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This work was prepared by OARS staff Suzanne Flint, Alison Field-Juma, and Jessica Furbeck and any errors or omissions are OARS’ responsibility. The Guidance is intended as a living document and we will endeavor to keep it up-to-date with the help of its readers and users.

**EXECUTIVE SUMMARY**

Lakes, ponds and rivers across the Commonwealth of Massachusetts are being choked by invasive water chestnut (*Trapa natans*). The result is degraded ecology and habitat value, loss of recreational value, and the high cost of control efforts. It can be challenging to figure out how to effectively manage water chestnut due to a lack of life-cycle information, diverse approaches to permitting, cost, and evolving control methods. This Guidance provides the latest research and management experience compiled for Conservation Commissions, communities, researchers and other stakeholders to use in developing effective management approaches and plans. The document reviews the control options and permitting needs for each option and provides model language for permitting under the Wetlands Protection Act for use by both applicants and Commissions. It includes a 5-year Water Chestnut Management Plan for the Sudbury, Assabet and Concord watershed, and extensive references. It is intended to be a living a document.
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**APPENDICES**

Appendix I: Responses to OARS/MACC Survey
Appendix II: Sample Permitting (On-line Version Only)
Appendix III: Water Chestnut Maps: OARS’ 2016 Survey (Map Index and Link to On-line Maps)
BACKGROUND

TAXONOMY

The water chestnut genus *Trapa* is currently classified in the *Lythraceae* family (Integrated Taxonomic Information System, 2016). Previously water chestnut was classified as a separate family, *Trapaceae* (Crow and Hellquist, 2000; Muenscher, 1944; USDA, 2016b) or *Hydrocaryaceae* (Gleason and Cronquist, 1963), with one genus, *Trapa*. There are between 2 and 11 species listed by various sources under the *Trapa* genus, the most common being *T. natans* and *T. bicornis*. The focus of this literature review is *T. natans* L., which is invasive in North America. *Trapa* species should not be confused with the “Chinese water chestnut” (*Eleocharis dulcis*) commonly used in Chinese cuisine.

HISTORY

Water chestnut, *Trapa* spp., is native to temperate and tropical Europe, Asia, and Africa. Archeological records suggest that *Trapa natans* was once widespread in northern Europe, but it is now nearly extirpated from the region (Hummel and Kiviat, 2004; Karg, 2006). *T. natans* is still an important agricultural product in China and India where the nuts are used (Kundu and Joshi, 2012). Although reportedly an important food in early European history, the nuts of *T. natans* are not known to be consumed in North America except by squirrels and other wildlife (Hummel and Kiviat, 2004).

While accounts vary, most agree that *Trapa natans* was introduced to North America in Middlesex County, Massachusetts, in the 1870s (Countryman, 1978). By 1874, the plant was cultivated in the Asa Gray Botanical Garden at Harvard University in Cambridge, Massachusetts. Louis Guerineau, the gardener at the botanical garden, introduced it to Fresh Pond and several other ponds in Cambridge, Mass., as an ornamental (Davenport, 1879). Davenport reported personally bringing nuts to Minor Pratt in Concord, Mass., where they placed the nuts and plants in a pond near the Sudbury River, remarking “but that so fine a plant as this, with its handsome leafy rosettes, and edible nuts, which would, if common, be as attractive to boys as hickory nuts now are, can ever become a ‘nuisance’ I can scarcely believe.” In 1886, Father J. Hermann Wibbe independently introduced the plant to Sanders Lake (now Collins Lake) near Schenectady, New York (Countryman, 1978). Over the last 150 years water chestnut spread from Sanders Lake down the Mohawk River into the Hudson River and from eastern Massachusetts across the region. It was first documented in the southern end of

Figure 1: Water chestnut, Sudbury River, Framingham, 2016 (OARS)
Lake Champlain in the early 1940s (Countryman, 1970), in a tributary to the Chesapeake Bay, Maryland, in 1955 (Allen and Strain, 2013), and in Quebec, Canada by 1998, and in the Connecticut River system in 1999.

Although *T. natans* had been in the Sudbury and Concord Rivers since 1886, it was reported to grow suddenly to nuisance proportions by 1945. Eaton (1947) reported “the still more spectacular explosion of the … water chestnut (*Trapa natans*) that took place in our part of the river [Sudbury River from Fairhaven Bay to Concord Village] summer before last and which continued during this past summer. … last summer it so multiplied in our stretch that no water at all was to be seen, except along the thread of the stream.” Eaton attributed the explosion of both *Trapa* and *Lemna* (duckweed) on the Sudbury to the increase in “alkaline sewage wastes,” as measured by soluble nitrates in the river. The plant continues to spread along waterways through accidental introductions. Efforts to control the plant followed in the wake of these introductions, and have been ongoing for several decades.

**BIOLOGY**

**ANATOMY**

*Trapa natans* is easily identified by its distinctive floating rosettes of leaves. The leaves on the water surface are alternate, green, and triangular with a toothed edge, a glossy upper surface, and a lower surface covered with soft hairs. The floating leaves form rosettes from 10 to 15” in diameter by late July (Groth et al., 1996; OARS, 2013) with leaves surrounding a central stem, kept afloat by petioles with air bladders. Small white flowers are borne in axils of the floating leaves. The fruits are large woody nuts with four sharp, recurved barbs. Below the water surface is a cord-like stem 2–5 meters long with feathery, leaf-like structures in opposite pairs along the stem. These plume-like structures are variously considered stipules, leaves, or adventitious roots. Further down the stem are black feathery roots which reach down into the

![Figure 2: Trapa natans](from Crow & Hellquist, 1983, Used with permission by Milne Special Collections and Archives Dept, University of New Hampshire, Durham, NH).
soft sediment. Each stem may produce several branches each terminating in a rosette (Crow and Hellquist, 1983; Crow and Hellquist, 2000; Gleason and Cronquist, 1963; Muenscher, 1944).

**LIFE CYCLE AND HABITAT**

*Trapa natans* is an annual, growing each year from seed (nut) and dying back by the end of the growing season. Most nuts sink to the bottom of the water body where they were produced. The nuts overwinter in the soft sediment and generate the bed of *T. natans* at that site the following year (Hummel and Kiviat, 2004). A portion of the seeds produced each year germinate in the following spring, the remainder accumulate and create a seed bank; in the sediments seeds are viable for up to 10–15 years (Methe et al., 1993; T. Largy, pers. comm.). To germinate, seeds must have a period of dormancy at cold temperatures (< 8°C) (Kurihara and Ikusima, 1991; Des Jardin, 2015); they germinate in the spring when water temperatures reach about 12°C. Seeds germinate fastest at moderately warm temperatures (17–19°C) but will germinate at a range of water temperatures from 10°C to 24°C and the final overall germination rate was found to be unaffected by these temperature ranges (Des Jardin, 2015). Contradicting earlier reports that the plants require full sun, Des Jardin (2015) reported that they are tolerant of partial shade.

