PLANNING AND REGULATION

Pond Use Planning & Regulations

STRATEGY SCALE

THREATS ADDRESSED				
✓ Excess Nutrients	✓ Pollutant Inputs	✓ Algal Blooms	✗ Erosion	✓ Invasive/Nuisance Species

STRATEGY GOALS

Protect	Manage	Rehabilitate
✓	✓	✓

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
Neutral	*Neutral*	*Neutral*

✓ **Permittable in Massachusetts**
Local review through Select Board or Town Council. List of potential permits available here.

✓ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod here.

✗ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✗ **Can be Performed at Homeowner Scale**

✓ **Nature-based Solution**

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
○	○	●

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
○	○	●

DESCRIPTION Pond overuse may adversely impact water quality, pond ecosystem function, visitor experience, and recreational opportunities. Freshwater resource area zoning and regulation are used to manage pond overuse, avoid user conflicts, control exposure to pathogens, and protect water quality. Local governments can establish zoning, bylaws, and regulations in freshwater pond resource areas to control activities in ponds and manage user conflicts. Bans or restrictions can be defined by area, time, or other parameters and may be based on the management issues present, the pond's physical characteristics, visibility, and the presence of existing management or monitoring infrastructure. Examples include designating swimming, boating, and fishing areas; restricting motorboats from certain ponds or to specific hours, limiting speeds or horsepower, and requiring boats to be cleaned, drained, and dried before entering another waterbody; placing restrictions on docks such as dimensional limits, required water depths, acceptable materials, and storage requirements; and closing beaches to swimming when harmful bacteria is present to protect public health.

ADVANTAGES

- Targeted, localized approach
- Compliance with pond use regulations may improve pond ecosystem function
- Compliance with pond use regulations may enhance the visitor experience
- Inexpensive to implement
- No or minimal equipment required

CONSTRAINTS

- Zones have to be defined and agreed upon
- May be difficult to enact and enforce
- Some pond users may not like areas of their pond being "off-limits" for certain activities
- Requires legal knowledge, and new zoning, bylaws and regulations may be subject to town and state approvals
- May be difficult for ponds that cross town boundaries as zoning, bylaws and regulations are adopted at the local level

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** May propose, review, and approve zoning, bylaws and regulations
- **Pond Groups:** May propose or support the adoption of pond use plans and regulations
- **Private Landowners:** May propose or support the adoption of pond use plans and regulations
- **Land Trusts:** May propose or support the local adoption of pond use plans and regulations

SITING REQUIREMENTS

- Ponds where use is high and user conflicts are prevalent

INFORMATION NEEDS

- Review of town's own and other towns' pond zoning, bylaws and regulations
- Pond uses and use statistics
- Mapping of zones for different habitats and uses
- Impact avoidance plan

IMPLEMENTATION EXAMPLES

Barnstable County's Beach Monitoring Program monitors bathing beaches for fecal bacteria in the summer to protect public health. Town Boards of Health close ponds to swimming if MA Department of Public Health bacteria limits are exceeded.

The Town of Eastham has a *Boating Bylaw* regulating the operation of motorboats on ponds to promote the protection of public safety and welfare.

The Town of Sandwich also has a *Boat Operations Bylaw* regulating the operation of watercraft to protect public health, safety and well being and protect the quality and viability of the Town's natural resources.

RESOURCES

- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

Variable

Variable depending on scope of planning process and regulations adopted

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning and information gathering including researching and mapping pond uses and collecting use statistics

Implementation: Public process including presenting at meetings, developing and posting informational materials, and adopting and enforcing regulations

Maintenance: Information will need to be kept up-to-date and regulations enforced

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

PLANNING AND REGULATION

Land Use Planning & Regulations

STRATEGY SCALE

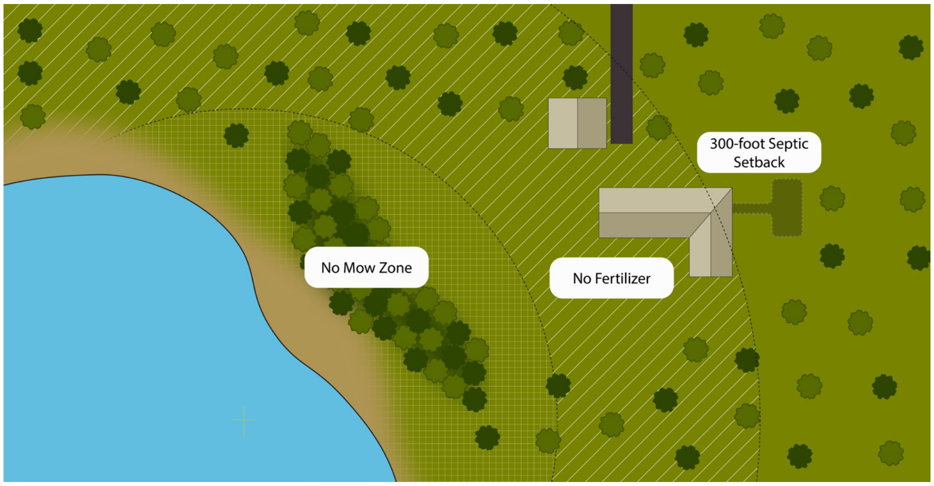
THREATS ADDRESSED				
✓ Excess Nutrients	✓ Pollutant Inputs	✓ Algal Blooms	✓ Erosion	✓ Invasive/Nuisance Species

STRATEGY GOALS

Protect	Manage	Rehabilitate
✓	✓	✓

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
Neutral	*Neutral*	*Neutral*



✓ **Permittable in Massachusetts**
Local review through Select Board or Town Council. List of potential permits available here.

✓ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod here.

✗ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✗ **Can be Performed at Homeowner Scale**

✓ **Nature-based Solution**

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
○	○	●

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
○	○	●

DESCRIPTION

The objective of land use planning and regulations around ponds is to protect pond health and the land surrounding ponds through the creation and implementation of regulations focused on reducing land-based inputs of pollution and pathogens to ponds. Land use planning and regulations are used to regulate specific land use practices around ponds based on community concern and to protect pond water quality and public health. Examples include mandating larger septic system setbacks, imposing development site stormwater management regulations, preventing vegetation clearing, requiring vegetated buffers made up of native vegetation, restricting use of fertilizers and pesticides, imposing limits on public access, and pet restrictions. Bylaws and regulations are drafted and adopted by a town or homeowner's association (HOA). The town or HOA may also develop outreach and education materials to inform residents of regulations.

ADVANTAGES

- Targeted, localized approach – communities can tailor plans or regulations to their local concerns
- Not expensive, no equipment required
- Towns can have stricter standards (e.g., wetland buffers, septic setbacks) than the state
- If an HOA sees benefits, regulations can spread to other communities and HOAs without needing town action
- Generation of beach parking and other user fees can be used for resource protection, preservation projects
- Compliance with land use regulations may improve pond ecosystem function
- Compliance with land use regulations may enhance the visitor experience

CONSTRAINTS

- Local bylaws / regulations have to be drafted / adopted based on scientific explanation / justification. Requires legal knowledge
- May be difficult to enact and enforce
- For septic setbacks, need to explore which properties it would apply to (e.g., all new construction, redevelopment), and whether it would make some lots unbuildable
- Some pond shore property owners may not like having restrictions placed on their land
- HOAs may prefer a landscaping aesthetic that may conflict with fertilizer restrictions or natural landscaping requirements
- User fees and licenses for parking/beach access require town involvement in granting licenses and personnel to staff the beach to regulate licenses

Land Use Planning & Regulations

IMPLEMENTATION

POTENTIAL ACTORS

Towns: May propose, review, and approve zoning, bylaws and regulations

Pond Groups: May propose or support the adoption of land use plans and regulations

Private Landowners: May propose or support the adoption of land use plans and regulations

Land Trusts: May propose or support the local adoption of land use plans and regulations

SITING REQUIREMENTS

- All ponds within a town or within a district

INFORMATION NEEDS

- Pond surrounding land use characterization and identification of potential causes and sources of land-based inputs, including survey of location and condition of septic and stormwater systems within pond buffer (e.g., 300')
- Groundwater flow/direction
- Nutrient sources/travel times/distances from sources to ponds
- Pond buffer plant survey
- Review of town's own and other towns' land use bylaws and regulations around ponds

IMPLEMENTATION EXAMPLES

The Town of Mashpee amended their *Wetlands Protection Bylaw and Regulations* to expand the buffer zone from 100' to 150'. The buffer zone was expanded to mitigate stormwater impacts to water quality, increase and enhance wildlife habitat, and protect properties from storms.

The Town of Brewster has a *Leaching Facility Setback Regulation* that prohibits new and replacement leaching facilities of septic systems within 300' of a pond.

Several towns on Cape Cod have proposed home rule petitions limiting or prohibiting the use of fertilizers and pesticides such as the *Town of Orleans Fertilizer and Pesticide Home Rule Petitions*.

RESOURCES

- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

Variable

Variable depending on scope of planning process and regulations adopted

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning and information gathering including researching and mapping land uses and collecting use statistics

Implementation: Public process including presenting at meetings, developing and posting informational materials, and adopting and enforcing regulations

Maintenance: Information will need to be kept up-to-date and regulations enforced

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**

Additional information regarding potential funding sources is available *here*.

PLANNING AND REGULATION

Watershed Planning

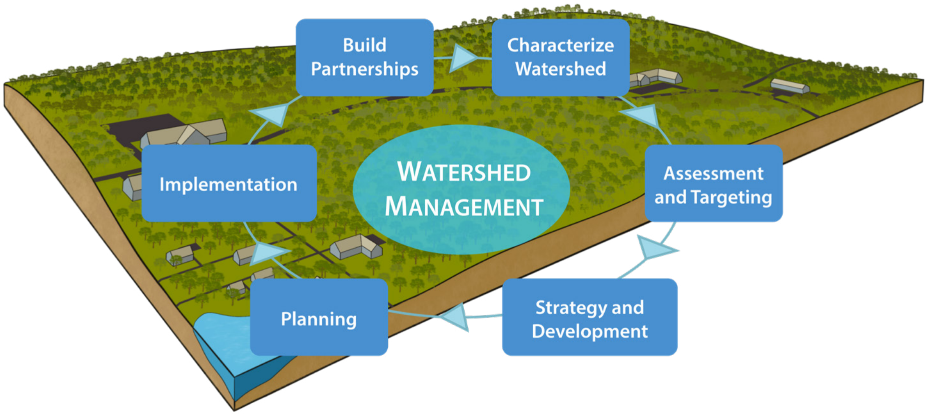
In-Pond | Pondshore | Watershed

STRATEGY SCALE

THREATS ADDRESSED: ✓ Excess Nutrients ✓ Pollutant Inputs ✓ Algal Blooms ✓ Erosion ✓ Invasive/Nuisance Species

STRATEGY GOALS: Protect ✓ | Manage ✓ | Rehabilitate ✓

STRATEGY CO-BENEFITS: Habitat – Neutral | Aesthetics – Neutral | Recreation – Neutral



✓ **Permittable in Massachusetts**
Watershed Plans and Permits require local and MassDEP approval and must be deemed consistent with Cape Cod's 208 Plan. List of potential permits available here.

✓ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod here.

✗ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✗ **Can be Performed at Homeowner Scale**

✓ **Nature-based Solution**

DURATION OF BENEFITS: Less than one month ○ | One season or year ○ | Multiple seasons or years ●

MAINTENANCE REQUIREMENTS: Monthly ○ | Annually ○ | Infrequent ●

DESCRIPTION

A Watershed Based Plan (WBP) is developed by convening stakeholders and building local partnerships to understand and address freshwater ponds in the context of the larger watershed. It provides a framework for managing efforts to restore water quality in degraded areas and protect overall watershed health. WBPs identify broad goals and objectives, describe environmental problems, outline alternatives for restoration, management and protection, and document where, how and by whom actions will be evaluated, selected and implemented. A WBP is required for towns to be eligible for MassDEP grants and may be the basis for a MassDEP Watershed Permit that establishes performance standards, authorized activities, and the time frames to meet water quality and habitat restoration goals. A Watershed Permit is a 20-year permit which utilizes an adaptive management approach, requiring permittees to monitor, evaluate and report results, and adjust and modify the strategies and practices as needed to address conditions that are causing water quality impairments.

ADVANTAGES

- Comprehensive planning has the potential to address all or most adverse impacts to freshwater ponds throughout a watershed
- Watershed management designed to protect healthy ponds may be effective, especially for small watersheds that do not exceed about 10x the pond's surface area, where significant areas remain undeveloped

CONSTRAINTS

- Depending on how different waterbodies and problems are addressed in the plan, freshwater ponds and threats to ponds may not be prioritized
- Watersheds may cross jurisdictional boundaries, and all towns within the watershed need to be engaged and committed
- Watershed management alone is too often insufficient or unreliable for mitigating existing impairments in ponds

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** In general, Towns develop watershed plans in collaboration with local stakeholders
- **Pond Groups:** May propose or support watershed planning
- **Private Landowners:** May propose or support watershed planning
- **Land Trusts:** May propose or support watershed planning

SITING REQUIREMENTS

- All ponds within a pond watershed
- For a MassDEP Watershed Permit, all ponds within a Natural Resource Area Nitrogen Sensitive Area

INFORMATION NEEDS

- Identification of stakeholders and partners
- Watershed delineation and characterization
- Identification of causes and sources of pollution
- Quantification of pollutant load and load reductions needed
- Develop management measures and implementation program
- Adaptive management plan

IMPLEMENTATION EXAMPLES

The *Pleasant Bay Watershed Plan and Permit* were developed to help the towns of Orleans, Chatham, Harwich, and Brewster meet nitrogen reduction targets in Pleasant Bay. The plan includes traditional and non-traditional nitrogen removal strategies. The permit outlines individual and collective steps for the Towns.

The Town of Brewster and partners prepared a *Namskaket Creek / Little Namskaket Creek Watershed Based Plan* focused on protecting and improving water quality in the estuary and the six freshwater ponds within the watershed.

The Mashpee Wampanoag Tribe, Town of Mashpee, and partners prepared the *Santuit Pond Watershed Based Plan* focused on the control of phosphorus within Santuit Pond and its associated watershed.

RESOURCES

- The U.S. Environmental Protection Agency has *Resources for Watershed Planning* to help communities develop and implement watershed plans to meet water quality standards and protect water resources
- MassDEP also has *Watershed-Based Plan Information* to help communities develop plans to address water quality problems in impaired waters and protect water quality in healthy waters.
- The Massachusetts Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

Variable

Variable depending on scope

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning and information gathering including researching and mapping watershed characteristics

Implementation: Public process including presenting at meetings, developing and posting informational materials, and implementing plan/permit

Maintenance: Information will need to be kept up-to-date and plan goals or permit conditions met

POTENTIAL FUNDING SOURCES

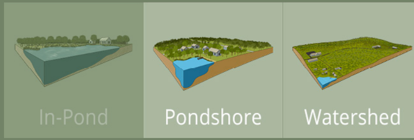
- **Community Preservation Act**
- **Capital Budget**
- **Grants**

Additional information regarding potential funding sources is available ***here***.

PLANNING AND REGULATION

DCPC

Freshwater Ponds District of Critical Planning Concern (DCPC)



STRATEGY SCALE

THREATS ADDRESSED

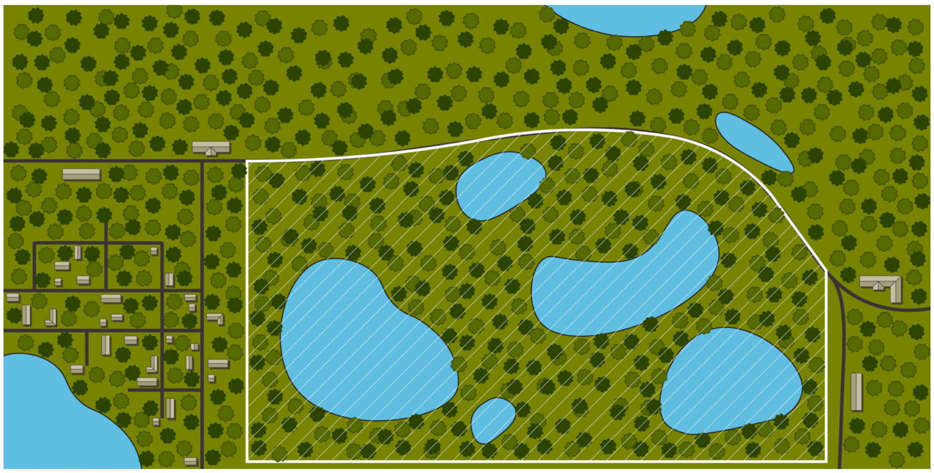
- ✓ Excess Nutrients
- ✓ Pollutant Inputs
- ✓ Algal Blooms
- ✓ Erosion
- ✓ Invasive/Nuisance Species

STRATEGY GOALS

Protect	Manage	Rehabilitate
✓	✓	✓

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
Neutral	Neutral	Neutral



✓ **Permittable in Massachusetts**
Requires votes of Cape Cod Commission, Assembly of Delegates, and County Commissioners. List of potential permits available here.

✓ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod here.

✗ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✗ **Can be Performed at Homeowner Scale**

✓ **Nature-based Solution**

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
○	○	●

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
○	○	●

DESCRIPTION

A District of Critical Planning Concern (DCPC) is a planning and regulatory tool available to a town or group of towns, which allows for the designation of a district for a defined purpose and to allow time, through a limited moratorium, to conduct planning studies and adopt regulations to address a specific problem. Districts of Critical Planning Concern are generally nominated by a town or several towns, although they may also be nominated by the Cape Cod Commission and by two bodies of Barnstable County regional government: the Barnstable County Commissioners (the executive branch) and the Barnstable County Assembly of Delegates (the legislative branch). The objective of a DCPC focused on freshwater ponds would be to protect ponds and the areas surrounding them through nominating these areas as a DCPC and creating implementing regulations to govern development in the designated area and promote best management practices.

ADVANTAGES

- A DCPC allows communities time to address a planning issue of concern during a finite “time-out” during which development may not proceed
- A DCPC allows for the application of regulations to a defined area based on a common resource concern or economic interest, and across towns
- The regulations adopted through a DCPC may eliminate some protections that would otherwise be afforded through zoning
- A DCPC allows for a comprehensive approach to regulatory changes, allowing for coordinated changes to zoning, Board of Health regulations, wetlands bylaws, etc.

CONSTRAINTS

- Requires a town(s) or Cape Cod Commission to nominate an area.
- Requires support from the local community and approval by the County Assembly of Delegates
- The moratorium can burden private property owners or projects about to start the permitting process
- It is an intensive planning process which requires advanced planning and ongoing coordination to result in regulations accepted and adopted at town meeting

Freshwater Ponds District of Critical Planning Concern (DCPC)

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** A town (or group of towns) proposes a DCPC
- **Pond Groups:** May support a DCPC and provide a supportive role through education
- **Private Landowners:** May support a DCPC
- **Land Trusts:** May support a DCPC and provide a supportive role through education

SITING REQUIREMENTS

- All ponds within an area, town, or region

INFORMATION NEEDS

- Pond and watershed delineations
- Pond buffers (e.g., 100', 300')
- Pond and pond buffer characterizations
- Characterization of pond resources and values
- Planning studies, public engagement

IMPLEMENTATION EXAMPLES

The *Three Ponds DCPC (Sandwich)* was designated in February 2000 to protect water quality, preserve open space, and maintain the character of nearly 700 acres of land and more than 300 acres of water in southeastern Sandwich.

Three Ponds area in Sandwich

The *Six Ponds DCPC (Harwich)* was designated in May 2000 to protect the water and natural resources and to manage growth over more than 1,200 acres of land and 110 acres of water in northeastern Harwich.

RESOURCES

- The Cape Cod Commission's *Districts of Critical Planning Concern* webpage has information on the DCPC process and designated DCPCs.

COST ESTIMATE

Variable

Variable depending on scope

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning and information gathering including researching and mapping DCPC characteristics

Implementation: Public process including presenting at meetings, developing and posting informational materials, and developing and implementing DCPC regulations

Maintenance: Information will need to be kept up-to-date and regulations enforced

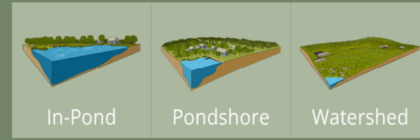
POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**

Additional information regarding potential funding sources is available *here*.

PLANNING AND REGULATION

Education & Outreach



STRATEGY SCALE

THREATS ADDRESSED: ✓ Excess Nutrients · ✓ Pollutant Inputs · ✓ Algal Blooms · ✓ Erosion · ✓ Invasive/Nuisance Species

STRATEGY GOALS	Protect	Manage	Rehabilitate
	✓	✓	✓

STRATEGY CO-BENEFITS	Habitat	Aesthetics	Recreation
	Neutral	Neutral	Neutral

- ✓ **Permittable in Massachusetts**
  List of potential permits available here.
- ✓ **Implemented on Cape Cod**
  See examples of pond projects implemented on Cape Cod here.
- ✗ **Listed in 208 Plan Technologies Matrix**
  Learn more about the nutrient management strategies in the Tech Matrix here.
- ✓ **Can be Performed at Homeowner Scale**
- ✓ **Nature-based Solution**

DURATION OF BENEFITS	Less than one month	One season or year	Multiple seasons or years
	○	○	●

MAINTENANCE REQUIREMENTS	Monthly	Annually	Infrequent
	○	○	●

DESCRIPTION

Education and outreach are used to engage with and teach the public about water quality, wastewater, stormwater, and land and pond use best management practices within ponds, lands surrounding ponds, town wide, and/or regionally. An educational outreach effort or campaign may consist of printed social media materials, and in-person or remote meetings, events, or trainings. Education and outreach make the public aware of pond problems and solutions and promotes best management practices in and around ponds.

ADVANTAGES

- Education can be tailored to a variety of age groups
- Education may inform action (best management practices), empowering people to make their own decisions
- Can be inexpensive

CONSTRAINTS

- Education is generally directed toward adults, but research suggests that long-lasting changes in behavior are best achieved by engaging youth through school or other activities as children can reach their parents with an educational message more effectively than agency professionals
- A campaign needs to have a strong objective and ask regarding what it's trying to achieve (more than just educating)
- Not enforceable
- Logistics of planning meetings/workshops and getting the public to attend can be challenging, as can developing and distributing educational materials
- Maintaining momentum can be challenging as each new homeowner, visitor needs to be educated

Education & Outreach

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** A town may develop an educational campaign focused on freshwater ponds
- **Pond Groups:** May develop or support an educational campaign
- **Private Landowners:** May develop or support an educational campaign
- **Land Trusts:** May develop or support an educational campaign

SITING REQUIREMENTS

- All ponds

INFORMATION NEEDS

- Survey of pond community concerns
- Review of existing resources from other towns and pond associations

IMPLEMENTATION EXAMPLES

The Orleans Pond Coalition created the *Orleans Blue Pages* to describe the Cape's water cycles and to provide practical information on how to do everyday tasks in a way that benefits Orleans waterbodies. The booklet includes tips on healthier practices and explanations of why some existing practices are harmful.

