Rapid Response Plan For Invasive Aquatic Plants, Fish, and Other Fauna

PART 1: PLANT PROTOCOL

Maine Department of Environmental Protection

In coordination with the

Maine Department of Inland Fisheries and Wildlife and Maine Department of Conservation

January 2006

Acknowledgements

This Rapid Response Plan is the result of a collaborative effort among the Maine Departments of Environmental Protection, Inland Fisheries and Wildlife, and Conservation. H. Dominie Consulting, with assistance on fish and permitting matters from E/PRO Consulting, drafted the plan following guidance from agency personnel. Pinegrove Associates provided production help. We also thank the many states, other jurisdictions, and researchers upon which the plan draws heavily, especially those who provided technical comments on Appendices C and D including Ken Wagner (ENSR Corporation), Lars Anderson (USDA-ARS Exotic and Invasive Weed Research Weed Science Program, UC Davis, CA), Ann Bove (VTDEC), Kathy Hamel (Washington DECY), Roberta Hill (Maine Volunteer Lakes Monitoring Program/Maine Center for Invasive Aquatic Plants), John Madsen (MSU), Gerald Nelsen, and Scott Williams (Maine Volunteer Lakes Monitoring Program/Maine Center for Invasive Aquatic Plants). We are grateful for their experience and knowledge. Lastly, we thank the U.S. Department of Interior Fish and Wildlife Service for the grant that made this project possible.

Contributors

Maine Department of Environmental Protection
Dawn R. Gallagher, Commissioner (through December 2005)
John McPhedran, Project Manager, Invasive Aquatic Species Coordinator, Division of Environmental Assessment
Roy Bouchard, Steering Committee member, Lake Assessment Section Leader, Division of Environmental Assessment
Andrew Fisk, Director, Bureau of Land and Water Quality
Michael Mullen, Director of Enforcement and Field Services, Division of Water Resource Reg.
Robert Stratton, Licensing, Division of Water Resource Regulation

Maine Department of Inland Fisheries and Wildlife
Roland D. Martin, Commissioner
John Boland, Steering Committee member, Director of Operations, Fisheries Division
Peter Bourque, Steering Committee member, Director of Program Development
Colonel Tim Peabody, retired Chief Maine Warden Service, currently Associate Professor of Conservation Law Enforcement at Unity College
Colonel Tom Santaguida, Chief Maine Warden Service

Maine Department of Conservation
Patrick McGowan, Commissioner
George Powell, Director, Boating Facilities Division
Tim Thurston, Navigation Aids Supervisor, Boating Facilities Division

Maine Office of the Attorney General
Jeff Pidot, Assistant Attorney General

Consultants

H. Dominie Consulting, Readfield, Maine
E/PRO Engineering and Environmental Consulting, LLC, Augusta, Maine
Pinegrove Associates, Winthrop, Maine (document design and formatting)

Interagency Agreement

The Departments of Environmental Protection and Inland Fisheries and Wildlife agree to implement this plan when responding rapidly to new introductions of aquatic invasive species.

ADOPTED BY:

______________________________	______________________________
David Littell, Commissioner Department of Environmental Protection	Roland D. Martin, Commissioner Department of Inland Fish and Wildlife
____________________	____________________
Date	Date

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Part 1 - Invasive Aquatic Plant Protocol

Introduction

This Rapid Response Plan implements a key task identified in Maine's *Action Plan for Managing Invasive Aquatic Species*, which was adopted by the Interagency Task Force on Invasive Aquatic Plants and Nuisance Species and the Land and Water Resources Council in 2002. It is intended to ensure that appropriate protocols, trained personnel, equipment, permits, and other resources are ready to go to contain or eradicate newly detected illegal aquatic plant or animal introductions as they are reported to or discovered by agency personnel.

The plan is an administrative blueprint for appropriate state agencies to work together and separately. The Department of Inland Fisheries and Wildlife (DIFW) has lead responsibility for fish and aquatic fauna; and the Department of Environmental Protection (DEP) has the same for aquatic plants. Both agencies will work with the Department of Conservation when surface use restrictions or other response initiatives affect state facilities and are needed to facilitate rapid control or eradication. They will also inform and include the public and affected parties, to the extent practical or as stipulated in statute, in the process.

Rapid response goes hand-in-hand with early detection. The Maine Department of Environmental Protection (DEP) in partnership with the Maine Volunteer Lake Monitoring Program and Maine Center for Invasive Aquatic Plants has established the Plant Patroller Program to train professionals and lake watchers to be on the lookout for invasive aquatic plants. Wildlife and Fisheries Biologists of the Department of Inland Fisheries (DIFW) receive reports about fish and other fauna.

Rapid Response Goals

The primary goal of rapid response deployment is to initiate eradication efforts (which may take years to complete) or critical interim measures to achieve effective containment while a longer term eradication or suppression strategy is formulated. This means mobilizing and deploying as quickly as possible to address a newly detected aquatic invasive plant *within the first season of detection, and, preferably, to treat the infestation in less than 30 days*. Inherent in rapid response is the need to use physical techniques or chemical treatments that can knock out an invasive species before it has a chance to proliferate, providing such techniques or treatments are practical and pose little risk to rare or endangered species or human health. We acknowledge that, in the short run, commonly occurring native communities may be compromised, or surface uses may be curtailed, but believe that these are acceptable tradeoffs to avoid spreading such harmful species to other parts of a water body or other waters of the state.

To the extent possible, treatment plans which are developed during rapid response operations will look beyond the first season of detection to identify a longer term strategy that will best take into account the nature of the species, site conditions, and efficacy of treatment and monitoring methods. In some instances, a rapid response assessment may point to the need for longer term surface use restrictions to limit the spread of infestations which prove impossible to eradicate.

Principles

To achieve rapid response, the agencies will follow the principles below. Rapid response initiatives will:

1. reflect sound biology and the particular situation;
2. strive for eradication as the primary goal of all rapid response deployments; be prepared to shift to a longer term "management" strategy if needed to achieve eradication or, if unsuccessful, shift to suppression;
3. facilitate fast action and interagency decision-making at the lowest level possible;
4. be a priority for staff attention so that water use restrictions may be lifted as soon as possible;
5. minimize infringement on public access, parks, and other facilities;
6. be fair and safe to all users;
7. use personnel and resources efficiently; and
8. be flexible, varying the protocol to accomplish steps concurrently or out of order as needed.

The agencies will consult the public early in the process, to the extent practical. In some instances, the agencies may need to proceed with minimal public notification in order to protect valued public resources and/or public safety, even if a proposed treatment plan is controversial.

Plan Organization

The plan is organized into two parts by area of responsibility.

Part 1. The protocol that will guide DEP in rapid response initiatives for plants is contained in Part 1. Appendices pertain to treatment techniques, species-appropriate techniques, and interagency agreements that facilitate fast action. In the future, there may also be appended operations checklists for selected techniques and a general permit for the application of herbicides under prescribed conditions.

Part 2. Part 2, under separate cover, contains similar information to guide the Department of Inland Fisheries and Wildlife (DIFW). While this plan focuses on fish, it does not preclude the department from using the same kind of procedures to respond quickly to other faunal infestations such as zebra mussels, though the appropriate treatment techniques will vary and must be further researched. Part 2 appendices include an analysis of treatment options, a draft general permit for rotenone application, and a bibliography.

Planning Process

DEP and DIFW initially formed a steering committee for the purpose of creating a streamlined and coordinated approach to mounting rapid response efforts. DEP contracted with H. Dominie Consulting for assistance in facilitating the process and drafting the plan.

The first step was to collect information and discuss issues of mutual concern. Toward this end, H. Dominie Consulting (Dominie) and E/PRO Engineering and Environmental Consulting, LLC

(E/PRO), surveyed the literature and contacted people with experience on rapid response planning and eradication techniques. Dominie also worked with the steering committee and DOC's Boating Facilities Program staff to identify issues and an approach for the imposition of surface use restriction orders as well as the placement of regulatory markers. In addition, E/PRO consulted with DEP and DIFW to identify the legal obstacles which now prevent DEP from issuing a general permit to apply a herbicide in rapid response. E/PRO also drafted a general permit for rotenone for application if such obstacles are overcome.

When this information was compiled, the team drafted response protocols for plants and fish. Each agency representative was responsible for making sure that others in their agency reviewed relevant provisions of their part of the plan as it was developed.

The final step will be for the Commissioners of DEP, DIFW, and DOC to review the plan and meet to discuss any concerns and/or desired changes they may wish to make. Following agreement on final provisions, and assuming no intransigent issues, the Commissioners will adopt the plan and charge their respective staffs with its coordinated implementation.

Plan Update, Evaluation, and Monitoring

DEP will be responsible for initiating an interagency effort to review the effectiveness of the plan at least every five years, but each agency may insert new information or make other adjustments excepting policy changes to their respective parts at any time with consultation with other agencies. It is to be a working and evolving document, improved over time through experience in Maine and elsewhere. Each agency will informally monitor how well the plan works. They will engage participants in evaluating the results of each specific rapid response initiative to learn from, and make adjustments to, the process.

The agencies will report progress annually to their Commissioners and the Invasive Aquatic Species Task Force, and recommend policy changes as necessary. The report will cover such topics as:

1. number, type, and results of response initiatives undertaken;
2. interagency coordination;
3. procedures and techniques;
4. staff training and responsiveness;
5. availability and deployment of resources;
6. overall costs and benefits of the approach;
7. unforeseen obstacles to the implementation of the plan and steps taken to overcome such obstacles; and recommendations for changes to the plan.

Overview of Part 1: Plant Protocol

The Department of Environmental Protection (DEP) will follow the procedures described in this part of Maine's Rapid Response Plan in responding to a newly detected invasive aquatic plant, unless unusual circumstances, such as its occurrence within a national park boundary, dictate working in a different way or deferring to another agency. The Invasive Aquatic Species Coordinator will manage DEP's response to a new outbreak following the five steps listed on the next page. As stipulated in the introduction, the primary goal of rapid response will be to knock out or contain (if more time is needed to prepare for eradication) the species within the first season of detection, and, preferably, initiate treatment in less than 30 days.

Advance Preparation for Rapid Response to Plant Infestations

Before a call comes in, DEP will have completed general preparations to ensure that all resources needed to achieve a rapid response are in place. Accordingly, DEP will:

1. **Equipment and Materials.** Complete procurement of needed equipment and materials for the most likely scenarios and keep them ready and in good order,

2. **Operations Checklists and Reporting Mechanism.** Develop checklists for techniques that will most likely be used to aid staff in carrying out rapid response initiatives. Also create a link from the DEP website to the Maine Center for Invasive Aquatic Plants reporting form,

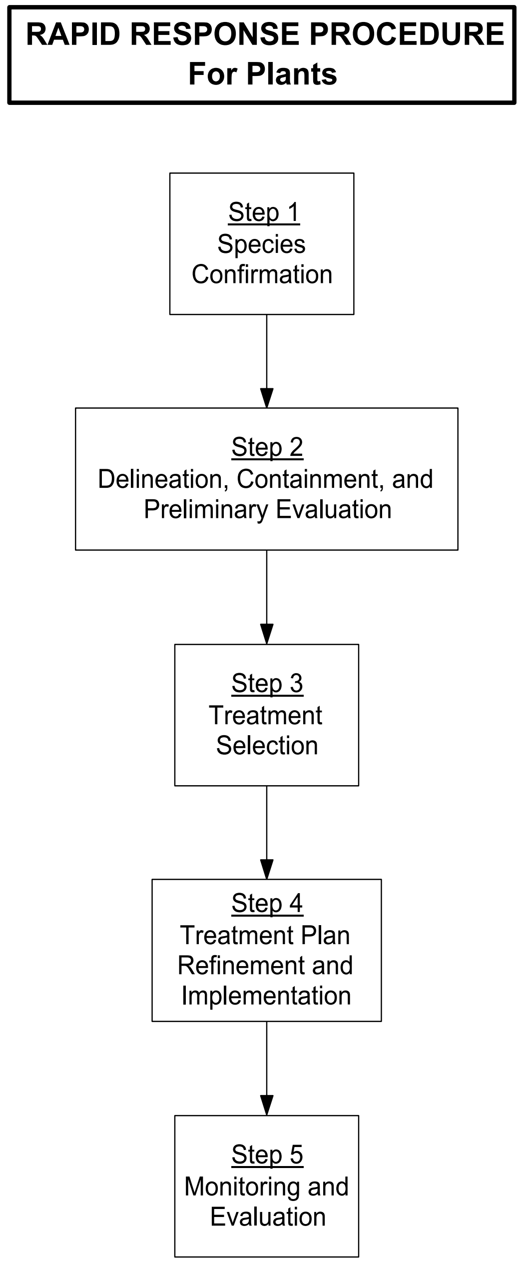
3. **Identification Experts.** Enter into an arrangement(s) with experts who will be on call to identify specimens which DEP and its cooperators (see Step 1) cannot positively ID,

4. **Permit(s).** Complete applications for general permits for the application of selected herbicides during rapid response initiatives (see Step 2),

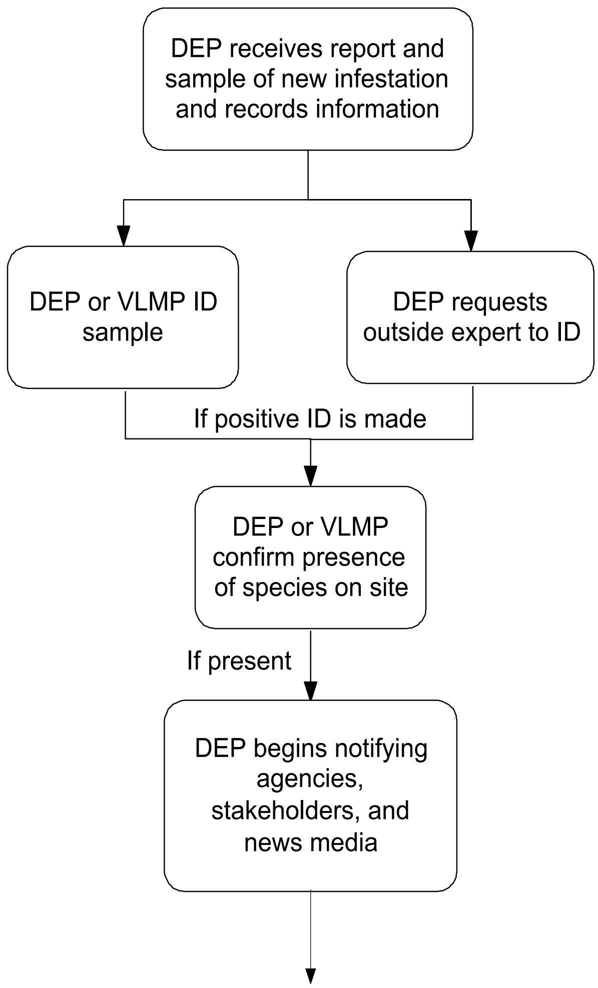
5. **Applicator(s).** Enter into a contract(s) with a professional applicator(s) to be on call to apply selected herbicides, apply benthic barriers, or otherwise conduct eradication efforts under a general permit,

6. **Contact List.** Maintain up-to-date contact information for all interested parties, state agencies and municipal officials, and

7. **Mutual Aid.** Explore with other northern-tier or New England states (NEANS Panel) opportunities to establish memoranda of understanding for mutual aid and/or a common data base for tracking and evaluating approaches to, and the efficacy of, treatments to eradicate invasive aquatic plants (see Step 5).


RAPID RESPONSE PROCEDURE
For Plants
Step 1
Species Confirmation
Step 2
Delineation, Containment, and Preliminary Evaluation
Step 3
Treatment Selection
Step 4
Treatment Plan Refinement and Implementation
Step 5
Monitoring and Evaluation

Step 1
SPECIES CONFIRMATION
Week 1



1. Species Confirmation

DEP will endeavor to confirm the presence of an invasive aquatic plant within one week's time of a report, providing that outside assistance such as DNA analysis is not required. DEP will work closely during the first and subsequent steps with the Volunteer Lakes Monitoring Program (VLMP) in Auburn, as appropriate.

Reporting. The DEP website and other information distributed to the public, other agencies, and organizations will direct people to report sightings and provide specimens, when possible, to the staff of the Invasive Aquatic Species Program (IASP) of the Division of Environmental Assessment. DEP will encourage people to file a written report, and for consistency, to use the form provided on the website of the Maine Center for Invasive Aquatic Plants, sponsored by the Volunteer Lake Monitoring Program (VLMP).[1] Reports of suspicious plants will be recorded in the agency's computerized database.

DEP will collect relevant information on:

- specific locations (using GPS) within the water body of the sighting/collection and size of water body,
- uses of water body, sources of water, and any downstream waters,
- date and time of the sighting/collection,
- phone number and postal and email addresses for the person reporting,
- known or suspected method of introduction,
- character of site(s) likely to be affected, and
- vectors of spread.

Instructions for collecting and mailing specimens may be found on the websites of the DEP and Maine Center for Invasive Aquatic Plants.

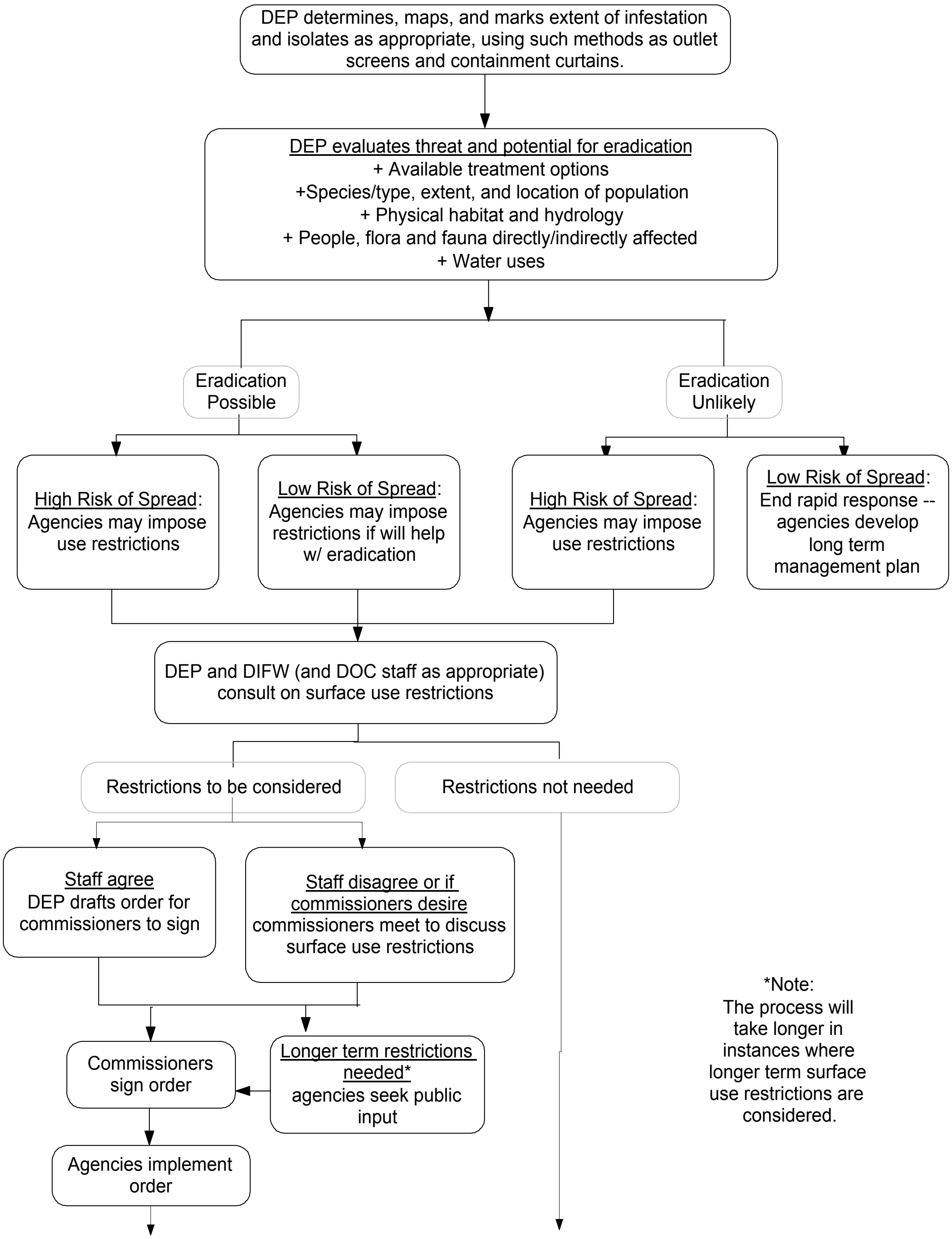
Identification. If a specimen is available from the person reporting the possible introduction, qualified DEP or VLMP personnel will make a positive identification or send it to an outside expert for assistance. Hybrids of any invasive species will be treated the same as the true species in rapid response, e.g. *Myriophyllum heterophyllum* X *M. laxum*.

On-site Confirmation. If a specimen is identified as invasive or if a specimen is unavailable, DEP and/or VLMP will conduct a targeted reconnaissance of the water body to confirm its presence.

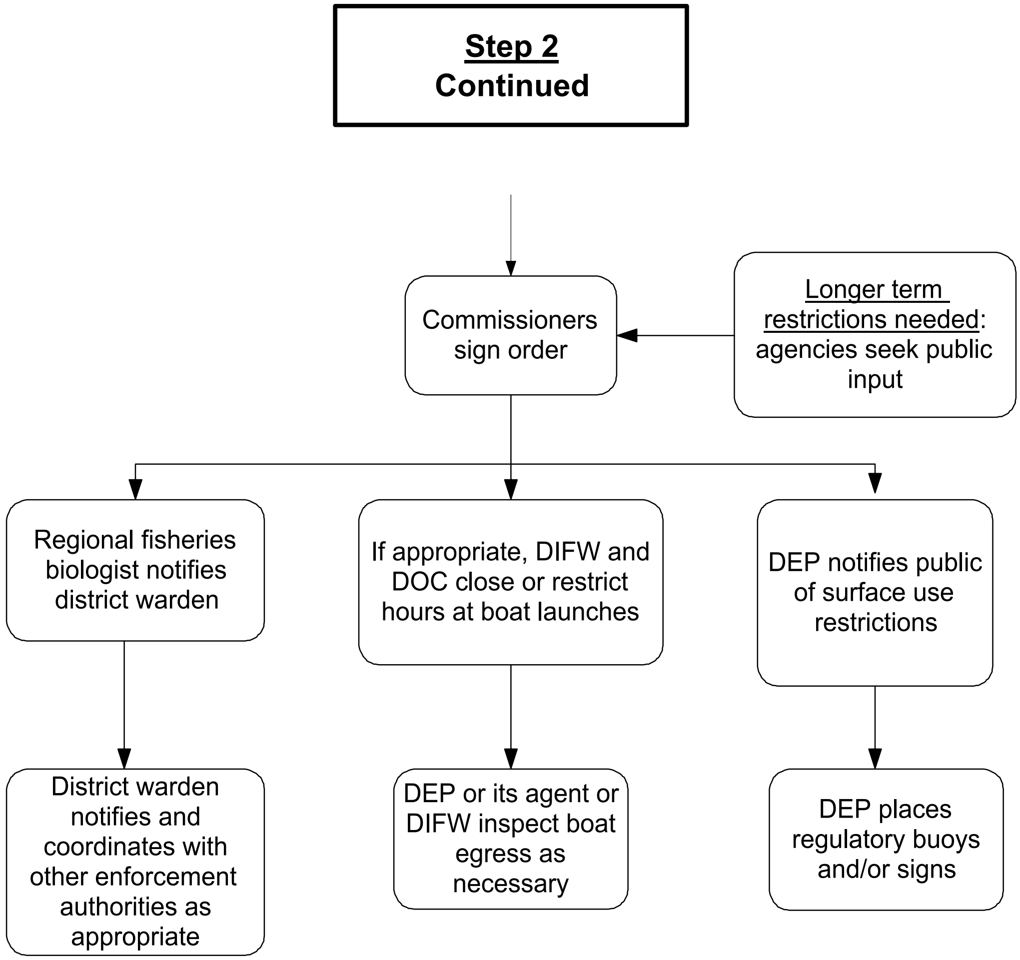
Notification. Following positive confirmation, DEP will immediately notify by phone the Department of Inland Fisheries and Wildlife (DIFW), Department of Conservation (DOC), and affected towns. DEP will then email or otherwise contact other stakeholders such as watershed associations, landowners, and news media of the species that has been found and process that will be undertaken in response. Notification may take longer than one week, depending upon the circumstances.

[1] Go to http://mainevolunteerlakemonitors.org/mciap/SuspiciousPlantForm.pdf

Step 2
DELINEATION, CONTAINMENT, AND PRELIMINARY EVALUATION
By end of week 2*



*Note:
The process will take longer in instances where longer term surface use restrictions are considered.



2. Delineation, Containment, and Preliminary Evaluation

Step 2 will be completed within two weeks of learning about the presence of the infestation, unless longer term surface use restrictions or other special circumstance requires a longer process.

Delineation and Containment. DEP will survey the distribution and abundance of the invasive plant within the water body and any interconnected waters that are likely to be involved. Staff will develop a map of infested populations using computerized geographical positioning system (GPS) coordinates or traditional field mapping techniques. They may mark the extent of each infested population with flagged stakes or buoys. They may also install barrier curtains or other containment devices as appropriate to isolate the infestation from the rest of the water body or downstream waters.

Preliminary Evaluation. DEP will compile and evaluate preliminary information to determine the threat posed by the infestation, as well as its potential for eradication. This evaluation will enable DEP to consult with the DIFW, and DOC as appropriate, to determine whether immediate surface use restrictions are critical, and if proceeding in rapid response mode makes sense. In addition to the species, type, extent, and location of the invasive, DEP will consider such information as:

- Depth, flow, water quality, bathymetry, and configuration of water body and watershed,
- People, flora, and fauna directly/indirectly affected,
- Rare or endangered plants or animals (from HCAP records and direct agency contacts),
- Water uses, and
- Available treatment options.

Surface Use Restrictions. Upon confirmation of an infestation, the Invasive Aquatic Species Program Coordinator (DEP) will consult with the appropriate Regional Fisheries Biologist (DIFW) to determine whether agreement can be reached upon a surface use restriction order for the infestation, if one is necessary. The regional fisheries biologist will also involve the DIFW boating facilities director as appropriate. If Department of Conservation boating facilities, parks, or other lands are involved, the Invasive Aquatic Species Coordinator will also consult with the Director of the Boating Facilities Division and/or the appropriate Regional Manager of the Division of Parks or Division of Lands within the Departments of Conservation.

Surface use restrictions may be necessary even when eradication is unlikely. If the risk of spread is high, the agencies may wish to move quickly to contain the infestation for immediate purposes and possibly for the long term. When the risk of spread is low and available methods for eradication are unproven, DEP and DIFW may take longer than the first season of discovery to evaluate options and consider surface use restrictions. In such case, the agencies will work in partnership with local officials and lake associations to develop a viable strategy for the water body. The preferred goal will still be eradication, but if such proves impractical, the goal will shift to suppressing the population and reducing or eliminating its risk of spread.

DEP and DIFW will develop and adopt surface use restrictions according to the policies and procedures stipulated in the Memorandum of Understanding for Surface Use Restrictions contained in Appendix A. DEP will place any regulatory buoys that may be needed in accordance with the State Permit to Place Regulatory Markers[2] obtained from the Department of Conservation (Appendix B). Under the terms of this state permit, DEP will GPS or otherwise map, mark, monitor, and maintain regulatory markers prohibiting boating in restricted areas. DEP will notify DOC of regulatory buoy locations to ensure that none poses a hazard to navigation. DEP may also enlist local cooperators to help maintain the buoys.

In all cases where restrictions are contemplated to ensure the safety of those involved in eradication efforts or to limit the spread of an infestation, DEP Invasive Aquatic Species Program staff and the appropriate DIFW regional fisheries biologist, delegated by their Commissioners, will consult to determine the type and extent of restrictions necessary. They will base their determination upon the risk of spread and conditions needed for safe and effective treatment. DEP and DIFW will also consult with representatives from DOC, municipalities, and any other entities as necessary, especially if limitations on boat launches or other public facilities are involved.

[2] DOC is authorized to issue a "state permit" for such activities.