In eastern Massachusetts, seeds generally germinate in May, with the first flat leaves reaching the water surface by early to mid-June, forming the floating rosette. Secondary branches and rosettes appear from the time the first leaves reach the surface until the first nuts are set (usually late July), at which point the number of rosettes per plant stabilizes (Groth et al., 1996). Leaves are produced from the meristem (growing tip of the stem) throughout the growing season as the stem elongates. Submersed leaves drop early and are replaced by pairs of fine, dissected leaves along the stem (Hummel and Kiviat, 2004). Small four-petal, white flowers are borne singly in the axils of floating leaves from late June to September (Hummel and Kiviat, 2004). Pollination occurs via self-pollination, cross-pollination, or by insects. Kadono and Schneider (1986) reported that the flowers are most often visited by beetles and true bugs (*Coleoptera* and *Hemiptera*). After fertilization, the peduncle holding the flower bends down into the water where the one-seeded green nut forms. Each rosette may produce 10–15 nuts. The plant continues to bloom and fruit into the fall or when cold temperatures end the season (S. Flint, pers. observation). When the seeds are mature, usually by early August, the nuts fall off and sink to the bottom of the water body and lodge in the sediment. The outer fruit layer of the nut disintegrates quickly to reveal a hard, black, woody nut with sharp barbed spikes. Although nut production is reduced, a rosette separated from its root can continue to produce nuts (Methe et al., 1993) and a stem can branch and form new rosettes by mid-August if the main stem is broken earlier in the summer (S. Flint, pers. observation).

Plant density affects many aspects of water chestnut growth and vigor, since they compete for two-dimensional water surface space rather than three-dimensional canopy space like terrestrial plants. *Trapa natans* in initially low-density plots (5–15 rosettes/square meter) are larger, more productive, and longer-lived than plants in high density plots (>100 rosettes/square meter). Compared with plants in high
density plots, low-density plants can have 5 times more rosettes and 8–10 times the biomass (Groth et al., 1996). Groth et al. reported that the largest plant from low-density plots bore 27 rosettes, while the largest from high density bore only five rosettes. In addition, low-density plants showed practically no mortality until the entire plant senesced in September, whereas rosettes of plants at high-density suffered continuous mortality, particularly to the secondary rosettes, through the growing season (Groth et al., 1996).

Water chestnut thrives in slow moving, nutrient-rich fresh water of ponds, lakes and rivers with muddy bottoms (Takamura et al., 2003). The plant prefers pH of 6.7–8.2 and tolerates salinity up to 0.1% and alkalinity of 12–128 mg/L calcium carbonate (Crow and Hellquist, 1983). It rarely grows where the substrate is low in organic matter or there is a swift current; the stems are weak and the plant is lightly rooted in the sediments by thin roots and the empty nut hull. It can survive in tidal freshwater marshes, such as the Hudson River (Coote et al., 2001) and can grow in depths up to 5 meters, but is most abundant in water around 2 meters deep (Muenscher, 1944).
Figure 3: Photos of *Trapa natans* (OARS)

Dry nut

Nut sprouting (with roots and underwater leaves)

Flower on short penducle

Flower in axil of floating leaves

Rosette close up—new leaves from center

Nut under rosette
Immature seed (early July)

Mature Seed (late August)

Underwater leaves (late August)
Petioles with air bladders (late August)

Large rosette with secondary rosette (July 20)

Petiole—bisected

Dense patch and OARS Rapid Response Team member
NATURAL ENEMIES

In water chestnut’s native range there are a number of natural enemies that could potentially be harnessed to control *T. natans* populations in North America. Field surveys identified 17 species (including insects, mollusks, fungi, and other pathogens) in Asia and 7 insects in Western Europe feeding on *Trapa* species. Several were investigated further: *Galerucella nymphaeae* L. (water lily beetle), *Galerucella birmanica* (beetle), and *Nanophyes japonica* (weevil) (Ding and Blossey, 2005). Of these, *Galerucella birmanica* was the most damaging to water chestnut and the most promising for biological control (Pemberton, 1999; Pemberton 2002; Ding et al., 2006a; Ding et al., 2006b). A North American beetle, *Pyrrhalta nymphaeae*, has also been reported to graze on *Trapa natans* in the Hudson River, but not extensively enough to inhibit nut production (Schmidt, 1986).

*Galerucella birmanica* is currently being studied by Dr. Bernd Blossey at Cornell University’s Department of Natural Resources as a potential biological control for water chestnut. Research started in the early 2000s, but were dropped when studies suggested that *G. birmanica* also grazes on a native water shield (*Brasenia schreberi*). More recent work shows that the beetle *G. birmanica* is host-specific and its preference for the leaves of *Trapa natans* continues even after the plant is almost completely defoliated (Cornell Chronicle, 2016). The beetle is likely able to survive New England’s climate, with best reproduction and generation survival occurring at 88–93°F (Zheng et al., 2008). Greater than 50 larvae per rosette were found to be needed to negatively impact the plant. At lower densities (10–50 larvae/rosette) the plant was able to increase leaf production at the expense of reproductive efforts (Ding et al., 2006b). Dr. Blossey hopes to have USDA approval for releasing *G. birmanica* in the United States by 2018 (Cornell Chronicle, 2016).

DISPERAL

Initially the greatest dispersal vector of *T. natans* in New England was intentional human introduction (Hummel and Kiviat, 2004; Les and Mehrhoff, 1999). *T. natans* has been listed as a nuisance or noxious species in 11 states, including Massachusetts (USDA, 2016a), although not at the federal level. As a result, intentional spread has likely stopped. However, nuts can still be distributed due to human activity by getting caught on nets, boats, construction equipment, and in excavated sediment. The sharply

Figure 4: Water chestnut on the edge of dam, Billerica, Sept. 2016 (OARS)
barbed nuts are thought to cling to the feathers of waterfowl and the fur of animals, which may also play a role in their dispersal, as well as in sediment washed downstream in floods. Propagation downstream can also occur by rosettes and fragments with nuts breaking off the stem and floating with the currents to populate a new area with suitable substrate.

**ECOLOGICAL IMPACTS**

Water chestnut can cover nearly 100% of the water surface, intercepting over 95% of incident sunlight (Caraco and Cole, 2002). The floating mats of vegetation shade out other submerged plants and can create large diurnal changes in the dissolved oxygen concentration in the water column (Kornijów et al., 2010). A study of dense water chestnut beds in a tidal section of the Hudson River reported dissolved oxygen values below 2.5 mg/L occurring up to 40% of the time in August and varying with tidal cycle (Caraco and Cole, 2002). Areas that are not flushed by tides may have longer periods of anoxic (depleted oxygen) conditions.

In spite of anoxic conditions, the impacts of dense water chestnut beds on macroinvertebrate and fish communities are varied (Schultz and Dibble, 2012). Studies of *T. natans* and native *Vallisneria* beds in the Hudson River found macroinvertebrate communities of different compositions (Feldman, 2001; Strayer et al., 2003; Teixeira et al., 2014; Kato et al., 2016). Strayer reported that the abundance of macroinvertebrates in the *Trapa* beds was higher than in *Vallisneria* beds. Kornijów et al. (2010) reported that water chestnut beds studied supported a rich community of macroinvertebrates, despite the common occurrence of hypoxia.

Several studies of fish abundance and species composition in water chestnut beds report that although fish do inhabit the beds, the species in greatest abundance are those with a wider tolerance for adverse conditions. Pelczarski (1990) reported that the abundance of fish in water chestnut beds in the Hudson was lower than reported in other vegetation types, but both adult and juvenile fourspine stickleback and carp were present in both beds. Coote et al. (2001) found young-of-the-year blueback herring using some beds. Most of the fish and macroinvertebrates studies in North America have been done on the tidal sections of the Hudson River; addition studies in non-tidal rivers would be warranted.