The Town of Eastham developed *Pond Fact Sheets* that provide information on the town's ponds, including physical and biological characteristics, water quality conditions, and recommended actions.

RESOURCES

- The Massachusetts Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.
- Other New England states have lake programs with educational components such as *Vermont's Lake Wise Program* and *Maine's Lake Smart Program*.

COST ESTIMATE

Variable

Variable depending on scope of education campaign

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning and information gathering regarding best management practices

Implementation: Public process including presenting at meetings, and developing and distributing informational materials

Maintenance: Information will need to be kept up-to-date

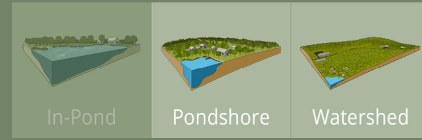
POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available ***here***.

PLANNING AND REGULATION

Land Protection

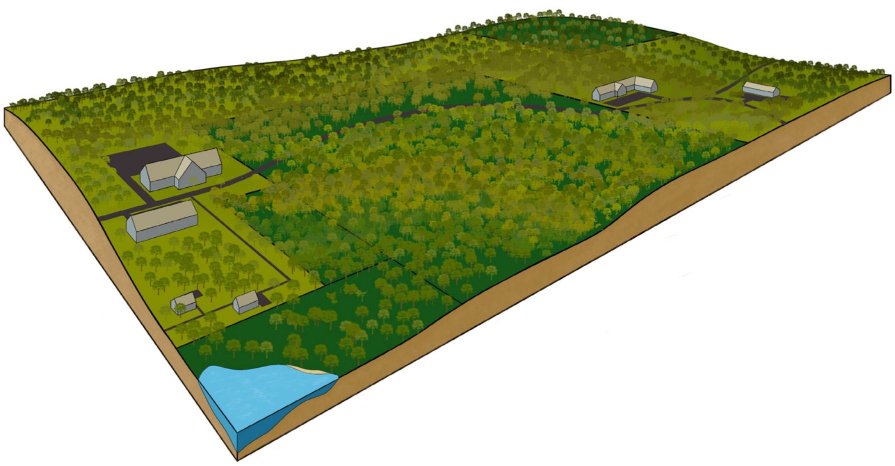


STRATEGY SCALE

THREATS ADDRESSED				
✓ Excess Nutrients	✓ Pollutant Inputs	✓ Algal Blooms	✓ Erosion	✓ Invasive/Nuisance Species

STRATEGY GOALS	Protect	Manage	Rehabilitate
	✓	✓	✓

STRATEGY CO-BENEFITS	Habitat	Aesthetics	Recreation
	✓ *Improve*	✓ *Improve*	✓ *Improve*



✓ **Permittable in Massachusetts**
Town meeting votes may be required for securing funding. List of potential permits available here.

✓ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod here.

✗ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✓ **Can be Performed at Homeowner Scale**
A homeowner could place a permanent Conservation Restriction on their land

✓ **Nature-based Solution**

DURATION OF BENEFITS	Less than one month	One season or year	Multiple seasons or years
	○	○	●

MAINTENANCE REQUIREMENTS	Monthly	Annually	Infrequent
	○	○	●

DESCRIPTION

Land protection involves a Town, land trust or private entity purchasing, donating or putting a restriction on land in order to limit or prevent development at that site to maintain open space and preserve the functions of the existing natural resources. Along with land protection, stewardship of protected land is important to maintain or restore natural habitats and resource functions. Land protection protects pond health and the land surrounding ponds through the permanent protection of land along the pond shore or within the pond watershed. Land protection also functions to prevent negative impacts of land use practices detrimental to pond health.

ADVANTAGES

- Land protection provides multiple benefits including wildlife and plant habitat protection, stormwater management, water filtration, nutrient uptake, and recreational benefits
- Land donation can provide a tax benefit to the private property owner
- Land protection prevents development within sensitive pond resource areas
- Benefits town-wide and regional land conservation efforts

CONSTRAINTS

- Fee simple acquisition of pond shore properties is expensive
- Need available land and landowners willing to place private land into conservation and forego development rights
- Legacy impacts and pollutants may reduce impact of land protection on water quality; therefore, land protection should be done in conjunction with other strategies where ponds are degraded

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** A town may protect land around ponds through purchase or transfer to Conservation Commission
- **Pond Groups:** May support land protection around ponds
- **Private Landowners:** May protect private lands around ponds or support land protection
- **Land Trusts:** May protect lands around ponds through purchase or Conservation Restriction

SITING REQUIREMENTS

- All ponds

INFORMATION NEEDS

- Land survey
- Natural resources / baseline inventory
- Property appraisal

IMPLEMENTATION EXAMPLES

The Compact of Cape Cod Conservation Trusts' undertook its *Priority Ponds Project* to provide local land trusts and municipalities with practical information regarding the current status and conservation values associated with the remaining undeveloped land surrounding Cape Cod's freshwater ponds and to support conservation of these lands.


The Six Ponds area in Harwich

The *Harwich Conservation Trust's Priority Ponds Project* provides landowners with land conservation options that help protect pond water quality and wildlife habitat. Building on that project, HCT purchased the 85-acre Six Ponds Great Woods property and launched the *Six Ponds Resource Management Initiative*.

RESOURCES

- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

Variable

Variable depending on size and value of land

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Property appraisal, natural resource/baseline inventory

Implementation: Acquisition costs vary with size and value of land

Maintenance: Monitoring and stewardship costs vary with size and condition of land

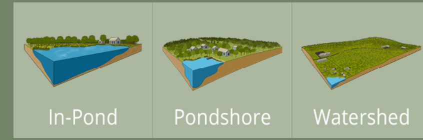
POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

PLANNING AND REGULATION

Comprehensive Wetland Restoration



STRATEGY SCALE

THREATS ADDRESSED

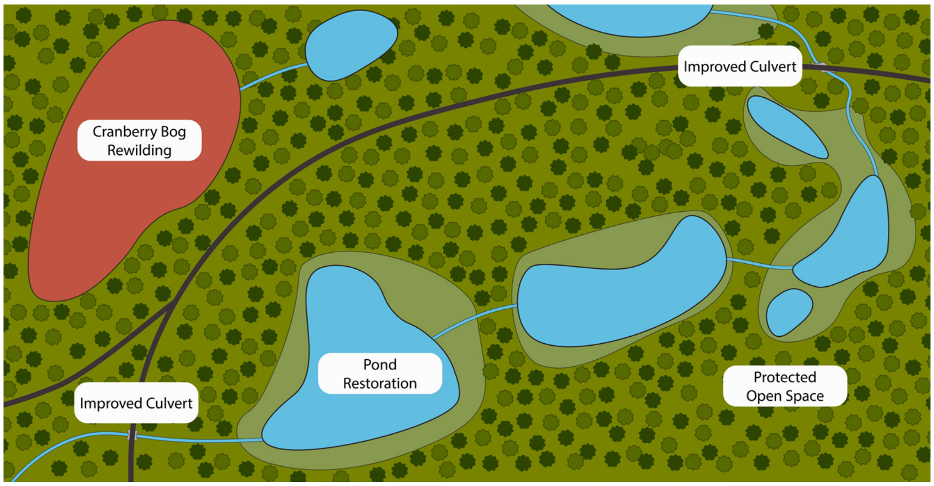
- ✓ Excess Nutrients
- ✓ Pollutant Inputs
- ✓ Algal Blooms
- ✓ Erosion
- ✓ Invasive/Nuisance Species

STRATEGY GOALS

Protect	Manage	Rehabilitate
✓	✓	✓

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
✓ *Improve*	✓ *Improve*	✓ *Improve*



✓ **Permittable in Massachusetts**
Local and state review. List of potential permits available here.

✓ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod here.

✗ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✗ **Can be Performed at Homeowner Scale**

✓ **Nature-based Solution**

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
○	○	●

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
○	○	●

DESCRIPTION

Comprehensive wetland restoration involves the rehabilitation of multiple waterbodies within a waterway or watershed to meet multiple objectives, including protecting water quality and quantity and restoring wetland functions. This method uses a holistic approach to plan and implement multiple wetland restoration projects within a waterway to maximize benefits. Comprehensive wetland restoration protects water quality and quantity through restoration of degraded wetlands and adjacent uplands to a more natural state and function. Planning for comprehensive wetland restoration may benefit from being considered during other town or watershed planning processes such as local comprehensive planning, open space and recreation planning, and watershed management planning.

ADVANTAGES

- Takes a holistic rather than one-off approach to water resource protection and rehabilitation
- Has multiple co-benefits, with potential to improve habitat, aesthetics, and recreational opportunities

CONSTRAINTS

- Need willing landowners
- Need community buy-in

Comprehensive Wetland Restoration

IMPLEMENTATION

POTENTIAL ACTORS

Towns: A town may propose or collaborate on comprehensive wetland restoration

Pond Groups: May support and collaborate

Private Landowners: May support and collaborate

Land Trusts: May propose, support and collaborate

SITING REQUIREMENTS

- All ponds

INFORMATION NEEDS

- Stakeholder engagement
- Locations of historical wetlands and their characteristics, if available
- Natural resources / baseline inventory
- Restoration plan(s)


Credit: Coonamessett River Trust

IMPLEMENTATION EXAMPLES

The *Coonamessett River Restoration Project* engaged numerous partners to restore health to the Coonamessett River and its bordering wetlands, including several freshwater ponds, in Falmouth. The project goals were to restore a healthy wetland ecosystem, increase climate resiliency, and enhance recreational and educational opportunities.

Several other river and cranberry bog restoration projects on and off the Cape will help restore health to connected ponds. These include the *Childs River Restoration Project* in Falmouth, the *Cold Brook Eco-Restoration Project* in Harwich, and the *Tidmarsh Farms Wetland Restoration Project* in Plymouth.

RESOURCES

- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

Variable

Variable depending on size and value of area to be restored

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Appraisals of properties, natural resource/ baseline inventory, outreach with landowners/stakeholders

Implementation: Acquisition costs vary with size and value of land, legal fees. Restoration costs vary with project scope.

Maintenance: Monitoring and stewardship costs vary with size and condition of land

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

NUTRIENT MANAGEMENT

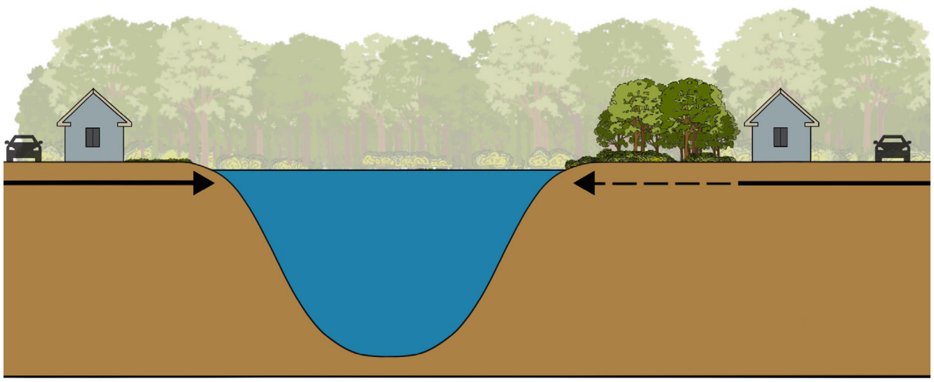
Pond Shore Buffer Plantings

STRATEGY SCALE

THREATS ADDRESSED: ✓ Excess Nutrients · ✓ Pollutant Inputs · ✓ Algal Blooms · ✓ Erosion · ✓ Invasive/Nuisance Species

STRATEGY GOALS: Protect ✓ · Manage ✓ · Rehabilitate ✓

STRATEGY CO-BENEFITS: Habitat ✓ *Improve* · Aesthetics ✓ *Improve* · Recreation ✓ *Improve*



✓ **Permittable in Massachusetts**
Local review through the Conservation Commission may be required. List of potential permits available here.

✓ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod here.

✗ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✓ **Can be Performed at Homeowner Scale**
Local review and permitting may be required.

✓ **Nature-based Solution**

DURATION OF BENEFITS: Less than one month ○ · One season or year ○ · Multiple seasons or years ●

MAINTENANCE REQUIREMENTS: Monthly ○ · Annually ○ · Infrequent ●

DESCRIPTION

Pond shore buffer planting involves the planting of native, beneficial plants within a buffer area along a pond shoreline or within the pond littoral (nearshore) zone. It may include enhancing existing pond shore plantings or replacing lawn, invasive species, and impervious surfaces within a certain distance (e.g., 100’-300’) of the pond with native plants suitable for the pond shore environment. In a pond, vegetation may be planted to enhance existing in-pond vegetation or to establish plants in a pond where there are none. Through pond shore buffer planting, plant roots and associated soils prevent erosion, intercept sediments, absorb stormwater, nutrients and other pollutants and prevent these from entering and degrading ponds. The roots and associated soils of in-pond vegetation will absorb pollutants and nutrients to help reduce excess levels of algae.

ADVANTAGES

- Simple to implement
- Low-maintenance if native plants used, “right plant, right place” principle followed, and once plants are established
- Enhances pond shore aesthetics and habitat value
- Depending on scale, may provide recreational opportunities, such as walking trails through restored areas or through enhanced fishing opportunities with in-pond vegetation planting

CONSTRAINTS

- Need to source or grow appropriate plants - experience/expertise with aquatic plant propagation may be less available than for terrestrial plants
- Up-front costs to purchase and install plants
- Plants require monitoring and maintenance
- Competition among plants will affect results, so expectations need to be managed and the choice of appropriate plants is important
- Invasive or aggressive species may need to be monitored and controlled to ensure success of desirable native species

Pond Shore Buffer Plantings

CAPE COD COMMISSION

IMPLEMENTATION

POTENTIAL ACTORS

Towns: Towns may protect or plant vegetated buffers on town-managed shorelines

Pond Groups: May collaborate on pond shore buffer plantings and provide a supportive role through education

Private Landowners: Installing and maintaining vegetated buffers is something the private homeowner can do to protect ponds

Land Trusts: Land trusts with pond shore properties can protect or install, and maintain vegetated buffers and provide a supportive role through education

SITING REQUIREMENTS

- All ponds, especially those with developed or altered pond shores
- Ponds with inadequate vegetation to support desired aquatic community
- Ponds where invasive species have been minimized but recolonization potential is high

INFORMATION NEEDS

- Shoreline and/or aquatic vegetation survey
- Landscape/restoration plan

Credit: Alison Leschen

IMPLEMENTATION EXAMPLES

A homeowner on Nyes Pond in Falmouth installed a pond shore buffer of native trees, shrubs and perennials. The project required an Order of Conditions from the local Conservation Commission. After the plants were established, the homeowner reported a noticeable increase in bird and insect activity.

RESOURCES

- The Cape Cod Commission and partners developed the *Cape Cod Freshwater Pond Buffer Guidance* to help homeowners and municipalities preserve and protect ponds through responsible landscape management.
- Other agencies and states also have buffer guidance including the *Massachusetts Buffer Manual*, *Maine's Buffer Handbook*, Vermont's *Guide to Healthy Lakes Using Lakeshore Landscaping*, and the Southeast New England Program's *Buffer Restoration Guide*.
- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

$$$$

Relative to other in-pond strategies

Variable depending on extent of planting area, sourcing of desired vegetation, planting method, monitoring level, and labor

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting (if applicable)

Implementation: Plants, equipment and installation

Maintenance: Monitoring plants, landscape maintenance, and replacement plants, as needed

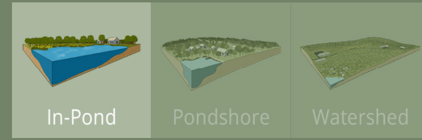
POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

NUTRIENT MANAGEMENT

Floating Wetlands



STRATEGY SCALE

THREATS ADDRESSED

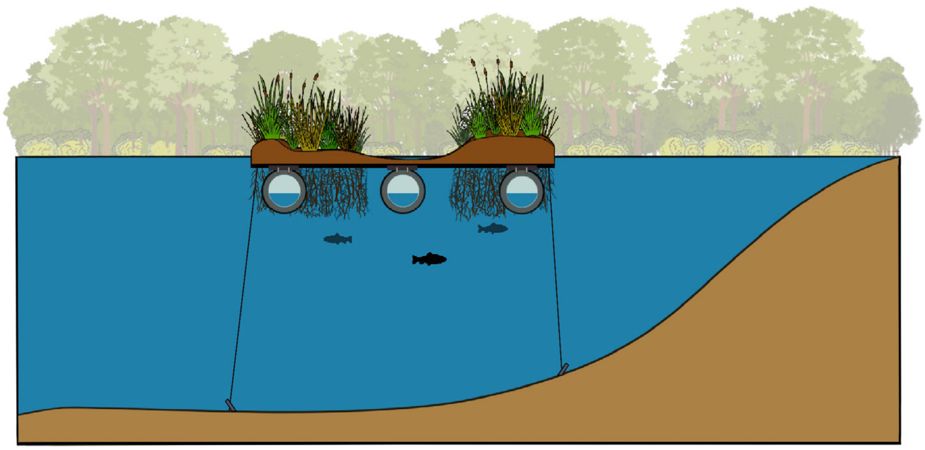
- ✓ Excess Nutrients
- ✓ Pollutant Inputs
- ✓ Algal Blooms
- ✗ Erosion
- ✓ Invasive/Nuisance Species

STRATEGY GOALS

Protect	Manage	Rehabilitate
○	✓	✓

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
✓ *Improve*	✓ *Improve*	✓ *Improve*



Permittable in Massachusetts (–)
Pilot. Local review through the Conservation Commission required. List of potential permits available here.

Implemented on Cape Cod (✓)
See examples of pond projects implemented on Cape Cod here.

Listed in 208 Plan Technologies Matrix (✓)
Learn more about the nutrient management strategies in the Tech Matrix here.

Can be Performed at Homeowner Scale (✓)
Local review and permitting may be required.

Nature-based Solution (✓)

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
○	○	●

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
○	○	●

DESCRIPTION

A floating wetland is a human-made island that provides a surface for plants to grow, allowing their roots to grow into the water. Floating wetland installations have the potential to address eutrophic issues with “top-down” control, meaning the aquatic life higher up on the food chain helps rebalance populations of lower forms. Floating wetland plants grow hydroponically, with the roots of the plants suspended in the water body. Nutrients required for plant growth are absorbed from the water column. Harvesting that vegetation annually is a potential means of removing nutrient pollution, notably phosphorus, from that ecosystem. A floating wetland increases habitat for algae-eating zooplankton populations and increases nutrient-absorbing plants, roots and microbes to help reduce excess levels of algae.

ADVANTAGES

- Enhances habitat for a variety of aquatic species
- In addition to nutrients, may also remove other pollutants such as metals
- Harvested material can be composted offsite and then used as a beneficial soil amendment

CONSTRAINTS

- Maintenance is essential for longer term benefits and long-term management of materials needs to be considered
- May require large coverage area and public may not welcome it in the pond
- May affect hydrology negatively
- Pilot status adds complexity to permitting process

Floating Wetlands

CAPE COD COMMISSION

IMPLEMENTATION

POTENTIAL ACTORS

Towns: Towns may propose to install floating wetlands in town-managed ponds

Pond Groups: May collaborate on floating wetland installation and provide a supportive role through education

Private Landowners: Installing and maintaining a floating wetland is something the private homeowner can do in some cases (i.e., small, private ponds)

Land Trusts: Land trusts with pond properties may install floating wetlands in their ponds and provide a supportive role through education

SITING REQUIREMENTS

- Most efficient in smaller, shallower ponds, but not too shallow to prevent platform plants from rooting into lake bottom sediment (>5′)
- Ponds where water quality can be improved and surface coverage is not a problem
- Ponds with inadequate plant habitat to support desired biota

INFORMATION NEEDS

- Nutrient profiles
- Pond depth and residence time
- Understanding the concentration range of specific pollutants within a system is essential to designing floating wetlands and assessing their potential to successfully improve the water quality of a given pond

IMPLEMENTATION EXAMPLES

- The Town of Barnstable is *piloting a floating wetland project in Long Pond, Marstons Mills* to grow native plants and let the submerged roots remove phosphorus from the water to help prevent algae blooms.
- The *Charles River Floating Wetland* explores an ecological intervention to reduce harmful algal blooms in the Charles, which threaten the river's health and limit the feasibility of swimming.
- A *floating wetland was installed in Polo Lake in Rhode Island* to raise awareness about the importance of wetlands and help improve water quality by cultivating biodiversity and regenerating the food web.
- Floating wetlands have been *installed in waterbodies around the country and the world* to address toxic legacies and support aquatic life.

RESOURCES

- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

**$$**$$

Relative to other in-pond strategies

Variable depending on extent of treatment area, sourcing of desired vegetation, planting method, monitoring level, and labor

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting will be more expensive than pond shore or in-pond planting due to additional studies and permitting

Implementation: Plants, materials, equipment, and installation

Maintenance: Monitoring, maintenance, and replacement plants, as needed

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

NUTRIENT MANAGEMENT

Freshwater Aquaculture

STRATEGY SCALE

THREATS ADDRESSED

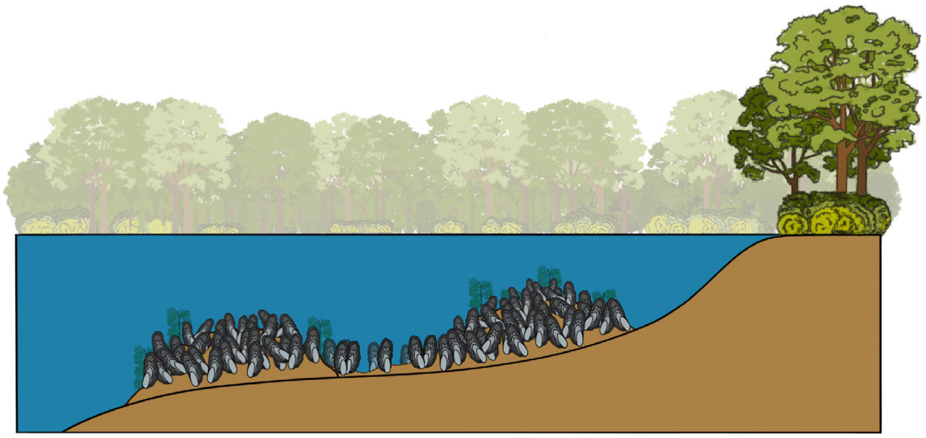
- ✓ Excess Nutrients
- ✓ Pollutant Inputs
- ✓ Algal Blooms
- ✗ Erosion
- ✗ Invasive/Nuisance Species

STRATEGY GOALS

Protect	Manage	Rehabilitate
○	●	●

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
✓ *Improve*	✓ *Improve*	✓ *Improve*



- ✓ **Permittable in Massachusetts**
  Local review through the Conservation Commission required. List of potential permits available here.
- ✗ **Implemented on Cape Cod**
  See examples of pond projects implemented on Cape Cod here.
- ✓ **Listed in 208 Plan Technologies Matrix**
  Learn more about the nutrient management strategies in the Tech Matrix here.
- ✗ **Can be Performed at Homeowner Scale**
- ✓ **Nature-based Solution**

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
○	○	●

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
○	○	●

DESCRIPTION

Freshwater aquaculture involves the reintroduction or enhancement of native freshwater mussel populations in ponds. Mussels serve as filter feeders, cleaning the water by removing small particles and potential contaminants, and consuming algae. Mussels can be raised in freshwater bodies to provide ecological remediation. The growing of mature mussels can sequester nutrients, while removing/harvesting mature mussels can remove nutrients from ponds. While aquaculture of shellfish (e.g., oysters) in marine environments is common and its nutrient management potential is documented, it is not common and benefits are not as well understood in fresh waterbodies. Freshwater mussels have a unique life cycle - mussel larvae (babies) undergo a metamorphosis as parasites on fish hosts. Some mussel species are “host specialists” using only one to a few fish hosts, while others are “generalists” and use many different fish species as hosts. To sustain a freshwater mussel population, suitable fish hosts must be present.

