extended detention ponds are enhanced with plunge pools near the inlet and a micropool at the outlet. These enhancements help prevent clogging and resuspension problems. Debris and sand deposits can quickly accumulate and periodic removal is essential to keep the pond functioning properly.

Wet ponds

Conventional wet ponds are designed to have a permanent pool of standing water. Pollutants, such as suspended sediments, nutrients, and heavy metals, are removed by gravitational settling, aquatic plant uptake, and decomposition. These types of ponds can be enhanced by designing a forebay to help trap incoming sediments and by establishing a wetland around the perimeter. If properly maintained with regular sediment clean out, wet ponds can function for more than twenty years.

Natural wetlands

Wetlands serve as buffers between land and water. They protect lakes by moderating surface water flow, slowing nutrient transport, and removing suspended sediments and other contaminants from stormwater runoff. Protection of natural wetlands is a priority for lake watershed management.

During the spring and summer, growing wetland plants remove significant amounts of nutrients from overlying waters. During the fall and winter, wetlands release nutrients as their vegetation decays. In this way wetlands help delay the transport of nutrients until after the growing season when they are unlikely to contribute to algae blooms and weed growth. Wetlands also control flooding and soil erosion by retaining water during periods of high runoff, releasing the water gradually.

To preserve these valuable functions, wetlands must be kept in their natural states. Alteration of a wetland reduces these buffering functions, contributing to the degradation of downstream lakes. A lake watershed management program should include participation in a town's wetland permit process, monitoring permit applications, and providing commentary on proposed wetland activities.

Artificial stormwater wetlands

Stormwater wetlands are constructed to create a water environment for the growth of wetland plants. Pollutants are removed from incoming water by vegetative uptake and settling. This is an effective BMP, but time and care must be taken to establish desired species. These wetlands can be enhanced with design elements such as a forebay and landscaping.

Infiltration trenches

Infiltration trenches are shallow, excavated trenches that have been backfilled with stone. This creates an underground reservoir for intercepted runoff water. The water gradually filters through the bottom of the trench into the subsoil. To prevent clogging, many infiltration trenches are designed with a pretreatment system to remove sediment and oil.

Infiltration basins

Infiltration basins function similarly to infiltration trenches, but are designed to be impoundment basins. Stormwater runoff is intercepted, retained, and allowed to filter through the bottom into the subsoil. Unfortunately infiltration basins clog easily and effective maintenance is usually difficult.

Sand filters

Sand filters have been effective in parts of the country. The first flush of stormwater runoff is diverted into a self-contained bed of sand. The runoff is strained through sand, collected in underground pipes, and transported back into a stream or channel. Sand filters have shown high rates of removal for sediment and heavy metals, and moderate removal rates for nutrients. Enhanced designs include the incorporation of layers of peat, limestone, and topsoil into the filter to increase pollutant removal.

Legal requirements on wetlands development

The Inland Wetlands and Watercourses Act, Sections 22a-36 through 22a-45 of the Connecticut General Statutes, protects wetlands through the regulation of development activities in wetland areas. Every town has a board or commission that administers a wetlands permit program and acts on permit applications for regulated activities in lake watersheds. This is particularly important for wetlands adjacent to lakes or their tributary watercourses. In addition, the Commissioner of Environmental Protection may intervene in municipal proceedings to enforce statutes and ensure the public policy established in Section 22a-36 of the Connecticut General statutes is met. For more information, call the CT DEP Division of Inland Water Resources, (860) 424-3019.

In-Lake Management

3.1 The Appropriateness of In-Lake Management

It is important to implement watershed management measures to reduce inputs of nonpoint source pollutants to lakes. Unfortunately, many Connecticut lakes have been on the receiving end of human-generated phosphorus, nitrogen, sand, silt, and other nonpoint source pollution for decades. As a consequence, cultural eutrophication is commonplace throughout the state. Typical symptoms include: (1) increased growth of algae and macrophytes; (2) increased growing space for macrophytes due to sediment deposition; and (3) loss of dissolved oxygen because the increased volume of organic material, such as dead algae and macrophytes, has triggered an increase of the respiring bacteria population. Such lake conditions diminish commercial and recreational opportunities and reduce the value of shoreline properties.

Communities facing in-lake eutrophication problems generally incorporate a two-pronged management approach. First, they implement BMPs to reduce the flow of pollutants from the watershed into the lake. Second, they investigate and initiate activities designed to control or manage the problem until the lake naturally adjusts to lowered pollution levels. **It is important to recognize**

that it is short-sighted for a community to focus attention on attacking only the in-lake symptoms of watershed pollution, such as algae blooms, weed beds, and sediment deposition. Long-term control of lake problems requires that communities deal with their land-based pollution sources as well.

A healthy lake will support a healthy and diverse population of algae and macrophytes. These plants are an integral part of the ecosystem, providing fish and other organisms with habitat, food, spawning areas, and oxygen through photosynthesis. **Management is necessary only when algae or weed growth becomes so extensive that it interferes with the desired uses of a lake. In-lake management should never be designed to completely eradicate algae or macrophyte populations; the goal is to bring them back into balance with the natural ecosystem and the desired uses.**

3.2 Managing Macrophytes

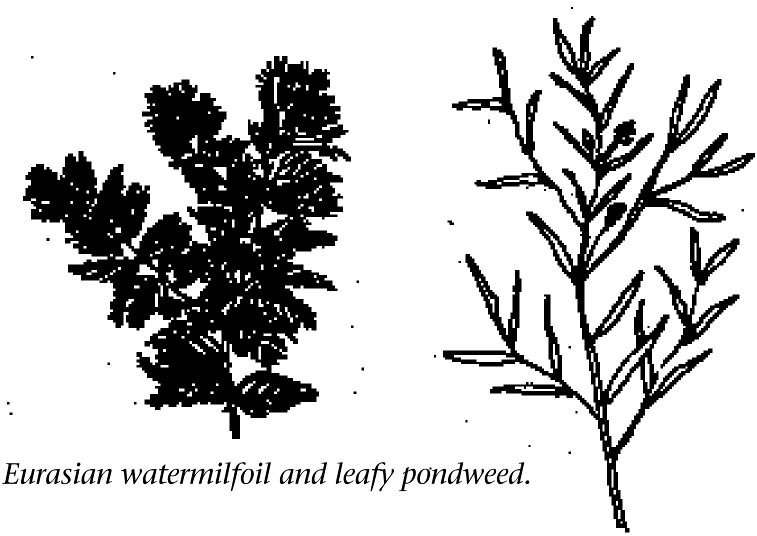
Duckweed, a free-flowing macrophyte

waterweed

Macrophytes are aquatic plants with roots, stems, and leaves that can be seen without the aid of a microscope. A survey of a typical Connecticut lake will reveal many different macrophyte species intermingling in the water and along the shoreline. There is a great variety in size and shape — from the seven foot tall cattails growing on the shore, to quarter inch duckweed plants floating in a bay. A natural system of checks and balances generally keeps any one species from dominating the ecosystem. This diversity is desirable and a sign of a healthy lake.