Water chestnut, like other large beds of aquatic plants, slows current velocity which leads to deposition of sediments, assisting in temporary water purification. Water chestnut has been shown to accumulate copper and cadmium in its roots, shoots, leaves and nuts (Sweta et al., 2015). Water chestnut (whole plants) harvested from the Sudbury River at Framingham, Mass., showed concentrations of cadmium and selenium above common soil concentrations; mercury, a major contaminant of sediments in the Sudbury River, was not detected and other contaminants tested were at low levels (OARS, 2013, pers. comm.). The fate of accumulated metals after water chestnut decomposes is unknown (Hummel and Kiviat, 2004).
IMPACTS ON RECREATION AND AESTHETICS

There is universal agreement that *T. natans* severely affects the recreational use of water bodies by creating impenetrable mats of vegetation that make the river inaccessible to boating, swimming, and fishing. The sharp barbed nuts can penetrate shoes and gloves and pose a hazard to swimmers and beachgoers. (Charles River Watershed Association, n.d.; Connecticut River Watershed Council, n.d.; Mystic River Watershed Association, n.d.; Nashua River Watershed Association, n.d.; Robinson, 2002). The decaying vegetation at the end of the growing season, or as a result of herbicide treatment, can create odors. In August 2016 a large mat of rotting water chestnut washed up against the dam on the Nashua River in Pepperell, its strong odor bringing notice in the local press: “The Nashua River flowing over the dam and underneath the Main Street Bridge stinks where a dense mat of bright green vegetation slowly dying to brown floats at the top of the dam.” (Nashoba Valley Voice, 2016). The loss of open water can significantly change the scenery and aesthetic beauty of a water body. These impacts can, in turn, impact real estate values (Robinson, 2002).

MANAGEMENT OPTIONS

An optimal management plan for controlling water chestnut will vary by the size of the infestation, the type of water body managed, any special characteristics of the site (e.g., rare species present or source water protection), the length of time managed, and the resources available for management. Unlike many invasive plants, water chestnut is strictly an annual and has been successfully controlled or eliminated in some water bodies, but only after persistent efforts. The most important aspects of successful water chestnut management are commitment to adaptive management, ongoing monitoring, and long-term maintenance. Below, the most commonly used and successful options for managing water chestnut are listed. Each of these techniques may be suitable as part of an overall adaptive management effort at different times and different locations.

Two points must be noted: First, excessive aquatic plant growth is promoted by nutrient-rich water. Efforts at water chestnut management should be accompanied by systematic efforts to reduce nutrient...
inputs to the water body. This may be done by reducing and treating stormwater runoff, fixing or eliminating failing septic systems, eliminating runoff of lawn fertilizer, reducing nutrients in effluent from wastewater treatment facilities, and other means depending on the sources of nutrients. Second, aquatic ecosystems should be managed as complex ecosystems with a goal of maintaining a healthy, diverse system that will continue to evolve. This will require protecting and encouraging native aquatic and riparian plants while discouraging invasive plants. It is important to consider the effects that removing water chestnut will have on the water body, so that successful treatment does not pave the way for a different invasives problem.

Several sources have detailed discussions of treatment methods suitable for all invasive aquatic plants (Gettys et al., 2014; Mass. EOEIA, 2004; Wagner, 2004). This discussion is intended as a general guide; detailed Standard Operating Procedures and guidelines should be consulted in preparation for starting any remediation project. The “guidelines” listed for each option here are primarily drawn from The Practical Guide to Lake Management in Massachusetts (Wagner, 2004).
<table>
<thead>
<tr>
<th>Water Chestnut Control Options</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Potential permitting</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hand-pulling</strong></td>
<td>Physical removal of plants before seeds drop; hand-pulling from small boats</td>
<td>highly selective control; limited impact to non-target organisms; good for shallow sites; removes plants from water column; can involve volunteers (lower cost)</td>
<td>Not good for large, dense infestations; labor intensive</td>
</tr>
<tr>
<td><strong>Mechanical Harvesting</strong></td>
<td>Physical removal of plants before seeds drop; requires mechanical harvester, conveyor, and truck</td>
<td>Capable of removing large/dense infestations; removes plants from water column</td>
<td>Minimally selective; not useable in shallow sites; fragmentation may spread other invasives; may impact aquatic fauna; requires larger access or use of crane; higher cost</td>
</tr>
<tr>
<td><strong>Hydroraking</strong></td>
<td>Physical removal of plants before seeds drop; requires hydrorake, barge, and truck</td>
<td>Capable of operating in shallower areas than mechanical harvester, removes stump and debris</td>
<td>Minimally selective; very disruptive in areas applied; may generate high turbidity; fragmentation may spread other plants; requires larger access or crane</td>
</tr>
<tr>
<td><strong>Drawdown</strong></td>
<td>Winter drawdown to kill seeds by freezing; summer drawdown to kill emerging vegetation before seeds set; timing duration are critical</td>
<td>Low cost; opportunity for shoreline cleanup or structure repair; needs outlet control</td>
<td>Non-selective; very disruptive; alteration of flows downstream during drawdown &amp; refill periods; more information needed on effectiveness of summer drawdown</td>
</tr>
<tr>
<td><strong>Dredging</strong></td>
<td>Sediment removal to reduce seed bank, reduce nutrient recycling, increase water depth</td>
<td>Removes the soft sediments, deepens the waterbody, effective on all rooted plants</td>
<td>Non-selective; very disruptive; alteration of flows during management; potential release of sediment; high cost</td>
</tr>
<tr>
<td><strong>Bethic Barriers</strong></td>
<td>Placement of barrier or bottom cover to prevent growth of rooted plants</td>
<td>Effective on growth of rooted plants in limited areas or create access lanes; complete elimination of plants in area</td>
<td>Non-selective; High cost of installation and maintenance; not suitable for large areas; difficult to install</td>
</tr>
<tr>
<td><strong>Herbicides</strong></td>
<td>absorbed or membrane-active chemicals that disrupt plant metabolism</td>
<td>Limited toxicity; rapid action; can be selectively applied</td>
<td>Potential toxicity to aquatic fauna; water use restrictions for varying time after application; increased oxygen demand from decaying vegetation</td>
</tr>
<tr>
<td><strong>Biological Control: Herbivorous insects</strong></td>
<td>Introduction of insects that feed selectively on target</td>
<td>Research on <em>Galerucella birmanica</em> ongoing; potentially very selective control; lower cost of application and potentially long-term control achieved</td>
<td>Involves introduction of non-native species; more research needed</td>
</tr>
</tbody>
</table>

Abbrev: DEP, Department of Environmental Protection; NHESP, Natural Heritage and Endangered Species Program; WPA, Wetlands Protection Act; ACOE, Army Corps of Engineers.
Pulling water chestnuts out by hand or with a rake can be done easily. The technique is well suited for working in shallow water, controlling small infestations, selective control where they are intermixed with other wetland or aquatic plants, or long-term maintenance when an infestation has been brought under control with other techniques. It is frequently used alongside a mechanical harvester to get to plants the harvester cannot reach or pick up dropped rosettes. Because minimal training and equipment is needed, hand-pulling is well suited for volunteer efforts, which can help build community investment in long-term management of the problem (Mass. DCR, 2007). The technique is not good for large-scale efforts when the target plants occur in dense and extensive beds (Wagner, 2004).

