

**Water Chestnut (*Trapa natans*) in the Chesapeake Bay
Watershed: A Regional Management Plan**



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**Regional *Trapa natans* Working Group
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Executive Summary

Trapa natans, commonly known as water chestnut, is a non-native aquatic macrophyte with a long invasion history in North America. Water chestnut is an annual herb with a floating rosette of leaves around a central stem that is rooted in the sediment. The plant spreads rapidly and seeds can remain dormant for up to 12 years. Due to its dense canopy formation, water chestnut impedes navigation and can have a substantial impact on native species of submerged grasses, as it is capable of blocking all sunlight from reaching the sediment surface. Since its first introduction in the late 1800's, many Chesapeake Bay partner states have been forced to devote extensive financial resources for combating water chestnut, including New York, Pennsylvania, Virginia, Maryland, and the District of Columbia. It has been demonstrated repeatedly that if discovered in the early stages of expansion, aggressive and persistent local control can be effective at reducing populations to near extinction. When allowed to expand unchecked, or if control is intermittent, massive problems develop that create both ecological change and substantial water use restrictions.

Water chestnut was first recorded in North America near Concord, Massachusetts in 1859. Wild populations have since become established in many locations in the Northeastern United States. Within the Chesapeake Bay watershed, water chestnut first appeared in the Potomac River near Washington, D.C. as a two-acre patch in 1923. The plant spread rapidly, covering 40 river miles within a few years. Water chestnut was first recorded in the Bird River in 1955 where it was combated with the herbicide 2,4-D, only to reappear 10 years later. Currently, the most problematic areas include the Bird and Sassafras Rivers in Maryland, the Hudson River, the Connecticut River valley and Lake Champlain. Pennsylvania and the District of Columbia currently have no known populations of the species.

Chemical control and manual and mechanical harvesting techniques have been used to eradicate water chestnut populations. Hand removal is effective on smaller populations as plants are easily spotted for removal. Mechanical harvesting techniques are effective on larger populations and to open up clogged waterways. Much of the management effort has been focused in Maryland on the Bird and Sassafras rivers. The combination of mechanical and hand removal of plants from 1999-2004 has proven to be so successful that there has been no need to use herbicides. It is clear, however, that continued efforts at water chestnut harvesting would be needed for many years before we are able to claim that the water chestnut has been fully eradicated from both Maryland rivers.

In Spring 2001, the Chesapeake Bay Program's Invasive Species Workgroup (ISW) began to address the following two goals of the Chesapeake 2000 Agreement: "By 2001, identify and rank non-native aquatic and terrestrial species which are causing or have the potential to cause significant negative impacts to the Bay's aquatic ecosystem. By 2003, develop and implement management plans for those species deemed problematic to the restoration and integrity of the Bay's ecosystem." In September 2001, the ISW developed and distributed a questionnaire to the Chesapeake Bay Program jurisdictions and federal partners to identify the top six aquatic nuisance species currently adversely affecting or having the potential to adversely affect the Bay ecosystem. The impact of water chestnut was identified as a great enough threat to warrant a regional management plan for the Chesapeake Bay. In May 2002, the Chesapeake Bay Program in partnership with Maryland Sea Grant College sponsored a workshop to develop draft regional management plans for each of the six priority species. In December 2002, the Chesapeake Bay Program appointed the Regional *Trapa natans* Working Group to develop a regional management plan. The Working Group was comprised of Chesapeake Bay Program signatory jurisdictional representatives and federal partners, as well as resource managers, and interested parties.

The goal of this management plan is to reduce the negative impacts of water chestnut, achieve no net gain, and maintain native biodiversity in the Chesapeake Bay watershed. The management plan recommends public outreach programs, monitoring programs, rapid response strategies, and possible eradication methods as well as actions and funding needs to implement each of the recommendations. Implementation tables were developed to include a time line for each action, and to identify lead agencies, partner involvement, funding/cost share, and funding sources.

The final plan will be submitted to the Chesapeake Bay Program's ISW and the Living Resources Subcommittee for comprehensive review. Comments will be collected and incorporated for final submission to the Chesapeake Bay Program's Implementation Committee. Upon approval, the Chesapeake Bay Program signatory jurisdictions will adopt the management plan and implement the recommended actions with the intended goal of slowing or halting spread of water chestnut in the Chesapeake Bay watershed.

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I. Introduction

Trapa natans, commonly known as water chestnut, is an aggressive annual aquatic plant native to Europe. Introduced in the mid 1800s, water chestnut is believed to have spread from ornamental use in ponds. The plant is capable of rapid expansion by natural intra-watershed spread by seeds. Water chestnut grows in nutrient-rich shallow lakes and rivers. It consists of a submerged floating stem that attaches to a buoyant rosette of leaves (<http://www.chesapeakebay.net>). Water chestnut colonization creates a canopy that interrupts the passage of light through water, which is necessary to maintain a well-functioning ecosystem. The species forms colonies that crowd out and alter the habitat of other native species and poses problem in recreational waters (<http://www.chesapeakebay.net>).

Water chestnut infestations occur in isolated areas. Currently populations exist on the Sassafras and Bird rivers of Maryland, and in a number of ponds, including a nontidal pond above Lloyds Creek and in Urieville Lake in Kent County, Maryland. Maryland has been active in efforts to remove the water chestnut since the 1960s. Water chestnuts can be removed by hand and by mechanical harvesting methods. The Maryland Department of Natural Resources has run a harvesting program since 1999, which has focused on the water chestnut populations on the Bird and Sassafras rivers (http://www.dnr.state.md.us/bay/sav/water_chestnut_report.html).

Water chestnut's arrival in the watershed presents a threat to the health of the Chesapeake Bay ecosystem. Water chestnut's ability to displace native flora and spread rapidly led to its identification as a high priority nuisance species in the watershed. As a result, the following management plan was drafted to identify strategies for prevention and control. The introduction briefly outlines the following components: species biology, ecological impacts, economic impacts, population status and distribution, management efforts in the Chesapeake Bay watershed, methods for control, and existing federal and state regulations. The detailed management plan addresses the following sections: Section 1, Leadership, Coordination, and Regulatory Authority; Section 2, Prevention; Section 3, Control and Management; and Section 4, Communication and Information Access. Implementation tables designate the appropriate lead agency to implement each of the specific strategies and indicate funding needs, potential sources of funding and a time line to accomplish each strategy.

A. Biology/Life History

Trapa natans was once thought to belong to the Trapaceae, a monogeneric family that is widely distributed in the Eastern Hemisphere (Cook *et al.*, 1974). However, modern molecular research places *Trapa* species in the Lythraceae in the order Myrtales (The Angiosperm Phylogeny Group, 1998). Because of the morphological variation in *Trapa* species, there has been little agreement about the number of species in the genus. *Trapa* species are determined by fruit morphology and plants with four stout horns on the fruit most often are called *Trapa natans*. The two commonly cultivated species in Asia, *Trapa bicornis* Osbeck and *Trapa bispinosa* Roxburgh, have two horns. An unrelated edible aquatic plant, *Eleocharis dulcis* (Burm.f.) Trin. ex Henschel, a sedge in the Cyperaceae, also is called water chestnut. The corm of *E. dulcis* is the familiar water chestnut, or Chinese water chestnut, sold in cans and commonly served in Chinese restaurants.

