Columbia River

Integrated Aquatic Vegetation Management Plan for the City of Richland, Washington

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EXECUTIVE SUMMARY

The purpose of the Columbia River: Integrated Aquatic Vegetation Management Plan for the City of Richland, Washington is to define a strategy and plan for the control of Eurasian watermilfoil in the City of Richland Parks. Once the plan is accepted by the Washington State Department of Ecology then the City is allowed to apply for further state funds to implement control.

The plan is organized around the following topics: a problem statement, management goals, community involvement, watershed and water body characteristics, aquatic plant control alternatives, an integrated treatment plan, cost estimation, implementation and evaluation, and funding sources. An appendix with publications on the plan is included.

The problem statement recognizes the many uses of the river by the public in the City of Richland Parks on the Columbia River and that these uses are being degraded by the increasing presence of the invasive alien aquatic plant, Eurasian watermilfoil (*Myriophyllum spicatum*).

The overarching management goal is to control noxious aquatic weeds in the Columbia River in City of Richland's Parks. This is to be done in a manner that allows sustainable native plant and animal communities to thrive, maintains acceptable water quality conditions, and facilitates recreational enjoyment of the river.

Control history has been short with efforts to control Eurasian watermilfoil starting in 2004 in the City of Richland. The City has used a harvesting boat to clear paths through Eurasian watermilfoil and other nuisance aquatic plant species in four parks. The growing presence of Eurasian watermilfoil has engendered the community to become involved in its control. This is recent and nascent. The Richland Yacht Club is particularly concerned because aquatic vegetation has significantly reduced the functional characteristics of their moorage. Three public meetings were held. A steering committee was formed to advise on the development of the plan. Outreach and education include placing information on the City of Richland webpage, publication of three articles in the Tri-City Herald, and presentations to the local media. Signs have been made to educate the public at boat launches.

The watershed of the Columbia River is defined to place the problems of the City of Richland Columbia River Parks into context. Water body characteristics are reviewed with attention to the possible relationships among Eurasian watermilfoil, nutrients, and siltation. Fish and wildlife of the Columbia River and environs is defined with recognition of the federally endangered and threatened fish species that may be affected by practices in the City of Richland Parks. Federally recognized plant species of concern, *Rorippa columbiae* is reviewed along with identification of state sensitive plant species in and near the Columbia. The beneficial and recreational uses of the Columbia River in the City Parks is defined and are associated with swimming, fishing, boating, bird watching, wildlife viewing, and hiking.

Nine locations in five parks were assessed for aquatic species plant cover in 2006 and 2007. In 2007 Eurasian watermilfoil cover was the highest (27.5%) in vegetated areas at the Howard

Amon North boat launch and at the Columbia Point boat launch. Eurasian watermilfoil cover was less than 5% at three sites and was not present at two sites. The total area of aquatic vegetation in all the parks was 3.54 acres. Of this area, 0.34 acres is composed of Eurasian watermilfoil. The two noxious weeds of the parks are Eurasian watermilfoil (Class B Designate noxious weed) and Curly pondweed (*Potamogeton crispus*), a Class C noxious weed. Eurasian watermilfoil control is required by state law. The Benton County Noxious Weed Control Board offers educational and technical support for curly pondweed management.

Herbicide, physical, and biological aquatic plant control alternatives were considered. Comparison of the control alternatives on the basis of the size of the infestation, regulatory difficulty, cost, and effectiveness resulted in the choice of a combination of hand pulling and bottom barriers as the suggested control strategy for the City of Richland Parks.

The integrated treatment plan consists of monitoring to determine infestation size before estimating the control effort, applying for permits, applying treatments (hand pulling at all sites and in addition potentially using bottom barriers at the Leslie Groves and Howard Amon public boat launches), and repeated monitoring. The long-term control strategy is to monitor all sites each year in the summer and using hand pulling to keep Eurasian watermilfoil populations out of the City of Richland Parks.

An effort to reduce populations in the first two years of treatment using hand pulling and bottom barriers should have a budget of about $11,000 in the first year with less in the second. The long-term strategy for monitoring and controlling Eurasian watermilfoil by hand pulling in the portions of the City of Richland Parks assessed in this study should have a continuing budget allocation of at least $5,600/year that increases with inflation. The true cost of control will be better estimated after initial control has been implemented.

Future research considerations that potentially could reduce Eurasian watermilfoil populations, thus reducing control costs, include biocontrol using weevils and ecological restoration planting native plant species to take the place of removed Eurasian watermilfoil plants.

Funding opportunities were reviewed. The primary opportunities are with the Washington State Department of Ecology Aquatic Weed Program. A number of other opportunities were identified from the Boise State University Environmental Finance Center Network webpage (http://efc.boisestate.edu/watershed/). Lastly, it is suggested that local funds can be raised by assessing fees at boat launches.

PROBLEM STATEMENT

The City of Richland's aquatic parks are located along the Columbia River (Fig. 1).

Figure 1. Five parks and boat launch areas along the Columbia River in Richland Washington.

The parks are heavily used by boaters, swimmers, people who fish, and the general public. The parks and the adjacent Columbia River are valuable wildlife habitat. The river is very important habitat for salmon, birds, and other wildlife. The water features of the parks are used by the residents of the Tri-Cities region and beyond.

Due to increasing growth of invasive aquatic noxious weeds, the City of Richland Parks are in danger of losing their aesthetic beauty, wildlife habitat, and recreational attributes. If left untreated, the worst of these weeds, Eurasian watermilfoil (*Myriophyllum spicatum*), will eventually blanket boat launch, fishing, and swimming areas preventing most recreational uses and eliminating badly needed wildlife habitat. There will be long-term financial and recreational losses and the loss of fish and wildlife areas in these parks affecting those who use the Columbia River. Increasing development in the area is likely to increase the number of people using the Columbia River in the City of Richland Parks in coming years accelerating the magnitude of the loss of beneficial uses to the community.

The shoreline provides excellent habitat for aquatic plants especially in the boat launch areas. In the past number of years aggressive, non-native Eurasian watermilfoil has invaded the river and is colonizing much of the near-shore aquatic habitat. The dense submersed growth of Eurasian watermilfoil has begun to cause a significant deterioration in the quality of the river and its value to the community. Boat launch areas have dense patches of Eurasian watermilfoil, which can spread to other waters by fragments on boat trailers.

Eurasian watermilfoil is the most significant submersed invasive threat but another noxious weed is also found in the river in the City of Richland's Parks. The other noxious weed is curly pondweed (*Potamogeton crispus*). These two species are noxious weeds as listed in WAC 16-750. Some of the native aquatic plants in the system can be a management issue especially when they grow in dense colonies. The native plants do provide important benefits to the aquatic system when not impeding recreational uses of the river. Removing the noxious invaders will halt the degradation of the system and allow the dynamic natural equilibrium to be maintained.

Unfortunately, dense aquatic plant growth poses a threat to swimmers especially that of Eurasian watermilfoil. This risk was realized on August 25, 2007 when a young man drown after being caught in Eurasian watermilfoil near a boat launch in Kennewick at the east end of Columbia Park. The drowning occurred in 10 to 12 feet of water about 25 feet from shore.

Eurasian watermilfoil:

- Poses a safety hazard to swimmers and boaters by entanglement,
- Snags fishing lines and hooks, eventually preventing shoreline and dock fishing,
- Crowds out native plants, creating monocultures lacking in biodiversity, and
- Significantly reduces fish and wildlife habitat, thereby weakening the local ecosystem as well as degrading wildlife and wildlife viewing opportunities

The community has recognized increasing Eurasian watermilfoil in the City of Richland's Parks along the Columbia River and desires more effective control of this noxious weed. The City and others have not been able to meet the current challenge of controlling or managing the Eurasian watermilfoil infestation. Significant action is necessary to control Eurasian watermilfoil and other invasive weeds.

The problems with aquatic plants in Richland parks (Fig. 1) are manifold and depend on particular uses of the river. For instance, divers will find extensive and dense aquatic vegetation dangerous especially if they need to work near the bottom. This is a public health issue for dive and rescue teams.

Infestations of noxious aquatic plants and native species can reduce the value of parks for the public with negative economic consequences. Dense aquatic vegetation will make it difficult to enjoy the parks by making it difficult and dangerous to swim. Members of the Richland Yacht

Club have noted that dense vegetation can foul and damage their engines. Use of the Yacht Club mooring area is difficult when there is so much vegetation with everything trapped in it making it is difficult to maneuver boats. When there is a lot of vegetation, water flow is restricted trapping trash, dead fish, and even dead cattle, which is unpleasant and unhealthy. Certainly, this is not going to be a selling point for visitors to Richland parks.

Similarly, dense vegetation can interfere with fishing by making it difficult to drive a boat, snagging lures, and changing the fish resource. Weedy areas provide cover for other fish like bass that can be a positive attribute for bass fisherman, but a negative attribute for salmon fishermen who may have fewer salmon if bass eat salmon smolt.

Dense aquatic vegetation can reduce oxygen at depth where vegetation is decomposing. This can have significant and negative effects on all biota and, thus the ecological pleasure afforded the public.

Dense aquatic vegetation is likely a disincentive for the public to stay at waterside hotels and motels. Kayakers and canoers certainly are not fond of paddling through dense aquatic vegetation.

Eurasian water milfoil is a Class B Designate noxious weed in Benton and Franklin counties along the Columbia River (http://www.nwcb.wa.gov/weed_list/regions/region9.htm). Control is required by law (WAC 16-750-011). The City currently hires a cutting boat to cut well below the surface and haul the vegetation out of the river. The expenses mount as the cut material is placed in a trash compacting truck and dumped at the city landfill.

Dense invasive aquatic vegetation can also have negative consequences for wildlife and other plant species. As noted earlier, heavily infested waters can change fishery quality. Dense vegetation likely reduces value of the water for ducks, otters, and beaver. Shellfish may also be negatively impacted by dense and decomposing vegetation. Reducing oxygen and occupying the bottom may affect muscles negatively. Invasive Eurasian watermilfoil infestations can crowd out the native flora reducing habitat quality.

MANAGEMENT GOALS

The overarching management goal is to control noxious aquatic weeds in the Columbia River in City of Richland's Parks. This is to be done in a manner that allows sustainable native plant and animal communities to thrive, maintains acceptable water quality conditions, and facilitates recreational enjoyment of the river.

There are four main strategies to ensure success in meeting this goal:

- Involve the community in each phase of management process,
- Use the best available science to identify and understand likely effects of management actions on aquatic and terrestrial ecosystems prior to implementation,

- Review the effectiveness of management actions, and
- Adjust the management strategy as necessary to achieve the overall goal.

Details related to the implementation of management objectives are covered in subsequent sections of this plan.

CONTROL HISTORY & COMMUNITY INVOLVEMENT

Control History

Eurasian watermilfoil was introduced into the Columbia River from British Columbia. Eurasian watermilfoil moved downstream into the Okanogan River and then into the Columbia River. This introduction probably occurred in late 1970's. It has been present in the City of Richland Park system for many years, but has become recognized as a serious problem more recently. The City of Richland has attempted control of Eurasian watermilfoil by contracting for the services of a harvesting boat and barge. The costs associated with managing aquatic vegetation continue to rise. In 2004, Richland spent $3,800 to mechanically harvest a path through nuisance aquatic vegetation at Columbia Park West and Columbia Point Marina. An additional $600 was spent to have a scuba diver survey aquatic vegetation. In 2005, Richland spent $4,300 to mechanically harvest nuisance aquatic vegetation at the same sites as in 2004, and in addition, the Howard Amon boat dock and Leslie Groves boat launch and dock. There were no expenditures to manage nuisance or noxious aquatic vegetation in 2006 or 2007. The strategy provides only temporary control. In 2007, Eurasian watermilfoil cover remains significant ranging from 18.8% at Leslie Groves Boat Launch to 27.5% and Howard Amon North Boat Launch and at the Columbia Point Boat Launch (see Table 10).

Community Commitment

The community has shown strong interest in managing aquatic vegetation (Table 1). Attendance at public hearings has been significant (Table 1). Given that the problem with Eurasian watermilfoil is relatively recent, there has been little concerted effort to manage this species in the Columbia River. It is likely that community commitment to control Eurasian watermilfoil will grow as the population of the Tri-Cities increases with increasing use of the river.

Table 1. Groups and individuals with an interest in aquatic vegetation management in the Columbia River in the Tri-Cities and in the City of Richland.

Group	Individual	Email or address
Atomic Ducks Dive Club		atomicducks@atomicducks.org
Badger Mountain Irrigation District	Brad Anderson	8033 W. Grandridge Blvd, Kennewick, WA 99336
Benton County Commissioners		commissioners@co.benton.wa.us
Benton County Conservation District	Rachel Little	415 Wine Country Rd., Prosser, 99350
Benton County Noxious Weed	Marc Stairet	weeddude@televar.com

Group	Individual	Email or address
Control Board	Steven Link	slink@wsu.edu
City of Kennewick	Bob Hammond	cminfo@ci.kennewick.wa.us
City of Pasco	Gary Crutchfield	zunkert@ci.pasco.wa.us
City of West Richland	Dale Jackson	djackson@westrichland.org
Columbia Basin Bass Club		www.columbiabasinbassclub.com
Columbia Basin Fly Caster Club	Gene Woodruff	woodysriffle@charter.net
Columbia Basin Chapter of the Washington Native Plant Society	Bob Fortman	Robertjfortman@aol.com
Columbia Irrigation District		www.columbiairrigation.com
Columbia Park marina	Lynn & Bev Koehlor	bev@sitez.com
Confederated Tribes of the Umatilla Indian Reservation	Stuart Harris	StuartHarris@ctuir.com
Desert Canoe and Kayak Club	Chris Feather	ww.dkcc.org
Franklin County Commissioner's		fbowen@co.franklin.wa.us
Franklin County Noxious Weed Control Board	William H. Frederickson	fcwb@co.franklin.wa.us
Kennewick Irrigation District		www.kid.org
Marina Vista Estates Homeowner's Association		158 Bradley Blvd., Richland, WA 99352
Marriot Richland Columbia Point		480 Columbia Point Drive, Richland, WA 99352
Pacific Northwest National Laboratory	Dr. David Geist	david.geist@pnl.gov
Port of Benton	Scott Keller	keller@portofbenton.com
Port of Kennewick and Owner of Columbia River Journey's	Tim Arntzen	ta@portofkennewick.org PO Box 26, Richland
Red Lion Hotel		www.redlion.rdln.com
Richland Lodging Tax Advisory Committee	Trish Herron	www.ci.richland.wa.us /RICHLAND/Clerk/ index.cfm?PageNum=27
Richland Rod and Gun Club	Dale Landon	rroguc@aol.com
Richland Yacht Club	Russ Hughes	350 Columbia Point Drive, Richland, WA 99352
Shilo Inn		www.shiloinns.com
Tapteal Greenway Assoc.	Scott Woodward	woodfish24@charter.net
US Army Corps of Engineers, Walla Walla District		cenww-pa@usace.army.mil
US Fish & Wildlife Service	Greg Hughes	Greg_M_Hughes@r1.fws.gov
Washington State Dept. of Fish & Wildlife	Dave Heimer Jeffrey Koenings	heimedmh@dfw.wa.gov director@dfw.wa.gov
Washington State Noxious Weed Control Board	Alison Halpern	Ahalpern@agr.wa.gov
Washington State University Tri-Cities	John Strand Steven Link	jstrand@tricity.wsu.edu slink@wsu.edu
Wildlands, Inc.	David Bradney	Djmbradney@aol.com

Group	Individual	Email or address
Yakama Indian Reservation	Katrina Strathmann	kstrathmann@yakama.com
	Tim Bush	ttbush@charter.net
	Jim Keck	jimkeck@bentonrea.com
	Gene Van Liew	1425 Goethals Dr., Richland
	Keith Woods	KWoods1507@aol.com

Public meetings

Three public meetings were held.

Richland City Parks Board meeting (May 10, 2007).

Dr. Steven Link, Washington State University Tri-Cities provided a presentation on the Eurasian Milfoil present in the boat basins along the Columbia River.

There are 2 types of noxious weeds present in these areas. How big a problem is this? It is being researched and will be addressed in his analysis. If you get too much milfoil, given, as they are not a natural weed, it can continue and dominate the system. The City has presently contracted for harvesting the last few years; chemicals can be used, although not an easy solution with the high river flow rate, bottom barriers are another option. Reduction is possible, but the milfoil will come back. Re-habitating with native species is another option for long-term control.

Dr. Link said the first public meeting has been scheduled for June 7 to gather information from surrounding cities and begin discussions on this growing problem.

Community meeting (June 7, 2007 (Fig. 2)).

A number of suggestions were made and questions were posed by 10 people.

- Is the problem the native plants and/or invasive species? The answer was, aquatic vegetation is a problem for: swimming, boating, the commercial boat trips, and pretty much and water related activity.
- Provide an early detection and rapid response section to the plan.
- The Corps of Engineers is going to operate the river at much lower water levels for the next several years than the previous years.
- Other noxious weeds to be aware of are parrot feather and yellow flag iris.
- Make sure the beach areas are covered in the plan.
- There are biological control methods for invasive plant control. Make sure these are covered in the plan.
- Do we cover riparian plants in the report?
- Include on the list of interested parties:
    - Columbia Basin Fly Caster Club
    - Bass Club
    - Irrigation Districts (KID, Columbia, and Badger Mountain)
    - Corps of Engineers (individual out of Lewiston/Clarkston)

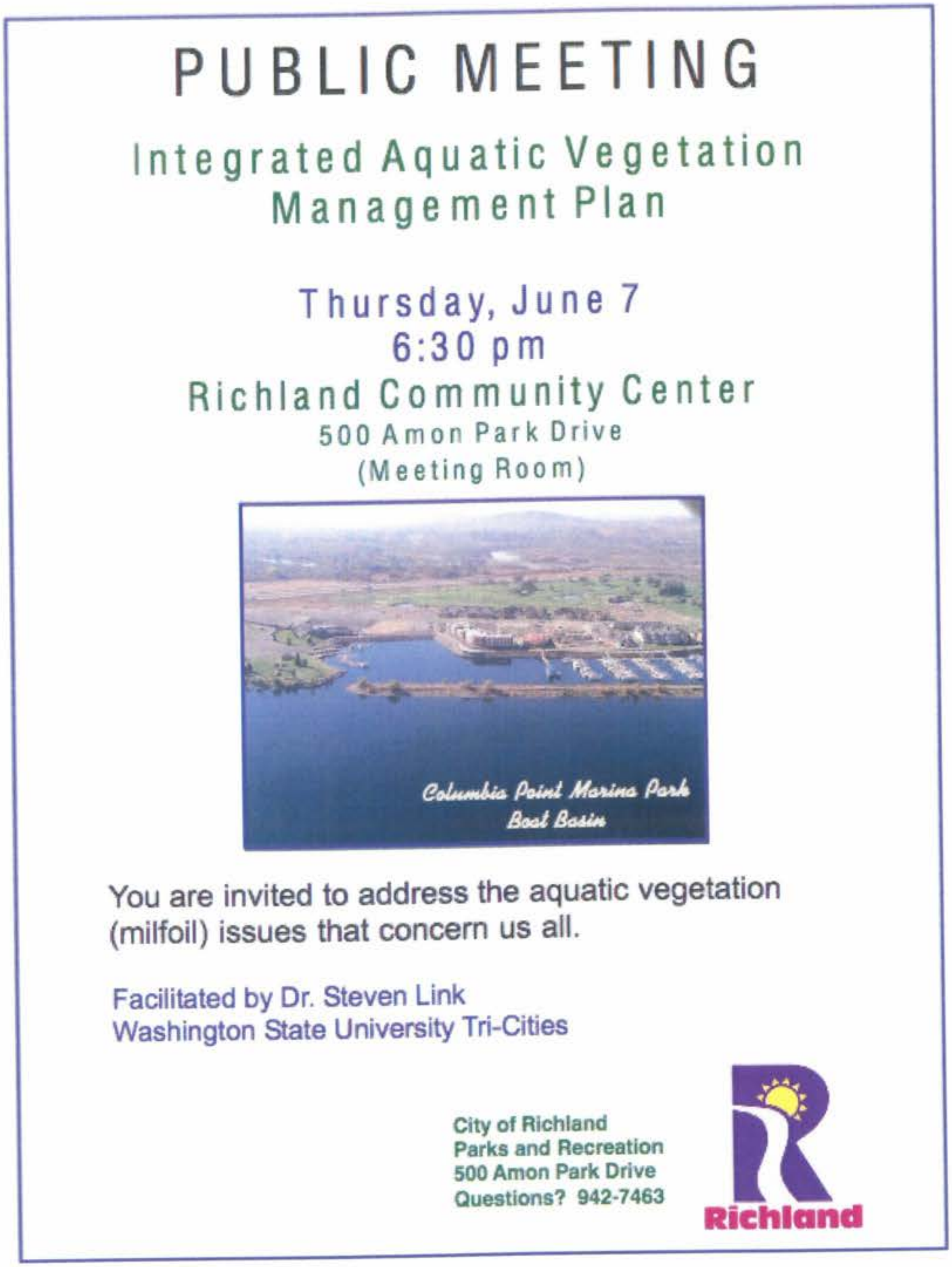

Figure 2. Announcement for the June 7 public meeting.

Richland City Council meeting (October 16, 2007)

Update on Area Milfoil Issues:

Dr. Steven Link, Washington State University Tri-Cities, briefed Council on the milfoil noxious binding weed infiltrating the Columbia River. He distributed copies of the presentation and provided a variety of strategies to reduce the milfoil.

COUNCIL MEMBER MAZUR asked Dr Link for suggestions on how the City could afford the cost to remove milfoil. She asked if there were any grants available to help offset the costs to remove milfoil.

Dr. Link explained that the City has to decide if there are other reasons, such as economic or safety reasons, to clean up the areas affected with milfoil. He offered to look into grant availability if Council agreed to it.

COUNCIL MEMBER FOX asked if cutting milfoil was legal or illegal in Washington State.

Dr. Link stated that he received conflicting information about the legality of cutting milfoil in Washington State and agreed to research it further.

Council and Dr. Link further discussed the various strategies to remove milfoil.

COUNCIL MEMBER MAZUR suggested enacting a license requirement for boat users to help fund the milfoil problem.

Steering Committee

The steering committee includes, John Strand, Keith Woods, and Bruce Schnabel. The steering committee provided review and guidance for the plan. The meeting was held on August 2, 2007 in the Richland Community Center.

A number of issues were discussed including:

- Consider the use of chemicals for control. There was some concern about regulations for chemical use in the Columbia River. I was tasked with investigating the regulatory concerns about chemical control of aquatic vegetation in the Columbia River.

- The effect of irrigation return flows on aquatic vegetation growth were discussed. It was thought that the temperature of irrigation return flow water may be higher than in high flows of the Columbia River and may be similar to temperatures in the calmer parts of the river where aquatic vegetation is more common.

- Nutrient loading was thought to be related to aquatic vegetation growth in the river with possible sources being the Yakima River, sewage flows into the river, and irrigation return flow water. It was thought that the Army Corps of Engineers may have some information on nutrient loading in the river. There was the observation that there is very little aquatic vegetation in the Columbia River near Portland, Oregon. It was suggested that an investigation of nutrient conditions in the Columbia River near Portland may explain the lack of aquatic vegetation.

- Reviewing unpublished literature was considered a worthwhile effort. This would entail finding others who are working on the topic and communicating with them and perhaps obtaining unpublished reports.

- An effort needs to me made to define city management goals. This would be done through discussions with parks officials such as Tim Werner and others as directed.

- A positive effort needs to be made to communicate with regulators to discuss various control strategies to find out which ones are recommended and which ones would fail to pass regulatory review. There is no need to review control strategies that cannot be used.

- There was a desire to encourage more city involvement in milfoil and aquatic vegetation control. City counsel members need to be directly involved to gain attention. The City wants to find the best ways to control aquatic vegetation in each park or other locations in its jurisdiction. Methods may vary by location.

- Preparation for the next meeting with City officials should include a review of control methods and consideration of regulatory concerns. As many people should be invited as possible especially those concerned with marinas.