Guidelines:

- Map the distribution of water chestnut and non-target species before treatment, and identify the boundaries of the work area.
- Identify the access points (boat launch and weed off-loading), disposal site(s), and disposal method (e.g., composting or incineration).
- File for and receive appropriate permitting before the start of the project. (See permitting section.)
- Train all personnel on plant identification, boating safety, harvesting techniques, and proper disposal of the weeds. Supply safety equipment: PFDs, bailers, and gloves.
- Work from canoes, kayaks or small boats, using laundry baskets to collect the weeds.
- Harvest as much of the plant as practical. In the early summer the entire stem and seed husk (sharp barbed) will come up easily. Later in the season, when the plants have long stems and multiple attached rosettes, the stems will have to be broken off. Handle the rosettes carefully to avoid dropping nuts back into the water. Leave the roots in the sediment to minimize stirring up silt which may damage the local ecosystem.
- Set up a sturdy and safe offloading point (e.g., a small dock is ideal)
- Some groups advocate multiple pulls (early and late) in a season to ensure full removal.
- Conduct follow-up monitoring in the same and following season.

Figure 6: Water Chestnut Pulling, Framingham, 2016
MECHANICAL HARVESTING AND HYDRORAKE

“Aquatic weed harvesters are like lawnmowers for aquatic weeds.” Aquamarine describes their mechanical harvesting process thus: “aquatic plant harvesters are hydraulically driven with reciprocating knives mounted on the harvesting head to cut the aquatic vegetation. The vegetation is then transferred onto the conveyor system located on the closed deck barge. The storage conveyors are gradually filled up with tightly packed plants and this harvested biomass is then transferred to the shoreline or into a dump truck via a shore conveyor” (Aquamarine, n.d.).

Mechanical harvesting is faster (0.2–0.6 acres per hour) than hand pulling and requires fewer people (Wagner, 2004). However significant amounts of time can be involved shuttling to and fro to offload the weeds. It can be challenging to find a suitable launch and offloading site, and often a crane is used at a bridge to lower the harvester into a river. Harvesters generally need a minimum of 2–3 feet of water depth. Harvesters cut off the rosettes, which may allow resprouting from the stem and the need for a second cutting later in the season.

Figure 7: Water Chestnut Harvester & Conveyor, Sudbury River, 2014 (OARS)

Hydroraking involves the equivalent of a floating backhoe; the tines of the rake are pulled through the sediment, uprooting plants, sediment and debris. SOLitude describes their hydrorake: “The hydro-rake can best be described as a floating barge upon which is mounted a backhoe with several different size and functioning rake attachments. The hydro-rake can operate in water as shallow as 1.0–1.5 feet and can remove nuisance vegetation and bottom debris from water depths ranging from 18 inches to 10 feet.” Hydrorakes don’t have on-board storage so they deposit weeds either on-shore or require a barge.
The hydrorake pulls the entire plant with roots out of the sediment and tend to stir up a lot of silt, some of which can be minimized by a skilled operator.

Guidelines:

- Map the distribution of water chestnut and non-target species before treatment, and identify the boundaries of the work area.
- Identify the access points (harvester launch and weed off-loading), disposal site(s), and disposal method (e.g., composting or incineration).
- File for and receive appropriate permitting before the start of the project. (See permitting section.)
- Identify methods for minimizing turbidity during harvesting and implement when feasible.
- Develop a fragment control plan for non-target invasive species likely to spread by fragmentation (e.g., milfoil).
- Schedule harvesting to take place before nuts mature.
- Plan hand-pulling to work in tandem with harvesting for edge areas and areas of mixed invasive/native plants.
- Avoid areas of known sensitive habitat during active use.
- Monitor collection of non-target fauna (e.g., fish, turtles).
- Develop a harvester maintenance plan.

WEED DISPOSAL FOR HAND-PULLING AND MECHANICAL HARVESTING

Once harvested, the weeds (sometimes large volumes) must be disposed of by composting or incineration. The weeds may be piled near the harvest site and allowed to dry for a few days to weeks before final disposal. The weight and volume of the pile will decrease significantly when it is allowed to drain and dry, making subsequent transportation and disposal easier. The pile should be kept away from the water’s edge to avoid washing back into the water in the event of heavy rain. Care in handling the piles is advisable, since the sharp-barbed nut husks of germinated plants commonly accompany the root. Viable nuts are heavier than water and sink to the bottom; floating nuts are husks of nuts that have already germinated and can penetrate rubber-soled shoes.

Composting is usually the least expensive option when a suitable site can be found. In OARS’ survey, of the towns reporting water chestnut harvesting in their area, most (13) reported composting the weeds, one reported incinerating the weeds, and the remaining towns (10) reported “do not know” because someone else was managing the harvesting (see Appendix I). In accordance with Massachusetts’ Department of Food and Agriculture regulations (330 CMR 25.00) compost piles should be placed in such a way as to minimize odors, the drift of materials and risk to humans and the environment. Due to the presence of the sharp nuts, reuse of the compost may be limited. Incineration as part of the municipal waste stream is sometimes used but is only efficient if the plants have had an opportunity to dry out naturally as much as possible prior to incineration.
Because of concerns about potential contamination, particularly mercury contamination, the heavy metal content of whole water chestnut plants from the Sudbury River was tested. Plants were pulled from the Fairhaven Bay and Saxonville impoundment sections of the Sudbury River, both areas suffering from significant mercury contamination. The samples were dried and sent for analysis by the Cornell Nutrient Analysis Laboratory. Mercury was undetectable in all samples (OARS, unpublished). The results were also compared with compost guidelines for application on food crops and reported typical soil levels (Brinton, 2000). Of the metals tested, cadmium, chromium, copper, manganese, nickel, selenium, and zinc exceeded the guidelines for application on food crops; only cadmium and selenium exceeded reported typical soil values (OARS, unpublished).

**DRAWDOWNS**

Winter drawdowns are not generally used for control of water chestnut because the seeds are likely to survive in the sediments (Wagner, 2004). Summer drawdowns have been used occasionally to control water chestnut. To be effective, a summer drawdown should be conducted after late May/early June when water chestnut has sprouted, and water levels are drawn down far enough to dry the sediment and kill the vegetation. Summer drawdowns used in the Concord Impoundments of the Concord River to improve habitat for migrating birds, were effective in reducing the water chestnut (see Concord Impoundments below). Drawdowns can be cost effective, depending on the ability to control water levels in the section of interest, but may have broad impacts on other plant and animal species. Recolonization from nearby areas may be rapid, depending on species, and the response of macrophyte species is quite variable (Wagner, 2004). Summer drawdowns have the potential to affect nearby wells and fire-fighting ponds, which could be critical during the lower-flow summer months.

Guidelines:

- Map the distribution of water chestnut and non-target species before treatment, and identify the boundaries of the work area.
- Evaluate the potential risks to non-target flora and fauna.
- Apply for and secure permitting from local Conservation Commission.
- Limit the drawdown to 3 ft or contract the Mass. Division of Fish and Game for help evaluating impacts of a greater drawdown.
- Keep outflow during drawdown below 4 cfs/square mile of watershed; once the drawdown is achieved, match outflow to inflow.
- Monitor water levels and water quality during the drawdown, and monitor the recovery of the water body.

**DREDGING**

Sediment dredging has been used successfully for weed control, but its utility is limited to areas that will not rapidly re-accumulate sediment. *The Practical Guide to Lake Management in Massachusetts* (Wagner, 2004) includes an extensive discussion of conventional wet, conventional dry, and hydraulic
dredging. Dredging can control water chestnut by physically removing its seed bank along with the soft sediment that support its growth, by removing nutrients and internal loading stored in the sediment, and/or increasing the depth of the water body. Dry dredging involves drawing down the waterbody to expose the sediment, controlling inflows during the process, and using conventional excavation equipment. Wet dredging may involve a partial drawdown (especially where water level control is limited) and use of specialized excavation equipment. Conventional wet dredging creates considerable turbidity and requires steps to limit downstream movement of the sediments and to de-water dredged sediments before they are removed for disposal. Hydraulic dredging involves a suction type of dredge to remove a slurry of sediments. The slurry is pumped into a containment area to remove excess water. Hydraulic dredging can work well for large volumes of sediments in areas that cannot be drained and contain relatively few rocks and stumps.