Trapa natans is an annual herb with a floating rosette of leaves around a central stem that is rooted in the sediment. The spongy inflated leaf petioles enable the rosette to float. The plant produces new leaves from a central terminal meristem in the rosette near the surface of the water. The inconspicuous flowers are born in the leaf axils of younger leaves above the water. As the meristem elongates and produces new leaves, the older leaves and developing fruit move, in

effect, down the stem and underwater. The single-seeded mature fruit are woody and bear four sharply pointed horns.

Water chestnuts begin to flower in early to mid June, with their nuts ripening approximately a month later. Flowering and seed production continue into the fall until the first frost kills the floating rosettes (<http://www.des.state.nh.us/factsheets/bb/bb-43.htm>). When mature, the fruits fall from the plant and sink to the bottom of the water body. Seed dormancy can be from four months to 12 years. The horns may act as anchors to limit the movement of the seed, keeping them in suitable depths of water. The seeds overwinter at the bottom of the water body and germinate throughout the warm season, producing shoots that grow to the water surface where the typical rosette is formed. After germinating, the hard seed coats can persist in the sediment for several decades.

Native to Europe, Asia and Africa, water chestnut grows best in shallow, nutrient-rich lakes and rivers and is 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. Naturalized populations can be found in various locations of the northeastern United States (http://www.mdsg.umd.edu/exotics/workshop/water_chestnut.html).

B. Biological and Ecological Impacts

Invasive species can have dramatic impacts on native species biodiversity and abundance within an ecosystem. Introduced, invasive species threaten 19% of all endangered and rare species worldwide. New diseases and alien pests and other threats loom on the horizon. For waterways, the full impacts of some alien invasive species are not yet known, but others have shown their wide-ranging impact on native habitats and species (<http://www.dcnr.state.pa.us>).

Due to its dense growth, the species impedes navigation and its low food value for wildlife potentially can have a substantial impact on the use of an area by waterfowl and other native species. Decomposition of the abundant detritus produced in the fall of each year as the plants senesce, could contribute to lower oxygen levels in shallow waters and thus impact other aquatic organisms (<http://www.paflora.org>). Such low oxygen conditions could potentially cause fish kills (www.nps.gov).

With four hard, half-inch spines that are sharp enough to penetrate shoe leather and large enough to keep people off beaches, water chestnut seeds are major impediments to water contact recreation. Additionally, water chestnut threatens native bay grasses by forming a complete canopy with up to three layers of leaves, blocking all sunlight from reaching the sediment surface and preventing the growth of other, desirable aquatic plant species. Water chestnut prevents nearly all water use where it occurs, creates breeding grounds for mosquitoes, and provides only marginal habitat for native fish and invertebrates.

There are many readily available anecdotes highlighting problems from areas with water chestnut (e.g. *"Motorboats and sailing craft could not use thousands of acres [along the Potomac].. formerly available during the summer months. The splendid duck hunting and fishing grounds for thousands of sportsmen were lost because the water chestnut destroyed the native plant life essential for waterfowl and game fish. Sanitary problems arose because of the fact that the thick beds collected and held quantities of organic waste, thus creating water pollution hazards, and swarms of mosquitoes bred prolifically among the plants. The recreational value of all bathing beaches to the mouth of the river was seriously lessened because of the spines of the drifting pods."* Reprinted from the winter, 1945 issue of Maryland Conservationist, Volume 21). For

these reasons, eradication has been attempted every time a population has been discovered in Maryland.

C. Economic Impacts

Aquatic Nuisance Species are more than just a nuisance. They can affect the natural resources of an area in many ways. Once introduced, many exotic species can become extremely difficult to control or eradicate. US Fish and Wildlife Services has estimated the total annual costs of invasive species at over \$100 billion (Southwest Florida ANS, webpage).

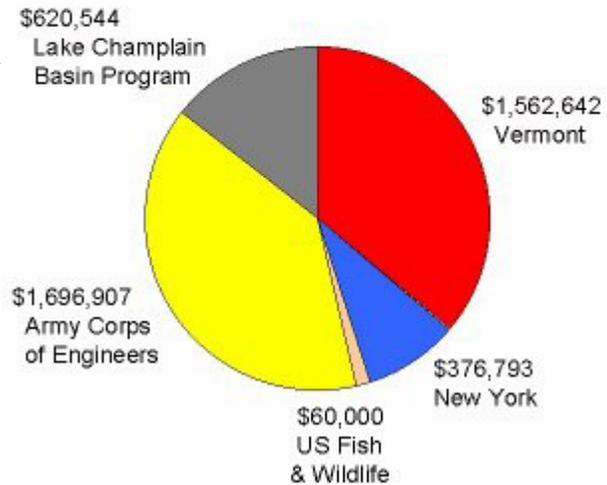
Water chestnut is simple to control compared to many species, but if populations become well established before control is initiated, bring the population back to near extinction is very expensive. The primary economic costs related to water chestnut are associated with the costs of chemical and mechanical control efforts.

Vigorous management efforts by the U.S.

Army Corps of Engineers during the 1950s and 1960s brought water chestnut populations in the United States largely under control, but these control programs were suspended because the programs' success and because of budgetary constraints (<http://www.invasive.org>). In response to the water chestnut expansion in the Potomac River, the U.S. Army Corps of Engineers conducted a massive removal effort from 1939 to 1945 at an estimated cost of \$3.7 million (converted from 1950 to 2004 dollars), with follow-up removal by hand until at least 1965

(<http://www.anr.state.vt.us/dec/waterq/ans/wcpage.htm>). From 1982 to 2001, over \$4,597,351 has been spent controlling water chestnut in both sides of Lake Champlain (<http://www.anr.state.vt.us/dec/waterq/ans/wcpage.htm>).

Funds Spent on Lake Champlain
Water Chestnut Management
1982-2001: \$4,316,886



D. Methods of Introduction

Water chestnut was first recorded in North America near Concord, Massachusetts in 1859. It is believed that ornamental use in ponds is the mechanism for introduction in all cases, followed by rapid, natural intra-watershed spread by seeds. Harvard botanist Asa Gray cultured the organism in his botanical garden in 1877. Its escape to local waters occurred by 1879 (Worobel 1996) and populations were documented in New York by the late 1800s. Further spread occurred through waterways and into Vermont and Massachusetts. Wild populations have since become established in many locations in the Northeastern United States. To help prevent further spread of this plant, the sale of all species of water chestnut are effectively banned from most of the United States, including Maryland.