Outreach and Education Process

The webpage where Eurasian milfoil information and this plan are found is at http://www.ci.richland.wa.us/RICHLAND/Parks/index.cfm?PageNum=141. The webpage has a link to the Washington State Department of Ecology Aquatic Plants, Algae, & Lakes webpage (http://www.ecy.wa.gov/programs/wq/links/plants.html) which has a great amount of information on Eurasian watermilfoil and its control. The Ecology webpage also has many links to other sites on Eurasian watermilfoil and related topics. A PowerPoint presentation is also found on the Richland City webpage.

Three Tri-City Herald newspaper articles were written on the topic (Link 2006; Link 2007a; Link 2007b) and are found in Appendix A. Two television interviews (Appendix A for one interview) were given and appeared on October 16 and 17, 2007 in association with a public meeting with the Richland City Council where I discussed the status of the Integrated Aquatic Vegetation Management Plan.

Signs (Fig. 3) were made for each of the five Richland Parks showing milfoil, describing the problem, and simple public responsibilities.

Eurasian watermilfoil

Myriophyllum spicatum

This aquatic weed can grow from a depth of 30 feet and can cover boat launches. It can be a swimming hazard and foul boat motors. Please remove any and all aquatic vegetation from your boat, motor, and trailer to keep it out of the next portion of the river or other waterbodies that you visit. Eurasian watermilfoil is a Class B Designate noxious weed in Benton and Franklin counties along the Columbia River. Control is required by law (WAC 16-750-011).

Figure 3. Sign placed in City parks.

WATERSHED & WATERBODY CHARACTERISTICS

Watershed Characteristics

A watershed is the land area that delivers runoff, sediment, and dissolved substances to a river and its tributaries. In turn, the health of the watershed affects the temperature, flow rate, aquatic life, and other physical components of the river.

Size and boundaries of the watershed

The Columbia's watershed spans seven states and one Canadian province (Fig. 4).

Figure. 4. The Columbia River watershed.

The northernmost reach of the watershed is found in the high glaciers of the Canadian Rockies. From there, the main body (or stem) of the Columbia River runs over a thousand miles before reaching the Pacific. As the river runs south and west, it is fed by many smaller rivers before it is joined by the Snake River in Pasco. Near the confluence of the Snake River the Columbia River turns sharply west, forming a natural border between Washington and Oregon where other rivers join the Columbia before it reaches the sea. The watershed covers nearly 260,000 square miles.

Riparian Zones

The riparian zone refers to the border of moist soils and plants that exist next to a body of water. The riparian zone can be composed of gently sloping shores, steep banks, or other types of terrain. As the Columbia and its tributaries move downstream, the channel widens, the gradient flattens, and the water slows. In these areas more permanent plant species can survive, such as tree and shrub communities and specialized grasses and forbs. These plant species, in turn, provide food and shelter for the rich diversity of wildlife living along the riverbank.

Near the Tri-Cities, elk and deer feed in these relatively lush riparian zones. Other smaller animals that live and feed along this biologically vital corridor include birds (ring-necked pheasant, grouse, geese, falcons, great blue herons, hummingbirds, warblers), small mammals (longtail weasel, striped skunk), large mammals (otter, beaver, porcupine, deer, elk), and reptiles (garter snake, western painted turtle).

The existence of riverside vegetation is also important to the health of the species that live within the river. Specifically, this vegetation helps maintain a river's health by influencing the amount and kind of sediment in the river. Riverside vegetation does this by anchoring soil, catching silt, filtering out pollutants, and absorbing nitrogen and phosphorus. Such vegetation also helps provide shade that cools the water and provides habitat for insects and their predators.

The effect of too much sedimentation can be seen when vegetation along riverbanks is removed by flooding or another event. Sediment washes back into the water, causing turbidity. Turbidity occurs when sediment is stirred up and suspended in water, and in a river can impair the respiration of fish or other aquatic organisms. Turbid conditions can also cause sediment to cover gravel used for fish spawning, raise the temperature of the water, and bury submerged plants.

Tributaries

The Columbia River's tributaries originate in mountainous areas characterized by subalpine forest. Here, the gradient is steep and stream velocity is high. As the Columbia's tributaries flow into the interior of the basin, pine and fir trees dominate the forest. In contrast to the higher elevations, the climate is drier, the gradient gentler, and the stream flow reduced.

The Columbia's tributaries are also strongly affected by seasonal runoff. Precipitation, primarily from winter snowfall, dramatically increases runoff from snowmelt during spring and early summer. This can cause flooding when unseasonably warm rains or winds occur.

Man-made tributaries are irrigation return flows. These waters have passed through agricultural lands and likely contain some amount of agricultural chemicals and nutrients that can influence aquatic vegetation near outflows. It has been suggested that the outflow near Ringold is associated with significant amounts of aquatic vegetation and more than surrounding areas that are not influenced by the outflow. It is possible that excess nutrient flow allows aquatic vegetation to grow rapidly. This hypothesized relationship needs to be documented to see if there is a relationship between agricultural outflow and aquatic vegetation. If there is, then control of or cleanup of outflow water can be considered one tool to control aquatic vegetation growth.

Plants, fish, and wildlife thrive around tributaries. Many large mammals and semi-aquatic species like the river otter make tributaries a part of their territory. Song sparrows and other small birds and mammals also live by these waters, particularly where insects are plentiful and forest cover is nearby. Fish such as the bull trout and cutthroat trout spawn in tributary headwaters, and mountain whitefish thrive in the cold, fast-moving areas of large streams.

The seven species of Pacific salmon (chinook, sockeye, coho, chum, pink, steelhead, and cutthroat trout) originate in the tributaries of the Columbia River Basin. When salmon fry emerge from their eggs, the specific tributary in which they are born is imprinted into their genetic code. They begin their descent downstream toward the ocean, allowing the current to sweep them along. When they return to the river as adults to perpetuate their life cycle, they miraculously return to the same tributary where they were hatched. For this reason, the health of tributaries is important in ensuring the genetic diversity of salmon and other migratory fish.

Wetlands

Interspersed throughout the watershed are wetlands. Located in lowland areas, wetlands are comprised of unique vegetation and saturated soils during all or part of the year. Wetlands serve three essential functions. These include providing critical wildlife habitat, assisting with water purification, and helping to store water during storms and floods.

The diverse vegetation found in wetlands may include cottonwoods and willows, rushes, cattails, and grasses. The unique conditions found in wetlands are home to many plants and species that are not commonly found.

This lush vegetation is well suited for a diversity of species. Some species are drawn to wetlands to feed and rest, others visit as part of their migratory path, and still others find wetlands to be an ideal setting for reproduction. As such, wetlands are densely and diversely populated areas. Birds such as the yellow-headed blackbird and kingfisher flit amid the sedges. Ducks and geese make wetland marshes their nesting place. And species as diverse as the high-diving osprey, the muskrat, and voles and shrews can be found there.

Beyond providing valuable wildlife habitat, wetlands also perform less noticeable functions. Wetlands along rivers and flood plains help regulate stream flow by storing water during periods of high runoff and heavy rainfall. By slowly releasing the water back into the surrounding environment, the frequency, level, and velocity of floods and riverbank erosion are reduced.

Wetlands also provide a natural water filtration process. For example, they can trap sediments and filter metals and organic pollutants like sewage and agricultural waste. This cleansed water is then released back into springs, streams, and aquifers that feed the tributaries.

Water body Characteristics

Water quality

Water quality can influence aquatic vegetation. High levels of phosphorus and nitrogen in the water promotes excessive aquatic plant growth (Shaw et al. 2004). Phosphorus originates from a variety of sources, many of which are related to human activities. Major sources include human and animal wastes, soil erosion, detergents, septic systems and runoff from farmland or lawns. Nitrogen may come from fertilizer and animal wastes on agricultural lands, human waste from sewage treatment plants or septic systems, and lawn fertilizers used on the shoreline property. Nitrogen may also enter the river from precipitation, surface runoff or groundwater sources (Shaw et al. 2004). Large aquatic plants need nitrogen and may depend on spring runoff from septic systems to recharge the sediments with nitrogen. Growth of Eurasian milfoil has been correlated with such fertilization of the sediment (Shaw et al. 2004).

Increases in phosphorus and nitrogen can be a cause of increased vegetative growth in the Columbia River especially near agricultural irrigation runoff water entry points, generalized fertilizer runoff from turfgrass near the river, and near heavily used areas like swimming beaches, boat launches, fishing docks, and marinas. Phosphorus concentrations (Table 2) are low (Poston et al. 2005) and similar to values in 1988 and 1953 (Becker and Gray 1992). Similarly, nitrogen levels are low. Both phosphorus and nitrogen levels in 1988 were within Washington State Standards for Class A waters (Becker and Gray 1992). In 1988, nitrate nitrogen was 0.28 mg l^{-1}, which was significantly greater than the 1953 level of 0.05 mg l^{-1} (Becker and Gray 1992). The increase was attributed to agricultural, groundwater seepage from Hanford, and atmospheric deposition (Becker and Gray 1992). Phosphorus and nitrogen samples (Becker and Gray 1992; Poston et al. 2005) were not taken from City of Richland Parks locations.

High silt loads can compromise the survival of salmon eggs in redds (Soulsby et al. 2001). Aquatic vegetation can slow water and cause silt to accumulate. Silt has accumulated to about 30 cm deep in the Richland Yacht Club boat yard which is has heavy vegetation growth (Bruce Schnabel, personal communication). It is likely that increasing Eurasian watermilfoil and other vegetation will cause increasing silt loads in the gravels that may have a negative effect on the ability of salmon to successfully reproduce.

Table 2. Water quality characteristics at Richland in 2004 (Poston et al. 2005).

Analysis	**Units**	**Median**	**Maximum**	**Minimum**
Temperature	°C	12	20	3.1
Dissolved oxygen	mg/L	11.2	13.5	9.8
Turbidity	NTU	<2	<2	<2
pH		8.0	8.1	7.7
Sulfate, dissolved	mg/L	9.2	9.4	7.9
Dissolved solids	mg/L	78	85	70
Specific conductance	□S/cm	138	150	126
Total hardness as $CaCO_3$	mg/L	66	71	57
Alkalinity	mg/L	58	62	50
Total phosphorus	mg/L	<0.04	<0.04	0.02
Dissolved chromium	□g/L	<0.8	<0.8	<0.8
Dissolved organic carbon	mg/L	1.2	1.5	1.1
Dissolved iron	□g/L	<6	<6	5

Dissolved ammonia as N	mg/L	<0.04	<0.04	<0.04
Nitrite + nitrate dissolved as N	mg/L	0.14	0.20	0.04

Fish and Wildlife Communities

The Columbia River in and around Richland provides habitat for a variety of fish, birds, and other animals.

Fish

There are many species of anadromous and warm water (WDFW 2005) fish in the river near Richland (Table 3).

Table 3. Fish of the Columbia River that can be found at Richland.

Family **Species**	**Common name**	**Native/Alien**
Acipenseridae		
Acipenser transmontanus	White Sturgeon	Native
Catostomidae		
Catostomus columbianus	Bridgelip Sucker	Native
Catostomus platyrhynchus	Mountain Sucker	Native
Centrarchidae		
Lepomis macrochirus	Bluegill	Alien
Micropterus dolomieu	Smallmouth Bass	Alien
Micropterus salmoides	Largemouth Bass	Alien
Pomoxis annularis	White Crappie	Alien
Pomoxis nigromaculatus	Black Crappie	Alien
Cliupeidae		
Alosa sapidissima	American Shad	Alien
Cottidae		
Cottus bairdi	Mottled Sculpin	Native
Cyprinidae		
Acrocheilus alutaceus	Chiselmouth	Native
Cyprinella lutrensis	Redside Shiner	Native
Cyprinus carpio	Carp	Alien
Mylocheils caurins	Peamouth	Native
Ptychocheilus oregonensis	Northern pikeminnow	Native
Ictaluridae		
Ictalurus punctatus	Channel Catfish	Alien
Percidae		
Perca flavescens	Yellow perch	Alien
Stizostedion vitreum vitreum	Walleye	Alien
Petromyzontiformers		
Ichthyomazon casteneus	River Lamprey	Native
Salmonidae		
Onchorhynhus kisutch	Coho Salmon	Native

Family Species	Common name	Native/Alien
Oncorhynchus mykiss	Steelhead	Native
Oncorhynchus tshawytscha	Chinook Salmon	Native
Prosopium williamsoni	Mountain Whitefish	Native
Salvelinus malma malma	Dolly Varden	Native
Zoarcidae		
Lampetra tridentata	Pacific Lamprey	Native

Abundant aquatic vegetation provides good habitat for largemouth bass from which they can prey on salmon smolts (Bonar et al. 2004). Aquatic vegetation provides good habitat for juvenile smallmouth bass, which are significant predators of Chinook Salmon smolts in the Columbia River (Tabor et al. 1993). It is likely that increasing aquatic vegetation cover will improve habitat for bass leading to reductions in salmon.

Sunfish can have an effect on potential use of weevils *(Euhrychiopsis lecontei)* for biological control of Eurasian watermilfoil. Weevil densities appear limited by sunfish predation (Ward and Newman 2006).

Native Shellfish

Shellfish (mollusks) such as the giant Columbia River limpet or shortface lanx (*Fisherola nuttalli*), the great Columbia River spire snail (Columbia pebblesnail, *Fluminicola columbianus (=fuscus)*), and the California floater (*Anodonata californiensis*) were once common throughout the Columbia River Basin. All three species require cold, clear water habitats. The shortface lanx prefers high-velocity portions of the system, whereas the California floater prefers lower-gradient areas with soft, silty substrate. Human alteration of the Columbia River system has limited the distribution and abundance of all three of these native shellfish species. Currently, all three mollusks species are state candidate species.

Birds

Table 4. Birds of the Columbia River that can be found in Richland (Ennor 1991).

Scientific name	Common name	Native/alien
Aechmophorus occidentalis	Western grebe	n
Agelaius phoeniceus	Redwinged Blackbird	n
Anas platyrhynchos	Mallard Duck	n
Ardea herodias	Great blue heron	n
Branta canadensis	Canada goose	n
Carpodacus mexicanus	House finch	n
Charadrius vociferus	Killdeer	n
Colaptes cafer	Red-shafted flicker	n
Contopus sordidulus	Western wood peewee	n
Corvus brachyrhynchos	American Crow	n
Euphagus cyanocephalus	Brewer's Blackbird	n
Falco sparverius	American kestrel	n

Scientific name	Common name	Native/alien
Hirundo rustica	Barn swallow	n
Hydroprogne caspia	Caspian Tern	a
Larus californicus	California Gull	n
Larus delawarensis	Ring-billed gull	n
Lophortyx californicus	California Quail	n
Megaceryle alcyon	Belted Kingfisher	n
Melospiza melodia	Song Sparrow	n
Molothrus ater	Brown-headed Cowbird	n
Passer domesticus	English house sparrow	a
Petrochelidon pyrrhonota	Cliff Swallow	n
Phalacrocorax	Double crested-cormorant	n
Phasianus colchicus	Pheasant	a
Pheucticus melanocephalus	Black headed grosbeak	n
Pica pica	Blackbilled Magpie	n
Riparia riparia	Bank swallow	n
Sterna forsteri	Forster's Tern	n
Sternus vulgaris	Starling	a
Turdus migratorius	Robin	a
Zenaidura macroura	Mourning Dove	n

Sensitive Animal Species

Federally Listed Threatened and Endangered Animal Species

The species in Table 5 were taken from current listings found at http://ecos.fws.gov/tess_public from the U. S. Fish and Wildlife Service and the National Marine and Fisheries Service at http://www.nwr.noaa.gov/ESA-Salmon-Listings/upload/snapshot0208.pdf. These species may be found or potentially could be found in the City of Richland Parks. This review of federally listed species is provided to assist with regulatory reviews required before any river manipulation that could potentially impact these species or their habitat. The condition and threats faced by threatened and endangered salmon and steelhead species in the Hanford Reach are reviewed in DOE/RL (2000).

Table 5. Federal endangered and threatened fish species listings for the City of Richland Parks.

Status	Scientific Name	Common Name or Origin
Threatened	*Salvelinus confluentus*	Bull trout
Endangered	*Oncorhynchus nerka*	Snake River Sockeye Salmon
Endangered	*Oncorhynchus tshawytscha*	Upper Columbia River Spring-Run Chinook Salmon
Threatened	*Oncorhynchus tshawytscha*	Snake River – Spring/Summer Run
Threatened	*Oncorhynchus tshawytscha*	Snake River – Fall Run
Endangered	*Oncorhynchus mykiss*	Upper Columbia River Steelhead
Threatened	*Oncorhynchus mykiss*	Middle Columbia River Steelhead
Threatened	*Oncorhynchus mykiss*	Snake River Basin Steelhead

Bull Trout (*Salvelinus confluentus*)

Bull trout are native to the Pacific Northwest, including Washington, Oregon, California, Idaho, Montana, Nevada, Alaska, Alberta, and British Columbia. They have been eliminated from the main stem of most large rivers where they historically occurred. Many remaining populations are isolated in headwater streams. Resident bull trout reside within or near spawning areas, but migratory bull trout can travel over 155 miles and utilize lakes, reservoirs, or large river systems for migratory corridors and over wintering habitats. Bull trout are a member of the North American salmon family, which includes salmon, trout, whitefish, char, and grayling. Members of this family tend to prefer cold, clear waters, and the bull trout is exceptional for its demand for especially cold--no more than 64° F water. Spawning, incubation and juvenile rearing are the bull trout life history stages that require the coldest water temperatures and lowest fine sediment levels. These activities usually occur in the small tributaries and headwater streams of the Columbia River. Greatest riparian protection needs to be provided around bull trout spawning and rearing streams. Protection of high quality water to downstream areas of the bull trout is even important in non-fish bearing streams. Bull trout can live up to ten years and are sexually mature after four. They spawn every year or every other year and require particularly clean gravel bars for their redds (Pratt 1992). Spawning success is even more sensitive to temperature. Eggs do best with temperatures of no more than 39° F (Goetz 1989).

According to the Washington Department of Fish and Wildlife, there are no resident populations of bull trout reported for Benton County. Populations in the lower Columbia River, below the confluence with the Snake River, are fragmented and remnants of a much wider distribution. There is no evidence of bull trout migrating through this section of the river.

Snake River Sockeye Salmon (*Oncorhynchus nerka*)

The threatened and endangered evolutionary significant units (ESUs) of sockeye salmon were listed under the Endangered Species Act (ESA) on June 28, 2005. The Snake River ESU and had been previously listed in 1991 and 1999, but the listings were reaffirmed in 2005. Critical habitat was designated for the Snake River ESU on December 28, 1993.

The size of an adult returning to spawn may measure up to 2.8 feet (86 cm) in length and weigh an average of 8 pounds (3.6 kg). The adult spawners are unique in appearance. They typically turn bright red, with a green head.

While Snake River Sockeye Salmon spawn in the Snake River drainage they can stray into the Columbia River.

Chinook Salmon (*Oncorhynchus tshawytscha*)

Chinook are easily the largest of any salmon, with adults often exceeding 40 pounds; individuals over 120 pounds have been reported. They are prized by commercial, sport, and tribal fishermen. Chinook use a variety of freshwater habitats, but it is more common to see them spawn in larger main stem rivers than other salmon species.

Upper Columbia River Spring-Run

Listed as an endangered species on March 24, 1999 (Federal Register, Vol.64, No.56, March 24, 1999, p.14308). The ESU (evolutionarily significant unit) includes all naturally spawned populations of chinook salmon in all river reaches accessible to chinook salmon in Columbia River tributaries upstream of the Rock Island Dam and downstream of Chief Joseph Dam in Washington, excluding the Okanogan River. Chinook salmon (and their progeny) from the following hatchery stocks are considered part of the listed ESU: Chiwawa River (spring run); Methow River (spring run); Twisp River (spring run); Chewuch River (spring run); White River (spring run); and Nason Creek (spring run). The major spawning areas of the Upper Columbia River ESU are far upstream from Richland. Critical habitat is proposed to include all river reaches accessible to chinook salmon in Columbia River tributaries upstream of the Rock Island Dam and downstream of Chief Joseph Dam in Washington, excluding the Okanogan River. In general, adult fish migrate through the Richland section of the river from January to July and young migrate downstream from March through July.

Snake River – Spring/Summer Run and Snake River – Fall Run

Snake River Spring/Summer Run Cinook Salmon were listed as a threatened species on April 22, 1992 (see correction on June 3, 1992); threatened status reaffirmed on June 28, 2005. The ESU includes all naturally spawned populations of spring/summer-run Chinook salmon in the Snake River drainage.

Snake River – Fall Run Cinook Salmon were listed as a threatened species on April 22, 1992 (see correction on June 3, 1992); threatened status reaffirmed on June 28, 2005. The ESU includes all naturally spawned populations of fall-run Chinook salmon in the Snake River drainage below Hells Canyon Dam.

While Snake River – Spring/Summer Run and Snake River – Fall Run Chinook Salmon spawn in the Snake River drainage they can stray into the Columbia River.

Steelhead (*Oncorhynchus mykiss*)

Steelhead typically migrate to marine waters after spending 2 years in fresh water and then reside in the ocean for 2 or 3 years; however, the life history is considerably more variable than for other salmonid species. Unlike salmon and cutthroat trout, steelhead may not die after spawning. They can migrate back out to sea and return in later years to spawn again. Adult steelhead migrate upstream in mid-May through October, and typically spawn between February and June. Juveniles rear in fresh water from 1 to 4 years before migrating to the sea. The coastal and inland subspecies are considered the two major genetic groups. Both Upper Columbia River and Middle Columbia River Steelhead are considered to be the inland subspecies *O. m. gairdneri*. In general, steelhead migrating through this section of the Columbia River will be in deep water and away from the shoreline of Richland.

Upper Columbia River Steelhead

Listed Endangered under ESA, Federal Register Vol. 62, No. 159, 43937, Monday, August 18, 1997. The major spawning areas of the Upper Columbia River are far upstream from Richland and include, for example, the Wenatchee, Methow and Okanogan Rivers.

There are no known spawning areas within 25 miles of Richland (DOE/RL 2000). Steelhead smolts migrating downstream along shoreline may occur in April through June. Critical habitat is proposed to include all river reaches and estuarine areas accessible to listed steelhead in Columbia River tributaries upstream of the Yakima River and downstream of Chief Joseph Dam, Washington.

Middle Columbia River Steelhead

Listed Threatened under ESA, Federal Register Vol. 64, No. 57, 14571, Thursday, March 25, 1999. Middle Columbia River Steelhead are prevalent in the Columbia River adjacent to the City of Richland during migration. The major spawning areas of the Middle Columbia River are upstream from Richland in the area downstream from Priest Rapids Dam to Ringold.

Spawning areas near Ringold are approximately 13 miles from Richland (DOE/RL 2000). Some adults remain in the river all year as an over wintering population in the McNary Pool. It is possible that a small number of over wintering steelhead may exist in the Columbia River in the vicinity of Richland. Steelhead smolts migrating along the shoreline may occur in April through June.

Snake River Basin Steelhead

Listed as a threatened species on August 18, 1997; threatened status reaffirmed on January 5, 2006. The distinct population segment (DPS) includes all naturally spawned anadromous *O. mykiss* (steelhead) populations below natural and manmade impassable barriers in streams in the Snake River Basin.

While Snake River Basin Steelhead spawn in the Snake River drainage they can stray into the Columbia River.

Shoreline and Riverbed Modifications

Shoreline and riverbed modifications might be considered an adverse risk to Upper Columbia River Spring-Run ESU chinook salmon or steelhead if any of the following conditions are true (DOE/RL 2000):

- The volume of excavated material below the ordinary high-water mark will exceed 19 m^3 or occurs within a known steelhead spawning area.
- The project will use fill material that is not clean, pre-washed, or free of fines.
- The project will use any upright structures within the floodplain (e.g., retaining walls, concrete or timber bulkheads).
- The area modified by the project, including any excavated area, will cause the loss of more than 400 m^2 of a special aquatic site, including native riparian and/or emergent

vegetation, wetlands, or critical steelhead or Upper Columbia River Spring-Run ESU chinook salmon habitat.

- Shoreline or riverbed modifications will exceed 75 m parallel to the flow of the river.
- The project will require bank protection exceeding 0.4 m^3 per running foot placed along the bank below the line of ordinary high water.
- The project will place fill material in wetlands, or in such a way that prohibits water flow into or out of a wet area.
- The project will place fill material below the ordinary high water line that is easily eroded by medium to high flows (e.g., gravel for bank protection).
- The project will construct boat ramps wider than 3.6 m or using more than 15 m^3 of material, or will locate the boat ramp within a steelhead spawning area.