ADVANTAGES

- Restores / enhances native populations of freshwater mussels
- Mussels filter water, improving water clarity
- Increases pond biodiversity

CONSTRAINTS

- Benefits, environmental impacts, and unintended consequences uncertain
- Untested in freshwater ponds in Massachusetts, therefore permitting difficulties expected
- Of the 12 freshwater mussel species in Massachusetts, 6 are protected under the Massachusetts Endangered Species Act, presenting permitting challenges
- Studies have shown mussels’ positive impact on stream habitats, but less research in ponds and lakes
- Sourcing of mussels and ensuring fish hosts presence present challenges

Freshwater Aquaculture

CAPE COD COMMISSION

IMPLEMENTATION

POTENTIAL ACTORS

Towns: Towns may investigate freshwater aquaculture in town-managed ponds

Pond Groups: May collaborate on freshwater aquaculture and provide a supportive role through education

Private Landowners: May collaborate on freshwater aquaculture

Land Trusts: Land trusts may collaborate on freshwater aquaculture and provide a supportive role through education

SITING REQUIREMENTS

- Ponds that have, or have historically had, freshwater mussels
- Ponds with suitable habitat and fish host species for freshwater mussels

INFORMATION NEEDS

- Mussel and fish surveys
- Mussel habitat assessment

IMPLEMENTATION EXAMPLES

New restoration efforts in the Chesapeake Bay are boosting freshwater mussels for their ecosystem benefits.

In *Lake Trafford, Florida*, the Florida Fish and Wildlife Conservation Commission and partners are experimenting with introducing freshwater mussels as natural filtration systems to improve the lake's water quality, benefiting hundreds of species in the area.


Freshwater mussels

The *Indian Ponds Association*, Barnstable is considering the merits and potential of repopulating several of the mussel species that lived in Association ponds prior to 2009 when the ponds experienced a major mussel die-off.

RESOURCES

- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.
- Learn more about the freshwater mussels of Massachusetts *here*.

COST ESTIMATE

Variable

Expected to be variable depending on scope of project

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting

Implementation: Mussels, materials, equipment and logistics

Maintenance: Monitoring, maintenance, replacement mussels, as needed, and mussel harvest considerations

POTENTIAL FUNDING SOURCES

- Community Preservation Act
- Capital Budget
- Grants
- Private Funding

Additional information regarding potential funding sources is available *here*.

Hydraulic Control

STRATEGY SCALE

THREATS ADDRESSED

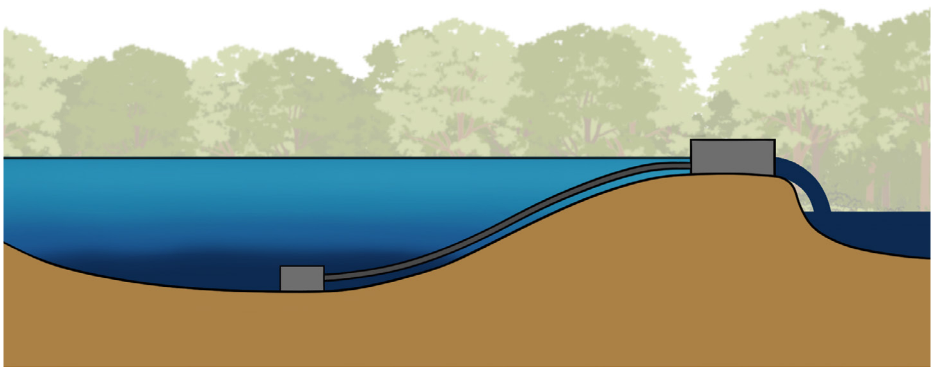
Excess Nutrients	✓
Pollutant Inputs	✓
Algal Blooms	✓
Erosion	✗
Invasive/Nuisance Species	✗

STRATEGY GOALS

Protect	Manage	Rehabilitate
○	✓	✓

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
Neutral	Neutral	Neutral



- ✓ **Permittable in Massachusetts**
  Local review through the Conservation Commission required. List of potential permits available here.
- ✗ **Implemented on Cape Cod**
  See examples of pond projects implemented on Cape Cod here.
- ✗ **Listed in 208 Plan Technologies Matrix**
  Learn more about the nutrient management strategies in the Tech Matrix here.
- ✓ **Can be Performed at Homeowner Scale**
  In small, private ponds. Local review and permitting may be required.
- ✗ **Nature-based Solution**

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
○	●	○

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
○	●	○

DESCRIPTION

Hydraulic control involves adding and/or withdrawing water from a pond to dilute or flush nutrients and reduce loading of phosphorus. Pond hydrology and residence time can be manipulated through diversion of a nutrient-rich inflow, adding low nutrient water to dilute nutrient concentrations, or flushing of nutrient-rich water from a pond. Through hydraulic control, the concentration of nutrients (typically phosphorus) within a pond is lowered by decreasing the load of nutrients entering (diversion) or present (withdrawal) in the pond, or by adding sufficient volumes of nutrient-poor water (dilution) from an external source. In an ideal scenario, a small amount of water containing a large amount of nutrients is diverted.

ADVANTAGES

- Can be an effective means of reducing nutrient inputs to lakes with the right characteristics
- May help improve low dissolved oxygen levels
- Withdrawn nutrient rich waters may be usable as irrigation water – subject to other water chemistry considerations (e.g. hydrogen sulfide)

CONSTRAINTS

- Requires a substantial external water source and/or means for water level control which are rare on Cape Cod
- Kettle ponds not good candidates based on hydrology
- Where it has been used, phosphorus levels have dropped, but still support algal blooms
- Sends contaminated water elsewhere without addressing the source of nutrients
- Dilution / flushing water may introduce undesirable taxa

Hydraulic Control

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** Towns may propose hydraulic control in town-managed ponds
- **Pond Groups:** May propose hydraulic control in public or private ponds and provide a supportive role through education
- **Private Landowners:** May propose hydraulic control in private ponds
- **Land Trusts:** Land trusts may provide a supportive role through education

SITING REQUIREMENTS

- For dilution and flushing, ponds with surface water inflows and outflows where the nutrient load is undesirable and the loss of the hydrologic load will not have undue negative impacts
- For selective withrdrawal, deeper, stratified ponds with considerable internal loading of phosphorus in pond bottom sediments and anoxic conditions
- Ponds with water level control
- Ponds with short residence time (2-5 years)

INFORMATION NEEDS

- Nutrient load analysis
- Pond depth and residence time
- Detailed hydrologic budget
- Fishery assessment

IMPLEMENTATION EXAMPLES

A well-known example of dilution is the *Clean Lakes Project* at Moses Lake in Washington State. Low-phosphorus water from the Columbia River was introduced to Moses Lake over time through existing infrastructure. The addition of water with very low phosphorus has diluted phosphorus in the lake. The lake's quality improved over the course of the Clean Lakes Project from being hypereutrophic to eutrophic through the 1980s to near-mesotrophic through the 2000s.

RESOURCES

- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

$$-$$$$

Relative to other in-pond strategies

Varies with technique, volume and availability of water, distance for transport, and water treatment (if needed)

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Hydrological, nutrient and fisheries studies; planning, design, and permitting

Implementation: Materials (pipes and pumps), equipment and installation

Maintenance: Monitoring and maintenance of materials and equipment

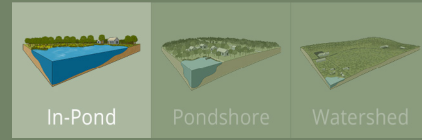
POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

NUTRIENT MANAGEMENT

Circulation



STRATEGY SCALE

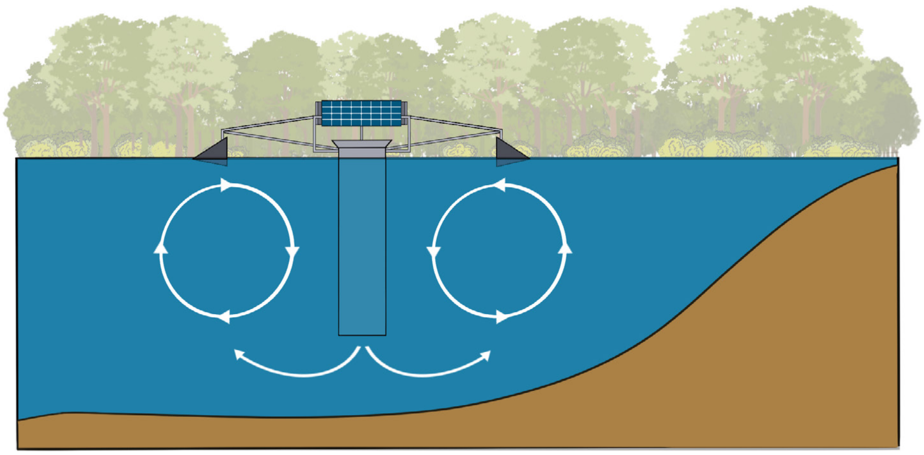
THREATS ADDRESSED		
Excess Nutrients	✓	
Pollutant Inputs	✗	
Algal Blooms	✓	
Erosion	✗	
Invasive/Nuisance Species	✗	

STRATEGY GOALS

- Protect: ○
- Manage: ✓
- Rehabilitate: ✓

STRATEGY CO-BENEFITS

- Habitat: *Neutral*
- Aesthetics: *Neutral*
- Recreation: *Neutral*



✓ **Permittable in Massachusetts**
Local review through the Conservation Commission required. List of potential permits available here.

✓ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod here.

✓ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✓ **Can be Performed at Homeowner Scale**
In small, private ponds. Local review and permitting may be required.

✗ **Nature-based Solution**

DURATION OF BENEFITS

- Less than one month: ●
- One season or year: ○
- Multiple seasons or years: ○

MAINTENANCE REQUIREMENTS

- Monthly: ●
- Annually: ○
- Infrequent: ○

DESCRIPTION

Circulation describes any process that initiates or enhances the horizontal and vertical movement of pond water. The objective of circulation is to mix water to break up or prevent stratification, delivering oxygen-rich surface water to deeper oxygen-poor waters. Circulation can also induce turbulence which may reduce risk of algal blooms. Methods of circulation include mechanical, using solar or electric powered circulators, or air-driven which includes bubblers or pneumatic circulators, to extend the depth or duration of water circulation. Specific circulation may be used to meet different objectives, including impellers that circulate water both vertically (updraft) and laterally; pumps to force water downward to break up stratification; and surface water fountains to draw the water from the pond bottom and spray water over the water body to promote mixing and oxygen exchange with the atmosphere. The type of aeration should be specific to the characteristics of the pond.

ADVANTAGES

- May promote conditions less favorable to cyanobacteria blooms
- May prevent internal phosphorus release and reduce nuisance algae
- Few negative impacts expected to non-target species
- May enhance fish habitat through improving dissolved oxygen levels
- May work to destratify systems
- Duration of benefits extended with ongoing operations and maintenance
- Effective when properly sized, distributed and operated

CONSTRAINTS

- Reliance on systems in constant operation creates potential for failure during unplanned system outages
- For some methods (e.g., surface spray systems including fountains), the benefits are very limited
- Some methods may bring poor water quality from the bottom to the surface
- May increase turbidity and decrease water clarity
- Highly sensitive to sizing, sediment composition, external nutrient loads
- When misapplied or lacking adequate diagnostics, engineering, or power, artificial circulation is neither reliable nor applicable and can sometimes do harm

Circulation

IMPLEMENTATION

POTENTIAL ACTORS

Towns: Towns may propose circulation in town-managed ponds

Pond Groups: May propose circulation in public or private ponds and provide a supportive role through education

Private Landowners: May propose circulation in private ponds

Land Trusts: Land trusts may provide a supportive role through education

SITING REQUIREMENTS

- Ponds with limited stratification or where preventing/breaking stratification has limited potential for adverse impacts
- Scalable, most suited for small ponds
- Updraft pumps most applicable for ponds that stratify seasonally
- Surface fountains are best for small, shallow ponds

INFORMATION NEEDS

- Water quality profiles (temp, DO, nutrients)
- Volume of water that must be moved weekly
- Oxygen demand
- Thermal structure
- Need enough power to overcome thermal gradient

IMPLEMENTATION EXAMPLES

- Several circulation projects have been implemented on Cape Cod as identified in the *Pond Restoration Projects Viewer*. A compressed air diffuser/diffused air circulator was deployed in Lovells Pond, Barnstable, and updraft pumps have been deployed in Skinequit and Flax Ponds, Harwich, Santuit Pond, Mashpee, Schoolhouse Pond, Barnstable, and Stillwater Pond, Chatham.
- There are many small pond surface spray (i.e., fountain) applications in MA. Layer aeration systems have been installed in CT and NJ (e.g., *Lake Waramaug, CT*). Downdraft pumps are generally not used in the U.S., but have seen more use in other parts of the world (e.g., Australia).

RESOURCES

- For more information on aeration and oxygenation techniques, see the *Spring 2015 Lakeline article "Aeration and Oxygenation Methods for Stratified Lakes and Reservoirs"*
- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

$$$$

Relative to other in-pond strategies

For all aeration/circulation strategies, costs vary substantially by pond volume and technology

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, permitting, including required studies (e.g., water quality and oxygen studies)

Implementation: Equipment (pumps, pipes, diffusers), and installation

Maintenance: Annual operating and maintenance including power costs and real time data collection, if applicable

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

NUTRIENT MANAGEMENT

Oxygenation

In-Pond | Pondshore | Watershed

STRATEGY SCALE

THREATS ADDRESSED

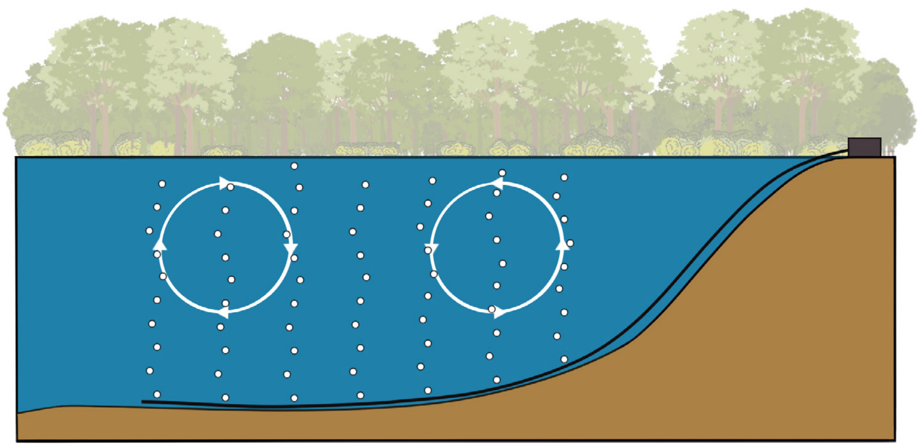
Excess Nutrients	✓
Pollutant Inputs	✗
Algal Blooms	✓
Erosion	✗
Invasive/Nuisance Species	✗

STRATEGY GOALS

Protect	Manage	Rehabilitate
○	●	●

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
Neutral	Neutral	Neutral



✓ **Permittable in Massachusetts**
Local review through the Conservation Commission required. List of potential permits available here.

✓ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod here.

✓ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✓ **Can be Performed at Homeowner Scale**
In small, private ponds. Local review and permitting may be required.

✗ **Nature-based Solution**

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
●	○	○

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
●	○	○

DESCRIPTION

Oxygenation describes any process that adds concentrated oxygen to target waters. Oxygenation is intended to increase oxygen levels thereby avoiding anoxia and reducing conditions, providing deep water habitat with sufficient oxygen. Oxygenation is a subset of aeration that delivers a gas stream with high oxygen concentration to pond water, improving aquatic habitat conditions and limiting internal phosphorus recycling. There are various methods of transferring oxygen gas into a water body including: sub surface; bottom up; submersed; hypolimnion aeration; and bottom diffused aeration. Generally oxygen is pumped into the pond from delivery equipment located on the bottom of the pond to promote exchange of oxygen from air bubbles to the surrounding water. By using concentrated oxygen, less air volume must be delivered which can maintain natural stratification. The details of an oxygenation system should be designed specific to the characteristics of the pond.

ADVANTAGES

- May promote conditions less favorable to cyanobacteria blooms
- May prevent internal phosphorus release and reduce nuisance algae
- Few negative impacts expected to non-target species
- Duration of benefits extended with ongoing operations and maintenance
- Creates an aerobic environment for fish and other aquatic biota through improving dissolved oxygen levels

CONSTRAINTS

- System must be sized appropriately to accommodate volume of water being managed
- Reliance on systems in constant operation creates potential for failure during unplanned system outages
- Less cost effective than other treatments for phosphorus control, such as alum
- Best to provide more than enough oxygen - target > 5 mg/L (more like 10, 15, or 20 mg/L) - to handle potential shutdown periods
- Biggest challenge is induced oxygen demand, created by movement of water in contact with sediment, which increases the rate of oxygen consumption - action taken to satisfy oxygen demand causes increased demand
- Likely requires winterization
- Compressor often needs to be sited within the pond buffer and makes some noise

IMPLEMENTATION

POTENTIAL ACTORS

Towns: Towns may propose oxygenation in town-managed ponds

Pond Groups: May propose oxygenation in public or private ponds and provide a supportive role through education

Private Landowners: May propose oxygenation in private ponds

Land Trusts: Land trusts may provide a supportive role through education

SITING REQUIREMENTS

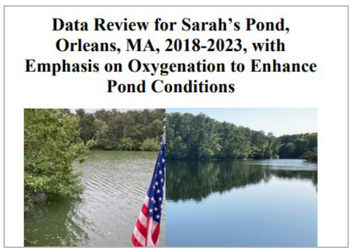
- Ponds with internal phosphorus loading and where enough natural phosphorus binders (e.g. iron and manganese) are present
- Most effective for deep lakes with anoxic bottom waters that experience sustained nutrient and sediment loading
- Onshore site for compressor, hoses, distribution system

INFORMATION NEEDS

- Watershed size, land use, waterbody size and depth, stratification, and lake trophic type need to be understood prior to assessing whether aeration is an appropriate tool or what type of aeration system design may be suitable to meet a particular management goal
- Water quality profiles (temp, DO, nutrients)
- Sediment oxygen demand
- Thermal structure
- Sediment composition

IMPLEMENTATION EXAMPLES

The Orleans Pond Coalition chose Sarah's Pond to test an *oxygen saturation technology system* as a preventive means for controlling nutrients and problem algae.


Data Review for Sarah's Pond, Orleans, MA, 2018-2023, with Emphasis on Oxygenation to Enhance Pond Conditions

RESOURCES

- For more information on aeration and oxygenation techniques, see the *Spring 2015 Lakeline article "Aeration and Oxygenation Methods for Stratified Lakes and Reservoirs"*
- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

$$$$

Relative to other in-pond strategies

For all aeration/circulation strategies, costs vary substantially by pond volume and technology, as well as oxygen demand

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, permitting, including required studies (e.g., water quality and oxygen studies)

Implementation: Equipment (pumps, pipes, compressor), and installation

Maintenance: Annual operating and maintenance including power and oxygen supplies, and real time data collection, if applicable

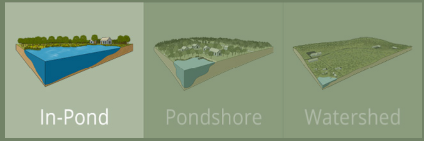
POTENTIAL FUNDING SOURCES

- Community Preservation Act
- Capital Budget
- Grants
- Private Funding

Additional information regarding potential funding sources is available *here*.

NUTRIENT MANAGEMENT

Nutrient Inactivation



STRATEGY SCALE

THREATS ADDRESSED

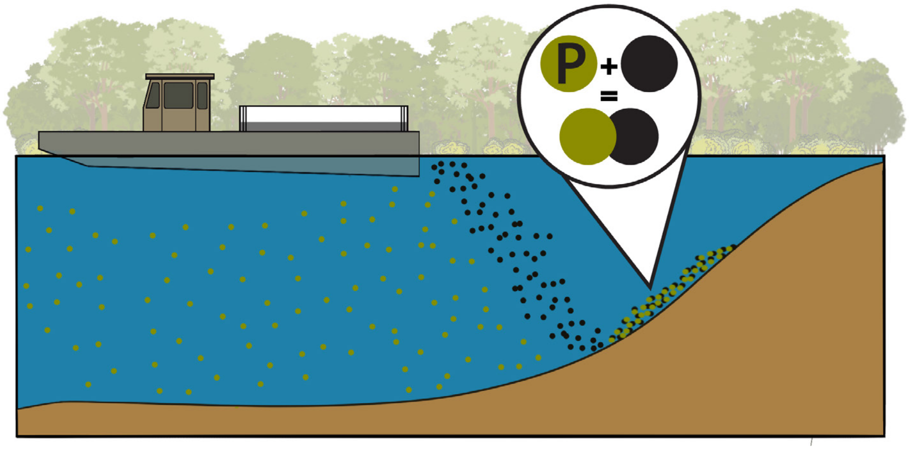
- ✓ Excess Nutrients
- ✗ Pollutant Inputs
- ✓ Algal Blooms
- ✗ Erosion
- ✗ Invasive/Nuisance Species

STRATEGY GOALS

Protect	Manage	Rehabilitate
○	●	●

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
⊖ *Neutral*	⊖ *Neutral*	⊖ *Neutral*



- ✓ **Permittable in Massachusetts**
  Local review through the Conservation Commission required. List of potential permits available here.
- ✓ **Implemented on Cape Cod**
  See examples of pond projects implemented on Cape Cod here.
- ✗ **Listed in 208 Plan Technologies Matrix**
  Learn more about the nutrient management strategies in the Tech Matrix here.
- ✓ **Can be Performed at Homeowner Scale**
  In small, private ponds. Local review and permitting may be required.
- ✗ **Nature-based Solution**

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
○	○	●

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
○	○	●

DESCRIPTION

Nutrient inactivation involves the use of phosphorus-complexing compounds, especially aluminum sulfate (alum), to mitigate excess phosphorus in ponds by converting mobile forms of sediment phosphorus into more stable/inactive forms. There are several different approaches to phosphorus inactivation. Water column phosphorus stripping uses a low dose of alum to strip an active algae bloom and phosphorus in the water column; maintenance is a seasonal low dose treatment on a recurring basis to remove phosphorus; sediment dosing is a high dose treatment targeted at reducing release of phosphorus from the sediment; and dosing stations are alum injections targeted at reducing an influx of phosphorus from a known surface source. These actions reduce phosphorus concentrations in the water or sediment and often result in decreased algae levels and increased water clarity. Other materials such as polyacrylamide, forms of iron, bentonite, clay powder and modified clays (e.g. Phoslock) may also be used to bind with and inactivate phosphorus. Inactivation of other nutrients (e.g., nitrogen) is not as well studied.