Permitting requirements and costs for dredging are generally higher than for other management options. Permitting required may include: Wetland Protection Act permit; MEPA review; Chapter 91 permit; 404 permit through Army Corps of Engineers; 401 Water Quality permit through Department of Environmental Protection (for projects involving dredging greater than 100 cubic yards of sediment).

Guidelines:

- Map the distribution of water chestnut and non-target species before treatment, and identify the boundaries of the work area.
- Project planning should address: reasons for dredging, volume and nature of material to be dredged, any protected resources, equipment access, disposal site or use/sale of material, site bathymetry, flow management, dredging methodologies, regulatory process, and costs.
- Apply for and receive all applicable permits (see permitting section).
- Conduct all work in accordance with permit conditions.
- Achieve depth or substrate limitation (depending on project goals).
- Restore or rehabilitate all access, temporary containment, and final disposal areas.
- Monitor containment area, downstream flows and water quality during dredging.
- Monitor recovery of the water body.

**Benthic Barriers**

Benthic barriers are used to prevent growth of rooted aquatic plants by limiting light and disrupting growth of all the rooted plants in the application area (Mass. DCR, 2007). Barriers may be clay, silt, sand, gravel, or sheets of artificial material (e.g., polyethylene, polypropylene, fiberglass, or nylon) manufactured to be negatively buoyant. Because of the expense, difficulty of application, non-selectivity, and need for maintenance, benthic barriers are usually used in limited areas and in areas without significant current or waves.
Guidelines:

- Map the distribution of water chestnut and non-target species before treatment, and identify the boundaries of the work area.
- Select a barrier with properties consistent with the project goals and site features.
- Apply for and receive all applicable permits (see permitting section).
- Install and anchor the barrier so that it is stable in response to waves, currents, and billowing up from sediment gasses.
- Post the area to inform potential users of the barrier’s presence.
- Leave in place for at least a month; check for movement and sedimentation.
- Monitor the barrier’s effectiveness and plant community before and after installation.

HERBICIDE TREATMENT

Several herbicides can be used to manage water chestnut. Herbicides can be classified by their chemical family, mode of action, or time of application (e.g. pre-emergence or post-emergence). They can also be classified as “contact” or “systemic.” Contact herbicides injure only the plant tissue that they come in contact with and are relatively fast acting (hours to days). Contact herbicides are applied in relatively high concentrations and have a short half-life in water. In contrast, systemic herbicides move from leaves into the roots and rhizomes and kill the plants within days to weeks; they are applied at lower concentrations (Haller, 2014; US Army Corps of Engineers, 2012). A surfactant is added to many contact herbicides to improve adhesion and absorption by the plant leaves. The surfactants are also chemicals, and should be specified and assessed as well.

Herbicides have three names: a trade name, a common name, and a chemical name. The trade name is trademarked by the manufacturer and is specific for each formulation of the herbicide. The common name and chemical name are assigned by the American National Standards Institute and are unique to the active ingredient (US Army Corps of Engineers, 2012). For example the active ingredient of Clearcast™, a trademark of BASF Corporation, is ammonium salt of imazamox, chemical name: 2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1 H-imidazol-2-yl]-5-(methoxymethyl)-3-pyridinecarboxylic acid (SePRO, 2015).

Aquatic herbicides must be registered with the EPA (under the Federal Insecticide, Fungicide, and Rodenticide Act) and the Massachusetts Department of Agriculture and approved for legal use in Massachusetts. The Massachusetts Pest Product Registration (Mass. DAR, 2016a; Mass. DAR, 2016b) currently lists nine herbicide formulations specifically approved for control of water chestnut in Massachusetts: Aquacide Pellets (2,4-D), Arsenal (imazapyr, isopropylamine salt), Clearcast (imazamox), Habitat (imazapyr, isopropylamine salt), Navigate (2,4-D), Navitrol DPF (triclopyr), Renovate Max G (combination 2,4-D and triclopyr), Renovate OTF (triclopyr), and Sculpin G (2,4-D).

In the past, the most widely used herbicide had been 2,4-D (Hummel and Kiviat, 2004; Poovey and Getsinger, 2007; Kishbaugh, 2014; Rector et al., 2015). More recently other chemicals have been used.
Since Clearcast was approved for control of water chestnut, imazamox has been used with initial good results (Nemecek and DeHollander, 2014; DeHollander, pers. comm.). SOLitude Lake Management reported using Clearcast and Renovate Max G to clear water chestnut in several small ponds in Fairfax, Virginia (SOLitude, 2016). The Perkiomen Watershed Conservancy reports using a combination of Habitat and Rodeo (glyphosate) to successfully clear a section of water chestnut on Perkiomen Creek (pers. comm.). The Onondaga County Health Department applied for aquatic permits to chemically treat 147 acres of water chestnut infestation on the Seneca River in 2016 using Clearcast and Rodeo (pers. comm.).

After 24 years of mechanical harvesting and unable to keep up with growth using one harvester, Oswego County Soil and Water Conservation District turned to a combination of methods including treatment with a variety of herbicides and hand-pulling to control water chestnut on the Oswego River and in the district. In 2004–2005, they expanded chemical treatments with special use permits from the New York Department of Environmental Conservation for Aqua-Kleen (granular 2,4-D), Rodeo (glyphosate) and Weedar 64 (2,4-D) at sites in Oneida Lake, Oneida River, Ox Creek and the Seneca River to compare the effectiveness of the herbicides. They reported that results using 2,4-D and glyphosate on large patches of water chestnut were “erratic at best.” In 2009–2013, they attempted undercutting without weed removal in conjunction with chemical treatments. In 2012–2016, large patches of water chestnut in the Oswego and Seneca Rivers were treated using Clearcast. By 2016, the over-220 acres of water chestnut were reduced to about 20 acres and chemical treatment was combined with hand-pulling to control the remaining population on the Oswego River (John DeHollander, pers. comm.; DeHollander, 2015; The Nature Conservancy, 2012; Nemecek and DeHollander, 2014).

General guidelines for chemical control:

- Map the distribution of water chestnut and non-target species before treatment, and identify the boundaries of the work area.
- Identify waterbody and downstream water uses that may be impacted.
- Inventory aquatic biota with emphasis on sensitive species.
- Develop treatment plan including does, areas treated, expected alteration of plant community, follow-up activities, and notifications about any water use restrictions.
- File and receive appropriate permitting before the start of the project (see permitting section).
- Application must be done by a licensed applicator.
- Monitor effectiveness and results, with emphasis on oxygen and nutrient levels if more than 10% of the waterbody area is treated.

2,4-D

2,4-D is a somewhat selective, systemic, broadleaf herbicide used to control a variety of submersed and floating aquatic plants. It has been registered by the US EPA for use in aquatic environments since 1959 (US Army Corps of Engineers, 2012). The chemical prevents the elongation of stems and roots, keeping
tissues juvenile. Depending on the form, the compound acts like the plant hormone auxin, affecting cell wall plasticity and nucleic acid metabolism in plants.