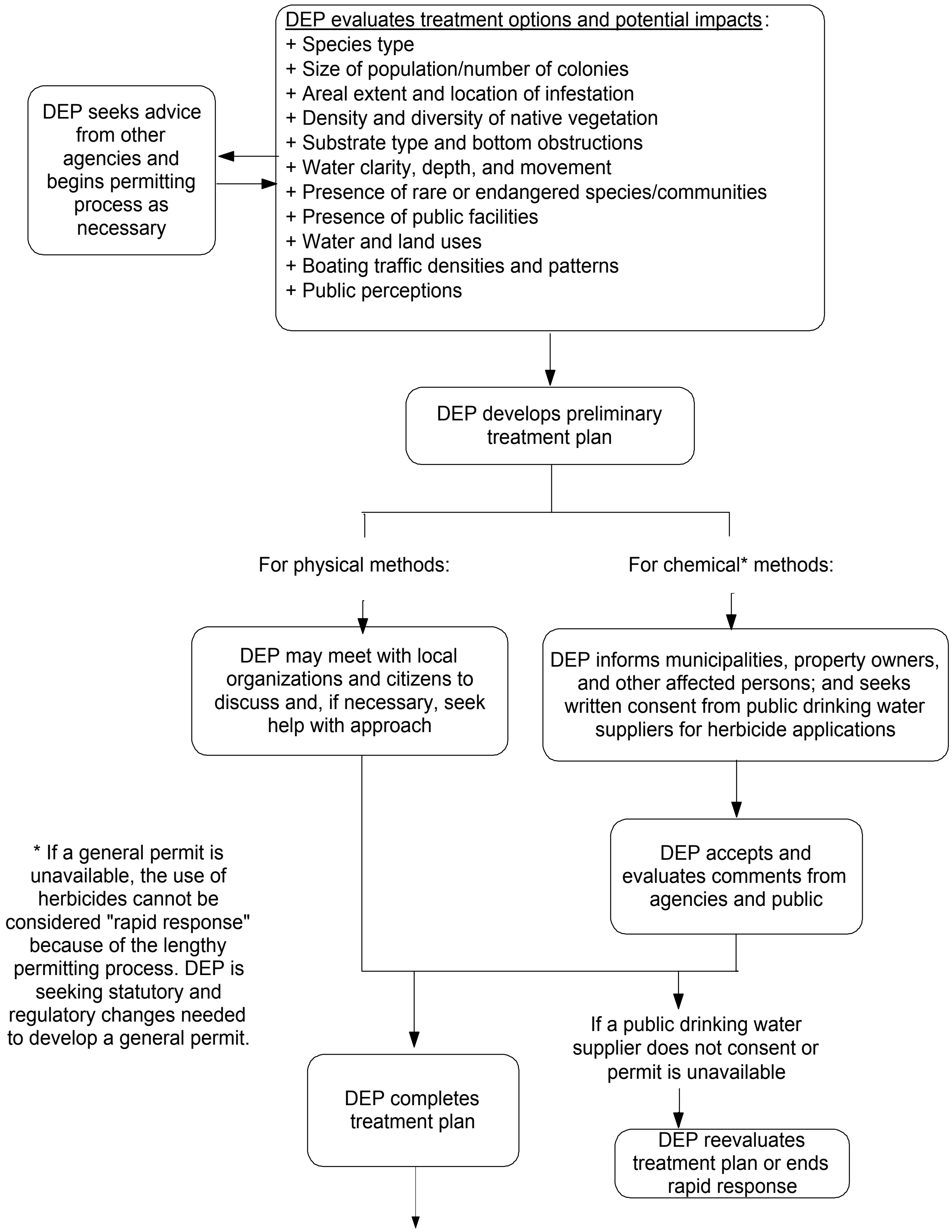
If staff designees agree on an approach, DEP will draft an order for the Commissioners to sign. Once an order is signed, DEP will mark the area(s), post signs, and notify the public. The Commissioners reserve the right to consult directly on any order, but are less inclined to do so if delegated staff agrees. They also agree to expedite the decision-making process to facilitate rapid action.

The regional fisheries biologist will notify the district warden, who will in turn notify, and coordinate with, any other enforcement authorities, such as harbor masters, who need to know about the specifications of the surface use order, i.e. why, when, and where restrictions are imposed, and their authority under it. Under Sec. A-4.12 MRSA § 7801, sub-§39, "A person who operates a watercraft in violation of an order issued under Title 38, section 1864 commits a civil violation for which a forfeiture of not less than $500 and not more than $5,000 per violation may be adjudged. Forfeiture under this subsection may not be waived by the court."

DEP, its agent, or DIFW will inspect boats as necessary at launch sites.

Other Activities That May Spread Aquatic Invasive Plants
Boating (use of watercraft) is the only activity under current law that may be controlled through surface use restrictions. DEP and DIFW recognize that other activities such as swimming, water removal, or sea plane landings may also pose a significant risk, but have decided not to seek a statutory change until more information or experience is obtained in support. For this reason, the agencies will continue to evaluate the issue and advise the Task Force on Invasive Plants and Nuisance Species on whether to seek a change in the law.

Step 3
TREATMENT SELECTION AND DESIGN
By end of week 3



3. Treatment Plan Selection and Design

During Step 2, DEP evaluates the potential of an infestation to spread and the likelihood that it can be eradicated. Once the decision to proceed, with or without surface use restrictions, is made, emphasis will shift in Step 3 to identifying the treatment option with the most advantageous combination of high potential to eradicate the target species and least potential to impair human or ecological health or other natural or cultural values. DEP is committed to achieving eradication or control without unacceptable long term adverse impacts. We will strive to accomplish the process of treatment selection within two or three weeks from receiving the report about the infestation.

Treatment Options Evaluation. DEP will identify the options available for the invasive species, and evaluate the efficacy and potential impacts of each option based upon the factors listed in the Step 3 flow chart on the preceding page. Figure 1.1.1 at the end of the Step 3 protocol summarizes treatment techniques that have been reported in the literature or by other states to be effective to varying degrees in eradication or control of the prohibited species listed in Maine Law.[3] Figure 1.C.1 in Appendix C presents a "thumb nail" sketch of the relative costs and benefits of, and conditions favorable to, each technique. DEP will consult these Figures, along with other detailed information contained in Appendices C and D. Operations planning checklists for priority techniques and a general permit for priority species will be developed in the future. As new information becomes available, DEP will update plan resources. Any threat or introduction of a harmful invasive plant not considered in this plan will necessitate research on species-appropriate treatment options and application thereof. In such cases, regulations specific to the state's list of "invasive aquatic plants" as defined in Sec. 1. MRSA §410-N will not apply, unless the department lists the species in a manner as specified in the law.

To streamline the process, DEP will seek advice from other agencies as soon as possible. A list of agency contacts may be found in Figure 1.1.2 at the end of the Step 3 protocol.

Treatment Selection and Design. DEP will develop a preliminary treatment plan prescribing:

- Methods and expected outcomes,
- Costs and sources of materials, labor, equipment, and other expenses,
- Timetable and assignment of responsibility for each action,
- Permitting requirements, if appropriate,
- Project management and coordination,
- Biomass tabulation and disposal methods,
- Pre-treatment data collection (see Step 4),
- Public information program, and
- Follow-up monitoring and evaluation.

A note about baseline data: it is important to establish useful information before the treatment about the ecological condition of the biota, chemistry, and physical aspects of the water body or in the zone of influence of the treatment. This will allow DEP to determine if and how quickly

[3] *An Act to Prevent Infestation of Invasive Aquatic Plants and to Control Other Invasive Species (Chapter 434)*, adopted by the Maine Legislature in 2001.

the natural order is restored after treatment. In addition, plant population sampling, and any existing profile of pre-infestation conditions, will allow DEP to track the extent to which the invasive species has already shifted non-target communities.

Water quality data may already be available, depending upon monitoring history. Rapid response, especially if herbicides are to be used, will require case-specific water quality monitoring – mainly simple water quality parameters, including temperature-oxygen profiles, conductivity, and alkalinity will be obtained before treatment begins following standard DEP lake sampling protocols. Physical sampling parameters will include bathymetry, stratification, and clarity. If the treatment includes herbicide application, the water body and selected associated shallow, non-bedrock wells serving camps within 250' may also be tested for background levels of the herbicide. (See Step 5.)

Permitting. DEP will place a high priority on filing permit by rule notifications or permit applications as soon as possible.

1. Natural Resources Protection Act. In most cases and unless a full permit is necessary, the Invasive Aquatic Species Program (IASP) staff will file a permit by rule notification of intent (NOI) for a Permit by Rule (PBR) for the use of exclusion barriers (in the water column), bottom barriers, diver-operated suction, mechanical harvesting equipment, or manual removal techniques, under the Natural Resources Protection Act (38 MRSA §§480-A et seq). DEP permitting staff is usually able to give "same day approval," if all filing requirements have been met, so that the 14-day waiting period should not be an obstacle to rapid response.

   With two exceptions, a full permit will be necessary if a proposed activity:

   - affects a resource of special concern,
   - will result in a significant environmental impact, or
   - may violate the standards of the NRPA (38 MRSA Section 480-D).

   The two exceptions are as follows:

   1. If a technique is needed to accomplish rapid eradication before a permit can be approved, the Department may take action under 38 MRSA section 410-N, which specifically excludes immediate eradication activities from NRPA permitting requirements.[4] In the rare instances when this occurs, DEP will conduct the work and simultaneously apply

[4] "A. The department or a person designated by the department may attempt eradication of an invasive aquatic plant from a water body if determined feasible by the department. If the commissioner determines that eradication activities must be undertaken immediately, a license is not required under section 480-C for the use of a physical, chemical or biological control material by the department or a person designated by the department if the use of the control material is specifically related to the immediate eradication of invasive aquatic plant populations in the water body. Prior to undertaking an eradication activity and to the extent practical, the department shall notify landowners whose property is adjacent to the area where the activity will be undertaken. [2001c. 232, §8 (and).]." Note: section 480-C is part of the Natural Resources Protection Act and does not apply to waste discharge licensing.

for a permit.

2. For any bottom barrier or other technique that requires installation for a period greater than 7 months, DEP may use Section 13 of the NRPA which permits a PBR for water quality improvement projects (among other activities) conducted by a public natural resource agency. DEP will consult with DIFW before placing any barriers in outflows to prevent downstream spread. Short term impacts on fish may be necessary to achieve long term protection of their habitat.

2. <u>Waste Discharge License</u>. DEP intends to use herbicides or other chemical agents only if no other method is appropriate for the eradication or control of a particular species or for the hydrologic conditions of a water body. Under state regulations, the Invasive Aquatic Species Program must first obtain a Maine Waste Discharge License (WDL) permit from DEP's waste discharge licensing staff. The permitting process for herbicides can take four months or longer, which precludes a rapid and effective response. For this reason, Invasive Aquatic Species Program staff is currently working with the licensing staff to clear the regulatory hurdles to obtaining a general permit for the application of certain aquatic herbicides for rapid response purposes. This permit will be added to this plan when available. It will include measures that safeguard the environment and public health.

   When and if a general permit is in force and use of a proposed herbicide qualifies, IASP staff will submit a Notification of Intent (NOI) to the DEP. Such an NOI consists of some basic information about the proposed project and includes a notification process to area residents. In order to qualify for a general permit, the IASP must also agree to abide by some pre-determined conditions related to such matters as application procedures, dosages, and follow-up monitoring. The notification process under a general permit process is estimated to take 2-4 weeks to complete.

   If a general permit is not in place, or if for some reason a particular project does not qualify, IASP staff will apply for an individual WDL permit. The individual permit process will entail development of a much more detailed application which will remove this component from rapid response.

Public Notification. DEP will notify and involve the public as soon as possible (see Step 1) and to the extent practical, given the particular rapid response circumstances.

1. If physical means -- manual removal, diver-operated suction, bottom barriers, and/or mechanical harvesting -- are proposed, DEP will notify and or consult in developing the plan with local organizations, landowners and other citizens, the Technical Subcommittee of the Interagency Task Force on Invasive Aquatic Plants and Nuisance Species and other state or federal agencies with an interest in the water body, to the extent possible within the time frame for rapid response. Some conditions may require simultaneous actions and consultation with, or notification of, stakeholders.

2. If herbicide use is deemed necessary for eradication or suppression, DEP will notify the public and provide at least one week for comments, or as otherwise specified in a general permit for waste discharge. Public comments will generally be considered "advisory." The DEP Commissioner may consult with the Technical Subcommittee of the Interagency Task Force on Invasive Aquatic Plants and Nuisance Species, but in all cases will carefully evaluate public comments before making a decision about whether and how to proceed. When a public drinking water supply(s) is affected, the DEP Commissioner will notify the public and obtain written consent from the public water supplier(s) before using chemical control agents, as required by law.[2] DEP will explore other options or end the rapid response initiative if a public water supplier does not consent in writing or a necessary permit is unavailable.

Figure 1.1.1: Treatment Options For Invasive Aquatic Species Prohibited in Maine

	Class		Special Care		Treatment Techniques									
					Physical-Mechanical				Chemical					
	Dicot (Magnoliopsida)	Monocot (Liliopsida)	Fragmentation (F), Rhizomes (R)	Turions (Tr), Tubers (Tb), or Seeds (S)	Manual Removal	Diver-operated Suction	Benthic Barrier	Mechanical Harvesting	Fluridone	2,4-D	Endothall	Diquat	Copper Chelate	Triclopyr
FLOATING ATTACHED-LEAVED PLANTS														
Water Chestnut, *Trapa natans*	X			S	X	X		X		#1				#2
Yellow Floating Heart, *Nymphoides peltata*	X		F	S	X	X	X		#2*	#2*				#2
SUBMERGED PLANTS														
Brazilian elodea, *Egeria densa*		X	F		X	X	X		#1			PT		
Curly-leaved Pondweed, *Potamogeton crispus*		X	R	Tr/S**	X	X	X	X	#2		#2	#2		
European naiad, *Najas minor*		X	F	S	X	X	X		#1		#2	#2		
Hydrilla, *Hydrilla verticillata*		X	F	Tb/S	X	X	X		#1		#2	PT	PT/C	
Fanwort, *Cabomba caroliniana*	X		F/R	S**	X	X	X		#1		#2			
Milfoil, Eurasian, *Myriophyllum spicatum*	X		F	S**	X	X	X		#1	#1	#2	#2	PT/C	#1
Milfoil, Variable, *Myriophyllum heterophyllum*	X		F		X	X	X		#2	#1	#2	#2		#2
Parrotfeather, *Myriophyllum aquaticum*	X		F/R		X		?			#2***		#2***		#2***
EMERGENT PLANTS														
European Frog-bit, *Hydrocharis morsus-ranae*		X		X	X			X				#2*		#2

Legend: #1 = commonly used for eradication and/or has a good track record in similar conditions as Maine, #2: partially effective or no consistent track record, PT = sometimes used for pretreatment, C = sometimes used in combination with other herbicides.

Sources: See References Cited, Appendix F, especially Getsinger (14), Mattson (30), US Army ERDC (56).

* Glyphosate is the herbicide most commonly used for water lilies, and thus, most probably for yellow floating heart and frog bit. Glyphosate is not in this figure because it is generally used on emergent wetland plants rather than on true aquatics.

** Seeds are not a primary sources of reproduction, at least in colder climates.

*** Imazapyr might be best choice (88).

Figure 1.1.2: Rapid Response Contacts

Department of Environmental Protection
Invasive Aquatic Species Program Coordinator, (207) 287-3901
"On Call System" Contacts, NRPA and Stormwater Programs, Bureau of Land and Water Quality:
- Augusta, (800) 452-1942
- Bangor, (888) 769-1137
- Portland, (888) 769-1036
- Presque Isle, (888) 769-1053

Waste Discharge Program Director, Division of Water Resource Regulation, (207) 287-3901

Department of Inland Fisheries and Wildlife
Chief Warden, Maine Warden Service, Augusta, (207) 287-2766
Fisheries Division Director of Operations, Augusta, (207) 287-8000
Regional Fisheries Biologists:
- Ashland, (207) 435-3231
- Bangor, (207) 941-4440
- Gray, (207) 657-2345
- Greenville, (207) 695-3756
- Sidney, (207) 547-5300
- Enfield, (207) 732-4131
- Jonesboro, (207) 434-5925
- Strong, (207) 778-3322

A 'call-sequence tree' would streamline the notification process. Developing one is of lower priority at this time, but will be considered in future.

Department of Conservation
Boating Facilities Division Director, Augusta, (207) 287-4952
Navigational Aids Supervisor, Richmond, 207 582-5771
Maine Natural Areas Program Director, Augusta, (207) 287-8044
Regional Parks Managers:
- Northern Parks Region, Bangor, (207) 941-4014
- Southern Parks Region, Augusta, (207) 624-6080

Regional Lands Managers:
- Northern Public Lands Office, Ashland, (207) 435-7963
- Western Public Lands Office, Farmington, (207) 778-8231
- Eastern Public Lands Office, Old Town, (207) 827-1818

Department of Transportation
Environmental Office Director, Augusta, (207) 624-3100

Department of Marine Resources
Stock Enhancement Division Director, Bureau of Resource Management, Hallowell, (207) 624-6550/6340

Department of Agriculture, Food and Rural Resources
Board of Pesticides Control Director, Augusta, (207) 287- 2731
State Horticulturalist, Division of Plants, Augusta, (207) 287-7602

Volunteer Lakes Monitoring Program
Director, Auburn, (207) 783-7733

Outside Plant Identification Contacts
The department has identified one or more outside contacts to call for the rare instances when in-house and VLMP help is insufficient.

Step 4
TREATMENT PLAN IMPLEMENTATION
By end of week 4, if possible

DEP consults operations checklist and mobilizes:
+ Materials and equipment
+Site and access preparation
+Staff, consultants, volunteers
+Biomass disposal
+Monitoring and safety protocols

↓

DEP implements treatment

↓

Agencies lift restrictions as soon as possible

↓

4. Treatment Plan Refinement and Implementation

The technical aspects of a treatment plan will vary according to the species involved, techniques to be used (see Appendices C and D), and factors related to location. A treatment plan may stipulate a combination of techniques, and/or same-season booster treatments to increase efficacy. For these reasons, no single approach is stipulated herein, but operations checklists will be developed in the future for selected techniques.

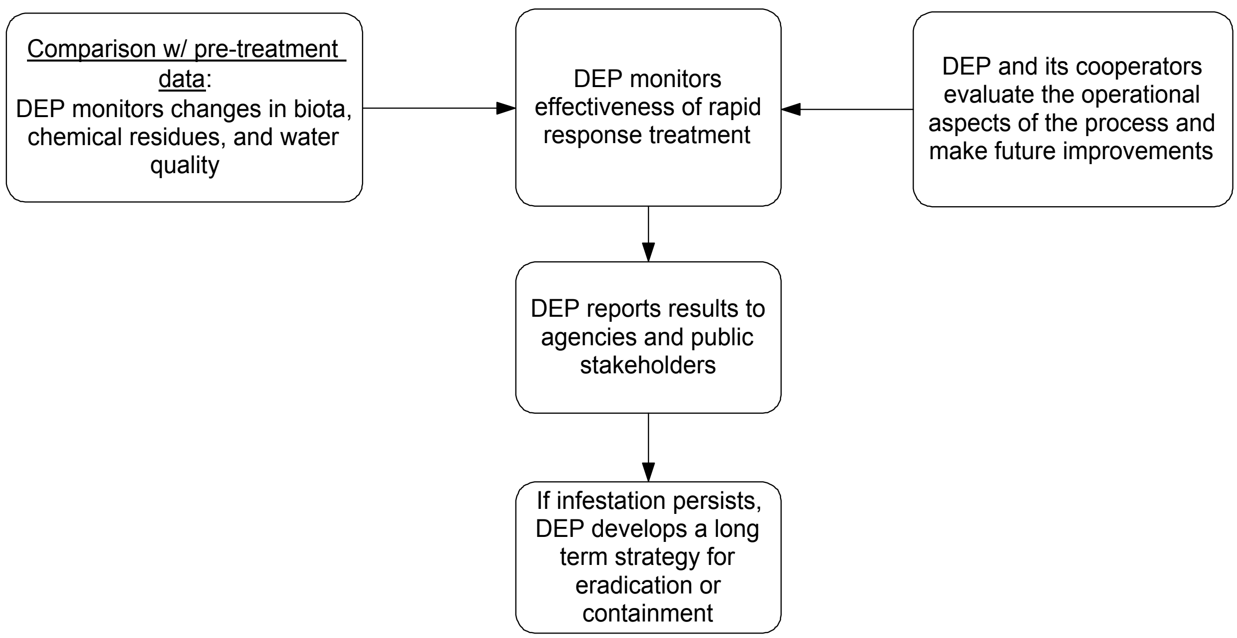
Prior to treating a water body, and in addition to implementing any surface use restrictions and public notification procedures initiated under Steps 1, 2, and 3, DEP will:

- secure any access agreements that may be required to stage the operation,
- solicit and coordinate volunteers or consultants,
- prepare the staging site, materials, and equipment,
- arrange for a biomass disposal site and procedures,
- establish safety and communication protocols,
- select water quality monitoring sites, if necessary,
- establish a schedule for operations and booster treatments, if necessary, and
- keep the public informed and involve as appropriate.

All plant material will be bagged or otherwise contained securely and removed from the site. Harvested plants will be placed in a compost facility, in the woods away from moisture where they can degrade and not reenter the water body or, if these options are inappropriate or unavailable, in a solid waste disposal or incineration facility.

As stipulated in the principles listed in the *Introduction* to this plan, DEP will give priority to completing the eradication or control process as soon as possible so that restrictions may be lifted and, if any public boating facility has been closed, normal activities may resume.

Step 5
MONITORING AND EVALUATION
Until water body is target plant-free



5. Monitoring and Evaluation

Monitoring and evaluation are integral to Maine's rapid response program for eradicating or controlling invasive plants. Monitoring will be tailored for the target species, conditions, and methods used. Post-treatment results will be compared with pre-treatment data (see Step 3). DEP may monitor sites from which infestations have been eradicated for a period of up to 3 years following the first year of infestation-free status.

Biological Monitoring. DEP will survey target and non-target plant populations, including plant propagules (e.g. tubers, seeds), at time intervals appropriate for each species in the zone of influence and downstream. Accepted methods include a variation on the Point-intercept Method (24) which uses a GPS grid of sampling points and bottom grapnel samples to determine species composition and relative abundance. This will be augmented with visual observation at selected fixed sampling points or diver transects. These methods and the ability to detect effects have been successfully used for a number of treatments conducted in Maine and other northern-tier states. In some cases, biomass or cover estimates, tuber or propagule counts, or other techniques may be required.

Chemical and Physical Monitoring. Pre- and post-treatment data on water chemistry and physical parameters will be obtained for all treatments at intervals appropriate for the circumstances (see the parameters listed under Step 3).

When herbicides are to be applied, staff will use appropriate and accepted monitoring methods and practices to sample for chemical residues in the water, air or biota, as stipulated in a general permit for each herbicide. The herbicide monitoring plan (details to be spelled out in permit) will likely include testing for concentrations immediately after treatment and at appropriate intervals, depending upon the species, thereafter until the non-detect level is reached. (For instance, the preferred test for fluridone is a proprietary immunoassay technique (SePro Corp. "FasTEST") which allows accurate and rapid turnaround time for reporting conditions to be achieved.) If a lake has an outlet, DEP will ascertain downstream concentrations to determine if detectable levels are reached downstream. In selecting testing locations, consideration will be given to including locations of highest likely effect – such as aquatic habitats where sensitive plant populations occur – and to effects of dilution from groundwater and tributaries.

Evaluation. DEP will consider the biological, chemical, and physical data in evaluating the effectiveness of the treatment. This will include assessment of whether booster treatments or other techniques are warranted in the same season, and in subsequent years, until the expected timeframe for eradication or effective suppression of a given species is reached without repopulation. DEP will report the results to public stakeholders and agencies.

Long Term Success. . .
depends upon local support and buy-in.

DEP is committed to partnership and encourages communities and lake associations to be prepared in case local waters become infested. This means establishing procedures (and contingency funds if possible) in advance to ensure that local support is available when needed.

If eradication is not achieved during the first season of discovery, DEP, in partnership with cooperators and the public, will develop a longer term strategy for eradicating the species from the water body or suppressing and limiting its spread. The IASP will need help in such endeavors. Other jurisdictions advise that follow-up for rapid response initiatives requires concerted local commitment and on-site follow-through, without which re-growth or re-introduction is likely to occur.

Operations Assessment. As soon as possible after the rapid response initiative is completed, DEP will solicit comments from personnel involved in the process, to ascertain which aspects worked well or could have been done differently. IASP staff will adjust operations checklists as necessary to guide future applications.

DEP will coordinate with other northern-tier states to explore the establishment of a joint data base for tracking approaches to, and the efficacy of, treatments to eradicate invasive aquatic plants.

Appendix A:

Memorandum of Understanding for Surface Use Restriction Orders

MEMORANDUM OF UNDERSTANDING FOR SURFACE USE RESTRICTION ORDERS

(To facilitate the eradication or management of invasive aquatic species)

PURPOSE AND APPLICABILITY

This memorandum of understanding stipulates policies and procedures that the Departments of Environmental Protection (DEP) and Inland Fisheries and Wildlife (DIFW) agree to follow in jointly deciding how and when to impose orders that restrict surface uses from areas on water bodies that are infested with invasive aquatic plants or fauna. It is a component of the State of Maine's Rapid Response Plan for Invasive Aquatic Species, and will also be used to guide decisions about the imposition of an order for longer term eradication or suppression. Surface use restrictions may be necessary during either rapid response or longer term initiatives to avoid unnecessary plant fragmentation, population dispersal, or harm to divers and others involved in such efforts. This memorandum will ensure that such orders can be implemented as swiftly and efficiently as possible.

AUTHORITY

Under 38 MRSA Chapter 20-A Sec. 1864, as amended in 2004, the commissioners of DEP and DIFW "… may jointly issue an emergency order to restrict access to or restrict or prohibit the use of any watercraft on all or a portion of a water body that has a confirmed infestation of an invasive aquatic plant. The order must be for a specific period of time and may be issued only when the use of watercraft on that water body threatens to worsen or spread the infestation. The order may require that watercraft on waters affected by the order be taken out of the water only at locations identified in the order and be inspected and cleaned by the department upon removal. The order may require inspections and cleaning of watercraft, watercraft trailers and equipment upon removal at sites that have been identified in the order. Inspections must be conducted by designated state boat inspectors. For purposes of this section, "designated state boat inspector" means a person employed by the State and identified by the department or the Department of Inland Fisheries and Wildlife as a person who is qualified to properly conduct inspection activities."

PRINCIPLES

A rapid response initiative is one that is directed toward the eradication or containment of an infestation in the first season in which it is discovered. "Management" is the term used herein for longer term efforts conducted during subsequent seasons as follow-up. Eradication will be the primary goal, but if unattainable, DEP will switch to suppression. Surface use restrictions may be needed to support either rapid response or management efforts.

DIFW and DEP agree to work together in a spirit of mutual trust and cooperation, following the principles below. Such orders shall:

1. reflect sound biology and the particular situation;
2. be used only where a surface use restriction will facilitate rapid response or management efforts;

3. facilitate fast action and interagency decision-making at the lowest level possible;
4. make implementation of rapid response and management efforts a priority for staff attention so that restrictions may be lifted as soon as possible;
5. minimize infringement on public access, parks, and other facilities;
6. be fair to all users; and
7. ensure efficient use of personnel and resources.

MOU UPDATE

This MOU will be reviewed periodically, for a period no longer than five years, to fine tune its provisions based upon experience gained during its implementation.

PROVISIONS

Furthermore, DEP and DIFW agree to follow the policies and procedures outlined in the Figure on the following pages, and to consult with the Department of Conservation, municipalities, and other entities whenever appropriate and as early as possible. These provisions are divided into two categories, one for instances where rapid response is needed and one where longer term management is needed.

AGENCY CONTACTS

Unless otherwise stated, "DEP staff" means Invasive Aquatic Species Program personnel and "DIFW staff" means the appropriate Regional Fisheries Biologist. The Commissioners shall ensure that systems are in place to inform other personnel within their agencies, in central and field offices, who need to know about or be involved in the order.

ADOPTED BY

____
David Littell, Commissioner
Department of Environmental Protection

____
Date

____
Roland D. Martin, Commissioner
Department of Inland Fish and Wildlife

____
Date

Figure 1.A.1: Policies and Procedures for Developing Surface Use Restriction Orders

ISSUE	RAPID RESPONSE (First Season)	MANAGEMENT (Subsequent Seasons)
1. When and under what circumstances shall restrictions apply?	An order for surface use restrictions for a rapid response deployment may be issued to protect human health and safety and water quality[1] and assure operational efficacy while efforts are conducted to contain and/or eradicate a discrete pioneer population or a few scattered colonies of an invasive aquatic species.	An order for surface use restrictions may be issued to protect human health and safety and water quality[1] and assure operational efficacy while management strategies are actively being pursued to limit the spread of an established population.
2. What is the process for issuing an order?	INVASIVE AQUATIC PLANTS In all cases where surface use restrictions are contemplated, DEP and DIFW staff, or others delegated by their commissioners, will consult to determine the type and extent of restrictions necessary in support of a rapid response initiative. They will base their determination upon a risk assessment that will be described in the Rapid Response Plan. They will also consult with the DOC Boating Facilities Division Director, municipalities, and any other entities as necessary. If DEP and DIFW staffs agree on an approach, DEP will draft an order for the Commissioners to sign. Once an order is signed, DEP will mark the area(s), post signs, and notify the public as described in subsequent issues. The Commissioners reserve the right to consult directly on any order, but are less inclined to do so if delegated staff agrees. The Commissioners will make reasonable efforts to expedite their consultations. <u>Priorities.</u> Species new to the state or those which pose a particularly high threat may require higher priority for rapid action.	INVASIVE AQUATIC PLANTS In all cases where surface use restrictions are contemplated, DEP and DIFW staff, or others delegated by their commissioners, will consult to determine the type and extent of restrictions necessary. They will also consult with DOC, municipalities, and any other entities as necessary. If staff designees agree on an approach, DEP will draft an order for the Commissioners to sign. Once an order is signed, DEP will mark the area(s), post signs, and notify the public as described in subsequent issues. The Commissioners reserve the right to consult directly on any order, but are less inclined to do so if delegated staff agrees. <u>Management Plan Required.</u> All surface use restrictions associated with a management action will be consistent with a management plan, at least in draft form, for suppressing or controlling the spread of an infestation on or between waters. DEP will take the lead in preparing the plan and providing opportunities for public involvement. <u>Temporary</u>: for operational purposes, the agencies will restrict use and DEP will mark areas where control techniques are to be applied.