New projects that may disturb the shoreline include improvements in existing boat launches. The impact of specific projects will be considered when the activity is scheduled and permitted through the normal permitting process. The Endangered Species Act Section 7 consultation regulations require a Federal agency to consult on actions that it proposes to authorize, fund, or carry out that are within its discretionary authority and may adversely affect an ESA-listed species or alter its critical habitat. Section 7 consultation with the appropriate federal agency will be required if a project will exceed any of the above criteria for shoreline and riverbed modifications. No impacts to Upper Columbia River Spring-Run ESU chinook salmon and steelhead will result. Mitigation actions that will be applied to these activities will include avoidance of sensitive habitats, avoidance of critical times of the year (i.e., spawning and rearing), prevention of all runoff and sedimentation, and minimization of area affected. Any application of herbicide in the riparian zone that may drift or runoff into the Columbia River will necessitate consultation with National Marine Fisheries Service (NMFS) before application (DOE/RL 2000). Consultation with NMFS is also advised for aquatic herbicide applications.

Washington State Department of Fish and Wildlife: Habitats and Animal Species

Information about State Species of Concern is available from the WDFW web site (http://www.wdfw.wa.gov/wlm/diversty/soc/soc.htm). The list should be consulted before significant habitat alteration is considered.

Sensitive Plant Species

Federally Listed Threatened and Endangered plus Washington Natural Heritage Program Plant Species of Concern

Plants that are species of concern at the federal and state levels and found or historically found in wetlands along the Columbia River in Benton County are listed in Table 6. They can be put at risk by activities that disturb shorelines and wetlands along the river. Such activities include any construction along the river.

Table 6. Rare plants listed by the US Fish and Wildlife Service and/or the Washington Natural Heritage Program found in and near the Columbia River in Benton County. State status codes are: E = Endangered, T = Threatened and likely to become Endangered, R1 = Review group 1,

Of potential concern but needs more field work to assign another rank, S= Sensitive. Vulnerable or declining and could become Endangered or Threatened in the state.

Scientific name	**Common name**	**Federal Status**	**State Status**
Ammannia robusta	Grand Redstem		T
Centunculus minimus	Chaffweed		R1
Hierochloe odorata	Common Northern Sweet Grass		R1
Hypericum majus	Canadian St. John's-wort		S
Lipocarpha aristulata	Awned Halfchaff Sedge		T
Rorippa columbiae	Persistentsepal yellowcress	Species of Concern	E

Beneficial and Recreational Uses

The Columbia River has many beneficial and recreational uses (Anderson et al. 2002) in the City of Richland park system (Figure 1). The public enjoys recreational activities including swimming, fishing, boating, bird watching, wildlife viewing, and hiking. Public boat launches are found in all the parks and are maintained by the City of Richland. Leslie Groves Park has a fishing pier, swimming area, boat docks, and a boat launch. Howard Amon Park has docks, swimming area, and a boat launch. Columbia Point Marina Park has boat docks, and a 4-lane boat launch. The Mudflats boat launch at WYE park also has a fishing dock. Columbia Park West has boat docks, and a 3-lane boat launch. The City of Richland park system is also attractive to out of town visitors.

Characterization of Plants in and Potentially in the City of Richland Parks in and along the Columbia River

A survey of the aquatic plants found in the City of Richland Columbia River Parks (Table 7) was performed on October 26, 2006 and on October 25, 2007. Riparian species were identified on October 25, 2007 (Table 8). The purpose of the survey was to determine species composition and species cover in and near boat launch docks and swimming docks. The identity of *Potamogeton praelongus* was difficult to ascertain with certainty in all locations. Some observations may have been *Potamogeton richardsonii.* These two species can be confused.

The parks include Leslie Groves, Howard Amon, Columbia Point Marina Park, WYE Park and Columbia Park West (Fig. 1). Locations in each park were surveyed by noting species composition and cover in sections of features such as a boat launch dock. Cover was estimated visually in an area of about 64 m^2 and done so in each of up to 8 positions at each site. Positions were along the docks. Cover data are presented as the mean ± 1 standard error of the mean. The area of each surveyed feature was estimated using a Bushnell Yardage Pro 450 sighting tool. Area was estimated as rectangles encompassing the limits of each park feature with estimates of the area associated with aquatic vegetation (Table 9).

Table 7. Aquatic plant species observed in the Columbia River study sites on Oct. 26, 2006.

Scientific name	Common name	Code	Origin
Ceratophyllum demersum	Coontail	Cede	Native
Elodea canadensis	Canadian waterweed	Elca	Native
Heteranthera dubia	Water star grass	Hedu	Native
Myriophyllum spicatum	Eurasian watermilfoil	Mysp	Alien
Potamogeton crispus	Curly pondweed	Pocr	Alien
Potamogeton* cf *praelongus	White-stemmed pondweed	Popr	Native

Table 8. Riparian plant species observed in the Columbia River study sites on October 25, 2007.

Scientific name	Common name	Life form	Origin
Acer saccharinum	Silver maple	Tree	Alien
Apocynum cannabinum	Common dogbane	Perennial herb	Native
Asclepias speciosa	Showy milkweed	Perennial herb	Native
Cornus stolonifera	Red-osier dogwood	Shrub	Native
Elaeagnus angustifolia	Russian olive	Tree	Alien
Kochia scoparia	Kochia	Annual herb	Alien
Morus alba	White mulberry	Tree	Alien
Phalaris arundinaceae	Reed canary grass	Perennial grass	Alien
Platanus occidentalis	American sycamore	Tree	Alien
Robinia pseudo-acacia	Black locust	Tree	Alien
Rubus armeniacus	Himalayan blackberry	Shrub	Alien
Salix exigua	Sandbar willow	Shrub	Native
Scirpus validus	Softstem bulrush	Perennial graminoid	Native
Solanum nigrum	Black nightshade	Annual herb	Alien
Solidago occidentalis	Western goldenrod	Perennial herb	Native
Ulmus pumila	Siberian elm	Tree	Alien

Leslie Groves Boat Launch

Leslie Groves Boat Launch (Figs. 5 and 6) had three aquatic species: Canadian waterweed (Fig. 7), Eurasian watermilfoil (Fig. 8), and Curly pondweed (Fig. 9). Most of the area sampled between the red line in figure 5 and the shoreline was covered with vegetation except near shore where gravel was prominent and the concrete pad (Fig. 10) for boat launching. There was no vegetation growing on the concrete at any site. Canadian waterweed was the most common aquatic plant species (Fig. 11). Eurasian watermilfoil was between 10 and 20% cover in 2006 and 2007 while curly pondweed was less than 10% cover in both years (Fig. 11). The area of the Leslie Groves Boat Launch is about 0.55 acres with about 90% of the area associated with vegetation (Table 9).

Figure 5. Leslie Groves boat launch area with the area assessed for cover within the red line and the shoreline.


Figure 6. Leslie Groves boat launch.

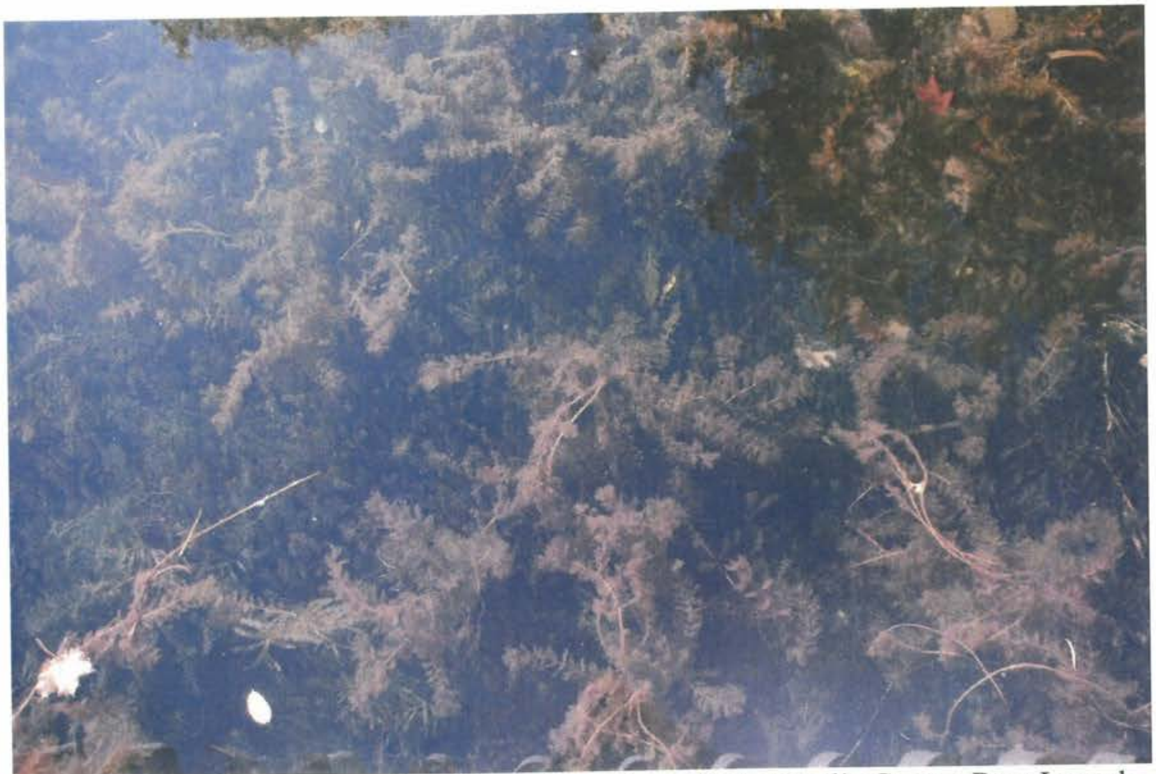

Figure 7. Canadian waterweed and Eurasian watermilfoil at Leslie Groves Boat Launch. Canadian waterweed is green and Eurasian watermilfoil is above and loaded with silt.

Figure 8. Eurasian watermilfoil loaded with silt at Leslie Groves Boat Launch.

Figure 9. Curly pondweed at Leslie Groves Boat Launch.

Figure 10. Concrete pads at boat launches without vegetation.

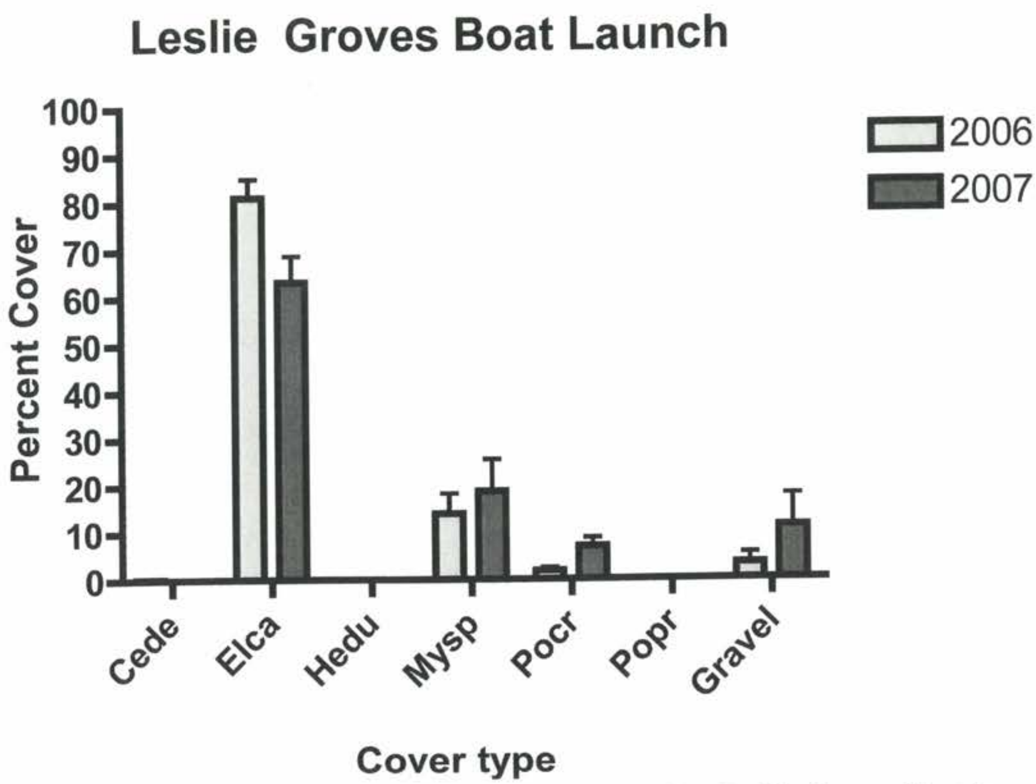

Figure 11. Cover of aquatic plant species and gravel at Leslie Groves Boat Launch in 2006 and 2007. Species codes are in Table 7.

Table 9. Estimated area of each surveyed feature in the City of Richland Parks with an estimate of the area with aquatic vegetation.

Park	Site	Feature acres	Vegetation acres
Leslie Groves	Boat launch	0.55	0.50
	Fishing dock	0.04	0.008
	Beach	2.48	2.23
Howard Amon	Boat launch	0.59	0.35
	Swim dock	0.51	0.05
	Boat dock	0.55	0.01
Columbia Point Marina Park	Boat launch	2.69	0.19
WYE	Mudflats Boat launch	0.05	0.005
Columbia West	Boat launch	0.41	0.20
All parks	Total	7.82	3.54

Leslie Groves Fishing Dock

Leslie Grove Fishing Dock (Figs. 12 and 13) had three aquatic species. Canadian waterweed, Eurasian watermilfoil, and white-stemmed pondweed (Figs. 14 and 15) were present in 2006. Canadian waterweed and white-stemmed pondweed were present in 2007. About 20% of the area sampled between the red line in figure 12 and the shoreline was covered with vegetation. In this small (Table 9) area, Canadian waterweed was the most common aquatic plant species (Fig. 16). Eurasian watermilfoil had about 10 % cover in 2006 while none was found in 2007. White-stemmed pondweed had 30% cover in 2006 and about 10% in 2007 (Fig. 16). The surveyed area of the Leslie Groves Fishing Dock is about 0.04 acres with only about 20% of the area associated with vegetation in 2006 (Table 9).

Figure 12. Leslie Groves fishing dock with the area assessed for cover within the red line and the shoreline.


Figure 13. Leslie Groves Fishing Dock.


Figure 14. White-stemmed pondweed.

Figure 15. Complete cover by white-stemmed pondweed.

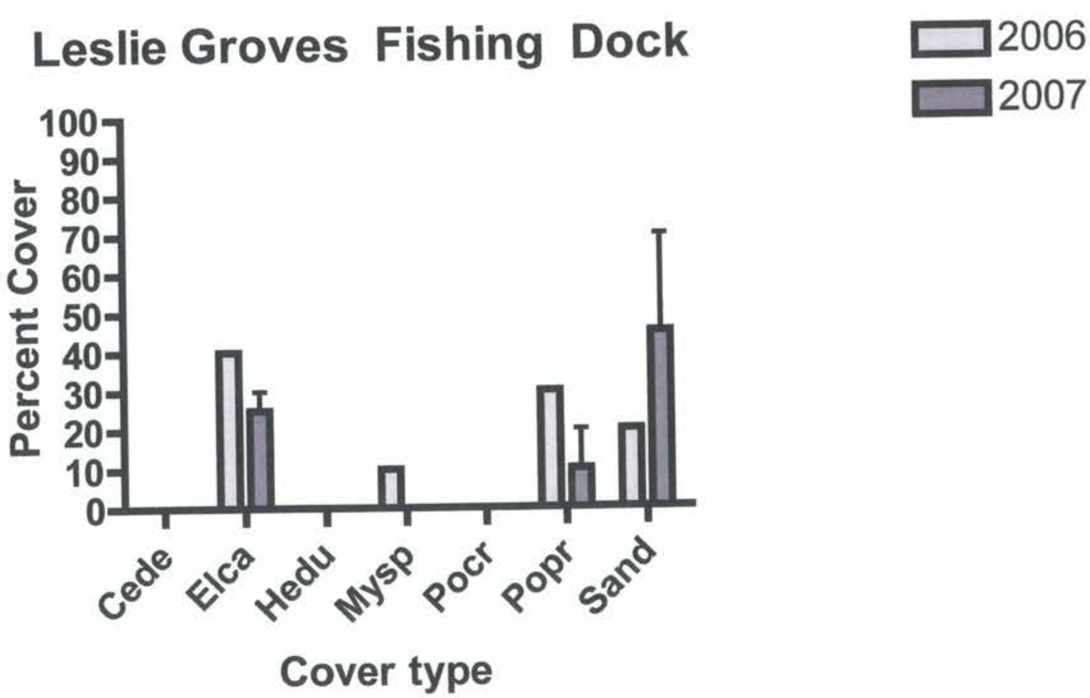

Figure 16. Cover of aquatic plant species, gravel, and sand at Leslie Groves Fishing Dock in 2006 and 2007. Species codes are in Table 7.

Leslie Groves Swimming Beach

Leslie Groves Swimming Beach (Figs. 17 and 18) had three aquatic species plus a tentatively, identified brown algae. Canadian waterweed, Eurasian watermilfoil, and white-stemmed pondweed were present. This area was surveyed in a boat at three distances (Fig. 19-20) from the shore in 2007. At each distance from shore cover data were collected in 6 to 8 locations while floating down river. At about 20 yards from shore white-stemmed pondweed was the most common with Eurasian watermilfoil at less than 10% cover (Fig. 19). At about 40 yards from shore white-stemmed pondweed was still most common while Eurasian milfoil cover dropped to about 1% (Fig. 20). At about 60 yards from shore only a trace of white-stemmed pondweed remained with no other aquatic vascular vegetation present. At 60 yards from shore brown algae became dominant (Fig. 21). All vascular aquatic vegetation cover decreases with increasing distance from shore. There was little vegetation very close to shore so the estimate of the beach area associated with vegetation is about 90% of the entire surveyed area (Table 9).

Figure 17. Leslie Groves Swimming Beach with the area assessed for cover within the red line and the shoreline.

Figure 18. Leslie Groves Swimming Beach.

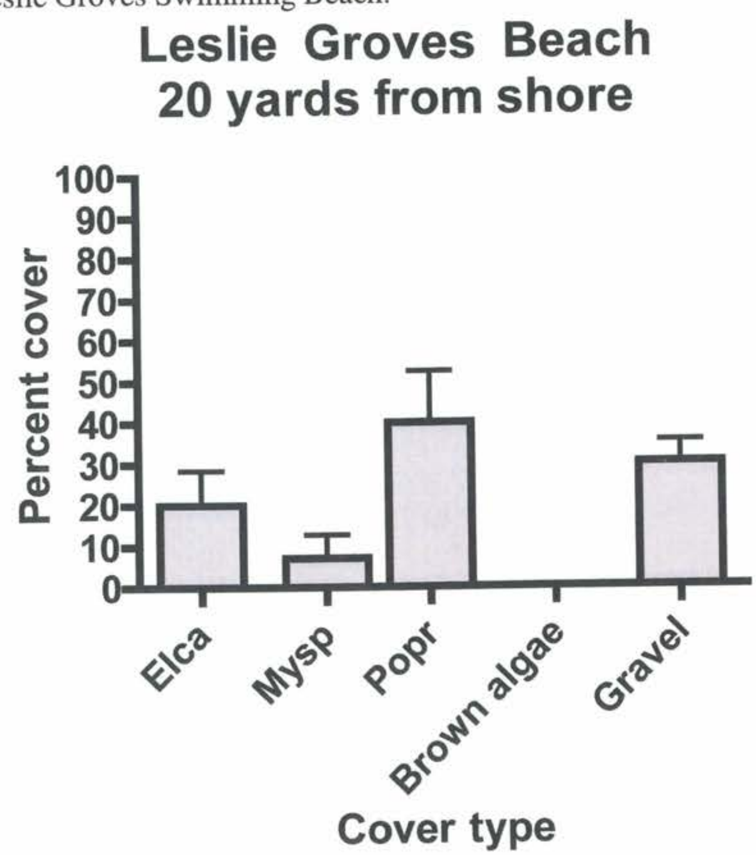

Figure 19. Cover of aquatic plant species, brown algae, and gravel about 20 yards from shore at the Leslie Groves Swimming Beach in 2007. Species codes are in Table 7.

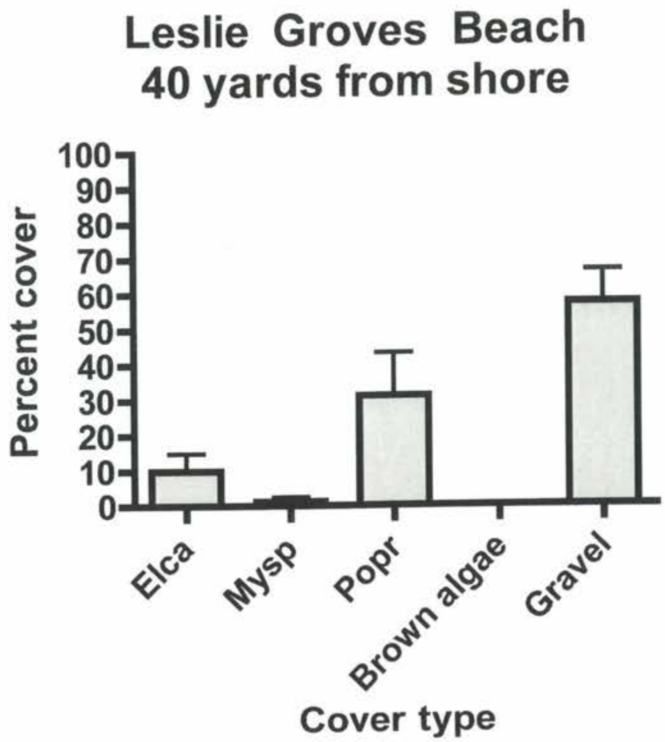

Figure 20. Cover of aquatic plant species, brown algae, and gravel about 40 yards from shore at the Leslie Groves Swimming Beach in 2007. Species codes are in Table 7.

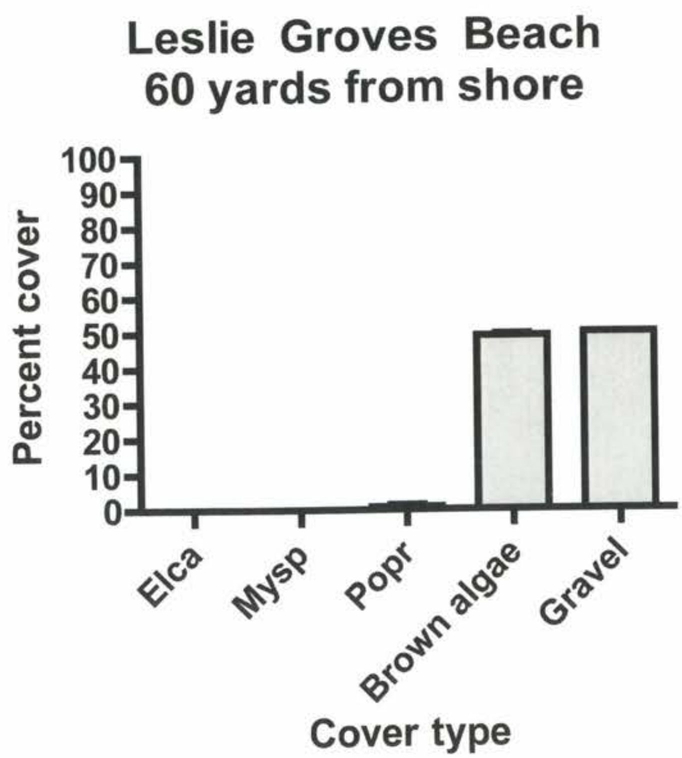

Figure 21. Cover of aquatic plant species, brown algae, and gravel about 60 yards from shore at the Leslie Groves Swimming Beach in 2007. Species codes are in Table 7.

Howard Amon Park Boat Launch

The Howard Amon Park Boat Launch (Figs. 17 and 18) had three aquatic species: Canadian waterweed, Eurasian watermilfoil, and curly pondweed. This area was surveyed in both 2006 and 2007. Canadian waterweed was most common in both years with Eurasian watermilfoil at about 30% cover in both years. Curly pondweed was present, but less than 5% cover in both years. About 60% of the survey area was associated with aquatic vegetation (0.35 acres, Table 9). Areas at the end of the boat launch were too deep for vegetation or vegetation was obscured.