The dispersal of water chestnut by human hands to the United States and other parts of the world can be attributed to its status as an ornamental plant having medicinal and nutritional value. In many parts of Asia, the fruit is a staple food source and used for livestock feed. The fruit has been

used medicinally to treat elephantitis, pestilent fevers, rheumatism and skin complaints (http://www.mdsg.umd.edu/exotics/workshop/water_chestnut.html).

Within the Chesapeake watershed, water chestnut first appeared in the Potomac River near Washington, D.C. as a two-acre patch in 1923. The plant spread rapidly, covering 40 river miles within a few years. By 1933, 10,000 acres of dense beds extended from Washington, D.C. to just south of Quantico, VA.

Water chestnut was recorded in the Bird River in Baltimore County for the first time in 1955. The Maryland Departments of Game and Inland Fish and Tidewater Fisheries used mechanical removal and an herbicide (2,4-D, the only fully-licensed herbicide that has been successfully used to control water chestnut) to control the population. However, in 1964 it reappeared in the Bird River and an additional 100 acres were discovered in the Sassafras River in Kent County, of which 30 acres were mechanically removed. A combination of removal techniques were used once again in 1965, when 200 acres existed in the Sassafras. This effort was believed to have been successful, and no plants had been noted in vegetation surveys until summer 1997.

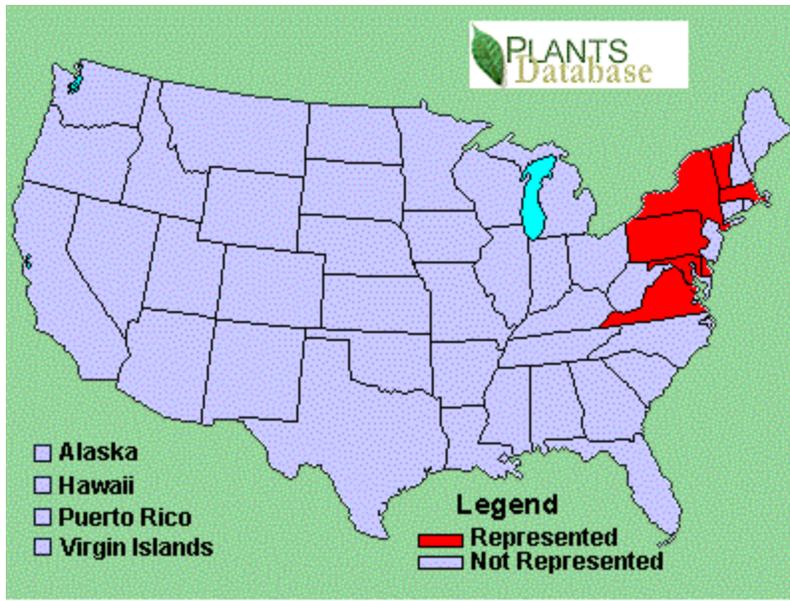
Unfortunately, a water chestnut population was rediscovered on the Bird River in 1997. The plants spread from approximately 50 plants in summer 1997 to over three acres in 1998, and approximately 30 acres in 1999. Upon investigation, it was discovered that the Sassafras River had a population as well, one that was slightly larger than the Bird River. A massive mechanical and volunteer harvesting effort began on both rivers in 1999, and resulted in the removal of approximately 400,000 pounds of plants from the two rivers. As impressive as the 1999 effort was, the fact that water chestnut seeds can remain viable in sediments for up to 12 years, means that follow-up efforts will continue to be necessary.

The most problematic populations currently occur in the Potomac and Hudson rivers and in Connecticut River valley, Lake Champlain region. In 1998, water chestnut was found in the South River in Quebec, which is connected to the Lake Champlain outlet via the Richelieu River. Its spread has continued because of the suitability of habitat; in 2001, for example, water chestnut was discovered in the Pike River, which flows into Mississquoi Bay.

E. Population Status and Distribution

North America

Water chestnut was first recorded in North America near Concord, Massachusetts in 1859. Wild populations have since become established in many locations in the Northeastern United States, including the Hudson River, Lake Champlain and six of its tributaries, the Nashua River in New Hampshire, and most recently the Connecticut River in Connecticut. To help prevent reintroduction and further spread, the sale of all species of water chestnut are effectively banned from most of the United States, including Maryland



Chesapeake Bay Watershed

Maryland

Water chestnut was recorded in the Bird River in Baltimore County for the first time in 1955. Mechanical removal and the herbicide 2,4-D were used to eradicate the population. However, in 1964, the population reappeared in the Bird River with an additional 100 acres found in the Sassafras River. A combination of removal techniques were used again in 1965 and were believed to be successful until a call from a landowner on the Bird River about an unusual plant led to the discovery of a small population of water chestnut in a cove just upriver from Railroad Creek in 1997 (<http://www.dnr.state.md.us>). From the summer of 1997 to the summer of 1999, these plants expanded from 3 acres to approximately 30 acres, and reports were also received of water chestnut growing in Lloyds Creek of the Sassafras River. Since this time, water chestnut has been located and removed from a number of the tributaries to both the Bird and the Sassafras rivers. One additional, apparently confined patch is also located in Urieville reservoir on Maryland's eastern shore.

Pennsylvania

No known populations in Pennsylvania, however, water chestnut infestations have been identified in isolated areas. There are currently no coordinated efforts to remove water chestnut in Pennsylvania at this time (http://www.mdsg.umd.edu/exotics/workshop/water_chestnut.html).

Virginia

Virginia has no known populations in the Chesapeake Bay watershed. However, water chestnut is listed as an occasionally invasive species in coastal areas by the Virginia Department of Conservation and Recreation (<http://www.dcr.state.va.us/dnh/pdflist.htm>).

Washington, D.C.

Washington, D.C. has no known populations in the Chesapeake Bay watershed.

E. Management Efforts in the Chesapeake Bay Watershed

Maryland Department of Natural Resources (DNR) is attempting to eradicate water chestnut from both locations. Removal activities took place in the Bird River, Harford County and the Sassafras River, Kent County from 1999 to 2004, and will continue into the future. The population in the Bird River had spread from approximately 50 plants in the summer of 1997 (based on conversations with local landowners) to over three acres in 1998. By this time, the three acre area was so heavily covered with plants that the water beneath the plants was barely visible.

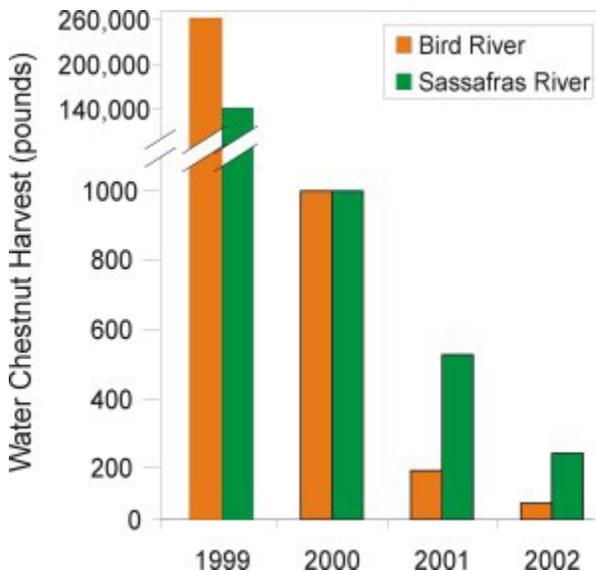


Figure 3. Declines in the amount of water chestnut harvested in the Bird and Sassafras Rivers between 1999 and 2002 demonstrate the success of eradication efforts. Effort was comparable in all years. A mechanical harvester assisted volunteers in removing water chestnuts between 1999 and 2001.