Some Connecticut lake ecosystems, however, are dominated by one or two species of macrophytes. This is not a balanced ecosystem. The overgrowth of a single plant can impair human use and enjoyment, especially if it forms a thick weed bed. The macrophyte Eurasian watermilfoil is a prime example of this type of plant. Milfoil is not native to North America. It was brought from Europe and Asia around the turn of the century and first appeared in abundance in the Chesapeake Bay around 1920. Its unusual growth characteristics permit it to out compete its neighbors for growing space and light. Eurasian watermilfoil overwinters as a standing plant, which gives it a head start on other plants at the beginning of the spring growing season. Also, even a moderate size milfoil population will form a dense canopy on the water surface, effectively blocking out sunlight for other species of plants. These characteristics, in addition to its being capable of vegetative reproduction, make Eurasian watermilfoil the number one nuisance macrophyte problem in Connecticut lakes.

Other species of macrophytes can also overpopulate and cause problems. These include curlyleaf pondweed, water lilies, cattails, purple loosestrife, and duckweed. Control techniques vary according to the species of plant and where it grows. Some macrophytes are free-floating and do not sink roots into the lake bottom. Duckweed, for example, is a tiny free-floater that reproduces rapidly and can cover the water surface of a small lake or bay. Cattails and water lilies are examples of emergent plants that have roots in the lake bottom and leaves extending into the air or floating on the surface. Submergent macrophytes, in contrast, have roots in the sediments but grow entirely underwater, although several have flowers that extend out of the water during part of the season. **Selecting the best technique for managing macrophytes in your lake is important. Contact the CT DEP Lakes Management Program, (860) 424-3716, for information.**



Eurasian watermilfoil and leafy pondweed.

The following management techniques are discussed in this section:

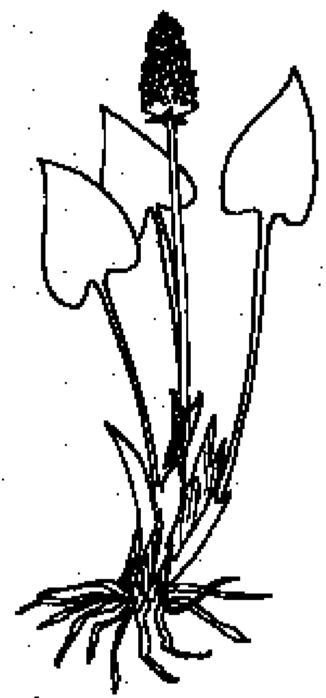
- Mechanical removal of plants
- Lake bottom barriers
- Sediment removal
- Grass carp
- Aquatic herbicides
- Light limiting dyes
- Wintertime drawdown
- Weevil predation

Mechanical removal of plants

There are three mechanical means of physically removing rooted macrophytes from a lake: cutting, raking, and uprooting. The following is a discussion of these techniques.

Cutting

Cutting is done to macrophyte stems. For small underwater areas, such as swimming beaches or around a dock, one might choose to use a hand held underwater cutter. There are several types and the most common has a V-shaped cutter blade. The cutter is thrown into the water and as it is reeled back in, the blade cuts the macrophyte stems. Manufactures have also developed battery powered cutters that use a scissor-action to clip underwater stems. For emergent macrophytes on or near the shore, garden-variety weed whips and scythes are often used.

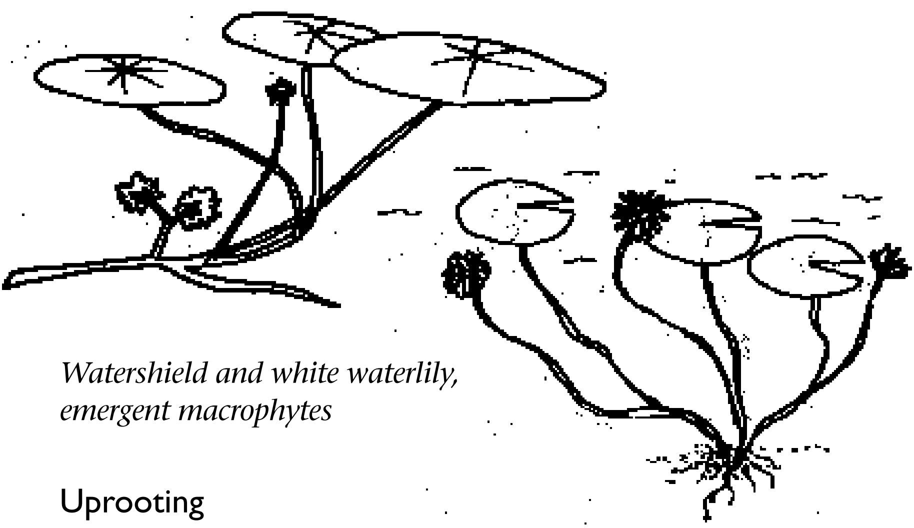


Pickerelweed

For larger lake areas, a specialized cutting machine mounted on the deck of a floating barge is frequently employed. The machine has a row of reciprocating sickle blades that are lowered to a desired depth. These cutters mow aquatic vegetation down as the barge moves through weed beds. Mechanical weed harvesters are similar to the mechanical cutters, except they have a conveyor system that loads the plants onto the barge after cutting. When the storage area is full, the harvester off-loads the material onto a separate shuttle barge or travels to the shore.

Raking

Raking is typically used to clear weeds from small shallow lake areas, such as swimming areas and beaches. Implements vary from ordinary garden rakes to tools specifically designed to gather water weeds. Raking is often done to clean up specific shore areas after cutting operations. It is labor intensive and generally not appropriate for large areas.