Figure 22. Howard Amon Park North Boat Launch with the area assessed for cover within the red line and the shoreline.

Figure 23. Howard Amon Park North Boat Launch.

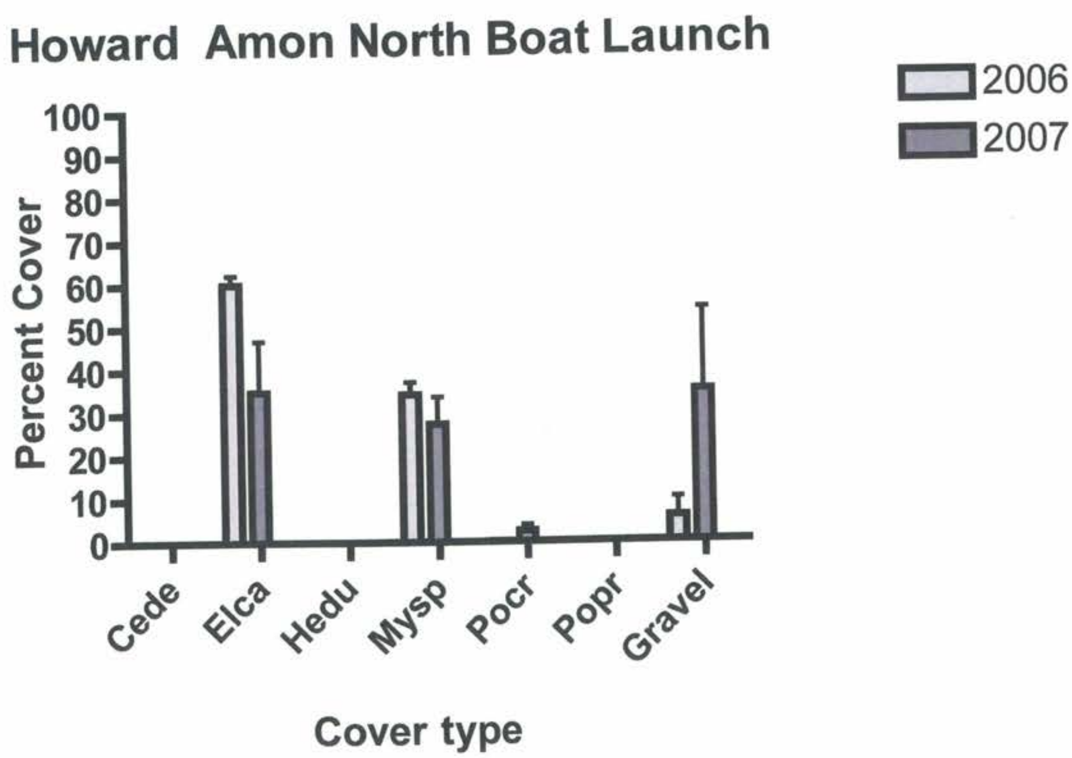

Figure 24. Cover of aquatic plant species and gravel at Howard Amon North Boat Launch in 2006 and 2007. Species codes are in Table 7.

Howard Amon Park Swim Dock

The Howard Amon Park Swim Dock (Figs. 25 and 26) had three aquatic species: Canadian waterweed, Eurasian watermilfoil, and curly pondweed. This area was surveyed in both 2006 and 2007. Canadian waterweed was most common in both years with Eurasian watermilfoil at about 10% cover in 2006 and about 20% cover in 2007 (Fig. 27). Curly pondweed was not present in 2006 and was only a trace in 2007. Only about 10% of the survey area was associated with aquatic vegetation (0.05 acres, Table 9). Areas at the end of the dock were too deep for vegetation or vegetation was obscured.

Figure 25. Howard Amon Park Swim Dock with the area assessed for cover within the red line and the shoreline.

Figure 26. Howard Amon Park Swim Dock.

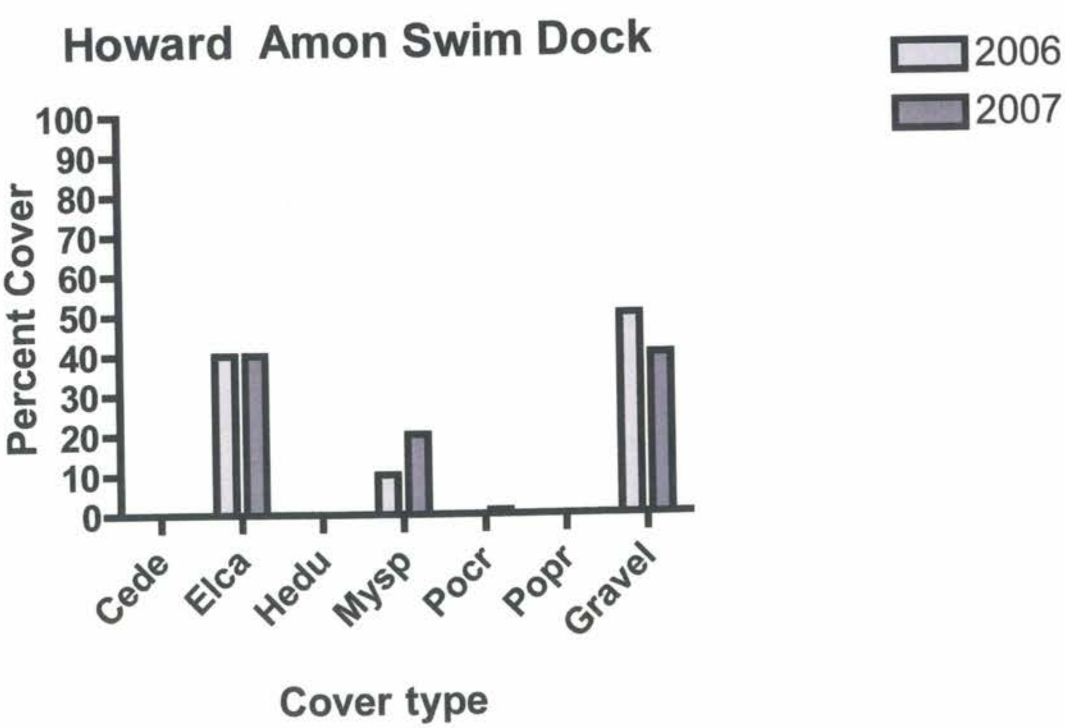

Figure 27. Cover of aquatic plant species and gravel at Howard Amon Swim Dock in 2006 and 2007. Species codes are in Table 7.

Howard Amon Park Boat Dock

The Howard Amon Park Boat Dock (Figs. 28 and 29) had two aquatic species: Eurasian watermilfoil and curly pondweed. This area was surveyed in both 2006 and 2007. Curly pondweed had cover of 2% in 2006 and was gone 2007. Eurasian watermilfoil was not present in 2006, but had a cover of 5% in 2007. Only about 2% of the survey area was associated with aquatic vegetation (0.01 acres, Table 9). The area with vegetation was midway across the entryway to the dock and was on a few feet wide. Areas at the end of the dock were too deep for vegetation or vegetation was obscured.

Figure 28. Howard Amon Park Boat Dock with the area assessed for cover within the red line and the shoreline.

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Figure 29. Howard Amon Park Boat Dock.

Columbia Point Marina Park Boat Launch

The Columbia Point Marina Park Boat Launch (Figs. 30 and 31) had five aquatic species: Coontail (Fig. 32), Canadian waterweed, water star grass (Figs. 33 and 34), Eurasian watermilfoil, and curly pondweed. This area was surveyed in both 2006 and 2007 (Fig. 35). A small amount of coontail was observed in 2006, but not in 2007. Canadian waterweed was the most common species in both years. Water star grass was observed in the same few places in 2006 and 2007. Eurasian watermilfoil was present in 2006, but only had a cover of 5%. Cover of Eurasian watermilfoil increased to 28% in 2007 with scattered individuals outside the cover assessment areas. Curly pondweed had cover of 2% in 2006 and was gone 2007. Only about 7% of the survey area was associated with aquatic vegetation (0.19 acres, Table 9). Areas along and at the end of the docks were too deep for vegetation or vegetation was obscured.

Figure 30. Columbia Point Marina Park Boat Launch with the area assessed for cover within the solid red line and the shoreline. Aquatic vegetation was found primarily within the dotted red areas.

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Figure 31. Columbia Point Marina Park Boat Launch.

Figure 32. Coontail (*Ceratophyllum demersum).*

Figure 33. Water star grass (*Heteranthera dubia*).

Figure 34. Water star grass (*Heteranthera dubia*) with adhering algae.

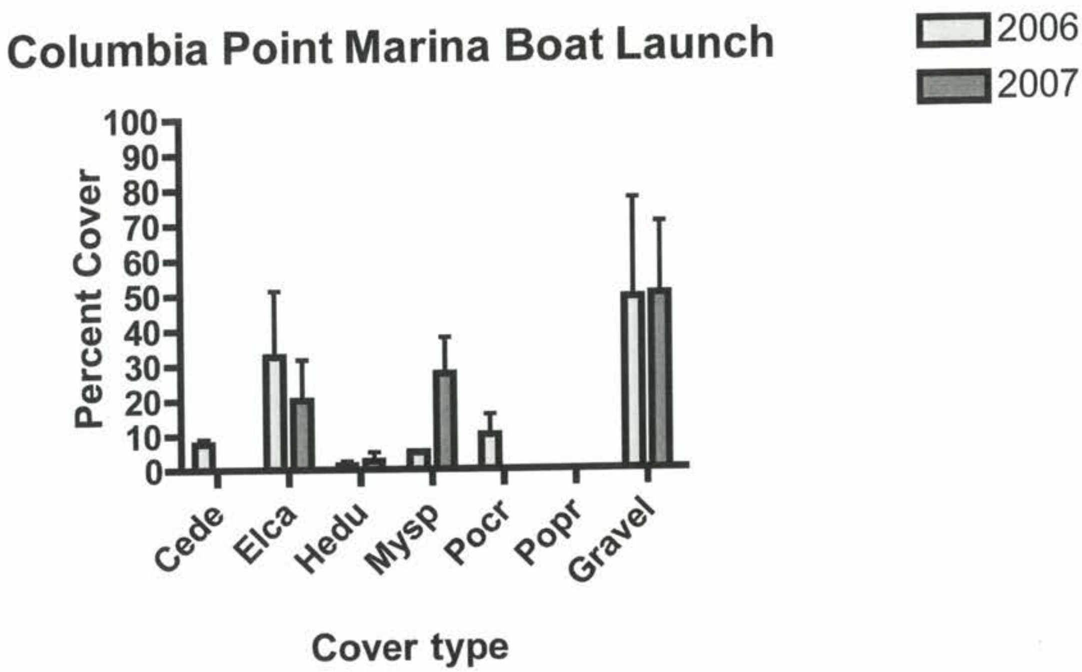

Figure 35. Cover of aquatic plant species and gravel at Columbia Point Marina Park Boat Launch in 2006 and 2007. Species codes are in Table 7.

WYE Park Mudflats Boat Launch and Fishing Dock

The WYE Park Mudflats Boat Launch and Fishing Dock (Figs. 36 and 37) had only water star grass. This area was surveyed in both 2006 and 2007. Water star grass was observed in the same place in 2006 and 2007. It covered about 50% of the surface in both years. The other cover type was mud. Only about 10% of the survey area was associated with the water star grass patch (0.005 acres, Table 9). Areas along and at the end of the docks were too deep for vegetation or vegetation was obscured.

Columbia Park West Boat Launch

The Columbia Park West Boat Launch (Figs. 38 and 39) had five aquatic species. Coontail, Canadian waterweed, water star grass, Eurasian watermilfoil, and curly pondweed were present. This area was surveyed in both 2006 and 2007 (Fig. 40). A small amount of coontail was observed in 2006, but not in 2007. Canadian waterweed was only observed in 2006 and had a small cover. Water star grass was the dominant species in both years. Eurasian watermilfoil was present in both years, but only a very low cover. Curly pondweed had a trace cover in 2006 and was gone 2007. Approximately half of the survey area was associated with aquatic vegetation (0.20 acres, Table 9). Areas along and at the end of the docks were too deep for vegetation or vegetation was obscured.

Figure 36. Mudflats Fishing Dock and Boat Launch at WYE Park with the area assessed for cover within the solid red line and the shoreline.

Figure 37. Mudflats Fishing Dock at WYE Park.

Figure 38. Columbia Park West Boat Launch with the area assessed for cover within the solid red line and the shoreline.

Figure 39. Columbia Park West Boat Launch.

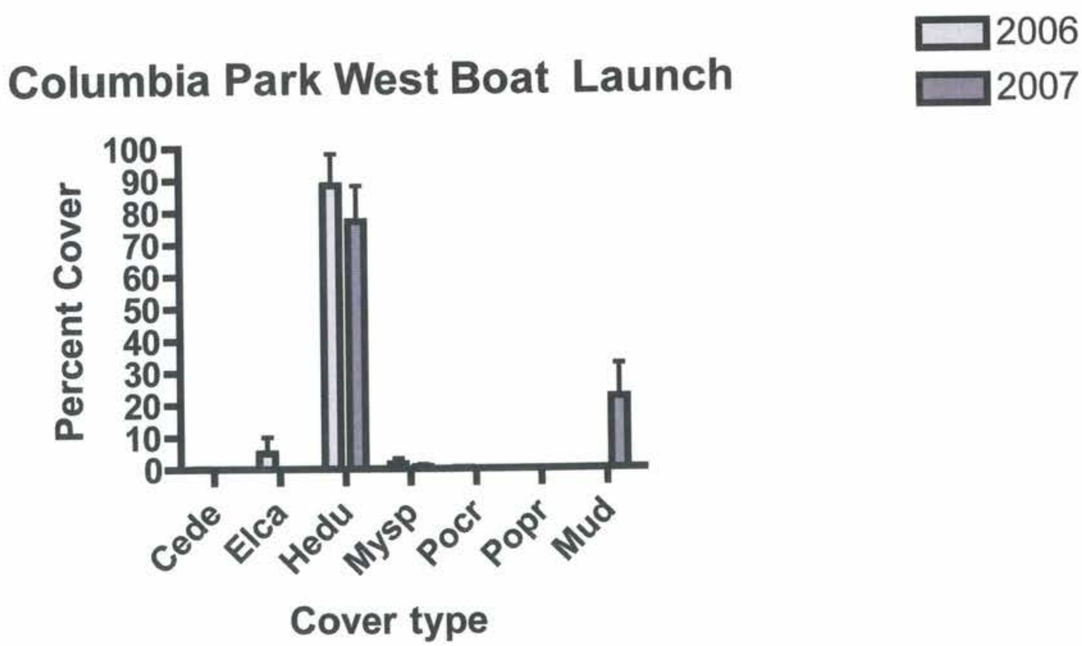

Figure 40. Cover of aquatic plant species and gravel at Columbia Park West Boat Launch in 2006 and 2007. Species codes are in Table 7.

Parks and areas within parks can be prioritized with respect to cover of noxious species and the mean vegetation cover of all species (Table 10). The North Boat Launch of Howard Amon Park has the highest cover of Eurasian watermilfoil followed by Columbia Point Boat Launch, near the swim dock at Howard Amon Park, and the Boat Launch at Leslie Groves Park. Other parks have little if any cover of Eurasian watermilfoil. More intensive control measures such as bottom barriers can be employed at the higher cover areas while the low cover areas can use simpler approaches such as hand pulling to remove a few plants. Boat launch areas have the highest mean vegetative cover among the sites. Eurasian watermilfoil cover increased from 2006 to 2007 in some areas and decreased in other areas (Table 10).

Table 10. Cover of vegetation and noxious weeds in the Columbia River study sites.

Park	**Area**	**Mean vegetation % cover**	**Eurasian watermilfoil % cover**	**Curly pondweed % cover**
		2006, 2007	2006, 2007	2006, 2007
Leslie Groves	Boat launch	97.2, 89.2	14, 18.8	1.8, 7.0
Leslie Groves	Fishing dock	80, 35	10, 0	0, 0
Leslie Groves	Beach	36.8	4.0	0
Howard Amon	North boat launch	94.4, 65	34.3, 27.5	0.1, 2.5
Howard Amon	Near Swim dock	50, 60	10, 20	0, 0
Howard Amon	Lee boat dock	2, 5	0, 5	2, 0
Columbia Pt Boat Launch	Boat launch	56.3, 50	5, 27.5	10, 0
WHY Mud Flat Launch	Dock	10, 0	0 0	0 0
Columbia Park West	Boat launch	95.5, 77.9	1.7, 0.7	0.3, 0

Noxious Aquatic Weeds

Eurasian watermilfoil (*Myriophyllum spicatum* L.)

Noxious weed status

Eurasian water milfoil is a Class B Designate noxious weed in Benton and Franklin counties along the Columbia River (http://www.nwcb.wa.gov/weed_list/regions/region9.htm). Control is required by law (WAC 16-750-011).

Description

Milfoil has finely dissected leaves that form in whorls of four on the stem (Fig. 4). Milfoil leaves fall off as they age, so there may be less than four leaves in a whorl, especially near the bottom of the plant. Leaves near the surface are often a reddish or brown color. Eurasian watermilfoil generally has 12-16 pairs of leaflets on each leaf. It's often difficult to separate Eurasian watermilfoil from its native cousins: northern watermilfoil and whorled watermilfoil.

Growth Habit

Eurasian watermilfoil is the culprit in many nuisance aquatic plant cases in Washington. It has been the subject of much research, and its growth habits are well known. Milfoil over winters as short bright green stems from a few inches to a few feet long - rooted in the sediments. Milfoil stores energy and nutrients in its roots over the winter. In early spring, plants grow rapidly to the surface where they can form a mat or canopy of branches. Rapid spring growth and canopy formation allows milfoil to outgrow and shade out other, more desirable native plants.

Propagation

Milfoil is spread primarily by stem fragments. Fragments are formed when pieces of the plant are cut off of the main plant body, such as by a boat propeller or during harvesting operations. These stems fragments can root and produce new plants. Milfoil also fragments naturally. In the late summer, the stems of milfoil become quite brittle and roots begin to form on the stem. Wave action or a duck paddling though a milfoil bed can cause stems to break.

Key features:

- 12 to 16 leaflets on each leaf
- No emergent leaves
- Emergent flower stalks sometimes are
- Leaves near surface may be reddish or present during the summer and brown (Figs. 7 and 8)
- Milfoil leaflets look like feathers

Curly-leaf pondweed (*Potamogeton crispus*)

Noxious weed status

Curly-leaf pondweed is a Class C noxious weed. A county may enforce control if control is beneficial to that county (for example, to protect crops). In Benton county education and technical support are offered for removal or control.

Description

Curly leaf pondweed has distinctly wavy-edged, crispy olive-green to reddish-brown leaves (Fig. 9). Leaves are alternate, all submersed, with no leaf stalks. Leaves are oblong, stiff, and translucent leaves (4-10 cm long, 5-10 mm wide) with fine teeth along the edges. Each leaf has three main veins. Sheaths (stipules) up to 1 cm long are free of the leaf base and disintegrate with age. It usually grows early in spring and dies back in summer.

Growth Habit

Curly pondweed is a perennial, rooted aquatic plant. Curly-leaf pondweed grows entirely underwater except for the flower stalk, which rises above the water. It is found in shallow to deep still or flowing water, tolerant of disturbance. It is found nearly worldwide. It is native to Eurasia, Africa, and Australia. It has been found in most of the United States since 1950.

Propagation

Curly pondweed produces seed, but the importance of seed in the spread and maintenance of populations is unknown (Stuckey 1979) and is assumed to be less important than turions (Sastroutomo 1981). In most portions of its range, *P. crispus* typically reaches peak biomass in the late spring or early summer months, forms turions (hardened stem tips), then declines and "survives" the warmer months in a dormant state (i.e., as a turion) (Stuckey 1979, (Sastroutomo 1981). As water temperatures cool during the late summer or fall months, the turions germinate, grow through the winter months with the plants reaching peak biomass in the spring before most other submersed macrophytes begin their growth cycle. Once established, the plants regrow and form colonies from rhizomes.

Curly leaf pondweed has a unique life cycle giving it competitive advantages over many native aquatic plants. By late spring it can form dense mats, which may interfere with recreation and limit the growth of native aquatic plants (Catling and Dobson 1985). Curly leaf plants usually die back in early summer in response to increasing water temperatures, but they first form vegetative propagules called turions. New plants sprout from turions in the fall (Catling and Dobson, 1985). In the Columbia River the existing plants found in the fall may have existed through the summer because water temperatures are cool throughout the summer.

Key features:

- No leaf stalks
- Alternate leaves that have curly or wavy edges
- Flowers are tiny with four petal-like lobes.
- Stems are up to 90 cm long and somewhat flattened

AQUATIC PLANT CONTROL ALTERNATIVES

This section outlines common methods used to control aquatic weeds and discusses strategies that have been used to control milfoil and other aquatic vegetation.

Much of the information in this section is quoted directly from the Ecology's website: http://www.ecy.wa.gov/programs/wq/plants/management/index.html.

Control/eradication methods discussed herein include Aquatic herbicides, Hand pulling, Hand cutting, Mechanical cutting, Harvesting, Raking, Diver dredging, Bottom barriers, Bottom tillage (rotovation), Biological methods, Drawdown, and No action. The alternatives take in to account opinions of the steering committee, others, and the public. Some approaches have been used in other water bodies, but are not likely to be applicable such as grass carp or controllable (drawdown) in the Columbia River and are not developed other than noting them and their drawbacks. Other control ideas (Weevils, Ecological restoration) are presented, but since they have not been permitted for use by the Washington Department of Ecology, they are presented as experimental approaches.

Aquatic herbicides

Aquatic herbicides are chemicals specifically formulated for use in water to eradicate or control aquatic plants. Herbicides approved for aquatic use by the United States Environmental Protection Agency (EPA) have been reviewed and considered compatible with the aquatic environment when used according to label directions. However, Washington State may also impose additional constraints on their use.

Aquatic herbicides are applied to the water in either a liquid or pellet form. Systemic herbicides kill the entire plant by translocating from foliage or stems and killing the root. Contact herbicides cause the parts of the plant in contact with the herbicide to die, leaving the roots alive and capable of re-growth (chemical mowing). Non-selective herbicides will affect all plants that they come in contact with. Selective herbicides will affect only some plants, usually dicots – broad leafed plants like Eurasian watermilfoil, will be affected by selective herbicides whereas monocots like some native pondweeds may not be affected.

Because of environmental risks from improper application, aquatic herbicide use in Washington State is regulated with certain restrictions. The Washington State Department of Agriculture licenses aquatic applicators. In addition, because of the March 2001 court decision (Federal 9th Circuit District Court), coverage under a discharge permit called a National Pollutant Discharge Elimination System (NPDES) permit must be obtained before aquatic herbicides can be applied to some waters of the U.S. This ruling, referred to as the Talent Irrigation District decision, has further defined Section 402 of the Clean Water Act. Ecology has developed a general NPDES permit, which is available for coverage under the Washington Department of Agriculture for the management of noxious weeds growing in an aquatic situation and a separate general permit for nuisance aquatic weeds (native plants). For nuisance weeds (native species also referred to as beneficial vegetation), applicators and the local sponsor of the project must obtain a NPDES permit from the Washington Department of Ecology before applying herbicides to Washington water bodies.

Although there are a number of EPA registered aquatic herbicides, the Department of Ecology currently is considering permits for eight aquatic herbicides as of Oct. 3, 2007 (Anonymous 2007b). Other herbicides are undergoing review and it is likely that other chemicals may be approved for use in Washington in the future. As an example, Renovate® (Triclopyr) was approved by the U.S. EPA for aquatic use in November 2002, making it the first aquatic herbicide to receive registration since 1988. Renovate® was recently approved for use in Washington waters. It should prove very effective on Eurasian watermilfoil and may be used in the Columbia River in future years.