The Sassafras population was believed to be slightly larger, but determining the exact quantity was not possible. Based on conversations with aquatic plant control experts from around the country, it was decided that application of the herbicide 2,4-D would be a safe and effective control technique. Despite this advice, public and state concern over the application of an herbicide to Chesapeake Bay waters lead DNR to reserve herbicide application as a last resort in the event that other techniques didn't work. Instead, in 1999 a hand harvesting was performed in June on both the Bird River and the Sassafras River. Between 50 and 80 volunteers spent each day in canoes harvesting plants by hand or with rakes. Mechanical harvesting with an aquatic plant harvesting boat also took place on the Sassafras on three days in June and one day in June on the Bird, removing an estimated 260,000 lbs. of water chestnut. Upon the discovery of surviving plants in the areas harvested from earlier, a follow-up hand harvesting effort took place on two days in July, at which time the remaining plants were removed.

In June 2000, follow up efforts were necessary to continue the attempted eradication in both rivers. Once again, a combination approach was used, with mechanical harvesting by boat followed by hand removal by volunteers. On two days in June, approximately 30 volunteers

manually removed plants from the Sassafras River. Approximately 40 volunteers manually removed plants from the Bird River on two days. Less than 1000 pounds of plants were discovered and removed from both rivers in 2000, indicating that mechanical and hand removal efforts were successfully reducing the total number of plants.

Over a 5-day period in June, 2001, a mechanical harvester was used in both the Bird and Sassafras Rivers. In the Sassafras River, about two acres of Lloyds Creek and three acres of Shallcross Creek contained scattered plants. In these areas, the harvester cut and collected the majority of plants over the course of two days. Groups of volunteers then combed the river for additional plants on two days in June, removing several more bushels. In the Bird River, the harvester was used for one day, cutting less than 150 lbs. of plants from a small tributary upriver of Railroad Creek. Volunteers finished the job in one day, with only a handful of additional plants being collected.

In 2002, control efforts once again took place on both rivers for hand removal only with approximately 80 volunteers. Not enough plants were present at any of these locations to justify using a mechanical harvester- a significant milestone for the overall eradication effort. The total volume of plants harvested declined once again, with only a few bushels of plants harvested from the Bird River, and about 200 lbs of plants from the Sassafras.

In 2003 and 2004, control efforts were performed on both rivers using personal watercraft. Pairs of DNR personnel surveyed all shoreline areas in the vicinity of the original populations and for several miles along the shoreline both upriver and downriver. In each year, a few hundred plants were found in each river in generally the same areas as the first several years. The combination of mechanical and hand removal of plants from 1999-2004 has proven to be so successful that there has been no need to use herbicides. It is likely, however, that continued efforts at water chestnut harvesting will be needed for several more years before we are able to claim that the water chestnut has been eradicated fully from both rivers.

F. Current Research and Control Efforts

The three methods used to eradicate water chestnut are mechanical harvesting, hand harvesting and chemical control. Currently, little research is currently being performed. Mechanical harvesting and chemical control techniques have not changed much while the majority of research efforts have on biological control techniques.

Biological Control

Biological control possibilities were investigated in the early 1990s. In 1992 and 1993, the U.S. Department of Agriculture conducted surveys that sought natural enemies of water chestnut in Northeast Asia. China, Japan, eastern Russia and South Korea were selected because of previous records of damaging insects on wild population of *Trapa* and published accounts of pest insects of cultivated *Trapa* in the region. Some of these natural enemies on *Trapa* occurred in areas with climates similar to those of the infested areas of North America (<http://www.invasive.org>).

In 1995, the survey was done in Europe. A beetle that consumes up to 40% of water chestnut leaf tissue, *Galerucella birmanica*, was studied as a prime candidate for biological control but was found to have various other plant hosts making it unsuitable for bio-control purposes in the U.S. (http://www.mdsg.umd.edu/exotics/workshop/water_chestnut.html). Other insects that feed on water chestnut were identified but were found to not be damaging to the plant. Two *Nanophyes*

weevils, which feed in the floating leaf petioles, were found in Asia. They are thought to be specific to *Trapa* but were not observed to be damaging. Low-density populations of polyphagous Homoptera were common. Chironomid midges also were frequently associated with the plants, but for the most part were filter feeders, not herbivores. In Europe, a similar insect fauna was found, but no species were very damaging to the plant. One Italian weevil, *Bagous rufimanus* Hoffmann, feeds within the fruit stalk and might be more damaging at higher than observed population levels (<http://www.invasive.org>).

In addition, predators found in India have potential but would not be able to withstand the cooler temperatures of the mid-Atlantic and Northeastern U.S. where water chestnut predominates (http://www.mdsg.umd.edu/exotics/workshop/water_chestnut.html).

Hand Harvesting

Hand removal is an effective means for the eradication of smaller populations as the roots of water chestnut are easily uplifted. It is critical to remove the plants as uplifted plants can float and further spread the seeds downstream. The potential for water chestnut seeds to lay dormant for up to 12 years makes complete eradication very difficult. Nonetheless, hand harvesting and raking have been useful and are a commons means used to promote community involvement.

Mechanical Harvesting

Control of water chestnut has consisted primarily of mechanical harvesting by means of weed harvesters used to clear waterways. Repetitive harvesting over a number of years may be effective in eradicating this aquatic weed in small-enclosed bodies of water.

Chemical Control

Chemical control methods have also been researched but not widely used. Such methods were used more frequently in the 1960s. Now, due to public perception, the use of chemicals as a method of eradication is seen as a last resort. The herbicide 2,4-D has been tested and deemed safe for use by federal and state agencies. Integrating all possible methods for water chestnut removal will be the most effective course for eradication of populations.

For large-scale control of water chestnut, herbicides and mechanical harvesting can both be effective. Aquatic plant harvesting boats are often employed in instances where waterways are blocked. An example of such harvesting can be found in 1999 when 260,000 pounds of water chestnut were removed on the Sassafras River by mechanical methods. However, harvesting boats cannot operate in the extremely shallow waters that water chestnut often inhabits. As a result, hand harvesting often compliments mechanical methods in Maryland on the Bird and Sassafras rivers (http://www.mdsg.umd.edu/exotics/workshop/water_chestnut.html).

G. Federal Laws and Regulations

Water chestnut is not a federally regulated species.