[1] 38 MRSA 465 defines water quality according to various types of water bodies. Beyond physical parameters such as dissolved oxygen, water quality, depending upon the type of water, can encompass utility for various types of uses such as habitat, recreation, and drinking.

ISSUE	RAPID RESPONSE (First Season)	MANAGEMENT (Subsequent Seasons)
	INVASIVE AQUATIC FAUNA No surface use orders, only advisory warnings, are contemplated at this time.	Longer term: the Commissioners may agree to place longer duration restrictions on isolated locations such as coves where certain uses could facilitate spread to rest of a water body or connected waters. INVASIVE AQUATIC FAUNA No surface use orders, only advisory warnings, are contemplated at this time.
3. How will the public be notified?	INVASIVE AQUATIC PLANTS Once an order is signed and while implementation proceeds, the public, public water suppliers[2], and other stakeholders will be notified about the effective date of surface use restrictions through such means as newspapers, radio, or posting of riparian property, launches, and local gathering places. The agencies will give notice so that people have an opportunity to remove watercraft and equipment from restricted areas prior to the effective date of an order. When public comments are required for an extension of an order within the same season, the agencies will hold a public meeting and allow a 14 day comment period. INVASIVE AQUATIC FAUNA DIFW will issue advisory warnings and notify the public, public water suppliers,[2] and riparian owners in advance of using chemicals to treat a water body as stipulated in a general (under consideration as of fall of 2005) or individual wastewater discharge license.	INVASIVE AQUATIC PLANTS The agencies will make management decisions jointly, upon staff recommendation, following more extensive risk assessment and the development of a management plan. The public, public water suppliers,[2] and stakeholders will be notified and invited to comment at a public meeting and in writing during a 30 day period prior to issuing any order. INVASIVE AQUATIC FAUNA DIFW will issue advisory warnings and notify the public, public water suppliers[2], and riparian owners in advance of using chemicals to treat a water body as stipulated in a general (under consideration) or individual wastewater discharge license.
4. How much of a water or	INVASIVE AQUATIC PLANTS Generic size limitations for restricted areas will not be specified in	INVASIVE AQUATIC PLANTS Generic size limitations for restricted areas will not be specified

[2] In the case of the proposed application of a chemical control agent to a public water supply, the agencies are required under law, 38 MRSA Chapter 20-A Sec.1865, to obtain written consent from a public water supplier prior to treatment.

ISSUE	RAPID RESPONSE (First Season)	MANAGEMENT (Subsequent Seasons)
shoreline will be restricted?	this MOU, but DEP will make every reasonable effort to minimize the affected area and the effects of treatment on a site-specific basis.	in this MOU, but DEP will make every reasonable effort to minimize the affected area and the effects of treatment on a site-specific basis.
5. How long will restrictions apply?	INVASIVE AQUATIC PLANTS For sites NOT associated with an access facility (e.g., ramps, parks, bank fishing): up to 90 days with public notification, and for a longer period in the same season with opportunity for public comment. For sites associated with an access facility (e.g., ramps, parks, bank fishing): up to 45 days with public notification, and for a longer period in the same season with opportunity for public comment. Lifting restrictions: as soon as possible, staff will recommend to the commissioners that restrictions be removed. Public boat ramps and other facilities will receive priority for reopening.	INVASIVE AQUATIC PLANTS Up to 5 years under the stipulations of a management plan, adopted following opportunity for public comments. Lifting restrictions: the commissioners will decide following an opportunity for public comment. The commissioners acting jointly may reconsider and rescind or modify an order at any time for good cause including (1) aims of management largely met or no longer require surface use restriction, (2) detriments to public use substantially outweigh the value of continuing restrictions, or (3) emergency situations.
6. What uses should be restricted?	INVASIVE AQUATIC PLANTS General. Existing law pertaining to invasive aquatic species allows surface use restrictions for watercraft only. The agencies may monitor public use in restricted areas to determine if problems exist that require extension of the law to other uses. Uses to be monitored include but are not limited to angling, surface use by aircraft, water withdrawal, and swimming, except in emergency situations where property or human safety is endangered. Riparian uses: The agencies may designate an access lane to open water for use by riparian owners, on a case-by-case basis, and may require that boaters move through such a lane without using motorized power. Fish or boat passage at outflows. DEP will consult with DIFW	INVASIVE AQUATIC PLANTS General. Existing law pertaining to invasive aquatic species allows surface use restrictions for watercraft only. The agencies may monitor public use in restricted areas to determine if problems exist that require extension of the law to other uses. Uses to be monitored include but are not limited to angling, surface use by aircraft, water withdrawal, and swimming, except in emergency situations where property or human safety is endangered. Fish or boat passage at outflows. DEP staff will consult on a

ISSUE	RAPID RESPONSE (First Season)	MANAGEMENT (Subsequent Seasons)
	before placing any barriers in outflows to prevent downstream spread (see Issue 8).	biannual basis with DIFW regional biologists to determine the efficacy of retaining any barriers placed in outflows to prevent downstream spread. DEP or a local cooperator must document the effectiveness of any barrier to be retained longer than two years. (See Issue 8.)
7. How are restricted areas to be marked and enforced?	Under the state permit between the DOC and DEP stipulating the deployment of regulatory markers, DEP will locate with a geo-positioning system, mark, monitor, and maintain restricted areas. DEP will notify DIFW of buoy locations to ensure accurate enforcement. DIFW will notify any other appropriate enforcement authorities, such as harbor masters, that need to know. (See Appendix B)	Under the state permit between the DOC and DEP stipulating the deployment of regulatory markers, DEP will locate with a geo-positioning system, mark, monitor, and maintain restricted areas, except in cases where a lake association or other entity receives a permit from DOC to monitor and maintain such buoys according to a deployment plan developed by DEP. DEP will notify DIFW of buoy locations to ensure accurate enforcement. DIFW will notify any other appropriate enforcement authorities, such as harbor masters, that need to know. (See Appendix B)
8. Are permits needed?	A permit is not necessary for the imposition of a surface use restriction order or for activities regulated under NRPA that are required for emergency response purposes. A permit is needed for the application of an herbicide or pesticide under the Maine Wastewater Discharge Licensing Program. (See Step 3 of the Plant Protocol.)	A permit is not necessary for the imposition of a surface use restriction order (or for activities regulated under NRPA that are excluded for water quality improvements). A permit is needed for the application of an herbicide or pesticide under the Maine Wastewater Discharge Licensing Program. (See Step 3 of the Plant Protocol.)

Appendix B:

State Permit to Place Regulatory Markers

STATE PERMIT TO PLACE REGULATORY MARKERS
In Great Ponds of the State

(To Facilitate the Eradication and Management of Invasive Aquatic Plants)

AN AGREEMENT BETWEEN THE MAINE DEPARTMENTS OF CONSERVATION and ENVIRONMENTAL PROTECTION

Purpose

Invasive aquatic plants commonly spread and colonize new areas by fragmentation. Wind and waves can cause plants to fragment but recreational activity also can play a key role. In addition, surface uses can threaten the safety of divers and other participants involved in invasive aquatic plant eradication or control operations.

Accordingly, the need exists to place regulatory markers at certain high risk areas associated with invasive plant infestations to (1) facilitate a rapid response initiative designed to eradicate or limit the spread of a pioneer population or (2) implement a management plan designed to limit the spread of an established population.

Applicability

This memorandum is considered a "state permit" by which the Department of Conservation (DOC) delegates to the Department of Environmental Protection (DEP) the authority to deploy and maintain regulatory markers for such purposes. It does not restrict DEP from using small, temporary marker buoys which may be used for operations such as marking plant beds for re-location, delimiting zones of treatment, or guiding staff in quantitative monitoring, providing such buoys do not pose a hazard to navigation.

It is understood that advisory markers, which fall under the category of "other waterway marking devices" and may be used by DEP to convey messages warning boaters about milfoil infestations, also do not require a permit, but must still meet the requirements of the Maine State Aids to Navigation System Rules and Regulations. Under the navigation rules, milfoil warning buoys may not be placed "in a marked channel or a Fairway or in a manner that would impede access to a public boat launch(ing) facility or deny the right of Free Navigation." DEP will use professional judgment in determining the deployment of such warning buoys, and will consult with DOC whenever navigation issues exist.

Procedure for Determining Buoy Deployment and Revocation

Regulatory markers will be deployed only under the conditions of a surface use restriction order issued by the Commissioners of DEP and Inland Fisheries and Wildlife (DIFW). Please refer to a separate memorandum of understanding between DIFW and DEP about such orders (Appendix A).

DEP will provide DOC with a map showing the GPS coordinates, location, and identification number of all buoys within 15 days of their deployment; and shall remove all buoys on or before the end date of the restriction order. To the extent practicable, DEP will remove all buoys before winter.

DOC reserves the right to remove, or cause the removal, of any buoy installed by DEP if it determines the buoy to be a hazard to navigation. Safety must come first.

Buoy Specifications

DEP will purchase buoy, anchor, chain, and connecting hardware for all buoys deployed under this permit.

Regulatory markers will be white with an orange diamond having a cross centered within the diamond with the written warning "AREA CLOSED." Two inch high letters or numbers must be used on a five inch diameter buoy and three inch letters or numbers on a nine inch diameter buoy. DEP will place a unique identification number near the top of the buoy, e.g., DEP 1, DEP 2, etc. At least a 40 pound anchor is recommended for five inch diameter buoys and 90 pounds for the nine inch variety. See attachment for a typical buoy installation apparatus.

DEP will apply a sticker to or otherwise mark each buoy with phone number and identification code.

Note: Milfoil warning buoys must be solid yellow with two inch block letters. Their deployment is regulated under the Maine State Aids to Navigation System Rules and Regulations.

Lake Associations and Other Cooperators

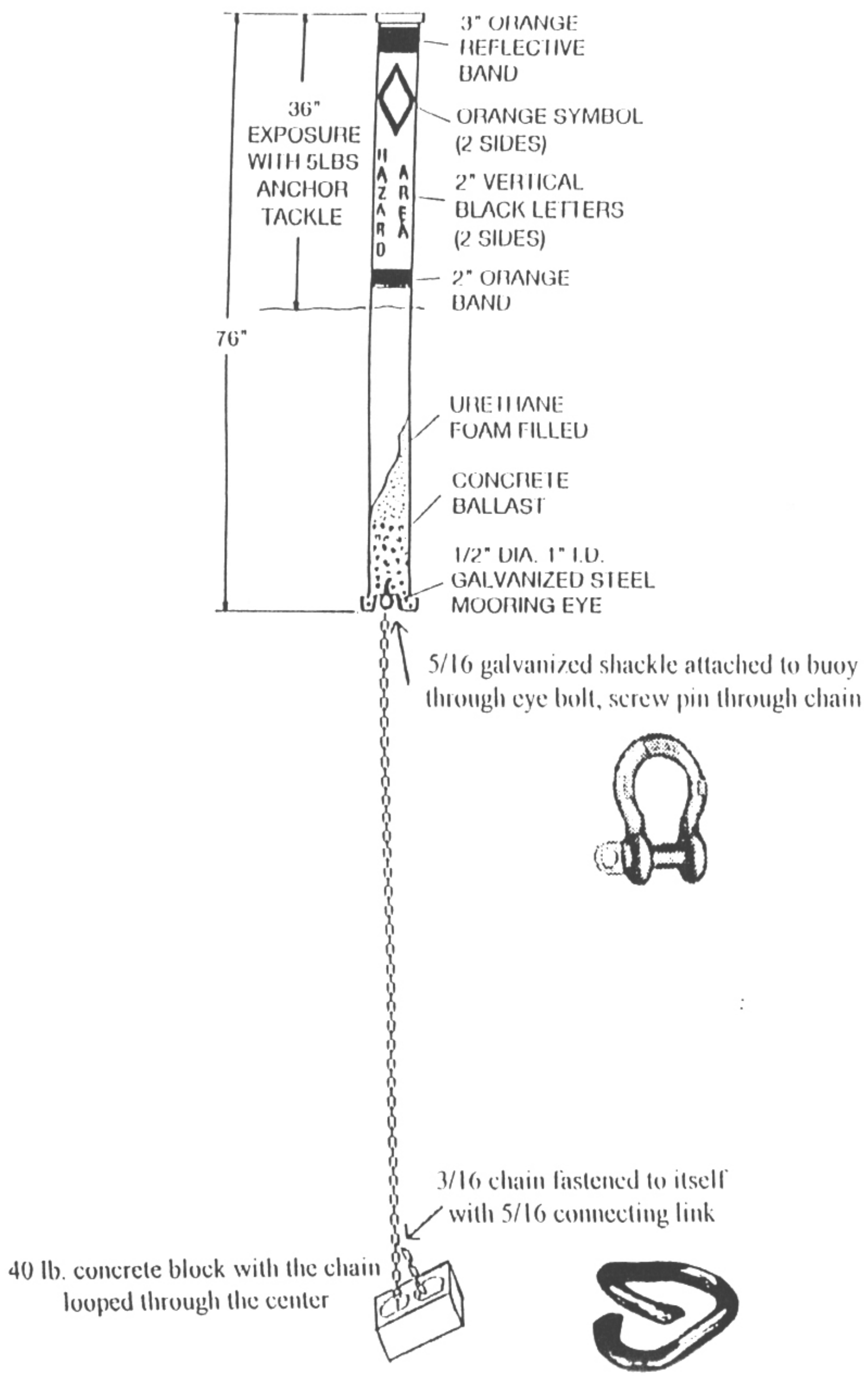
It is also understood that this permit applies solely to the Department of Environmental Protection. If DEP decides that a lake association or other cooperator is better able to place and maintain regulatory markers required for long term management, it will recommend approval to DOC of the cooperator's individual application for a permit, or file a joint application with the cooperator. DEP will in all cases determine where and when such buoys will be deployed, in a manner that is consistent with this state permit and with any surface use restriction order issued jointly by DIFW and DEP.

ADOPTED BY:

______________________________	______________________________
David Littell, Commissioner Department of Environmental Protection	Patrick McGowan, Commissioner Department of Conservation
____________________	____________________
Date	Date

Attachment: Typical Buoy Installation

Typical buoy installation as used on State marked lakes. Anchoring techniques are optional on water bodies marked under the permit system.



Appendix C:

Rapid Response Treatment Options

INTRODUCTION

Because extensive information already exists on techniques used to eradicate invasive aquatic plants, this appendix draws heavily upon the work of many other states, federal agencies, and researchers, giving preference to information from locales with conditions similar to Maine. In particular, Lars Anderson (USDA, UC Davis), Ann Bove (VTDEC), Kathy Hamel (Washington DECY), Roberta Hill (VLMP/MCIAP), John Madsen (MSU), Gerald Nelson, Ken Wagner (ENSR Corporation), and Scott Williams(VLMP/MCIAP) reviewed and provided excellent comments on Appendices C and D.

The technique selected for a given infestation will depend upon many factors, including:

- kind, amount, and distribution of target species
- kind of water body: lake or river, its volume and water flow
- uses of the water body: drinking water supply, recreational, commercial, wildlife
- growth stage of target plant and non-target vegetation
- other environmental variables such as wind speed and direction, water and air temperature, oxygen levels of water
- kinds and numbers of personnel and equipment required and available
- economic and environmental costs
- amount of time available

Figure 1.C.1 on pages C-3 through C-7 compares the relative cost, advantages, disadvantages, limitations, follow-up, and permits required for each option that DEP may contemplate using. These options are discussed in greater detail in the remainder of this appendix.

DEP will use manual removal, bottom barriers, diver-operated suction, and mechanical harvesting as the first options of choice. Aquatic herbicides will only be used for rapid response when none of the commonly accepted techniques will work, and when there is a strong likelihood that an infestation can be eradicated or controlled from spreading through its application. The aim of control using herbicides other than for eradication is to facilitate the effective use of other eradication or suppression methods.

Biological controls such as triploid grass carp are not deemed suitable for rapid response purposes, and may not be appropriate under any circumstances in Maine.

Figure 1.C.1: Comparison of Treatment Options for Plants (after Mattson et al, 30)

Method	Estimated Cost	Factors Promoting Success	Advantages	Limitations	Follow-up	Permits
1. Manual Removal **Divers use hands or hand-held tools to remove entire plant from sediment and water column**	$400/day/diver plus surface support and containment barriers; less with volunteer labor Plus disposal/transport costs. <u>Other Sources:</u> Cost per acre estimated to be $150-$300 for new, sparse infestations (30) and $80-$360, depending upon density and height (45)	• Small area of infestation, low density • Effective fragment containment • Low density native vegetation • Thorough plant spotting • High water clarity • Sandy or loose substrate allowing easier/complete removal	• Can target specific locations • Can target specific species • Has a minimum impact on native flora and fauna • Can be used near obstructions • Can be used where herbicides are not an option • Plants may be composted, depending upon the species	• Is slow, labor intensive, and expensive over a large area • Increases turbidity in short-term • Impaired diver visibility can restrict effectiveness • May spread species if fragments are not collected • In high density situations, may impact non-target species	Inspections at least monthly during growing season; new plants removed if spotted	Permit by rule under NRPA with exceptions described in Step 3 of this protocol.
2. Diver-Operated Suction **Divers use venturi pump systems to suction plants and their roots <u>after removing them manually</u> from the sediment. This approach accelerates manual removal.**	$1,100-2,000/day, depending upon plant density, ease of removal, and number of divers. Plus disposal/transport costs. One suction system can cover approximately 1 acre/week <u>Other Sources:</u> Cost per acre varies from $5000 to $15,000 (30)	• Monoculture of invasive species (few or no native plants) • Moderate or high density infestation over relatively small area (<2 acres) • High initial water clarity • Effective fragment containment • Sandy or loose substrate allowing easier/complete removal • Effective surface support for motor/compressor operation, plant collection and turbidity control	• Can target specific sites • Can target specific species • Can be used near obstructions • Can be used where herbicides are not an option • Allows more efficient harvest of denser vegetation than manual removal alone • Plants may be composted, depending upon the species	• Is labor intensive and slow • Increases turbidity in short-term • Impaired diver visibility can restrict effectiveness • Fragment production may be hard to control • May spread seeds and tubers • Could release nutrients into water column to facilitate algae growth	Inspections at appropriate intervals during growing season; new plants removed if spotted	Permit by rule under NRPA with exceptions described in Step 3 of this protocol.

Method	Estimated Cost	Factors Promoting Success	Advantages	Limitations	Follow-up	Permits
3. Bottom Barriers **Semi-permanent materials are laid over the top of plant beds to reduce light and suppress plant growth**	$0.35 to $1.25/sq.ft. (includes: $.15 to $0.75/sq.ft. for material; $0.25 to $0.50/sq.ft. for labor plus removal cost) Other Sources: Cost per acre is estimated at $20,000 to $50,000 for design, materials, installation, and maintenance for a year. Material costs: • Texel @ $0.25/sq.ft. • Palco @ $0.40/sq.ft. • Aquatic Weed Net @ $0.60/sq.ft. (30)	• Effective installation that deters barrier from shifting location • Limited boat wake, wave, spring, and current action in water column • Lack of bottom obstructions that can puncture barrier or hinder its installation • Depths ≥ 5 feet best. Need at least 3 ft separation from boats in protected areas w/ no boating action and at least 2 ft separation from surface to avoid ice scouring in winter. • Clear responsibility for maintenance	• Kills plants within one to two months • Some materials can be reused; removal for replacement or maintenance is often possible • Targets specific locations • Can be used adjacent to structures or obstructions • Is effective around docks, boat launches, swimming areas, and other small intensive use areas	• Is not species selective • Impacts non-mobile bottom dwelling organisms; most suitable for small (<1 acre) areas • Requires maintenance for safety and performance reasons • Fishing gear, propeller backwash, or boat anchors may damage or dislodge bottom screens • Improperly anchored and maintained screens may create safety hazards for swimmers and boaters • Some bottom screens are difficult to anchor on deep muck sediments • Without regular maintenance aquatic plants may colonize the bottom screen • Expensive for large areas	Inspect and maintain every 7-14 days for 30 days, then once a month thereafter during the season of use Removal within 3 months is preferred to allow native colonization; can leave barrier in place over winter and remove at start of swimming season	If low intensity, permit by rule under NRPA, applicable ONLY to natural resource agenices and its cooperators. Policy clarification is needed for the permit by rule process under Section 13 and to facilitate more intensive applications.
4. Mechanical Harvesting **A large specialized machine, with an underwater cutterbar, is used to "mow" and collect the plants from the top 4-10 feet of the water column** **Would only be used if a large population were discovered, and in the case of seed/tuber producers, preferably before their maturation**	$200-$600/acre, depending upon transport cost, at least for milfoil (Could be more for dense growths – which would likely not be treated in rapid response mode (87)) Plus disposal costs. Typical equipment costs range from $100,000 to $250,000, with operation for a season at roughly $25,000 to $50,000. Contract harvesting is more likely for rapid response actions	• Harvest before seeds, turions, tubers, or autofragments form • Wide and deep water body • Few bottom obstructions such as rocks, stumps, and changes in bottom contours • Limited wind and wave conditions • Absence of sensitive habitat • Suitable launching and off-loading site(s) • Effective fragment containment for species that fragment	• Produces immediate results, i.e. removal to cutting depth (4 to 10 ft.) • Can address larger areas more quickly than with other physical techniques • Produces minimal bottom disturbance, unless intentionally using harvester to disrupt root systems • Plant materials may be composted • Reduces internal loading of nutrients	• Is not species specific, except by timing or depth of cutting • Plants must be composted or disposed of • Can result in high level of fragmentation • Weather-dependent operation • Requires high initial capital investment or contractual arrangement • Can result in fuel or hydraulic fluid leaks into water body • Leaves root systems; only an eradication technique for annual plants • May increase phytoplankton growth in high nutrient lakes	Monitor regrowth rate. Some treatment programs monitor and manually remove plants, and associated tubers and turions after mechanical harvesting, during remaining growing season	If low intensity, permit by rule under NRPA, applicable ONLY to DEP and its cooperators. Policy clarification is needed to facilitate more intensive applications.

Method	Estimated Cost	Factors Promoting Success	Advantages	Limitations	Follow-up	Permits
5. Chemical Control: FLURIDONE • **Systemic** • **Slow-acting** • **Broad spectrum at high dose, more selective at low dose** **(inhibits carotene pigment formation)** Dosage Guidelines (87) • < 6 ppb risks low effectiveness • 6-9 ppb some target species if long contact time possible • 10-20 ppb more effective on all target species, but also kills many non-target spp. Typical Dosage (87): 6-10 ppb for 60 days, then gradually allow attenuation to 2 ppb for another 60+ days for Eurasian water milfoil or slender naiad; 10-15 ppb for 60 days for other susceptible target species (e.g., fanwort, variable milfoil), applied early in growing season, with attenuation over another 60 days.	$500 to $1,000 per acre for liquid form $800 to $1,200 for pelletized form $1,000 to $2,000 per acre for sequestered treatments; where a portion of lake is to be sequestered, add an additional cost of $10 to $20 per linear foot for the sequestration barrier (30)	• Combination with a limnocurtain will increase effectiveness and reduce impacts outside target area • Slow flushing rate – need 13+ week contact time in spring for maximum effect • Liquid formulation (SONAR AS) is more predicFigure (90). Granular form best for targeted (but not spot, i.e., colonies) applications such as in coves with slow flushing rates unless areas are curtained. Slow release pellet form or drip application of liquid form are possible in slow-moving streams or springs (90) • Accurate information about volume to be treated • Weekly tracking of fluridone concentration by FasTEST	• Low dosage compared to other herbicide • Can use booster treatments to maintain concentration over required contact time • Some success at concentrations less than 8 ppb, especially Eurasian watermilfoil and hydrilla • No swimming and fishing restrictions • No drinking water restrictions at concentrations below 20 ppb (fed std) • Slow die-off process means low oxygen conditions should not develop • At low dose: native submersed plant communities not necessarily affected in year of treatment; algal blooms won't necessarily form; floating and emergent plants not significantly affected (35, 91, 92) • Complete kill of susceptible vegetation possible at higher concentrations (10-20 ppb)	• Very long contact time needed; less effective with high flow and dilution (30) • Labels warn against using water for irrigation for 7-30 days post treatment because of its non-specific targeting • At high doses, many native submerged and some floating leaved plants may be killed • Indirect impacts may ensue from change in fish habitat • Native species community may shift at least in short term • At high doses, sometimes increased algal blooms are observed in first and second years after treatment (90) • Acquired resistance has only been noted for hydrilla (90) • Not to be used within ¼ mile of potable water supply at >20 ppb • Partial lake treatment (w/o sequestration) and pellet release rates can be unpredictable (30)	Unless the treatment area is sequestered, physical plant removal may be necessary for inlets and areas where the herbicide may be diluted by flowing water including in-lake springs. Inspect the littoral zone after each contact period (assuming boosters) and in the fall after treatment, and thereafter at least once a year during the growing season	Section 413 Wastewater Discharge Permit needed. "Rapid" response is most likely impractical without a General Permit under this regulation.

Method	Estimated Cost	Factors Promoting Success	Advantages	Limitations	Follow-up	Permits
6. Chemical Control: 2,4-D • **Systemic** • **Fast-acting** • **Selective (dicots, at low rates)** **(influences plant growth regulation)** Dosage (87) 50-200 lb/acre granular (water < 10 ft deep) • 0.5 mg/l for 72 hrs • 1.0 mg/l for 48 hrs • 2.0 mg/l for 24 hrs Typical dose: 50-100 lb/acre at average water depth of 4-8 ft, with a resulting concentration of 0.5 - 1 ppm for 3 days.	\$300 to \$800 per acre (30) \$1.80/lb to \$90.00/50 lb of granular product @ an application rate of 50-200lbs/acre (granular)	• Waters where milfoil has recently invaded, but where extent is beyond hand-pulling or bottom screening • Best results achieved w/ spring or early summer application • Higher applications necessary in water with dense colonies, water > 5' deep, or high flushing rate • Treat from shore outward to allow fish to migrate (30)	• Is suitable for spot treatment in granular form which has limited drift, including partial shoreline treatments; 24-72 hours of contact time needed • Rapid (3 to 5 day) return to accepFigure concentrations • Inexpensive on small scale • Complete kill of susceptible species possible	• Alternative drinking water sources are needed until concentrations have declined to 70 ppb or less; 21 day use limit, not for application <1500 ft from intake. • Fish toxicity is possible at doses >1 ppm, but rarely observed in lake treatments • Does not kill seeds and certain winter buds; follow up treatment or physical controls may be needed • Label warns that treatment of dense beds may result in oxygen depletion, but in practice rarely occurs since death and decomposition are relatively slow (88, 90) • Public perceptions of 2-4D	Thorough survey after 4-6 weeks, depending upon rate of die-back, and remove any survivors manually. Wait until plants are thoroughly decomposed for any follow up treatments (3).	Section 413 Wastewater Discharge Permit needed. "Rapid" response is most likely impractical without a General Permit under this regulation.
7. Chemical Control: ENDOTHALL (Aquathol K, Super K) • **Contact** • **Fast-acting** **(disrupts plant protein synthesis)** Dosage (30) • 0.5 mg/l for 48 hrs • 1.0 mg/l for 36 hrs • 3.0 mg/l for 18 hrs Typical dose: 1 gal/acre-foot	\$400 to \$700 per acre (30)	• Apply after ice out before native plants start growing (invasive species are often first to appear in spring) • Often used for spot treatment of limited areas as a follow-up to more selective lake-wide controls (30) • Most effective at temperatures greater than 65°F/18°C, which contrasts to suggested spring application to avoid damage to natives (30) • Evenly spread granular formulation (30)	• Low exposure time so can be used for spot treatment (12-36 hours) • Rapid action (7-14 days) • Areally selective, i.e., limited drift or impact outside target area • Relatively low cost • Fast breakdown of toxic components	• Does not kill root system or propagules, although Washington DECY has observed some systemic effects[7] • Temporary effect in vast majority of cases • Some label restrictions for swimming, fishing, and domestic water use	• Check for survivors about 3 weeks after treatment • Apply to additional areas after 3 weeks if more than 10% of waterbody to be treated	Section 413 Wastewater Discharge Permit needed. "Rapid" response is most likely impractical without a General Permit under this regulation.