Amine and butoxy-ethyl ester formulations in liquid and granular formulations of 2,4-D can be used against water chestnut effectively (US Army Corps of Engineers, 2012; Rector et al., 2015). These go by the trade names of Navigate (2,4-D ester) and Platoon, DMA-4, and CleanAmine (liquid 2,4-D amine) (ACT, 2015). The liquid amine formulation of 2,4-D is typically used to control both emergent and submersed plants, and granular butoxy-ethyl ester formulation is used for submersed plants only (ACOE 2012). Though widely used as a water chestnut herbicide, updated regulations lowered the allowable dose concentration for 2,4-D, and it may be less effective on water chestnut (pers. comm..). All 2,4-D products are prohibited in Zone II wellhead protection areas due to toxicity and concerns about migration into groundwater (Aquatic Control Technology, 2015a).

**TRICLOPYR**

Triclopyr is a selective systemic herbicide and auxin mimic that has been shown to be effective on water chestnut (Poovey and Getsinger, 2007). Although triclopyr is not as effective as 2,4-D, it can be used in public waters where 2,4-D use is not allowed (Netherland, 2014). Liquid and granular formulations of triclopyr amide are available to control submersed, floating and emergent dicotyledonous (and some broadleaf monocotyledonous) aquatic plants (Wagner, 2004; US Army Corps of Engineers, 2012).

**CLEARCAST**

Clearcast is a liquid herbicide containing the ammonium salt of imazamox. It is active on many submerged, emergent, and floating broadleaf and monocot aquatic plants, applied as a foliar (onto the leaves) spray on emergent or floating plants, or applied directly to the water to control submersed plants.

Study of Clearcast for aquatic vegetation management began in 2004, with aquatic Experimental Use Permit (EUP) programs conducted in some 16 states starting in 2006, and the treatment of up to 4,750 acres per year. Clearcast received full EPA approval in 2008 (AECOM, 2009). In the spring of 2015, the Massachusetts Department of Agriculture registered Clearcast for controlling vegetation in and around aquatic sites and terrestrial non-crop sites (Aquatic Control Technologies, 2015a). A foliar application of Clearcast with a surfactant is used for treatment of water chestnut. It should be noted that control will be reduced if spray is washed off foliage by wave action or rain, and repeat applications may be necessary.

**BIOLOGICAL CONTROL**

“Successful biological control depends on the ability of host-specific herbivores to suppress populations of their host plant” (Ding et al., 2006b). Biological control agents can kill the target plants outright or damage them thus limiting their reproduction or ability to compete with other plants. Research on *Galerucella birmanica* as a biological control for water chestnut is ongoing (see Natural Enemies, above). Any biological control agent must be thoroughly studied for host-specificity and effectiveness and approved for use by the US Department of Agriculture and individual states. A Plant Protection and
Quarantine (PPQ) 526 permit from the USDA is required to transport biological controls across state lines and for release into the environment.

**FUNDING**

At the state and federal level, most funding for water chestnut control comes through annual budget appropriations or Environmental Bond funding to DCR (Mass. Department of Conservation and Recreation) or US Fish and Wildlife Service. Mass. DEP does not currently have funding for circuit riders for invasives control. At the local level, municipal budgets have provided funds, sometimes drawing on Community Preservation Act money. Local land trusts and watershed organizations have been able to secure funds through grants, donations, and environmental penalties. Volunteer contributions in surveying and hand-pulling are invaluable.

Possible grant programs for invasives control include: Section 106 of the Clean Water Act (EPA), Section 319 of the Clean Water Act—Healthy Watershed Initiative, and DCR matching funding for areas abutting or sharing DCR land.

**PERMITTING FOR CONTROL EFFORTS**

**LEGAL STATUS**

In Massachusetts, the sale, planting, transport, and traffic in water chestnut is specifically banned by Massachusetts general law Title XIX Ch. 128 Sec. 20A (Commonwealth of Massachusetts, 2016) and water chestnut is on the Massachusetts Prohibited Plant List (Mass. EOEEA, 2016). The Massachusetts Invasive Plants Advisory Group (MIPAG) lists water chestnut as a “Category 1” early detection priority species; Category 1 species should be reported and eradicated if found anywhere in Massachusetts (MIPAG, 2011). The Mass. DCR Lakes and Ponds Program lists water chestnut on their Rapid Response List.

In 1949 New York State enacted a law prohibiting transport, transplant or traffic in water chestnut. The National Invasive Species Act of 1996 specifically mentioned *Trapa natans* as a species of concern, but imposed no restrictions or penalties (Hummel and Kiviat, 2004). Currently, it is not on the federal noxious weed list. As of 2016, *Trapa natans* is listed as a “noxious weed” in 11 states, including Massachusetts (USDA, 2016).

**RESPONSIBLE PARTIES**

Control of aquatic invasives is not legally mandated, and, thus, not the responsibility of any agency or municipality. Various groups have taken the lead in managing aquatic invasive plants, depending on ownership/management, municipal involvement, and the existence of lake or watershed associations. For example, the Department of Conservation and Recreation (DCR) through their Lakes and Ponds Program manages invasives on DCR-owned properties has taken the lead in Massachusetts to provide
information and training to support control efforts statewide. DCR’s Division of Water Supply Protection manages invasives in the water supply reservoirs, including the Sudbury Reservoir (Mass. DCR, 2010). US Fish and Wildlife Service takes the lead managing water chestnut on the Sudbury River within the Great Meadows National Wildlife Refuge in coordination with the Town of Lincoln, Town of Concord, and the Concord Land Conservation Trust. Outside of the state parks and reservations, control of invasive plants is largely a function of local desire to protect and maintain the resource.

PERMITTING IN MASSACHUSETTS

A key guide to the permitting process is DEP’s Guidance for Aquatic Plant Management in Lakes and Ponds as it Relates to the Wetlands Protection Act (Langley et al., 2004), available on the DEP website. This guide is specific to lakes and ponds, but can generally be applied to rivers as well. Another key resource is Protecting Wetlands and Open Space: MACC’s Environmental Handbook, which is available on-line for a fee. The local Conservation Commission will be involved due to the Wetlands Protection Act. It is highly recommended that anyone considering water chestnut control discuss their proposed activities as early as possible with the Commission so that they, or the conservation agent, may advise on the best approach. The DEP’s Wetlands Circuit Rider (Central, Southeast and Western regions only) is a great resource for applicants and Commissions alike.

All water chestnut control projects fall under the permitting requirements of the Massachusetts Wetlands Protection Act (MGL Ch. 131, Sec. 40) primarily because they may “alter” (change the condition of) “land under water” and may also require approval under local wetlands bylaws/ordinances. “Alterations” include sedimentation, flow patterns, vegetation, or the physical, biological or chemical condition of the water. In some cases, “bordering vegetated wetlands” may also be affected. Conservation Commissions have the discretion to determine that minor hand-pulling efforts to remove water chestnut plants that do not significantly disturb the sediment may go ahead without permitting. Where large equipment may need to access the waterbody, projects may also alter “banks” or “floodplains” or other resource areas, potentially creating erosion or sedimentation. Plants removed by harvesting (whether by hand or machine) will need to be disposed of properly. See Figure 8 describing the permitting process. All forms and instructions for filing under the Wetlands Protection Act can be found at: www.mass.gov/eea/agencies/massdep/water/approvals/wetlands-and-waterways-forms.html#4. Sample permitting is provided in Appendix II.