ADVANTAGES

- Provides rapid removal or inactivation of available phosphorus from the water column or sediment
- Good for lakes with low or no external phosphorus load and high internal phosphorus load (release from sediment) and high natural alkalinity to provide pH buffering
- Relative low cost per unit phosphorus (as low as a few hundred dollars per kg phosphorus removed)
- Addresses typical cause of cyanobacteria dominance (excess phosphorus)
- Works quickly and can be effective for extended periods of time (months for low dose and years for high dose)

CONSTRAINTS

- Need to know the source or reservoir of phosphorus
- Reapplication interval will depend on dose, whether target is sediment or water column phosphorus, and level of external loading of phosphorus
- Limited duration of effect if external loading is significant - benefits may be short-lived if external nutrient sources are not “turned off”
- Potential for elevated aluminum levels and low pH which may adversely impact aquatic life if proper dosing/buffering not used
- The toxic effects of dissolved aluminum on non-algal, aquatic organisms and humans are not well documented
- If not well-designed or monitored, may result in non-target species impacts (typically at higher doses)
- Time of year issues may need to be considered (e.g., if herring present)

Nutrient Inactivation

CAPE COD COMMISSION

IMPLEMENTATION

POTENTIAL ACTORS

Towns: Towns may propose nutrient inactivation in town-managed ponds

Pond Groups: May propose nutrient inactivation in public or private ponds and provide a supportive role through education

Private Landowners: May propose nutrient inactivation in private ponds

Land Trusts: Land trusts may provide a supportive role through education

SITING REQUIREMENTS

- Most effective for deeper ponds with high internal versus external phosphorus loading
- Deeper ponds with stable thermal stratification
- Used primarily on lakes with significant internal nutrient loading and where the external nutrient loads have been reduced as much as possible
- Poorly buffered lakes may not be good candidates for alum addition
- Access/launch site for dosing vessel and an area for chemical storage accessible for tanker truck deliveries

INFORMATION NEEDS

- Nutrient (total phosphorus) loading, pH and alkalinity analyses
- Dosing study and sediment coring to account for site constraints and determine appropriate dosing/buffering to minimize impacts to aquatic life
- Survey of potentially sensitive populations

IMPLEMENTATION EXAMPLES

Multiple nutrient inactivation projects have been implemented on Cape Cod as identified in the *Pond Restoration Projects Viewer* and as reviewed in *"Aluminum treatments to control internal phosphorus loading in lakes on Cape Cod, Massachusetts."*

- Cape ponds treated include: Great Pond and Herring Pond, Eastham; Cliff Pond and Upper Mill Pond, Brewster; Uncle Harvey's Pond, Orleans; Lovers Lake and Stillwater Pond, Chatham; Hinckleys and Skinequit Pond, Harwich; Long Pond, Brewster/Harwich; Hamblin, Mystic, Lovells, and Shubael Ponds, Barnstable; Ashumet Pond, Mashpee/Falmouth.

RESOURCES

- For more information on the use of aluminum treatment to control phosphorus in lakes and ponds, see the *North American Lake Management Society's Alum Position Statement*
- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

$$$$

Relative to other in-pond strategies

Varies by dose, treatment area, and price of products used

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting, including required studies (e.g., dosing studies)

Implementation: Equipment and supplies

Maintenance: Monitoring, reapplication, as needed

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

NUTRIENT MANAGEMENT

Biochar

STRATEGY SCALE

THREATS ADDRESSED

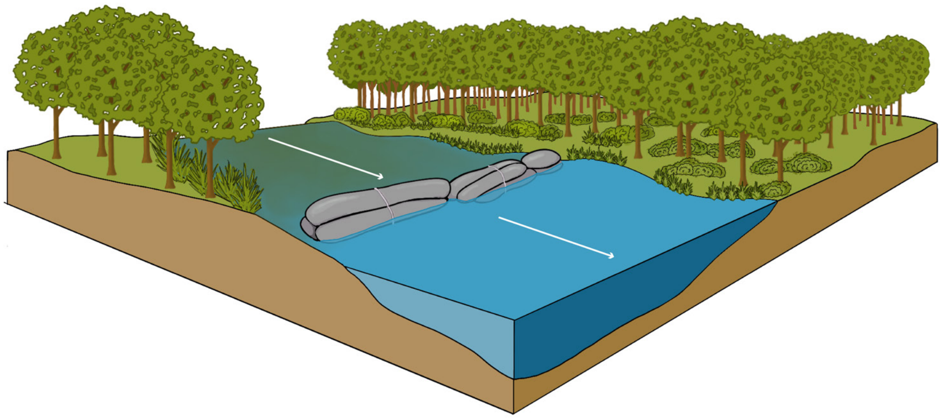
- ✓ Excess Nutrients
- ✓ Pollutant Inputs
- ✓ Algal Blooms
- ✗ Erosion
- ✗ Invasive/Nuisance Species

STRATEGY GOALS

Protect	Manage	Rehabilitate
○	○	●

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
⊖ Neutral	⊖ Neutral	⊖ Neutral



✓ **Permittable in Massachusetts**
Local review through the Conservation Commission required. List of potential permits available here.

✗ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod here.

✗ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✓ **Can be Performed at Homeowner Scale**
In small, private ponds. Local review and permitting may be required.

✓ **Nature-based Solution**

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
●	○	○

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
○	●	○

DESCRIPTION

Biochar, a carbon-rich material made from the partial combustion of biomass wastes, is an emerging material of interest as it can remediate pollutants and could be used to remove nutrients and other contaminants from ponds. Similar to activated charcoal, biochar has adsorbent properties that allow it to remove impurities from water. To make biochar, wood products are processed in a high heat, low oxygen environment to create highly porous carbon-rich properties with high affinity to absorb contaminants and nutrients. In a pond setting, biochar is placed inside permeable socks or bags which can be suspended in the water column or installed in racks or structures where water is most likely to flow through or pass over them. The biochar particles can attract and trap nutrients, metals, and other pollutants. The socks or bags need to be removed from the water and the biochar disposed of or repurposed to fully remove the pollutants. Other proprietary phosphorus filtration and inactivation technologies, such as EutroSORB, also work to filter and inactivate phosphorus similar to biochar, but are not approved for use in Massachusetts.

ADVANTAGES

- Biochar may be perceived as a "natural" material
- Biochar material can be repurposed as garden or lawn fertilizer
- Low maintenance

CONSTRAINTS

- Limited track record
- More appropriate for pond tributaries, therefore not applicable to kettle ponds
- Requires continual maintenance, upkeep, and repeated deployments
- Producing and sourcing biochar can be difficult, and expensive
- May reduce pond water fertility on a temporary basis

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** Towns may propose the use of biochar in town-managed ponds
- **Pond Groups:** May propose the use of biochar in public or private ponds and provide a supportive role through education
- **Private Landowners:** May propose the use of biochar in private ponds
- **Land Trusts:** Land trusts may provide a supportive role through education

SITING REQUIREMENTS

- Ponds with tributaries
- Better in ponds with moving waters, if not, can be used in combination with aeration or circulation

INFORMATION NEEDS

- Nutrient loading analysis
- Quantity of product needed and frequency of application

Biochar flotation bags at Lake Hopatcong – photo by Lake Hopatcong Commission

IMPLEMENTATION EXAMPLES

The use of biochar in freshwater ponds and lakes on Cape Cod has been explored but has not been implemented. Biochar has been used in a *pilot project in a cranberry bog restoration in Marstons Mills*.

Biochar flotation bags were installed in Lake Hopatcong, NJ to improve the lake's water quality by removing nutrients.

RESOURCES

- For more information on the use of biochar for the removal of nutrients in water, see a review paper in *Water Research*
- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

Variable

Varies based on amount and price of product used

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting

Implementation: Materials and installation

Maintenance: Monitoring and reapplication

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

NUTRIENT MANAGEMENT

Waterfowl Management

STRATEGY SCALE

THREATS ADDRESSED				
✓ Excess Nutrients	✓ Pollutant Inputs	✓ Algal Blooms	✓ Erosion	✓ Invasive/Nuisance Species

STRATEGY GOALS

Protect	Manage	Rehabilitate
○	●	○

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
Neutral	*Improve*	*Improve*

✓ **Permittable in Massachusetts**
Local review through the Conservation Commission may be required. List of potential permits available here.

✓ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod here.

✗ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✓ **Can be Performed at Homeowner Scale**
Local review and permitting may be required.

✗ **Nature-based Solution**

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
●	○	○

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
●	○	○

DESCRIPTION

Waterfowl include birds such as ducks, geese, and swans that can naturally be found in and around water. Waterfowl in excess numbers are often attracted to residential, commercial, and municipal lakes and ponds due to a lack of vegetation and predators in these areas. Waterfowl can damage ponds through causing erosion and sediment accumulation, damaging aquatic plants, and polluting beaches and ponds with their fecal matter. Waterfowl management involves the control of waterfowl through various mechanisms including: ensuring no one is feeding them; maintaining a natural, tall, thick vegetated pond shore buffer around the pond; installing physical barriers like fencing or flagging to control waterfowl; human habitat modification such as avoiding areas with concentrations of waterfowl; using noisemakers, pyrotechnics, or trained dogs to deter waterfowl; and destroying eggs or adults. The duration of benefits and maintenance requirements will vary depending on method(s) used, and adaptive management approach is advised as waterfowl are intelligent and adaptive. The objective of waterfowl management is to reduce nutrients and pathogens from bird droppings from getting on pond beaches or entering ponds where they may contribute to elevated bacteria levels.

ADVANTAGES

- Can be inexpensive depending on which mechanism used
- If combined with native pond shore buffer plantings, can enhance habitat and aesthetics

CONSTRAINTS

- Can be controversial, especially if lethal control is attempted
- Requires adaptive management as waterfowl are intelligent and will adapt to control methods over time

Waterfowl Management

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** Towns may propose waterfowl management at town-managed beaches
- **Pond Groups:** May propose waterfowl management on public or private beaches and provide a supportive role through education
- **Private Landowners:** May propose waterfowl management on private beaches
- **Land Trusts:** Land trusts may provide a supportive role through education

SITING REQUIREMENTS

- All ponds where waterfowl (e.g., geese, ducks) are a problem

INFORMATION NEEDS

- Waterfowl survey
- Waterfowl integrated pest management plan

IMPLEMENTATION EXAMPLE

Wequaquett Estates Beach Association uses a "Goose-Line" (a rope stretched across the beach at the water's edge) to keep geese and their droppings off the beach. Association members rope off the beach each evening and take the rope down in the mornings.

RESOURCES

- The Northeastern Integrated Pest Management Center's "Canada Geese: The Bird Control Challenge of the Decade" has useful information on how to manage Canada Geese.
- The Massachusetts' Department of Conservation and Recreation's Lakes and Ponds Program provides related resources.

COST ESTIMATE

Variable

Varies depending on scale of problem and mechanism used

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting, including bird survey

Implementation: Equipment and supplies

Maintenance: Monitoring and maintenance

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

IA

NUTRIENT MANAGEMENT

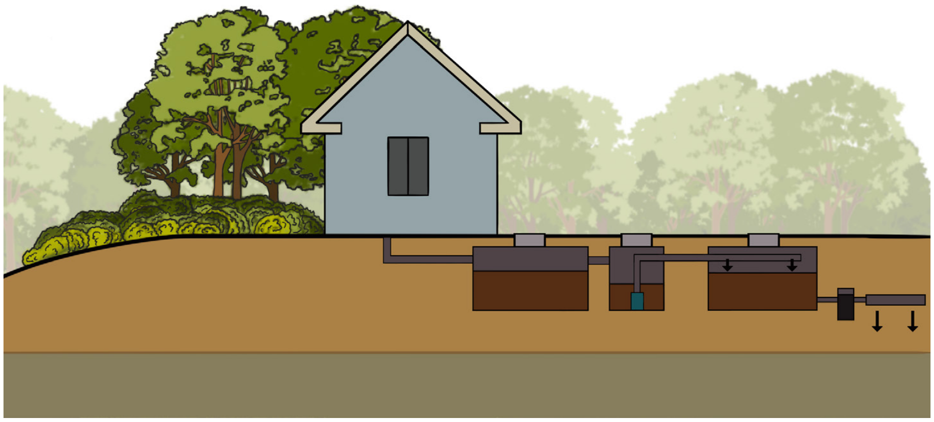
Innovative / Alternative (I/A) Septic System

STRATEGY SCALE

THREATS ADDRESSED				
✓ Excess Nutrients	✗ Pollutant Inputs	✓ Algal Blooms	✗ Erosion	✗ Invasive/Nuisance Species

STRATEGY GOALS	Protect	Manage	Rehabilitate
	✓	✓	✓

STRATEGY CO-BENEFITS	Habitat	Aesthetics	Recreation
	Neutral	Neutral	Neutral



✓ **Permittable in Massachusetts**
MassDEP Approved for Piloting Use under Title 5. Local Board of Health review. List of potential permits available here.

✓ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod here.

✓ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✓ **Can be Performed at Homeowner Scale**
Local review and permitting may be required.

✗ **Nature-based Solution**

DURATION OF BENEFITS	Less than one month	One season or year	Multiple seasons or years
	○	○	●

MAINTENANCE REQUIREMENTS	Monthly	Annually	Infrequent
	○	○	●

DESCRIPTION

An I/A septic system is an alternative technology to a traditional onsite Title 5 septic system that is specially designed to treat wastewater beyond the capability of a standard (septic tank and leach field) system. The objective of using an I/A septic system is to prevent nutrients (mainly nitrogen and phosphorus) from entering freshwater ponds from septic effluent via groundwater. Multiple techniques include precipitation (using aluminum or iron rich media), ion exchange (using ion exchange media), and biological (using microorganisms) methods. An I/A system can be installed as a new system or a retrofit to an existing septic system. Most I/A systems have focused on nitrogen removal but there are some technologies that remove phosphorus. The Massachusetts Department of Environmental Protection (MassDEP) must approve alternative septic systems for use in Massachusetts.

ADVANTAGES

- Targets nutrients at the source
- When sited correctly, reduces external nutrient loading
- I/A septic systems can be similar to conventional septic systems from the homeowner perspective
- Decentralized approach can be implemented lot by lot, does not require a centralized collection system

CONSTRAINTS

- Can be expensive to install; however, tax credits and low/no interest loans may be available to help lower installation costs
- Depending on condition of existing system, may require a total replacement or component upgrades
- Systems have been developed and approved for nitrogen removal, but there is not an extensive list of phosphorus removing I/A systems to choose from and those available are being piloted in MA
- Precipitates / media / biosolids removal requires routine maintenance

Innovative / Alternative (I/A) Septic System

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** Towns may propose the installation of I/A systems at town-managed ponds and provide a supportive role through permitting and education
- **Pond Groups:** May propose I/A systems around public or private ponds and provide a supportive role through education
- **Private Landowners:** May install I/A systems
- **Land Trusts:** Land trusts may provide a supportive role through education

SITING REQUIREMENTS

- All ponds with upgradient development (particularly within 300 feet) using Title 5 or other non-nutrient treating septic systems

INFORMATION NEEDS

- Survey / inspection of existing septic systems
- Wastewater flows and groundwater flow direction
- Nutrient sources, travel times, and distances

IMPLEMENTATION EXAMPLES

The *Massachusetts Alternative Septic System Technology Center* (MASSTC) collaborated on the approval, design, installation and/or monitoring of five phosphorus removing systems near freshwater ponds on Cape Cod. The objective of the project was to validate these technologies for protecting freshwater resources from phosphorus inputs from onsite septic systems.

RESOURCES

- MassDEP maintains a *list of approved Title 5 I/A technologies*.
- MASSTC has information on phosphorus removal in onsite septic systems *here*.
- The Barnstable Clean Water Coalition is working with partners to *install I/A systems in one neighborhood around Shubael Pond*.
- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

Variable

Varies depending on technology and site conditions

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting

Implementation: Equipment, supplies, and labor all vary depending on system

Maintenance: Inspections and septic pumping schedule depends on performance monitoring requirements

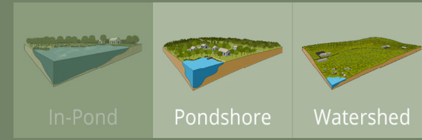
POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

NUTRIENT MANAGEMENT

Composting Toilets



STRATEGY SCALE

THREATS ADDRESSED

Excess Nutrients	✓
Pollutant Inputs	✗
Algal Blooms	✓
Erosion	✗
Invasive/Nuisance Species	✗

STRATEGY GOALS

Protect	Manage	Rehabilitate
✓	✓	✓

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
Neutral	Neutral	Neutral

- ✓ **Permittable in Massachusetts**
  MassDEP Approved for General Use under Title 5. Local Board of Health review. List of potential permits available here.
- ✓ **Implemented on Cape Cod**
  See examples of pond projects implemented on Cape Cod here.
- ✓ **Listed in 208 Plan Technologies Matrix**
  Learn more about the nutrient management strategies in the Tech Matrix here.
- ✓ **Can be Performed at Homeowner Scale**
  Local review and permitting may be required.
- ✗ **Nature-based Solution**

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
○	○	●

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
●	○	○

DESCRIPTION

Composting toilets are an alternative toilet technology to traditional toilets that may prevent nutrients (mainly nitrogen and phosphorus) from entering freshwater ponds from septic effluent via groundwater. A composting toilet is a self-contained waterless toilet designed to decompose nonwater-carried human wastes through microbial action on a carbon source and store the resulting matter for further treatment and reuse or disposal. Residuals refer to the solid compost and liquid leachate generated by a composting toilet. By regulation, the finished solid compost residual may be buried beneath six inches of cover by the toilet owner and the leachate must be transported by a licensed septage hauler or diverted to a septic system. When nutrient management in a watershed is desired, onsite disposal strategies may still release varying amounts of nutrients into the watershed, which needs to be evaluated relative to any nutrient limits established to protect natural resources.

ADVANTAGES

- Targets nutrients at the source
- Reduces water usage
- Improves energy savings, nutrient recovery, and nutrient recycling

CONSTRAINTS

- Requires a significant number of citizens to participate to be effective at scale
- Homeowners may be resistant due to real and perceived operation and maintenance differences relative to conventional toilets
- If composting toilets are widely used, a regional facility for processing residuals would be necessary
- If residuals are used as fertilizer, application at the right time, right amount, and right place is essential to minimize losses to the environment
- May cause odors and attract insects, may not deactivate pathogens in solid waste, and requires ongoing maintenance to function correctly
- A conventional septic system is still required for graywater treatment

Composting Toilets

CAPE COD COMMISSION

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** Towns may propose to install composting toilets at town-managed ponds and other town facilities, and provide a supportive role through permitting and education
- **Pond Groups:** May propose composting toilets around public or private ponds and provide a supportive role through education
- **Private Landowners:** May install composting toilets
- **Land Trusts:** Land trusts may provide a supportive role through education

SITING REQUIREMENTS

- All ponds with upgradient development (particularly within 300 feet) using Title 5 or other non-nutrient treating septic systems
- Need disposal options for residuals and licensed septage hauler

INFORMATION NEEDS

- Survey of existing septic systems
- Wastewater flows and groundwater flow direction
- Nutrient sources, travel times, and distances

IMPLEMENTATION EXAMPLES

As part of an overall wastewater management strategy, the Town of Falmouth has investigated the efficacy of diversion toilets or "eco-toilets" for the management of nutrient inputs to groundwater with specific reference to nitrogen and phosphorus. Two types of eco-toilets were investigated: composting toilets and urine-diverting toilets. Project information can be found on the MASSTC website *here*.

RESOURCES

- MassDEP maintains a *list of approved Title 5 I/A technologies*.
- MASSTC has information on phosphorus removal in onsite septic systems *here*.
- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

$$$$

Varies depending on technology

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design and permitting

Implementation: Equipment, supplies and installation

Maintenance: Ongoing maintenance required

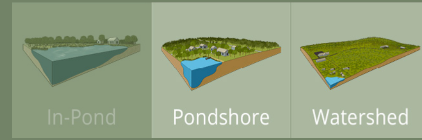
POTENTIAL FUNDING SOURCES

- Community Preservation Act
- Capital Budget
- Grants
- Private Funding

Additional information regarding potential funding sources is available *here*.

NUTRIENT MANAGEMENT

Urine Diversion Toilets



STRATEGY SCALE

THREATS ADDRESSED	
Excess Nutrients	✓
Pollutant Inputs	✗
Algal Blooms	✓
Erosion	✗
Invasive/Nuisance Species	✗

STRATEGY GOALS	Protect	Manage	Rehabilitate
	✓	✓	✓

STRATEGY CO-BENEFITS	Habitat	Aesthetics	Recreation
	Neutral	Neutral	Neutral

✓ **Permittable in Massachusetts**
MassDEP Provisional Approval for General Use under Title 5. Local Board of Health review. List of potential permits available here.

✓ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod here.

✓ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✓ **Can be Performed at Homeowner Scale**
Local review and permitting may be required.

✗ **Nature-based Solution**

DURATION OF BENEFITS	Less than one month	One season or year	Multiple seasons or years
	○	○	●

MAINTENANCE REQUIREMENTS	Monthly	Annually	Infrequent
	●	○	○

DESCRIPTION

Urine diversion toilets are an alternative toilet technology to traditional toilets that may prevent nutrients (mainly nitrogen) from entering freshwater ponds from septic effluent via groundwater. Urine diversion is the practice of keeping human urine separate from the rest of the wastewater stream. This is typically done using a urinal or specialized toilet that is connected to a urine storage tank. Urine-diverting flush toilets have a special urine collection basin at the front of the toilet bowl, which catches the urine and drains it to the urine collection tank. The stored urine is periodically collected by a servicing company which empties the tank for disposal or conversion to a fertilizer. When nutrient management in a watershed is desired, onsite disposal strategies may still release varying amounts of nutrients into the watershed, which needs to be evaluated relative to any nutrient limits established to protect natural resources.