H. State Laws and Regulations

Water chestnut is on the noxious weeds lists of 35 states. For states in which water chestnut is listed as a noxious weed, it is illegal to propagate, sell or transport the weed. Water chestnut regulations vary from state to state across the Chesapeake Bay watershed. For a listing of state regulations and permit requirements, contact one of the following specific state information sources.

Maryland

In Maryland, water chestnut is listed as a noxious weed, and sale is not permitted.

For further details on these regulations and associated penalties pertaining to water chestnut, please contact:

Maryland Department of Natural Resources
580 Taylor Avenue, E-1
Annapolis, MD 21401
Phone: 410-260-8540
<http://www.dnr.state.md.us>

Pennsylvania

Water chestnut is not regulated in the Commonwealth of Pennsylvania. However, water chestnut is listed as a threat to Southeastern Pennsylvania. The Pennsylvania Department of Conservation and Natural Resources recommends that the plant not be introduced as it will escape, spread, and naturalize. The species is not known to be a major concern throughout the rest of the state, as of yet (<http://www.dcnr.state.pa.us/forestry/wildplant/invasive.aspx>).

For further details on these regulations and associated penalties pertaining to water chestnut, please contact:

Pennsylvania Department of Agriculture
Bureau of Plant Industry
2301 North Cameron Street
Harrisburg, PA 17110-9408
<http://www.agriculture.state.pa.us/plantindustry/site/default.asp>

Virginia

Water chestnut is not regulated in the Commonwealth of Virginia but is listed as an occasionally invasive species.

For further details on these regulations and associated penalties pertaining to water chestnut, please contact:

Virginia Department of Conservation and Recreation, Natural Heritage Program
217 Governor Street
Richmond, VA 23219
Phone: 804-786-7951
<http://www.dcr.state.va.us/dnh/>

Washington, DC

Water chestnut is not regulated in the District of Columbia.

For further details on these regulations and associated penalties pertaining to water chestnut, please contact:

National Park Service
1849 C Street NW
Washington, DC 20240
Phone: 202-208-6843
<http://www.nps.gov/>

II. Management Plan

Goal: Eradicate *T. natans* in the Chesapeake Bay Watershed.

A. Leadership, Coordination, & Regulatory Authority

Needs: A coordinated regional or watershed-wide effort to limit the spread and establishment of new populations of water chestnut in the Chesapeake Bay Watershed.

Objective 1: Create a Regional Coordinating Group to promote effective coordination across jurisdictions.

Actions:

- 1.1 Establish a Regional Coordinating Group (RCG) with representatives from state invasive species councils and natural resource agencies
- 1.2. Engage in periodic meetings to discuss new technology and control methodology that could be utilized across the jurisdictions.
- 1.3. Interact with Regional Communications Coordinator (see D2) to facilitate regional communication.

B. Prevention

Needs: Enhance the regional monitoring network to provide for early detection of new infestations and to minimize the risk of spread through pioneer plant populations.

Objective 1: Educate the public and natural resource managers on preventing future introductions.

Actions:

- 1.1. Design and implement outreach activities to educate target audiences on preventing the further spread of water chestnut.

Examples: For hikers, distribute posters and ID cards at state and national parks, make available water chestnut ID cards local outdoor outfitters. For nurseries, garden centers, and roadside markets, distribute a brochure of native alternatives and provide educational seminars on invasive plants.

Objective 2: Expand capacity and coordination of water chestnut monitoring programs.

Actions:

- 2.1 Review water chestnut monitoring needs in the Chesapeake Bay watershed. This Action will require each state to:
 - Review the status of water chestnut monitoring plans in their state;
 - Identify gaps in existing state monitoring networks (i.e. unknown populations or high sensitivity areas that may be a management priority);
 - Identify priority sites to monitor for the presence of pioneer plants that could lead to new infestations.

- Evaluate and communicate existing sampling protocols.

2.2 Improve monitoring efforts based on identified needs by:

- Expanding the number of monitoring stations throughout the Bay by enlisting the aid of state natural resource agency monitoring programs, volunteer programs, or other organizations (i.e. nurseries and garden clubs).
- Establishing target goals, such as monitoring X% of priority sites by 200X;

2.3 Establish email and web-based reporting on CBP's water chestnut web page and encourage monitoring and reporting by organizations such as sportsmen's associations and garden clubs.

- Create standardized, web-based data reporting form to track long-term trends.
- Provide for regional coordination of state monitoring programs through the Chesapeake Bay Program website and GIS maps (see C2).

2.4 Coordinate long-term monitoring and periodically assess efficacy of control efforts by documenting successes and lessons learned.

Objective 3: Encourage local government and municipalities to take a proactive role in water chestnut prevention.

3.2 Develop information items and tools for local government implementation. This would involve:

- Assessing management or regulatory tools available to local municipalities,
- Developing a Best Management Practices (BMP) manual to distribute to garden clubs, parks, natural resource personnel etc.

C. Control & Management

Needs: Provide up-to-date information to natural resource managers, the public, agricultural community and recreationalists on the threat potential and approved treatment methods for water chestnut. Determine and implement appropriate eradication measures at priority sites.

Objective 1. Clarify the various threats water chestnut poses to the environment.

Actions:

1.1 Conduct a Risk Assessment to determine the vulnerability and potential biological and economical impacts of water chestnut invasions. This Risk Assessment should be based on:

- Conducting an assessment to determine the suitability of Chesapeake Bay Watershed to the further spread of water chestnut;
- Conducting a comprehensive literature review to determine the potential biological and ecological impacts to Chesapeake Bay Watershed and surrounding non-infested areas;

- Conducting an assessment to determine the potential economic impacts to Chesapeake Bay Watershed and surrounding non-infested areas.

Objective 2. Develop state specific Regional Maps of Infestations in order to delineate priority areas in need of management action.

Actions:

2.1. Create state specific GIS maps by:

- Conducting an extensive review of the infestation location, site conditions, type of water body, aerial coverage, abundance, and density;
- Identifying a central contact person who compiles confirmed reports of water chestnut sightings for each state and produces, archives, and updates regional maps (see D2); and
- Providing the update maps to the Chesapeake Bay Program for inclusion on the website (see D3).

Objective 3. Review Eradication and Control measures that are currently available and determine which measures could be implemented in the Chesapeake Bay Watershed.

Actions:

3.1. Determine the feasibility of various eradication and control measures by:

- Conducting an extensive review of biological, chemical, and mechanical eradication and control methods evaluated in laboratory and/or field (Literature and professionals);
- Consulting with state and federal agencies (including EPA) for obtaining status compliance, and potential eradication and control measures;
- Reviewing relevant current and pending legislation and local regulations that contain provisions for access to affected properties for surveys, containment, control, and eradication.

Objective 4. Develop site-specific Integrated Pest Management (IPM) Guidelines for control.

2.2. Develop site-specific Integrated Pest Management (IPM) Guidelines for control by:

- Establishing a multi-state panel (i.e. Regional Coordinating Group see A1);
- Creating protocol to prioritize sites that pose the greatest threat;
- Implementing most practical control method for priority site (i.e. herbicide, biological, mechanical removal);

- Maintaining a database of maps, actions, and findings to compare effectiveness of actions for specific habitats; and
- Conducting follow up surveys to monitor change in acreage of infestation.