[7] Systemic effects have been observed on a Washington State lake treated with endothall for an infestation of Eurasian milfoil. Milfoil was much reduced and this continued for several years following treatment (88)

Method	Estimated Cost	Factors Promoting Success	Advantages	Limitations	Follow-up	Permits
with a resulting concentration of 1.5 ppm for 1-2 days.						
8. Chemical Control: DIQUAT • **Contact** • **Fast acting** • **Non-selective agent** **(disrupts plant cell membrane integrity)** Dosage (30) • 1-2 gal/acre in water >4 ft deep for submergents • 0.5-0.75 gal/acre for floating plants • 0.1-0.3 ppm (0.7 ppm max)	$200 to $500 per acre (30) $90 to $100/gallon @ 1-2 gallons per surface acre at depths of less than 4 feet (30)	• Low flow conditions • Clear water needed; inactivated by muddy conditions (30) • Sometimes combined with copper chelates to increase effectiveness • Often used for spot treatment of limited areas as a follow-up to more selective lake-wide controls (30) • Adjuvant (e.g. Nalquatic), may be necessary in flowing water (30) • Best early in growing season, but can be applied anytime	• Rapid action, i.e., 12-36 hours • Limited drift or impact outside of target area • Effective against a wide variety of targeted vegetation	• Does not kill root system so must be used in combination with other technique(s)[8] • Some label restrictions for domestic use • Treatment of dense beds may result in oxygen depletion, but removal of dense canopy may counteract this (90)	• Check for survivors about three weeks after treatment	Section 413 Wastewater Discharge Permit needed. "Rapid" response is most likely impractical without a General Permit under this regulation.
9. Chemical Control: COPPER CHELATES (complexed copper) • **Fast-acting** • **Additive to other herbicides** **(toxic to plant cells but not effective on most**	$120 to $340 per acre, depending upon species present Can be < $50 per acre (87); chemical is very inexpensive, it is the application labor that controls cost with copper.	• Excessive periphyton growths limit access by other herbicides • Sometimes used with diquat to increase its effectiveness • Also used ahead of fluridone where plants are algae encrusted (87)	• Inexpensive (5) • Rapid action (7-10 days) • Approved for drinking water and water contact uses • Low exposure time required (18-72 hours) • Also controls many algae	• Only effective on narrow range of rooted vascular plants (90) • Does not biologically degrade • Potential toxic effects to many non-target organisms • Accumulates in sediments • Should not be used in trout-bearing waters where alkalinity is ≤ 50 ppm, especially at warmer temperature	• Follow up as appropriate for herbicides with which Cu chelates are used as adjunct (87)	Section 413 Wastewater Discharge Permit needed. "Rapid" response is most likely impractical without a General Permit under this regulation.

[8] Washington invasive aquatic species managers observed what appeared to be a systemic kill when diquat was used on a lake for *Egeria densa*. One year after treatment, very little *Egeria* was observed. They speculate that there were not enough carbohydrate reserves in the rhizomes to allow the plants to regrow (88).

Method	Estimated Cost	Factors Promoting Success	Advantages	Limitations	Follow-up	Permits
vascular plants) Dosage (30): 0.05-0.3 ppm, 1.0 ppm maximum, usually applied based on dilution in 10 ft deep band of water						
10. Chemical Control: TRICLOPYR • **Systemic** • **Fast-acting** • **Selective (dicots)** **(stimulates growth while preventing synthesis of essential plant enzymes)** Dosage (30): 0.25 ppm for 72 hr 0.5 ppm for 48 hr 1.0 ppm for 36 hr 1.5 ppm for 24 hr 2.0 ppm for 18 hr	$600 to $800 per acre (30)	• Target species in a dicot • Spot treatment needed; used after whole lake treatment w/ other herbicides such as fluridone (30), but not as effective for areas less than 1 acre as diquat or endothall (94)	• Complete kill of susceptible vegetation • Lower necessary exposure time allows for treatment in areas of greater water exchange • Low risk of direct impacts on fauna • Can be used in larger plots than 2,4-D because has fewer non-target effects (93)	• Lowered oxygen levels are possible as a function of vegetation decay but rarely occur (90) • Limited experience in field applications; new aquatic herbicide in 2002.	• Look for survivors after about 3 weeks	Section 413 Wastewater Discharge Permit needed. "Rapid" response is most likely impractical without a General Permit under this regulation.

Sources: See *Sources Cited* in Appendix F, especially Getsinger et al (14), Madsen (24), Mattson et al (30), US Army Corps of Engineers (56), and Washington DECY (79).

MANUAL REMOVAL

Application

Manual removal is exactly what it sounds like: a person wading (in water 2 ft deep or less) or diving (in deeper water) with a snorkel or scuba equipment surveys an area and selectively pulls out unwanted plants on an individual basis. This technique is easy to plan and implement and is often the best way to manage infestations that are lightly scattered singly or in small patches within the littoral zone or it can be used to follow-up herbicide or mechanical harvesting treatment. Although it is labor intensive, this technique is species-selective and can target the invasive plants with little or no damage to non-target species. In denser areas, manual removal may be supplemented with bottom barriers or diver-operated suction after plant materials have been uprooted. It is often used as a follow-up or complimentary treatment to other techniques.

The size of areas and density of plants considered suitable for manual removal vary, and Maine will develop its own guideline with more experience. Madsen recommends this method only for scattered plants which cover an area of 3-5 acres or less (90). According to ENSR (83), manual removal is best for milfoil when plants:

- cover an area less than two acres or
- cover an area less than 5 acres and are sparse and less than a foot tall.

Washington DECY (12) uses a rule of thumb of 3 acres or less (if infestation is concentrated), while Minnesota (73) targets areas with fewer than 0.75 acres or 100 plants. Massachusetts suggests the technique for areas with less than 500 stems per acre (30), which is about one plant for every 10 square feet. Manual removal may also be an essential alternative for sites where herbicides or other methods cannot be used, such as water supplies and sensitive wildlife habitat.

Efficacy

Factors that affect the success of manual removal include: water clarity, sediment type, suppression of milfoil fragments, density of target species and native aquatic plants, and quality and amount of effort expended. Target plants must be well marked or divers well trained in identification. Good visibility is especially important for the divers to locate target plants. If water clarity is poor, manual control methods may not be suitable. Harder sediment may require the use of a knife or tool to help loosen sediment from around the roots. In very hard sediments, fragments break off from such species as milfoil, leaving the roots behind and compromising the control effort. It is also not effective against plants with deep underground stems and roots which, if left behind, will re-sprout. The potential for dispersal of plant fragments must be considered in deciding whether to use manual removal as a technique.

Procedure

DEP staff will conduct or direct all manual removal operations for rapid response initiatives. Lake Assessment Section staff of the Land and Water Quality Bureau will follow the conditions specified for invasive plants under the PBR (Permit by Rule) regulations (38 MRSA § 480-H and 341-D(1), § 12 of Chapter 305) and its standard operating procedures which are summarized and supplemented below:

All removal from the soil will be done by hand, either by divers or snorkelers, sometimes using hand tools to loosen roots from sediments. Plants in more than 2-3 feet of water usually need scuba-equipped divers, although snorkelers using belt weights can remove plants effectively in shallow water. Divers need to be able to stay down long enough to be able to carefully work on a plant. Because a lot of turbidity is produced when removing plants, several visits may be needed to the same spot during a session to adequately remove of plants, especially larger clumps. It is particularly helpful to mark areas of harvest effort, and to create demarcated "lanes" of operation for divers to cover the target area in an orderly and efficient fashion.

When the water body is target-plant free after treatment, it will be resurveyed (at least in likely habitat areas) one or two times each year thereafter for at least the number of seasons appropriate to the target species, e.g. 5 years for curly-leaved pondweed.

DEP will keep records of all manual removal efforts, including:

- Date and location, using GPS coordinates of scattered plant locations or circumscribed areas (generally four corners) where denser concentrations occur
- Sketch map of the area
- Names of project manager and crew working on the project
- Tally sheet of removed plants
- Estimate of total number, volume, or weight of plants removed and how & where they were disposed of

DEP will follow the steps below in conducting a manual removal operation for rapid response:

1. PBR. File a PBR notification of intent under the Natural Resources Protection Act.

2. Survey and Marking. Survey all likely habitat areas, prior to commencing Manual Removal operations, to identify the extent of the infestation. Mark and record the boundaries and/or coordinates of all infested areas (or locations of scattered plants if only a few) to be removed. An enlarged topographic or bathymetric map is useful for this purpose. Very large clumps should have markers around the perimeter at 2-6 foot intervals, set about 2 feet outside the edge. Marking can be done with small diameter PVC pipe or non-floating landscape stakes. This allows observers to find plant locations the next year to ensure that re-growth. White color stakes will work, but fluorescent orange is best since algae growth on the white plastic can make it difficult to find later. Mark area clearly and be sure that the boundary will remain in place for future monitoring. Be sure that the boundary markers will not pose a hazard to boaters or swimmers.

3. Implementation Plan. Determine how many divers, waders, and support crew (including for disposal or composting) are needed, what each will be doing, and how quickly they can be deployed. For each team of 3 or fewer divers, arrange a spotter boat with a support crew of two: one to drive (driver) and another to net any fragments that may float up and one to tally harvested plants/areas (collector). Larger operations (greater than 5 acres) may need shore personnel to tally and process bags (4 shore personnel were needed for the West Pond operation). Determine how many fragment barriers, boats, fragment containers, and other equipment and materials will be needed.

4. Site Preparation. Install fragment barriers prior to beginning removal efforts. Select and equip a site for off-loading biomass for transport to a disposal or composting site. Plan/establish “lanes” or compass transects for each diver so all may work at their own pace.

5. Timing and Safety. Choose a day with suitable weather conditions (days with good visibility, calm conditions, and no predicted storms). Divers should wear a wet suit or other suitable clothing. It is important for divers to be able to achieve neutral buoyancy. This is the point at which the diver is neither too heavy nor too light but can maintain position in exactly the right position to work effectively without disturbing the plants or sediment unless by intent. If it is a very large plant, five or six feet high, the ability to hover motionless or in a slight feet up-head down position can be an advantage. Then if the diver needs to change position, the moving fins are less likely to disturb the plant and cause it to scatter. When wearing a dry suit, this can be done with some air trapped in the diver’s boots. If scuba divers are required, the divers will follow the safety guidelines outlined by PADI or other certifying organization.

   Ideally, divers should work in pairs and take into consideration weather conditions such as extreme heat or approaching storms. Non-motorized watercraft (e.g. row boats, canoes, surf boards) should be used for spotting. If motorized craft must be used for logistical reasons, operate motors outside of dive area and coordinate with divers to ensure safety. Boat crews should use life jackets and always follow boating/water rules and regulations.

6. Starting Point. Begin at the furthest boundary of each defined area and line up the teams along the boundary along established “lanes.” In large shallow areas, it is advantageous for the divers to use a compass to keep a straight course. Work towards the shore. Following the silt trail from the previous transect can also guide divers.

7. Harvesting. Removal techniques vary. Each method is effective under different conditions and the diver quickly learns which condition is best served by which method. Ideally before removing a plant and when only a few plants are involved, use a dive bag or mesh bag (such as large onion bags) to encase the plant so that it is less likely to create fragments. Remove both shoots and roots. Instead of ripping up plants, work fingers into sediment and carefully work plants and roots out as completely as possible. With larger infestations, use an approach which expedites the process such as grabbing hold of the top of the plant and winding it around the hand or arm as you move down the stem toward the bottom. Then with the other hand dig up the roots and transfer the whole plant to the “goodie” bag. Another method is to carefully locate the bottom of the stem, loosen the roots and then wind the rest of the plant around the hand.

   The spotter boat should remain near the transect, either down wind or current, with the “collector” on board or in the water who will use a fine mesh net (such as a butterfly net, pool skimmer, or kitchen strainer) or driver-operated suction device to collect any fragments and place them in storage. The “driver” needs to be very cautious of those in the water. Once the entire transect has been covered, repeat this step to ensure the area is thoroughly treated.

Diver efficiency is increased by the use of floats attached to dive bags which are hauled up by a collector when full and sent back down empty.

8. Recording. The "recorder" in the boat should record how many plants or how much biomass (e.g., number of 5 gallon buckets or 20 gallon trash cans) is removed from each scattered plant location or circumscribed area, using a simple tally sheet, keyed to GPS coordinates or a sketch map.

9. Disposal. Arrange for disposal locally if possible. All plant material will be bagged or otherwise contained securely and removed from the site. Harvested plants will be placed in a compost facility, in the woods away from moisture where they can degrade and not reenter the water body or, if these options are inappropriate or unavailable, in a solid waste disposal or incineration facility.

10. Monitoring. Monitor the site at least monthly or more frequently depending upon the species, during the growing season to evaluate and record the effectiveness of the treatment. Conduct a careful survey of the area of removal operations, preferably using divers, looking for re-growth or missed plants especially in the areas where marked plants occurred. Remove target plants as necessary and keep records as stipulated above.

Sources

- Maine DEP, 82
- Mattson et al, 30
- Washington DECY, 81
- Bove (89), Hamel (88), and Wagner (87), personal communication

DIVER OPERATED SUCTION

Application

This technique is to be used in Maine only as a means to assist divers with the removal of biomass from the water column so that they do not have to come to the surface when their biomass collection bags are full. It entails the use of barge-mounted pumps and strainer devices with hoses used by divers to "vacuum up" plants that are first uprooted by hand. The suction hose pumps the plant material and sediment which may be clinging to plants or suspended in the water column to the surface where they are deposited into a screened basket. The water and sediment may be returned back to the water column and the plant material is retained. Turbid water is generally discharged to an area curtained off from the rest of the lake by a silt curtain, if the installation of one is feasible. If the discharge area is not curtained off, it is best to discharge as far from the harvesting site as feasible, as turbidity will increase over the duration of work.

Since diver-operated suction is very expensive (>$5,000/acre, 30), it will be used only for denser sites or larger plants where hand bagging is not cost-effective. There are few commercial services available at this time and none within Maine.

Efficacy

Diver-operated suction operations are most appropriate for supporting hand harvest of dense pioneering plant colonies because of the labor-intensive nature of this procedure and the subsequent high cost of operation. Water clarity has a direct bearing on the effectiveness of this type of operation. The better the visibility, the better job divers can do at collecting target plants while avoiding non-target species. In waters with poor visibility, functions may take additional time, but can still be performed by feel by an experienced suction harvesting diver. The suction harvester allows the removal of biomass without divers having to make a trip to the surface and potentially losing track of their position in the transect. It also allows more effective collection of dense target beds with less chance of fragmentation or missed plants at the point of collection. The potential for plants to escape or fragments to be created in the surface part of the operation can be mitigated by surrounding the equipment with a fragment barrier or operating in an enclosure of some kind (e.g., a modified pontoon boat with collection area in the center).

Procedure

A diver and a tender should work together, although a second diver may be advantageous for safety and continuous operation and a second tender may be necessary to divide the labor associated with surface equipment operation and plant compaction/disposal. While ideally the tender should be in direct communication with the divers to provide direction and safety, this approach requires expensive gear and is unnecessary if other safety precautions are in place.

Plant fragments can be formed from this type of operation, as divers move through established plant stands, touching nearby plants and causing them to tear and break. Consider deploying personnel near the divers to skim fragments from the surface. Dispose of all biomass properly (see page 1-14).

Sources

- U.S. Army Corps or Engineers, 56
- Mattson et al, 30
- Bove (89), Hamel (88), Madsen (90), and Wagner (87), personal communication

BENTHIC BARRIERS

Application

A bottom barrier is a screen or thin "rubber" material that covers the lake bottom like a blanket. Bottom barriers compress aquatic plants while reducing or blocking light, thus preventing the growth of most aquatic plants.

Bottom barriers are an effective but fairly costly ($20K-$50K per acre) technique suitable for areas less than two acres in size with dense concentrations of the target species. They require diligent maintenance and have some other important drawbacks; they are too expensive to use over widespread areas and alter benthic communities, heavily impacting non-mobile organisms and eliminating all live plants without consideration of species. Installation and maintenance difficulties can be created by species with large roots and the mucky sediments in which they sometimes grow, and by obstructions such as boulders and sunken logs. Plants that do not root in the sediment can not be controlled by bottom barriers.

Bottom barriers can be moved from site to site as one area is cleared of an infestation, or they can remain in place to prevent regrowth. However, barrier surfaces can be re-colonized if they are in place for extended periods and desirable flora and fauna are excluded. Barriers should be removed in 2-3 months unless special conditions exist. One way to extend the benefits of a benthic barrier involves flipping it over into the adjacent area after one to two months, depending upon the material used. Plants are killed over that time period, and the barrier can be redeployed to the adjacent plot as part of normal maintenance. In this manner, two or three times the area of the benthic barrier can be treated in a single growing season.

DEP will file a notification of intent under the permit by rule standards of the Natural Resources Protection Act, or apply for a full permit if sensitive habitat is involved, for all rapid response installations (see Step 3 of Protocol). Benthic barriers installed for rapid response purposes are intended to be removed during the same season.

Efficacy

Materials. The success of this technique depends heavily on using the right material in the right location:

> "Ideally barrier materials should be heavier than water and permeable to the gases that will be generated by rotting vegetation. Many materials have been used, including sheets or screens of organic, inorganic and synthetic materials, sediments such as dredge sediment, sand, silt or clay, fly ash, and combinations of the above (Cooke 1980b; Nichols 1974; Perkins 1984; Truelson 1984). The problem with using sediments is that new plants establish on top of the added layer (Engel and Nichols 1984). The problem with synthetic sheeting is that the gases, evolved from induced decomposition of plants and normal decomposition of the sediments, collect under and lift the barrier (Gunnison and Barko 1992). Benthic barriers will typically kill plants under them within 1 to 2 months, after which they may be removed (Engel 1984). Sheet color is relatively unimportant; opaque (particularly black) barriers work best, but even clear plastic barriers will work effectively (Carter et al. 1994). Sites from which barriers are removed may be rapidly re-colonized (Eichler et al. 1995), either by native species with seeds or other propagules in the sediment or by invasive or opportunistic species from adjacent areas. In addition, synthetic barriers may be left in place for multi-year control but will eventually become sediment-covered and will allow colonization by plants." (56)

Material selection accordingly should take into account key factors such as cost, durability, potential for reuse, size dimensions, and ability to dissipate gas. Porous barriers are easier to manipulate (more easily removed and/or relocated) but must be cleaned (usually removed) annually. Solid sheet barriers are more permanent, but are more prone to billow (from trapped gases) and any sediment that accumulates on them must be removed eventually (it is often difficult to move the barrier) (87). Massachusetts lists products such as Texel, Palco, and Aquatic Weed Net for bottom barrier use, advising against less expensive substitutes that lack the effective properties of these products (30).

Sheeting materials come in a variety of dimensions, although custom sizes are available. Porous barriers most often come in 100 by 7 ft rolls, with an option for a double roll (14 ft wide, folded once so roll is still only 7 ft long for easier transport). Solid sheets may be wider, sometimes by 20 feet, but usually have a narrower base width and are made wider by heat seaming sheets together.

Gas Buildup. Success also depends upon managing gas buildup under barriers, which can be a problem even during the first year of installation. Covering sediments, which normally exchange gases with the water column, will trap those gases. This type of gas generation is not extensive in clay or sand substrates. But covering highly organic sediments will require that the project manager consider this and develop a maintenance program to deal with it. In addition, if the barrier is placed over actively growing weeds, those plants will die and decompose under the mat. This will also create gas problems in the short term. Gas buildup can be dealt with fairly easily. The project manager should direct divers to periodically inspect the mats and push gas bubbles to the edge of the mat, where they are released. Divers can also cut small slits in the material to vent this gas. Pinning the material to the bottom will also help. Alternatively, a porous barrier can be used to diminish gases, but will allow settling plant fragments to root and grow so annual maintenance is essential. Please note that even porous barriers may trap gas as algae and other small particles accumulate and clog the pores.

Locational Factors. Care must also be taken to site benthic barriers in locations without obstructions and which will not be overly disrupted by boat traffic or current or wave action. Typically, installation is not advised in water less than 3-5 feet deep with significant boat traffic. It is possible to support such installations, but greater anchoring and maintenance will be necessary.

Procedure

1. Survey. Survey all likely habitat areas, prior to commencing barrier installation, to identify the extent of the infestation. Record the sediment type and features, including any obstructions, hydraulic issues, or other interference factors. Prior to installation, mark and record the GPS locations of all areas to be covered.

2. Special Considerations. File a Notification of Intent for Permit By Rule. Consult with the Department of Inland Fisheries and Wildlife and Maine Natural Areas Program concerning habitat considerations, such as spawning and protected species. Also consult with the Department of Inland Fisheries and Wildlife, Department of Conservation, community, or private interest concerning any affected boating or public access facilities under their jurisdictions, and notify the nearest landowner(s) to the proposed bottom barrier location. Provide at least 10 days for all to comment. Do not place any bottom barrier until after fish spawning activity in that area is over, unless the delay compromises treatment effectiveness.

3. Implementation Plan. Develop an installation and maintenance plan, including type and amount of material to be used; methods and resources required for installation and maintenance; a map showing the area(s) in the lake where bottom barrier is proposed; the approximate date(s) of installation and expected removal; the estimated size and biomass of each area; consider a planting plan for revegetating areas after barrier removal to minimize the potential for re-infestation.

4. Installation. Assign qualified DEP staffers or other professionals to install the barrier (see methods below). Make sure it is not installed while people other than the installer(s) are in the work area. Follow one of the methods for installation described below. Place regulatory buoys if a surface use restriction is in effect or warning signs otherwise as necessary.

6. Inspections. Inspect the bottom barrier every 7-14 days for 30 days, then once a month thereafter. Check for gas bubbles and outbreaks of invasive plants. If plants are spotted, pull and dispose of them properly (see page 1-14). If gas bubbles are forming under the material, cut one or two additional slits on top of the bubble to release the gas.

7. Removal and Monitoring. Remove barrier no sooner than four weeks after installation; generally no longer than 2-3 months unless extenuating circumstances apply or the installation is intended to be permanent. Re-vegetate the area with indigenous plants, if appropriate and feasible. In subsequent years, monitor and hand pull any regrowth from the area once or twice a season until the infestation is adequately controlled for two years or more, depending upon the target species.

Installation Methods

ROLL-OUT METHOD

(After K. Wagner, 87)

The roll-out method is less costly and labor intensive than the "frame" method described subsequently. Roll-out will be the preferred approach for rapid response because it can be installed relatively quickly and more easily stored and transported.

1. Choose barrier material based on features of the barrier and area to be targeted.

2. Create a barrier shape conducive to the target area. Almost any rectangular shape can be generated by attaching available sheets, and most people find a 14 to 20 ft width with a 50 to 100 ft length most manageable (big enough to make a difference, small enough to be manipulated by 2 to 4 people).

3. Lay out the barrier on an open area of ground. If attaching small weights, do it under these conditions. Small weights can be stitched on with fishing line, but it is often easier to weight the barrier in place once installed. Roll the barrier up at full width around a PVC pipe of a length about 6 inches to 1 ft longer than the roll is wide, so that a small portion of pipe sticks out each end. If the pipe and roll are more than 14 ft wide, a person may have to support the middle while moving the roll, to avoid pipe fracture under the

weight of the material.

4. Position the roll at one end of the area to be covered. If from shore, start at the shoreline end. If away from shore, start at the shallow end. Sink roll and anchor leading edge by weighting or staking. Patio block or jute bags filled with clean gravel work well for weighting. If stakes must be used, they should be long enough to grab in whatever sediment is present, and be painted orange if they protrude from the sediment in an area near a swimming area.

5. Put a thinner pipe, dowel, or large screwdriver into each end of the pipe that forms the core of the roll, and roll out the barrier like a paper towel roll. Keep it elevated off the sediment to avoid excessive turbidity, but no higher than necessary, to limit shifting as it settles to the bottom. Weight sections as it is rolled out or wait until the end, depending on how even the installation is.

6. If there are areas of non-overlap or large wrinkles, smooth out by pulling at the edges. Do not walk on or push down on central areas (this disturbs sediment and pulls on other areas of the barrier). Allow for about 1 ft of overlap where more than one roll is installed.

7. Remove porous barrier after 1 to 2 months or at end of season, or simply flip it in place or into adjacent area (if control in the next area is desired). Solid barriers are not usually removed, but must be monitored for accumulated sediment and swept clean or otherwise maintained.

8. Removal of barrier from shoreline areas is best accomplished with a winch arrangement (see diagram on next page provided by Ken Wagner), which rolls the barrier back onto the PVC pipe. In deeper areas, remove weights and fold or tow barrier to shoreline. Spread to dry or use winch area to roll it up again.

BAYSTATE
ENVIRONMENTAL CONSULTANTS, INC.
296 North Main Street
EAST LONGMEADOW, MASSACHUSETTS 01028
(413) 525-3822

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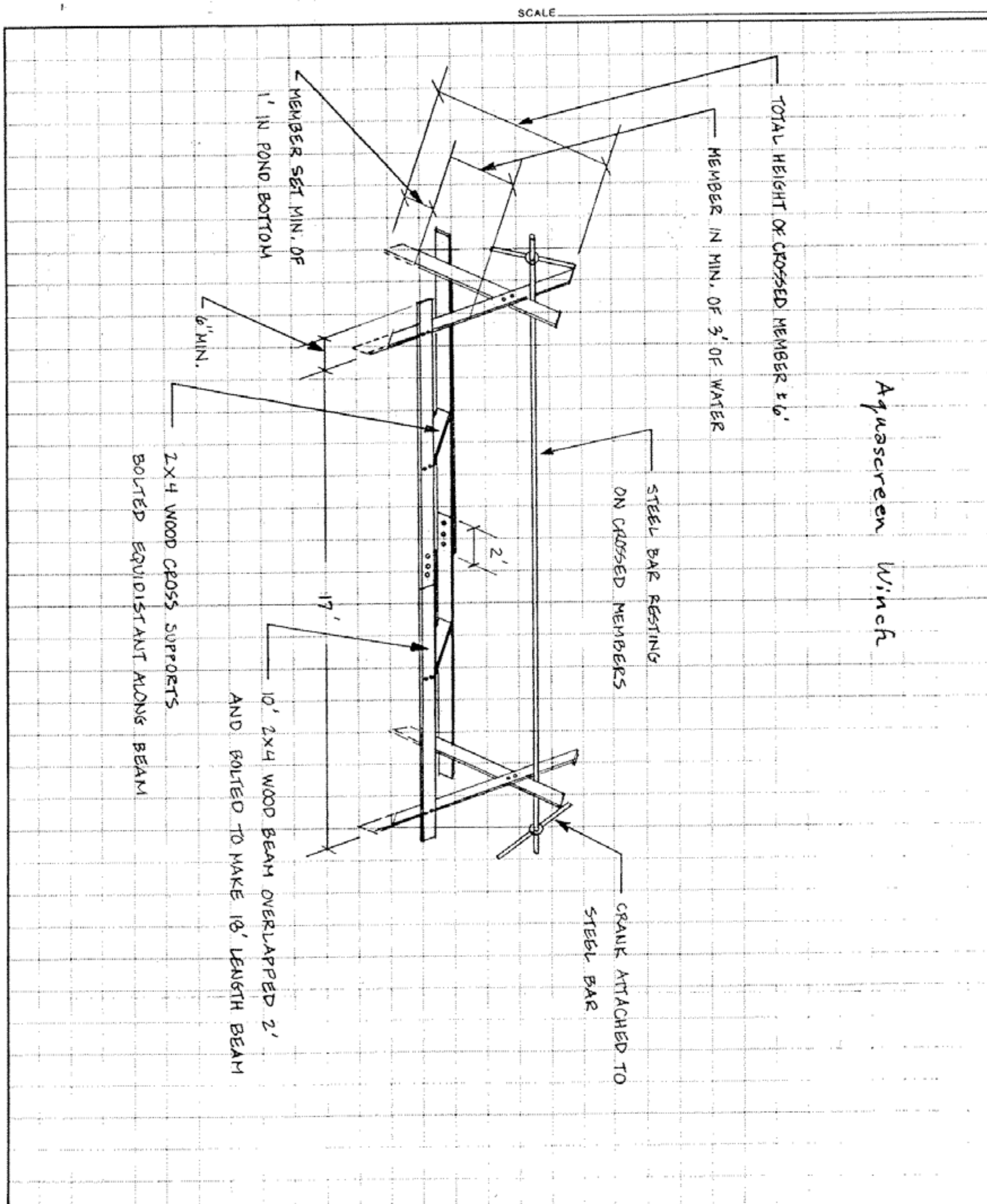
JOB 88-0617
SHEET NO. 1 OF 1
CALCULATED BY ______ DATE ______
CHECKED BY ______ DATE ______
SCALE ______



FRAME METHOD

(After Washington DECY and Thurston County, WA, Lakes Program; this method has also been used on Pleasant Lake in Maine by Jim Chandler)

> This method is best for longer term installations where the barrier will be moved to several locations on the lake. Disadvantages include the relative cost of materials and effort needed for construction and installation compared with the "roll-out" method.