ADVANTAGES

- Targets nutrients at the source
- Can enhance nitrogen removal compared to composting toilet designs that combine urine and solids together
- Requires little to no water to flush urine, resulting in substantial water savings
- Improves energy savings, nutrient recovery, and nutrient recycling
- Potential to reduce or eliminate synthetic fertilizer use by utilizing the collected urine which can be used as fertilizer

CONSTRAINTS

- Unclear whether urine diverting toilets can be installed to meet plumbing code
- Requires a significant number of citizens to participate to be effective at scale
- Homeowners may be resistant due to real and perceived operation and maintenance differences relative to conventional toilets
- If urine diversion toilets are widely used, a regional facility for urine disposal and processing into fertilizer would be necessary
- If urine is used as a fertilizer, application at the right time, right amount, and right place is essential to minimize losses to the environment
- Still need conventional septic system for solid waste and graywater treatment
- Requires ongoing maintenance to function correctly

Urine Diversion Toilets

CAPE COD COMMISSION

IMPLEMENTATION

POTENTIAL ACTORS

Towns: Towns may propose to install urine diversion toilets at town-managed ponds and other town facilities, and provide a supportive role through permitting and education

Pond Groups: May propose composting toilets around public or private ponds and provide a supportive role through education

Private Landowners: May install composting toilets

Land Trusts: Land trusts may provide a supportive role through education

SITING REQUIREMENTS

- All ponds with upgradient development (particularly within 300 feet) using Title 5 or other non-nutrient treating septic systems
- Urine disposal/processing site(s) and licensed urine hauler

INFORMATION NEEDS

- Survey of existing septic systems
- Wastewater flows and groundwater flow direction
- Nutrient sources, travel times, and distances

IMPLEMENTATION EXAMPLES

The Town of Falmouth has investigated the efficacy of "eco-toilets" for the management of nutrient inputs to groundwater. Two types of eco-toilets were investigated: composting toilets and urine-diverting toilets. Project information can be found on the MASSTC website *here*. In addition, the *Green Center initiated a project in Falmouth* to assess how much urine volume could be collected and what amount of nutrients could be diverted from residental wastewater flows using urine diversion.

RESOURCES

- MassDEP maintains a *list of approved Title 5 I/A technologies*.
- MASSTC has information on phosphorus removal in onsite septic systems *here*.
- *The Rich Earth Institute* has more information on recycling human urine into fertilizer
- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

$$$$

Varies depending on technology

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design and permitting

Implementation: Equipment, supplies and installation

Maintenance: Ongoing maintenance required

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available ***here***.

NUTRIENT MANAGEMENT

Permeable Reactive Barrier

STRATEGY SCALE

THREATS ADDRESSED

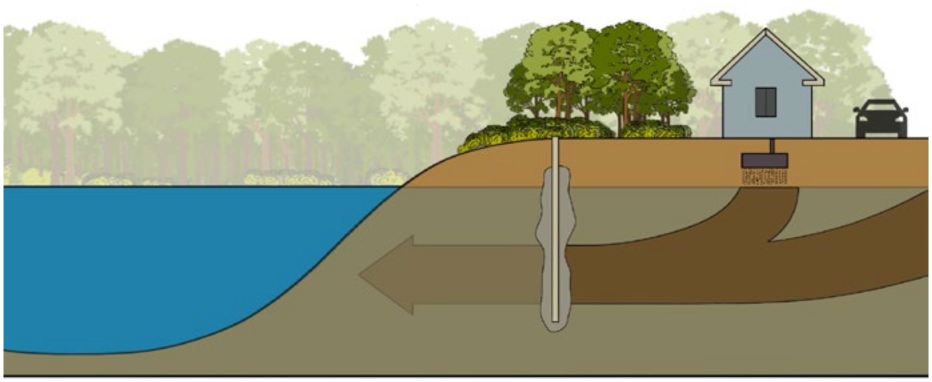
- ✓ Excess Nutrients
- ✓ Pollutant Inputs
- ✓ Algal Blooms
- ✗ Erosion
- ✗ Invasive/Nuisance Species

STRATEGY GOALS

Protect	Manage	Rehabilitate
✓	✓	✓

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
Neutral	Neutral	Neutral



✓ **Permittable in Massachusetts**
A MassDEP Underground Injection Control permit may be required. List of potential permits available here.

✓ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod here.

✓ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✓ **Can be Performed at Homeowner Scale**
Local review and permitting may be required.

✗ **Nature-based Solution**

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
○	○	●

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
○	●	○

DESCRIPTION

A permeable reactive barrier (PRB) is a wall created below ground to intercept and treat contaminated groundwater and may be used to prevent nutrients (mainly nitrogen and phosphorus) from entering freshwater ponds via groundwater. The wall is permeable, allowing groundwater to be treated as it flows through. The reactive materials that make up the wall can remove contaminants through different processes: contaminants can sorb (stick) to the surface of the reactive material; be converted to less harmful forms by reacting with the reactive material; be chemically immobilized by forming solid precipitates; and can be biodegraded by microbes in the PRB. A PRB is typically built by digging a long, narrow trench perpendicular to the path of contaminated groundwater flow which is filled with a reactive material, such as iron or mulch. PRBs may also be constructed by installing a series of injection wells to introduce the reactive material into the subsurface. Trench and injection methods may also be used in combination.

ADVANTAGES

- Relatively low capital and operating costs
- No above ground structures
- Potential for high nutrient (or other pollutant) removal rates
- Improves energy savings / nutrient recovery / recycling
- Improves management of flooding / extreme events

CONSTRAINTS

- Need ample land to site and siting can be limited due to wetlands, public utilities and abutter concerns
- Need detailed knowledge of local groundwater hydrology and chemistry
- Projects may require extensive groundwater modeling and monitoring
- Permitting requirements may be extensive and time consuming

Permeable Reactive Barrier

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** Towns may propose to install PRBs on town-owned properties around ponds and provide a supportive role through permitting and education
- **Pond Groups:** May propose or support the use of PRBs around public or private ponds and provide a supportive role through education
- **Private Landowners:** May install or support the use of PRBs
- **Land Trusts:** Land trusts may provide a supportive role through education

SITING REQUIREMENTS

- Ponds with upgradient development on Title 5 or other non-nutrient treating septic systems
- Ponds where groundwater is a known source of nutrient or pollutant loads
- Ponds with suitable areas in close proximity to pond and perpendicular to groundwater flow for PRB installation
- Works best when the source or reservoir of nutrient or pollutant is well defined

INFORMATION NEEDS

- Survey of existing septic systems
- Groundwater flows and flow direction
- Groundwater chemistry data
- Nutrient or other pollutant sources, travel times, and distances
- Projects may require a hydrogeologic investigation and groundwater modeling to estimate effectiveness of PRB

IMPLEMENTATION EXAMPLES

In 2006, the Town of Mashpee and partners installed a PRB in Ashumet Pond to help address algal blooms from elevated phosphorus levels. More information about the project can be found in the *2009 USGS report: Distribution of Treated-Wastewater Constituents in Pore Water at a Pond-Bottom Reactive Barrier, Cape Cod, Massachusetts*.

The Towns of *Orleans* and *Eastham* have also installed PRBs and maintain information on their websites regarding these projects.

RESOURCES

- The U.S. Environmental Protection Agency developed a *Community Guide to Permeable Reactive Barriers*.
- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

Variable

Varies depending on scope of project and PRB method used

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting, including groundwater modeling studies

Implementation: Equipment, supplies, and installation

Maintenance: Annual monitoring, operations and maintenance

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

NUTRIENT MANAGEMENT

Advanced Wastewater Treatment

STRATEGY SCALE

THREATS ADDRESSED

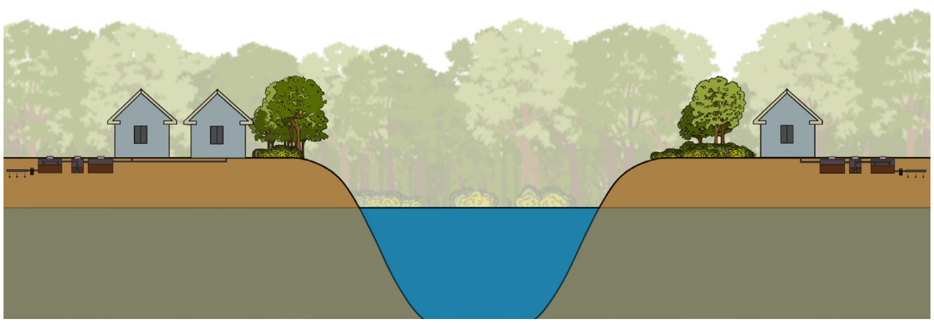
- ✓ Excess Nutrients
- ✓ Pollutant Inputs
- ✓ Algal Blooms
- ✗ Erosion
- ✗ Invasive/Nuisance Species

STRATEGY GOALS

Protect	Manage	Rehabilitate
✓	✓	✓

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
Neutral	*Neutral*	*Neutral*



✓ **Permittable in Massachusetts**
Local planning process. List of potential permits available [here](#).

✓ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod [here](#).

✓ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix [here](#).

✗ **Can be Performed at Homeowner Scale**

✗ **Nature-based Solution**

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
○	○	●

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
○	○	●

DESCRIPTION

Advanced wastewater treatment in relation to freshwater ponds refers to the prioritization and implementation of wastewater treatment with high nutrient removal rates, which can include sewering, package plants, and I/A systems designed for nutrient removal around ponds and/or within pond watersheds. The objective of advanced wastewater treatment is to expedite wastewater planning around freshwater ponds to protect pond water quality by removing or reducing wastewater nutrient load sources. It requires a recognition and prioritization of freshwater ponds through regulations, permits (e.g., NPDES, MS4, Title 5, Watershed Permit), and/or Watershed Management Plan, Comprehensive Wastewater Management Plan, or Targeted Watershed Plan.

ADVANTAGES

- Planning process promotes community acceptance
- I/A, cluster, or centralized sewer systems have higher treatment efficiency than individual systems
- Implementation may also benefit marine water quality, groundwater quality, and freshwater quality

CONSTRAINTS

- Changing priorities in a town's water resources planning has tradeoffs
- Wastewater treatment near ponds may be one of several objectives in a town's plan, and its prioritization relative to other concerns (drinking water quality, coastal waters) will vary
- Implementation of alternative systems may require the installation of a collection system
- I/A and cluster systems may have lower treatment efficiencies than conventional wastewater treatment facilities

Advanced Wastewater Treatment

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** Towns facilitate the planning process and may install systems
- **Pond Groups:** Pond groups may support and participate in the planning process and the installation of systems
- **Private Landowners:** Support and participate in the planning process and may install systems
- **Land Trusts:** Support and participate in the planning process

SITING REQUIREMENTS

- All ponds with upgradient development (particularly within 300 feet) on Title 5 or other non-nutrient treating septic systems

INFORMATION NEEDS

- Public planning process to identify appropriate locations for wastewater treatment infrastructure

IMPLEMENTATION EXAMPLES

Cluster septic systems were installed around Red Lily Pond, Barnstable to move effluents from defective septic systems to large, cluster soil absorption systems farther from the pond. Towns across Cape Cod have been planning for sewering near ponds as part of their wastewater planning processes. For example, the Town of Orleans is planning for the design, bidding, and construction of their sewer collection system to service their *"Lakes and Ponds" area* in Phase 3 of their wastewater management and sewering plan.

RESOURCES

- The U.S. Environmental Protection Agency has *Resources for Watershed Planning* to help communities develop and implement watershed plans to meet water quality standards and protect water resources.
- MassDEP also has *Watershed-Based Plan Information* to help communities develop plans to address water quality problems in impaired waters and protect water quality in healthy waters.
- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

Variable

Varies depending on scope of project and technology pursued

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting, including planning process and studies

Implementation: Equipment and supplies (depending on technology selected)

Maintenance: Annual monitoring, operations and maintenance depends on technology selected

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

SEDIMENT MANAGEMENT

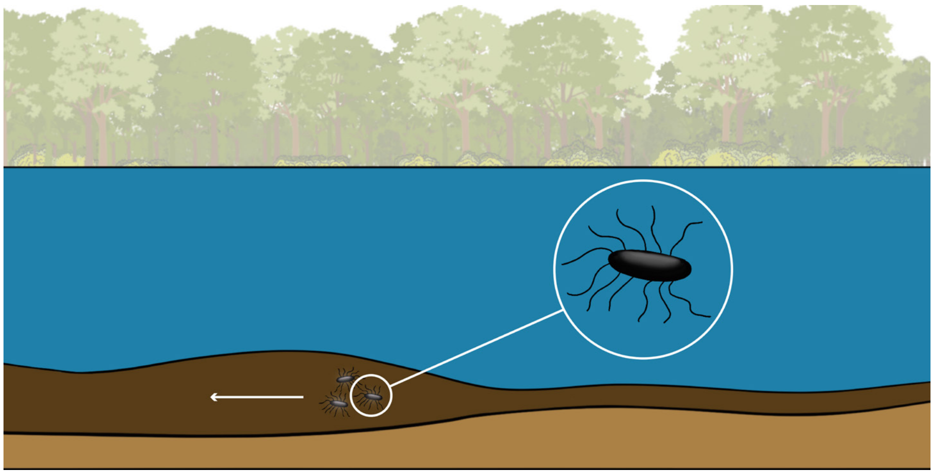
Biological Sediment Digestion

STRATEGY SCALE

THREATS ADDRESSED					
	✓ Excess Nutrients	✓ Pollutant Inputs	✓ Algal Blooms	✗ Erosion	✗ Invasive/Nuisance Species

STRATEGY GOALS	Protect	Manage	Rehabilitate
	○	✓	✓

STRATEGY CO-BENEFITS	Habitat	Aesthetics	Recreation
	⊖ *Neutral*	⊖ *Neutral*	⊖ *Neutral*



- ✗ **Permittable in Massachusetts**
  Not permitted in MA. List of potential permits available [here](#).
- ✗ **Implemented on Cape Cod**
  See examples of pond projects implemented on Cape Cod [here](#).
- ✗ **Listed in 208 Plan Technologies Matrix**
  Learn more about the nutrient management strategies in the Tech Matrix [here](#).
- ✗ **Can be Performed at Homeowner Scale**
- ✓ **Nature-based Solution**
  If native species used

DURATION OF BENEFITS	Less than one month	One season or year	Multiple seasons or years
	○	○	●

MAINTENANCE REQUIREMENTS	Monthly	Annually	Infrequent
	○	○	●

DESCRIPTION

Biological sediment digestion (aka "biological dredging") makes use of Bacillus spores, microorganisms, and enzymes to enhance natural sediment degradation processes. The approach has been marketed as a "natural" means to clean bottom muck, which can potentially clean the water. The objective of using biological sediment digestion is to decrease pond bottom sediment and organic matter.

ADVANTAGES

- Potential for minimal physical disruptions to pond
- May be considered a "natural" solution if native biological agents used

CONSTRAINTS

- Not much support for success in peer reviewed literature
- Largely experimental, and not currently permitted in MA
- Introducing novel organisms may disrupt pond ecosystem
- May further consume dissolved oxygen

Biological Sediment Digestion

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** Towns may explore potential for biological sediment digestion in town-managed ponds
- **Pond Groups:** May support exploration of biological sediment digestion in public or private ponds and provide a supportive role through education
- **Private Landowners:** May explore potential for or support exploration of biological sediment digestion
- **Land Trusts:** May support exploration of biological sediment digestion and provide a supportive role through education

SITING REQUIREMENTS

- Ponds with sediment with high organic content

INFORMATION NEEDS

- Sediment sampling
- Organic content of sediment
- Bottom DO monitoring

IMPLEMENTATION EXAMPLES


Hess Lake was one of the three lakes reviewed in the Michigan assessment

Researchers in Michigan assessed the effectiveness of *muck-digesting bacterial pellets*. Controlled laboratory experiments were conducted and changes in organic matter, dissolved organic carbon, bacterial community composition, and water quality were assessed at various times throughout the experiments. The researchers found no statistically significant differences in changes of organic matter between treatments with pellets and those without pellets. Based on these results, the researchers concluded that these pellets are not an effective treatment to reduce sediment organic matter.

RESOURCES

- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

Variable

Varies depending on scope of project and biological agent

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting, including sediment sampling costs

Implementation: Biological agents, equipment and logistics

Maintenance: Annual monitoring of biological agents, sediments, and other parameters, and reapplication, as needed

POTENTIAL FUNDING SOURCES

- **Grants**
- **Private Funding**

As it is not allowed in MA, public funding may not be available.

Additional information regarding potential funding sources is available ***here***.

SEDIMENT MANAGEMENT

Dredging

In-Pond	Pondshore	Watershed

STRATEGY SCALE

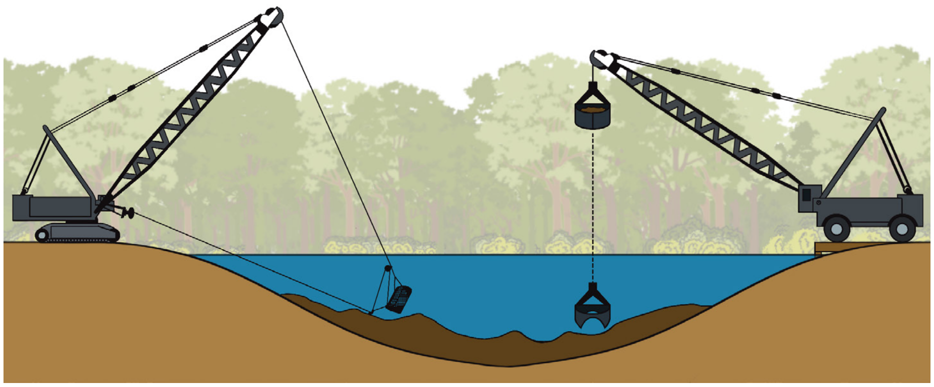
THREATS ADDRESSED: ✓ Excess Nutrients · ✓ Pollutant Inputs · ✓ Algal Blooms · ✗ Erosion · ✓ Invasive/Nuisance Species

STRATEGY GOALS

Protect	Manage	Rehabilitate
○	○	●

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
Detrimental	*Neutral*	*Neutral*



✓ **Permittable in Massachusetts**
Local planning process. List of potential permits available here.

✓ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod here.

✓ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✗ **Can be Performed at Homeowner Scale**

✗ **Nature-based Solution**

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
○	○	●

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
○	○	●

DESCRIPTION

Ponds store and accumulate nutrients and pollutants within their sediments and these can be released into the water column. Accumulation of sediment itself can also be a problem. Dredging physically removes sediment where pollutants are stored, with possible re-use or disposal of dredged sediment. Dredging may also be used to remove aquatic invasive or nuisance plant species. Sediment is removed by wet or dry excavation or by using hydraulic dredging. Dredged sediment is deposited in a containment area for dewatering/disposal. Other in pond sediment management strategies permitted as “dredging” include reverse sediment layering, which uses hydraulic jetting to extract glacial sand from under the nutrient rich anaerobic organic sediment layer and place it on top of these sediments, and sediment capping, which is a containment technology that isolates contaminated sediments from the surrounding aquatic environment using clean layers of geological material and/or synthetic liners. These strategies are used to reduce the sediment-water interaction to reduce sediment-bound nutrients and other contaminants in sediment from becoming mobilized. Another use of sediment capping is to prevent the growth of rooted macrophytes.

ADVANTAGES

- Over the long term, dredging may “reset” or “rebalance” pond system
- Can remove large quantities of sediment and dramatically change pond hydraulics over a short period of time
- Can remove significant mass of phosphorus resulting in diminished internal phosphorus recycling
- Increases pond depth and retention time which may improve pollutant removal, sediment deposition, and flood control
- Can improve spawning habitat for fish species

CONSTRAINTS

- Over the short term, dredging may disrupt the aquatic ecosystem through physical removal of both native and invasive plants and animals; cause silting and increase in short-term turbidity, which can stress and can kill aquatic life; and change pond bathymetry
- Dredging activity can mobilize otherwise stable pollutants
- May temporarily impact recreational and other uses during dredging operations
- Off-site reuse or disposal of dredged sediment dependent on chemical testing of sediment

Dredging

IMPLEMENTATION

POTENTIAL ACTORS

Towns: Towns may propose dredging in town-managed ponds

Pond Groups: May propose or support dredging of public or private ponds and provide a supportive role through education

Private Landowners: May propose or support dredging of ponds

Land Trusts: May support dredging of ponds and provide a supportive role through education

SITING REQUIREMENTS

- Ponds with excessive sediment and/or significant sediment nutrient loading present
- Hydraulic / suction dredging may be better suited for large lakes or large-scale dredging as it can utilize a pipeline to reduce or eliminate truck trips
- Generally more suitable for shallow lakes (< 10 ft)
- Access/boat launch for large equipment

INFORMATION NEEDS

- Sediment characterization, quantity, grain size, and quality analyses
- Site specific information, based on hydraulics and other characteristics
- Depending on purpose of dredging (i.e., removal of nutrient/pollutant laden sediments or rehabilitation of pond to increase attenuation), additional data may be needed

IMPLEMENTATION EXAMPLES


Lake Elizabeth, Barnstable

There are very few examples of dredging in Cape Cod ponds. Reverse sediment layering was attempted on *Lake Elizabeth* in Barnstable. The project pumped glacial sand from below the sediment layer in the pond but was stopped when a concrete-like layer of "river till" beneath was encountered, and therefore there was not enough sand to pump to complete the re-layering process. Cranberry farmers were hired to distribute sand over the thick sediments.

RESOURCES

- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

$$$$

Relative to other in-pond strategies

Varies depending on scope of project, type of dredging, volume of material to be removed, whether sediment needs to be treated, and distance sediment needs to be transported

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting, including sediment characterization studies

Implementation: Dredging equipment and sediment disposal

Maintenance: Monitoring and mitigation

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

SEDIMENT MANAGEMENT

Erosion Control

BMP

STRATEGY SCALE

THREATS ADDRESSED					
	Excess Nutrients ✓	Pollutant Inputs ✓	Algal Blooms ✓	Erosion ✓	Invasive/Nuisance Species ✗

STRATEGY GOALS	Protect	Manage	Rehabilitate
	✓	✓	✓

STRATEGY CO-BENEFITS	Habitat	Aesthetics	Recreation
	Neutral	Neutral	Neutral

✓ **Permittable in Massachusetts**
Local planning process. List of potential permits available [here](#).

✓ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod [here](#).

✗ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix [here](#).

✓ **Can be Performed at Homeowner Scale**
Local review and permitting may be required.

