LAKE LAWRENCE
INTEGRATED AQUATIC VEGETATION MANAGEMENT PLAN

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PROJECT OVERVIEW

Lake Lawrence is a 331-acre lake located in southeastern Thurston County. The lake is divided into two distinct basins. The larger East basin is 277 acres in size while the West basin is 54 acres. The lake has a very popular County park and a State Fish and Wildlife boat launch along the southwestern shore of the East basin. There are several other private community access locations at the lake that have boat launches, picnic facilities, and designated swimming areas. An examination of aerial photographs taken in 2002 revealed that approximately 50% of the lake shoreline remains undeveloped. A considerable portion of these areas are maintained as fish and wildlife conservancy areas.

Fragrant waterlily (*Nymphaea odorata*), a state-listed noxious weed, was discovered in the lake in the late 1980's. Both physical and chemical control methods have been used to suppress the growth of this plant in past years. The state-listed noxious weed yellow flag (*Iris pseudacorus*) was also recently discovered at the lake. Both fragrant waterlily and yellow flag are currently not widespread but their populations could rapidly expand and threaten beneficial uses at the lake.

Mechanical harvesting of submerged native plants has taken place at Lake Lawrence on a somewhat annual basis since 1986. Without these mechanical harvests, these plants impede recreational uses of the lake. The annual harvests are used to improve these recreational uses (e.g., swimming, boating, skiing, and fishing) during the summer months.

It is important to understand that aquatic plant control activities are entirely funded by the Lake Lawrence Lake Management District (LMD) and not by public agencies. The LMD was formed in 1986 and lake residents have continued to supply volunteer time and financial resources for lake management activities.

In 2002 Lake Lawrence Lake Management District (LMD) and staff from the Thurston County Department of Water and Waste Management applied for a grant to develop a plan for long-term control of aquatic plants. Thurston County was awarded a grant the following year for development of an Integrated Aquatic Vegetation Management Plan (IAVMP). The main purpose of developing this IAVMP was to perform a comprehensive review of all aquatic plant control methods approved for use in the State and Thurston County in the context of current plant management goals at the lake. This management plan serves as an update to the sections of the 1995 Lake Lawrence Management Plan (Thurston County 1995) dealing with aquatic plant control.

An aquatic plant survey was conducted as part of this planning effort. Both fragrant waterlily and yellow flag were identified during the survey along with many other native plants. Approximately 40% (130 acres) of the lake was inhabited by aquatic plants, which is consistent with plant surveys conducted in past years.

This report provides a description of the aquatic plant control plan developed for Lake Lawrence. The elements of this plan were developed during a public involvement process with the residents of the lake. The basic recommendations selected for aquatic plant control in Lake Lawrence are:

- Use of Rodeo® for the eradication of fragrant waterlily and yellow flag.
- Use of harvesting (short-term) and grass carp (long-term) for the control of native submerged plants.
- Allow for use of local small-scale plant control efforts in front of residents' homes using hand tools, bottom barriers, etc.
- Conduct surveys to track the status of aquatic plants and monitor for the introduction of new noxious weeds.
- Continue to support the Aquatic Plant Advisory Committee for the lake whose function is to make decisions annually about controls needed and review aquatic plant management goals.
- Promote lake and watershed stewardship education with an emphasis on identifying noxious weeds and protecting habitat for fish and wildlife.
- Enhance water quality in the lake by controlling excessive aquatic vegetation.

Although the purpose of this project is aquatic plant management, water quality is also an issue. An additional element in this project was to review past water quality studies and present an updated cost assessment for two water quality improvement techniques, sediment dredging and the addition of buffered alum. This updated assessment is included as an attachment at the end of this plan. It should be noted that both of these water quality treatment techniques could impact aquatic plants. Lake sediment dredging, if it occurred in the nearshore area could decrease aquatic plant habitat. A buffered alum treatment can result in increased plant growth due to increased water transparency and light penetration.

PUBLIC INVOLVEMENT

Public involvement for this project has included steering committee meetings and public meetings. Each element is described below.