Materials Required for Three 12'x12' Bottom Barrier Frames

- Fifteen 2" x 2"s, each twelve feet long. *Note: Fir, spruce, pine or cedar 2" x 2"s are suitable and may be more readily available in twelve foot lengths.*
- Nails (#6 Spiral) or screws, 2" long.
- Marine plywood, ¼" for making gussets. *Forty-eight gussets are required for bracing, top and bottom of each of the three 12'x12' frames (see sketch below). Approximately twelve square feet of plywood is required.*
- Lath (if nails instead of staples are used for securing material to the frames). About 165 lineal feet required.
- Screening material, allowing for some extra for finished edge, about 440 square feet required.
- Twelve polypropylene bags, about 2'x2', for use as sandbags; grain bags work well.
- Clean sand or gravel to fill twelve bags approximately ¾ full, about 1 cubic yard.
- Twine or string to secure bags

Tools Required

- Hammer
- Screw gun if screws are used
- Saw
- Utility knife or heavy scissors for cutting material
- Staple gun (if staples are used instead of lath for securing material to the frames)
- Twine or string

Building Instructions

1. Lay out the 2 x 2's for one frame – four sides, plus middle brace.

2. Measure and cut gussets from the ¼' marine plywood. These will be triangular pieces with each side 6" long. Sixteen gussets are required for each frame.

3. Nail or use screws to secure gussets at each corner of the frame and at both ends of the center brace on the "up" or visible side of the frame.

4. Carefully turn the frame over and lay the screening material on top. *Note: Screening material can be used in* six *foot widths if it is more conveniently available.*

5. Nail gussets or use screws to secure them to one end of the frame with the screening material underneath.

6. From the opposite end of the frame, pull the material tight and nail or screw down gussets

7. Staple the screening material to each of the 2 x 2's so that it is secured along the entire length (or nail down, using the lath).

8. Trim excess material even with the outside of the frame; and use it for other purposes.

9. Repeat for other frames.

10. Fill each sand bag about full with clean sand or gravel (fill material containing dirt cloud the water as the bags are put into place). If the screen site has a soft or muck bottom try filling the bags only ½ full. The bags may cause the screens to sink if the sediment is very soft. Tie the bags closed with string.

Installation Instructions

Installation is easier when plants have died back in the fall or in early spring before the plants start growing. Rapid response, however, may require installation during the growing season when it is desirable first to cut or manually remove the plants.

Be aware that boat propellers may dislodge bottom screens in shallow areas. Also fish hooks can get caught in the material. If the screened area is to be used for boat mooring, swimming, fishing, or wading, it may be prudent to post a sign or issue a surface use restriction to discourage or prohibit use of the area, depending upon the threat from disturbance.

1. Remove any sticks and stones from the area to be screened, especially where the edges of the frame will lie.

2. Slide the frame into the water. This can be more easily done with two people.

3. While the screens are floating on the surface, cut slits about one inch long in the material. This will allow the air trapped under the screen to escape, making it easier to lower the screen to the bottom. The slits will also allow gases generated by rotting vegetation to escape.

4. If installing the screen near a dock, line up the frame with the dock. Lower the frame into place by placing a sandbag on each corner and allowing the frame to slowly sink. Once it is on the bottom and in the position you want, add a sandbag to each end of the center brace.

5. Install the second and third frames adjacent to each other. If two people are working together, one can push while the other squeezes the frames together. Make sure there are no gaps between each frame and that the cross pieces are parallel with the other frames.

6. Place the remaining sand bags, concentrating the weight where the frames meet. Overlap the bags so that they rest partly on each frame. This will help to keep the frame in place.

7. Pull the aquatic weeds along the edge of the frames to keep them from growing over the screened area. Milfoil tends to "canopy" over adjacent areas.

8. If the screened area is to be used for boat mooring, swimming, fishing, or wading, it may be prudent to place warning buoys or post a sign telling users that the bottom screen is in place.

Screen relocation

Bottom screens installed during the growing season will suppress the plants within about four weeks. The bottom screens can then be moved to a new location or be removed for storage.

Sources

- U.S. Army Corps or Engineers, 56
- Mattson et al, 30
- Washington Department of Ecology (WDECY), 81
- NH Department of Environmental Services (NHDES), 36
- Village of Derby Center, Vermont, 84
- Bove (89), Hamel (88), Madsen (90), and Wagner (87), personal communication

MECHANICAL HARVESTING

Application

Mechanical harvesting is most often associated with large machines on pontoons that cut and collect vegetation. In its simplest form, plants are cut with a blade of some kind, severing the active apical meristem (location of growth) and possibly much more of the plant from the remaining rooted portion.

DEP expects to use mechanized harvesting mainly to arrest the spread of water chestnut, when a newly detected infestation is too advanced or other techniques are inappropriate. Mechanical harvesting is more appropriate for water chestnut than other species because it does not spread by fragmentation. By the same token, this technique may not eradicate a water chestnut infestation without augmentation by manual removal, bottom barriers, or 2,4-D, unless conducted for multiple years (3-10 suggested) in advance of any seed production. It may be especially useful for large applications where 2,4-D is ill-advised.

Harvesting is also the primary means for attacking European frog bit, a floating plant that can choke the water surface, but we have very little experience with this plant in New England at this time. Mechanized harvesting may also be useful to reduce biomass in an area slated for other control methods, such as bottom barriers, but the risk of spread by fragments will limit its applicability and require extra precautions.

Advanced harvesting technology involves the use of mechanized barges, in which plants are collected for out-of-lake disposal. Less advanced “harvesters” that only cut the plants are not recommended.

Advanced harvesting machines have numerous blades, a conveyor system, and a substantial storage area for cut plants. Some have offloading capacity, allowing easy transfer of collected plant material from the harvester to trucks that haul it to a composting area. For large jobs where the transport distance is substantial, an intermediate barge and/or high speed transporters may be used to accelerate harvesting speed, but at increased cost. On-land composting or disposal is not usually a problem since aquatic plants are more than 90 percent water and their dry bulk is comparatively small.

Commercial machines can clear a target area of plant biomass to a selected depth, usually 5 to 7 feet, but as little as 4 or as much as 10 feet depending upon the machine. Cutting rates tend to range from about 0.2 to 0.6 acres per hour, or 1 to 3 acres per day, depending on machine size, operator ability, type of transport mechanism, and distance to the offloading location.

Key issues in choosing a harvester include depth of operation, volume and weight of plants that can be stored, reliability and ease of maintenance, along with a host of details regarding the hydraulic system and other mechanical design features.

Efficacy

Regrowth of some water chestnut plants is expected. If they can be cut close enough to the bottom, or repeatedly, they will sometimes die, but this is more the exception than the rule. This technique is definitely ill-advised as a rapid response method for plants which fragment such as milfoils and fanwort. It is possible to just cut water chestnut without collection and get a decline in biomass; a project in the Watervliet Reservoir in New York is a good example of where cutting (no removal) greatly reduced water chestnut seed production (96). However, unless harvesting is completed before mid-July, the risk of some seed production exists, and possible oxygen deficits from decaying biomass suggest that collection and removal is preferred. Cutting and collecting over multiple years has greatly reduced water chestnut in multiple systems, including the Charles River Lakes District near Boston (30).

Procedure

Implementation Plan. As with all techniques, a detailed and thorough treatment program will be developed. The U.S. Army Corps of Engineers Aquatic Plant Control Research Program has developed a predictive model named HARVEST, which can be used to configure a combination of harvesters and transport vessels that will best serve the size of the harvest area and distance to offload site. This system allows the user to evaluate different mixes of equipment against the parameters that impact performance of harvesting systems and develop cost and time analyses. Copies of the model are found on the Aquatic Plant Information System website (56). Planning with this tool, particularly in conjunction with a GIS, is a significant asset in optimizing harvest performance (90).

Cost. Cost will be one of the most critical factors. In terms of capital cost, the needed equipment is expensive ($100,000-$250,000). If only a short term program is planned, contract harvesting may be preferable to purchase. As relates to operational costs, aquatic plant harvesting consists of collection of plants, transport of the plants to shore, and disposal of the vegetation, possibly with significant transport costs. As such, the efficiency of the harvesting operation is often determined by how far the harvester has to transport a load of cut vegetation and how far it must be taken once on shore. If a harvester can work close to a shore unloading site, it is possible to minimize the time that the craft spends transporting cut plants and maximize the time spent harvesting. The more offloading sites located near the areas to be harvested, the better the efficiency of the equipment. Where shoreside composting can be arranged, or a nearby farmer is willing to accept the plant material, transport costs are minimized. It is reasonable to assume that a season of harvester operation will cost on the order of $25,000 to $50,000, based on labor, maintenance and overhead costs. This approach may be most efficient when several projects, particularly if they are each small, are necessary.

Timing. Timing can play an important role in the efficiency and cost-effectiveness of water chestnut harvesting operations. The ideal time to harvest water chestnut is typically in the middle part of the plant's growing season after all of the nuts which have over-wintered have germinated but before new seeds have set. While it is important to wait long enough so that the amount of biomass is worth the effort, care must be taken not to wait too long as the efficacy of the harvester is directly related to how much time it spends harvesting versus transporting.

Prevailing winds and currents. Another consideration is the direction of the prevailing wind. Floating plants can disperse when pockets of open water occur. The removal of large areas of floating plants will require removal operations to occur over days or weeks and wind patterns can push vegetation back into areas already cleared. Managers should attempt to remove plants so that new open water areas created are not infested by wind blown plants.

Equipment Inspection. All equipment should be inspected both prior to and following the operation to prevent unintentional spread of other invasive species. Require contractors to provide written documentation describing the measures that have been taken to prevent the spread of non-native species to or from the infested waterbody, including the removal of all visible plant fragments, seeds, and animals from the equipment and proper drainage of bilge water. Cleaning can be accomplished by rinsing the equipment with hot water or a water-bleach mixture, drying it in the sun for at least five days prior to being placed in or near a waterbody, or using another proven method.

Disposal. See Step 4 of Protocol

Sources

- Madson (24)
- Mattson et al (30)
- New York State Canal Corporation
- US Army Engineer Research and Development Center (ERDC), 56
- Bove (89), Hamel (88), John Madsen (90), and Wagner (87), personal communication

HERBICIDES

Overview

Chemical treatment is one of the oldest methods used to manage invasive aquatic plants, and is still the most frequently applied approach in many states. Other than perhaps drawdown, few alternatives to herbicides were widely practiced until relatively recently (30). There are few aspects of plant control that breed more controversy than the use of herbicides. In some cases, however, herbicides are essential as the first line of attack to effect eradication, and, if this proves impossible, to contain and suppress an infestation; their immediate application may significantly reduce the overall environmental impacts from an infestation than could otherwise be achieved from prolonged use of non-chemical methods.

In general, DEP will use herbicides when no other technique or combination of techniques offers a realistic chance of eradicating a new infestation - or when the particular species or situation poses a very high risk of introducing a new species to the state or to a region of the state.

Herbicide Selection[9]

Having established that an herbicide application is the appropriate rapid response for a particular infestation, and knowing which herbicides are permitted for use in Maine (check latest list with Board of Pesticides Control), the next step is to select the optimal herbicide and application method. Several factors can influence these selections:

- specifications on the label, especially which species are susceptible,
- extent of area to be treated,
- water uses (see Figure 1.C.3.),
- environmental conditions, including non-target species or sensitive habitat,
- cost-effectiveness, and
- permit requirements.

<u>Effectiveness</u> of an herbicide in controlling the target plant species is normally the primary consideration (see Appendix D). Other factors determine possible choice between two or more potentially effective herbicides; these include, for instance, necessary dose, and whether a treatment is actually feasible as a function of non-target species. Effectiveness may be influenced by such factors as timing, rate and method of application, and weather conditions. Additionally, treatment planning should consider detention time, morphometry and water hardness to maximize effectiveness. DEP intends to select from the herbicides listed in Figure 1.C.2 for rapid response for invasive submerged plants, but may sometime consider glysophate or imazapyr, which are not in the figure, for species with floating or emergent vegetation.[10]

<u>Application rates</u> will depend upon the extent of area treated, water depth, water temperature (stratification), water exchange (flow) rates, target species type and density, weather conditions, water clarity, bottom sediment type, and suspended particles. DEP will use licensed applicators to determine the optimal amount to achieve desired results, minimize nontarget toxicity, eliminate unnecessary expense, and comply with the legal requirements. Care will be taken to

[9] Much of the information in this section is "adapted" from the Massachusetts Generic Environmental Impact Statement for Aquatic Plant Management (30).
[10] Imazapyr is now approved for use by the US EPA as a low-risk pesticide. Imazapyr (sold as Arsenal) is very broad-spectrum, but is effective on some species upon which glyphosate is not particularly effective or where timing of application is limited. Preliminary results in Washington State show it may be effective on parrotfeather (90).

apply the right herbicide at the correct time, at the correct rate, and in accordance with label instructions and permit provisions. In general, depending upon the target species, the optimal timing for application is in spring, when the invasive species is actively growing, the water is cool, and decay is slow. Higher spring flows may compromise maintenance of critical concentrations, however, necessitating later application. Fall can sometimes be a good time to treat some emergent species since the herbicide will be translocated into the roots.

Applicators will read and follow the label instructions faithfully. Only applicators licensed by the Maine Board of Pesticides Control may apply herbicides in Maine waters.

Before application, DEP will notify users as to the required waiting period(s) for restricted uses specified on the label.

One of the chief factors in selection of an aquatic herbicide is the exchange rate of the water, which must be known to determine how long the plant will be exposed to the herbicide at the required treatment concentration. The rapid response team needs to match an herbicide with an appropriate concentration and exposure-time relationship for the target species.

The concentration and exposure-time relationship for a given compound have been determined from laboratory experiments and field experience. For instance, if it is known from water exchange studies that the exposure time will ensure only 24 hours of contact with 1 mg/liter of 2,4-D if applied at full label rate, then a 75% control rate for Eurasian watermilfoil can be expected. If longer exposure times are expected, then lower concentrations can be applied or a higher percentage of kill can be achieved. Where lower application rates are possible, they allow applicators to save money on herbicides and to introduce a lower total amount of herbicide into the aquatic environment. For faster exchange rates, the applicator will have to use higher concentrations of the contact herbicides diquat or endothall, the more rapidly acting systemic triclopyr, or the gradual release, pelletized form of 2,4-D; slower exchange rates allow the use of the systemic herbicide fluridone.

Some or all herbicides may be completely inappropriate in some systems because it is never permissible to apply them at levels higher than the allowed EPA maximum label rate, and high flushing will result in concentrations too low to be effective. Wherever possible, the smallest volume of lake that can be treated should be, with sequestering curtains, slow release pellets, multiple "split" treatments, and other techniques applied to maximize exposure time at the lowest effective dose.

Contact herbicides are toxic to plants by uptake in the immediate vicinity of external contact, while **systemic** herbicides are taken up by the plant and are translocated throughout the plant. In general, contact herbicides are more effective against annuals than perennials. This is because they generally do not come into contact with and kill the roots, seeds or tubers of perennials, thus allowing them to grow back. While reproductive structures are not likely to be affected by a contact herbicide, with proper timing and perhaps several treatments, growths can be eliminated much the same way harvesting can eliminate annual plants. Systemic herbicides tend to work more slowly than contact herbicides because they take time to be translocated throughout the plant. Systemic herbicides generally provide more effective control of perennial plants than contact herbicides, as they kill the entire plant under favorable application circumstances. Systemic herbicides will also kill susceptible annual species, but regrowth from seeds is usually substantial. If annual species are the target of control, additional treatment will be required, normally a year after initial treatment and for as long as the seed bank facilitates new growths.

Another way to classify herbicides is by whether the active ingredients are selective or broad spectrum, although the split is not so simple; dose, exposure, and timing of application affect species differently. **Selective herbicides** are more effective on certain plant species or types of plants, e.g., dicots, than others, with control of that selectivity normally dependent on dose and exposure duration. Plant factors that influence selectivity include plant morphology, physiology and the stage of growth. Even a selective herbicide can kill most plants if applied at high rates. Likewise, contact herbicides may show some selectivity based on dose and plant features, but tend to induce impacts on a broad spectrum of plant species.

In addition to active ingredients, herbicides may also contain **adjuvants**. An adjuvant is any chemical added to an herbicide to increase its effectiveness of the application. The only herbicides likely to require the use of adjuvants in Maine are those which target floating or emergent vegetation. In this case, adjuvants would help the herbicide penetrate the cuticle of the leaf. Only those approved for aquatic use will be considered.

Figure 1.C.2: Use Suggestions For Selected Aquatic Herbicides

(Modified from Getsinger et al, 14, and Madsen, 24)

Herbicide	Activity	Systems Where Effectively Used	Exposure Time	Plant Species Response
Complexed Copper	SYSTEMIC Plant cell toxicant	Higher exchange areas; moving and still water	Intermediate, 18-72 hr	Broad-spectrum, acts in 7-10 days or up to 4-6 weeks
2,4-D	SYSTEMIC Selective plant growth regulator	Lakes and slow-flow areas; moving and still water	At higher concentrations: Short, 8-24 hr At lower concentrations: Medium, 3-5 days	Selective to broad-leaves, acts in 5-7 days up to 2 weeks
Diquat	CONTACT Disrupts plant cell membrane integrity	Shoreline, localized treatments, higher exchange rate areas; moving and still waters	Short, 4-24 hr	Broad-spectrum, acts in 5-7 days
Endothall	CONTACT Inactivates plant protein synthesis	Shoreline, localized treatments, higher exchange rate areas; moving and still waters	Short, 4-24 hr	Broad-spectrum, acts in 7-14 days
Fluridone	SYSTEMIC Disrupts carotenoid synthesis	Localized (with limnocurtain and/or in granular form) or whole lake treatments	At lower concentrations (<40 ppb) Long, 60-90 days; may get desired results in 45-60 days if > 10ppb	Broad-spectrum, acts in 30-90 days at > 10 ppb; more selective at < 10ppb
Triclopyr	SYSTEMIC Selective plant growth regulator	Lakes and slow-flow areas; moving and still water	Intermediate, 12-72 hr	Selective to broad-spectrum, acts in 7-10 days, up to 2 weeks

Toxicity and Water Use Restrictions. Aquatic herbicides must be registered by the EPA and the Maine Board of Pesticide Control. The list of registered herbicides for 2005, along with their EPA registration numbers and manufacturers, may be found in Appendix E. The criteria addressed in the registration process include data on forms of toxicity, impacts to non-target organisms, environmental persistence, breakdown products and fate of the herbicide constituents in the aquatic environment. Herbicide toxicology reports generally characterize toxicity in terms of LC50 or LD50. The LC50 is usually defined as the concentration (in ppm or mg/L of active ingredient) in water that will result in 50 percent mortality of the test species within the time period (usually 48 hours) and conditions of the test. The LD50 is defined as the amount of pesticide administered per kg of body weight of the test organism that will result in 50 percent mortality of the test species within the time period (usually 48 or 96 hours) and conditions of the test. The LC50 tests are usually conducted for aquatic species such as fish and zooplankton, for which uptake is generally via gills or other direct absorption. The LD50 tests are usually conducted for birds and/or mammals such as rats or mice, and the tests usually refer to oral dosage.

Toxicology data are usually given in parts per million (ppm), which is roughly equivalent to mg/L. In some toxicology reports, only the mass (weight) of the active cation or the equivalent mass of the acid form of the active anion is considered when reporting units of concentration. The nature and variability in toxicity reporting can be confusing and ambiguous in herbicide evaluations. Risk is a function of toxicity and exposure, and expressions of risk should address both of these key elements. While it is generally considered prudent to avoid contact with water immediately after treatment, and some states have their own use restrictions, there are no swimming restrictions on the federal label for any herbicide currently registered for use in Maine. Irrigation restrictions of several days or more are common. Only fluridone and triclopyr products are typically used in human drinking water supplies for treatment of invasive rooted aquatic plants, but others can sometimes be used with restriction. (30)

Selection of an appropriate aquatic herbicide requires consideration of the restrictions on water use that may be required following treatment because of its potential toxicity. These restrictions provide a balance between the risks involved in use of the herbicide in an aquatic system and the benefits that are realized from its application. Restrictions are required where there may be significant risk to people, livestock, or wildlife. It is necessary to consider the uses made of an aquatic system during the planning stages so that appropriate decisions on water use or temporary restrictions can be implemented prior to actual treatment. In some cases, uses can be shifted to alternative water bodies with prior planning.

Whether an herbicide is appropriate for a water body or aquatic system with a particular water use is clearly specified on the product label. Instructions on the current product label must be followed. Figure 1.C.3 summarizes water use restrictions for aquatic herbicides. **Consult the label for the latest standards**. See US Army Engineer Research and Development Center website for definitions for these uses (56). Figure 1.C.4 summarizes maximum application rates and concentrations, though the latest label should be consulted for definitive guidance.

DEP and its contractors will always consult an up to date label before selecting or applying an herbicide.

Sources

- Getsinger et al, 14
- Madsen, 24
- Mattson et al, 30, including direct quotes
- US Army Engineer Research and Development Center (ERDC), 56
- Anderson (97), Bove (89), Hamel (88), Madsen (90), and Wagner (87), personal communication

Figure 1.C.3: Water Use Restrictions for Aquatic Herbicide Applications

CHECK LABEL FOR CURRENT STANDARDS

(After US Army Engineer ERDC, 56)

<table>
<tr><th></th><th colspan="3">Human and Domestic</th><th>Livestock</th><th colspan="3">Irrigation</th></tr>
<tr><th>Herbicide/
Formulation</th><th>Drinking</th><th>Swimming</th><th>Fish Consumption</th><th>Watering</th><th>Turf Ornamentals</th><th>Forage</th><th>Food Crops</th></tr>
<tr><td>Complexed Coppers
VARIOUS</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>2,4-D, granular
AQUAKLEEN
NAVIGATE</td><td>Conc. ≤ 0.07 ppm</td><td>0</td><td>0</td><td colspan="4">Conc. ≤ 0.1 ppm</td></tr>
<tr><td>2,4-D, liquid
DMA*4 IVM</td><td>Conc. ≤ 0.07 ppm and not within 1,500 ft of intake</td><td>0</td><td>0</td><td>Conc. ≤ 0.07 ppm and not within 1,500 ft of intake</td><td colspan="3">Conc. ≤ 0.1 ppm and not within 1,500 ft of intake</td></tr>
<tr><td>Diquat
REWARD</td><td>1-3 days</td><td>0</td><td>0</td><td>1 day</td><td>1-3 days</td><td>5 days</td><td>5 days</td></tr>
<tr><td>Endothall, K_2 salt
AQUATHOL K</td><td>7-25 days</td><td>1</td><td>3 days</td><td>7-25 days</td><td>0</td><td>7-25 days</td><td>7-25 days</td></tr>
<tr><td>Endothall, K_2 salt
AQUATHOL SUPER K</td><td>7 days</td><td>1</td><td>3 days</td><td>7 days</td><td>0</td><td>7 days</td><td>7 days</td></tr>
<tr><td>Fluridone
SONAR A.S.
SONAR Q
Sonar PR</td><td>Conc. <0.02 ppm within ¼ mile of intake</td><td>0</td><td>0</td><td>0</td><td colspan="3">7-30 days
(30 suggested by manufacturer)</td></tr>
<tr><td>Glysophate
RODEO
AQUAPRO</td><td><0.7 ppm</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Triclopyr
RENOVATE 3</td><td>< 0.4 ppm</td><td>0</td><td>0</td><td>21 days</td><td>0</td><td>120 days or nondetectable</td><td>120 days or nondetectable</td></tr>
</table>

* Should not be used in fish-bearing waters.

Figure 1.C.4: Aquatic Herbicide Maximum Use Rates

CHECK LABEL FOR CURRENT STANDARDS

(For selected products approved for use in Maine, see Appendix E. Note that applied rates are usually well below maximum allowed by label, and should be planned based on dose necessary to kill the target species.)

	EPA Registration Number/Form*	Persistence (half-life, days)**	Maximum Application Rate***	Maximum Water Concentration***(ppm)
Copper Complexes Komeen® (8% CU EDA)	1812-312/L	3	3.34 gal/acre-ft	1.0
2,4-D AquaKleen® granular (27.6% BEE) Navigate® (27.6% BEE) DMA 4 IVM (DMA)	228-378-4581/G 228-378-8959/G 62719-3/L	7.5	200 lbs/acre 200 lbs/acre 4.75 gal/acre (52)	5.3 5.3 7.1
Diquat dibromide Reward Landscape and Aquatic Herbicide (36.4%)	100-1091	1-7	1 gal/acre (≤2 ft depth) 2 gal/acre (≥4 ft depth)	0.37
Endothall Aquathol® K (40.3% DP salt) Aquathol® Super K (63% DP salt)	4581-204/L 4581-388/G	4-7	3.2 gal/acre-ft 22 lbs/acre-ft	5
Fluridone Sonar® A.S. (41.7%) Sonar® PR Precision Release Sonar® Q	67690-4/L 67690-12/G 67690-3/L	20-40	0.4 gal/acre-ft 8.1 lbs/acre-ft 8.1 lbs/acre-ft	0.15 ****
Triclopyr Renovate® 3	62719-37-67690	3.7-4.7(85)	2.3 gal/acre-ft	2.5****

* Formulation: L = liquid; G = granular; P = slow release pellet.
** Unless otherwise noted, half lives are from Madsen, 24.
*** From specimen labels for ponds and lakes. Check the label. Specimen labels may not be current.
**** Total in any growing season.

Appendix D:

Species-Specific Treatment Options

Species-Specific Treatment Methods

FLOATING-LEAVED ATTACHED PLANTS

WATER CHESTNUT (*TRAPA NATANS*)

Growth and Habitat Considerations

- Long stems on this annual can reach up to 16 feet in length. Additional leaves can be found along the submerged stem. Has both submerged and floating leaves (36). Very fine roots generally anchor the plant into a muddy substrate (14).
- Grows rapidly in calm, shallow nutrient-rich waters (quiet streams, ponds, freshwater regions of estuaries, and mud flats) with soft muddy bottoms (14);
- Generally found in waters with a pH range of 6.7 to 8.2 and alkalinity of 12 to 128 mg/L of calcium carbonate (33).
- Dispersal primarily limited to the detachment of rosettes from their stems and or displacement of nuts by waves, winds, or human and wildlife interactions. Lateral dispersal can also occur when plants are uprooted and flow downstream (28).
- Produces a nut that has four extremely sharp horns connected to a spine with several barbs. The mature nuts sink to the bottom, can withstand drying and other extreme environmental conditions, and germinate up to 8-12 years later, though most germinate within two years. The nut is the only part of the plant that will overwinter successfully. Germination occurs in the spring; one seed can give rise to 10-15 rosettes, each of which can produce 15-20 seeds. Each seed can produce 300 new seeds in a single year (28).
- Success at colonization is due to its ability to produce an abundance of vegetative growth quickly in response to low density of other aquatic plants and to shade them out (14).

Eradication and Control Techniques

Treatment of water chestnut is season specific and needs to be completed prior to the formation and dropping of seeds. Fortunately, it is possible to eradicate this species successfully without using herbicides so manual removal and other physical methods will be preferred. Disposal of the plant biomass of this prodigious species is a challenge, but problems are hugely diminished if plants are pulled early when they are small, and before any seed has set. Because water chestnut can repopulate an area quickly, close follow-up monitoring is essential.

Response to Physical Methods

Manual Removal. Water chestnut can be eradicated through manual removal, if the infestation is detected before large masses accumulate, or where a large volunteer work force is available.

A successful manual removal effort in the Mystic River Watershed in Massachusetts began in 1999 (13). Eradication in Alewife Brook and Little Pond is complete, with no plants having been seen for three years, the time during which seeds readily sprout. As of 2003, Yates Pond, Spy Pond, Perch Pond, Little River, and Wellington Brook were almost water chestnut free. As of early summer 2004, Blair Pond – which three years before had over 30,000 plants removed –

had yielded only six plants. They have now turned their attention to other ponds in the watershed which are heavily infested. In experimenting with land composting of the harvested biomass, the group believes that the seeds may be destroyed in 60 to 90 days.

Also in Massachusetts, annual hand harvesting in Morse Pond in Wellesley has kept water chestnut from becoming established (30). An annual volunteer program is successfully removing new growths which typically fill one to three canoes each year.

Mechanical Harvesting. Mechanical harvesting in conjunction with hand removal may be required if a more substantial population of water chestnut is discovered. Getsinger et al. report that mechanical harvesting is a short term method appropriate for initial control of small to moderate infestations of water chestnut (14).

The Tidewater Ecosystem Assessment staff of the Maryland DNR coordinated a large mechanical and volunteer water chestnut harvesting effort on the Sassafras and Bird Rivers between 1998 and 2002 (27). Because mechanical harvesting boats cannot operate in shallow areas, mechanical harvesting was complemented with removal by hand and rake. Mechanical harvesting in 1999 on the Sassafras River removed an estimated 260,000 pounds of water chestnut, which was composted in the water using floating cages. Populations have steadily decreased, and in 2002 only a few plants were found and removed by hand on each river.

Harvesting efforts over a three year period on the Charles River in Boston have controlled water chestnut well. A 1996 harvest had no observable effect, while repeated harvesting in 1997 significantly reduced growth. Follow-up harvesting is now on a maintenance basis.[11] Some areas of Lake Champlain in Vermont and New York, which were choked with water chestnut and repeatedly harvested mechanically in the past, are now reduced enough to allow manual removal operations as the primary control technique (30).