✓ **Nature-based Solution**
If natural products used, not hard engineered structures

DURATION OF BENEFITS	Less than one month	One season or year	Multiple seasons or years
	○	○	●

MAINTENANCE REQUIREMENTS	Monthly	Annually	Infrequent
	○	○	●

DESCRIPTION

Sediments from land disturbance activities, including but not limited to development, grading, and vegetation clearing, can carry nutrients and other pollutants into ponds through erosion and stormwater. Sediments in runoff can reduce water levels in ponds, cloud aquatic habitats, and limit plant growth. These sediments can also carry nutrients and other attached pollutants that can further harm water quality and habitats and pose a health hazard at swimming beaches. Erosion and sediment controls include methods that reduce erosion of exposed soils, capture sediments and attached pollutants, and slow or redirect the flow of stormwater. Erosion and sediment control options—such as covering exposed soils with erosion control blankets, redirecting runoff to vegetated areas using water bars, and blocking runoff using straw wattles—can help prevent these impacts.

ADVANTAGES

- Scalable
- Can be inexpensive depending on which mechanism used
- Can be easy to install depending on mechanism, scale of project, and site conditions
- If properly installed, should be low maintenance

CONSTRAINTS

- Can get expensive as scale of project expands
- Requires adequate space to work within to install control measures
- Erosion controls must be designed to ensure that stormwater is infiltrated onsite, not transferred offsite, to avoid impacting neighboring properties or transferring the problem elsewhere

Erosion Control

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** Towns may install erosion controls around town-managed ponds
- **Pond Groups:** May propose or support erosion control projects around public or private ponds and provide a supportive role through education
- **Private Landowners:** May propose or support erosion control projects
- **Land Trusts:** May propose or support erosion control projects and provide a supportive role through education

SITING REQUIREMENTS

- All ponds, and especially those with steeper slopes
- Wherever land disturbance (e.g., development, human social trails to ponds) is a concern

INFORMATION NEEDS

- Identification of sources of erosion
- Determining extent of erosion which may require surveying the pond shore during rainfall / runoff events
- Space requirements for proper installation

IMPLEMENTATION EXAMPLES


Credit: NPS/AmeriCorps Cape Cod

Cape Cod National Seashore, with the assistance of AmeriCorps Cape Cod Service Members, assessed the condition of freshwater ponds within the Seashore, developed action plans to fix erosion hot spots, and installed erosion controls, as documented in their *Pond Condition Progress Report and Work Plan*. Restoration work included placing jute netting along steep banks to hold soil in place, planting native vegetation to help stabilize the soil, and the installation of water bars to direct runoff.

RESOURCES

- The Massachusetts Office of Coastal Zone Management developed a *stormwater solutions for homeowners fact sheet* for preventing erosion.
- The *Massachusetts Stormwater Management Handbook* provides detailed information on a wide variety of erosion control strategies.
- The Environmental Protection Agency has a *menu of Best Management Practices* for controlling stormwater runoff from construction sites.

COST ESTIMATE

Variable

Varies depending on method used and scale of project

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting, including erosion source studies

Implementation: Materials and installation

Maintenance: Regular monitoring as site stabilizes and during storm events - once site stabilizes, minimal maintenance

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

Stormwater Management (Structural)

STRATEGY SCALE

THREATS ADDRESSED

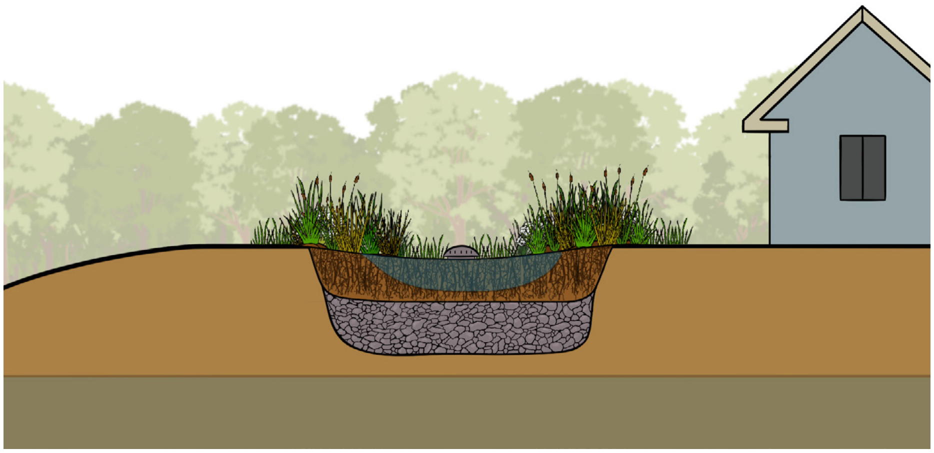
- ✓ Excess Nutrients
- ✓ Pollutant Inputs
- ✓ Algal Blooms
- ✓ Erosion
- ✗ Invasive/Nuisance Species

STRATEGY GOALS

Protect	Manage	Rehabilitate
✓	✓	✓

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
Neutral	Neutral	Neutral



✓ **Permittable in Massachusetts**
Local planning process. List of potential permits available here.

✓ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod here.

✓ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✓ **Can be Performed at Homeowner Scale**
Some methods, for example rain gardens. Local review and permitting may be required.

✓ **Nature-based Solution**
Some measures are nature-based.

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
○	○	●

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
○	○	●

DESCRIPTION

Structural stormwater management techniques direct and treat stormwater to prevent or reduce point or non-point source pollutants from entering surface waters or groundwaters. They are designed, constructed, and maintained to attenuate peak flows, capture and treat runoff, and provide recharge to groundwater. Structural stormwater control measures are used to protect water quality and quantity by preventing pollution from stormwater and controlling and infiltrating it at its source. Structural stormwater control measures include basins, discharge outlets, swales, rain gardens, filters, including low impact development (LID) techniques, among others.

ADVANTAGES

- Scalable
- Manages stormwater before it enters the pond
- Can be inexpensive depending on which mechanism used
- Easy to identify problem areas
- Once installed, should be low-maintenance

CONSTRAINTS

- Need enough space to install right-sized stormwater controls to treat anticipated flows
- Design and installation can get expensive

Stormwater Management (Structural)

CAPE COD COMMISSION

IMPLEMENTATION

POTENTIAL ACTORS

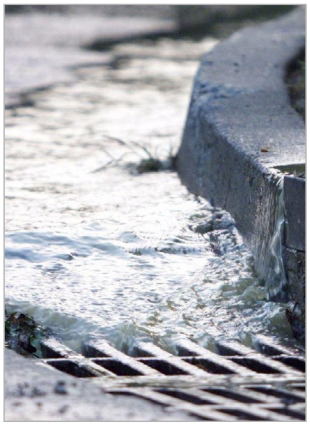
- **Towns:** Towns may install structural stormwater controls around town-managed ponds and pond watersheds
- **Pond Groups:** May propose or support stormwater management projects around public or private ponds and provide a supportive role through education
- **Private Landowners:** May propose or support stormwater management projects
- **Land Trusts:** May support stormwater management projects and provide a supportive role through education

SITING REQUIREMENTS

- All ponds with stormwater inputs

INFORMATION NEEDS

- Stormwater sources
- Catchment area



IMPLEMENTATION EXAMPLES

Towns across Cape Cod are implementing stormwater management projects to protect freshwater ponds. For example, the Town of Eastham, with partners, is developing stormwater improvement projects to decrease the nutrients entering Schoolhouse Ministers Pond, including a wet swale at Fisherman's Landing behind Eastham Elementary School. In partnership with the Towns, the Association to Preserve Cape Cod is developing projects to manage stormwater at public boat ramps.

RESOURCES

- The Massachusetts Stormwater Management Handbook provides detailed information on a wide variety of erosion control strategies.
- The New England Stormwater Retrofit Manual also provides detailed information on a wide variety of stormwater control measures.

COST ESTIMATE

Variable

Varies with technique, size, special features, and local site conditions

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting

Implementation: Materials and installation

Maintenance: Regular monitoring as site stabilizes and during storm events - once site stabilizes, minimal maintenance

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available here.

SEDIMENT MANAGEMENT

Stormwater Management (Non-Structural)

STRATEGY SCALE

THREATS ADDRESSED

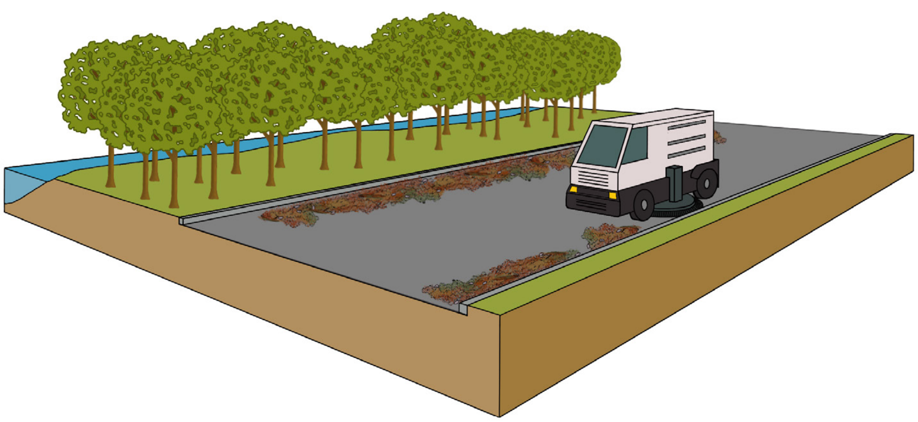
- ✓ Excess Nutrients
- ✓ Pollutant Inputs
- ✓ Algal Blooms
- ✓ Erosion
- ✗ Invasive/Nuisance Species

STRATEGY GOALS

Protect	Manage	Rehabilitate
✓	✓	✓

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
Neutral	Neutral	Neutral



Permittable in Massachusetts
Local planning process. List of potential permits available here.

Implemented on Cape Cod
See examples of pond projects implemented on Cape Cod here.

Listed in 208 Plan Technologies Matrix
Learn more about the nutrient management strategies in the Tech Matrix here.

Can be Performed at Homeowner Scale
Some methods, for example fertilizer mgt. Local review and permitting may be required.

Nature-based Solution
Some measures are nature-based.

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
○	○	●

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
○	○	●

DESCRIPTION

Non-structural stormwater management measures are planning and design approaches to prevent or reduce point or non-point source pollutants from entering surface waters or ground waters. Non-structural stormwater control measures are used to protect water quality and quantity by preventing pollution from stormwater and controlling and infiltrating it at its source. Non-structural stormwater management includes measures such as impervious disconnection, pollution prevention measures, and source controls including materials management at industrial sites, fertilizer and pest management in residential areas, reduced road salting in winter and snow management, and street sweeping. It also includes developing and implementing a bylaw or regulation promoting smart growth, low impact development, or nature based solutions focused on benefits and protection for water quality.

ADVANTAGES

- Helps control sources of water quality degradation
- Helps prevent stormwater and all the contaminants it carries from entering ponds
- Local governments may be rewarded with regulatory credits and incentives by the State and EPA for incorporating smart growth practices within their stormwater plans

CONSTRAINTS

- Requires the review, drafting, adoption and enforcement of stormwater bylaws and regulations
- An implied requirement of comprehensive stormwater management practice implementation is that all parties, properties, and stakeholders will implement, maintain, and monitor practices

Stormwater Management (Non-Structural)

CAPE COD COMMISSION

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** Towns may develop stormwater bylaws and regulations, and implement non-structural stormwater practices
- **Pond Groups:** May propose or support non-structural stormwater management and provide a supportive role through education
- **Private Landowners:** May propose or support non-structural stormwater management practices
- **Land Trusts:** May support non-structural stormwater management practices and provide a supportive role through education

SITING REQUIREMENTS

- All ponds with stormwater inputs

INFORMATION NEEDS

- Stormwater sources and catchment area
- Review of existing stormwater bylaws, regulations, and practices

IMPLEMENTATION EXAMPLES

The *Taunton River Watershed project*, conducted by EPA, examined headwater stream segments to understand the impacts of, and potential approaches for managing impervious cover. Through this study a Watershed Protection Standard was developed to provide communities with resilient alternative site development stormwater management performance standards designed to protect and restore watershed and water resource health from impacts associated with development activities.

RESOURCES

- The Environmental Protection Agency maintains information and resources for *Stormwater Discharges from Municipal Sources* and *Stormwater Tools in New England*.
- The *Massachusetts Stormwater Management Handbook* provides detailed information on a wide variety of erosion control strategies.

COST ESTIMATE

Variable

Varies widely depending on approach and scale

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting

Implementation: Implementing practice(s)

Maintenance: Depends on approach

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available ***here***.

ALGAE MANAGEMENT

Algaecide

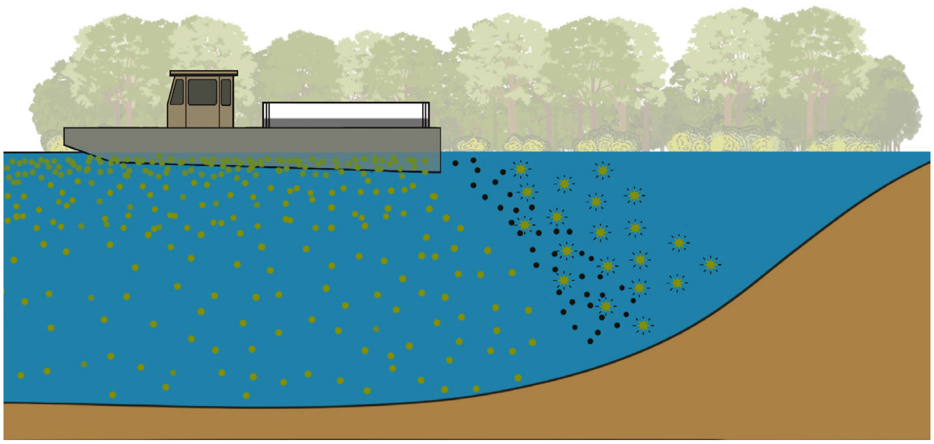
In-Pond | Pondshore | Watershed

STRATEGY SCALE

THREATS ADDRESSED: Excess Nutrients ✗ | Pollutant Inputs ✗ | Algal Blooms ✓ | Erosion ✗ | Invasive/Nuisance Species ✗

STRATEGY GOALS: Protect ○ | Manage ✓ | Rehabilitate ✓

STRATEGY CO-BENEFITS: Habitat – *Neutral* | Aesthetics – *Neutral* | Recreation – *Neutral*



✓ **Permittable in Massachusetts**
Local planning process. List of potential permits available here.

✓ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod here.

✓ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✓ **Can be Performed at Homeowner Scale**
In small, private ponds. Local review and permitting may be required.

✗ **Nature-based Solution**

DURATION OF BENEFITS: Less than one month ○ | One season or year ● | Multiple seasons or years ○

MAINTENANCE REQUIREMENTS: Monthly ○ | Annually ● | Infrequent ○

DESCRIPTION

Algaecides are chemicals that kill algae. Algaecides can decrease respiration and photosynthesis rates of cyanobacteria and other algae and can cause the algae cell walls to lyse or pop, releasing internal nutrients. The application of algaecides can reduce the use impairments associated with excessive algal growth in ponds. Algaecides are generally copper-based chemicals which are toxic to algae. Copper sulfate is the most common algaecide and one of the most popular algae control techniques. Peroxide has also been used but is more expensive. Barley straw, when exposed to sunlight and oxygen, is thought to produce a chemical that inhibits new growth of algae; however, its use for algae control is not currently permitted in Massachusetts.

ADVANTAGES

- Effective as a "last line of defense"
- Scalable, selective as a short-term solution
- Quick action, low cost per dose
- Algaecides can be useful in providing short-term relief while management plans are developed for the long-term problem of controlling nutrients
- Some selectivity possible with different formulations

CONSTRAINTS

- Short-term solution, not addressing source of nutrients or algal blooms, no lasting water quality benefits
- Best applied to prevent a bloom, so requires frequent tracking of algal populations
- Multiple applications may be required
- Ineffective on some algae and repeated treatments may favor resistant algae
- Dangerous to handle, toxic
- Restrictions on water use after treatment
- Limited data on toxicological effects of copper on humans and aquatic organisms, and accumulation in sediments

Algaecide

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** Towns may propose the use of algaecides in town-managed ponds
- **Pond Groups:** May propose or support the use of algaecides in public or private ponds and provide a supportive role through education
- **Private Landowners:** May propose or support the use of algaecides
- **Land Trusts:** May support the use of algaecides and provide a supportive role through education

SITING REQUIREMENTS

- Ponds with excess or harmful algae
- Application may be restricted to particular sites within a lake due to the mixing capabilities of the lake, the dose rate, and the proximity to the treatment site of any significant recreational sites, inflow-outflow streams and water infrastructure
- Access/boat launch

INFORMATION NEEDS

- Phytoplankton abundance and species composition, preferably at weekly frequency, to determine correct timing (during the exponential growth phase, so must know when algal growth is accelerating)
- Water chemistry
- Must know enough about water chemistry and algae species present to determine most appropriate form of algaecide

IMPLEMENTATION EXAMPLES

There have been numerous algaecide applications in Massachusetts as it is the most used algae control technique. On Cape Cod, a copper-based algaecide was used to control nuisance algae in Perera Pond in Yarmouth.

RESOURCES

- The Massachusetts' Department of Conservation and Recreation's Lakes and Ponds Program provides related resources.

COST ESTIMATE

$$$$

Relative to other in-pond strategies

Varies widely depending on algal population

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting, including algal studies

Implementation: Varies with treatment area and product used

Maintenance: Monitoring for additional blooms and reapplications, as needed

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

ALGAE MANAGEMENT

Ultrasonic

STRATEGY SCALE

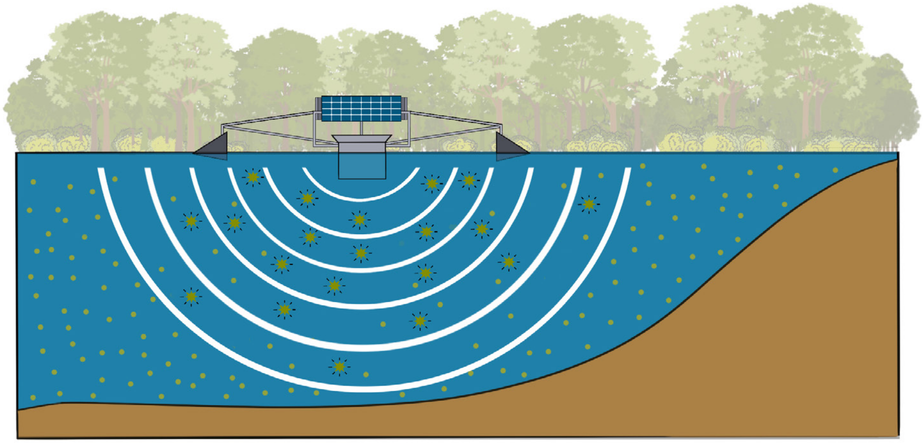
THREATS ADDRESSED	Excess Nutrients	Pollutant Inputs	Algal Blooms	Erosion	Invasive/Nuisance Species
	✗	✗	✓	✗	✗

STRATEGY GOALS

Protect	Manage	Rehabilitate
○	●	●

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
Neutral	Neutral	Neutral



- ✓ **Permittable in Massachusetts**
  Local planning process. List of potential permits available [here](#).
- ✗ **Implemented on Cape Cod**
  See examples of pond projects implemented on Cape Cod [here](#).
- ✗ **Listed in 208 Plan Technologies Matrix**
  Learn more about the nutrient management strategies in the Tech Matrix [here](#).
- ✓ **Can be Performed at Homeowner Scale**
  In small, private ponds. Local review and permitting may be required.
- ✗ **Nature-based Solution**

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
●	○	○

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
●	○	○

DESCRIPTION

Ultrasound refers to sound waves with frequencies higher than the upper audible limit of human hearing. At specific frequencies, these sound waves can be used to control algae growth. Ultrasonic algae control uses a transducer to emit sound waves at specific vibrational frequencies that will interfere with algae. These ultrasonic vibrations pass through the water in an all-around pattern blocking algae's access to sunlight and nutrients or causing the vacuoles inside the algae cells to resonate and break, thus reducing excess levels of algae in a pond.

ADVANTAGES

- Works well on most problem cyanobacteria
- Safe for other aquatic life; no known direct impacts to zooplankton or fish
- Scalable

CONSTRAINTS

- Not all algae affected, ultimately favors resistant algal forms
- Lack of information on the upscaling of ultrasonic for algae control to larger water bodies
- Needs a consistent power supply
- Emerging technology - not well-studied

Ultrasonic

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** Towns may propose ultrasonic algae control in town-managed ponds
- **Pond Groups:** May propose or support ultrasonic algae control in public or private ponds and provide a supportive role through education
- **Private Landowners:** May propose or support ultrasonic algae control
- **Land Trusts:** May provide a supportive role through education

SITING REQUIREMENTS

- Small ponds
- Where certain species of algae are present
- Defined treatment areas or pond-wide

INFORMATION NEEDS

- Phytoplankton abundance and species composition

IMPLEMENTATION EXAMPLES

There have been very few pond applications of ultrasonic algae control in Massachusetts and these have been at small, mostly private ponds.

RESOURCES

- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

$$$$

Relative to other in-pond strategies

Varies depending on size of treatment area

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting

Implementation: Transducers, installation, and power supply

Maintenance: Operations and maintenance including power supply

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

ALGAE MANAGEMENT

Biological Control

STRATEGY SCALE

THREATS ADDRESSED

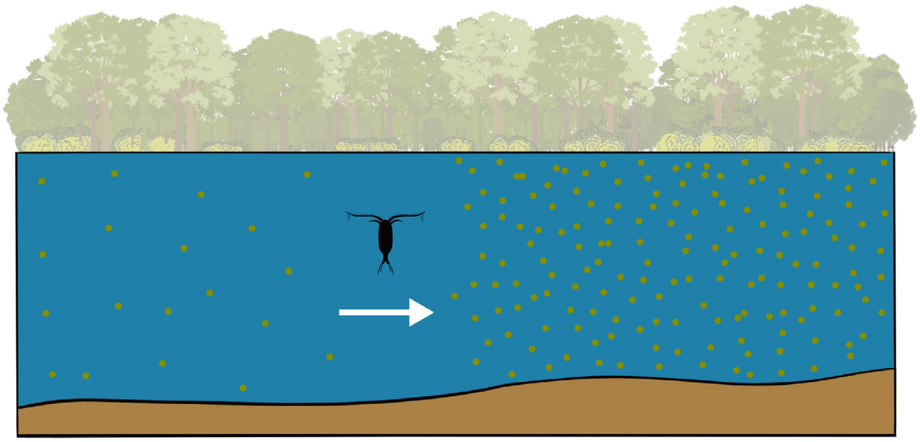
- ✗ Excess Nutrients
- ✓ Algal Blooms
- ✗ Pollutant Inputs
- ✗ Erosion
- ✗ Invasive/Nuisance Species

STRATEGY GOALS

Protect	Manage	Rehabilitate
○	✓	✓

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
⊖ *Neutral*	⊖ *Neutral*	⊖ *Neutral*



✓ **Permittable in Massachusetts**
Depends on biological control agent used. List of potential permits available [here](#).