The use of herbicides in the Columbia River depends on how fast the water is flowing in a potential application area. Liquid applications are likely to wash away from the application area immediately in high flow portions of the river. In lower flow areas a liquid application will still be washed away. Options for chemical use in the Columbia River are improved by using granular herbicides that can fall to the bottom and gradually exude active ingredient into the water near plants. Other options are to place a curtain in the water to reduce flow rates in an application area or to use a tent that can reduce flow rates in a small area (Mason Lake Project: An Innovative Approach to Using Aquatic Herbicides, http://www.ecy.wa.gov/programs/wq/plants/management/Mason_Lake_Project.html).

Tank mixes are permitted in the state of Washington for the control of aquatic weeds in public waterways (Kathy Hamel, personal communication). Ecology must approve the specific formulation as well as the active ingredient. "Inert materials" in a formulation may interact with the pesticide to give antagonistic, additive, cumulative or synergistic effects against target plants (aquatic weeds and algae) and non-target fish and aquatic invertebrates. For example, endothall acid is considerably more toxic to rainbow trout and bluegill sunfish when certain "inerts" are added, possibly due to a synergistic effect.

If surfactants are used, care should be taken to use those registered for aquatic uses since they have potential toxicity to fish (Anonymous 2001a). Thickening agents like Polysar® or Nalquatic® are used in other states to control drift with liquid endothall products that are applied to floating weeds and may also allow subsurface applications to sink more deeply into the water column where they can be most effective. However, these two adjuvants are not registered for use in Washington State and therefore are not allowed for distribution here (Anonymous 2001a)

Follow-up is essential to ensure the success of chemical applications. For example, used alone, 2,4-D and triclopyr are generally not eradication tools (Anonymous 2005). Some plants typically survive the treatment and regrow, so these plants must be removed by other means. Even a few milfoil fragments can start a new infestation, or boaters may reintroduce milfoil into the lake. Diver and surface inspections should continue at least twice a year during the growing season. Survey work should be as frequent as can be afforded, since small milfoil plants or fragments may be easily overlooked, especially within native plant beds. Surveys done in Minnesota indicated that 2,4-D use by itself did not result in eradication of milfoil over the long term (Crowell 1999). Treated lakes for which there was no follow up survey work or treatment eventually ended up with milfoil throughout the littoral zone. There is some anecdotal evidence that repeated treatments may select for plants that are more resistant to 2,4-D. If this occurs and the plant population is too large to be hand removed, consider using triclopyr. There is also some anecdotal evidence that milfoil may germinate from seeds in areas where water levels dropped and then returned. This may happen in low rainfall or low runoff years. It is important to check those areas when the water returns in order to remove any milfoil that may have germinated (Anonymous 2005).

Technique

The primary application methods and nozzle considerations in aquatic weed control (FACT SHEET FOR AQUATIC NOXIOUS WEED CONTROL GENERAL NPDES PERMIT, http://www.ecy.wa.gov/Programs/wq/pesticides/final_pesticide_permits/noxious/finalnoxiousfactsheetfeb3.pdf) are:

1. Subsurface injection just below the water surface for submersed weed control: Usually short hoses are spaced at approximately 2-ft intervals on a short, bow or stern mounted boom. Hoses are just long enough to place the nozzle at the water surface or just below it. The nozzle body contains a disk that meters the flow into the water.

2. Bottom placement or deep-water injection: Nozzles are located at the end of long hoses that trail from a boom on the bow of the boat. Hoses are usually weighted to keep the herbicide placement deep within the weed mat or near the bottom. A common arrangement involves constructing a nozzle by drilling small holes in a piece of galvanized pipe. The length of the pipe depends on how much weight is needed to lower the hose to the desired depth. Pipe length varies from 9 to 30 in. The pipe is capped on one end and attached to the hose on the other. Deep-water injection hoses must not have any clamps or protrusions that will catch and hold plants.

3. Bow-mounted centrifugal or blower-type spreaders: Granular herbicides are normally applied with a bow-mounted centrifugal or blower-type spreader. Centrifugal spreaders use a rotor that slings the material. Blower-type spreaders use air pressure to propel the granules.

The aquatic herbicides that are currently permitted for use in 2007 (Anonymous 2007b) and may be effective for control of Eurasian watermilfoil in the Columbia River are:

- Diquat dibromide
- Endothall
- 2, 4-D
- Fluridone
- Triclopyr

Imazapyr, while registered for use in Washington (Anonymous 2007b), is not recommended for any submerged aquatic species in Florida (http://plants.ifas.ufl.edu/guide/sup3herb.html#imazherb) and will not be developed here. Glyphosate, also registered for use in Washington (Anonymous 2007b), is not effective on submerged plants (Anonymous 2001a) and will not be developed here.

Diquat dibromide

Westerdahl and Getsinger (1988) report excellent control with diquat. Dibromide – 6,7-dihydrodipyrido (1,2-a:2',1''-c) pyrazinediium dibromine - (REWARD®) or Diquat is authorized for use in aquatic environments in Washington State to control submerged aquatic plants subject to all Federal Insecticide, Fungicide, Rodenticide Act (FIFRA) label requirements and the following conditions:

1. Treatment with Diquat can be used on submersed plants. A two-meter buffer from the shoreline must be used except for noxious weed control.
2. Diquat treatments are subject to Washington Dept. of Fish and Wildlife timing tables (http://www.ecy.wa.gov/programs/wq/pesticides/final_pesticide_permits/noxious/timingrestrictionslakes032503.doc).
3. No treatments are allowed where state and federal Endangered Species Act (ESA)-listed species may be present until the appropriate agencies are contacted and a mitigation plan is prepared to protect the species. Buffers and other protective measures must be employed for any known endangered plant species when necessary to protect

them.

4. The following buffer applies unless otherwise mitigated through an approved Integrated Aquatic Vegetation Management Plan or if treating noxious weeds:
    a. Flowing water (e.g., rivers, streams, canals): Do not apply within 1600 feet upstream of operating potable water intake sites.
5. Except for early infestation of noxious weeds, the second treatment (and treatments thereafter) are only allowed under an approved integrated Aquatic Vegetation Management Plan.
6. A 24-hour swimming advisory must be posted at all public entry sites to the treatment area warning that exposure to treated water may result in eye irritation. Diquat dibromide is a moderately toxic chemical for mammals, birds, fish, and invertebrates.
7. Although allowed by label, pouring Diquat concentrate into water directly from the container is prohibited.

Details on Diquat and environmental impacts are reviewed in Anonymous (2001a).

Breakdown in water: Information on breakdown in water was taken from the Extension Toxicology Network (http://extoxnet.orst.edu/pips/diquatdi.htm). Studies on the erosion of diquat-treated soils near bodies of water indicate that diquat dibromide stays bound to soil particles, remaining biologically inactive in surface waters, such as lakes, rivers, and ponds. When diquat dibromide is applied to open water, it disappears rapidly because it binds to suspended particles in the water. Diquat dibromide's half-life is less than 48 hours in the water column, and may be on the order of 160 days in sediments due to its low bioavailability. Microbial degradation and sunlight play roles in the breakdown of the compound. At 22 days after a weed infested artificial lake was treated, only 1% of the applied diquat dibromide remained in the water and 19% was adsorbed to sediments.

Technique

REWARD® is a contact herbicide. For Eurasian watermilfoil use 1 to 2 gallons REWARD® per surface acre applied either as an invert emulsion or deliver diluted REWARD® to near the bottom of the water body with weighted hoses. A non-selective, highly active contact material, REWARD® spreads quickly through the water and makes fast contact with aquatic weeds. Water-soluble, it is absorbed by target plants in just minutes, providing broad-spectrum control of submersed weeds.

Advantages

- Effective and non-selective so it will kill all vegetative elements it comes in contact with for nuisance conditions.
- Fast acting

Disadvantages

- Will damage all vegetation and should not be used unless in a monoculture of Eurasian watermilfoil or in nuisance conditions.

- Requires a tent or curtain to maintain the chemical in place in the fast waters of the Columbia River.
- Would require repeated treatment.
- Monitoring of herbicide levels in the water is required
- Many people have strong feelings against using herbicides in water.

Permits

As of Oct. 10, 2007 the Washington Department of Ecology is issuing joint NPDES and state waste discharge general permits for the use of aquatic herbicides. The use of herbicides in a river is covered under the Aquatic Noxious Weed Control NPDES General Permit. This permit is in the process of being reissued with an expected issuance date is February 6, 2008. The draft permit is available online (http://www.ecy.wa.gov/programs/wq/pesticides/index.html).

A NPDES permit is needed. For noxious weed control, the applicator must apply to the Washington Department of Agriculture (WSDA) for coverage under their NPDES permit each treatment season. There is no permit or application fee to obtain NPDES coverage under Agriculture's permit for Noxious Weeds. The City of Richland may require a permit for application of herbicide in Sensitive Areas to submergent aquatic plants. This falls under their Clearing and Grading Permit. Diquat treatments are subject to Washington Dept. of Fish and Wildlife timing tables (http://www.ecy.wa.gov/programs/wq/pesticides/final_pesticide_permits/noxious/timingrestrictionslakes032503.doc).

Costs

It is estimated to cost about $340/acre for chemical and application (Anonymous 2007a). A 100-foot long and 10 foot deep curtain costs $2576.

Other considerations

Details on Diquat and environmental impacts are reviewed in Anonymous (2001b).

Suitability for the City of Richland Parks in the Columbia River

Diquat is only suitable when applied under controlled conditions where the chemical can be maintained within a curtain or in a tent. Chemical use in the river would require public notification and restrictions on the use of the river during application.

Endothall

Westerdahl and Getsinger (1988) report excellent control with endothall dipotassium salt. Aquathol® - Active ingredient the dipotassium salt of endothall. Aquathol® is a fast-acting non-selective contact herbicide, which destroys the vegetative part of the plant but does not kill the roots. Aquathol® may be applied in a granular or liquid form. Generally endothall compounds are used primarily for short-term (one season) control of a variety of aquatic plants. However, there has been some recent research that indicates that when used in low concentrations, Aquathol® can be used to selectively remove exotic weeds, leaving some native species relatively unaffected. Because it is fast acting, Aquathol® can be used to treat smaller areas effectively. There are water use restrictions associated with the use of Aquathol® in Washington.

Aquathol® will control the aquatic macrophytes listed on the label including milfoil (*Myriophyllum* spp.), pondweed (*Potamogeton* spp., and coontail (*Ceratophyllum* spp.) Aquathol® Super K should not be used to control species of weeds that are not specified on the label. *Elodea canadensis* is known to be tolerant to Aquathol® and may become dominant after other more susceptible species have been controlled.

Liquid formulations can be expected to result in higher initial water concentrations than granular formulations, since all of the endothall is applied directly to the water. Granular formulations generally yield higher endothall sediment concentrations and longer persistence in or on sediments due to a prolonged release of endothall from the granules. Granular formulations can therefore result in lower water concentrations that may persist somewhat longer than if liquid formulations are used.

Technique

Aquathol Super K should be applied while plants are actively growing. The granular material can be applied with a cyclone spreader. Treatment of milfoil species is described on the product label (http://plants.ifas.ufl.edu/guide/aquatholsuperk_label.pdf) and indicates that for spot or water margin treatment that 13.2-17.6 lbs./acre foot be applied. The rate for application in 5 feet of water then is 66-88 lbs./acre. The label needs to be followed and permits obtained before using this herbicide.

Aquathol is only suitable when applied under controlled conditions where the chemical can be maintained within a curtain or in a tent.

Advantages

- Effective and not extremely selective. May be able to damage Eurasian watermilfoil and Curly pondweed with less damage to Canadian waterweed so it may be useful for somewhat selective control of the noxious weeds.
- The granular form may work better in a river than the quickly diluted liquid formulation.

Disadvantages

- Requires a tent or curtain to maintain the chemical in place in the fast waters of the Columbia River.
- Would require repeated treatment.
- Monitoring of herbicide levels in the water is required
- Many people have strong feelings against using herbicides in water.

Permits

As of Oct. 10, 2007 the Washington Department of Ecology is issuing joint NPDES and state waste discharge general permits for the use of aquatic herbicides. The use of herbicides in a river is covered under the Aquatic Noxious Weed Control NPDES General Permit. This permit is in the process of being reissued with an expected issuance date is February 6, 2008. The draft permit is available online (http://www.ecy.wa.gov/programs/wq/pesticides/index.html).

A NPDES permit is needed. For noxious weed control, the applicator must apply to the Washington Department of Agriculture (WSDA) for coverage under their NPDES permit each treatment season. There is no permit or application fee to obtain NPDES coverage under Agriculture's permit for Noxious Weeds. The City of Richland may require a permit for application of herbicide in Sensitive Areas to submergent aquatic plants. This falls under their Clearing and Grading Permit. Endothall treatments are subject to Washington Dept. of Fish and Wildlife timing tables (http://www.ecy.wa.gov/programs/wq/pesticides/final_pesticide_permits/noxious/timingrestrictionslakes032503.doc).

Costs

It is estimated to cost about $340/acre for chemical and application (Anonymous 2007a). A 100-foot long and 10 foot deep curtain costs $2576.

Other considerations

Details on endothall and environmental impacts are reviewed in Anonymous (2001b).

Suitability for the City of Richland Parks in the Columbia River

Endothall is only suitable when applied under controlled conditions where the chemical can be maintained within a curtain or in a tent. Chemical use in the river would require public notification and restrictions on the use of the river during application.

2, 4-D

Westerdahl and Getsinger (1988) report excellent control with 2,4-D. 2,4-D (2,4-Dicholorophenoxy acetic acid) is the active component in a variety of systemic herbicide products used for both terrestrial and aquatic application sites. 2,4-D is a selective plant hormone type product that is translocated within the plant to the susceptible sites. Its mode of action is primarily as a stimulant of plant stem elongation. 2,4-D stimulates nucleic acid and protein synthesis and affects enzyme activity, respiration and cell division. It is absorbed by plant leaves, stems, and roots and moves throughout the plant, accumulating in growing tips. Its primary use is as a post-emergent herbicide.

2,4-D is formulated in a multitude of forms, however only two active ingredient forms are currently being supported by the manufacturers for use in aquatic sites. These are the dimethylamine salt (DMA*4IVM®) and the butoxyethyl ester (2,4-D BEE). Only the liquid formulation is allowed to be used in lakes with salmon populations (Anonymous 2001a) and thus in the Columbia River.

DMA*4IVM® - Dimethylamine Salt of 2,4-D is a liquid formulation that is labeled for aquatic weed control. 2,4-D DMA is rapidly converted to 2,4-D acid, effective in controlling Eurasian watermilfoil.

2,4-D can be effective for spot treatments of Eurasian watermilfoil. 2,4-D has been shown to be selective in controlling Eurasian watermilfoil when used at the labeled rate, leaving native aquatic grass species relatively unaffected.

Sites suitable for treatment include water bodies partially infested with Eurasian watermilfoil and water bodies where Eurasian watermilfoil has recently invaded, but where the extent of the infestation is beyond what can be removed by hand pulling or bottom barriers. In these situations, a herbicide like 2,4-D can be used to reduce the amount of Eurasian watermilfoil so that hand pulling can remove any Eurasian watermilfoil plants that are not killed by the herbicide. 2,4-D is suitable for spot treatments because it is a fast-acting herbicide that only needs a 48-hour contact time with the plant.

A few days after the 2,4-D treatment, the growing tips of Eurasian watermilfoil plants twist and look abnormal. These plants will sink to the sediments usually within one to two weeks after treatment. Unless treatment takes place in dense beds of Eurasian watermilfoil, it is unlikely for low oxygen conditions to develop during the decomposition process. Results of spot treatment may be variable depending on water movement, size of treatment plot, size of the water body, density of Eurasian watermilfoil, weather conditions, underwater springs, etc.

Follow-up is essential to ensure eradication. Without follow-up, 2,4-D is not an eradication tool. Some plants will likely survive the treatment and re-grow, so these plants must be removed by other means or controlled with a follow-up treatment (Anonymous 2007a).

Another important physical process affecting 2,4-D persistence in larger water bodies is transport of treated water away from the treated area and replacement with untreated water through lateral circulation or vertical movement of water. As a result, use of 2, 4-D compounds in the Columbia River would require use of curtains or tents to hold the chemical close to the plant and long enough to be effective

Exposure to salmonids at all life stages must be avoided. When treatments are unavoidable due to infestations of noxious aquatic weeds that compromise designated uses of a water body (as specified under WAC 173-201A-030(5) or WAC 173-201A-120(1) when revised) applicants should use the lowest effective concentration. If endangered species are present, WDFW must sign off on the application prior to treatment. Follow label restrictions for oxygen ratios.

Technique (Anonymous 2001a)

The liquid formulation of 2,4-D is applied using subsurface trailing hoses to give a water concentration of 2-4 ppm. The amount of gallons used per treatment depends on the water depth at the treatment sites. In 2003, Spring Lake was treated with liquid 2,4-D for an established, but not widespread, infestation of milfoil. In 2004, no milfoil was detected in either the spring or the summer survey. A specimen label for DMA®4VM is at http://www.cdms.net/ldat/ld4JS000.pdf.

Advantages

- 2,4-D DMA has been shown to be effective in controlling smaller infestations of Eurasian watermilfoil in Washington.

Disadvantages

- Non-targeted plants as well as nuisance plants may be controlled or killed by 2,4-D DMA.
- Water users must be identified prior to herbicide application. Water within the treatment areas cannot be used for drinking until 2,4-D concentrations have declined to 70 ppb at the intake and water used for irrigation cannot be used until the concentrations are 100 ppb or less at the intake.
- Monitoring of herbicide levels in the water is required
- The Washington State Department of Ecology recommends that swimmers stay out of the treatment area for 24-hours after 2,4-D treatment.
- Use in the Columbia River would require curtains or tents and would restrict use of those parts of the river while the area is being treated.
- Many people have strong feelings against using 2,4-D DMA in water.

Permits

As of Oct. 10, 2007 the Washington Department of Ecology is issuing joint NPDES and state waste discharge general permits for the use of aquatic herbicides. The use of herbicides in a river is covered under the Aquatic Noxious Weed Control NPDES General Permit. This permit is in the process of being reissued with an expected issuance date is February 6, 2008. The draft permit is available online (http://www.ecy.wa.gov/programs/wq/pesticides/index.html).

A NPDES permit is needed. For noxious weed control, the applicator must apply to the Washington Department of Agriculture (WSDA) for coverage under their NPDES permit each treatment season. There is no permit or application fee to obtain NPDES coverage under Agriculture's permit for Noxious Weeds. The City of Richland may require a permit for application of herbicide in Sensitive Areas to submergent aquatic plants. This falls under their Clearing and Grading Permit. 2,4-D treatments are subject to Washington Dept. of Fish and Wildlife timing tables (http://www.ecy.wa.gov/programs/wq/pesticides/final_pesticide_permits/noxious/timingrestrictionslakes032503.doc).

Costs

Approximate costs for one-acre herbicide treatment (costs will vary from site to site) is $500-700 (Anonymous 2007a). The cost of the amine formulation of 2,4-D is about $300 per acre (Kathy Hamel, personal communication). A 100-foot long and 10 foot deep curtain costs $2576.

Other Considerations

EPA studies yield the parameters LD50 (acute lethal dose to 50% of a test population), NOEL (No Observable Effect Level, which is the highest test dosage causing no adverse responses), and RfD (EPA Reference Dose determined by applying at least a 100-fold uncertainty factor to the NOEL). The EPA defines the RfD as the level that a human could be exposed to daily with reasonable certainty of no adverse effect from any cause, in other words, a "safe" dose. Exposures to bystanders or consumers are deemed safe when the RfD is not exceeded (Felsot 1998). Since all substances, natural or manmade, may prove toxic at a sufficiently high dose, one should remember the old adage "dose makes the poison." The LD50 value is useful for comparing one compound with another and for grouping compounds into general hazard classes.

According to Felsot (1998), any pesticide, such as 2,4-D, that does not produce adverse effects on aquatic organisms until levels in water reach milligram per liter (i.e., mg/L, equivalent to a part per million, ppm) would be considered of comparatively low hazard. Substances that are biologically active in water at levels one thousand- fold less, (i.e., µg/L, parts per billion, ppb), are considered highly hazardous to aquatic life. Most pesticides falling in the latter category are insecticides rather than herbicides.

Also, compounds that have half-lives less than 100 days are considered non-persistent. The half-life of 2,4-D is about 7 days in water.

As far as restrictions for aquatic 2,4-D applications, there is no fishing restriction, and three to five days after treatment the water is generally below the drinking water standard (70ppb, irrigation standard is 100ppb for broad-leafed plants). Although 2,4-D should not damage grass or other monocots, it is not recommended that one use treated water to water lawns during this first three to five days since over-spray will kill ornamentals or plants such as tomatoes and grapes that are very sensitive to 2,4-D. There is no swimming restriction for 2,4-D use. Ecology advises that swimmers wait for 24 hours after application before swimming in the treatment area, but that is an advisory only. The choice is up to the individual. There is little risk for human and mammalian health at label dose levels of 2,4-D (Anonymous 2001b).

Based on laboratory data reported in the Department of Ecology's Risk Assessment of 2,4-D, 2,4-D DMA has a low acute toxicity to fish (LC50 ≥100 to 524 mg a.i./L for the rainbow trout and bluegill sunfish respectively). No Federally sensitive, threatened or endangered species were tested with 2,4-D DMA. However, it is likely that endangered salmonids would not exhibit higher toxic effects to 2,4-D DMA than those seen in rainbow trout. Since the maximum use rate of 2,4-D DMA would be no higher than the maximum labeled use rate (4.8 mg a.i./L) even the most sensitive fish species within the biota should not suffer adverse impacts from the effects of 2,4-D DMA. In conclusion, 2,4-D DMA will not effect fish or free-swimming invertebrate biota acutely or chronically when applied at typical use rates of 1.36 to 4.8 mg a.i./L (Washington State Dept. of Ecology, 2001b). However, more sensitive species of benthic invertebrates like glass shrimp may be affected by 2,4-D DMA, but 80 and 90% of the benthic species should be safe when exposed to 2,4-D DMA acutely or chronically at rates recommended on the label. Fieldwork indicates that 2,4-D has no significant adverse impacts on fish, free-swimming invertebrates and benthic invertebrates, but well designed field studies are in short supply.

Suitability for the City of Richland Parks in the Columbia River

Use of 2,4-D DMA in the City of Richland Parks may not be easily accepted by the public. These chemicals require significant regulatory review for approval for use and significant expenses for curtains and tents making this approach more difficult than non-chemical strategies. This approach can be considered as a last resort.

Fluridone

Fluridone (Trade names include: Sonar® and Avast!®) is a slow-acting systemic herbicide used to control Eurasian watermilfoil and other submersed plants. It may be applied as a pellet or as a liquid. Westerdahl and Getsinger (1988) report good control with fluridone. In Washington, fluridone (brand name Sonar®) has been successfully used to eradicate Eurasian watermilfoil in Steel Lake, King County; Goss Lake, Island County; and Carlisle Lake, Lewis County. In other lakes where eradication using Sonar® was attempted, generally all but a few milfoil plants remained. To be effective, fluridone concentrations of 10-15 ppb must be maintained in the water column for 10 to 12 weeks. Follow-up diver surveillance and hand pulling of surviving plants is essential to the success of this technique. Some eradication attempts with fluridone have had mixed success in Washington. Factors such as surface and ground water inflows affect the success rate. Fluridone can offer excellent control of submersed plants where there is very little water movement and an extended time for plants to absorb the herbicide is allowed. Its use in the Columbia River would be limited and would require long periods of isolation to keep the chemical concentrated enough the have an effect on Eurasian watermilfoil, thus Fluridone is not recommended.

Triclopyr

Unlike fluridone, triclopyr requires a short contact time (18 to 48 hours) and will selectively control Eurasian watermilfoil while leaving many native aquatic plants relatively unaffected. Triclopyr is fast acting (24-48 hour contact time) herbicide that can control infestations of Eurasian watermilfoil and other broad-leaf water plants (Anonymous 2005). Eurasian watermilfoil is more sensitive to triclopyr than many native aquatic species including coontail, rushes and cattails. Triclopyr can therefore be used at label concentrations to remove Eurasian watermilfoil without killing many native plants. One triclopyr product is currently registered and marketed for aquatic weeds - Renovate 3™. The U. S. Corps of Engineers indicates triclopyr shows a low order of toxicity to microbial communities and higher aquatic organisms and residue accumulation in sediment, shellfish, and fish is negligible (Netherland and Getsinger 1992).