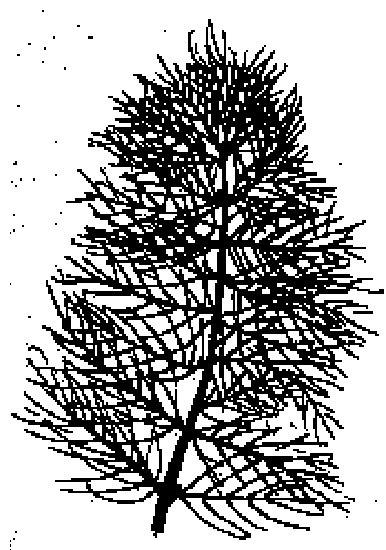


Watershield and white waterlily, emergent macrophytes

Uprooting

Another mechanical method of macrophyte removal is uprooting where the plant is removed roots and all. Most aquatic plants, especially the nuisance species, are very hardy. Simply cutting these plants has the same effect as mowing the grass on a lawn, it will grow back. Uprooting has longer-term effects because individual plants are removed from the lake. An intensive uprooting program will result in a weed-free area until new plants move in and begin growing.

There are many ways to uproot macrophytes. The method chosen is generally dictated by how strongly the plant roots in the sediments. Many of aquatic plants, such as bushy pondweed, commonly referred to as naiad species, are rooted very weakly. They can be pulled up by hand with little effort. Other species, such as Eurasian watermilfoil, are more strongly rooted. Their stems usually break off if one tries to pull up the roots by hand, leaving the roots intact. Still other species, such as cattails, purple loosestrife, and water lilies, have extensive root systems and are practically impossible to pull up by hand.


Watermilfoil

In these latter cases, the uprooting approach to macrophyte removal requires the use of tools. The imagination is often the limit. Macrophytes on the shore have been uprooted using various means, such as chains and cables. Dragging tools are often used for uprooting submergent plants. Dragging the bottom has proven especially effective after a harvesting operation has removed most of the stems and leaves. Lake groups have also used chain link fence, rebars, and old bedsprings for this purpose.

A hydrorake is a motorized weed remover mounted on a barge similar to a weed harvester. Instead of the harvester-type cutting bar, a hydrorake has a forked implement that digs into the sediment and lifts out macrophytes, roots and all. If uprooting is used, the hydrorake is usually the most convenient tool, especially if a large area needs clearing or shoreline access presents a problem for pulling or dragging equipment.

Collection and disposal of the aquatic vegetation that has been cut, raked, or uprooted is a very important part of a mechanical macrophyte removal program. Many nuisance species, including Eurasian watermilfoil, reproduce vegetatively. This means that fragments left in the lake can grow back into new full-sized plants. For this reason it is important to collect as much of the plant material as possible after a harvesting operation and remove it from the water. Some macrophytes, including Eurasian watermilfoil, are very buoyant immediately after cutting and float right to the surface. Surface containment booms can be used to catch drifting material. Other plants, such as naiads and other pondweeds, do not float after cutting. For these plants, weighted seine nets can be used to trap material drifting in the water column and haul it to shore. It is important, however, to use nets with a mesh width large enough so that fish are not trapped.

Cattails

The preceding paragraphs describe how rooted macrophytes are cut, raked, and harvested. Unrooted, free-floating plants present a special challenge for mechanical removal. The free-floating macrophyte species that cause most problems are duckweed and watermeal. These tiny plants reproduce very rapidly and, under ideal conditions, can cover an entire bay or pond in a matter of weeks. Being free-floating, they can be blown by the wind and often accumulate in great numbers in bays or on beaches. Duckweed can be collected using homemade screening devices. Once corralled and pushed to shore, the plants can then be heaped into containers and hauled away.

All species of macrophyte that have been mechanically removed from a lake must be transported away from the lake. As discussed in Chapter 2, dead vegetation is rich in organic matter. If harvested plants are allowed to decay near the shore, nutrients from them will enter the lake and fertilize aquatic growth. **The best course of action is to create compost sites at a distance from the lake and recycle the compost as soil conditioner and land-based fertilizer.**

Legal requirements on mechanical removal of plants

Before initiating any plan for mechanical removal of plants, contact the local inland wetlands commission to determine if a local permit is required.

Lake bottom barriers

Benthic weed barriers are sheets of fiberglass mesh screening or perforated black nylon that cover the bottom of a lake. Barriers kill rooted plants by physically restricting their growth up from the sediments. They also block sunlight from reaching plants. Barriers are most effectively installed early in the growing season. In late spring or summer it is difficult to lay the barriers flat on the bottom because strong stands of vegetation prop them up.

The cost of materials and labor of benthic weed barriers, especially if scuba divers are used, usually restricts their use to areas of high activity, such as boat launches, swimming areas, and boat lanes. They must be fully secured to the bottom at all times. Stakes and weighted anchors are typically used, but whatever the method, the barriers should be inspected regularly. If the barriers become detached from the bottom, they can present a dangerous situation.

Over time, sand and silt will settle on benthic barriers, especially if a barrier is near a storm drain outlet that directs sediment-laden water toward the barrier. Even a light coating of sediment on top of bottom barriers will allow new macrophytes to establish themselves, rendering the barrier useless. Barriers should be removed at the end of each summer, cleaned, and stored for reinstallation in the spring.

Sediment removal

The input of sediments from the watershed can result in increased macrophyte growth by making the lake shallower, thereby increasing growing space for rooted plants. Also, watershed sediments, especially from developed land, carry nutrients and organic wastes that fertilize the new growth. For these reasons, it is important to prevent sediment from moving into a lake.

In lakes where sedimentation has taken place for decades and nuisance macrophytes grow, sediment removal is often used with watershed BMPs designed to prevent sediments from getting into the lake. There are two basic approaches to sediment removal. The first is to drawdown the lake, let the bottom dry out, and excavate the sediments using conventional equipment, such as loaders and backhoes, customized as needed for working in soft sediments. The second option is to keep the water in the lake and conduct a hydraulic dredging operation from the surface. Both methods reduce weed habitat by increasing water depth and removing nutrient-rich sediments, as well as removing the problem macrophyte.