Response to Herbicides

Granular 2,4-D (BEE) is the herbicide of choice for water chestnut, and should be followed up at least annually with manual removal until no regrowth is detected (87). A web-based fact sheet from Cayuga County, New York, advises that up to 75% of the water chestnut in a treated area will brown, wilt, shrivel and die. One project in New York should be watched. In 2003, the Central New York Water Chestnut Task Force and cooperating counties implemented a chemical control demonstration project using Aqua-Kleen on test plots covering eight acres of water chestnut in Oneida Lake. A permit was obtained from New York State Department of Environmental Conservation for the herbicide application, the public was informed, and extensive pre- and post-application monitoring was conducted to test the effectiveness of the herbicide on water chestnut as well as impacts on the aquatic ecosystem. A report is to be compiled for use by other groups considering chemical treatment of water chestnut.

Cerexagri, Inc., the distributor of Aqua-Kleen, suggests using the high side of the range for this granular 2,4-D product on water chestnut and other "slightly to moderately resistant weeds" (product label). Consequently, where a local native plant community is valued, herbicide

[11] Contact Marc Bellard, Applied Aquatic Control, Inc.

treatment may not be appropriate. The company especially recommends the higher range if the water is more than eight feet deep, and has a high density of weeds and large volume of turnover.

Figure 1.D.1: Water Chestnut Herbicide Guidelines
Consult Label for Latest Standards

Order of preference	**Preferred Chemical**	**Alternative Chemical**
Herbicide or formulation	Granular 2,4-D: Aqua-Kleen	None recommended at this time.
Conditions favoring one formulation over another	Only granular form normally used to maximize exposure in what are usually flowing or open exchange systems; restrictions for potable water supplies, well recharge areas, livestock and irrigation	
Application rate (from field experience, generally not from label; source, Ken Wagner, unless otherwise specified)	100-200 lbs/acre	
Target concentration	3-5 mg/l (87)	
Exposure time	~ 1 day (87)	
Re-treatment or follow-up conditions	Manually or mechanically harvest surviving plants (87)	
Timing issues	In spring when starts to grow (56), not later than when rosettes begin to form	
Notes: Harvesting is preferable to minimize non-target impacts, and can succeed over a period of several years.		

YELLOW FLOATING HEART (*NYMPHOIDES PELTATA*)

Growth and Habitat Considerations

- Bottom rooted perennial with long branched stolons that extend up to one meter or more and lie just beneath the surface (72).
- Prefers slow moving rivers, lakes, reservoirs, ponds, and wetlands from 0.5 to 4 meters deep (39), where it dominates with a thick mat of floating leaves; can also grow in damp mud (72).
- Reproduces by seeds and fragmentation of broken stems and leaves with attached stem parts; can spread to new areas by water flow during rain events and/or by waterfowl. Viable seeds are produced abundantly and germinate readily (72).

Eradication and Control Techniques

Little is known about the control of yellow floating heart. Because this species has a similar growth habit to the fragrant waterlily, some believe that methods used to manage waterlilies can also be expected to be effective. Waterlilies can be controlled by cutting, harvesting, use of bottom barriers, and treatment with aquatic herbicides such as Rodeo (glyphosate) (66). New Zealand advises that smaller infestations can be cleared by hand, while larger sites can be controlled by the laying of bottom barriers and use of herbicides such as glyphosate (37).

Response to Physical Methods

Because of the growth habit of yellow floating heart, bottom barriers would have to be installed in early spring before much plant growth (87).

Response to Herbicides

No herbicide treatment of floating heart has been reported in the United States, but Westerdahl and Getsinger report excellent control of the fragrant waterlily with glyphosate. At least two formulations (Rodeo™ and Aquaneat™) are registered in the state should the need arise. The application of glyphosate allows specific plants or areas of plants to be targeted for removal. Generally two applications of glyphosate are needed. The second application controls the plants that were missed during the first herbicide application.

Other herbicides besides glyphosate may work on yellow floating heart, but, with the exception of imazapyr, are more intrusive because they impact the water column (88). One drawback of using herbicides, at least for waterlilies which is the only reference point for treatment of yellow floating heart in the US, is the "uplifting" of mats of decomposing roots that can form large floating islands in the water body after the herbicides have killed the plants. Harvesting waterlilies before treating the water with a systemic herbicide such as fluridone has been shown to stress the plants and provide greater impact of the herbicide to the plants, as was demonstrated during the 1991 fluridone application to Long Lake, Thurston County (67).

2,4-D is also used for waterlilies (and watermilfoil) but carries significant restrictions (39). The South Carolina Department of Natural Resources specified the application of granular 2,4-D BEE for use on such emergent species as floating heart and waterlily in its 2004 Aquatic Plant Management plan (52). Good control of waterlilies has been also obtained with endothall dipotassium salt (75).

Figure 1.D.2: Floating Yellow Heart Herbicide Guidelines

Consult Label for Current Standards

In order of preference	**Preferred Chemical**	**Alternative Chemical**	Alternative Chemical
Herbicide or formulation	Glysophate (or imazapyr) with or without penetrant (37,72)	Granular 2,4-D BEE (87)	Fluridone, possibly preceded by harvesting (67)
Conditions favoring one formulation over another	Allows application to leaves so impacts water column less.	Impacts water column and carries restrictions.	Impacts water column but with fewer restrictions than 2,4-D.
Application rate (from field experience, generally not from label; source, Ken Wagner, unless otherwise specified)	No field experience reported; see label.	150-200 lbs/acre, depending upon species (52)	1.5-2 oz/acre-foot
Target concentration		3-5 mg/l (87)	15-20 ppb
Exposure time		~ 1 day (87)	45-60 days
Re-treatment or follow-up conditions	2 applications needed	Hand harvest survivors	Hand harvest survivors
Timing issues	After floating leaves are present	Before plants reach surface	Before plants reach surface
Notes: Harvesting, as with water chestnut, would be the preferred control approach, to avoid non-target impacts, and could be effective over several years.			

SUBMERGED PLANTS

BRAZILIAN ELODEA (*EGERIA DENSA*)

Growth and Habitat Considerations

- Generally rooted in depths of up to 20 feet or drifting, in both still and quietly flowing waters (14).
- Lacks specialized storage organs such as rhizomes or tubers.
- Reproduction is primarily vegetative in the United States; seeds and/or female flowers have never been reported (63). Specialized double nodes produce lateral buds, branches, and adventitious roots. Only shoot fragments of Brazilian elodea which contain double node regions can develop into new plants, but such fragments are readily produced. Plant root crowns also develop from double nodes along an old shoot. When a shoot sinks to the bottom during fall and winter senescence, a new root crown may develop at one or several double nodes along the new shoot. Researchers at Portland State University are investigating the frequency of double nodes and whether they exhibit a weak period of development that can be exploited for optimal control purposes (44); DEP Invasive Aquatic Species Program staff will monitor progress.
- About 25% of the biomass overwinters along the bottom in a dormant-like, evergreen condition (as reported for Long Lake in Washington State). Growth is initiated when temperatures reach 10 degrees centigrade (50 degrees F). Two growth spurts occur in spring and fall, each followed by periods of senescence with a loss of biomass from sloughing and decay of tips and branches. (63)

Eradication and Control Techniques

Egeria densa may be Oregon's worst invasive plant problem; the state has spent over one million dollars in controlling one infestation (63). According to Kathy Hamel, "this is one heck of a plant to try and eradicate." Washington State has, however, eradicated *Egeria densa* from Silver Lake by stocking 83,000 triploid grass carp – at the expense of all submerged vegetation – so the state is exploring other less drastic options (88).

Response to Physical and Mechanical Methods

British Columbia reportedly eradicated pioneering colonies from large lakes using bottom barriers that covered biomass and root crowns (56). Diver-operated suction has also been effectively used (97). Because this species spreads readily through fragmentation, physical removal through manual removal and diver operated suction must be attempted with care, preferably in early spring when plants first appear, but as soon as possible in any case, using containment nets or curtains to trap fragments.

Mechanical harvesting of any means is ill advised unless the infestation has spread to all available niches and control is the objective. Localized control can be achieved by covering the sediment with a benthic barrier (14). King County, Washington is currently manually removing an early infestation in Doloff Lake, and may subsequently follow-up with diquat; their experience may provide helpful guidance to Maine in the future (88).

Drawdown is unsuitable in most Maine lakes as a rapid response technique largely for climatic reasons but timing and site conditions on an impoundment may allow its use as one among several tools. A decrease in mass can be anticipated for Brazilian elodea in cold climates (30). Consecutive drawdowns in Black Lake, Louisiana, successfully eradicated an infestation but such results may not necessarily be achievable in northern climes (16).

Response to Herbicides

Fluridone and diquat appear to be the herbicides of choice for this species. California Division of Boating and Waterways has obtained good control with fluridone, as well as with complexed copper alone (63); water managers there also sometimes pretreat or treat with diquat (39). Copper is not generally a good choice, especially in lakes with low alkalinity (87, 88). The Division is now using Sonar Precision Release rather than Sonar Slow Release (SRP) where a pellet formulation is needed; and has conducted research on mechanical and chemical control methods at various sites throughout the "Delta" to answer questions about potential environmental impacts. See the Division's Addendum to 2003 Environmental Impact Report for results.

Washington State lake managers used fluridone (Sonar) to treat Lake Limerick in 1995 with good results; a year after treatment, plant biomass had declined about 95 percent throughout the lake (63). They are subsequently treating another lake used for fishing with fluridone (12 ppb over a 10-12 week period); and may follow-up by stocking a limited number of grass carp and using divers to manually remove any remaining plants. They also tried an early application of diquat on *Egeria* to "burn it back," and when regrowth occurred, applied fluridone. This approach does not appear to have been more successful than the use of fluridone alone (88).

Figure 1.D.3: Brazilian Elodea Herbicide Guidelines

Consult Label for Current Standards

Order of Preference	**Preferred Chemical**	**Alternative Chemical**	
Herbicide or formulation	Fluridone PR, SRP, or Q (depending upon flow and sediments) alone or with diquat; AS form if extended contact can be achieved. (87)	Diquat Liquid form applied to target areas; may eliminate *Egeria* because it has minimal root structure or food storage	
Conditions favoring one over another	Liquid AS form generally preferred, but effectiveness decreases in waters with high flow and dilution without sequestration (87); pellet forms used if exchange not prevenFigure, with Q having fastest release and PR the next fastest.	Water exchange too high for fluridone, biomass high and growth stage is old.	
Application rate (from field experience, generally not from label; source, Ken Wagner, unless otherwise specified)	Liquid: 0.12 to 2.44 quarts per acre depending upon depth (52); typically 1-2 oz/acre-foot Pellet: 15 to 80 pounds/acre depending upon depth (52); typically 1-5 lb/acre-foot	0.25-0.50 gal/acre-ft	
Target concentration	10-20 ppb range (87), 12 ppb (88) if no exchange	0.1-0.2 ppm	
Exposure time	10-12 weeks (88)	3 days	
Re-treatment or follow-up conditions	Manual removal of survivors	Re-treat after 3 weeks if necessary, or manully remove survivors	
Timing issues	Early in season (87) is preferable	Early in season is preferable, but when diquat is chosen, it is typically a mid-season application	
Notes	California has used diquat to pretreat the " Delta" at intervals of 4-14 days until it dissipates and O_2 level is restored	Expect to treat for 2 years in a row	

CURLY-LEAVED PONDWEED (*POTAMOGETON CRISPUS*)

Growth and Habitat Considerations

- Prefers alkaline, brackish and nutrient rich waters, but can tolerate a wide range of conditions, including low light and low temperature (30).
- Reproduces mainly by turion production, but also from rhizome growth. Fruits, turions and seeds are produced in late spring/early summer. By July, curly-leaved pondweed has died

back in most, but not necessarily all, lakes and years (87). The fruits and turions survive and germinate in the fall. The new plants grow to a few centimeters tall and over-winter in a dormant stage. In spring the small plants have a head start on native macrophytes and can quickly form dense stands (48).

- Turions may remain viable for up to 5 years (53).
- Forms seeds; their importance in the overall maintenance of the population is uncertain; also forms new colonies from rhizome growth (48).

Eradication and Control Techniques

Eradication of curly-leaved pondweed is season-specific and needs to be completed prior to the formation and dropping of seeds, or, more importantly, in time to curb turion production. In any case other than very early detection, assume that the action will have to be repeated for 2-5 years to account for turion production (87). This species is often ignored because it rarely persists at elevated densities beyond the end of June, and interferes only slightly with recreation; early season management action is critical to successful control. Choice of control method can be based in part on the flow chart in Figure 1.D.4.

Response to Physical Methods

After turions have formed, containment or eradication through manual removal takes a great deal of time. No experience is reported on the use of benthic barriers on *P. crispus*, but the Army Corps lists them for use. Madsen advises using diver-operated suction when the area impacted by this species is one 1 acre or less (90). Mechanical harvesting can be effective on larger areas if practiced early in the growing season (May-June) and plants are cut near the bottom of the stem to collect turions, but multiple years of effort are likely to be necessary. Hand harvesting can be applied to new, sparse growths.

Response to Herbicides

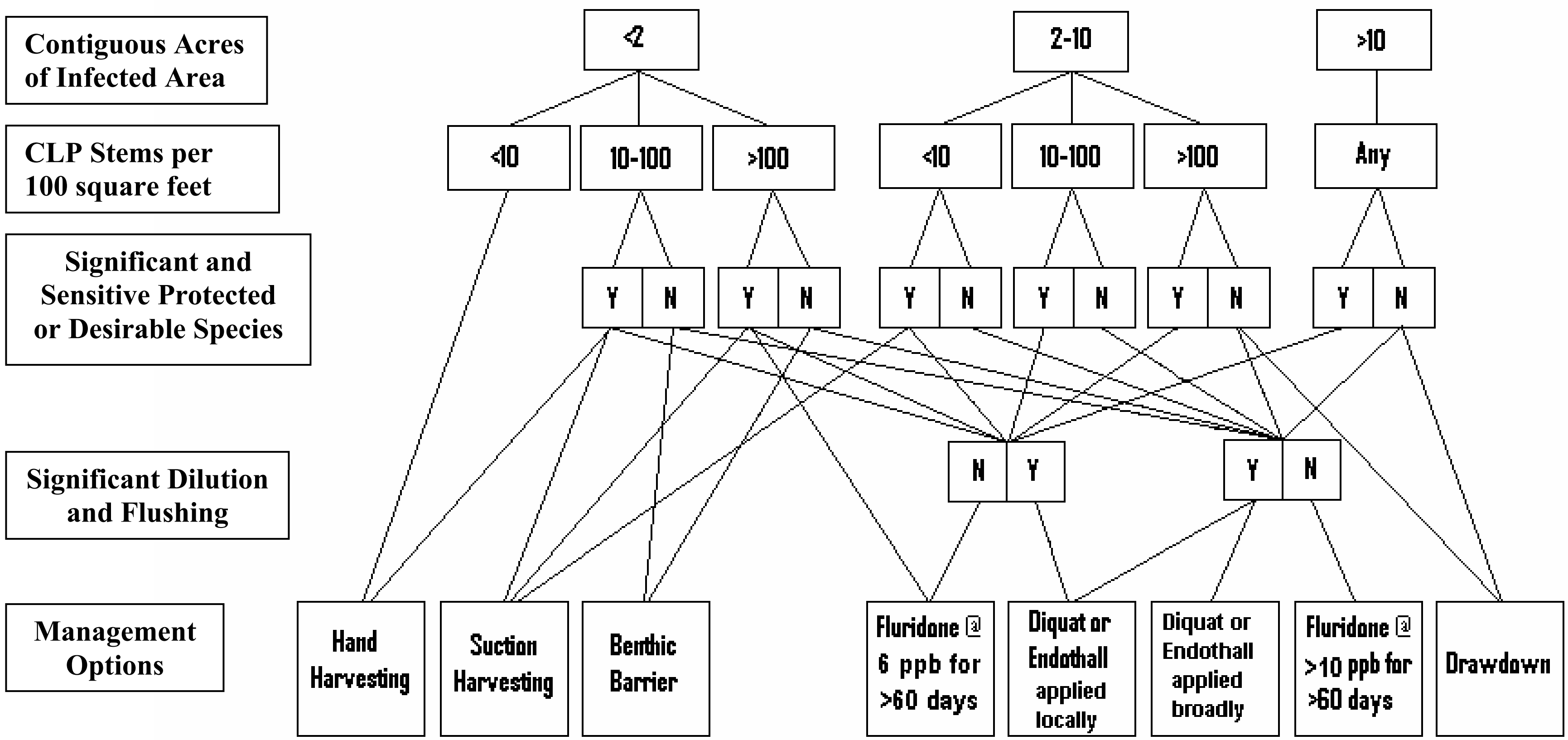
Curly-leaved pondweed is considered most responsive to endothall (Aquathol or Hydrothol 191), fluridone (Sonar AS or SRP), and diquat, the first two of which are labeled for such application. Mattson et al. report best "control" results in Massachusetts with endothall (30), but eradication has not been reported by chemical means.

Early treatment (April/early May) with fluridone effectively controls overwintering perennials such as *P. crispus* before some of the beneficial species of pondweed and naiad begin to grow (30). Treatment early with endothall or diquat is also effective, and may perform better in higher flows than fluridone, but will not control rhizomes as well (87). Treatment at the right temperature is key; in one greenhouse study of the contact herbicides, application at a water temperature of 18 degrees C reduced turion densities by 86%, whereas application at 25 degrees C resulted in only a 40% reduction. Treatment at colder temperatures is not as efficacious, however, for reducing plant mass (34).

The Ontario Ministry of Agriculture and Food reports that *P. crispus* is susceptible to diquat (98).

Figure 1.D.4: Curly-leaved Pondweed (*Potamogeton crispus*) Decision Tree

(After Dr. Ken Wagner, ENSR Corp, Westford, MA & MA DCR, Boston, MA (106))



Notes: Hand harvesting and suction harvesting must include root system removal, and are best conducted before turions are formed. Benthic barrier should remain in place for 30 to 60 days. Fluridone use in spring may require flow control in target area. Choice of diquat or endothall is linked mainly to water uses. Drawdown use is dependent on many factors, including hydrology and use as a water supply. Moderate to dense growth over an extensive area (>10 acres) may not be appropriate for rapid response consideration

Figure 1.D.5: Curly-leaved Pondweed Herbicide Guidelines

Consult Label for Latest Standards

Order of Preference	**Preferred Chemical**	**Alternative Chemical**	Alternative Chemical
Herbicide or formulation	Fluridone AS – liquid SRP, PR, Q - pellets	Endothall Aquathol K – liquid Aquathol Super K – gran.	Diquat
Conditions favoring one formulation over another	Liquid AS form is most reliable, but requires low water exchange rate, sequestration, or sequential treatments. Pellet forms (SRP, PR, Q) are useful where flow can't be controlled in target area, although release may be impaired in highly organic subtrate (30).	Super K is sometimes preferred because it releases the product near the roots, getting a higher kill.	Liquid form applied to target areas; may eliminate Curly-leaf pondweed if done before turions form for several successive years. Water exchange too high for fluridone, biomass high and growth stage is old. Used where toxicity of endothall is a concern
Application rate (from field experience, generally not from label; source, Ken Wagner, unless otherwise specified)	0.6-1.0 oz/acre-foot (87) 0.5-2.5 lb/acre-foot	0.65-1.3 gal/acre-foot (liquid-Aquathol K) 2.2-6.6 lb/acre-ft (granular Super K)	0.25-0.50 gal/acre-ft
Target concentration	6-10 ppb (30)	1-3 ppm (usually about 1.0 ppm)	0.1-0.2 ppm
Exposure time required	60 days – May and June, but longer may be helpful (87)	3 days	3 days
Re-treatment or follow-up conditions	Same season booster applications may be necessary. Retreatment necessary for at least 5 years if turions formed before response (87).	Could re-treat after about 3 weeks if survivors evident. Retreatment necessary for at least 5 years if turions formed before response (88).	Could re-treat after about 3 weeks if survivors evident. Retreatment necessary for at least 5 years if turions formed before response (88).
Timing issues	Best when applied in early spring before other plant growth is substantial, before turions have formed, and while temperature is cold (34); time for dissipation before uptake by native plants, although some overlap is needed for best control (87).		
Notes	Difficulty experienced in controlling water exchange for spring treatments	Will not kill rhizomes; eradication unlikely	Will not kill rhizomes; eradication unlikely

EUROPEAN OR SLENDER NAIAD *(NAJAS MINOR)*

Very little experience is reported related to slender naiad. It is not a common problem in New England, and is of lesser nuisance potential than many other invasive species where it is common. It can be treated like common naiad, having a similar ecology and response to controls.

Growth and Habitat Considerations

- Grows 'very commonly' in lakes with hard water (98)
- Leaves are submerged
- Produces many seeds per plant; reproduction also occurs by propagation of cuttings and submerged shoots (30)

Eradication and Control Techniques

The same treatment as is used for *Najas flexilis* (water naiad) is expected to be effective (87).

Response to Physical Methods

The U.S. Army Corps website for this species lists benthic barriers and cutting as the preferred management options. Both techniques have potential for success if done early in the growing season and over repeated seasons. A 1980 study in Lake Washington (WA), found that a population of *Najas flexilis* survived under an Aquascreen bottom barrier for one month, but was virtually eliminated in 2 months (105). Recovery from seeds is very common, necessitating repeated physical controls until the seed bed is exhausted.

Response to Herbicides

Three herbicides are considered to be effective in the management of *European naiad*, including endothall, fluridone, and diquat; the ERDC website does not rate their relative effectiveness. Massachusetts reports successful control of naiads with all three chemicals (30). The South Carolina DNR has treated four lakes, at least two since 1988, using endothall (55). In 1988 the state and Army Corps achieved a 90% reduction in Lake Greenwood with Aquathol K, at an application rate of 3 gallons per acre. The state DNR is still managing Lake Greenwood for *European naiad*, as well as for hydrilla, using the guideline application rates specified below. South Carolina's experience in warmwater conditions may not be transferable to Maine, and it appears to be directed more at control than eradication.

The Ontario Ministry of Agriculture and Food reports that *N. flexilis* is susceptible to diquat (98).

Figure 1.D.6: Slender Naiad Herbicide Guidelines

Consult Label for Latest Standards

Summary of Experience in Controlling or Eradicating Slender Naiad			
Herbicides or formulations	Endothall		
Conditions favoring one formulation over another			
Application rates (from field experience, generally not from label)	3-5 gal. per acre, depending upon depth (52)		
Target concentrations	0.5 to 1.5 ppm (product label)		
Exposure time required			
Re-treatment or follow-up conditions			
Timing issues			
Notes			

FANWORT *(CABOMBA CAROLINIANA)*

Growth and Habitat Considerations

- Spreads primarily by stem fragments and rhizomes, which are fragile and easily broken in late summer. Does not produce tubers. Produces seeds readily in southeastern US, but seeds collected in New Jersey, where conditions are more akin to Maine, failed to germinate (19).
- Generally rooted in water 0.5 to 3 meters deep in lakes, ponds and quiet streams but can continue to grow free-floating if uprooted or fragmented (87).
- Thrives in direct sunlight (76); *Cabomba caroliniana* requires less light than other fanworts (19).

Eradication and Control Techniques

Eradication of fanwort is very difficult once established (47), so rapid response will receive high priority from DEP. The initial goal will be to reduce the amount and limit spread while determining an effective eradication approach. Choice of control method can be based in part on the flow chart in Figure 1.D.7.

Response to Physical Methods

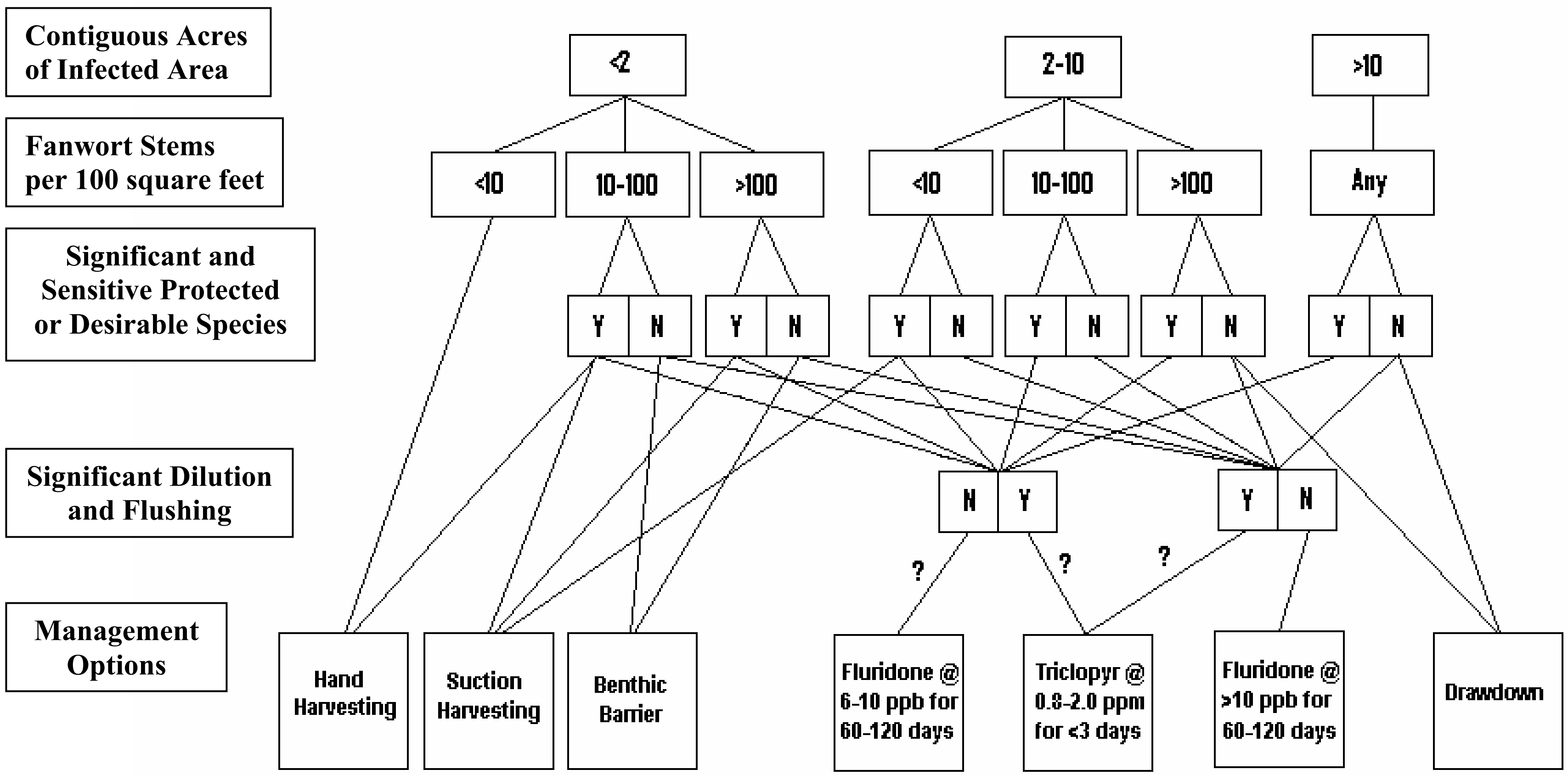
Some experience supports that fanwort, if discovered in its pioneer stage, can be eradicated through manual removal or bottom barriers (47). Shading with bottom barriers is reported to be effective on more concentrated populations of less than 1-2 acres (19). Cutting and mechanical harvesting are not recommended because of fanwort's tendency to fragment. Drawdown is effective against fanwort (30), but affects many other species and is not feasible at many lakes.

Response to Herbicides

The ERDC lists only fluridone (Sonar AS and SRP) for this species (56), and the Sonar label specifically lists its application. According to a report prepared for the Massachusetts Department of Environmental Protection, doses of fluridone greater than 10 ppb are almost always applied for fanwort control, with doses of 12-15 ppb showing signs of success and doses near 20 ppb providing nearly complete fanwort kill. At doses approaching 20 ppb nearly all other submergent vegetation will be impacted (30).

Because fluridone requires a long exposure time at lower concentrations (60-90 days), sequestration of the treatment area may be necessary where the water exchange rate is too rapid to hold the required concentration.

Figure 1.D.7: Fanwort (*Cabomba caroliniana*) Decision Tree
(After Dr. Ken Wagner, ENSR Corp, Westford, MA & MA DCR, Boston, MA (107))



Notes: Hand harvesting and suction harvesting must include root system removal. Benthic barrier should remain in place for 30 to 60 days. Fluridone is effective at >10 ppb with >60 days exposure; lesser doses and exposure time may yield some control. Triclopyr approved for use in 2002; experience is limited. Drawdown use is dependent on many factors, including hydrology and use as a water supply. Moderate to dense growth over an extensive area (>10 acres) may not be appropriate for rapid response consideration.