✗ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod [here](#).

✗ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix [here](#).

✓ **Can be Performed at Homeowner Scale**
Local review and permitting may be required.

✓ **Nature-based Solution**
If native species used

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
○	●	○

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
○	●	○

DESCRIPTION

Biological control of algae involves the introduction of organisms such as bacteria, phages, fungi, zooplankton, or fish to control algae. These biological control agents have adverse effects on algae through infection, predation or production of algicidal compounds. Biological control may reduce excess levels of algae.

ADVANTAGES

- Specific to the target organism
- No direct chemical pollution that might affect humans
- Can be inexpensive to implement at a small scale
- No infrastructure required

CONSTRAINTS

- Not a replacement for nutrient control but can improve conditions where nutrients are not excessive
- Reapplication depends on whether desirable populations can be established
- Limited destruction of target organism and may have impacts on non-target organisms
- Water quality can be indirectly impacted by biological control
- Problems of large-scale production, storage and application
- Successful in lab settings, less understood under field conditions

Biological Control

CAPE COD COMMISSION

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** Towns may propose biological control in town-managed ponds
- **Pond Groups:** May propose or support biological control in public or private ponds and provide supportive role through education
- **Private Landowners:** May propose or support biological control
- **Land Trusts:** May provide supportive role through education

SITING REQUIREMENTS

- All size ponds (scalable)
- Ponds with target organism present
- Ponds that could benefit by food web adjustments that will favor algae control (e.g., low zooplankton body size and biomass, overabundance of panfish)

INFORMATION NEEDS

- Understanding of food web
- A full biological survey and study should be conducted to determine what type of manipulation is best suited to achieve the desired goals while minimizing possible adverse impacts

IMPLEMENTATION EXAMPLES

Biological controls for algae management are not being used in Massachusetts; however, there is a *study being done at Lower Mill Pond in Brewster* on the effects of herring on zooplankton and water clarity.

RESOURCES

- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

**$$-$$$**$

Relative to other in-pond strategies

Varies depending on size of treatment area

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting

Implementation: Biological control agents, application

Maintenance: Monitoring and reapplications, as needed

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

ALGAE MANAGEMENT

Algae Harvesting

In-Pond | Pondshore | Watershed

STRATEGY SCALE

THREATS ADDRESSED

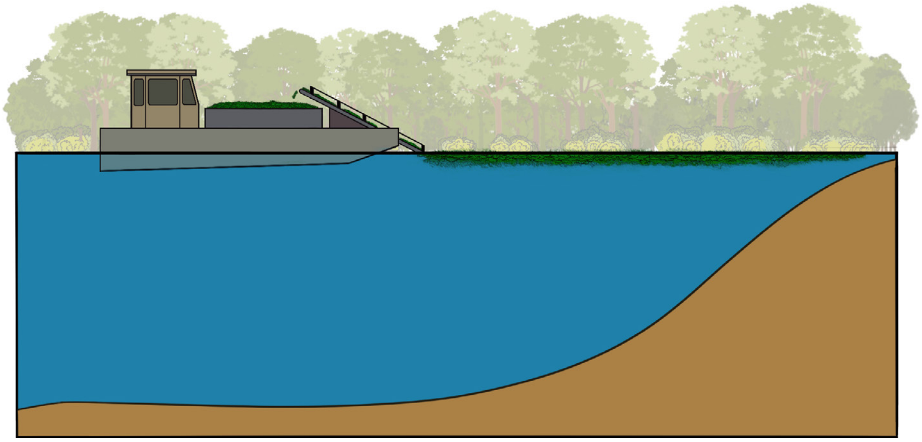
Excess Nutrients	✗
Pollutant Inputs	✗
Algal Blooms	✓
Erosion	✗
Invasive/Nuisance Species	✗

STRATEGY GOALS

Protect	Manage	Rehabilitate
○	✓	✓

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
Neutral	*Improve*	*Improve*



✓ **Permittable in Massachusetts**
Local planning process. List of potential permits available here.

✗ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod here.

✗ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✓ **Can be Performed at Homeowner Scale**
Local review and permitting may be required.

✗ **Nature-based Solution**

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
○	●	○

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
●	○	○

DESCRIPTION

Algae harvesting is the removal of algae and algal mats from a pond by hand or mechanical methods. Algae may be physically removed by various methods including by hand or with a "skimmer." The skimmer is dragged across the surface of the water to collect surface/filamentous algae.

ADVANTAGES

- Effective rapid-response tool
- When done properly, harvesting should not significantly disturb the substrate
- Provides cosmetic control of excessive growth to sustain popular recreational uses

CONSTRAINTS

- Limited track record but some promise
- Non-selective, may also remove desirable organisms
- May need to be performed several times per year
- Provisions must be made to minimize turbidity
- Hand harvesting is not practical for large areas

Algae Harvesting

IMPLEMENTATION

POTENTIAL ACTORS

Towns: Towns may propose algae harvesting in town-managed ponds

Pond Groups: May propose or support algae harvesting in public or private ponds and provide supportive role through education

Private Landowners: May propose or support algae harvesting

Land Trusts: May provide supportive role through education

SITING REQUIREMENTS

- Smaller ponds where whole water volume can be impacted in short time period
- Most useful for small ponds or areas of ponds (e.g., swimming and docking areas)
- Drying and disposal sites

INFORMATION NEEDS

- Phytoplankton abundance and species composition
- Volume of water to be handled on weekly basis
- Bathymetry
- Wind pattern


White Pond in Concord, MA

IMPLEMENTATION EXAMPLES

The Town of Concord has used *trap and removal devices in White Pond* to target, contain, and remove harmful algal blooms, their toxins, excess nutrients, and their total organic carbon content from surface water and sediment.

RESOURCES

- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

Variable

Varies with method, treatment area, and algal density

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting

Implementation: Harvesting equipment, labor

Maintenance: Monitoring and additional harvesting, as needed

POTENTIAL FUNDING SOURCES

- Community Preservation Act
- Capital Budget
- Grants
- Private Funding

Additional information regarding potential funding sources is available *here*.

Shading

STRATEGY SCALE

THREATS ADDRESSED

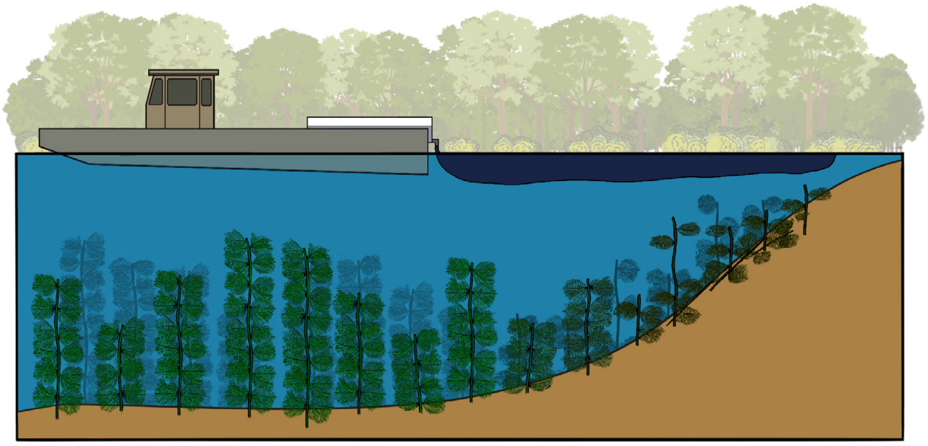
- ✗ Excess Nutrients
- ✗ Pollutant Inputs
- ✓ Algal Blooms
- ✗ Erosion
- ✓ Invasive/Nuisance Species

STRATEGY GOALS

Protect	Manage	Rehabilitate
○	✓	✓

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
Neutral	Neutral	Detrimental



✓ **Permittable in Massachusetts**
Local planning process. List of potential permits available here.

✗ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod here.

✗ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✓ **Can be Performed at Homeowner Scale**
In small, private ponds. Local review and permitting may be required.

✗ **Nature-based Solution**

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
○	●	○

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
○	●	○

DESCRIPTION

Shading uses surface covers or non-toxic vegetable dyes to prevent light penetration into the water column inhibiting algal/plant growth. Shading using surface covers, such as opaque sheet material applied to water surface, inhibits light penetration to prevent algal/vegetative growth. Shading using dyes treats an entire waterbody and is most often used in small (e.g., farm) ponds. Shading is rarely used on large lakes, due in large part to cost considerations. The dye treatment duration is a function of water retention time – when applied to lakes with significant inflow or outflow, dyes will quickly dilute or be flushed downstream. Dyes may persist throughout much of the recreational season, depending on the flushing rate of the lake.

ADVANTAGES

- Non-toxic, quick action, low cost
- Reliability may be high if target area permanently covered (surface covers)
- Produces appealing color and creates illusion of greater depth (dyes)
- Can provide localized (e.g., dockside, swimming areas) control on a temporary (e.g., April - June) basis

CONSTRAINTS

- Short-term solution, not long-term control
- Non-selective, all algae / plants within treatment area affected
- May not control all target species
- May alter thermal regime
- Covers are restricted to areas where there's limited access or ecological interference
- Covers interfere with atmospheric gas exchange and can be aesthetically unpleasing
- Wind and waves may compromise effectiveness of covers
- Dyes are not recommended in highly flushed systems and may require multiple applications
- Public may perceive dyes to be another "toxic chemical"

Shading

CAPE COD COMMISSION

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** Towns may propose shading in town-managed pond docking or swimming areas
- **Pond Groups:** May propose or support shading in public or private ponds and provide a supportive role through education
- **Private Landowners:** May propose or support shading
- **Land Trusts:** May provide a supportive role through education

SITING REQUIREMENTS

- Small shallow ponds or small shallow area of larger pond (e.g., docking or swimming areas)
- No outlet (dyes)
- Long residence time of pond water

INFORMATION NEEDS

- Survey of target plants or algae
- Thermal and oxygen profiles
- Survey of potentially impacted populations

Example dye application

IMPLEMENTATION EXAMPLES

Dyes have been used very rarely in Massachusetts and these have been done at small, mostly private ponds. Covers are not widely used in recreational lakes (generally used in drinking water storage reservoirs) likely because of access restrictions.

RESOURCES

- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

**$-$$**$$

Relative to other in-pond strategies

Cost: Varies with method, materials used, and treatment area

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting

Implementation: Equipment (dye/cover), labor

Maintenance: Monitoring and cover maintenance or dye reapplication, as needed

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

VEGETATION MANAGEMENT

Vegetation Harvesting

STRATEGY SCALE

THREATS ADDRESSED

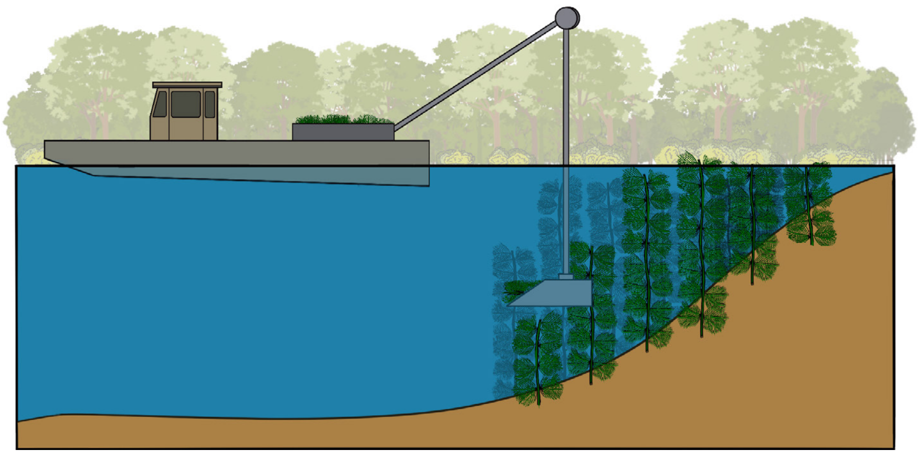
Excess Nutrients	✓
Pollutant Inputs	✓
Algal Blooms	✗
Erosion	✗
Invasive/Nuisance Species	✓

STRATEGY GOALS

Protect	Manage	Rehabilitate
○	✓	✓

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
✗ *Detrimental*	✓ *Improve*	✓ *Improve*



✓ **Permittable in Massachusetts**
Local planning process. List of potential permits available [here](#).

✓ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod [here](#).

✗ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix [here](#).

✓ **Can be Performed at Homeowner Scale**
In small, private ponds. Local review and permitting may be required.

✗ **Nature-based Solution**

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
○	●	○

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
○	○	●

DESCRIPTION

Vegetation harvesting is used to remove nuisance or invasive aquatic plants from a pond by hand or mechanical methods, including hand harvesting, diver harvesting, mechanical harvesting, rotovating, or hydro-raking. Hand harvesting is the most labor intensive and is most effective when used in concert with whole-lake control strategies, or as a follow-up to prevent re-establishment of large beds of weeds. Scuba divers will be required for hand harvesting large plant beds, or for plants growing in water greater than a few feet deep. Mechanical harvesting uses machines to remove the upper portion of rooted aquatic plants, cutting and transporting the vegetation to shore. Rotovating uses a rototilling machine to cut aquatic plants and their roots from the sediment and remove them from the lake. Hydro-raking uses a mechanical rake to collect and remove plants by the root. Collected plants may be placed on shore for composting or other disposal. Harvesting also removes nutrients stored in the plant structure.

ADVANTAGES

- Effective, flexible, inexpensive, non-toxic, and selective rapid-response tool
- When done properly, harvesting should not significantly disturb the substrate
- Harvesting at the sediment level may disrupt plants and provide greater longevity of results or shift to more desirable species
- It is one of the few large-scale options for controlling weeds in lakes where herbicides are not allowed, drawdown and dredging are heavily regulated, and other options are too costly

CONSTRAINTS

- Hand and diver harvesting are labor intensive and not practical for large areas or plants with extensive root systems
- Heavy machinery, potentially high cost, and slow results, may contribute to public dissatisfaction
- All methods may need to be performed several times per year and over several years, depending on the density, growth rates, and types of vegetation
- May cause fragmentation of plants, turbidity and bottom disturbance; therefore, provisions must be made to minimize turbidity and to remove the floating cut plants before they disperse

VEGETATION MANAGEMENT

Vegetation Harvesting

CAPE COD COMMISSION

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** Towns may propose vegetation harvesting in town-managed ponds
- **Pond Groups:** May propose or support vegetation harvesting in public or private ponds and provide a supportive role through education
- **Private Landowners:** May propose or support vegetation harvesting
- **Land Trusts:** May provide a supportive role through education

SITING REQUIREMENTS

- Ponds with nuisance or invasive aquatic plants
- All ponds (littoral zone) for hand-harvesting
- Machine methods can be used in larger and deeper ponds, but depth may be a limiting factor
- Vegetation drying site, preferably near the pond so water can drain back in
- Vegetation disposal sites, preferably away from the shore to minimize re-infestation of the lake - town composting may be a good option if available

INFORMATION NEEDS

- Macrophyte survey (species composition and abundance)
- Mapping of infestation areas to be harvested
- Fragment control plan, harvesting plan, and monitoring plan
- Fish habitat survey
- Drying and disposal sites identified

Credit: Brewster Ponds Coalition

IMPLEMENTATION EXAMPLES

Vegetation harvesting has been implemented at several ponds on Cape Cod, including Walkers Pond and Elbow Pond in Brewster, Mystic Pond in Barnstable, and Schoolhouse/ Ministers Pond in Eastham. At Elbow Pond in Brewster, the Town's harvesting barge was used to remove macrophytes with the goal of removing phosphorus from the sediment and water column.

RESOURCES

- The Massachusetts' Department of Conservation and Recreation's Lakes and Ponds Program provides related resources.

COST ESTIMATE

$-$$$$

Relative to other in-pond strategies

Varies depending on technique used, equipment needed, extent of infestation, and effort required

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting, including macrophyte survey

Implementation: Harvesting equipment, labor

Maintenance: Monitoring and additional harvesting efforts, as needed

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

VEGETATION MANAGEMENT

Benthic Barriers

STRATEGY SCALE

THREATS ADDRESSED

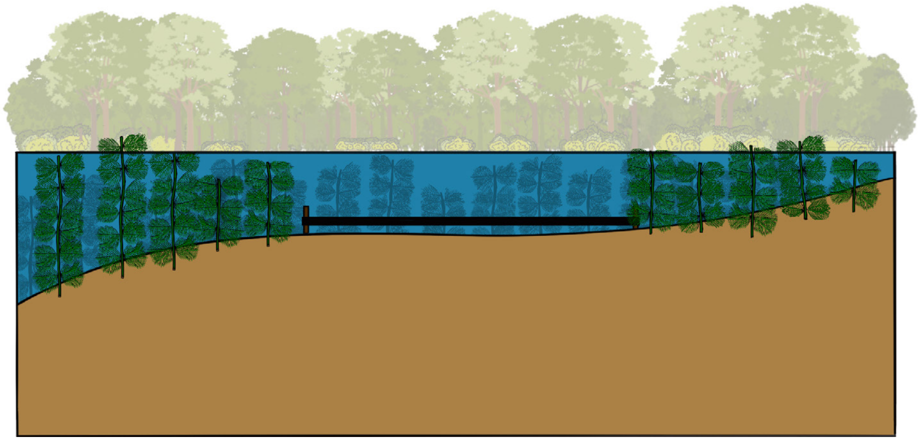
- ✗ Excess Nutrients
- ✗ Pollutant Inputs
- ✗ Algal Blooms
- ✗ Erosion
- ✓ Invasive/Nuisance Species

STRATEGY GOALS

Protect	Manage	Rehabilitate
○	✓	✓

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
Detrimental	*Neutral*	*Neutral*



✓ **Permittable in Massachusetts**
Local planning process. List of potential permits available here.

✓ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod here.

✗ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✓ **Can be Performed at Homeowner Scale**
In small, private ponds. Local review and permitting may be required.

✗ **Nature-based Solution**

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
○	○	●

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
○	●	○

DESCRIPTION

A benthic barrier, or bottom cover, is a mat of variable composition placed on top of plants on the pond bottom. The barrier composition can be porous or non-porous synthetic materials, or sediment (also see “dredging - reverse-sediment layering”). The benthic barrier prevents plant growth by blocking light from penetrating to the bottom, physically disrupting growth, and allowing unfavorable chemical reactions to interfere with plant development. Barriers can be temporary or permanent and are usually applied in high-use areas - around boat docks or launches and swimming areas.

ADVANTAGES

- Useful on localized basis, limit to <10% of littoral zone
- Good for small areas near docks or beaches without affecting the rest of the waterbody
- Can be an effective management strategy, particularly when plant densities are low
- Non-toxic, and can be flexible and selective
- Can improve fish habitat by creating edge effects

CONSTRAINTS

- Difficult to install and maintain - need to inspect often
- May be damaged by boat anchors
- Must anchor barrier as gases from plant decomposition may cause the barrier to float up
- May kill everything under the barrier, not just target species
- May cause anoxia at sediment-water interface
- May inhibit fish spawing/feeding, and may be harmful to benthic community
- Upon barrier removal, area prone to recolonization by invasive species

Benthic Barriers

IMPLEMENTATION

POTENTIAL ACTORS

Towns: Towns may propose the use of benthic barriers in town-managed ponds

Pond Groups: May propose or support benthic barriers in public or private ponds and provide a supportive role through education

Private Landowners: May propose or support benthic barriers

Land Trusts: May provide a supportive role through education

SITING REQUIREMENTS

- Ponds with nuisance or invasive aquatic species
- Often limited to areas of either intensive recreational activities or strong aesthetic concern

INFORMATION NEEDS

- Macrophyte survey (species composition and abundance)
- Mapping of infestation areas to be covered (area to be covered as % of littoral zone)
- Fish habitat survey


Credit: Red Lily Pond Association

IMPLEMENTATION EXAMPLES

The Red Lily Pond Project Association installed a *"Lake Blanket"* in Lake Elizabeth in Barnstable to prevent regrowth of plants where macrophytes had been cut and removed and in the area of a new dock.

RESOURCES

- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

**$$**$$

Relative to other in-pond strategies

Varies depending on material used and maintenance required

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting, including macrophyte survey

Implementation: Material, labor

Maintenance: Inspecting and patching or replacing material, as needed

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

VEGETATION MANAGEMENT

Herbicide

In-Pond | Pondshore | Watershed

STRATEGY SCALE

THREATS ADDRESSED

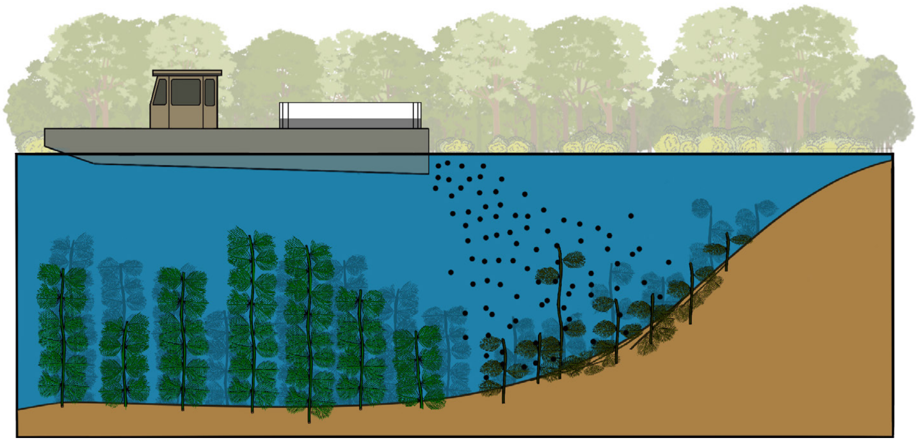
Excess Nutrients	Pollutant Inputs	Algal Blooms	Erosion	Invasive/Nuisance Species
✗	✗	✗	✗	✓

STRATEGY GOALS

Protect	Manage	Rehabilitate
○	✓	✓

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
Detrimental	Neutral	Neutral



✓ **Permittable in Massachusetts**
Local planning process. List of potential permits available here.

✓ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod here.

✗ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✓ **Can be Performed at Homeowner Scale**
In small, private ponds. Local review and permitting may be required.