Water chestnut control projects may also fall under other regulations. The site location, funding sources, scope, and methods will define the regulatory requirements. Permitting can take several months so it should be started during the winter for the following summer. For projects that will require obtaining funding and an Order of Conditions and any other permits, getting started the preceding fall is advisable.

Under the Wetlands Protection Act, water chestnut control may be considered an “Ecological Restoration Limited Project.” Such a project must meet the definition: “a project whose primary purpose is to restore or otherwise improve the natural capacity of a Resource Area(s) to protect and maintain the interests identified in M.G.L. c.131 § 40, when such interests have been degraded or destroyed by
anthropogenic influences.” (310 CMR 10.04). To be considered a “Limited Project,” the activity must exceed the thresholds for the three resource areas shown in the table below. If it is less than those thresholds, it goes through the same process as any other project under the Act.

Table 2: Thresholds for filing "Limited Projects"

<table>
<thead>
<tr>
<th>Resource Area</th>
<th>Threshold for Wildlife Habitat Evaluations in Inland Resource Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank</td>
<td>50 linear feet or 10% of Bank on the property, whichever is less (310 CMR 10.54(4)(a)(5))</td>
</tr>
<tr>
<td>Land Under Waterbodies and Waterways (LUW)</td>
<td>5,000 square feet or 10% of LUW on the property, whichever is less (310 CMR 10.56(4)(a)(4))</td>
</tr>
<tr>
<td>Bordering Land Subject to Flooding (BLSF)</td>
<td>5,000 square feet or 10% of BLSF presumed significant for wildlife habitat, whichever is less (310 CMR 10.57(4)(a)(3))</td>
</tr>
</tbody>
</table>


The project cannot be Dam Removal, Freshwater Stream Crossing Repair and Replacement, Stream Daylighting, Tidal Restoration, Rare Species Habitat Restoration, or Restoring Fish Passageways. These six project types are considered “Ecological Restoration Projects” and require a different form (Form 3A) and process (310 CMR 10.13 (2-7)).

Under the “Limited Project” type, the applicant must show that a project improves the natural capacity of a specific resource area. This includes projects proposed primarily to enhance fisheries habitat, address eutrophication, or increase dissolved oxygen or improve overall water quality in a water body. Ecological Restoration Limited Projects fall into five categories; #5 is “Other Restoration Projects.” According to the MACC Handbook (2016, p. 18.7.4), this category applies to projects designed “to enhance biodiversity through the removal and/or management of invasive species and through native plantings. It can also be used to justify removal of aquatic nuisance vegetation, and thinning or planting of vegetation to improve habitat value.” DEP’s Guidance (2004, p. 1) notes that “projects involving removal of aquatic nuisance vegetation must demonstrate that the vegetation is a ‘nuisance’ to the interests of the act.” Water chestnut, as a non-indigenous invasive plant species, fits the definition of nuisance vegetation.

As an Ecological Restoration Limited Project, the environmental impacts are reviewed at two levels: the local Conservation Commission, which has jurisdiction under the Wetlands Protection Act and any local wetland bylaw/ordinance, and the Massachusetts Environmental Policy Act (MEPA) Unit, which has jurisdiction over state-funded or state-authorized projects of a certain size or scope. Mass. DEP may choose to review projects as part of the Wetlands Protection Act and other regulations. If there are rare species in or adjacent to the waterbody, approval for control actions will be needed from the Natural Heritage and Endangered Species Program (NHESP). Other agencies and approval programs may apply, depending upon the features of the waterbody (e.g., naturally large enough to be a statutory Great Pond), its location (e.g., in an Area of Critical Environmental Concern), or its uses (e.g., as a water supply) (ENSR, 2005; Langley et al., 2004). Provided there is no discharge of dredge or fill materials, the
federal Clean Water Act (Section 404) should not apply. The Clean Water Act’s Sec. 401 Water Quality Certificate should not be required for the same reason unless a herbicide is used.

Small-scale hand-pulling efforts may not need formal approval, at the discretion of the Conservation Commission. However, organized larger-scale hand-pulling may significantly disturb sediment (resource area = “land under water”) and generate quite a lot of pulled material and may need to be reviewed through a Request for Determination of Applicability (RDA). This is at the discretion of the Conservation Commission so meeting with the Conservation Agent well in advance of any planned work is advisable. For organized hand-pulling that is seen to disturb “land under water,” a Request for Determination of Applicability is submitted to the municipal Conservation Commission. The Commission may issue a negative Determination (thus not requiring a Notice of Intent), with the provision that DCR’s Standard Operating Procedures are used (Mass. DCR, 2007), and other conditions as needed. This process enables the Commission to confirm that proper methods are being used for the hand-pulling and disposal of the weeds. If a positive Determination is issued, the next step is for the applicant to submit a Notice of Intent.

There were differences of opinion about permitting hand-pulling among the towns responding to OARS’ survey question: “What type of permitting would be needed for hand-pulling?” (see Appendix I). The Request for Determination should probably be used more frequently than it is currently because it provides information to the Conservation Commission and provides a record in case of local complaints or concerns. Using equipment such as harvesters and hydrorakes to remove water chestnut, on the other hand, will generally need permitting through an Order of Conditions.

Table 3: Survey Responses

<table>
<thead>
<tr>
<th>Permitting for Handpull (49 responses)</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administrative or none</td>
<td>13</td>
</tr>
<tr>
<td>Request for Determination</td>
<td>18</td>
</tr>
<tr>
<td>Order of Conditions</td>
<td>12</td>
</tr>
<tr>
<td>Emergency Order</td>
<td>2</td>
</tr>
<tr>
<td>Unsure</td>
<td>4</td>
</tr>
</tbody>
</table>

To obtain an Order of Conditions, the applicant must submit a Notice of Intent that specifies the scale and scope of the project, location(s), and equipment and disposal methods. The forms for the Limited Project are the Wetlands Protection Act (WPA) Form 3 (Notice of Intent) and Appendix A (Ecological Restoration Limited Project Checklists). These cannot be filed electronically. The Limited Project application requires submitting a plan, a determination letter from the Natural Heritage and Endangered Species Program (if there is an endangered plant or animal species habitat mapped in that area), and publication in the Environmental Monitor (www.mass.gov/eea/agencies/mepa/submitting-notices-to-the-environmental-monitor.html), and abutter notification. While there is a fee for the filing for most applicants, town departments are exempt from the fee.

If the project does not exceed these thresholds for a Limited Project (Table 2), a regular Notice of Intent without Appendix A is appropriate. This can be filed electronically and does not need publication in the
Environmental Monitor. It does require abutter notification. The Order of Conditions may be written to cover similar efforts elsewhere in the municipality (a “generic” Order of Conditions) if so requested in the Notice of Intent. In this case it is preferable to have one town entity or person designated as the coordinator who can delegate the work to other groups, departments, consultants or individuals in order to maintain accountability and compliance with the Conditions. This is often a municipal department, such as Public Works.

The Order of Conditions should include erosion control at the location where equipment is put in the water, proper plant disposal, and minimizing disruption of bottom sediments, particularly where they may be contaminated. These aspects should be thought through in advance by the applicant and included in the Notice of Intent where possible. Orders of Conditions may be issued for 3-5 years and be extended upon request an indefinite number of times. Applicants and Commissions should review the *Guidance for Aquatic Plant Management in Lakes and Ponds as it Relates to the Wetlands Protection Act* (Langley et al., 2004). Useful procedures are described in DCR’s *Standard Operating Procedures: Using Hand Pulling and Benthic Barriers to Control Pioneer Populations of Non-Native Aquatic Species, A Guide for Volunteers* (2007, on the DCR website), and in the much more detailed document *Final Generic Environmental Impact Report: Eutrophication and Aquatic Plant Management in Massachusetts* (Mass. EOEA, 2004), available on the EOEEA website.