The first option, drawdown and excavation, requires professionally designed drawdown and refilling plans. Outlet pipe and control structures must be maintained in good working order. If these structures are not present, alternative methods of drawdown include pumping and siphoning. The impact on area wells, fish, and other aquatic life must also be considered before the drawdown. Drawdowns greatly affect the community of aquatic insects living on the lake bottom in the exposed areas. These creatures are an important link in the food chain and less mobile species are likely to perish.

Drawdown can also cause shoreline slumping, increased beach erosion, and damage retaining walls when sediments consolidate or wave action erosion occurs at the lower water level. The growth of some species of macrophytes is actually enhanced by drawdown. All of these potential impacts must be carefully weighed against the benefits of sediment removal. However, when properly employed, excavation has been found to be a cost-efficient and effective macrophyte control method.

For lakes where drawdown and excavation is not feasible, the alternative for sediment removal is hydraulic dredging. A hydraulic dredge is a specialized barge with a long pipe that extends to the bottom of the lake. Rotating blades break up the sediments at the end of the pipe, and the resultant slurry, is pumped up to the surface. The slurry is then sent through a pipeline into a series of containment basins. The sediment settles out as the slurry drains through the basin system. In the last basin the water is usually treated with a chemical flocculent or coagulant to remove the remainder of the sediment before discharge back to the lake.

An extensive feasibility study must be completed by a qualified engineering/environmental firm before undertaking a hydraulic dredging project. Capital outlays are high and include either the purchasing or leasing of a dredge and related equipment or the contracting for dredging and engineering services, as well as the acquisition of property rights and construction permits for the basins. Proper disposal of the removed sediments is an important concern for both excavation and dredging operations. Locating and acquiring a dewatering site is also a significant part of the feasibility study. If sediments are not contaminated by toxic pollutants, such as heavy metals or hydrocarbons, dredge spoils may be used for as a soil conditioner or landfill cover.

Legal requirements on sediment removal

Permits that may be required include:

- a water pollution discharge permit from the CT DEP Bureau of Water Management, Permitting, Enforcement and Remediation Division
- Army Corps of Engineer 404 permit
- Army Corps of Engineer 401 permit
- local inland wetlands permits
- reviews by various CT DEP divisions

Grass carp

Natural growth regulation of nuisance macrophyte species through food chain interactions and competition among species is desirable. In this spirit, some managers in North America have been promoting a species of fish known as the grass carp, or white amur, as a natural method of macrophyte management. These fish are vegetarians and eat standing crops of certain species of plants. In Connecticut, private pond owners can apply to the state for a permit to use grass carp to control aquatic weeds. Since long-term impacts on the environment are unknown, only the sterile variety, referred to as triploid carp, are legal.

There are some inherent problems with stocking grass carp in a lake. The grass carp is Asian and not native to North America; therefore, there is no natural system of checks and balances to control grass carp. Potentially, it could dominate the ecosystem. Lake groups must decide how many and what size fish to stock. Stocking too many fish may eventually strip the lake of macrophytes while stocking too few may not provide the reduction in macrophytes desired. Also troubling is the fact that the fish prefer some plants to others. Eurasian watermilfoil, for example, is not one of their favorites. Grass carp might eat other plants in the lake before going after the target nuisance macrophyte.

Grass carp also tend to accelerate the recycling of nutrients in the lake. They eat up to two to three times their body weight per day, returning most to the water as waste material. This waste material can function like a fertilizer and trigger increased algae growth. Grass carp can also increase water turbidity as they routinely stir up bottom sediments in their constant search for food. This action reduces sunlight in the water column and impacts the habitat and metabolic functions of native fish, insects and other organisms in the lake.

For these and other ecological reasons, the CT DEP Lakes Management Program does not advocate grass carp for control of aquatic weeds. However, Connecticut allows importation of sterile grass carp for private ponds and lakes through a permit program administered by the CT DEP. For further information, contact the CT DEP, Division of Fisheries, (860) 424-3474.

Legal requirements on grass carp

Permit conditions require:

- inspection and recommendation by a CT DEP technical assistance fisheries biologist
- written permission of all property owners
- screened inlet and outlet

Aquatic herbicides

Herbicides are sometimes used to kill nuisance macrophytes in specific lake areas. In Connecticut, herbicides can be applied only through a permit process administered by the CT DEP, Bureau of Waste Management, Pesticide Management Division. There are three types of herbicides in general use: contact, systemic, and heavy metal. A contact herbicide destroys plant cells at the point where the poison makes contact, thereby weakening the plant until it eventually dies. A systemic herbicide is absorbed at the point of contact and then spreads throughout the plant and interferes with the metabolic system, such as its ability to photosynthesize or to reproduce cells. Systemics can kill the roots as well as the tops of plants. A metallic herbicide employs a metal that migrates throughout the plant and interferes with one or more of the plant's critical metabolic processes. Copper compounds are the only metallic aquatic herbicide.

- In general, the use of herbicides is not recommended and is not eligible for funding under the CT DEP grant program for recreational lakes. The primary reason is that herbicide control is short-term in its effect. The nuisance macrophyte may grow back and additional applications are usually necessary. Herbicides, unlike harvesting, may have unknown consequences, such as the long-term impacts of the chemical applications on nontargeted species of plants and animals. Thus, lake groups often choose a more conservative approach, especially if there is a lot of swimming in the lake.

If an herbicide is used in a small lake, the associated decomposition of large amounts of dead macrophytes could tax the dissolved oxygen supply. The decaying plant matter also increases the amount of muck on the lake bottom, which impacts fish spawning sites and aquatic insect habitat. These considerations must be understood before herbicides are used for macrophyte control.

Legal requirements on aquatic herbicides

State regulations require a permit for every chemical treatment. All pesticide-related issues are the responsibility of the CT DEP Bureau of Waste Management, Pesticide Management Division. Permits are reviewed with respect to the nature of the vegetation condition, the proposed chemical and dosage, application procedures, and potential adverse effects on water uses. The permit application includes the following:

- review by the CT DEP Bureau of Waste Management, Pesticide Management Division, Division of Fisheries, and other DEP divisions
- a review and comments from the local inland wetlands commission
- submission of a vegetation control plan
- and, if your lake is in the watershed of a public drinking water supply waterbody, a review by the local water utility and the State of Connecticut Department of Health Services.

Additional information on aquatic herbicides

More information can be obtained in "Control of Aquatic Weeds and Algae," available from the CT DEP, Bureau of Waste Management, Division of Pesticide Management, (860) 424-3369.