Objective 5. Implement eradication and control measures at priority sites identified by state.

Actions:

- 5.1 Develop a work plan that tailors eradication and control measures for the targeted infestation.
- 5.2 Implement a work plan.
 - Determine and implement the most appropriate eradication or control method;
 - Conduct follow up surveys to determine if eradication or control measures have been effective.

Objective 6. Evaluate the potential for obtaining a regional permit for application of 2,4-D, an herbicide for controlling aquatic weeds in water.

Actions:

- 6.1 Investigate procedure for regional permit approval and applicator training.
- 6.2 If feasible, apply for regional permit.
- 6.3 Investigate willingness of state and local authorities to perform applications.

D. Communication & Information Access

Needs: Interstate communication and public and school outreach programs could be greatly enhanced through a coordinated suite of web-based and printed materials. A central contact needs to be established to report new water chestnut sightings for each state and update range maps for the Chesapeake Bay watershed.

Objective 1. Develop and implement a public knowledge and attitude survey.

Actions:

- 1.1. To develop outreach programs, first it is necessary to have a clear understanding of public knowledge and attitudes about water chestnut and other invasive species. The survey should cover several major invasive species and act as a springboard for local outreach strategies.

Objective 2. Hire a Regional Coordinator to work on developing, implementing, and overseeing communication and outreach programs and activities.

- 2.1. Employ a part-time Regional Coordinator to act as a point of contact within the region. Responsibilities will be decided by the Regional Coordination Group and may include coordinating with the Regional Coordination Group (see A1), producing and updating state specific GIS maps, collaborating with CBP to develop a water chestnut web page (see D3), creating water chestnut ID posters and card, and developing and maintaining a water chestnut informational clearinghouse.

Objective 3. Create website on Aquatic Nuisance Species in the Chesapeake Bay.

Actions:

- 3.1. It is recommended that the Chesapeake Bay Program as part of their existing website framework host a dedicated aquatic nuisance species website. Wherever the website is housed, the host site should have the capability to quickly update information. The species that are included in the website should be those identified as high-risk. Lower-risk species could be added as time and resources allow. Using the water chestnut as an example, the website should include at a minimum:

- General introduction to water chestnut and its impacts;
- Fact sheet (PDF) that is updated when appropriate;
- Map of water chestnut infestations in Chesapeake Bay watershed, updated as necessary. It is recommended that each Bay state establish a contact person who reports GPS-referenced data on the sites and dates of confirmed water chestnut sightings, introductions, and established populations;
- Links to each Chesapeake Bay state's regulatory information on water chestnut;
- Links to additional sources of current, scientifically accurate information, i.e. USGS Non-Indigenous Aquatic Species maps, the ANS Task Force website, Sea Grant Non-indigenous Species website (SGNIS), etc.
- Guidelines on how individuals should report a water chestnut sighting:
 - o photographs and drawings of water chestnut and native vegetation to help with accurate identification;
 - o descriptive content on physical characteristics and range of water chestnut vs. native vegetation;
 - o contact information for each state for reporting new purple loosestrife infestations.
- Links to contacts for water chestnut volunteer monitoring programs;
- Audience-specific sections:
 - o press page with media releases and contact information for each state;
 - o educators page with links and listings of resources and curriculum materials;
 - o resource managers' page with content and links on risk factors, monitoring strategies, control options, fact sheets, regional contacts, etc.

Objective 4. Produce and distribute new posters and identification (ID) cards.

Actions:

- 4.1. Prepare a single poster displaying images and information about Chesapeake Bay aquatic invasive species, including water chestnut. One poster design will help create a consistent message and image, as well as lower costs to agencies. Posters should be distributed to nurseries and landscaping businesses, home and garden center, roadside markets, nursery and landscape associations, etc. Contact information on the poster can be made specific to each jurisdiction.
- 4.2. Develop ID cards displaying images and information about Chesapeake Bay aquatic invasive species, including water chestnut. Like the poster, the basic information on the ID card can be identical for all Bay jurisdictions, but contact information on the back of the card should be specific to each state.

Objective 5. Identify and disseminate existing science education programs to educators and the public.

Actions:

- 5.1. Distribute water chestnut materials to classroom teachers, as well as to educators in science museums, horticultural clubs, natural and environmental groups, summer enrichment for inclusion in environmental curricula, or for incorporation into educational programs offered by Virginia Marine Science museum, or Wallops Island Marine Science Consortium, Chesapeake Bay Program, 4H Centers, etc. Information could be produced in hard copy and posted on the CBP's water chestnut website.
- 5.2. Compile a list of educational materials and post it on the CBP's water chestnut website (create links to and from the Chesapeake Bay Program's Chesapeake Science on the Internet for Educators "ChesSIE" website).
- 5.3. Provide educational seminars to private and public landowners to help them learn how to control water chestnut on their property.
- 5.4. Collaborate with state landscaping and nursery associations to create a list of native alternatives for planting and propagation.
- 5.5. Develop and distribute IPM materials (see C2) and make the publications available to citizen groups, gardeners, nurseries, and other organizations. For example, see Penn State's IPM website at www.cas.psu.edu/docs/CASDEPT/IPM/

III. Implementation Table

An implementation table is provided for each of the four management components. For each action identified under the components, we have identified a time frame for completing the actions, identification of agencies responsible for leading actions, the partners that should be involved, the funding/cost share, and the source of funding.

A. LEADERSHIP, COORDINATION, & REGULATORY AUTHORITY

<u>Objective/Action</u>	<u>Tasks</u>	<u>Task Description</u>	<u>Task Duration</u>	<u>Cost</u>	<u>Funding Source</u>	<u>Lead Agency</u>	<u>Partners</u>
Objective 1. Develop a Regional Coordination Group							
1.1) Establish Regional Coordination Group	1.1.a	Identify potential state candidates for Group membership and participants to represent each CBP jurisdiction	1 week	\$0		EPA's Chesapeake Bay Program Office	State agencies (PDA, VA DCR, MD DNR)
	1.1.b	Contact and confirm Group membership and commitment	1 month	\$0		Same as 1.1.a	Stakeholders, Assistant Secretaries of natural resource agencies
	1.1.c	Convene an Organizational Meeting for the Group to define and review its mission statement	3 months	\$1000		Same as 1.1.a	VA DCR, MD DNR, PDA, NPS, academia, scientific experts, Sea Grant programs, interested non-governmental agencies (NGOs), Nature Conservancy, MA-EPPC