Technique

Triclopyr is a liquid formulation and is applied using subsurface trailing hoses to achieve a water concentration of 0.75 to 2.5 ppm (Anonymous 2005). The total amount of gallons used depends on the water depth in the treatment area. The greater the water exchange in the water body, the higher the application rate needs to be. Areas may need to be treated twice; however, the amount of triclopyr applied cannot exceed 2.5 ppm per treatment area for the growing season. A curtain or tent is needed to maintain adequate exposure time in the Columbia River. A specimen label for Renovate3™ is at http://www.sepro.com/documents/Renovate_Label.pdf.

Advantages

- Triclopyr (Renovate3™) has been shown to be effective in controlling small infestations of Eurasian watermilfoil in Washington (Anonymous 2005).
- Triclopyr is not subject to timing and can be applied outside of the salmon work windows defined by the Washington State Department of Fish and Wildlife.

Disadvantages

- Coontail Canadian waterweed may be adversely impacted by treatment rates higher than 2.5 ppm a.i. (Anonymous 2001b).
- Water cannot be used for irrigation until triclopyr in the water intakes is undetectable by laboratory analysis. Drinking water cannot be used until triclopyr is 40 ppb or less measured at the intake.
- Monitoring of herbicide levels in the water is required
- The Washington State Department of Ecology has imposed a 12-hour swimming restriction after treatment with triclopyr.
- Ground water or sediment monitoring is required prior to the third application of triclopyr on a previously treated site within a three-year period.
- Use in the Columbia River would require curtains or tents and would restrict use of those parts of the river while the area is being treated.
- Many people have strong feelings against using herbicides in water.

Permits

As of Oct. 10, 2007 the Washington Department of Ecology is issuing joint NPDES and state waste discharge general permits for the use of aquatic herbicides. The use of herbicides in a river is covered under the Aquatic Noxious Weed Control NPDES General Permit. This permit is in the process of being reissued with an expected issuance date is February 6, 2008. The draft permit is available online (http://www.ecy.wa.gov/programs/wq/pesticides/index.html).

A NPDES permit is needed. For noxious weed control, the applicator must apply to the Washington Department of Agriculture (WSDA) for coverage under their NPDES permit each treatment season. There is no permit or application fee to obtain NPDES coverage under Agriculture's permit for Noxious Weeds. The City of Richland may require a permit for application of herbicide in Sensitive Areas to submergent aquatic plants. This falls under their

Clearing and Grading Permit.

Costs

Approximate costs for one-acre herbicide treatment (costs will vary from site to site) is $950 (Anonymous 2007a). A 100-foot long and 10 foot deep curtain costs $2576.

Suitability for the City of Richland Parks in the Columbia River

Use of Triclopyr in the City of Richland Parks may not be easily accepted by the public. These chemicals require significant regulatory review for approval for use and significant expenses for curtains and tents making this approach more difficult than non-chemical strategies. This approach can be considered as a last resort.

Physical Methods

Hand-pulling

Technique

During hand pulling, milfoil plants are manually removed from the bottom, with care taken to remove the entire root crown and not create fragments. In deeper water, divers are usually needed to reach the plants.

Due to expense and the time intensive nature of manual methods, sites suitable for hand pulling are limited to areas only lightly infested with Eurasian watermilfoil. This method is suitable for very early infestations of milfoil and for follow-up removal after a chemical treatment, or other approaches. To be cost-effective, generally the total amount of milfoil in the water body should be three-acres or less in area, if all the milfoil plants were grouped together in one location. This is on the order of the size of infestation in the Richland Parks system. If the infestation advances beyond this point, it is more effective to consider other eradication techniques.

Hand pulling can be done easily in areas with sufficient silt to allow for easy removal of the entire root crown. This condition occurs at the WHY Mudflats boat launch and at the Columbia Park West boat launch. Other areas primarily have a cobble bottom. The ability to remove root crowns from cobble substrates is not known for the Columbia River. It may be possible to use hand tools to dig rootballs from cobble substrates.

Hand pulling has been used in Washington and mainly in lakes. The Washington State Department of Ecology has produced an assessment of hand pulling (*http://www.ecy.wa.gov/programs/wq/plants/management/manual_strategies.html*) and a version is presented here with adaptations to the Columbia River

Lakes where manual methods are being used for milfoil eradication typically have milfoil lightly scattered singly or in small patches within the littoral zone. To determine the extent of the infestation, the littoral zone of the lake is surveyed immediately prior to starting control work and milfoil locations are mapped and Global Positioning System (GPS) points established. Mapping can be done in this manner in the City of Richland Parks where control of aquatic vegetation (milfoil) is needed. The survey can be conducted prior to the removal effort. Hand pulling can begin as soon as milfoil can be easily seen and identified - generally in the spring or as soon as it is discovered.

Both surface and underwater surveys should be conducted several times during the growing season. During the surface survey, a surveyor moves slowly through the littoral zone in a boat, looking into the water (often using a viewing tube), and marking the locations of milfoil plants with buoys. Surveyors advise wearing wide-brimmed hats, polarized sunglasses, and looking straight down into the water. Wind, rain, or surface disturbance, such as boat wakes, interferes with the ability to see. Morning to noon is often the most suitable time for survey work.

The surface survey is immediately followed by an underwater diver survey. Because known milfoil locations have been marked during the surface surveys, the divers can concentrate their efforts at these locations. Since diver time is expensive, it can be cost-effective to conduct surface surveys before underwater surveys.

During hand pulling, the divers dig around and beneath the plant roots with their hands or with a tool and gently lift the entire plant out of the sediment. The ease of removal is dependent on sediment type. Milfoil plants can be readily removed from loose or flocculent sediments. In hard sediments or rocky substrate, hand tools must be used to loosen the root crown before the plant can be dislodged. Sometimes fine roots are left behind; these will not regrow, but it is important to remove the root crown (the fleshy, fibrous roots at the base of the stem). Once plants are removed, the diver places them into bags for transportation to the surface. Sometimes divers may use a suction device to deliver the plant to the surface. The plant is sucked up into the boat (generally using a gold dredge), the plants are retained in a sieve, and the water is discharged back into the lake.

In locations with denser milfoil colonies, divers should make several passes through the area to ensure that all plants have been located and removed. As the divers work, the people in the support boat mark the locations of milfoil plants. An accurate location is important since the areas need to be resurveyed a few weeks later. There have been instances when small fragments or plants have been overlooked and have become large plants upon resurvey. Removed plants can be used for compost rather than having to be discarded as solid waste.

Special care must be taken to prevent the release of milfoil fragments. At certain times of the year (generally after flowering), milfoil plants can fracture into hundreds of fragments, each having the potential to form a new plant. To help contain the fragments, individual plants may be covered with a mesh bag before they are pulled. The driver of the diver support boat must also be careful not to create additional fragments by keeping the boat and propeller out of the milfoil plants. People in the support boat should use net skimmers to retrieve any fragments accidentally released by the divers.

Hand pulling may increase turbidity in the area of removal. This can affect the efficacy of removal if the turbidity interferes with the ability of the divers to see the milfoil plants.

Advantages

- Hand pulling easy around docks and swimming areas.
- The equipment is inexpensive.
- Hand-pulling allows removal of undesirable aquatic plants while leaving desirable plants.
- Hand pulling is environmentally safe.
- Hand pulling does not require expensive permits.

Disadvantages

- As plants re-grow or fragments re-colonize the cleared area, the treatment may need to be repeated several times each year.
- Because hand pulling is labor intensive, it may not be practical for large areas or for thick weed beds.
- The strategy is expensive using divers in the deeper waters of the Park system.
- Even with the best containment efforts, it is difficult to collect all plant fragments leading to re-colonization.
- Pulling weeds stirs up the sediment and makes it difficult to see remaining plants.
- Hand pulling impacts bottom-dwelling animals.

Permits

Hydraulic Project Approval is required for all hand pulling projects. This permit is given in a pamphlet called Aquatic Plants and Fish (http://www.wdfw.wa.gov/hab/aquaplnt/aquaplnt.htm) and is available from the Washington Department of Fish and Wildlife.

Costs

Hand pulling, using divers, could cost up to $50/h for each diver and expenses for a boat and operator ($50/h). Expenses for removal of the plant material have to be considered. Costs for disposal include a truck and charges for using the Richland landfill. These costs will go down if the material can be used for mulch. Costs also need to be included for repeated surveys to determine the efficacy of the work. Two divers and a boat tender could cost $1200/day. It may be possible to hand pull Eurasian watermilfoil for $6000/acre, but a better estimate of costs will require initial trials.

Other considerations

Hand pulling will cause some fragmentation of milfoil increasing risk of recolonization. This risk is more significant in lakes, but is less of an issue in the Columbia River where fragments continually enter Park areas from upstream. It is good neighborly practice to remove as much of the plant as possible, but it not likely that loss of some fragments will greatly impact downriver resources.

Suitability for the City of Richland Parks in the Columbia River

Hand pulling is suitable for many elements of the City park system. Using divers to hand puller in boat launch areas would require notification and signage to direct boaters to other launch sites.

Hand Cutting

Technique

Cutting differs from hand pulling in that plants are cut and the roots are not removed. Cutting is performed by standing on a dock or on shore and throwing a cutting tool out into the water. A non-mechanical aquatic weed cutter is commercially available. Two single-sided, razor sharp stainless steel blades forming a "V" shape are connected to a handle, which is tied to a long rope. The cutter can be thrown about 20 – 30 feet into the water. As the cutter is pulled through the water, it cuts a 48-inch wide swath. Cut plants rise to the surface where they can be removed. Washington State requires that cut plants be removed from the water. The stainless steel blades that form the V are extremely sharp and great care must be taken with this implement.

Advantages

- Cutting is easy around docks and swimming areas within 20 feet of shore.
- Removes all vegetation including nuisance native species.
- Immediate removal.
- The equipment is inexpensive.
- Will not impact bottom-dwelling animals.
- Hand cutting does not require expensive permits.

Disadvantages

- As plants re-grow or fragments re-colonize the cleared area, the treatment may need to be repeated several times each year.
- Even with the best containment efforts, it is difficult to collect all plant fragments, leading to re-colonization.

Permits

Hydraulic Project Approval is required for cutting projects. This permit is given in a pamphlet called Aquatic Plants and Fish (http://www.wdfw.wa.gov/hab/aquaplnt/aquaplnt.htm) and is available from the Washington Department of Fish and Wildlife.

Costs

Cutting is less expensive than hand pulling with divers because entry into the water is not needed. A commercial grade weed cutter costs about $130 with accessories. This approach, when done from shore or from a dock, only requires two workers, one to cut and the other to gather the vegetation and place it in a truck. This could be done by the City or contracted out for about $30/h for each worker. Costs for truck use and landfill charges depend on how much material is gathered. It is likely that a single boat launch area could be cleaned and material disposed of in one day. Using the material for mulch will be less expensive than taking the material to the landfill.

<u>Suitability for the City of Richland Parks in the Columbia River</u>

Cutting is not considered to be a suitable method for controlling milfoil when the infestation is in early stages, but is considered suitable for managing nuisance native plants (Anonymous 2005). Cutting is considered suitable when milfoil dominates the aquatic vegetation because the effect of cutting on fragmentation is not greatly different from natural fragmentation for large numbers of plants (Anonymous 2005). Cutting can be considered a suitable approach when Park areas are completely infested with vegetation (native and non-native). Fragments caused by cutting will move downstream and be added to the continuous load of fragments from upstream. The addition may be significant for short periods of time. The consequences of cutting fragmentation are not well known for rivers. In addition, use of manual cutters from a boat is considered dangerous because the tool is very shape and has to be thrown by hand (Murphy 2003).

Mechanical cutting

<u>Technique</u>

Mechanical cutting uses a motorized cutter attached to a boat and is faster than hand cutting. The Jenson Lake Mower™ HD5000 (http://www.lakemower.com/index.htm) attaches to a small boat, cutting vegetation down to a depth of 7 feet. The blade is four feet wide. The motor is powered by a 12V battery and lasts for 7 hours. Cut plants rise to the surface where they can be removed. Washington State requires that cut plants be removed from the water. A rake is attached to facilitate taking cut vegetation to shore.

<u>Advantages</u>

- Cutting is easy around docks and swimming areas.
- Removes all vegetation including nuisance native species.
- Immediate removal.
- The equipment is inexpensive.
- Will not impact bottom-dwelling animals.
- Mechanical cutting does not require expensive permits.

<u>Disadvantages</u>

- As plants re-grow or fragments re-colonize the cleared area, the treatment may need to be repeated several times each year.
- Even with the best containment efforts, it is difficult to collect all plant fragments, leading to re-colonization.

Permits

Hydraulic Project Approval is required for cutting projects. This permit is given in a pamphlet called Aquatic Plants and Fish (http://www.wdfw.wa.gov/hab/aquaplnt/aquaplnt.htm) and is available from the Washington Department of Fish and Wildlife. The permit is obtained free of charge from WDFW. For projects costing over $2,500, a shoreline permit may be required.

Costs

Mechanical cutting is initially more expensive than hand cutting because of the expense of the cutting tools ($3,560), but is faster than hand cutting and would eventually cost less than hand cutting. This approach requires two workers, a boat, and access to a truck to haul cut vegetation from shore. This could be done by the City or contracted out for about $30/h for each worker. Costs for truck use and landfill charges depend on how much material is gathered. It is likely that two boat launch areas could be cleaned and material disposed of in one day. Using the material for mulch will be less expensive than taking the material to the landfill.

Suitability for the City of Richland Parks in the Columbia River

Cutting is not considered to be a suitable method for controlling milfoil when the infestation is in early stages, but is considered suitable for managing nuisance native plants (Anonymous 2005). Cutting is considered suitable when milfoil dominates the aquatic vegetation because the effect of cutting on fragmentation is not greatly different from natural fragmentation for large numbers of plants (Anonymous 2005). Cutting can be considered a suitable approach when Park areas are completely infested with vegetation (native and non-native). Fragments caused by cutting will move downstream and be added to the continuous load of fragments from upstream. The addition may be significant for short periods of time. The consequences of cutting fragmentation are not well known for rivers.

Harvesting

Mechanical harvesters are large machines which both cut and collect aquatic plants. Harvesting is usually performed in late spring, summer, and early fall when aquatic plants have reached or are close to the water's surface. Plants are cut as deep as 5-10 feet below the water's surface in a swath 6 to 20 feet wide, collected by conveyer, and stored until they are disposed on land. The shore station equipment is usually a shore conveyor that mates to the harvester and lifts the cut plants into a dump truck. Harvested weeds are disposed of in landfills, used as compost, or in reclaiming spent gravel pits or similar sites.

Harvesting removes surfacing mats and creates open areas of water. However, because of its rapid growth rate, Eurasian watermilfoil generally needs to be harvested twice during the growing season. Factors such as frequency and timing of harvest, water depth, and depth of cut may influence the duration of control. Harvesting has not proven to be an effective means of sustaining long-term reductions in the growth of Eurasian watermilfoil. Regrowth of Eurasian watermilfoil to pre-harvest levels typically occurs within 30-60 days depending on water depth and the depth of cut. Any effects on the control of Eurasian watermilfoil are short term.

Harvesting is most suitable for open areas with few surface obstructions. A specific location can be targeted leaving an area open for fish and wildlife. There is usually little interference with recreational use of the water body during harvesting operations. By cutting only the top several feet of the plant, some habitat remains. However, since mechanical harvesting removes both Eurasian watermilfoil and native submersed plants, repeated harvesting may select for Eurasian watermilfoil if it grows back faster than native species and forms a light-excluding canopy.

Cut plant material requires collection and removal from the water, and off-loading sites are needed for plant disposal. Collecting machines fill quickly, which makes the process time consuming. Harvesting creates numerous plant fragments, which contributes to the spread of Eurasian watermilfoil. It is not species specific and can enhance the growth of opportunistic plant species that invade harvested areas.

Mechanical harvesting is most appropriate for water bodies with widespread, well-established Eurasian watermilfoil populations. Harvesting is not recommended in water bodies with early infestations of Eurasian watermilfoil since the resulting fragments are never completely contained and harvesting may increase the spread of Eurasian watermilfoil throughout the water body.

Harvesting can interfere with carbohydrate allocations from roots and shoots, which in turn can weaken the plant making it more susceptible to natural controls (Anonymous 2001b). It can also affect storage of nutrients so that it may not over winter as well and may not grow as vigorously the following year (Anonymous 2001b).

Advantages

- This technique has been used by the City of Richland, thus it will be easier to use in the future as costs are recognized.
- Immediate removal.
- Harvesting can weaken the plant.
- Cut material may be used for mulch.

Disadvantages

- Like cutting the grass, mechanical harvesting has to be repeated.
- May select for Eurasian watermilfoil over native species.
- Mechanical harvesters can kill up to 25% of small fish in a given treatment area (Anonymous 2001a).
- Cut material requires disposal.

Permits

Hydraulic Project Approval is required for cutting projects. This permit is given in a pamphlet called Aquatic Plants and Fish (http://www.wdfw.wa.gov/hab/aquaplnt/aquaplnt.htm) and is available from the Washington Department of Fish and Wildlife. The permit is obtained free of charge from WDFW. If the intent of the project is to remove aquatic beneficial plants, prior authorization by the Department shall be required. Mechanical harvester and cutter operations shall only be conducted in waters of sufficient depth to avoid bottom contact with the cutter blades. Mechanical harvesters and cutters shall be operated at all times to cause the least adverse impact to fish life. Mechanical harvesters and cutters shall be well-maintained and where practicable, food-grade oil in the hydraulic systems should be used. Fish life that may be entrained in the cut vegetation during mechanical harvester operations shall be immediately and safely returned to the watercourse. Harvest operators should be properly trained to operate the equipment to be used. Operators should also carry and be trained in the use of containment equipment. Individuals hiring harvesters should request to see maintenance logs for decontamination of equipment. Because the Northern Leopard Frog (*Rana pipiens*), a State Candidate species occurs in the Columbia River it is important to contact the WDFW Area Habitat Biologist for more information before initiating work. For projects costing over $2,500, a shoreline permit may be required.

Costs

In 2004, Richland spent $3,800 to mechanically harvest a path through nuisance aquatic vegetation at Columbia Park West and Columbia Point Marina. An additional $600 was spent to have a scuba diver survey aquatic vegetation. In 2005, Richland spent $4,300 to mechanically harvest nuisance aquatic vegetation at the same sites in 2004, and in addition Howard Amon boat dock, and Leslie Groves boat launch and dock.

Raking

Technique

A sturdy rake is used to remove aquatic plants. Attaching a rope to the rake allows removal of a greater area of weeds. Raking tears plants from the sediment, breaking some plants off and removing some roots. Specially designed aquatic plant rakes are available. Rakes can be equipped with floats to allow easier plant and fragment collection. The operator should pull towards the shore because a substantial amount of plant material can be collected in a short distance.

Advantages

- Raking is easy around docks and swimming areas within 20 feet of shore.
- Removes all vegetation including nuisance native species.
- Immediate removal.
- Raking likely will pull out some root balls
- The equipment is inexpensive.
- Raking does not require expensive permits.

Disadvantages

- As plants re-grow or fragments re-colonize the cleared area, the treatment may need to be repeated several times each year.
- Even with the best containment efforts, it is difficult to collect all plant fragments, leading to re-colonization.
- Raking stirs up the sediment and makes it difficult to see remaining plants.
- Will impact bottom-dwelling animals.

Permits

Hydraulic Project Approval is required for raking projects. This permit is given in a pamphlet called Aquatic Plants and Fish (http://www.wdfw.wa.gov/hab/aquaplnt/aquaplnt.htm) and is available from the Washington Department of Fish and Wildlife.

Costs

Raking like cutting is cheaper than hand pulling with divers. A specially designed aquatic plant rake costs about $95 to $125. A homemade weed rake costs about $85 (asphalt rake is about $75 and the rope costs 35-75 cents per foot). This approach, when done from shore or from a dock, only requires two workers, one to rake and the other to gather the vegetation and place it in a truck. This could be done by the City or contracted out for about $30/h for each worker. Costs for truck use and landfill charges depend on how much material is gathered. It is likely that a single boat launch area could be cleaned and material disposed of in one day. Using the material for mulch will be less expensive than taking the material to the landfill.

Suitability for the City of Richland Parks in the Columbia River

Raking is not considered to be a suitable method for controlling milfoil when the infestation is in early stages, but is considered suitable for managing nuisance native plants (Anonymous 2005). Raking is considered suitable when milfoil dominates the aquatic vegetation because the effect of raking on fragmentation is not greatly different from natural fragmentation for large numbers of plants (Anonymous 2005). Raking can be considered a suitable approach when Park areas are completely infested with vegetation (native and non-native). Fragments caused by raking will move downstream and be added to the continuous load of fragments from upstream. The addition may be significant for short periods of time. The consequences of raking fragmentation are not well known for rivers.

Diver dredging

Technique

SCUBA divers use hoses attached to small dredges like those for mining gold from streams to suck plant material from the sediment. The purpose of diver dredging is to remove all parts of the plant including the roots. The technique allows removal of Eurasian watermilfoil while leaving native species untouched. The suction hose pumps the plant material and sediments to the surface and into a screened basket. Water and sediment are returned to the water column (if the permit allows this) retaining the plant material. The turbid water is can be discharged to an area curtained off from the rest of the river by a silt curtain. The plants are disposed of on a dock or on shore. Diver dredging can cover approximately 0.25 to 1 acre per day depending on plant density, sediment type, size of team, and efficiency. Diver dredging is more effective where softer sediment allows easy removal of the entire plants, although water turbidity is increased with softer sediments. Harder sediment may require the use of a knife or tool to help loosen sediment from around the roots. In very hard sediments, milfoil plants tend to break off leaving the roots behind and defeating the purpose of diver dredging.

Diver dredging has been used in British Columbia, Washington, and Idaho to remove early infestations of Eurasian watermilfoil (Murphy 2003). In a large-scale operation in western Washington, two years of diver dredging reduced the population of milfoil by 80 percent in Silver Lake (Murphy 2003). Diver dredging is less effective on plants where seeds, turions, or tubers remain in the sediments to sprout the next growing season. For that reason, Eurasian watermilfoil is generally the target plant for removal during diver dredging operations (Murphy 2003).

Advantages

- Diver dredging can be a very selective technique for removing pioneer colonies of Eurasian watermilfoil.
- Divers can remove plants around docks and in other difficult to reach areas.
- Diver dredging can be used in situations where herbicide use is not an option for aquatic plant management.

Disadvantages

- Diver dredging is very expensive.
- Dredging stirs up large amounts of sediment. This may lead to the release of nutrients or long-buried toxic materials into the water column.
- Will impact bottom-dwelling animals.
- Only the tops of plants growing in rocky or hard sediments may be removed, leaving a viable root crown behind to initiate growth.
- Permit acquisition can take a long time.

Permits

Diver dredging requires Hydraulic Approval from the Department of Fish and Wildlife. The City and Benton county may have local requirements to be considered before proceeding with a diver-dredging project. Also diver dredging may require a Section 404 permit from the U.S. Army Corps of Engineers.

Costs

Depending on the density of the plants, specific equipment used, number of divers and disposal requirements, costs can range from $1,500 to $2,000 per day (Murphy 2003) and perhaps up to

$6000/acre depending on the difficulty with working in cobble substrates common at most sites.

Other Considerations

Diver dredging can be a good spot control method in subsequent years (coordinated with diver survey).

Suitability for the City of Richland Parks in the Columbia River

The deep silt sediments in parts of the Park system (Mudflats boat launch and Columbia Park West boat launch) should make this method effective. However, permit costs may warrant having this work done as diver hand pulling since the roots can be largely removed from the loose sediments without the need for dredging. Diver dredging greatly disturbs sediments and can affect nutrient concentrations although these will be washed downstream. If other techniques of for removal are suitable, this should not be considered.

Bottom barriers

Technique

A bottom barrier covers the sediment like a blanket, compressing plants while reducing or blocking light. Burlap, plastics, perforated black Mylar, and woven synthetics can be used as bottom screens. There are two commercial bottom screens specifically designed for aquatic plant control and are preferred for the Columbia River (Miller 2008). These are:

- *Texel®* A heavy, felt-like, polyester material, and
- *Aquascreen®* A polyvinylchloride-coated fiberglass mesh which looks similar to a window screen.