Light limiting dyes

Submergent macrophytes need clear water so that sunlight can reach their leaves. They cannot thrive in waters where photosynthesis is inhibited. This concept has lead to the marketing of dyes that color water so that light waves are blocked at or near the water surface. These dyes have been used primarily in small water bodies. To be effective, the lake or pond must have little or no inflow or outflow of water. Water movement in and out of the waterbody will dilute the dye and quickly lessen its effectiveness. Furthermore, Connecticut, due to the potential downstream impacts with discoloration and reduced aesthetic value, the use of water dyes is restricted to lakes without outlet streams.

The use of water dyes is most appropriate in special situations, such as ornamental ponds. The majority of lakes in Connecticut have inlets and outlets, which inhibits the use of dyes. The use of dyes artificially controls submergent vegetation. A healthy, natural ecosystem cannot be established if light is not allowed to penetrate the water column.

Legal requirements on light limiting dyes

All applications of light limiting dyes must be permitted by CT DEP Bureau of Waste Management, Division of Pesticide Management.

Wintertime drawdown

Winter drawdown of lakes and ponds exposes sediments and macrophytes to freezing temperatures. This technique has been proven very effective in killing Eurasian watermilfoil beds when circumstances are right. The kill is most complete, for example, when the freeze occurs after the sediments have had a chance to dry.

The primary advantage of winter drawdown is the relatively low cost compared to other weed control options. A primary disadvantage of winter drawdown is that the control and effect is limited to the area exposed. To initiate a winter drawdown, several aspects of the process should be considered. First, the water level of the lake must be lowered; if the spillway does not have this capability, the lake must be pumped or siphoned. If shoreline residents utilize on-site wells, the effect to the water table must be investigated prior to drawdown. Releases of water must also be controlled to prevent downstream flooding. Refill must both maintain downstream flows and achieve the normal summer lake level before the beginning of the growing season, which is approximately April 15 in Connecticut. If a lake is lower than normal during the growing season, areas previously too deep for weed growth may subsequently develop infestations of weeds.

In addition, there may be adverse biological effects from a winter drawdown. The area along the shore exposed to freezing is the most biologically productive and diverse of the lake. Winter exposure will kill many desirable native plants and allow more problematic exotic plants to become established. Unless nuisance weeds become intolerable, winter drawdown should be avoided.

Legal requirements on winter drawdown

Before initiating drawdown, the following should contact the CT DEP Bureau of Water Management, Division of Inland Water Resources and your local inlands wetland commissions to determine whether drawdown is regulated.

Weevil predation

Some lakes in Connecticut have experienced a reduction in Eurasian water milfoil. These cyclical declines are usually found in lakes that have not been extensively managed for water milfoil. It is suspected that herbivorous aquatic weevils and caterpillars may be responsible for the reduction. It is also suspected that water milfoil control programs such as winter drawdown, harvesting, and herbicide applications may have an adverse impact on these beneficial organisms. Therefore, until the results of research on these organisms are available, and a determination has been made on cyclical reduction of water milfoil in a given lake, it may be to the advantage to delay water milfoil control programs.

This approach is recommended only for lakes with established populations of Eurasian water milfoil; any instances of new infestations should be reported to the CT DEP to determine the most appropriate management method.

Additional information on weevil predation

For additional information on weevil predation, contact the CT DEP Bureau of Water Management, Lakes Management Program, (860) 424-3716.

3.3 Controlling Algae

Algae are plants that contain chlorophyll but do not have true roots, stems, or leaves. Some species exist as microscopic single cells. Other species grow in mass aggregates of cells, termed colonies, or in strands, termed filaments. Some algal species even resemble macrophyte growing on the lake bottoms.

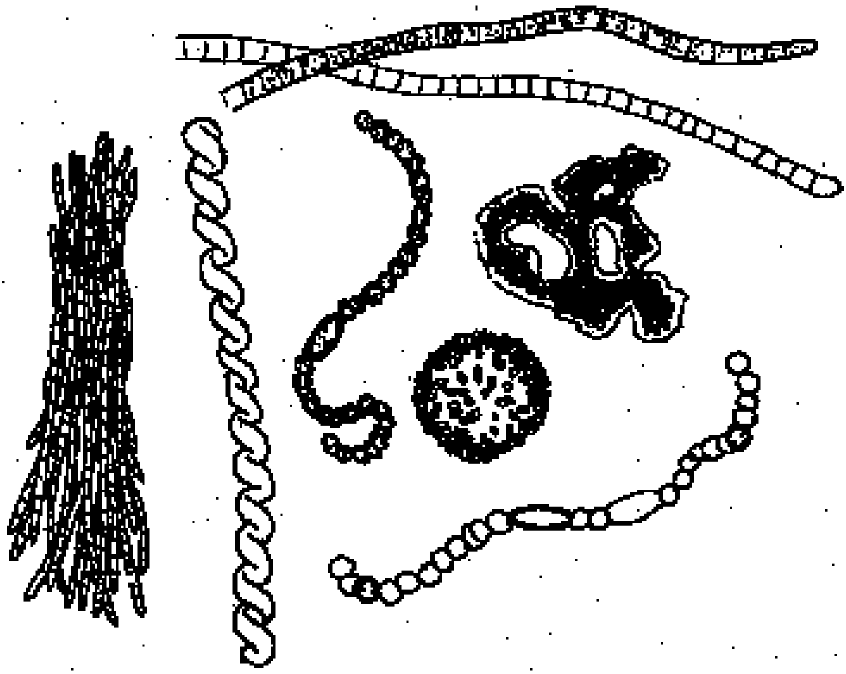
Algae are a natural component of the aquatic ecosystem and all lakes in Connecticut contain some algae. As with macrophytes, problems generally occur when one or two species grow out of control. When this happens, it is termed an algae bloom. Blooms can give water an unpleasant taste or odor, reduce water *clarity*, and color the lake a vivid green, brown, yellow, or even red, depending on the species. Filamentous and colonial algae are especially troublesome because they form scums or mats on the lake surface. These mats can drift and clog water intakes, foul beaches, and ruin recreational opportunities.