The Lake Lawrence LMD has been in existence since 1986. The LMD is represented by a steering committee that typically meets on the second Thursday every month. One of the primary topics of discussion during meetings held early in 2003 was how to guide the development of an updated IAVMP for Lake Lawrence. The steering committee reviewed plant control efforts and management goals, organized public meetings, selected aquatic plant control alternatives, and reviewed funding options during meetings held in 2003-2004.

The following are members of the steering committee: Jim Bachmeier and Ryan Langan of Thurston County Water and Waste Management, Larry Phillips of the State of Washington Department of Fish and Wildlife, and lake residents Greg Halsey, Tom Fischer, John Gray, Skip Meredith, Bob Patrick, Debbie Anderson, Chuck Flory, Steve Hannon, Carroll Kastelle, Dan Moffett, Hugh Ackermann, Ed Freelund, Dan Haw, Carroll Malloy, Dave Olson, Marvin Stewart, Anita and Dave Drummond, Kathy Hasslinger, Nic Loch, Lee Landon, Patrick McCaulay, and Kit Corollo.

Three public meetings were held from October 2003 to January 2004 as part of the process to update the Lake Lawrence IAVMP. The Lake Lawrence LMD steering committee and the Thurston County Department of Water and Waste Management, sponsored these meetings. The first public meeting was held on October 9, 2003. The purpose of the meeting was to provide background information about Lake Lawrence, discuss aquatic plant management goals and objectives, generate a problem statement, and seek comments and questions from the public. A second public meeting was held on December 10, 2003 to review aquatic plant control alternatives and a dredging and alum treatment feasibility assessment. A few aquatic plant control alternatives were selected at this second meeting for further review. The final public meeting was held on January 8, 2004. At this meeting a few plant control scenarios were presented in more detail and a preferred plant control scenario was selected. Appendix A contains a summary of the public meeting agendas and a list of attendees.

LAKE AND WATERSHED CHARACTERISTICS

PHYSICAL CHARACTERISTICS

Lake Lawrence and its 1,340 acre watershed are located approximately 6 miles south of Yelm in Thurston County. The lake has a total surface area of 331 acres and a total lake volume of 4,617 acre-feet. It is divided into two distinct basins (Figure 1). The larger East basin has a surface area of 277 acres with a mean and maximum depth of 12.5 feet and 26 feet, respectively. The smaller West basin has a surface area of 54 acres with a mean and maximum depth of 9.8 feet and 22.5 feet, respectively. Physical characteristics of the lake are summarized in Table 1.