Figure 1.D.8: Fanwort Herbicide Guidelines

Consult Label for Latest Standards

In order of preference	**Preferred Chemical**		
Herbicides or formulations	Fluridone AS – liquid SRP, PR, Q - pellets		
Conditions favoring one formulation over another	Liquid AS form is most reliable, but requires low water exchange rate, sequestration, or sequential treatments. Pellet forms (SRP, PR, Q) are useful where flow can't be controlled in target area, although release may be impaired in highly organic subtrate (30).		
Application rates (from field experience, generally not from label; source, Ken Wagner, unless otherwise specified)	1.0-2.0 oz/acre-foot (87) 1-5 lb/acre-foot		
Target concentrations	10-20 ppb (30)		
Exposure time required	90+ days; 120-150 days minimizes resurgence (87)		
Re-treatment or follow-up conditions	Same season booster applications may be necessary.		
Timing issues	Prolonged exposure to a moderate dose is necessary for complete kill; start in May or June and plan on maintaining 10 ppb through August if at all possible (87).		
Notes	Because elevated dose will kill most non-target plants, best to sequester smaller target areas and/or plan to introduce desired vegetation the year after treatment. If a larger area or whole lake is affected, sacrifices may be needed to minimize spread to other lakes.		

HYDRILLA *(HYDRILLA VERTICILLATA)*

Growth and Habitat Considerations

- Can grow in almost any freshwater and seawater up to 7% salinity (18), and in depths ranging from a few inches to 20 feet deep.
- Forms dense stands of very long stems up to 25 feet (23)
- Reproduces mainly by regrowth of stem fragments; also by growth of axillary buds (turions) and subterranean tubers (23). Usually dies back in late season, leaving tubers and seeds in the sediment for re-starting growth the next year (26).
- Occurs in two biotypes in United States: monoecious and dioecious; but 26 types are known around the world. The US types are very different from one another in their ecology, life history, and in response to management. Monoecious hydrilla (found in Pickerel Pond in ME) is a temperate plant; whereas the dioecious type favors warmer water and forms more tubers and fewer turions (90).
- Can rapidly colonize an area devoid of vegetation (68).
- A single tuber can produce more than 6,000 new tubers per square meter in a year (23). Tubers can remain viable for more than 4 years (60). Some research indicates that tubers can be viable for up to ten years (21).
- Tuber and turion production is a response to changing photoperiod. As daylight hours decrease, generally starting around August 1 to 15 (in Clear Lake in California, at least), production of vegetative propagules increases significantly. From September through November, plant growth slows down and hydrilla transfers its resources and energy into tuber production. (42)
- Somewhat winter-hardy; optimum growth temperature is 68-81° F; maximum temperature is 86° F (20). Northern populations overwinter as and regrow from tubers (23).
- Can grow in only 1% of full sunlight. Low light compensation and saturation points and low CO_2 compensation point allow it to grow in low light before other plants do (59 and 6).

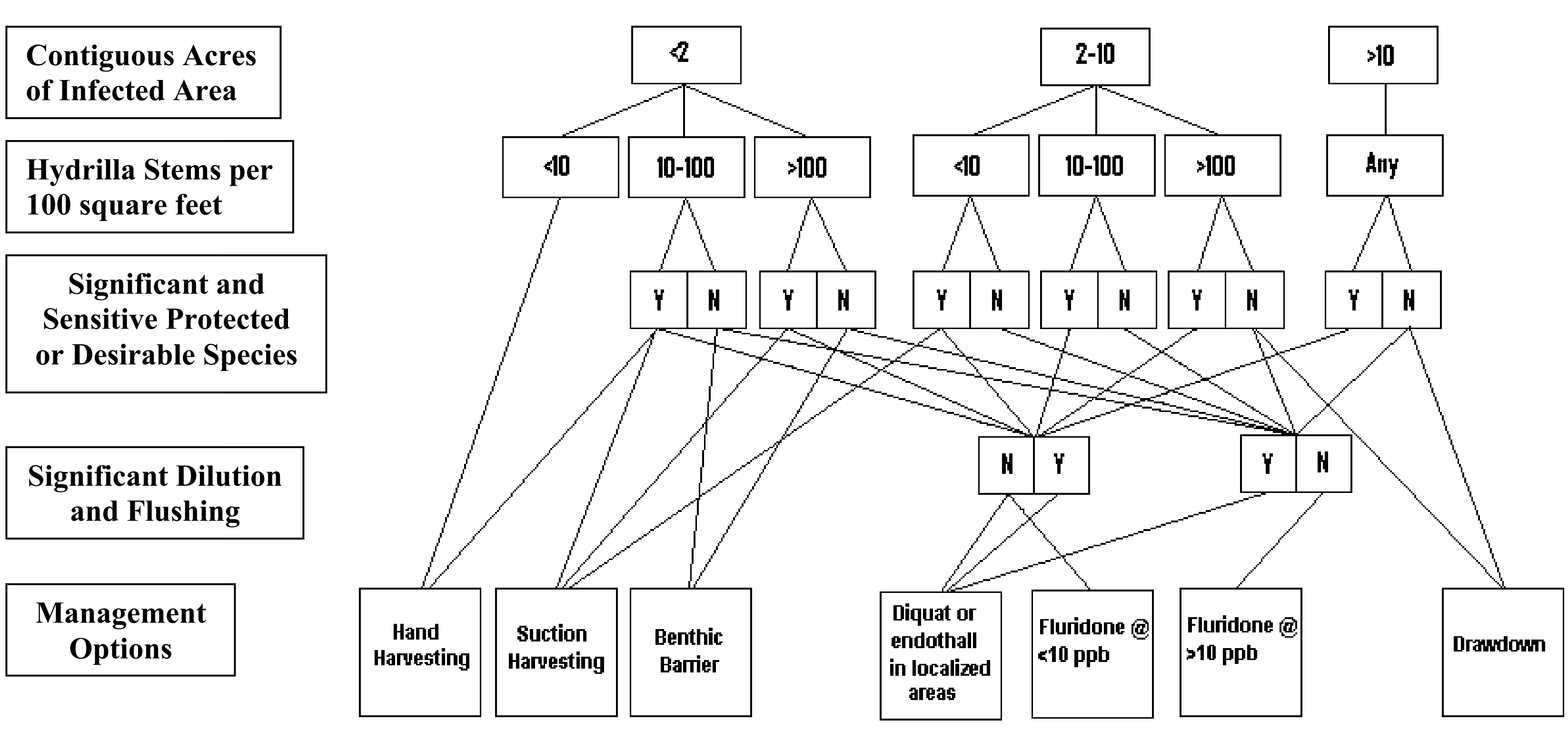
Eradication and Control Techniques

Hydrilla has perhaps the highest growth and spread rate of any invasive aquatic plant on Maine's list. This species is one of the most difficult to eradicate, and widely believed to be among the most problematic invasive aquatic plants in the United States. The tubers are particularly troublesome, since they serve as a source of regrowth in areas where the hydrilla shoots have been controlled by chemical or mechanical methods (68). Tuber density can be significantly reduced, but not easily eliminated, by killing back newly sprouted plants before they have a chance to produce new tubers and seeds, usually starting in late July (26). Choice of control method can be based in part on the flow chart in Figure 1.D.9.

Many states have experience controlling hydrilla, and those with the monoecious type – notably California, Washington State, and Maryland - are more applicable to Maine (68). California reports eradication in nine of seventeen counties that have had infestations of monoecious hydrilla. While much of this eradication has occurred in very small ponds and irrigation ditches,

Figure 1.D.9: Hydrilla (*Hydrilla verticillata*) Decision Tree

(After Dr. Ken Wagner, ENSR Corp, Westford, MA & MA DCR, Boston, MA (108))



Notes: Hand harvesting and suction harvesting must include root system removal. Benthic barrier should remain in place for 30 to 60 days. Use of diquat or endothall is mainly to minimize spread of the plant; eradication is not expected. Fluridone use may include liquid, pellets, sequestration and repeat (boost or bump) treatments to maximize exposure, with treatments at >10 ppb potentially eradicating hydrilla but also damaging many native plant species. Drawdown use is dependent on many factors, including hydrology and use as a water supply. Moderate to dense growth over an extensive area (>10 acres) may not be appropriate for rapid response consideration.

three small 'lakes' are also included: Lake Murray (160 acres), Spring Lake (72 acres), and Lake Ellis (31 acres) (8).

Response to Physical Methods

The use of physical methods alone is probably not a good idea, unless a population is detected very early. The drawback to physical methods is the difficulty in finding all of the hydrilla tubers and stems among the native vegetation, especially in a large water body and at the right time. For this reason, Kathy Hamel recommends combining manual removal with the application of fluridone, which, in Washington, has had the effect of turning the hydrilla plants pink and thus making them stand out from the native plants. The danger of proceeding without fluridone, or some other mechanism which differentiates hydrilla plants from among the natives, was illustrated on the Potomac River in Maryland, where within 2 months after an extensive diver-dredging project, hydrilla was reestablished at levels equal to nondredged areas either by fragments from adjacent areas or new plants regenerated from the tubers that were missed by divers (68).

King County in Washington State used Manual Removal exclusively for a couple of years in Pipe Lake and Lake Lucerne while the use of herbicides in the state was being contested. It is now using manual removal only as a follow-up to herbicide treatments (22).

Drawing on the experience of California and Washington State, Oregon developed an hydrilla management plan which identified boating restrictions, diver-dredging, and bottom barriers as the best available management options for "a natural lake with a small pioneer infestation," and along with herbicides for larger colonies (54). The plan recommends the quarantine of waters with boat launches. Diver assisted suction gear, if used, must have secondary screening adequate to catch tubers after other portions of the plant have been captured. Maine has shut down the informal launch area at Pickerel Pond, the only water body in the state that contains hydrilla as of this time; such restrictions are dealt with in Appendix A.

According to a University of Florida website (only the dioecious type has been found in Florida), hydrilla is only partially controlled by drawdown and underground tubers can survive several drawdowns, resprouting and overwhelming the native plants as soon as the water body is refilled (58).

Response to Chemical Methods

Many jurisdictions, including Maine, use fluridone as a first line of attack for this extremely aggressive species. One greenhouse study evaluated combinations of herbicides including Aquathol K (1.0 mg/L endothall) + Cutrine (0.5 mg/L copper) and Aquathol K (1.5 mg/L endothall) + Reward (1 gal/acre 0.25 mg/L diquat), which achieved greater than 90% control (42), but endothall and diquat do not kill the roots so they are not considered an effective option for in-lake treatment (22). Since fluridone does not destroy the reproductive parts, treatment must occur for at least another 2-3 years to eliminate all growth of tubers.

California has successfully used a fluridone and chelated copper combination (54). The state also uses metam-sodium (a weed killer) to kill tubers when drawdown is part of the strategy. It has successfully controlled and in some parts eradicated hydrilla from Clear Lake, the state's largest natural lake with approximately 43,000 surface acres (O'Connell, 40). The lake is almost 20 miles long by 8 miles wide and has approximately 100 miles of shoreline. It is relatively shallow, with an average depth of 18 to 22 feet. It was treated initially with monthly surface and subsurface applications of Komeen, a copper-based herbicide, at a rate of 12 or 15 gallons/acre, depending upon depth and vegetative density. Subsequently, better control was achieved with Sonar and Komeen, which was used in some cases to control all the plants to facilitate detection of hydrilla once regrowth occurred. Generally, once an infested area had been treated with Sonar no further use of Komeen was required.

California applied a slow release pellet fluridone formulation (Sonar SRP) at a rate of 10 parts per billion (ppb) twice a week for seven weeks in some locations of Clear Lake. Some application rates were increased to 20 ppb followed by subsequent treatments at 10 ppb. In other locations, the formulation was applied at 20 to 30 ppb on a weekly basis. All the treated areas received a total maximum annual concentration of 150 ppb in accordance with label direction. Complete control of all submersed aquatic weeds was obtained in all areas treated with Sonar™. In a few locations, a single application of Komeen was made after two or three Sonar treatments to kill those mature plants that showed some signs of activity (chlorosis) but had not slumped to the bottom. The last Sonar application of the year in 1996 was made in November to control plant biomass and stop production of tubers and turions, a major requirement for hydrilla eradication.

Beginning in 1995, King County treated Lake Lucerne and Pipe Lake with fluridone (Sonar AS liquid) for three years, maintaining levels from 10 to 20 ppb over eight weeks (21). The hydrilla responded well (99% kill), but a substantial viable tuber bank remained in the sediments, which necessitated whole lake treatments, in conjunction with Manual Removal, through 2000. This approach greatly reduced the infestation throughout both lakes, although localized populations continued to exist. Divers hand pulled for the next two years, finding most of the remaining plants at depths of 10 to 15 feet. In the fall of 2002 after extensive hand-pulling efforts during the summer, a large regrowth of hydrilla was discovered and spot treated with Aquathol Super K granular herbicide. The significance of finding hydrilla meant that divers were missing plants during the hand-pulling efforts. Missed plants were setting tubers, which would prolong the eradication effort. The County concluded that the hand-pulling only strategy alone was not effective as an eradication method for an established population.

In the following year, the County switched from liquid to granular slow-release Sonar PR, applied to maintain a 5 ppb concentration in the water column throughout the summer, following California's lead. Because no more than 150 ppb of fluridone could be applied within a season to any one hydrilla location, the treatments were broken down into four treatments to maintain an effective concentration. The first two each targeted 50 ppb and then the last two were calculated at 25 ppb for a total of 150 ppb, the limit for the season. Divers were used between treatments to identify and manually remove new growth and adjust the location of areas to be treated.

The County speculates that the liquid formulation of fluridone did not effectively treat plants below the thermocline. Temperature gradients can prevent liquid herbicides from mixing below the upper warm water layers. The new granular formulation allowed herbicide to be applied directly to the plants and nearby areas. Because the granules sink to the bottom, fluridone can be released below the thermocline if needed. And a side benefit – the water quality of Pipe and Lucerne Lakes has improved over the last decade (88).

Maine has fledgling experience with the eradication of hydrilla (monoecious type) which was detected in Pickerel Pond in Limerick late in 2002. Management efforts with fluridone have greatly reduced biomass as of 2005. To treat Pickerel Pond, the Maine DEP targeted a concentration of 6-10 ppb of fluridone in 2003 and 5-8 ppb in 2004 and 2005. DEP applied Sonar AS three times in 2003, each treatment for a 13 week exposure, and two times in 2004 and 2005. DEP observed no plants in a survey at the end of summer in 2005, and will check for regrowth from turions in the spring before determining to retreat or hand pull in 2006.

Because the concentration of fluridone must be sustained for such a long period, regular testing of the water column is essential, especially to ensure that granular forms, if used, are releasing from sediments at the appropriate rate. Washington State tested Lucerne Lake every 14 days. In addition, a plant assay originally developed for research purposes has been modified and proven to be an excellent predictive tool for quantifying the response of hydrilla, Eurasian watermilfoil, and Egeria to various concentrations of fluridone. This assay is called the PlanTEST.™ It can be used proactively to screen for populations with increased tolerance and to determine the level of fluridone likely to elicit a phytotoxic response for a range of aquatic plants. In addition, the use of biochemical monitoring of the vegetation (called the EffecTEST™), in conjunction with the FasTEST immunoassay, provides a mechanism for evaluating the status of an ongoing treatment over time. (35)

Figure 1.D.10: Hydrilla Herbicide Guidelines

Consult Label for Latest Standards

Order of Preference	**Preferred Chemical**	**Alternative Chemical**	
Herbicides or formulations	Fluridone AS – liquid SRP, PR, Q - pellets	None recommended at this time	
Conditions favoring one formulation over another	Liquid AS form is most reliable, but requires low water exchange rate, sequestration, or sequential treatments, and does not diffuse below the thermocline. Pellet forms (SRP, PR, Q) are useful where flow can't be controlled in target area, and can be applied below the thermocline, although release may be impaired in highly organic subtrate (30).		
Application rates (from field experience, generally not from label; source, Ken Wagner, unless otherwise specified)	0.5-3.0 oz/acre-foot (87) 0.5-10 lb/acre-foot Depends on strategy; either use lower dose on new infestation to		

Order of Preference	Preferred Chemical	Alternative Chemical	
	preserve native species, or use high dose to maximize kill but sacrifice many natives.		
Target concentration	5-30 ppb (30); higher doses preferred unless preservation of native species is considered essential, but hydrilla is sensitive to lower doses, if monitored and maintained for the growing season.		
Exposure time required	Entire growing season preferred; resurgence of hydrilla from tubers necessitates longer term control		
Booster treatment or follow-up conditions	Same season booster applications are expected to maintain desired concentration. Assume 2-3 years of treatment.		
Timing issues	Can initiate treatment any time, even fall/winter. Prolonged exposure is necessary for complete kill and control of later germinating plants. Some concern for developing resistant strains at continual low doses, but initial 2-3 year attempt to control new infestations with low doses should not be a problem.		
Notes	Because elevated doses will kill most non-target plants, sequestration or lower doses seem preferable, but the serious threat represented by hydrilla warrants the most complete kill possible to protect state resources overall. Careful monitoring and adaptive follow up are essential.		

EURASIAN MILFOIL *(MYRIOPHYLLUM SPICATUM)*

Growth and Habitat Considerations

- Grows in still to flowing waters, rooted in water 0.5 to 5 meters deep (can grow at lower depths with stable water level); can tolerate salinities of up to 15 parts per thousand and pHs from 5.4 to 11, survives under ice, and grows over a broad temperature range (64, 87).
- Grows best in fine-textured, inorganic to moderately organic sediments and relatively poorly in loose, highly organic sediments. Prefers soft water lakes (98) of moderate to high alkalinity. Typically found in greatest abundance in mesotrophic or slightly eutrophic lakes (49), but has been found in oligotrophic lakes like Lake Chelan, WA, and hyper-trophic lakes like Carlisle Lake, WA (64).
- Vegetative spread through fragmentation is the primary mode of reproduction. Can regrow in days or weeks (30). Seeds exhibit prolonged dormancy, germination is enhanced by prolonged period of drying, but it has been suggested that seeds rarely germinate in nature (89). However, observations of Eurasian watermilfoil recovery in many lakes after treatment suggests that some seed germination does occur, necessitating follow up treatment for perhaps 5+ years.
- Plants that will fragment easily can be recognized by the multiple stems and many rooted (adventitious roots) side branches (64).
- Known to become dominant in as little as 2 years (Mamanasco Lake, CT), but can be held in check by healthy native plant community and/or sediment conditions for over 10 years (Lake George, NY) (87).
- Exhibits annual growth pattern. In spring, shoots begin to grow rapidly as temperatures approach 15 degrees Centigrade. When they near the surface, shoots branch profusely. The leaves below 1 meter senesce in response to self-shading. After flowering, usually in mid to late July, plant biomass declines as a result of stem fragmentation. Where flowering occurs early, a second flowering may occur. During fall, plants die back to root crowns, which sprout again in spring as temperature increases (64). In years with low snowfall, may not die back but remain under ice (89).
- Other than coontail and naiads, grows the deepest of listed species in New England lakes (87). Plants in clear, deep water generally do not reach the surface. Under low light and turbid conditions at depth, development of surface canopy is favored (4, 32).
- Can develop into a land form (tolerates some exposure to air) in situations where water evaporates slowly and the plants gradually become stranded (64). However, winter drawdown is known to kill this plant in New England lakes (30).

Eradication and Control Techniques

The Washington DECY advises that, despite Eurasian milfoil's tendency to fragment more readily during the fall, removal should be undertaken as soon as possible after it is discovered--no matter how late in the season (64).

Early attempts to eradicate milfoil and restore the natural ecology of infested North American lakes were largely unsuccessful due to the high degree of fragmentation exhibited by Eurasian watermilfoil (30, 4). Positive results have been achieved more recently, as we have learned to minimize fragmentation, collect fragments and follow up on controls over a period of several years.

King County has mounted a number of successful projects where Eurasian watermilfoil was totally eradicated or maintained at very low levels. The county's control plan advises that eradication is a suitable goal for small to medium-sized (up to 350-acres) lakes where lake residents are willing to conduct follow-up monitoring and prevention programs (12).

Maine will generally follow Figure 1.D.11 guidelines for determining which treatment type is best for a particular Eurasian watermilfoil infestation, should one be detected, but will also consider the experience of other states.

Response to Physical Methods

Lakes with lightly scattered milfoil, as single plants or in small patches, and those used for municipal water supply are most suited to manual removal, bottom barriers, and diver-operated suction harvesting. Mechanical controls such as cutting, with or without collection, are definitely unsuitable because of fragmentation.

Manual Removal. Establishing a guideline for manual removal for Maine must ultimately follow any experience the state may encounter in the future, paying particular attention to conditions specific to Maine. Other states have established guidelines, presumably which reflect the characteristics of their water resources. Key considerations include plant coverage, density, and height.

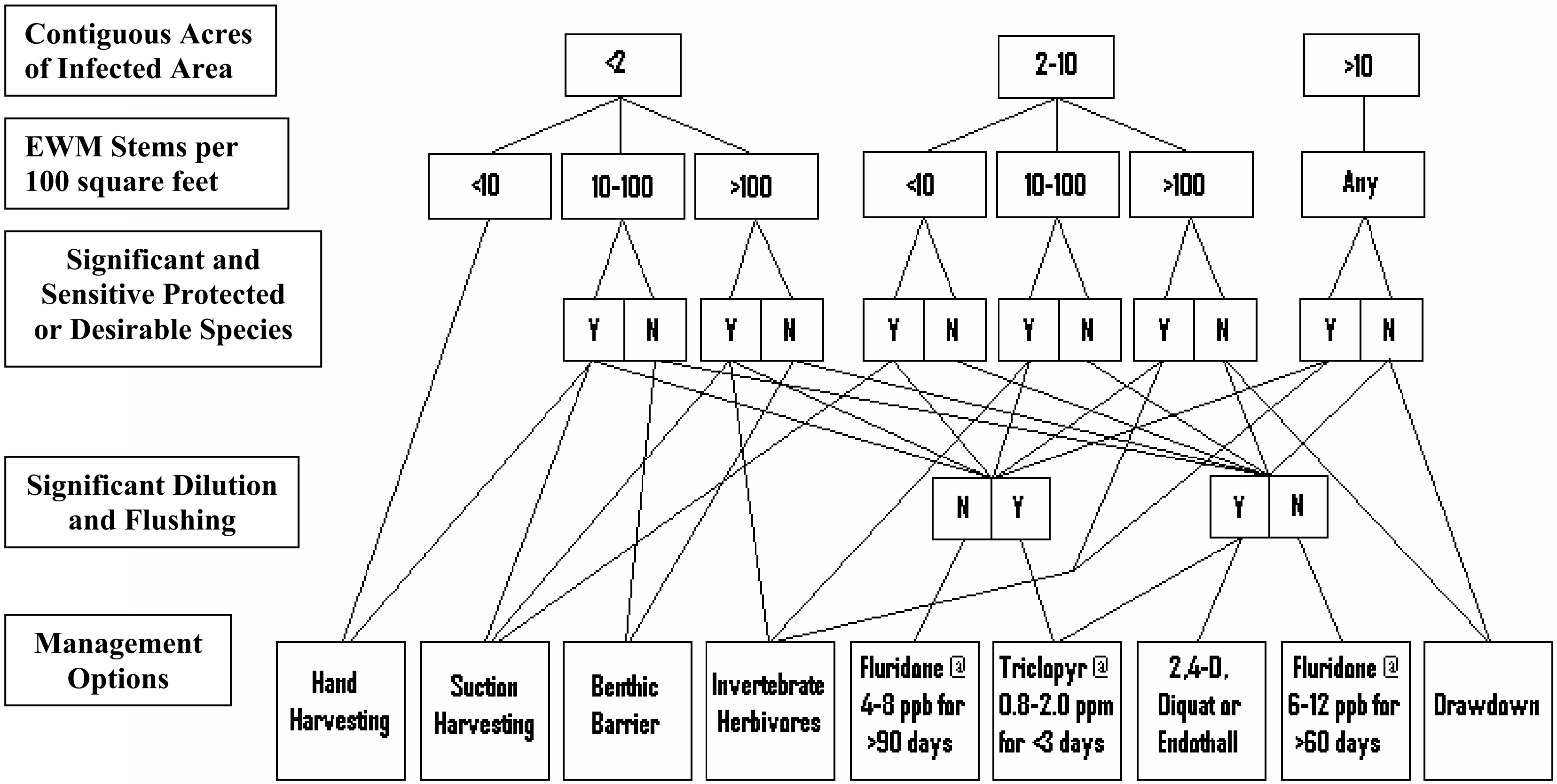
The State of Washington's control strategies for manual removal of Eurasian milfoil stipulate that, to be cost effective, generally the total amount of milfoil in the water body should be three acres or less in area, if all the plants are grouped together in one location. If the infestation has advanced beyond this point, or if after two follow-up dives milfoil is still found, another strategy may be needed for its removal or control (12).

Wisconsin uses a lower threshold for manual removal, targeting colonies of under 0.75 acres or fewer than 100 plants. That state advises that, whenever possible, milfoil control sites should become customized management zones – where native plants are planted to stabilize sediments against wave action, build nurseries for fry, attract waterfowl, and compete against new milfoil invasions or rapid regrowth of old ones (73).

University of Idaho researchers have estimated that the time and cost per acre for manual removal of Eurasian milfoil are roughly 2.5 to 4 times higher for plants that are 10 feet tall as opposed to those still at the one foot level. And not surprisingly, time and effort is 6-8 times greater for dense versus scattered infestations. Their estimates also indicate that chemical treatment is generally more cost effective when infestation density and height necessitate six hours or more per acre to pull (45).

Figure 1.D.11: Eurasian Milfoil Decision Tree

(After Dr. Ken Wagner, ENSR Corp, Westford, MA & MA DCR, Boston, MA (109))



Notes: Hand harvesting and suction harvesting must include root system removal. Benthic barrier should remain in place for 30 to 60 days. Herbivorous insect use is limited by fish predation; where appropriate, expect a 5 year process with multiple stockings. Fluridone use may include liquid, pellets, sequestration and repeat (boost or bump) treatments to maximize exposures. Triclopyr approved for use in 2002; experience is limited. Choice of 2,4-D, diquat or endothall is linked mainly to water uses. Drawdown use is dependent on many factors, including hydrology and use as a water supply. Moderate to dense growth over an extensive area (>10 acres) may not be appropriate for rapid response consideration.

Bottom Barriers. A 1980 study concluded that the compression of Eurasian watermilfoil against bottom sediments rather than reduction in light for photosynthesis was the operative factor in application of this technique (30).

Washington advises the installation of bottom barriers if colonies are too dense for efficient manual removal, or if repeated visits to the same site indicate that many fragments or plants are being created or missed. The DECY prefers burlap or other natural materials because they will naturally decompose over a 2-3 year period (64).

The Massachusetts Final Generic Impact Report for aquatic plant management discusses some liner materials that have been used in combating Eurasian milfoil (30, 99). Dartek, installed at Lake George in New York over three acres in two areas, suppressed an infestation to less than 25% for about three years. Without supplementary efforts, recolonization occurred, however. Aquascreen (a fine mesh material) and Palco Pond Liner (an impermeable membrane) have also been installed at 8 sites on Lake George. Both barrier types were initially successful in eliminating targeted milfoil beds, although recolonization of Aquascreen left in place was far greater than for the solid Palco material (30).

Manual removal and bottom barriers were both used to eradicate milfoil from Lake Youngs in King County. Lake Youngs is a 283-hectare (700-acre) reservoir that provides drinking water to over one million people in the Seattle metropolitan area. Eurasian watermilfoil was first observed in the reservoir in September 1992. A control program was initiated in 1993 with the installation of a bottom barrier and hand-pulling of plants on the east shore. Hand-pulling continued in 1994 and 1995. A new infestation was detected on the west shore in 1996, but was brought under control with a bottom barrier. Milfoil has not been detected in the reservoir in the past three years, indicating that eradication is possible without the use of herbicides if rapid response to early detection is conducted (Zisette, 77).

Diver-operated Suction. Opinions vary on the efficacy of driver-operated suction for rapid response (pioneering colonies). It is primarily used to maximize diver efficiency where Eurasian watermilfoil density is high. Getsinger et al. report that diver operated dredging has been especially effective against this species, removing both the plant and root crown from the lake system (14). Maine intends to use diver-operated suction in the water column only to vacuum plants which have already been removed from sediment by hand for environmental reasons, but the suction harvesting process increases the efficiency of this process and moves the plant from hand to containment with the least chance of fragmentation or remnant root crowns.

Drawdown. Winter drawdown can be helpful for Eurasian milfoil control, except in deep ponds where it must be combined with other techniques because milfoil grows at depths much greater than drawdown can typically reach (30). According to Ken Wagner, drawdown has limited milfoil growth in many lakes and over a long term can alter peripheral sediment to discourage growth (87). Shifts from drawdown sensitive to drawdown tolerant species also can occur, however. In Massachusetts, an 8 foot drawdown in Lake Garfield limited Eurasian milfoil growth but promoted dense stands of the native, seed-producing, annual, broad-leaf pondweed (*Potamogeton amplifolius*).

Response to Herbicides

Herbicide application can begin as soon as milfoil starts rapidly growing. Effective treatments can be made as early as April or May and as late as early September. Treatment in the spring/summer should be followed by a late summer survey and possible retreatment if large patches remain or if more milfoil is discovered in untreated areas of the lake.