Herbicide application to water bodies or aquatic plants requires permitting under the Wetlands Protection Act through a Notice of Intent. The herbicide must be applied by a licensed applicator. Herbicide licenses issued by the Mass. DEP, Office of Watershed Management (Bureau of Resource Protection) using Form BRP WM 04 are also required to apply chemicals for the control of nuisance aquatic vegetation in waterways. No herbicide license is required for treating a privately-owned pond with a single owner from which there are no flowing outlets, although this activity will still require approval from the Conservation Commission.

Dredging permitting is more complex. Typically a study is done first to determine what native species are present and how dredging will affect them. This requires the Department of Fish and Game to look at the proposed location and ensure it will not be harmful. An Order of Conditions will be required from the local Conservation Commission. Restrictions may then be put on the extent of drawdown and dredging and other elements of the project. The Army Corps of Engineers must also issue a permit under the Clean Water Act, Section 404 which requires a permit before dredged or fill material may be discharged into waters of the United States. Depending on the amount of material dredged, a Section 401 Water Quality Certificate from Mass. DEP may also be required.
**Figure 8: Wetlands Protection Act Permitting Flow Chart**

- **Request for Determination of Applicability (RDA)**
  - Positive
  - Notice of Intent (NOI) required
  - Exceeds thresholds?
    - Yes: Ecological Restoration Limited Project
      - Notice of Intent Form 3 + Appendix A
      - Order of Conditions Form 5
      - Request 3-year Extension Permit Form 7
    - No: Reapply @ 3 years
  - Negative: Determination with conditions

- **Scale of effort**
  - Large
  - Small
MODEL PERMITTING LANGUAGE

REQUEST FOR DETERMINATION OF APPLICABILITY (RDA)

An RDA is made to the Conservation Commission to determine whether the proposed work requires filing a Notice of Intent and issuance of an Order of Conditions, or not. In this case, the question is not whether the work is in a resource area, as by definition it is in “land under water,” but rather whether the proposed work will affect the resource such that it needs a more complete review and Order of Conditions under the Act or a local bylaw/ordinance to ensure protection of resource areas. An applicant can skip the RDA and go directly to filing a NOI if they prefer. The applicant uses WPA Form 1. There are instructions on the same web page. There is no fee or abutter notification under the state Wetlands Protection Act, although local bylaws/ordinances may require one or both. The applicant must pay for a legal notice of the application in a local newspaper that is published at least five days prior to the hearing. The Conservation Commission can advise regarding placing the public newspaper notice. The RDA should include a narrative describing the work to be done and at least a sketch plan showing the areas where removal is proposed, along with any other proposed activity.

DETERMINATION OF APPLICABILITY

The outcome of an RDA filing will either be a positive or a negative Determination of Applicability, using Form 2. A positive Determination means that the applicant must file a Notice of Intent for the proposed work. A negative Determination means that the work does not require permitting, and can be issued with or without conditions. While a Negative Determination with conditions is has fewer procedural requirements, the commission retains the right to require an NOI if the conditions are not followed. Note, however, that no abutter notice and no public hearing is required for an RDA/Determination under the state Wetlands Protection Act. So the public doesn’t get official notice, other than the request being listed on a Conservation Commission’s agenda. Members of the public may feel uninformed if they subsequently observe control activities. A negative Determination expires after three years, after which a new RDA must be submitted. It cannot be extended. See sample RDA in Appendix II.

Possible conditions could be:

1. A preconstruction site visit shall be held to review work and inspect the erosion control barrier.
2. A report shall be submitted after the project has been completed documenting that the work has been conducted in accordance with all conditions of this Determination of Applicability.
3. Invasives shall be disposed of at an appropriate off-site location or covered with a tarp and “cooked.”
4. Hand-pulling of invasives is permitted site-wide in perpetuity.
NOTICE OF INTENT (NOI)

Applicants for Ecological Restoration Limited Projects use WPA Form 3 plus Appendix A for the NOI. Appendix A is an Ecological Restoration Limited Project Checklist that “guides the applicant in determining if their project is eligible to file as an Inland or Coastal Ecological Restoration Limited Project” MACC, 2016, p. 18.7.4). Applicants for Ecological Restoration Projects (not “limited”), such as larger dredging projects, use an Ecological Restoration NOI form, WPA Form 3A, instead.

Before filing an NOI for an Ecological Restoration Limited Project, an applicant must: (1) submit notification to the Environmental Monitor 14 days prior, and (2) if the project will occur within “Priority Habitats of Rare Species” (shown on the most recent Estimated Habitat Map of State-listed Rare Wetlands Wildlife as yellow cross-hatching, http://maps.massgis.state.ma.us/PRI_EST_HAB/viewer.htm), the applicant must receive a written determination from the Natural Heritage and Endangered Species Program (NHESP) that Preliminary Massachusetts Endangered Species Act Review has been met (see 310 CMR 10.11). Similarly, if the project will occur within “Estimated Habitats of Rare Wildlife” (shown on the same map as green cross-hatching), the applicant must receive a written determination from NHESP as to whether or not the project will have long- or short-term adverse impacts.

Figure 9: Sample Priority Habitat Map of State-listed Rare Species
Additionally, if there are time-of-year restrictions in a coastal water body, or the project will affect a diadromous (migratory) fish run, a determination from the Division of Marine Fisheries is required. Work that generates silt, or involves dredging of over 100 cu. yds., also has specific requirements. These requirements are spelled out in the Wetlands regulations at 310 CMR 10.11 and 10.12 and must be met.

Because water chestnut control always requires several years of continuous work, it is advisable for the applicant to seek an Order of Conditions for the maximum duration, 5 years, and that provides for adaptive management. Adaptive management allows adjustment of the control method based on the actual conditions. This approach should include annual monitoring and reporting to the Conservation Commission. The Commission should approve any adjustment of the control approach, e.g., moving from mechanical to hand harvesting when population densities are significantly reduced. An adaptive management approach will be more effective, and save time and money over permitting one single approach without monitoring and adjustment. See sample NOI in Appendix II.

ORDER OF CONDITIONS (OOC)

Orders of Conditions use WPA Form 5; these can be issued for a maximum 5 year duration, and be extended upon request. As noted above, there are many advantages to issuing a 5 year permit which covers all desired methods, with monitoring and switching of method as needed. The schedule for monitoring and reporting to the Conservation Commission should be made clear and be in sync with the seasonal growth patterns of the plant and the work to be performed. See sample OOC for mechanical harvesting in Appendix II.

GENERAL/GENERIC TOWN-WIDE PERMIT REQUIRING CC NOTIFICATION OF SPECIFIC ACTIVITIES

If there are many sites within a municipality where water chestnut control is needed, or can be anticipated, it may be more efficient for the applicant to apply for a town-wide “generic” permit. This is best done when a single NOI applicant will be managing all of the covered waterbodies, such as a municipal department, or is able to delegate or contract the management to others, such as community groups or lake management consultants. This should also take an adaptive management approach, recognizing the different stages and needs of each waterbody in the community, and include monitoring.
REFERENCES


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Mystic River Watershed Association (n.d.) mysticriver.org/water-chestnut