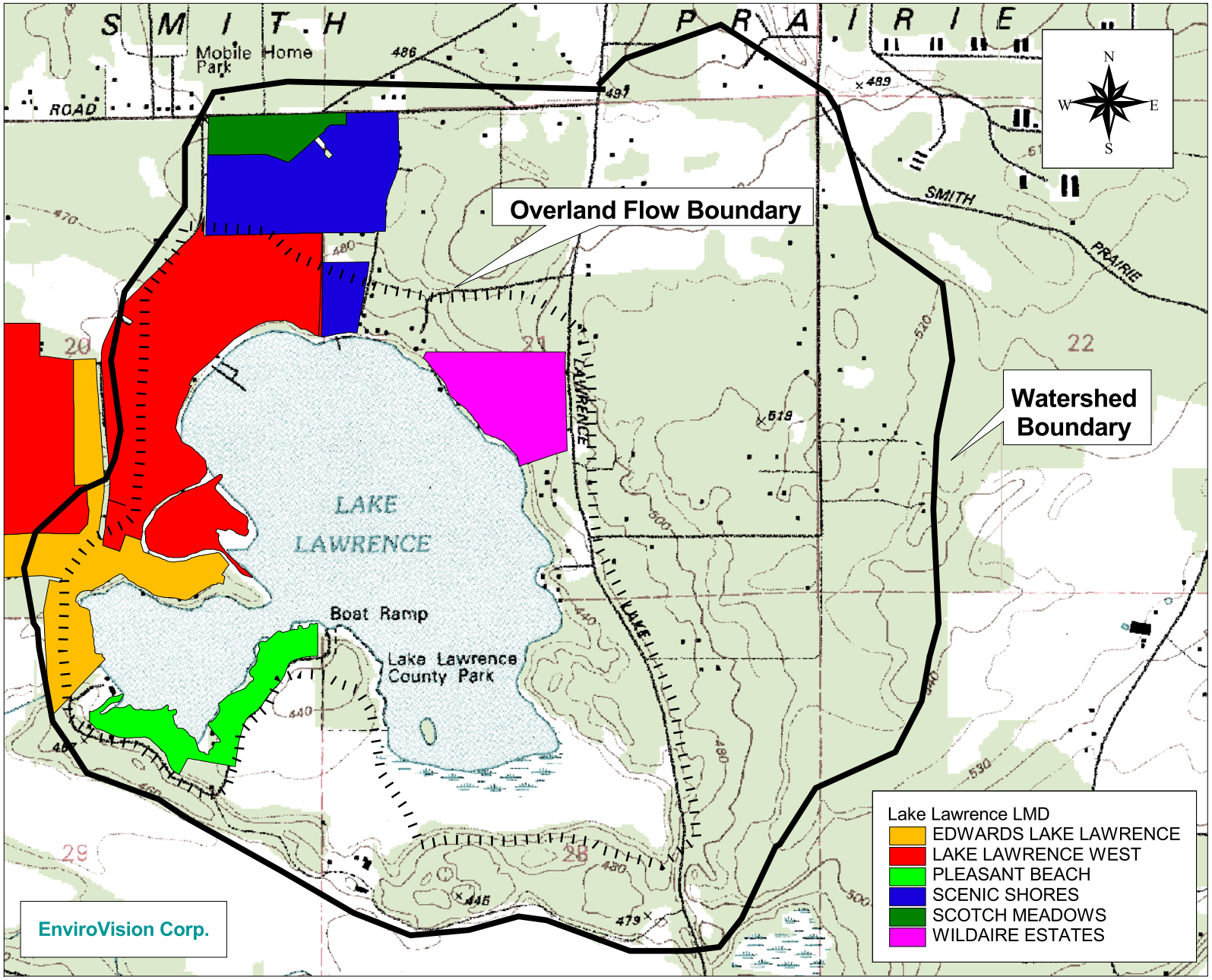
Table 1. Physical characteristics of Lake Lawrence and its watershed.

Characteristic	Units
Watershed area	1,340 acres
Surface area	331 acres
Lake volume	4,617 ac-ft
Maximum depth	26 feet
Mean depth	12.5 feet
Shoreline length	21,120 feet
Aquatic plants	100-130 acres

Watershed soils are primarily Vashon-age recessional outwash, which are characterized by high (though variable) permeability and provide a direct hydraulic connection between surface water and the groundwater aquifer (KCM 1991). Water enters Lake Lawrence via groundwater seeps, direct precipitation onto the lake, or stormwater runoff from the surrounding watershed.

Lake Lawrence is the headwaters for an unnamed, intermittently or seasonally flowing creek (WDFW ID# 122961468453) located along the western shore of the West basin. This unnamed creek is a tributary of the Deschutes River. This creek has historically served as habitat for Sea-run and resident Cutthroat Trout. However, fish are prevented from entering Lake Lawrence

Figure 1. Lake Lawrence watershed, overland flow, and LMD boundaries. Revised from KCM 1991.



from the creek due to the presence of a dam structure and a fish screen. The dam structure was likely installed sometime before 1908 when Olympic Light and Power started to use the lake as a reservoir to supplement the Tumwater Power Plant (KCM 1991). These operations ceased in 1928 but the structure remains.

Details concerning historic uses of the lake were presented in the Lake Lawrence Phase I Restoration Analysis (KCM 1991). Some past events that may be contributing to current excessive plant growth include:

- Operation of at least two sawmills in the late 19th and early 20th century. Sawdust from these mills was dumped into the lake for many years and has recently been observed in the lake sediments (Langan, R. Pers. Comm.). The sawdust likely created a much larger portion of the lake that could be inhabited by plants.
- Use of Lake Lawrence as a reservoir to supplement the Tumwater Power Plant. Sediment-laden water was diverted from the Deschutes River to create the reservoir and likely caused an increase in area habitable for plants.