Unlike rooted macrophytes that rely on the sediments as their source of nutrients, algae generally receive their nutrient supply from the water. When nutrients in the water column are plentiful, there is a good chance that an algal bloom will occur. Three common nuisance species found in Connecticut lakes are all in the blue-green algae family: Anabaena, Aphanizomenon and Microcystis. Before an algae control method is used, the algae should be identified by someone familiar with species classification.

Techniques to control algae fall into two basic categories: methods that reduce the availability of essential nutrients in the water and methods that kill or directly remove algae from the lake. These techniques are discussed in the next sections.

Reducing phosphorus availability

Phosphorus is one of several essential nutrients that



A variety of algae types, enlarged

algae need for growth and reproduction. In most natural lakes phosphorus is in short supply and serves as the limiting factor for algae growth. Lakes in developed watersheds, however, receive unusually generous amounts of phosphorus through such sources as stormwater runoff and septic systems. Phosphorus may also enter a lake from its sediments when, under certain conditions, it is released to the water column.

To reduce the availability of phosphorus, lake management specialists can do two things: strip it out of the water column and/or seal the bottom sediments so that phosphorus is not allowed to move into the water column. In the first process, a chemical agent is added to the lake water to combine with phosphorus forming a floc that settles to the lake bottom. The second process is primarily accomplished by keeping the bottom waters oxygenated. When oxygen is present, phosphorus chemically combines with other elements, primarily iron, and is essentially locked in the bottom sediments. The absence of oxygen results in the breakdown of chemical bonds, which frees the phosphorus from the sediments. This allows the phosphorus to move into the hypolimnion. Anytime the bottom waters are churned to the lighted surface water, its load of phosphorus becomes available to algae. This phenomenon often occurs during spring and fall overturn; strong storms can also cause the circulation of phosphorus-rich bottom waters to the surface. The following discusses four specific techniques for reducing the availability of phosphorus.

Buffered alum

Buffered alum is a mixture of aluminum sulfate and calcium compounds. This compound is applied to the water surface, usually from a boat criss-crossing the lake. Heavier than water, alum forms a precipitate glob that soaks up phosphorus as it sinks to the bottom. On the bottom, it continues to capture and hold phosphorus. In this manner, phosphorus is essentially stripped from the water column and without this essential nutrient algae cannot grow.

An analysis of a lake and application methods is required to determine whether alum treatments will be successful and environmentally sound. If inflowing waters carry a significant supply of phosphorus, the effect of an alum application will be short-lived. Therefore, it is important that watershed management measures are implemented in conjunction with alum control to reduce phosphorus pollution and its effects.

Legal requirements for alum applications

Applications of alum is regulated by CT DEP Bureau of Waste Management, Pesticide Program. For more information on permit requirements call the Pesticide Program, (860) 424-3369.

Hypolimnetic aeration

Hypolimnetic aeration refers to a process that introduces oxygen-rich water into the bottom waters without disturbing the natural stratification of the lake. As discussed above, oxygen in the bottom waters effectively seals phosphorus in the sediments. Maintaining stratification is especially important in lakes that support a "two-story fishery"; that is, a lake that has warm water fish (e.g., bass and pan fish) living in the epilimnion and cool water fish (e.g., trout or walleye) living in the hypolimnion.

Hypolimnetic aeration is accomplished using a specially designed, self-contained, underwater cylinder composed of inside and outside chambers, both open at the bottom. Air is pumped to the bottom of the inside chamber. The rising air bubbles carry the bottom water to the top of the cylinder where it is aerated. The newly oxygenated water then is cycled down the outside chamber and released at the lake bottom.

It is essential to perform a feasibility study of the physical and chemical characteristics of a lake to determine whether hypolimnetic aeration will control phosphorus releases from the sediments as well as to determine the size and type of equipment needed.

Hypolimnetic withdrawal

Hypolimnetic withdrawal reduces the amount of phosphorus in the hypolimnion by pumping the phosphorus-rich bottom water out of the lake into an outlet stream. A project feasibility study must be conducted to determine the amount of phosphorus cycling in and out of the lake. Since hypolimnetic water can also contain iron, sulfides, and other constituents that degrade the water quality of receiving streams, the water must be treated by aeration prior to discharging. The study must also examine other possible adverse effects on streams receiving the low oxygen/high phosphorus water.

Legal requirement on hypolimnetic withdrawal discharge

The Permits, Enforcement and Remediation Division of the CT DEP Bureau of Water Management requires a water pollution discharge permit for hypolimnetic withdrawal discharges, (860) 424-3705.

Artificial circulation

Artificial circulation, also known as conventional aeration, can be accomplished by introducing air bubbles at the bottom of the lake. The rising air bubbles then carry the oxygen-poor bottom waters to the surface. Artificial circulation can also be accomplished in shallow lakes by physically mixing the water with a fountain or surface aerator. This method ensures that all the water will at some time be displaced to the lake surface where oxygen is transferred to the water from the atmosphere. These methods discourage the growth of certain types of blue-green algae that do not grow well in moving water.

While the benefits of having oxygen throughout the water column may be great (e.g., sealing phosphorus in the sediments), there are tradeoffs. For example, artificial circulation breaks down natural stratification. All of the water will, therefore, be circulating as in a swimming pool, maintaining uniform temperature and oxygen levels from top to bottom. So, the potential for a two-story fishery is lost. Additionally, artificial circulation may allow phosphorus rich water from the bottom of the lake to move to the surface where sunlight is available creating ideal conditions for algae blooms.

As with hypolimnetic aeration and withdrawal, a detailed diagnostic feasibility study for artificial circulation proposals is needed. Poor design or installation that does not destratify the lake, may not improve water quality and could increase algal growth.

Killing or directly removing algae

Algae may be killed with an algicide or directly removed in a variety of ways. The following is a description of both approaches to controlling algae.

Aquatic algicides

Copper-based compounds, such as copper sulfate, are typically used as algicides. These compounds inhibit photosynthesis, which eventually kills plant cells. They can be applied in either liquid or granular form. In Connecticut, however, only a limited number of algicides are approved for use.

Legal requirements on aquatic algicides

Legal requirements for algicides are the same as the legal requirements for herbicides discussed in section 3.25.

Additional information on aquatic algicides

"Control of Aquatic Weeds and Algae" may be obtained from the CT DEP Bureau of Waste Management, Division of Pesticide Management, (860) 424-3369.