✗ **Nature-based Solution**

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
○	●	○

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
○	○	●

DESCRIPTION

Herbicides are used in ponds to kill or interfere with problem plants. Only herbicides registered for use in Massachusetts through the Department of Agricultural Resources (DAR) may be used, and then only by licensed applicators with proper permits. An updated list of registered herbicides can be obtained from DAR. Herbicides (e.g., copper-based herbicides, diquat, endothall, Aquathol K, glyphosate, 2,4-D, fluoridone, triclopyr, flumioxazin, ProcellaCOR, imazapyr, imazamox, carfentrazone, metsulforn) kill macrophytes or inhibit their normal growth through direct toxic reactions or by hampering their photosynthetic ability. Some chemicals are species-specific and others affect a broad spectrum of plants. Some are contact herbicides, toxic to only those parts of the plant contacted by the herbicide, and others are systemic herbicides that affect the plant's metabolic growing processes.

ADVANTAGES

- Very effective technique for controlling invasive species
- Ideal for large areas, but may also be used to spot treat specific plants
- Can restore balance to plant community
- Can open areas for human access and recreation

CONSTRAINTS

- Herbicides, herbicide residues and degradants may be toxic and may affect pond water quality
- Some herbicides are non-specific, killing all (or most) plants in the treatment area
- Herbicide applications must be properly timed to correlate with lake conditions, plant life cycles and recreational uses of a lake
- Reapplication(s) may be necessary and plants may develop resistance to herbicides
- Decomposing plant matter may release nutrients and decrease oxygen levels in the water

Herbicide

CAPE COD COMMISSION

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** Towns may propose the use of herbicides in town-managed ponds
- **Pond Groups:** May propose or support the use of herbicides in public or private ponds and provide a supportive role through education
- **Private Landowners:** May propose or support the use of herbicides
- **Land Trusts:** May provide a supportive role through education

SITING REQUIREMENTS

- All ponds with nuisance or invasive plant species present (littoral zone)
- Access/launch site for herbicide application vessel

INFORMATION NEEDS

- Macrophyte survey (species composition and abundance)
- Choice of herbicide to maximize intended effect while minimizing non-target impacts
- Fish habitat survey

Hydrilla from Long Pond/Mystic Lake

IMPLEMENTATION EXAMPLES

Herbicides have been applied in many ponds in Massachusetts, including several on Cape Cod. For example, the Town of Barnstable has used herbicides in Long Pond and Mystic Lake to control Hydrilla (*Hydrilla verticillata*).

RESOURCES

- The Massachusetts' Department of Conservation and Recreation's Lakes and Ponds Program provides related resources.

COST ESTIMATE

$$$$

Relative to other in-pond strategies

Varies depending on chemical used and area to be treated

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting, including macrophyte survey

Implementation: Chemical, application equipment, and labor

Maintenance: Monitoring and reapplication, as needed

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

VEGETATION MANAGEMENT

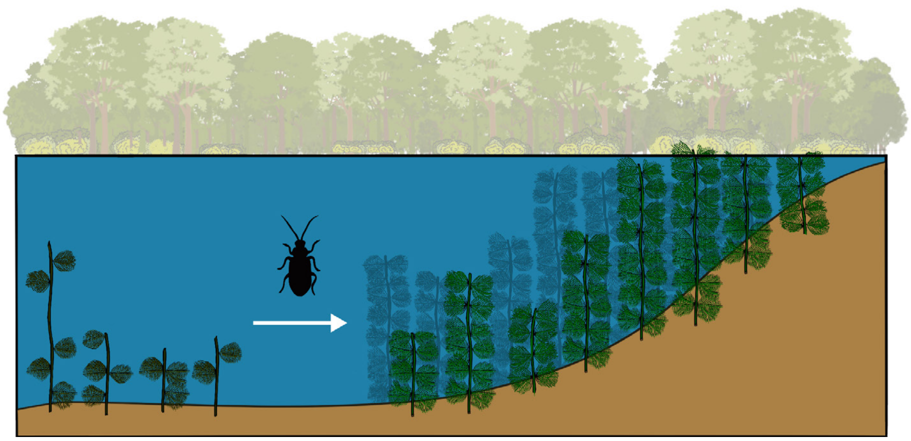
Biocontrol

STRATEGY SCALE

THREATS ADDRESSED					
	✗ Excess Nutrients	✗ Pollutant Inputs	✗ Algal Blooms	✗ Erosion	✓ Invasive/Nuisance Species

STRATEGY GOALS	Protect	Manage	Rehabilitate
	○	●	●

STRATEGY CO-BENEFITS	Habitat	Aesthetics	Recreation
	Neutral	*Neutral*	*Neutral*



Permittable in Massachusetts
Limited. Insects are permitted. Fish and pathogens are not. Local planning process. List of potential permits available here.

Implemented on Cape Cod ✓
See examples of pond projects implemented on Cape Cod here.

Listed in 208 Plan Technologies Matrix ✗
Learn more about the nutrient management strategies in the Tech Matrix here.

Can be Performed at Homeowner Scale ✓
In small, private ponds. Local review and permitting may be required.

Nature-based Solution ✓
If native species used.

DURATION OF BENEFITS	Less than one month	One season or year	Multiple seasons or years
	○	●	○

MAINTENANCE REQUIREMENTS	Monthly	Annually	Infrequent
	○	●	○

DESCRIPTION

Biocontrol involves the introduction of herbivorous fish (e.g., grass carp, tilapia), insects (e.g., milfoil moth, milfoil weevil, root boring weevil, leaf beetles, loosestrife beetle), or pathogens (e.g., fungi, bacteria, viruses) to a pond to consume aquatic plants and reduce excess levels of nuisance or invasive aquatic species. Biocontrol harnesses biological interactions to produce desired conditions. In Massachusetts, some insect biocontrol agents are permitted, while fish and pathogens are not permitted. Effectiveness and potential impacts of plant pathogens are not well understood.

ADVANTAGES

- Use of herbivorous biocontrol agents is low maintenance and unobtrusive
- Can involve species native to region, or even targeted lake
- Expected to have no negative effect on non-target species
- Plant biomass is reduced slowly, minimizing risk of oxygen loss
- Duration of benefits extended with self-sustaining population

CONSTRAINTS

- There is a fundamental biological limitation to this approach as control agents do not eliminate their targets, so oscillating cycles are common, making this technique generally unreliable
- Any introduction of organisms may have imperceptible impacts on water quality, the aquatic community structure and food web
- Often involves introduction of non-native species and generally not self-sustaining
- Biocontrol agents may adversely affect non-target species
- May eliminate all plant biomass, funneling energy into algae
- Logistical difficulties with producing and distributing biocontrol agents

Biocontrol

CAPE COD COMMISSION

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** Towns may propose the use of biocontrols in town-managed ponds
- **Pond Groups:** May propose or support the use of biocontrols in public or private ponds and provide a supportive role through education
- **Private Landowners:** May propose or support the use of biocontrols
- **Land Trusts:** May provide a supportive role through education

SITING REQUIREMENTS

- Ponds with target nuisance or invasive aquatic species present and susceptible to available biocontrol species
- Ponds with no surface connections and little concern for unintended consequences
- Permitting issues affect use in MA, especially for fish and pathogens

INFORMATION NEEDS

- Macrophyte survey (species composition and abundance)
- A full biological survey and study should be conducted to determine what type of manipulation is best suited to achieve the desired goals while minimizing possible adverse impacts

Purple Loosestrife

IMPLEMENTATION EXAMPLES

In the 2000's, the State and partners initiated a *Purple Loosestrife Biocontrol Project*. The Galerucella beetle was introduced to control purple loosestrife, an invasive wetland plant species that invades areas and excludes native species from growing. On Cape Cod, Great Pond in Eastham was included in the project. The beetles consumed the loosestrife and kept it from spreading into other ponds in the area.

RESOURCES

- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

**$-$$**$$

Relative to other in-pond strategies

Varies depending on biocontrol agent used, magnitude of application, monitoring requirements, and mitigative measures

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting, including full biological survey

Implementation: Biocontrol agent, logistics

Maintenance: Monitoring, mitigation, and reapplication, as needed

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available ***here***.

VEGETATION MANAGEMENT

Water Drawdown

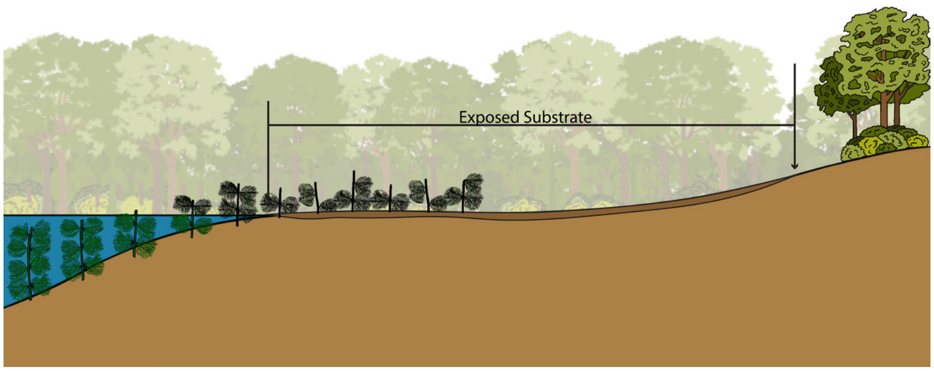
STRATEGY SCALE

THREATS ADDRESSED

- ✗ Excess Nutrients
- ✗ Pollutant Inputs
- ✗ Algal Blooms
- ✗ Erosion
- ✓ Invasive/Nuisance Species

STRATEGY GOALS	Protect	Manage	Rehabilitate
	○	✓	✓

STRATEGY CO-BENEFITS	Habitat	Aesthetics	Recreation
	✗ *Detrimental*	⊖ *Neutral*	⊖ *Neutral*



✓ **Permittable in Massachusetts**
Local planning process. List of potential permits available here.

✗ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod here.

✗ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✓ **Can be Performed at Homeowner Scale**
In small, private ponds. Local review and permitting may be required.

✗ **Nature-based Solution**

DURATION OF BENEFITS	Less than one month	One season or year	Multiple seasons or years
	○	●	○

MAINTENANCE REQUIREMENTS	Monthly	Annually	Infrequent
	○	●	○

DESCRIPTION

Water drawdown is the winter manipulation of lake water level to expose rooted aquatic vegetation and sediments to the freezing and drying action of cold air to reduce excess levels of nuisance or invasive aquatic species. It requires draining large volumes of water for extended periods of time. Lower water levels create an inhospitable environment for nuisance or invasive aquatic plants, providing seasonal vegetation control, and creating opportunities for beneficial plants. Water drawdown disrupts plant life cycles by desiccation or freezing. Plants that reproduce by seeds are less susceptible to drawdown than plants that reproduce by rhizomes and other vegetative means. Over the longer-term (decades), water drawdown can change the substrate composition.

ADVANTAGES

- Simple management strategy for smaller lakes for which water levels can be fully controlled
- Magnitude, duration, and frequency of drawdown are major variables; few impacts documented in MA where average drawdown is 2-3 ft.
- Provides widespread control in increments of water depth
- Public response is generally favorable due to the low cost and the winter timing that does not interfere with summer recreation
- Non-toxic, no chemicals or significant mechanical equipment used

CONSTRAINTS

- Draining large volumes of water for extended periods of time may be impractical and may have non-target impacts
- Weather conditions may alter effectiveness - most effective if combined with freezing
- Groundwater seepage may mitigate or negate destructive effects on target submergent species
- Not species specific and variable species tolerance to drawdown
- Can negatively affect benthic and fish habitat and adjacent wetlands
- Should be used every other year or twice every three years to discourage the establishment of resistant plant species
- Removal of sediment-anchoring plants along the shoreline has the potential to increase turbidity, erosion or re-suspension of sediments and nutrients
- If too much water is removed, or there's drought, water levels may take a long time to return to normal levels

Water Drawdown

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** Towns may propose water drawdown in town-managed ponds
- **Pond Groups:** May propose or support the use of water drawdown and provide a supportive role through education
- **Private Landowners:** May propose or support the use of water drawdown
- **Land Trusts:** May provide a supportive role through education

SITING REQUIREMENTS

- Ponds with substantial littoral zone with excessive nuisance or invasive plants and soft substrate

INFORMATION NEEDS

- Macrophyte survey (species composition and abundance)
- Fish habitat survey
- Timing, duration of exposure, and degree of dewatering


Water level drawdown example
Credit: Door County, WI

IMPLEMENTATION EXAMPLES

Water drawdown has not been implemented on Cape Cod, but is a common management strategy in other Massachusetts lakes. Information on the impacts of water drawdown can be found in the research article *here*.

RESOURCES

- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

**$-$$$**$

Relative to other in-pond strategies

Varies depending on if water level controls need to be installed and magnitude of drawdown

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting, including macrophyte survey

Implementation: Water level controls, pumps

Maintenance: Monitoring and maintenance of water level controls and pumps, reapplications, as needed

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

VEGETATION MANAGEMENT

UV-C Light Exposure

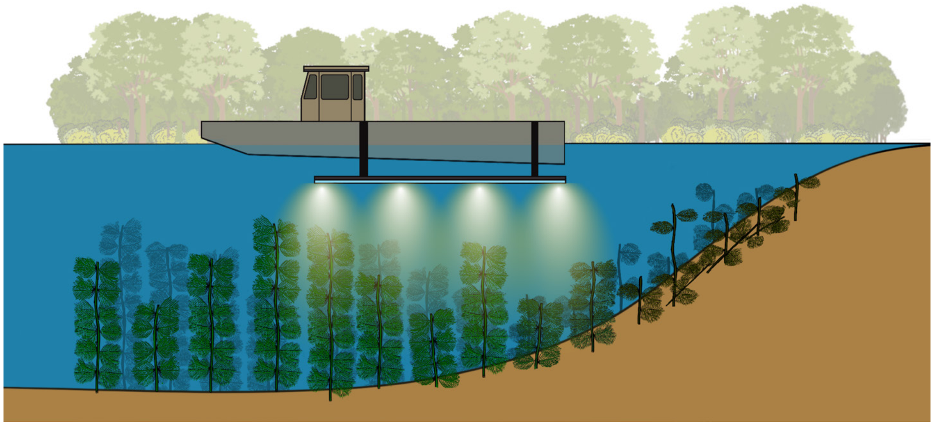
In-Pond | Pondshore | Watershed

STRATEGY SCALE

THREATS ADDRESSED: Excess Nutrients ✗ | Pollutant Inputs ✗ | Algal Blooms ✗ | Erosion ✗ | Invasive/Nuisance Species ✓

STRATEGY GOALS: Protect ○ | Manage ✓ | Rehabilitate ✓

STRATEGY CO-BENEFITS: Habitat – Neutral | Aesthetics – Neutral | Recreation – Neutral



✗ **Permittable in Massachusetts**
Not permitted in MA. List of potential permits available here.

✗ **Implemented on Cape Cod**
See examples of pond projects implemented on Cape Cod here.

✗ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✓ **Can be Performed at Homeowner Scale**
In small, private ponds. Local review and permitting may be required.

✗ **Nature-based Solution**

DURATION OF BENEFITS: Less than one month ○ | One season or year ● | Multiple seasons or years ○

MAINTENANCE REQUIREMENTS: Monthly ○ | Annually ● | Infrequent ○

DESCRIPTION

UV-C light is used to treat microbes and other living organisms and is used in applications such as food, air and water purification. UV-C light is a short-wave electromagnetic radiation light that damages the DNA and cellular structure of organisms. In a pond setting, UV-C light can be used to control aquatic plants and their fragments. Exposing plants to UV-C light kills the plants, reducing excess levels of nuisance or invasive aquatic species.

ADVANTAGES

- May remove undesirable species, improving aesthetics, habitat, and recreational access
- May kill plants in 7-14 days after exposure to UV-C light
- May treat an acre a day depending on the size of the light array, number of barges, and crew
- Non-toxic

CONSTRAINTS

- Timing, temperature, and water quality all play a role in treatment effectiveness
- Macrophytes should be treated early in the growing season and treatment may need to be conducted several times throughout a season or multiple seasons - plant height and density may predicate additional treatments
- Optimum intensity and duration of UV-C light treatment may not be known
- UV-C light does not penetrate the sediment, so roots may be shielded
- Requires specialized equipment - lights, barge(s), fish deterrents
- Non-selective and not well-studied

UV-C Light Exposure

CAPE COD COMMISSION

IMPLEMENTATION

POTENTIAL ACTORS

- **Towns:** May propose UV-C in town-managed ponds
- **Pond Groups:** May propose or support the use UV-C in public or private ponds and provide a supportive role through education
- **Private Landowners:** May propose or support the use of UV-C
- **Land Trusts:** May provide a supportive role through education

SITING REQUIREMENTS

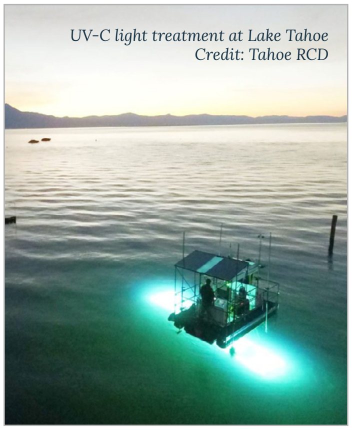
- All ponds with excessive nuisance or invasive plants (littoral zone)
- Access/launch site

INFORMATION NEEDS

- Macrophyte survey (species composition and abundance)
- Fish habitat survey

IMPLEMENTATION EXAMPLES

UV-C light treatment has not been used in Massachusetts. In Lake Tahoe, California, the use of UV-C light has been tested at *Lakeside Marina and Lakeside Beach* to treat Eurasian watermilfoil and curly-leaf pondweed. The results from the project support initial laboratory findings that the application of UV-C light results in observed mortality of submerged aquatic plants, both in an enclosed waterbody (i.e., marinas) and open waterbody (i.e., beach littoral) systems.



RESOURCES

- The Massachusetts' Department of Conservation and Recreation's *Lakes and Ponds Program* provides related resources.

COST ESTIMATE

Variable

Varies depending on treatment area and equipment costs

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting, including macrophyte survey

Implementation: Equipment, logistics

Maintenance: Monitoring and maintenance of equipment, reapplications, as needed

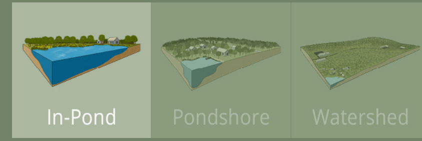
POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.

FISHERIES MANAGEMENT

Liming



STRATEGY SCALE

THREATS ADDRESSED

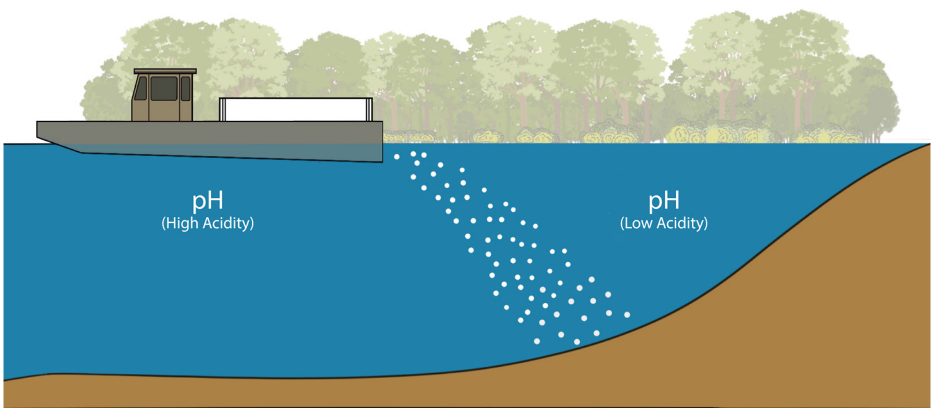
Excess Nutrients	✗
Pollutant Inputs	✓
Algal Blooms	✗
Erosion	✗
Invasive/Nuisance Species	✗

STRATEGY GOALS

Protect	Manage	Rehabilitate
○	✓	✓

STRATEGY CO-BENEFITS

Habitat	Aesthetics	Recreation
Detrimental	*Neutral*	*Neutral*



✗ **Permittable in Massachusetts**
Not permitted in MA. List of potential permits available here.

✓ **Implemented on Cape Cod**
Implemented in the 1980's on Cape Cod. See more current examples of pond projects implemented on Cape Cod here.

✗ **Listed in 208 Plan Technologies Matrix**
Learn more about the nutrient management strategies in the Tech Matrix here.

✓ **Can be Performed at Homeowner Scale**
In small, private ponds. Local review and permitting may be required.

✗ **Nature-based Solution**

DURATION OF BENEFITS

Less than one month	One season or year	Multiple seasons or years
○	●	○

MAINTENANCE REQUIREMENTS

Monthly	Annually	Infrequent
○	○	●

DESCRIPTION

Lime is applied to pond to stabilize water chemistry. Fish spawning and water quality can be impacted by low pH and liming is used to mitigate effects of acidification and aid in fisheries management. Liming directly increases alkalinity, and the total concentration of bases is usually made up of bicarbonate and carbonate. Alkalinity concentrations are important in any fishery because they indicate the water's ability to neutralize acid and stabilize pH. Liming neutralizes acid waters and can be an effective stopgap measure to maintain fish on a small scale in otherwise acidic lakes and ponds; however, liming has the potential to cause harm to other aquatic organisms, limiting its appropriateness and effectiveness.

ADVANTAGES

- Liming a pond to maintain consistent and optimal alkalinity concentrations can improve ecosystem health and maximize fish growth

CONSTRAINTS

- Raising pH may favor species previously not present or abundant and invites algal blooms
- Has the potential to alter the species composition of phyto- and zooplankton and benthic invertebrates
- Duration of benefit affected by degree of ongoing acid inputs
- Alters water chemistry
- Not "natural"

Liming

CAPE COD COMMISSION

IMPLEMENTATION

POTENTIAL ACTORS

Towns: Towns may propose liming in town-managed ponds

Pond Groups: May propose or support the use liming in public or private ponds and provide a supportive role through education

Private Landowners: May propose or support the use of liming

Land Trusts: May provide a supportive role through education

SITING REQUIREMENTS

- Ponds where pH is low and fish production is primary goal

INFORMATION NEEDS

- Water chemistry
- Fisheries survey

IMPLEMENTATION EXAMPLES

Concerns about acid rain and its impacts on fish populations led to the addition of ground limestone in many stocked trout ponds in the 1980s, including several ponds on Cape Cod. The passage of clean air legislation has led to a notable reduction in acid rain impacts to Cape Cod ponds and reduced the need for liming.

RESOURCES

- The Massachusetts' Department of Conservation and Recreation's Lakes and Ponds Program provides related resources.

COST ESTIMATE

Variable

Varies depending on treatment area

ADDITIONAL FINANCIAL CONSIDERATIONS

Assessment: Planning, design, and permitting

Implementation: Cost of lime, logistics

Maintenance: Monitoring and reapplications, as needed

POTENTIAL FUNDING SOURCES

- **Community Preservation Act**
- **Capital Budget**
- **Grants**
- **Private Funding**

Additional information regarding potential funding sources is available *here*.