An ideal bottom screen should be durable, heavier than water, reduce or block light, prevent plants from growing into and under the fabric, be easy to install and maintain, and should readily allow gases produced by rotting weeds to escape without "ballooning" the fabric upwards. Both commercial materials perform well in recent tests in the Columbia River (Miller 2008).

Even the most porous materials, such as window screen, will billow due to gas buildup. Therefore, it is important to anchor the bottom barrier to the bottom. Unsecured screens can create navigation hazards and are dangerous to swimmers. Anchors must be effective in keeping the material down and must be regularly checked. Natural materials such as rocks or sandbags are preferred as anchors. The duration of weed control depends on the rate that weeds can grow through or on top of the bottom screen, the rate that new sediment is deposited on the barrier, and the durability and longevity of the material. For example, plants can grow through window screening material, and can grow on top of felt-like Texel fabric. Regular maintenance is essential and can extend the life of most bottom barriers (Miller 2008). Bottom screens will control most aquatic plants, however free floating species like coontail will not be controlled.

In addition to controlling nuisance weeds around docks and in swimming beaches, bottom screening is an important tool to help eradicate and contain early infestations of noxious weeds such as Eurasian watermilfoil. Pioneering colonies that are too extensive to be hand pulled can sometimes be covered with bottom screens. When using this technique for Eurasian watermilfoil eradication, divers should recheck the screen within a few weeks to make sure that all milfoil plants remain covered and that no new fragments have taken root nearby.

Bottom screens can be installed by a commercial plant control specialist. Installation is easier in winter or early spring when plants have died back. In summer, it is still possible to apply bottom barriers even with high vegetative cover (Miller 2008). Miller (2008) used bottom screens attached to frames that allows for easy reuse in nearby areas. Miller (2008) cut slices in the screen to minimize gas accumulation and no billowing was observed.

Bottom barrier material shall be securely anchored with pea-gravel filled bags, rock or similar mechanism to prevent billowing and movement offsite. Bottom barrier or screen and anchors shall be regularly maintained while in place to ensure the barrier or screen and anchors are functioning properly. Barriers or screens that have moved or are billowing shall immediately be securely reinstalled or removed from the watercourse.

Advantages

- Installation of a bottom barrier creates an immediate open area of water.
- Bottom barrier are easily installed around docks and in swimming areas.
- Properly installed bottom barrier can control up to 100 percent of aquatic plants.
- Barrier materials are readily available and can be installed by divers.

Disadvantages

- Because bottom barrier s reduce habitat by covering the sediment, they are suitable only for localized control.
- For safety and performance reasons, bottom barrier s must be regularly inspected and maintained.
- Harvesters, rotovators, fishing gear, propeller backwash, or boat anchors may damage or dislodge bottom barrier s.
- Improperly anchored bottom barrier s may create safety hazards for boaters and swimmers.
- Swimmers may be injured by poorly maintained anchors used to pin bottom barrier s to the sediment.
- Some bottom barriers are difficult to anchor on deep muck sediments.
- Bottom barriers interfere with fish spawning and bottom-dwelling animals.
- Without regular maintenance aquatic plants may quickly colonize the bottom barrier.

Permits

Using bottom barriers in Washington requires hydraulic approval, obtained free from the Department of Fish and Wildlife. A shoreline permit may be required. Bottom barrier projects for boating and swimming access, which cover a large area, shall require prior authorization by the WDFW. Bottom barrier and anchor material that is not biodegradable shall be completely removed within two years of placement to encourage recolonization of aquatic beneficial plants unless otherwise approved by the WDFW.

Costs

Barrier cost about $1 per square foot including maintenance. The cost of some commercial barriers includes an installation fee. Commercial installation costs vary depending on sediment characteristics and type of bottom screen selected. It costs up to about $1,000 to have 1,000 square feet of bottom screen installed.

Suitability for the City of Richland Parks in the Columbia River

Bottom barriers have worked at the Richland Yacht Club (Miller 2008) and are likely to work well in similar areas in the parks. Similar areas are in the boat basins and other protected areas where water flow is relatively low. Use in fast flowing areas such as the Leslie Groves swimming beach may need extra care and more frequent inspection. Bottom barriers are suitable for management of Eurasian watermilfoil and curly pondweed in the parks.

Bottom tillage (rotovation)

Rotovation is performed using agricultural tilling machines that have been modified for aquatic use, or machines that have been specially designed for rotovation. Rotovators use underwater rototiller-like blades to uproot aquatic plants. Rotating blades churn seven to nine inches deep into the lake or river bottom to dislodge plant roots. Plant roots are generally buoyant and float to the surface of the water. Generally, rotovators are able to extend 20 feet under water to till substrate, and may be able to till shallow shoreline areas if access is not limited by the draft of the machine. Rotovators do not collect roots and plant fragments as plants are uprooted. However, plants and roots may be removed from the water using a weed rake attachment to the rototiller head, by harvester, or manual collection.

In Washington and British Columbia, rotovation is primarily used to remove Eurasian watermilfoil from lakes and rivers. Rotovation appears to stimulate the growth of native aquatic plants, so it would probably not be an effective tool to manage excessive growth of nuisance native species. The optimum time for rotovation extends from late fall to spring. During this period, plant biomass is reduced as is the number, buoyancy, and viability of plant fragments; water levels; and conflicts with beneficial uses of the water body. Due to increased plant biomass during summer months, plants must be cut before rotovation. Otherwise the long plants tend to wrap around the rototilling head. The area that can be rotovated per day can range from 2 acres to less than 1-acre depending on plant density, time of year, bottom obstructions, plant species, and weather conditions. Generally, rotovators are not able to operate efficiently in winds over 20 miles per hour. Imprecise tracking of treated areas may result in incomplete removal of target plants, ultimately reducing long term-control. Tracking efficiency can be improved with use of buoys. Rotovation can effectively control milfoil for up to two seasons. Deep-water rotovation has resulted in an 80% to 97% reduction of milfoil, with control lasting up to two years. The rotovated area is eventually recolonized by milfoil fragments that float in from untreated areas or from plants remaining after rotovation.

The Washington State Department of Fish and Wildlife considers rotovators to impact fish and invertebrates in at least three ways: 1) There is a high potential for rotovators to cause direct mortality; 2) Disturbance of the lake bottom increases turbidity; and 3) There is a potential release of toxic substances and nutrients from sediments. Other impacts include removal of vegetative habitat and an increase in predation of small fish by larger fish due to increased visibility. Rotovation temporarily disrupts the benthic community, which in turn could impact benthic feeders. Rotovation is not selective within the treatment area and could result in removal of desirable species such as wetland vegetation or "unique" species. However, removal of monotypic vegetation such as milfoil may ultimately increase diversity of desirable species and rotovation appears to stimulate the growth of native aquatic plants. Use of rotovators can result in plant fragments. If not collected, decaying plant fragments could reduce dissolved oxygen levels and increase nutrients. Plant fragments could also clog water intakes and trash racks of dams, and may result in increased dispersal and colonization of some species (including Eurasian watermilfoil). Rotovation should be used only in water bodies where Eurasian watermilfoil fully occupies its ecological niche. Otherwise rotovation could tend to spread Eurasian watermilfoil throughout the water body rapidly.

Advantages

- Can significantly reduce Eurasian watermilfoil populations
- Can promote growth of native aquatic plant species
- Can improve salmon spawning areas by removing a monoculture of Eurasian watermilfoil.

Disadvantages

- Would require retreatment after Eurasian watermilfoil reinvades the space.
- Can create Eurasian watermilfoil fragments that can establish elsewhere in the river.
- Will cause siltation in the river.
- There is a high probability of hydraulic fluid or fuel leakage into water.
- Turbidity and disturbance caused by rotovation may interfere with juvenile salmon or fish passage.

Permits

Permits and compliance with the State Environmental Policy Act are required prior to rotovation. Ecology requires a temporary modification of water quality standards issued by the regional offices, and a Hydraulic Project Approval is required from WDFW and any priority, threatened or endangered species need to be identified. In addition the U.S. Army Corps of Engineers requires a section 404 permit.

Costs

Rotovation costs (Gibbons et al. 1999) range from $1,000-1,700 per acre, depending on the size of the treatment area, plant density, equipment needed, and scale of removal. There may be additional fees for disposal of plant material. These cost estimates are at least 10% higher after 10 years.

Suitability for the City of Richland Parks in the Columbia River

This technique may work well in bottom soils that are without large rocks and cobble. This technique may work at WHY and Columbia Park West that have mucky bottoms, but may not work well in other parks that have rocky and cobble bottoms. Because timing restrictions are severe in salmon-bearing waters and because rotovation is temporary, it may not be suitable for the City of Richland.

Water-level drawdown

While it is not likely that the City of Richland will be able to request a substantial drawdown of the Columbia River, drawdowns may occur in the future for other reasons. If water levels are kept down long enough for Eurasian watermilfoil to die then control will occur.

BIOLOGICAL METHODS

Biological control methods are based on recreating the grazer or pathogen environment for an invasive plant species. Eurasian watermilfoil is not aggressive or invasive in their native range. This is, in part, because their populations are kept under control by insects, disease, or other factors not found in North America. In North America it forms monocultures without it's natural grazers. The biological control of aquatic plants focuses on the selection and introduction of other organisms that have an impact on the growth or reproduction of a target plant, usually from their native ranges. Theoretically, by stocking an infested water body with these organisms, the target plant can be controlled and native plants can recover.

Native watermilfoil weevil (*Euhrychiopsis lecontei*)

Sometimes a native herbivore can be used to control an alien species. A native insect that feeds and reproduces on northern milfoil (*M. sibericum*), which is native to North America, was found to also use Eurasian watermilfoil. The native watermilfoil weevil (*Euhrychiopsis lecontei)* also feeds on Eurasian watermilfoil caused the stems to collapse. Because native milfoil has thicker stems than Eurasian watermilfoil, the mining activity of the larvae does not cause it the same kind of damage. A number of declines of Eurasian watermilfoil around the United States may, be caused by *E. lecontei.* The following information and citations (updated) on the watermilfoil weevil are taken from the Washington State Department of Ecology's website (http://www.ecy.wa.gov/programs/wq/plants/management/weevil.html).

The milfoil weevil, *Euhrychiopsis lecontei*, has been associated with declines of Eurasian watermilfoil (*M. spicatum*) in the United States (e.g. Illinois, Minnesota, Vermont, and Wisconsin). Researchers in Vermont found that the milfoil weevil can negatively impact Eurasian watermilfoil by suppressing the plants growth and reducing its buoyancy (Creed and

Sheldon 1995). In 1989, state biologists reported that Eurasian watermilfoil in Brownington Pond, Vermont had declined from approximately 10 hectares (in 1986) to less than 0.5 hectares. Researchers from Middlebury College, Vermont hypothesized that the milfoil weevil, which was present in Brownington Pond, played a role in reducing Eurasian watermilfoil (Creed and Sheldon 1995). During 1990 through 1992, researchers monitored the populations of Eurasian watermilfoil and the milfoil weevil in Brownington Pond. They found that by 1991 Eurasian watermilfoil cover had increased to approximately 2.5 hectares (approximately 55-65 g m^{-2}) and then decreased to about 1 hectare (<15 g m^{-2}) in 1992. Weevil abundance began increasing in 1990 and peaked in June of 1992, where 3 – 4 weevils (adults and larvae) per stem were detected (Creed and Sheldon 1995). These results supported the hypothesis that the milfoil weevil played a role in reducing Eurasian watermilfoil in Brownington Pond.

Another documented example where a crash of Eurasian watermilfoil has been attributed to the milfoil weevil is in Cenaiko Lake, Minnesota. Researchers from the University of Minnesota reported a decline in the density of Eurasian watermilfoil from 123 g m^{-2} in July of 1996 to 14 g m^{-2} in September of 1996. Eurasian watermilfoil remained below 5 g m^{-2} in 1997, then increased to 44 g m^{-2} in June and July of 1998 and declined again to 12 g m^{-2} in September of 1998 (Newman and Biesboer 2000). In contrast, researchers found that weevil abundance in Cenaiko Lake was 1.6 weevils (adults and larvae) per stem in July of 1996. Weevil abundance, however, decreased with declining densities of Eurasian watermilfoil in 1996 and by September 1997 weevils were undetectable. In September of 1998 weevil abundance had increased to >2 weevils per stem (Newman and Biesboer 2000).

Based on observations made by researchers in Vermont, Ohio and Wisconsin it seems that having 2 weevils (or more) per stem is adequate to control Eurasian watermilfoil. However, as indicated by the study conducted in Cenaiko Lake, Minnesota, an abundance of 1.5 weevils per stem may be sufficient in some cases (Newman and Biesboer 2000).

In Washington State, the milfoil weevil is present primarily in eastern Washington and occurs on both Eurasian and northern watermilfoil, the latter plant being native to the state (Tamayo et al. 1999). During the summer of 1999, researchers from the University of Washington determined the abundance of the milfoil weevil in 11 lakes in Washington. They found, that weevil abundance ranged from undetectable levels to 0.3 weevils (adults and larvae) per stem. Fan Lake, Pend Oreille County had the greatest density per stem of 0.6 weevils (adults, larvae and eggs per stem). The weevils were present on northern watermilfoil. These abundance results are well below the recommendations made by other researchers in Minnesota, Ohio, Vermont, and Wisconsin of having at least 1.5 – 2.0 weevils per stem in order to control Eurasian watermilfoil.

To date, there have not been any documented declines of Eurasian watermilfoil in Washington State that can be attributed to the milfoil weevil, although Creed speculated that declines of Eurasian watermilfoil in Lake Osoyoos and the Okanogan River may have been caused by the milfoil weevil. In Minnesota, Cenaiko Lake is the only lake that has had a Eurasian watermilfoil crash due to the weevil; other weevil lakes are yet to show declines in Eurasian watermilfoil.

Researchers in Minnesota have suggested that sunfish predation may be limiting weevil densities in some lakes (Sutter and Newman 1997). The latter may be true for Washington State, as sunfish populations are present in many lakes in the state, including those with weevils. In addition, other environmental factors that may be keeping weevil populations in check in Washington, but have yet to be studied, include over-wintering survival and habitat quality and quantity (Jester et al. 1997; Tamayo et al. 2000). Although the milfoil weevil shows potential as a biological control for Eurasian watermilfoil more work is needed to determine which factors limit weevil densities and what lakes are suitable candidates for weevil treatments in order to implement a cost and control effective program.

Since the above review was made available on the web (http://www.ecy.wa.gov/programs/wq/plants/management/weevil.html) some new information (Newman 2004a; Newman 2004b) has become available. In Minnesota lakes, sustained milfoil reductions have been observed in two lakes and in a shallow bay of another lake and all were associated with milfoil weevils. Newman (2004) indicates that adequate weevil densities that persist throughout the summer are required for sustained milfoil declines. Lakes with low densities of weevils (<0.1 per stem) showed no evidence of herbivore induced declines during the 5-10 years of study. Weevil densities appear limited by sunfish predation (Ward and Newman 2006). Lakes with persistent declines had low densities of sunfish. Sunfish densities greater than 25-30 per trapnet may severely limit weevil populations and their ability to control Eurasian watermilfoil (Newman 2004a). Newman (2004) concludes that the milfoil weevil can cause sustained declines of Eurasian watermilfoil if sufficient densities are maintained throughout the summer each year. Sunfish appear to be limiting herbivore densities in many lakes and lakes with high densities of sunfish will likely not support adequate weevil populations to achieve milfoil control. A positive rooted native plant response is also likely required for sustained control and more research into methods to reduce sunfish predation and to enhance native plant response is needed (Newman 2004a).

While weevils have been used in lakes in the eastern U. S. less work has been done in the west. In Washington, use of weevils and other biological control agents for milfoil control is under consideration, but requires further study before it may be used for widespread control (Madsen et al. 2000). According to K. Hamel (Madsen et al. 2000) weevil use in Washington State depends on a number of factors from the regulatory and management perspective. Before weevils and other native insect herbivores are accepted by the public in Washington State as an effective management tool, control needs to be demonstrated within a 3 to 4 year time frame and be proven as cost-effective as other management methods. In addition, further research needs to be conducted on other native insects as potential biocontrol agents, augmentation rates using native insects, flowing water problems and weevil population densities in Washington State. Currently, the State of Washington's Department of Agriculture has not approved a permit to import and release weevils into Washington waters, and any permit issued will be for experimental use only.

Advantages

- Milfoil weevils offer a biological alternative to aquatic plant control.
- They may be cheaper than other control strategies.
- Biocontrols enable weed control in hard-to-access areas and can become self-supporting in some systems.
- If they are capable of reaching a critical mass, biocontrols can decimate a weed

population.
- Native insects as a biological control agent are more acceptable to the public than the introduction of exotic biocontrol agents.
- State permitting is easier for indigenous native insects

Disadvantages

- There are many uncertainties as to the effectiveness of this biocontrol in Washington waters.
- Washington State does not have the resources available to be involved in weevil production as of 2000
- Insect cultures imported from other states have to be guaranteed free from exotic pests such as zebra mussels, parasites, and pathogens
- Scientists, resource managers, and citizens have expressed concerns about different weevil or Eurasian watermilfoil genotypes being introduced into Washington State. The Washington State Department of Ecology does not want to introduce distant weevil genotypes into the state.
- There have not been any documented declines of Eurasian watermilfoil in Washington State that can be attributed to the milfoil weevil.
- Bio-controls often don't eradicate the target plant species, and there would be population fluctuations as the milfoil and weevil follow predator-prey cycles.

Cost

Weevils are $1200 for 1000 insects and are available from EnviroScience Inc. (http://www.enviroscienceinc.com/). The number required to significantly reduce Eurasian watermilfoil is not well defined, but 3000/acre may be reasonable.

Permits

The milfoil weevil is native to Washington and is present in a number of lakes and rivers. It is found associated with both native northern milfoil and Eurasian watermilfoil. A company is selling milfoil weevils commercially. However, to import these out-of-state weevils into Washington requires a permit from the Washington Department of Agriculture. Washington As of February 11, 2008 no permits have been issued for Washington.

Suitability for the City of Richland Parks in the Columbia River

Since the milfoil weevil is a new bio-control agent in Washington, it has not been released yet to control Eurasian watermilfoil other than for experimental trials. It is uncertain how effective the weevil will be and whether populations per stem can be maintained at levels high enough to eradicate Eurasian watermilfoil in the Columbia River. Because areas under consideration for control in Richland Parks are small, experimental trials of weevils will not be very expensive, and thus the approach is suitable in Richland as an experiment. Weevil use is best considered for areas with relatively heavy Eurasian watermilfoil infestations such the Howard Amon boat launch. Weevils are not advised for areas where there is only low cover of Eurasian watermilfoil.

Grass Carp

The Washington Department of Fish and Wildlife (WDFW) requires that all inlets and outlets to a water body be screened to keep grass carp from leaving the system. Therefore, grass carp are generally not allowed in water bodies with salmon or steelhead since these fish need to pass freely between the water body and salt water. Grass carp cannot be used in the Columbia River.

Ecological Restoration

Interspecific competition can be an effective aquatic plant control method in some situations. Establishment of native aquatic plants can help prevent the spread of nuisance exotic plants directly by the principle of competitive exclusion (Smart et al. 1998). Establishing native plant species in a New Zealand stream excluded non-native invasive aquatic species (Larned et al. 2006), thus it may be possible to use native species to exclude or reduce the cover of Eurasian watermilfoil in the Columbia River. Further research is needed to determine specific conditions that enable native plant species to out compete invasive species like Eurasian watermilfoil (Anonymous 2001a). It was observed that Eurasian watermilfoil populations were relatively less dense when growing in Canadian waterweed at Leslie Groves Park boat launch than without Canadian waterweed. This observation needs corroboration and further research is needed determine if planting Canadian waterweed in areas freed of Eurasian watermilfoil would reduce the likelihood that Eurasian watermilfoil will re-establish.

No Action

One option for managing aquatic noxious weeds and other vegetation in Richland City Parks in the Columbia River is to let aquatic noxious weeds continue to grow, and do nothing to control them. This alternative would acknowledge the presence of the aquatic plants, but would not outline any management plan or enact any planned control efforts. Eurasian water milfoil is a Class B Designate noxious weed in Benton and Franklin counties along the Columbia River (http://www.nwcb.wa.gov/weed_list/regions/region9.htm). Control is required by law (WAC 16-750-011).

Advantages

- No cost.

Disadvantages

- Continued degradation of the City of Richland Parks water resources.
- Noncompliance with WAC 16-750-011.

Suitability for the City of Richland Parks in the Columbia River

The milfoil infestation is currently moderate, but unless control measures are enacted, it is likely to increase each year until entire park elements become dominated by milfoil. Based on informal surveys of long-term residents infestations of milfoil have greatly increased over the years. If there is no control effort, it is likely that weed infestations will continue to grow, making City of Richland Parks a prime source of milfoil fragments for downstream infestations. The no-action alternative likely would not be supported by the public.

COMPARISON OF CONTROL ALTERNATIVES

The control alternatives can be compared on the basis of regulatory difficulty, cost, and years of treatment application. Regulatory difficulty is low for low risk approaches such as hand pulling and high for potentially high-risk approaches such as some chemical approaches. Cost varies greatly with bottom barriers estimated as most expensive and mechanical cutting least expensive. The years of treatment application range from one with chemical treatments to every year for treatments that only manage Eurasian watermilfoil without eradication. The control alternatives are scored on these three attributes for comparative purposes (Table 10). The best approaches attempt to eradicate Eurasian watermilfoil and reduce populations to low levels. Even though eradication is the goal it will never be achieved because Eurasian watermilfoil will re-establish itself naturally, thus long-term management is required. Chemical, hand pulling, diver dredging, and bottom barrier treatments can reduce populations to low levels. Hand pulling and bottom barriers have low regulatory difficulty compared with chemical treatments. The cost of hand pulling is similar to chemical treatments while bottom barriers are more expensive. Chemical control would only be done one time to reduce populations to levels that would accommodate hand pulling as the long-term control strategy. In the first control year a combination of hand pulling and bottom barrier treatments likely will be the best strategy with hand pulling being the best long-term control strategy.

Table 10. Comparison of control alternatives based on permitting difficulty (1 = easy, 10 = difficult), estimated cost/year ($), and years of treatment application.

		High cover boat launch 0.24 acres		Beach 0.01 acres		Low cover Rock (2) 0.01 acres		Low cover Muck 0.0014 acres		No cover 0.02 acres	
Treat	Permit difficulty	$/y	yrs	$/y	yrs	$/y	yrs	$/y	yrs	$/y	yrs
Diquat	4	2858	1								
Endothall	4	2858	1								
2,4-D	4	2920	1								
Fluridone	NA										
Triclopyr	4	3004	1								
Hand Pull	1	2400	2	1200	2	600	2	300	2		
Hand Cut	1	1080	10	600	10	240	10	120	10		
Mech Cut	2	540	10	300	10						
Harvest	7	4000	10	1000	10						
Rake	1	1080	10	600	10	240	10				
Dredge	3							300	2		
Barrier	2	5000	3								
Rotovate	8										
Weevils	NA										
Restore	NA										
None	0										
Monitor	0	480	10	360	10	120	10	120	10	120	10

Integrated Treatment Plan

The integrated vegetation management plan considers control alternatives with regard to:

- The extent of Eurasian watermilfoil infestation with preferred control strategies.
- Scale, intensity, and timing of treatment effectiveness against target plant(s),
- Human health concerns
- Environmental impacts and mitigation, if needed
- Permit requirements (federal, state, local)
- Program costs and long-term control strategy.

The extent of Eurasian watermilfoil infestation with preferred control strategies.

The extent of the Eurasian watermilfoil infestation in the City of Richland Parks is defined in Table 11. In some areas the infestation can be classified as an early infestation with only a small percentage of the area covered with Eurasian watermilfoil (Anonymous 2005). The park sites are ordered from large to small infestations with a preferred control strategy assigned to each park site. The greatest area and concentration of Eurasian watermilfoil occurred at the Howard Amon and Leslie Groves boat launches. Hand pulling and bottom barriers are reasonable strategies. The Leslie Groves beach is large, but has low Eurasian watermilfoil cover occurring in a number of separate patches. Hand pulling is a reasonable strategy at the beach as long as divers can work in relatively high flow rates. The strong flow also may make it difficult the use barriers. If barriers can be placed they can accommodate a number of small patches. Workability of hand pulling and barriers in strong flows has not been assessed and should be attempted before trying mechanical cutting, harvesting, raking, or the use of chemicals. Chemicals would require the use of tents or curtains to allow the chemical to remain in contact with the plants long enough to affect the plants and these structures may not be workable in relatively high river flow rates at the beach. The other smaller infestations can be controlled by hand pulling. The sites without Eurasian watermilfoil can be monitored as part of the long-term need to monitor all sites.