B. PREVENTION

<u>Objective/Action</u>	<u>Tasks</u>	<u>Task Description</u>	<u>Task Duration</u>	<u>Cost</u>	<u>Funding Source</u>	<u>Lead Agency</u>	<u>Partners</u>
Objective 1. Educate the public and natural resource managers							
1.1) Design and implement outreach to prevent the further spread of water chestnut	1.1.a	Target outdoor enthusiasts by distributing posters and ID cards to parks and outdoor outfitter	1 year	\$5,000		EPA's Chesapeake Bay Program Office	State agencies (PDA, VA DRC, MD DNR), Sea Grant, NPS, Nature Conservancy
	1.1.b	Target nurseries, garden centers, and roadside markets by distributing a brochure of native alternatives and provide educational seminars on invasive plants	Ongoing	\$5,000		Same as 1.1a	State agencies (PDA, VA DRC, MD DNR), Sea Grant, NPS, Nature Conservancy, MA-EPPC, PLNA
Objective 2. Expand capacity and coordination of water chestnut monitoring programs							
2.1) Review water chestnut monitoring needs in the Watershed	2.1.a	Review the status of water chestnut monitoring in each state	6 year	\$2,000		EPA's Chesapeake Bay Program Office	State agencies (PDA, VA DCR, MD DNR), NPS, Nature Conservancy, state game conservancies

	2.1.b	Identify gaps in existing state monitoring networks	6 months	\$0 (included in 2.1.a)		Same as 2.1a	Same as 2.1.a
	2.1.c	Identify priority sites to monitor for pioneer plants that could lead to new infestations	1 year	\$0 (included in 2.1.a)		Same as 2.1a	Same as 2.1.a
	2.1.d	Evaluate and communicate existing sampling of protocols	3 months	\$1,000		Same as 2.1a	Same as 2.1.a
2.2) Improve monitoring efforts based on identified needs	2.2.a	Expand the number of monitoring stations throughout the region based on Action 2.1 findings	Ongoing	\$20,000 +		Same as 2.1a	State natural resource agency monitoring programs, volunteer programs, or other organizations (e.g. garden clubs, sportsmen's associations, nurseries)
	2.2.b	Establish target goals, such as monitoring X% of priority sites by 200X	3 months	0\$ (included in 2.2.a)		Same as 2.1.a	Same as 2.2.a
2.3) Establish email and web-based reporting	2.3.a	Create standardized, web-based reporting on CBP's water chestnut web page	6 months	\$2,000		EPA's Chesapeake Bay Program Office	
	2.3.b	Provide for regional coordination of state monitoring programs through the Chesapeake Bay Program website and	Ongoing	\$6,270		Same as 2.3.a	

		GIS maps (see sections E1. and E4.)					
2.4) Coordinate long-term monitoring and periodically assess efficacy of control efforts	2.4.a	Document and consolidate control success and failures in a 3 year report	Ongoing			EPA's Chesapeake Bay Program Office	State agencies (PDA, VA DCR, MD DNR), NPS
Objective 4. Encourage local governments and municipalities to take a proactive role in water chestnut prevention							
3.1) Develop information items and tools for local government implementation	3.1.a	Assessing management or regulatory tools available to local municipalities				EPA's Chesapeake Bay Program Office	State agencies (PDA, VA DCR, MD DNR), NPS
	3.1.b	Developing a Best Management Practices (BMP) manual to distribute to garden clubs, nurseries, and parks, natural resource personnel, etc.				Same as 3.1.a	Same as 3.1.a

C. CONTROL & MANAGEMENT

<u>Objective/Action</u>	<u>Tasks</u>	<u>Task Description</u>	<u>Task Duration</u>	<u>Cost</u>	<u>Funding Source</u>	<u>Lead Agency</u>	<u>Partners</u>
Objective 1. Clarify the various threats water chestnut poses to the watershed							

1.1) Conduct a Risk Assessment to determine the vulnerability and potential biological and economical impacts of water chestnut	1.1.a	Conduct assessment to determine the suitability of Chesapeake Bay watershed to further spread of water chestnut	1 year	\$15,000		EPA's Chesapeake Bay Program Office	State agencies (PDA, VA DCR, MD DNR)
	1.1.b	Conduct a comprehensive literature review to determine the potential biological and ecological impacts to the Chesapeake Bay watershed	1 year	\$0 (Included in 1.1.a)		Same as 1.1.a	Same as 1.1.a
	1.1.c	Conduct an assessment to determine the potential economic impacts to the Chesapeake Bay watershed	1 year	\$0 (Included in 1.1.a)		Same as 1.1.a	Same as 1.1.a
Objective 2. Develop state specific Regional Maps of Infestation							
2.1) Create State specific regional maps of infestation to determine priority areas	2.1.a	Conduct an extensive review of the infestation location, site conditions, type of water body, aerial coverage, abundance, and density.	1 year	\$2,000		MD DNR	State agencies (PDA, VA DCR, MD DNR), CBPO
	2.1.b	Identify a central contact person who compiles confirmed reports of water chestnut sightings for each state and produces, archives, and updates regional maps annually	3 months	\$10,000		MD DNR	

	2.1.c	Provide the update maps to CBP for inclusion on the website	Ongoing	\$0		Same as 2.1.b	
Objective 3. Review Eradication and Control measures that are currently available and determine which measures could be implemented in the Chesapeake Bay Watershed							
3.1) Determine the feasibility of various eradication and control measures	3.1.a	Conduct extensive literature review of biological, chemical and mechanical eradication and control methods evaluated in laboratory and/or field; contact all relevant professionals to determine eradication/control strategies	6 months/ ongoing			VA DRC, MD DNR, PDA, NPS	Same as 1.1.a, CBP
	3.1.b	Consult with state and federal agencies (including EPA) for obtaining status, compliance, and permits applicable to potential eradication and control measures	6 months			EPA's Chesapeake Bay Program Office	Same as 1.1.a
	3.1.c	Review relevant current and pending legislation and local regulations that contain provisions for access to affected properties for surveys, containment, control, and eradication	Ongoing			EPA's Chesapeake Bay Program Office	Same as 1.1.a
Objective 4. Develop Integrated Pest Management (IPM) Guidelines							
2.2) Develop site-specific Integrated	2.2.a	Establish a multi-state panel (i.e. Regional	See Action	See Action		See Action A1.1	See Action A1.1

Pest Management Guidelines		Coordinating Group see Action1)	A1.1	A1.1			
	2.2.b	Create protocol to prioritize sites that pose the greatest threat	1 year			MD DNR	CBPO, State agencies (PDA, VA DCR), USFWS
	2.2.c	Implement most practical control method for priority site	Ongoing	Range		Same as 2.2.b	Same as 2.2.b
	2.2.d	Maintain a database of maps, actions, and findings to compare effectiveness of actions for specific habitats	Ongoing			MD DNR	CBPO, State agencies (PDA, VA DCR)
	2.2.e	Follow up with surveys to monitor changes in acreage of infestation	Ongoing			MD DNR	Same as 2.2.d
2.2) Develop site-specific Integrated Pest Management Guidelines	2.2.a	Establish a multi-state panel (i.e. Regional Coordinating Group see Action1)	See Action A1.1	See Action A1.1		See Action A1.1	See Action A1.1
Objective 5. Implement appropriate eradication and control measures							
4.1) Develop a work plan as appropriate	4.1.a	Assess the site invaded by water chestnut and determine whether eradication or control is the best option	1 month			State agencies (PDA, VA DRC, MD DNR)	NPS, CBP
	4.1.b	Develop a work plan to determine the needed information to implement an eradication or control protocol	2 months			Same as 3.1.a	NPS, CBP
4.2) Implement work plan	4.2.a	Carry out work plan, and determine and implement the most appropriate	9 months			Same as 3.1.a	NPS, CBP

		eradication or control methods					
	4.2b	Conduct follow up surveys to determine if eradication or control measures have been effective	Ongoing			Same as 3.1.a	NPS, CBP
Objective 6. Evaluate potential use of Garlon							
6.1) Obtain approval for use.		Investigate procedure for permit approval and applicator training.	3 months				
6.2) Obtain regional permit.		Apply for a regional permit, if feasible.	1 year				