The historic Lake Lawrence Lodge is located on the western shore of the East Basin and is part of the Lake Lawrence West residential development. Other residential developments on the lake include Wildaire Estates, Scenic Shores, Edwards Lake Lawrence, and Pleasant Beach (Figure 1). Most of the lots in these developments are less than 1.5 acres in size. More recent development (post-1990) along the eastern shore of the East basin has a requirement of one dwelling unit per five acres. Several large tracts of land adjacent to the wetlands along the southern and eastern shores of the East Basin are owned by a private landowner and are zoned for agriculture.

Prior to 1990, the Lake Lawrence watershed was classified as an "unmapped use district", which essentially means that there were few land use or density of development controls (KCM 1991). The watershed is now classified as "rural residential", and 5 acres is the minimum lot size for new residential construction. As of 1990 (KCM 1991), land uses for the Lake Lawrence watershed were:

- Private woodlots – 32%
- Small farms on pasture/hay land – 26%
- Rural residential – 18%
- Commercial forestland – 11%
- Wetlands/lakes – 12%

The Washington State Department of Ecology (Ecology) publishes land use/land cover information for all the Water Resource Inventory Areas in the State. Landsat TM data from 1986-1996 was used to categorize land use/land cover information for the Lake Lawrence watershed. The land uses and land cover types from the Phase I Lake Restoration study were compared against Ecology classifications. Although the more recent land uses were not categorized by Ecology in exactly the same manner as the KCM report, they are reasonably similar to those identified in 1991.

Thurston County owns a significant amount (1,500 feet) of shoreline in proximity to the large wetlands in the East basin, which is managed as priority habitat for wildlife.

Access is provided at numerous places along the shoreline, primarily through small boat launches associated with the residential developments. There is a public boat launch owned by the Washington Department of Fish and Wildlife (WDFW) just north of the Lake Lawrence County Park in the East basin (Figure 1).

WATER QUALITY

"Eutrophication" is a term used to describe the physical, chemical, and biological changes associated with enrichment of a lake due to increases in nutrients and sediment over time. Although eutrophication occurs over time as a natural process, it can be greatly accelerated by human activities in a watershed. Natural eutrophication processes occur on a time scale of hundreds to thousands of years and are generally not observable in a single human lifetime. Human induced or "cultural" eutrophication can result from activities within the watershed including development, forestry, resource extraction (i.e., peat mining) landscaping, gardening, and animal keeping. All of these activities contribute nutrients and sediment to surface waters. Sediment inputs from watershed activities results in the slow filling in of lakes which also accelerates the overall eutrophication process. Cultural eutrophication can result in observable changes within a few decades, or less.

The most common way lakes are classified is by their trophic state, which defines a lake in relation to the degree of biological productivity. Lakes with low nutrients, low algae levels, and clear water are classified as nutrient poor or "oligotrophic". Lakes with high nutrients, high algae levels, and low water clarity are classified as nutrient rich or "eutrophic". "Mesotrophic" lakes have water quality characteristics between these two classifications.

Classifying a lake based on its trophic state is a useful way to describe changes in a lakes' water quality over time and assess the potential sensitivity of a specific lake to additional nutrient loading. Total phosphorus, chlorophyll *a*, and transparency are the three water quality parameters most often used to rate the overall trophic condition of a lake. Phosphorus is one of the essential nutrients for plant growth. Total phosphorus includes all soluble, organic, and particulate forms of phosphorus. Chlorophyll *a* is one of a family of green pigments that allows green plants to perform photosynthesis. Chlorophyll *a* concentration is correlated to the abundance of algae in a lake. Water transparency is commonly measured as the depth at which a black-and-white disk (i.e., Secchi disk), when lowered into the water, ceases to be visible. Algal growth, organic acids, and suspended solids all influence Secchi depth transparency.