Table 11. Estimated area covered with Eurasian watermilfoil with control strategies in the City of Richland Parks.

Park	Site	Vegetation acres	Eurasian Watermilfoil Cover (%)	Eurasian Watermilfoil Area (acres)	Control strategy
Howard Amon	Boat launch	0.35	27.5	0.096	Hand pulling, Barrier
Leslie Groves	Boat launch	0.50	18.8	0.094	Hand pulling, Barrier
Leslie Groves	Beach	2.23	4	0.089	Hand pulling
Columbia Point Marina Park	Boat launch	0.19	27.5	0.052	Hand pulling
Howard Amon	Swim dock	0.05	20	0.01	Hand pulling
Columbia West	Boat launch	0.20	0.7	0.0014	Hand pulling
Howard Amon	Boat dock	0.01	5	0.0005	Hand pulling
Leslie Groves	Fishing dock	0.008	0	0	Hand pulling
WYE	Mudflats Boat launch	0.005	0	0	Hand pulling
All parks	Total	3.54		0.343	

Scale, intensity, and timing of treatment effectiveness against target plant(s)

The Washington State Department of Fish and Wildlife (Anonymous 1997) considers early infestations to be managed most effectively by hand pulling, bottom barriers, or diver dredging with chemical control viewed as marginal. All other approaches are not recommended. Well-established infestations (Howard Amon and Leslie Groves boat launches) are small and may best be controlled as early infestations.

The intensity of treatment can be judged as enough labor and materials to remove all the Eurasian watermilfoil in control areas. This effort can only be estimated until early efforts are made to control the plant. Control can start when the plants are large enough to recognize in the late spring or summer. Hand pulling and/or bottom barriers can be repeated until all plants that can be controlled in these ways are eliminated. The first effort likely will remove most individual plants. Monitoring should be done perhaps 2 months after the first control effort to define the degree of success and effort needed to reduce the populations again. This monitoring and control pattern should be repeated until the populations are gone. Subsequent yearly monitoring will be done to note new infestations and to define the level of continued effort required to maintain control.

Human health concerns

Human health concerns are primarily with the workers who perform the control. There will always be at least two divers working together along with shore and boat worker(s). If bottom barriers are used then they need to be inspected periodically to recognize damage or if they have lifted creating a boating hazard. Notification through signage at work areas needs to be placed to warn the public about workers and to notify them not to run boat motors and jets near bottom barriers.

Environmental impacts and mitigation, if needed

There is little environmental impact from hand pulling other than suspending silt. The loss of Eurasian watermilfoil fragments can be minimized by carefully placing material in bags. Bottom barriers may have an environmental impact because they will kill all plants under their surface and may have an effect on bottom invertebrates and mussels. Bottom barriers can be removed a number of weeks after application. Miller (2008) observed complete control 13 weeks after placing bottom barriers.

Permit requirements (federal, state, local).

Hydraulic Project Approval is required for all hand pulling and bottom barrier projects. This permit is given in a pamphlet called Aquatic Plants and Fish (http://www.wdfw.wa.gov/hab/aquaplnt/aquaplnt.htm) and is available from the Washington Department of Fish and Wildlife. A shoreline permit may be required. Bottom barrier or screen projects for boating and swimming access, which cover a large area, shall require prior authorization by the WDFW. Bottom barrier or screen and anchor material that is not biodegradable shall be completely removed within two years of placement to encourage recolonization of aquatic beneficial plants unless otherwise approved by the WDFW.

The final task is to take all the information and formulate a long-term action program (plan) for aquatic plant management. Aquatic plant control is an ongoing concern that requires long-term commitment.

Program costs and long-term control strategy

If current populations can be reduced significantly then a combination of regular monitoring and hand pulling will keep Eurasian watermilfoil populations under control. This strategy will have to become a permanent element of the City of Richland Park's Department budget. The cost of monitoring all parks once a year is estimated to be $1080 while hand pulling in all the parks should be less than $4,500/year and will depend on the size of new Eurasian watermilfoil populations. A true evaluation of cost would require estimation after starting work. The level of difficulty associated with removing entire plants by digging them out the cobble is not clear.

An effort to reduce populations in the first two years of treatment using hand pulling and bottom barriers should have a budget of about $11,000 in the first year with less in the second. Bottom barriers are estimated to cost $\$1ft^{-2}$. If framed bottom barriers of about 100 ft^2 were used and if

10 frames were placed then 1000 ft^2 could be treated over a two-month period. They can then be moved. It could take three people 8 hours to pick up 10 frames, clean and repair them, and place them again. At $40/h this would be $960/day. For Howard Amon boat launch with 0.096 acres (4,182 ft^2) of Eurasian watermilfoil this could cost $1,000 for 10 barriers and about $1000 to move them for a total of about $5000 (Table 10) for four moves. It is likely that a combination of hand pulling in thin populations and bottom barriers in dense populations would be used. The true cost of control will be better estimated after initial control has been implemented.

The long-term strategy for monitoring and controlling Eurasian watermilfoil by hand pulling in the portions of the City of Richland Parks assessed in this study should have a continuing budget allocation of at least $5,600/year that increases with inflation.

IMPLEMENTATION AND EVALUATION

The City of Richland will manage aquatic vegetation according to the IAVMP. The City will review the proposed plan and develop a timeline with specific tasks. The IAVMP will guide this process. The City will issue a Request for Proposals for weed survey and control work. The needed permits will be obtained. Permit application will be coordinated with the contracted applicator. Signage and public education about controls plans need to be implemented. Control treatments then need to be applied. Monitoring of all City of Richland Parks for Eurasian watermilfoil needs to be done in association with control activities and at least yearly thereafter with follow-up control. Professional contractors can complete this work under supervision of City of Richland staff.

FUTURE RESEARCH CONSIDERATIONS

The relationship between environmental condition and aquatic vegetation in the Columbia River in and near Richland may help define causal factors and may help define more management strategies. This would allow the City to establish long-term control strategies that should be cost effective. Now, harvesting boats are used to manage aquatic vegetation growth, but like cutting the lawn, the effect is short term requiring continued expenditures.

To examine the relationships between causal factors and aquatic vegetation it will be necessary to sample at a number of sites that cover the range of condition for aquatic vegetation. Sampling in areas without vegetation is needed to understand the suite of factors that are not conducive to aquatic vegetation. Sampling in areas with vegetation will define those conditions that are conducive to aquatic vegetation growth. It will be important to also examine sites with a midrange of vegetation.

The number of sites to examine should be about 81 to gain statistical power. Sites range from high vegetation to mid-range vegetation to no vegetation. The factors that can influence aquatic vegetation growth in the Columbia River include flow rate, substrate quality (rock to silt), depth, substrate nutrients, light or turbidity, dissolved oxygen, temperature, substrate organic content, pH, and conductivity. I have ordered the factors from potentially high to potentially low correlation with aquatic vegetation. Factors that can be manipulated are flow rate, substrate quality (rock to silt), substrate nutrients, and depth. The best experimental design is to do at least three replicates of all combinations of the four driving variables (number of observations = 3^4 = 81). This may not be perfectly achieved because some of the variables will change together. For instance, it is not likely to find high silt in high flow areas.

These factors may be assessed, for instance in each park where a transect can be run from shore to high vegetation to mid-range vegetation, and out to areas without vegetation. Other sites could be chosen to capture to range of conditions associated with vegetation. It should be possible to isolate the top two or three factors associated with vegetation growth.

At each site, aquatic species can be identified and cover assessed. Flow rates and depth can be measured at each site. Flow rate can be measured at the surface, mid-depth and at the bottom. Flow rates and depth vary diurnally so flow and depth can be measured every two hours at three sites that cover the range of site conditions. With these data it will be possible to normalize data collected at all other sites.

Substrate quality can be assessed using a variety of tools to assess soil texture, organics, and nutrients in the bottom sediments. Sediment depth can be measured from the surface using a measuring stick when possible or measured by a diver. Sediment cover relative to rocks can be assessed visually. Shallow sediments over rocks can be collected by a diver. Thick sediments can be collected with a coring tool. Soil texture can be determined using screens for collected samples. Some sediment will be tightly packed (very dense preventing root growth) and difficult to remove. These can be assessed by a diver for relative ease of penetration with a tool or taken to the surface for bulk density assessment. Soil organic content can be determined by a testing laboratory as will nitrogen and phosphorus content.

Light/turbidity can be determined with a Secchi disc. Dissolved oxygen, temperature, pH, and conductivity can be determined.

Plant species and cover can be associated with the measured characteristics of the river. Regression and principal components analyses can be done to assess the relative predictive strength of the measured variables for prediction of vegetation cover.

The results of such research will allow the City of Richland to consider other control strategies that may reduce the likelihood that Eurasian watermilfoil will re-establish. This should reduce the costs of long-term control.

FUNDING OPPORTUNTIES

Funding opportunities are found in many places. These opportunities are organized by noting the Washington State Department of Ecology Aquatic Weed Program, numerous possibilities obtained from the WEB, and local activities that may be successful in raising funds for the purpose of managing and controlling Eurasian watermilfoil populations in the City of Richland Parks.

Washington State Department of Ecology Aquatic Weed Program

Aquatic Weeds Management Fund Early Infestation Grant Application

http://www.ecy.wa.gov/programs/wq/plants/grants/

This is the grant application for the Aquatic Weeds Management Fund Early Infestation for Washington state. Applicants must be local or state government, tribes, or Special Purpose Districts (does not include Lake Management Districts).

This program provides funding for projects dealing with the problems caused by an early infestation of a noxious freshwater invasive weed such as Eurasian watermilfoil or Brazilian elodea. Projects must be located in public water bodies that have a public boat launching facility. Grants are awarded at any time, but on a first come, first served basis. The applicant must demonstrate that the noxious freshwater weed is present only in limited amounts and that early action can prevent its spread. We require verification of the plant identification and amount in the water body before awarding funds.

Please contact Joan Clark (jcla461@ecy.wa.gov) or 360-407-6570.

Aquatic Weeds Management Fund Grant Application

http://www.ecy.wa.gov/programs/wq/plants/grants/

This is the grant application for the Aquatic Weeds Management Fund Program for Washington state. Applicants must be local or state government, tribes, or Special Purpose Districts (does not include Lake Management Districts).

This program provides funding for projects dealing with the problems caused by freshwater invasive weeds such as Eurasian watermilfoil and Brazilian elodea. Projects must be located in public water bodies that have a public boat launching facility. State-listed noxious freshwater weeds have priority over problematic native plants.

Types of projects funded include development of integrated aquatic vegetation management plans, education, implementation of vegetation plans (control), mapping and survey, project evaluation, and applied research (pilot projects).

The annual grant funding cycle opens on October 1 of each year and closes on November 1.

Please contact *Joan Clark (jcla461@ecy.wa.gov) or 360-407-6570.*

WEB Sources

The following funding sources were obtained from http://efc.boisestate.edu/watershed/, and were obtained by defining search fields associated with aquatic resources.

Aquatic Ecosystem Protection, www.nwfund.org

Aquatic Lands Enhancement Account (ALEA), Washington Interagency Committee for Outdoor Recreation, www.iac.wa.gov/iac/grants/alea.htm

Boating Facilities Program, Washington State, www.iac.wa.gov/iac/grants/bfp.htm

Bonneville Environmental Foundation Watershed Program, www.b-e-f.org/

Bullitt Foundation - Aquatic Ecosystems Program, www.bullitt.org

Challenge Cost Share, Bureau of Land Management, www.dfw.state.or.us/ODFWhtml/VolunteerProg/STEP.html

Columbia Basin Water Transactions Program, www.cbwtp.org/jsp/cbwtp/index.jsp

Compton Foundation Environmental Grants, The, www.comptonfoundation.org/environ.html

FishAmerica Foundation, www.fishamerica.org

Five-Star Restoration Program, EPA, www.epa.gov/owow/wetlands/restore/5star/

Habitat Conservation - Partners for Fish and Wildlife Program, U.S. Fish & Wildlife Service, www.fws.gov/partners/

Harry Chapin Foundation, fdncenter.org/grantmaker/harrychapin/

Jubitz Family Foundation, www.jubitzff.org

Lamb Foundation Grants, www.thelambfoundation.org

Lawrence Foundation, The, www.thelawrencefoundation.org/grant/guidelines.html

Pacific Grassroots Salmon Initiative, National Fish and Wildlife Foundation, www.nfwf.org/programs/programs.htm

Plum Creek Foundation, www.plumcreek.com/community/default.php

Proactive Species Conservation Program, http://www.nmfs.noaa.gov/pr/species/concern/grant.htm

Salmon Recovery Funding Board, Washington, www.iac.wa.gov

Washington Wildlife and Recreation Program (WWRP), Washington State, www.iac.wa.gov/iac/grants/wwrp.htm

Local fund raising possibilities

Other options for covering the expenses for management Eurasian watermilfoil in the City of Richland Parks include efforts to assess a fee for the use of Columbia River water resources and creation of an aquatic weed management district. Such an aquatic weed management district could be associated with all the municipalities and other governmental entities with concerns and responsibilities for aquatic invasive plants in the Columbian River near the Tri-Cities. Fees may be assessed for the use of boat launch facilities in the City specifically designed and advertised for the control of Eurasian watermilfoil. Collection boxes could be located at each launch facility.

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Appendix A: Education and Outreach Documents

Eurasian milfoil a nuisance

Eurasian milfoil is an aquatic plant now in the Columbia River that should be recognized by all because it is a serious invasive weed that can cause misery and frustration for all who enjoy the river.

The plant first made its way into the Columbia River in the 1970s. It is now found throughout the United States.

Eurasian milfoil (*Myriophyllum spicatum*) can be recognized by its finely dissected, featherlike leaves. They are arranged in whorls of 4 (rarely 5) around the stem at each node.

It grows in water to depths of 30 feet and can grow to the surface from 15-foot depths. It has been observed growing in Lake Chelan at depths of 45 feet! It grows best on fine-textured, inorganic sediments, although I've seen it growing from the cobble near the shore of the Columbia River in Richland.

It reproduces by fragmentation, meaning that leaves that break off can develop into new plants. This vegetative reproduction is one reason this plant is so prolific. It is commonly caught on boats and trailers and taken to the next body of water.

It can grow very rapidly and has taken over some lakes. It can shade out native vegetation forming a monoculture, which is poor habitat for fish and wildlife.

Dense growth in Eastern Washington also has led to impacts on power generation and irrigation systems by clogging dam trash racks and intake pipes. In some areas, Eurasian milfoil interferes with swimming, boating, fishing and water skiing.

Washington spends $1 million or more per year on its control.

Until recently, there was relatively little activity to understand and control milfoil in the Tri-Cities. But with support from the Benton County Noxious Weed Control Board, Marc Miller and Jean Vanni, graduate students at Washington State University Tri-Cities, are conducting experiments to test the use of bottom weed cloth barriers to kill it and to understand how much nitrogen and phosphorus it can take from the water.

The city of Richland and the Richland Yacht Club are supporting Miller in his study of the use of two types of weed cloth to control its growth. Eurasian milfoil and other aquatic vegetation can grow to such density at the Yacht Club that trash and dead fish are caught in vegetation, making it very unpleasant. The dense vegetation also can foul engines.

Control of Eurasian milfoil is difficult, and until there are successful biological control agents it is likely we will only be able to manage it. Efforts to control it using boats to cut and collect it have been tried along the Columbia River, but it just grows back. Cutting it also helps to spread it downriver because it reproduces best vegetatively.

The control experiment using bottom barriers at the Yacht Club is working so far. After about eight weeks the bottom barriers remain in place and have kept Eurasian milfoil and other aquatic vegetation under control.

Strategies to manage Eurasian milfoil are going to be investigated by the city of Richland. The city was offered a grant from the Washington State Department of Ecology to develop an integrated aquatic plant management plan for Richland's parks along the Columbia River. The city will be working with Washington State University to develop this plan.

The overall goal of the plan is to manage nuisance non-native and native vegetation to improve recreational and commercial use of Richland's waterfront and to maintain habitat diversity for fish and wildlife.

I have had fishermen tell me that getting rid of milfoil would make them very happy because it fouls their lures. Perhaps with collaborative efforts of interested parties in the Tri-Cities it will be possible to keep Eurasian milfoil under control. It is possible.

Some of the information for this article was taken from the Washington State Department of Ecology Aquatic Plants & Lakes Web site (www.ecy.wa.gov/programs/wq/links/plants.html)

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Aquatic plant management needed

I have the good fortune of working with the City of Richland on an Integrated Aquatic Plant Management Plan (IAPMP). The IAPMP is being developed for Richland parks along the Columbia River.

The goal of the IAPMP is to manage nuisance non-native and native vegetation to improve recreational and commercial use of Richland's waterfront and maintain habitat diversity for fish and wildlife.

The first activity in the project was to survey the parks to identify the aquatic species and estimate their cover. This was done last fall. I examined areas primarily near boat launches and swimming docks in the parks.

I found six species in the river. These include Eurasian milfoil (*Myriophyllum spicatum*), coontail (*Ceratophyllum demersum*), Canadian waterweed (*Elodea canadensis*), curly pondweed (*Potamogeton crispus*), white-stemmed pondweed (*Potamogeton praelongus*), and water star grass (*Heteranthera dubia*).

There certainly are nuisance plants in the Columbia River. The biggest problem is the noxious weed, Eurasian milfoil. It is commonly caught on boats and trailers and taken to the next body of water. It can shade out native vegetation forming a monoculture, which is poor habitat for fish and wildlife. I found milfoil with about 30 percent cover at the Leslie Groves Beach and the

Howard Amon North Boat Launch. It was found in the other areas, but only with about 10 percent or less.

Curly pondweed is another European invasive aquatic plant that is now a Class C noxious weed. This species can be easily recognized by its leaves, which are very curly along the edges. It was not as common as milfoil with only about 10 percent cover at the Leslie Groves Boat Launch and at Columbia Point Boat Launch near the shore.

Coontail is a native species with dense whorls of leaves making it look like a tail. This species was only found at the Columbia Point Boat Launch and only had about 10 percent cover.

Canadian waterweed was the most common species. It is native and has whorls of three leaves along its stem. Each leaf is up to a half-inch long and a little less than an eighth-inch wide. It was most common at Leslie Groves Boat Launch and at Howard Amon North Boat Launch where its cover was up to 60 percent. It was found at all sites.

White-stemmed pondweed is a native species. It was only found in deeper water at the Leslie Groves Beach and the Leslie Groves Fishing Dock. This plant has large leaves. The whitish stem separates it from most other aquatic species. I found it in deep fast moving water where it had about 50 percent cover.

Water star grass is another native species. Water star grass has small star-shaped yellow flowers that float or rise just above the water surface. The dark green leaves are long and grasslike. I found it dominating the Columbia Park West Boat Launch with cover of about 90 percent. Water star grass grows in shallow water up to 1 meter deep, including slow streams, rivers, lakes and ponds. It can survive on mud banks and is tolerant of alkaline water. Columbia Park West is south of the confluence of the Yakima River. In the Yakima River, water star grass has become very dense.

These water plants can cause trouble for those who use the Columbia River. For instance, the Richland Yacht Club is dominated by water plants causing trouble with boat moorings. I certainly would not want to swim or fish in that area. I suspect kayakers and other boaters do not like going through dense vegetation.

It is critical that those in our community who are concerned with these aquatic plants and especially with Eurasian milfoil contact me. I will organize public meetings with the City of Richland to address concerns with these plants. Public participation is needed for the successful development of the Integrated Aquatic Plant Management Plan.

Some of the information for this article was taken from the Web site of Washington State Department of Ecology Aquatic Plants & Lakes. (www.ecy.wa.gov/programs/wq/ links/plants.html).

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Several factors play into aquatic vegetation growth

There certainly can be lots of aquatic vegetation in the Columbia and Yakima Rivers under the right conditions. In the Yakima River, one can now see the surface becoming covered with water stargrass. Water stargrass does well in shallow water up to 3 feet deep. It can survive on mud banks and is tolerant of alkaline water. This native species has become prominent in the last number of years. Its presence is associated with the clearer waters of the Yakima River compared with the much soil laden past.

Aquatic plants, like all plants, need light. If an aquatic plant is going to grow well then it must have access to light when it is young and rooting in the bed of the river. If there is too little light, then the plant can never get started. There are questions about nutrient levels and if they affect water stargrass growth in the Yakima River.

While there is little water stargrass in the Columbia River, the Columbia River can be filled with a variety of aquatic species. Much of the aquatic vegetation can be found near boat launches and marinas where the flow is slower than other parts of the Columbia. I have found Eurasian milfoil near the shoreline of the Columbia in a narrow band. In this observation, the river flows rapidly, but perhaps not as fast as further out in the river. Perhaps, some species require a slow enough flow to establish and grow successfully. An assessment of flow rates and the presence of aquatic vegetation in the Columbia River would help define how strong a controlling factor flow is for aquatic vegetation growth. If flow rates are really a very strong determinant for the establishment and growth of aquatic vegetation then some management strategies may include opening up boat launch areas and marinas to higher river flows.

Other factors can influence aquatic plant growth including depth, water clarity, substrate characteristics such as rock versus silt, and substrate nutrients. Some aquatic species may be limited by depth. In some very clear lakes aquatic vegetation can be found at depths of 45 feet. The Columbia River is relatively clean, but it is not clear and the depth to which vegetation can grow may be limited by light. It is possible to kill aquatic vegetation by covering it with black fabrics, which certainly reduce light.

Characteristics of the substrate can strongly influence the ability of aquatic vegetation to establish. Very rocky bottoms like much of the Columbia River do not allow roots to penetrate, effectively preventing vegetation from becoming established. I have noted aquatic vegetation growing in apparently rocky bottoms, but these bottoms may have enough fine silt and flows may be low enough for plants to gain a foothold. I have noticed this in boat launch areas. Once vegetation becomes established they can slow down flows and capture silts. These silts can fall to the bottom improving conditions for plants. At the Richland Yacht Club, which was built on a gravel bed, it is now recognized that the silt layer is several inches thick. This addition of silt is likely associated with dense vegetation and slow flows.

High nutrients are also recognized as promoting aquatic vegetation growth. The addition of nitrogen and phosphorus has caused many lakes to become eutrophic (filled with vegetation, lacking oxygen, and essentially dying). The Columbia River may have some characteristics of overfertilized lakes with so much vegetation in some locations.

Aquatic vegetation generally acquires nutrients from the substrate and if Columbia River silts are loaded with nutrients then this may be a reason for lush growth. I plan to take silt samples to determine nutrient contents in areas without plants and in areas with lots of plants to see if there is an association between nutrients and vegetation. Brett Tiller (President of Environmental Assessment Services, Richland) has suggested that even the mussels can add ammonia to the silts and promote vegetation growth.

An assessment of factors that contribute to vegetation growth in the Columbia River will help identify possible management strategies to control the vegetation. This should improve our enjoyment of the Columbia River. I don't like to get my spinning lures caught in the weeds!

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Richland City Council Hears About Milfoil Problem In The Columbia River

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RICHLAND, Wash. - Some people believe that milfoil is a growing problem in the Columbia River.

WSU employees and a handful of students are looking at ways to fight it.

Tuesday night plant scientist Dr. Steven Link presented the Richland City Council with his findings and information about ways the reduce the amount of milfoil in the rivers.

Milfoil grows like a weed in water and spreads very quickly. In August, a 22-year-old man died in the Columbia River while swimming at night near the Blue Bridge and authorities think milfoil might have played a role in his death.

Link said he thinks milfoil in the river is a public safety hazard. He said, "Do people want to swim in it? Do they want to boat in it? Fish in it? No, they would not like to have that problem around. It's an issue."

Link said it is a problem that many communities around the United States deal with.

He said there are chemicals it can be treated with, screens and barriers that can be placed on it. He said there is even the option of laying concrete over it.

He said you can never get rid of it completely but believes our local waters would be more desirable if the plant wasn't so prevalent.

He will continue to study the water and look at ways of reducing the problem. Tuesday's presentation gave city council more information on the problem.