D. COMMUNICATIONS & INFORMATION ACCESS

<u>Objective/Action</u>	<u>Tasks</u>	<u>Task Description</u>	<u>Task Duration</u>	<u>Cost</u>	<u>Funding Source</u>	<u>Lead Agency</u>	<u>Partners</u>
Objective 1. Develop and implement a public knowledge and attitude survey.							
1.1) Develop and implement public survey	1.1.a	Create survey to address public knowledge concerning several invasive species	1 year	\$2,000		EPA's Chesapeake Bay Program Office	State agencies (PDA, VA DCR, MD DNR), NPS
Objective 2. Hire a Regional Coordinator to work on developing, implementing, and overseeing communication and outreach programs and activities.							
2.1) Employ a part-time Regional Coordinator to act as a point of contact	2.1.a	Decided upon Regional Coordinator's responsibilities with the Regional Coordinating Group	3 months	\$0		EPA's Chesapeake Bay Program Office	State agencies (PDA, VA DCR, MD DNR), NPS

	2.1.b	Hire or appoint a Regional Coordinator	3 months	\$25,000		Same as 2.1.a	Same as 2.1.a
Objective 3. Create website on Aquatic Nuisance Species in the Chesapeake Bay.							
3.1) Enhance Chesapeake Bay Program Website on Invasive Species by developing water chestnut pages	3.1.a	Develop general fact sheet	1 year	\$2000		MD DNR	PDA, VA DGIF, CBPO, Sea Grant, NOAA Chesapeake Bay Office
	3.1.b	Create watershed map water chestnut infestations; update as needed	Ongoing	\$2000		Same as 3.1.a	State agencies (PDA, VA DCR, MD DNR)
	3.1.c	Provide links to state regulatory information	6 months	\$3400		Same as 3.1.a	Same as 3.1.b
	3.1.d	Provide links to scientifically accurate resources	6 months	\$3400		Same as 3.1.a	Cornell University, Sea Grant, NPS, Nature Conservancy
	3.1.e	Provide guidelines on reporting new water chestnut sightings	1 month	\$3400		Same as 3.1.a	Same as 3.1.b
	3.1.f	Develop audience-specific sections, i.e. press page, educators page, natural resource managers page	1 year	\$3400		Same as 3.1.a	State agencies (PDA, VA DCR, MD DNR), Regional press media
Objective 4. Produce and distribute educational materials							
4.1) Produce posters	4.1.a	Prepare poster displaying images and information about Chesapeake Bay aquatic invasive species, including water chestnut	1 year	\$10,000		EPA's Chesapeake Bay Program	State agencies (PDA, VA DCR, MD DNR), USFWS, Sea Grant, NPS
	4.1.b	Distribute posters to nurseries, landscaping	Ongoing	\$0			State agencies (PDA, VA DCR, MD DNR),

		business, home and garden center, etc.					Sea Grant, NPS
4.2) Produce new identification cards	4.2	Develop a water chestnut ID cards with contact information tailored to individual states (160,000 copies)	3 months	\$10,000		NPS	State agencies (PDA, VA DCR, MD DNR), USFWS, CBP
Objective 5. Identify and disseminate existing science education programs							
5.1) Identify and Disseminate existing education programs	5.1.a	Distribute educational materials to classroom teachers, botanical educators, educational programs at museums or nature centers or horticultural clubs	Ongoing	\$8,000		Sea Grant	Mid-Atlantic Sea Grant Programs, VA Marine Science Museum, Wallops Island Marine Science Consortium, Chesapeake Bay Program, 4H Centers, DE Teacher's Estuary Institute; Centers for Watershed Protection, NERRS, NWRs
5.2) Post a list of recommended educational materials on website	5.2.a	Compile list of educational materials and post on CBP water chestnut website	1 month	\$3400		EPA's Chesapeake Bay Program Office	Mid-Atlantic Sea Grant Programs
5.3) Provide educational seminars	5.3.a	Give seminars to private and public landowners to help them learn how to control water chestnut on their property	Ongoing	\$10,000		Sea Grant	State agencies (PDA, VA DCR, MD DNR), USFWS, CBP, NPS
5.4) Collaborate with state	5.4.a	Produce a list of native alternatives for planting	1 year			EPA's Chesapeake	State agencies (PDA, VA DCR, MD DNR),

landscaping and nursery associations		and propagation				Bay Program Office	USFWS, CBP, NPS, PLNA, MA-ECCP, NY Invasive Species Council
5.5) Create IMPs (see C2)	5.5.a	Make available to citizen groups, gardeners, nurseries, etc, by placing web links on CBP's water chestnut web page	3 months			EPA's Chesapeake Bay Program Office	State agencies (PDA, VA DCR, MD DNR)

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Invasive Species in the Chesapeake Bay - Water chestnut:
http://www.mdsg.umd.edu/exotics/workshop/water_chestnut.html

Invasive and Exotic Species in North America:
<http://www.invasive.org>

Maryland Department of Natural Resources
<http://www.dnr.state.md.us>

Michigan State University, Michigan Sea Grant - Purple Pages:
<http://www.miseagrant.org/pp/>

Minnesota DNR - Water chestnut Management Program:
http://www.dnr.state.mn.us/ecological_services/exotics/plprog.html

Pennsylvania Department of Conservation and Recreation
<http://www.dcnr.state.pa.us/forestry/wildplant/invasive.aspx>

Pennsylvania Flora Project
<http://www.paflora.org>

Southwest Florida Aquatic Nuisance Species, Surveillance and Education Network
<http://www.swfwc.org/ANS/Impacts.htm>

Virginia Department of Conservation and Recreation, Natural Heritage Program:
<http://www.dcr.state.va.us/dnh/invlist.htm>

Virginia Native Plant Society:

<http://www.vnps.org>

Virginia Nursery and Landscape Association:

<http://www.vnla.org/default.htm>

Washington State Department of Ecology – Non-native Plants:

<http://www.ecy.wa.gov/programs/wq/plants/weeds/aqua009.html>

Wisconsin DNR - Water chestnut Fact Sheet:

<http://www.dnr.state.wi.us/org/land/er/invasive/factsheets/loose.htm>