Mechanical removal

Many species of filamentous algae float on the surface in unsightly mats. Each mat is composed of millions of tiny interwoven filaments. Techniques described in the "Managing Macrophytes" section and the section on "Mechanical removal of plants" earlier in this chapter, and the removal of duckweed and clippings from harvested weed beds can also be employed to collect and remove floating filamentous algae. Modified fish seines are typically used to corral algae mats. After the mats are pushed to shore, they can be heaped into containers and hauled away.

CONCLUSION

This booklet provides your lake organization with the resources to improve and maintain the water quality of your lake. Although this guide will not train the lakeside property owner to be a *lake manager* or limnologist, it will give lake users a general understanding of lake science and an overview of the principals and techniques of managing these unique and valuable resources. The CT DEP lakes management staff looks forward to providing technical assistance and acting as a liaison between your group and other government agencies. If you have any concerns about questions concerning lake water quality, please contact us at (860) 424-3716.

In addition to the distribution of this guide, our staff can provide the following:

- in-lake algae and weed control techniques
- watershed management guidelines
- general information on algae and weed control
- general water quality data on a large number of Connecticut lakes
- technical assistance and review of proposed plans for lake projects
- environmental review team reports
- information on state and federal financial assistance programs for algae and weed control activities
- information on lake management services provided by consultants and contractors
- enforcement related to environmental concerns related to lake water quality

Appendix A: Technical Glossary

acidification: The process in which acid deposition or acid runoff from the watershed causes an increase in acidity and lowers the pH (measure of hydrogen) of a waterbody.

atmospheric diffusion: The process of atmospheric oxygen moving into or out of a body of water in order to reach equilibrium.

best management practice (BMP): A practice, procedure, structure, or combinations thereof, that is planned and implemented to prevent, minimize or control point or nonpoint source pollution of ground or surface water.

chlorophyll-*a*: A pigment associated with photosynthesis that serves as an index of algal productivity.

clarity: The distance one can see into water. Transparency is measured with a white and black disk called a secchi disk.

criteria: Elements of Connecticut's Water Quality Standards, expressed in parameters and their constituent concentrations and levels, or in narrative statements, representing a quality of water that supports a particular designated use.

cultural eutrophication: See eutrophication.

designated use: Those uses specified in Connecticut's Water Quality Standards for each surface watercourse or groundwater area.

dissolved nutrients: Nutrients, which include any chemical element, ion, or compound required by an organism for the continuation of growth, reproduction, and other life processes, found in solution in water and readily available to aquatic organisms.

dissolved oxygen: The oxygen found in solution in water and readily available to aquatic organisms. It is usually expressed in milligrams per liter or as the percent of saturation.

ecology: The study of organisms and their relationship to the environment.

ecosystem: A system where organisms and their environment are interdependent on one another.

epilimnion: The warm surface layer of a lake during summer stratification.

erosion: Movement of soil from its place of origin by wind or water.

eutrophic: A lake or pond that is rich in plant nutrients usually having extensive rooted plant and algae growth.

eutrophication: Increased aquatic plant growth and the associated physical, chemical, and biological changes in a waterbody due to nutrient and organic matter enrichment, and sedimentation. If the process is accelerated by man-made influences, it is termed "cultural eutrophication".

heavy metals: Lead, copper, cadmium, zinc, nickel, and chromium examples of heavy metals naturally occur in the environment; high levels come from marinas, automobiles, industrial waste and polluted atmosphere. Deposition in a lake can prove toxic to aquatic species.

hydrocarbons: The primary component of motor fuels and engine oil.

hypolimnion: The coldest bottom layer of a lake during summer stratification. This layer is often void of dissolved oxygen.

internal nutrient loading: The process of nutrients being released within a lake through its sediments.

lake manager: One involved with administering and conducting activities related to lake water quality, recreation, fisheries, and other concerns related to maintaining and improving lake resources.

limiting nutrient: The nutrient that is least available relative to the growth needs of an organism. In freshwater systems, phosphorus or nitrogen may be the limiting nutrient for plant growth.

limnology: The scientific study of lakes and ponds.

limnologist: A scientist who studies lakes and ponds.

macrophytes: Aquatic plants with roots.

mesotrophic: the condition of lakes or ponds being only moderately rich in plant nutrients

metalimnion or thermocline: The layer of rapid temperature and density change during summer stratification, often referred to as the thermocline, situated between the epilimnion and hypolimnion in a stratified lake.

nonpoint source pollution: Entry of effluent into ground or surface water in a diffuse manner where the source is not readily discernible, e.g., soil erosion, stormwater, or runoff from poorly managed land use activities.

nutrient: A chemical element required for life processes. In lakes, phosphorus and nitrogen are the two nutrients of primary concern.

oligotrophic: A lake or pond with little nutrients and sediments, low in plant productivity, and high transparency.

organic matter: Material of plant or animal origin.

pathogen/pathogenic bacteria: A microorganism capable of causing a disease.

pesticide: A chemical agent that kills plant or animal pests. Aquatic herbicides and algicides are all categorized as pesticides.

photosynthesis: The process of plants using light energy to convert inorganic substances into organic material. Oxygen is a by-product of this process.

point source pollution: Pollution discharged from a discernable source with a definite point of entry into ground or surface water.

sediment: The soils of the bottom of a waterbody.,

sedimentation: The process of soil and organic materials being transported from their sites of origin and becoming suspended in the water column or accumulating on the bottom of a waterbody. Sedimentation causes reduced clarity, increased nutrient loading, and decreased water depth.

stratification: The condition that results when the warmer surface of a lake lays above colder bottom waters.

thermocline: See metalimnion.

trophic classification: The classification of the biological productivity of a lake, as measured by the nutrient concentrations, water clarity, and other parameters. The trophic categories are oligotrophic, early mesotrophic, mesotrophic, late mesotrophic, eutrophic, and highly eutrophic.

water quality: The physical, chemical and biological characteristics of surface or ground waters.

water quality classifications: A classification system establishing the designated uses of surface and ground waters and the criteria necessary to support those uses.

watershed, or drainage basin: The drainage area where all land and water drains or flows toward a central collector such as a stream, river, or lake at a lower elevation.