All of the herbicides under consideration for rapid response in this plan, except copper chelate, are well suited to eradicating or controlling Eurasian milfoil. 2,4-D and fluridone are most suited to eradicating pioneer colonies of Eurasian milfoil (12). Triclopyr holds great promise because, unlike fluridone, it requires a short contact time (18 to 48 hours), will control Eurasian milfoil while leaving many native plants relatively unaffected (64); and can be used in water supplies and well recharge areas. Endothall and diquat have less utility in eradication, as they do not affect root crowns, but can be used for control to minimize spread while other techniques are in planning or permitting stages.

Triclopyr. Results from concentration/exposure time studies conducted at the US Army Engineer Waterways Experiment Station Center (WES, 57) showed that trichlopyr provided excellent control of the submersed species Eurasian watermilfoil (hereafter called milfoil) under laboratory conditions when that plant was exposed to concentrations ranging from 2.5 to 0.25 ppm triclopyr for 18 to 72 hours (Netherland and Getsinger 1992, 86). Pend Oreille River and Guntersville Reservoir (WA) field studies have demonstrated that triclopyr can be an effective herbicide for the selective control of milfoil, given short but sufficient contact time. The Pend Oreille cove treatment also demonstrated that if water-exchange patterns can be determined within the target plant stand, herbicide doses below the maximum label rates can be used to provide accepFigure plant control.

Fluridone. Rapid response managers need to make careful decisions about the concentration and contact time for fluridone. There are limits to the lower ends of each, but higher end levels kill non-target vegetation (87). Typical fluridone treatment rates range from 6 to 10 ppb, and sometimes require 12 ppb; follow-up with diver surveillance and hand-pulling are essential to success (51). Washington used higher concentrations, 10-15 ppb maintained in the water column for 10 to 12 weeks, to eradicate milfoil from Goss, Steel, and Carlisle Lakes. And it used sequestered treatments in parts of Shoecraft Lake, at an average dose of 20 ppb for about 55 days, to virtually eliminate milfoil with no discernible impact on the remainder of the lake (62, 88). Plants outside of the barrier were removed by hand. Washington usually obtains 100% removal for the first two years after a whole lake treatment with fluridone; in the third to fifth year after treatment some milfoil returns, presumably from new introductions (88) but possibly from seeds.

Closer to home, near eradication was achieved in Snyders Lake (NY) with one booster treatment to raise the concentration back to near 12 ppb after a month (30). Gradual development of a lush native community was observed over four years. Waneta Lake was cleared of milfoil in 2003 with a treatment at 12 ppb with no booster, but the concentration remained higher than 4 ppb for over 180 days and many native species were impacted. No milfoil was observed in 2004, and only scattered plants were observed near one inlet so far in 2005. Native revegetation has followed the Snyders Lake pattern.

Minnesota is conducting a study of six lakes to determine the efficacy of fluridone whole lake treatment at a rate of 4 to 5 ppb. The state's goal is to achieve eradication without causing unacceptable harm to native plant species or a decrease in water clarity for at least two years following treatment. Three lakes, including Schutz, Eagle, and Crooked have been treated; three others serve as an untreated control group. Results as of 2002 indicated that the populations of Eurasian watermilfoil and curly leaf pondweed were reduced to zero in Shultz Lake, and milfoil was similarly reduced in Crooked Lake. The treatments were also associated with a slight reduction in the total number of taxa found in the lake and the average number of native taxa per sampling site.

Fluridone has proven to be especially effective in combination with barrier curtains in areas of high dilution and flow:

> "During the summer of 2000, Aquatechnex biologists deployed a unique barrier curtain technology to segment a 167 acre lake into treatment and non-treatment areas. Eurasian Milfoil was present in the lake and dominated the north and south coves. The remainder of the shoreline had not yet been infested. The barrier curtain was designed to be non-permeable. Two curtains were deployed. The north barrier was approximately 900 feet in length and isolated a treatment area of about 5 acres. The south barrier was approximately 2,300 feet in length and isolated just over 20 acres. Sonar was applied at a concentration of 0.01 to 0.03 ppm and maintained behind these barriers using 5 split applications spaced at two week intervals.
>
> Over 200 FasTEST samples were collected both in and outside the treatment areas from 13 sampling sites. The FasTest data was used to monitor conditions and maintain Sonar levels in the treatment areas. It also was used to document the levels outside the curtain.
>
> This project resulted in excellent control of Eurasian Milfoil in these isolated areas of the lake. The FasTEST data confirmed these barriers could be used to segment the lake into treatment and non-treatment areas. There was little or no Sonar detected outside these isolation areas and no impact on aquatic vegetation outside the treatment areas.
>
> This technology will allow lake managers to target Eurasian Milfoil in large lake and river systems or protect native aquatic plants in the non-target portion of the lake. When combined with SePRO's new PlanTEST and EffecTEST technologies, the potential now exists to determine that the barrier could be removed earlier if the target plants show fatal symptoms." (31)

The sequestration described above was the first ever used with fluridone. There have been a few others since, including 3-4 in New England and one installed recently in New York in 2005 (87). Hourglass shaped lakes, coves with narrow mouths, and shallow expanses are easiest to sequester, and the process adds cost per unit area and requires monitoring, but overall costs can be reduced and non-target impacts can be reduced.

The Big Bear Municipal Water District in California has used Sonar to successfully eradicate Eurasian milfoil from Grout Bay and other relatively protected coves in Big Bear Lake (the district has used mechanical harvesting in the large body of the lake). This initiative was not aimed at a pioneering population – 800 of the lake's 3,000 acres were infested with this and other invasive species – but it demonstrates the capacity of fluridone for use in isolated coves of large lakes.

From the wide experience with fluridone, the key is to get the longest duration of exposure at a concentration in excess of 4 ppb. As uptake, dilution and natural photodegradation can reduce the concentration by half in a matter of several weeks in most cases, and more quickly in many cases, starting concentrations have to be higher than 6 ppb and should approach 8-10 ppb. Where risk of rapidly lowered concentrations exists, higher starting concentrations are needed or careful monitoring with quick response booster treatments are essential. Use of pelletized forms can help prolong exposure, but release rates are not completely reliable and monitoring is still essential. To maximize the kill, concentrations as high as 15-20 ppb can be used, but appear unnecessary for this species in most cases. The duration of exposure should be on the order of 60 days, with 90 days preferred and even 120-150 days providing benefits. However, the potential for some plants to survive (mostly as root crowns) or for viable seeds to be present (however low a percentage of the total) necessitates follow up management for several years.

2,4-D. This herbicide breaks down quickly and is relatively selective for milfoil and fast acting; its effectiveness increases at low pH (41). 2,4-D can not, however, be used in an active drinking water source, as the necessary concentration exceeds the allowable limit for potable water. where it can be applied, the Washington DECY advises that:

> ". . . sites suitable for treatment with 2,4-D include lakes or ponds partially infested with Eurasian watermilfoil such as waterbodies where milfoil has recently invaded but the extent of the infestation is beyond what can be removed by Manual Removal or bottom screening. In these situations an herbicide, like 2,4-D, that is effective for spot treatment can be used to reduce the amount of milfoil so that Manual Removal can remove any milfoil plants that are not killed. 2,4-D can be used for milfoil control in heavily infested lakes, but it does not provide the nearly 100 percent kill of the herbicide fluridone. . .
>
> There is some anecdotal evidence that milfoil plants may become resistant to 2,4-D. Applicators have reported that milfoil in Loon Lake [WA] did not respond as well to treatment in 2002 as it had in previous years. If this occurs and the plant population is too large to be hand removed, consider using endothall, diquat, or . . . triclopyr. There is also some anecdotal evidence that milfoil may germinate from seeds in areas where water levels dropped and then returned. This may happen in low rainfall or low runoff years. It is important to check those areas when the water returns to remove any milfoil that may have germinated." (65)

For an example of monitoring results for use of 2,4-D (liquid, DMA*IVM) in King County's Spring Lake, which was treated in 2003, consult the DECY website (69). In the Spring Lake application, the concentrations of 2,4-D remained high so that no booster treatment was undertaken.

Triclopyr. Triclopyr was used on Capitol Lake (WA) in 2004 with excellent results (88). Experience with this herbicide is limited thus practical field experience is lacking. In lab and experimental trials, triclopyr has provided desirable results where water exchange was too high for fluridone and water supply or other concerns prevented 2,4-D use.

Endothall and Diquat. These contact herbicides are commonly used to knock back dense growths of milfoil, but rarely achieve more than one season of control and can not be considered viable eradication chemicals in a rapid response action. They may have value in controlling growths in more highly flushed systems until an eradication program can be implemented.

Figure 1.D.12: Eurasian Milfoil Herbicide Guidelines

Consult Label for Latest Standards

Order of Preference	Preferred Chemical	Alternative Chemical	Alternative Chemical
Herbicides or formulations	Fluridone AS – liquid SRP, PR, Q - pellets	Granular 2,4-D BEE	Triclopyr (86, 88)
Conditions favoring one formulation over another	Liquid AS form is most reliable, but requires low water exchange rate, sequestration, or sequential treatments. Pellet forms (SRP, PR, Q) are useful where flow can't be controlled in target area, although release may be impaired in highly organic subtrate (30).	Not used in active drinking water supplies. Requires shorter contact time..	Spot treatments supported Lower contact time required Logical follow up chemical after lakewide fluridone treatment
Application rates (from field experience, generally not from label; source, Ken Wagner, unless otherwise specified)	0.6-1.5 oz/acre-foot (87) 0.5-5 lb/acre-foot	50-150 lbs/acre, depending on water depth	Highly variable, depending upon water depth and expected contact time
Target concentrations	6-15 ppb (30)	0.5-2.0 ppm	To achieve 85% reduction in biomass: 2.0-2.5 ppm for 18 hrs 1.5 ppm for 24 hrs 1.0 ppm for 36 hrs 0.5 ppm for 48 hrs 0.25 ppm for 72 hrs (30)
Exposure time required	90+ days; 120-150 days minimizes resurgence (87)	1-3 days	18 to 72 hours
Re-treatment or follow-up conditions	May require several years of treatment or hand pulling to eradicate; re-introduction is always a threat.		
Timing issues	Spring is best as milfoil begins growing before native plants, but high flows can impair fluridone effectiveness (87)		
Notes	If the infested area is small, focus on eradication and give less consideration to non-target impacts. Where a larger area is affected, the large ecosystem may warrant greater protection.		

VARIABLE MILFOIL *(MYRIOPHYLLUM HETEROPHYLLUM)*

Growth and Habitat Considerations

- Flowers between July and August (78).
- Prefers to grow in relatively calm and shallow (less than 20 feet) waters with a muddy bottom (78). In Maine, has been found in several lakes but does especially well in slowly moving waters and streams (ME DEP file notes).
- Reproduces primarily by fragments that break off and grow roots (78).
- Grows up to one inch per day and beneath the ice during winter (78).
- Usually in waters with pH < 7; acid water equivalent of Eurasian milfoil (87).

Eradication and Control Techniques

Eradication techniques for variable milfoil are similar to those for Eurasian milfoil, but fluridone is less effective (87). The flow chart in Figure 1.D.13 provides options in relation to key considerations.

Response to Physical Methods

Manual removal and bottom barriers are suitable for eradicating small colonies. They have been used in several locations in Maine, such as Bryant Pond in Woodstock, Cushman Pond in Lovell, and Lily Brook between Pleasant Lake and parker Pond in Casco

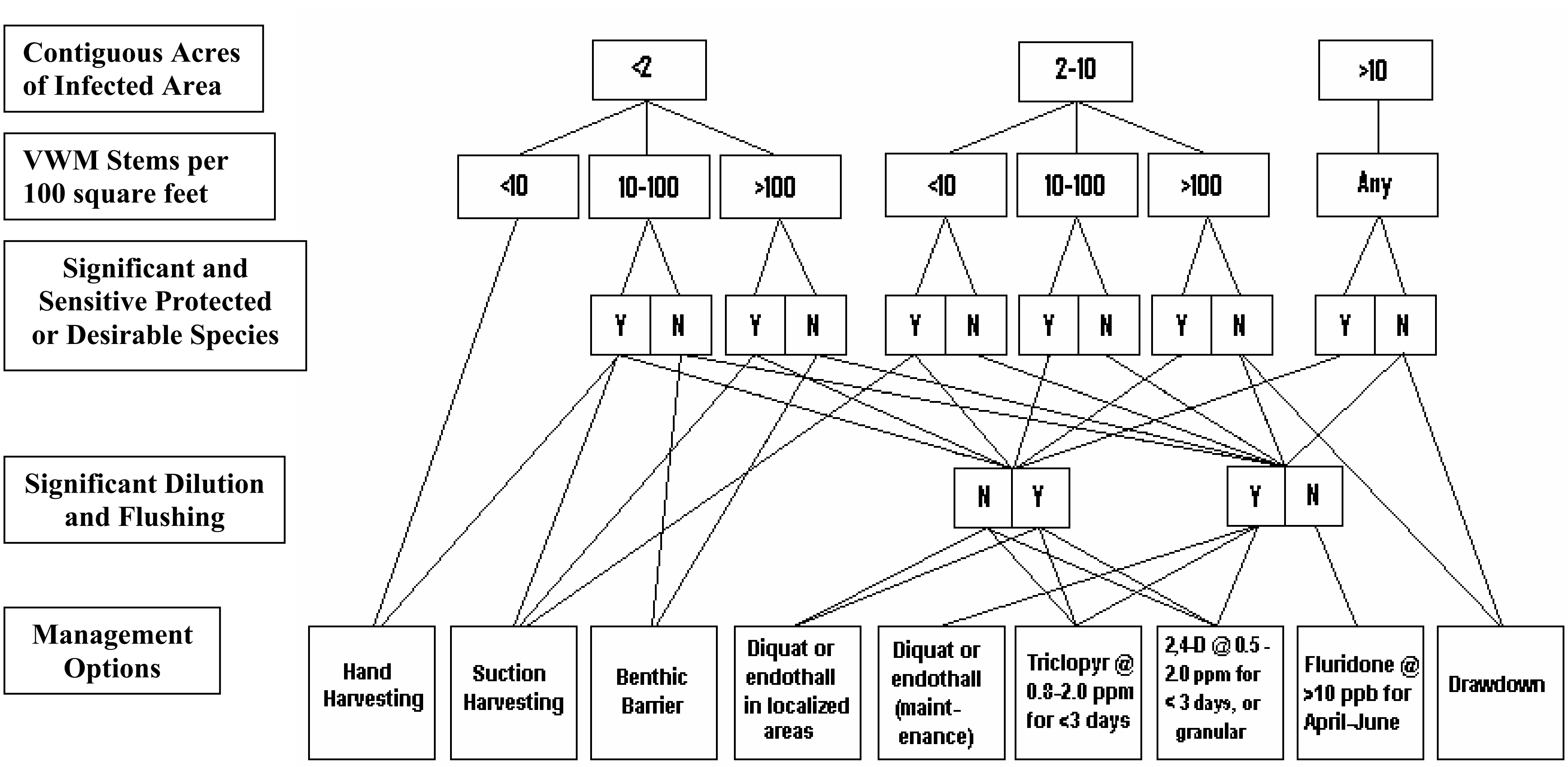
Response to Chemical Methods

The US Army Corps lists 2,4-D and fluridone as effective for variable milfoil, and states that labels for diquat and endothall indicate their application for this species (56). The Renovate 3 label for triclopyr also lists this herbicide as effective on milfoils in general at 0.7 to 45.3 gallons per acre depending upon desired concentration and depth, not to exceed an application rate of more than 2.5 ppm per annual growing season. Only 2,4-D has a consistent track record of variable milfoil control.

2,4-D was applied in 2004 on Lower Suncook Lake in New Hampshire. The Lower Suncook implementation plan called for the application of 2,4-D, with diver follow-up and Manual removal through the fall (17). Other examples are provided in the Massachusetts GEIR (30) and suggest excellent control of variable milfoil for smaller patches to a few acres in area. However, prohibition on 2,4-D use where wells may draw water from the lake limits application. Efforts with fluridone, diquat and endothall have yielded inconsistent results, and triclopyr was approved for use in Massachusetts only in late 2004.

Where 2,4-D is not allowed, the use of fluridone very early in the growing season and for an extended period of exposure appears to have the best probability of success, at least until more experience is gained with triclopyr. This may be difficult in light of high spring flows, and will probably necessitate sequestration and/or sequential treatments. Triclopyr offers potential for killing the whole plant at a shorter contact time, but experience is limited. Diquat and endothall will provide some control, but are not known to eradicate variable milfoil; root systems remain viable and support new growths within a year in most cases.

Figure 1.D.13: Variable Milfoil Decision Tree
(After Dr. Ken Wagner, ENSR Corp, Westford, MA & MA DCR, Boston, MA (110))



Notes: Hand harvesting and suction harvesting must include root system removal. Benthic barrier should remain in place for 30 to 60 days. Triclopyr approved for use in 2002; experience is limited. Choice of 2,4-D is linked mainly to water uses. Fluridone use may be appropriate for sequestered areas treated early in the growing season. Diquat and endothall will not eradicate populations but can control VWM until other techniques can be applied. Drawdown use is dependent on many factors, including hydrology and use as a water supply. Moderate to dense growth over an extensive area (>10 acres) may not be appropriate for rapid response consideration.

Figure 1.D.14: Variable Milfoil Herbicide Guidelines

Consult Label for Latest Standards

Order of preference	**Preferred Chemical**	**Alternative Chemical**	**Alternative Chemical**	**Alternative Chemical**
Herbicides or formulations	Granular 2,4-D BEE Liquid 2,4-D DMA	Fluridone AS – liquid SRP, PR, Q - pellets	Diquat	Triclopyr
Conditions favoring one formulation over another	Not used in active drinking water supplies. Requires shorter contact time..	Liquid AS form is most reliable, but requires low water exchange rate, sequestration, or sequential treatments. Pellet forms (SRP, PR, Q) are useful where flow can't be controlled in target area, although release may be impaired in highly organic substrate (30).	Liquid form applied to target areas where 2,4-D not allowed and water exchange too high for fluridone Endothall would also be a possible maintenance chemical, but diquat is more used as toxicity of endothall is a concern	Spot treatments supported Lower contact time required Logical follow up chemical after 2,4-D or fluridone treatments
Application rates (from field experience, generally not from label; source, Ken Wagner, unless otherwise specified)	50-150 lbs/acre, depending on water depth	1.0-2.0 oz/acre-foot (87) 1-5 lb/acre-foot	0.50 gal/acre-ft	Highly variable, depending upon water depth and expected contact time
Target concentration	0.5-2.0 ppm	10-20 ppb (30)	0.2 ppm	To achieve maximum reduction in biomass: 2.0-2.5 ppm for 18 hrs 1.5 ppm for 24 hrs 1.0 ppm for 36 hrs 0.5 ppm for 48 hrs 0.25 ppm for 72 hrs (30)
Exposure time required	1-3 days	90+ days; 120-150 days minimizes resurgence (87)	3 days	18 to 72 hours
Re-treatment or follow-up conditions	May require second treatment after several weeks, or hand harvest of survivors	Same season booster applications may be necessary.	Could re-treat after about 3 weeks if survivors evident.	Assume need for follow up controls, but limited experience to date
Timing issues	Best results early in growing season	Prolonged exposure to a moderate dose early in growing	Tends to be used after substantial biomass has	Best results early in season, but may be used later

Order of preference	Preferred Chemical	Alternative Chemical	Alternative Chemical	Alternative Chemical
		season is necessary for maximum effect	formed, but less desirable than early season control	
Notes		Results have been mixed, but above process will maximize success	Will not kill root crowns; eradication unlikely	

PARROTFEATHER *(MYRIOPHYLLUM AQUATICUM)*

Growth and Habitat Considerations

- Grows in freshwater lakes, ponds, streams, and canals, rooting in mud or gravel up to 2 meters deep (3).
- Prefers slowly moving or still waters, but can grow in fast-moving water (3).
- Grows best when rooted in shallow water, but has been known to occur as a floating plant in the deep water of nutrient-enriched lakes (70). Biomass and rate of growth appear to increase in eutrophic waters; prefers total sunlight to shade.
- Emergent stems can survive on wet banks of rivers and lake shores, so it is well adapted to moderate water level fluctuations (70). Has been observed growing on a dry bank in the British Isles.
- In the spring, shoots begin to grow rapidly from overwintering rhizomes as water temperatures increase. Rhizomes function as a support structure for adventitious roots. Emergent stems and leaves extend from a few inches to over one foot above the water's surface. Underwater leaves tend to senesce as the season advances. Flowers usually in the spring but sometimes in the fall, when the plant typically dies back to the rhizomes (70).
- Reproduces exclusively by fragmentation and from rhizomes, which serve the same functions as do the tubers, turions, and winterbuds of other species. Unlike Eurasian watermilfoil, generally does not form autofragments. However, fragments can be formed mechanically and will readily root. No seeds are produced in North America.
- Does not store phosphorus or carbon in its rhizomes and this characteristic may explain the (so far) limited presence of parrotfeather in areas with severe winters (70). However, it is found both in Yakima, WA and Boise, ID, both of which have severe winters so Maine should not be complacent (88). Parrotfeather is known from several lakes in the Hudson River Valley of NY/MA, and a lake on Cape Cod in MA was found to contain parrotfeather in 2003 (87).
- Exceedingly robust rhizomes buried in sediment survive winter drawdowns in California irrigation canals (70).

Eradication and Control Techniques

Eradication of parrotfeather is exceedingly difficult (88), and there is minimal experience with this plant in New England.

Response to Physical Methods

No experience with manual removal or benthic barriers is reported, but both techniques are likely to have the same effectiveness as for Eurasian watermilfoil. Mechanical harvesting is not advised while parrotfeather is still invading as they will tend to enhance its rate of spread (70). Because this species can spread readily through fragmentation of rhizomes, mechanical controls such as cutting and harvesting should be used only when the extent of the infestation is such that all available niches have been filled.

Response to Chemical Methods

Several herbicides are cited as effective for controlling the spread of parrotfeather. Washington is currently funding some herbicide trials of parrotfeather. Preliminary results indicate that imazapyr might be the best choice for control. For the Yakima early infestation, lake managers are using a combination of herbicides, applied several times a season, followed by hand removal of remaining plants in late fall. After several years of this approach, they are making good progress, according to Kathy Hamel (88).

If an infestation in a reservoir should occur, the IASP will check with Ken Manual at the NCDEHNR, as North Carolina seems to have the most experience in such a setting with this species.

According to the Washington DECY:

> "Although parrot feather is considered by some to be susceptible to herbicides, it is difficult to achieve complete control. The emergent stems and leaves have a thick waxy cuticle and it requires a wetting agent to penetrate this cuticle. Often the weight of the spray will cause the emergent vegetation to collapse into the water where the herbicide is washed off before it can be translocated throughout the plant. Westerdahl and Getsinger report excellent control of parrot feather with 2,4-D, diquat, diquat and complexed copper, endothall dipotassium salt, and endothall and complexed copper. Fair control was obtained with glyphosate. The Monsanto Company suggested that applying a 1 3/4 percent solution of Rodeo (aquatic version of Roundup) with surfactant to the plants in the summer or fall when water levels are low would give about 95 percent control of the plants. Control of parrot feather may be achieved with low-volatility ester of 2,4-D at 4.4-8.9 kg/ha, sprayed onto the emergent foliage. The granular formulation of 2,4-D was needed to control parrot feather for periods greater than 12 months. It is more effective when applied to young, actively growing plants (70)."

The State of South Carolina DNR, in its annual plan, targets a concentration of 2 to 8 quarts per acre of triclopyr for the control of this species, but also uses diquat. The DNR planned to use 0.5 gallons of Reward (diquat) per acre to control parrotfeather and European frogbit in Black Mingo Lake in 2004 (52).

EUROPEAN FROGBIT *(HYDROCHARIS MORSUS-RANAE)*

Growth and Habitat Considerations

- Free-floating, with a well developed root system that generally is not anchored in sediment (10).
- Inhabits quiet edges of rivers, lakes, and open marshes (61).
- Several plants may be connected by runners, which can reproduce rapidly over a season (61).
- Also reproduces by seed and winter buds, the latter of which develop in the fall, separate from the plant and sink to the bottom where they overwinter, and then rise to the surface in the spring to form a new plant (61).
- Many populations are totally or almost totally one sex and thus little fruit set occurs in this mostly dioecious species (9).
- Has a high probability of successful establishment in Minnesota, a state with a climate similar to Maine (25).

Eradication and Control Techniques

Little information is available on the control of European frogbit (9, 16). A Washington state biologist with the DECY concluded there is no feasible way to control frogbit so the state has not treated the one outbreak that has been detected (88).

Response to Physical Methods

Vermont concludes:

> "Based on the plant's habit, mechanical and hand removal would likely be most effective. It is not known whether biological or chemical controls are effective on European frogbit (61)."

Response to Chemical Methods

Two states report intent to control or eradicate European frogbit. Washington plans to attempt to eradicate or contain frogbit in Meadow Lake in Snohomish County. South Carolina used Reward in 2004 to control an infested area of parrotfeather and European frogbit. These states could be potential resources if this species arrives in Maine.

Appendix E:

Revised Aquatic Herbicide List

Revised Aquatic Herbicide List

(All herbicides approved for aquatic use by the Maine Board of Pesticides Control, as of 2004)

Company	EPA #	Tradename
Agriliance LLC	9779-263 1381-103	2,4-D Amine 4 2,4-D Amine 4
Albaugh Inc	42750-15 42750-19	2,4-D LV4 2,4-D Amine 4
Amrep Inc	8123-37-10807	Misty Weedtrol VF
Applied Biochemists	8959-10 8959-9 228-378-8959 8959-53 228-365-8959	Cutrine Plus Liquid Weedtrine D Aquatic Herbicide Navigate Cutrine Ultra Shore-Klear Aquatic Herbicide
Aquacide Co	5080-2	Aquacide Pellets
Aquashade	33068-1	Aquashade
BASF	241-426	Habitat Herbicide
Becker Underwood	67064-1 67064-2	Admiral WSP Admiral Liquid
Cerexagri Inc	4581-172 228-365-4581 228-378-4581 4581-204 4581-388 4581-174	Hydrothol 191 Granular Aquaneat Aquatic Herbicide Aquakleen Aquathol K Aquathol Super K Hydrothol 191
Chemical Products Tech	70829-2	Clearout 41 Unloaded
Cheminova	67760-58 4787-34	Glyfos Custom Herbicide Glyfos Aquatic Herbicide
Dow AgroSciences	62719-324 62719-324 62719-324 62719-3 62719-37	Rodeo Glypro Accord Concentrate DMA 4 IVM Garlon 3A Herbicide
Drummond American Corp	8123-37-40208 10807-203-40208	Sea-Cide Sea-Cide
EI Dupont De Nemours	352-609	Glyphosate VMF Herbicide
FMC Ag Products Group	279-3194 279-3241 279-3242	Stingray Herb Stingray EC Herbicide Stingray EW Herbicide
SePRO (formerly Griffin LLC)	1812-312 1812-435 1812-447 352-609-1812	Komeen Avast Avast SRP Eagre
Helena Chemical Co	524-445-5905 5905-501	Rattler Herbicide Opti-Amine
Loveland Products	34704-606 34704-120	Savage Dry Soluble Herbicide Clean Crop Amine 2,4-D Weed Killer
Monsanto	524-343	Aquamaster Herb

Company	EPA #	Tradename
Nufarm Americas-Riverdale	228-365 228-95 228-145 228-381	Riverdale Aquaneat Aquatic Herbicide Riverdale 2,4-D L.V. 6 Ester UAP Timberland Platoon Riverdale Foresters' Non-Selective Herbicide
Nufarm Inc	71368-1 524-343-71368	Weedar 64 Broadleaf Herbicide Nufarm Aquaneat Aquatic Herbicide
PBI/Gordon Corp	1812-312-2217 2217-850 56576-1-2217 67064-2-2217 2217-847 1812-312-2217	Pondmaster Aquatic Herbicide Pondmaster Surface & Shoreline Herbicide Pondmaster Copper Sulfate Crystals Pondmaster Blue Pro Turf Ornamental Glyphomate 41 Weed & Grass Killer Plus Aquatic Herbicide Aquacare Aquatic Herbicide
Phelps Dodge Refining	1278-5 1278-8	Triangle Brand Copper Sulfate Triangle Brand Copper Sulfate
Sepro Corp	67690-3 67690-4 67690-12 62719-324-67690 67690-3 62719-37-67690 67690-9 67690-10	Sonar SRP Sonar AS Sonar PR Precision Release Aquapro Sonar Q Renovate 3 Captain Nautique
Syngenta Crop Protection	100-1091 100-1194	Reward Landscape & Aquatic Herbicide Reward AccuGel Aquatic Herbicide
Voluntary Purchasing Group	7401-459	Hi-Yield Killzall Aquatic Herbicide
Zeneca Ag Products	10182-404	Reward Landscape & Aquatic Herbicide

Appendix F:

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Appendix G:

General Permit (To Be Added at a Later Date)

Appendix H:

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