Appendix B: County Agricultural Centers

Fairfield County NRCS, S&WCD
UCONN Agricultural Center
67 Stony Hill Road
Bethel, CT 06801
(203)774-6108

Hartford County NRCS, S&WCD
Agricultural Center
627 River Road
Windsor, CT 06095
(860)688-7725

Litchfield County NRCD, S&WCD
1185 New Litchfield Street
Torrington, CT 06790
(860)626-8258

Middlesex County NRCD, S&WCD
UCONN Extension Center
P.O. Box 70
Haddam, CT 06438
(860)345-3219

New Haven County NRCD, S&WCD
UCONN Extension Service
900 Northrop Road
Wallingford, CT 06492
(203)269-7509

New London County NRCD, S&WCD
UCONN Extension Service
238 West Town Street
Norwich, CT 06360
(860)887-3604

Windham County, NRCD, S&WCD
UCONN Extension Center
P.O. Box 112
139 Wolf Den Road
Brooklyn, CT 06234
(860)774-9600 or (860)774-0224

Tolland County NRCD, S&WCD
UCONN Agricultural Center
24 Hyde Avenue
Vernon, CT 06066
(860)875-3881

Appendix C: Summary of the Trophic Classifications of Connecticut Lakes

Lake	Town(s)	Surface Area (Acres)
	Oligotrophic	
Bashan	East Haddam	276.3
Beach Pond	Voluntown	394.3
Billings	North Stonington	105.1
Mashapaug Lake	Union	297.1
Riga Lake	Salisbury	169.5
Uncas Lake	Lyme	69.0
West Hill Pond	New Hartford	238.0
	Early Mesotrophic	
Bigelow Pond	Union	18.5
Candlewood Lake	New Fairfield, Sherman, New Milford, Danbury & Brookfield	5420.0
Columbia Lake	Columbia	277.2
Coventry Lake	Coventry	378.0
Cream Hill Pond	Cornwall	72.0
Dodge Pond	East Lyme	33.0
East Twin Lake	Salisbury	562.3
Higganum Reservoir	Haddam	32.0
Killingly Pond	Killingly	137.5
Mohawk Pond	Goshen	15.2
Mt. Tom Pond	Litchfield, Morris, & Washington	31.5
Norwich Pond	Lyme	27.5
Pachaug Pond	Griswold	830.9
Pattaconk Pond	Chester	55.5
Rogers Lake	Lyme & Old Lyme	264.9

Lake	Town(s)	Surface Area (Acres)
S. Spectacle Lake	Kent	93.0
Wauregan Reservoir	Killingly	68.0
Lake Winchester	Winchester	229.0
Wyassup Lake	North Stonington	92.4
	Mesotrophic	
Lake Alexander	Killingly	190.4
Anderson's Pond	North Stonington	54.3
Ball Pond	New Fairfield	89.9
Black Pond	Woodstock	73.4
Lower Bolton Lake	Bolton & Vernon	178.4
Burr Pond	Torrington	85.6
Cedar Lake	Chester	68.0
Crystal Lake	Ellington & Stafford	200.9
Gardner Lake	Salem, Montville & Bozrah	486.8
Glasgo Pond	Griswold	184.2
Gorton's Pond	East Lyme	53.0
Green Falls Reservoir	Voluntown	46.9
Halls Pond	Ashford & Eastford	82.3
Hatch Pond	Kent	61.0
Highland Lake	Winchester	444.0
Little (Schoolhouse)	Thompson	65.4
Morey Pond	Ashford & Union	40.0
Park Pond	Winchester	76.7
Pataganset Lake	East Lyme	123.0
Lake Pocotopaug	East Hampton	511.7
Powers Lake	East Lyme	152.6
Quaddick Reservoir	Thompson	466.8
Lake Quassapaug	Middlebury	271.0
Quonnipaug Lake	Guilford	111.6
Shenipsit Lake	Vernon, Ellington & Tolland	522.8
Terramuggus Lake	Marlborough	83.0
Tyler Lake	Goshen	182.0
West Side Pond	Goshen	42.4

Lake	Town(s)	Surface Area (Acres)
Lake Wononscopomuc	Salisbury	352.6
Wrights Pond	Westbrook, Essex & Deep River	37.0
Late Mesotrophic		
Beseck Lake	Middlefield	119.6
Black Pond	Meriden & Middlefield	75.6
Middle Bolton Pond	Vernon	114.9
Fitchville Pond	Bozrah	71.1
Lake Hayward	East Haddam	198.9
Hitchcock Lake	Wolcott	118.4
Long Pond	Ledyard & North Stonington	98.6
Mamanasco Lake	Ridgefield	95.0
Moodus Reservoir	East Haddam	451.0
Mudge Pond	Sharon	201.0
Squantz Pond	New Fairfield & Sherman	288.0
Taunton Pond	Newtown	126.0
Lake Waramaug	Warren, Washington & Kent	680.2
Eutrophic		
Amos Lake	Preston	105.1
Aspinook Pond	Lisbon & Canterbury	333.3
Avery Pond	Preston	50.6
Bantam Lake	Litchfield & Morris	916.0
Batterson Park Pond	Farmington & New Britain	162.7
Crystal Lake	Middletown	65.5
Dog Pond	Goshen	71.3
Eagleville Lake	Mansfield	80.0
Lake Housatonic	Shelton	328.2
Howell Pond	Hartland	17.3
Lake Kenosia	Danbury	56.0
Leonard Pond	Kent	15.0
Lake Lillinonah	Southbury, Bridgewater, Brookfield & Newtown	1900.0
Linsley Pond	North Branford & Branford	23.3

Lake	Town(s)	Surface Area (Acres)
Long Meadow Pond	Bethlehem	11.7
Moosup Pond	Plainfield	97.2
Rainbow Reservoir	Windsor	235.0
Red Cedar Lake	Lebanon	141.0
Roseland Lake	Woodstock	88.0
Lake Wononpakook	Salisbury	164.0
Lake Zoar	Newtown, Monroe, Oxford & South	975.0
Highly Eutrophic		
Dooley Pond	Middletown	28.0
Hanover Pond	Meriden	73.0
Holbrook Pond	Hebron	72.5
Hopeville Pond	Griswold	149.4
North Farms Reservoir	Wallingford	62.5
Pickerel Lake	Colchester	88.6
Silver Lake	Berlin & Meriden	151.0
West Thompson Lake	Thompson	195.0
Lake Winnemaug	Watertown	120.0
Wood Creek Pond	Norfolk	151.0
1860 Reservoir	Wethersfield	35.0