Water quality data has been sporadically collected from Lake Lawrence since 1974. Water quality data for 1974-75, 1981, and 1986-89 is summarized in a grass carp feasibility study completed in 1990 (Thomas et al. 1990). Water quality was also measured in 1990 as part of a Phase 1 Restoration Analysis (KCM 1991) and in 1998 by staff members of the Thurston County Environmental Health Department. The data collected in 1998 represents the most recent complete data set.

The trophic status of Lake Lawrence was determined in 1990 (KCM 1991) and 1998 (Thurston County 2002) using Carlson's (1977) trophic state indices (TSI) for Chlorophyll *a*, total phosphorus, and Secchi disk depth (Table 2). The data consistently indicate the lake is eutrophic in terms of total phosphorus and Chlorophyll *a* concentrations, and borderline eutrophic in terms of Secchi disk depth. Phosphorus originating from sediments and ground water are the main contributors of high phosphorus levels. The lake has been recommended for inclusion in the 2002/2004 Section 303(d) list of impaired waters of the federal Clean Water Act (WDOE 2004) for total phosphorus. It is important to understand that most monitored lakes in the Puget Sound Basin are likely to be included on this list for total phosphorus.

Table 2. Trophic State Classification (TSI)[(1)] for total phosphorus (TP), Chlorophyll *a* (Chl *a*) and Secchi Disk (SD) depth.

Year	TSI_{TP}	TSI_{Chla}	TSI_{SD}
1990 East Basin[(2)]	69	64	49
1990 West Basin[(2)]	58	66	47
1998 East Basin[(3)]	52	53	44

(1) TSI's calculated using Carlson's (1977) trophic state indices. TSI values of 0 – 40 = oligotrophy, 40 – 50 = mesotrophy, and >50 eutrophy.
(2) Data collected June – September. Source: KCM 1991.
(3) Data collected May – October. Source: Thurston County 2002.

WATER RIGHTS

A search of the WDOE's Water Rights Applications Tracking System indicated that there is one active surface water "Claim" with no assigned water withdrawal rate and one active surface water "Certificate" (WDOE 2003). The active Certificate, established in 1938, has a maximum water withdrawal rate of 0.27 cubic feet per second for irrigation of a maximum of 26 acres. The State of Washington Department of Ecology issues a disclaimer associated with water rights that states "*Because of unauthorized changes or non-use, Ecology cannot guarantee the validity of Permits, and Certificates."*

FISH AND WILDLIFE COMMUNITY

The Washington Department of Fish and Wildlife (WDFW) has managed Lake Lawrence as a trout fishery for many years. The lake has been chemically treated with rotenone numerous times as a means of eliminating non-trout species that may compete with trout for food or habitat. The last treatment occurred in 1985 and was considered successful (Thomas et al. 1990). However, a recent fish survey indicated that several fish species have been re-introduced (WDFW 2003b) since the 1985 survey (Table 3). These species included Pumpkinseed Sunfish (*Lepomis gibbosus*), Brown Bullhead (*Ameiurus nebulosus*), Largemouth Bass (*Micropterus salmoides*), Yellow Perch (*Perca flavescens*) and Largescale Sucker (*Catostomus macrocheilus*).

Table 3. Fish species composition summary for fish sampled (age 1 year and older) for Lake Lawrence in the spring of 2003 (revised from WDFW 2003b).

	by Weight		by Number		Size Range (mm)	
Fish species	**kg**	**%**	**No.**	**%**	**Min.**	**Max.**
Largescale sucker	3.75	9.82	2	0.34	495	585
Largemouth bass	4.70	12.30	6	1.02	91	538
Rainbow trout	6.57	17.20	17	2.88	251	531
Yellow perch	15.89	41.59	523	88.64	82	325
Brown bullhead	2.83	7.41	29	4.92	105	285
Brown trout	4.04	10.58	2	0.34	495	585
Pumpkinseed	0.42	1.11	11	1.86	67	195

The lake has been stocked with a combination of rainbow (*Oncorhynchus mykiss*), cutthroat (*Oncorhynchus clarki*), and/or brown (*Salmo trutta*) trout for the past seven years (WDFW 2003b). Stocking levels by year, species, and size class are shown in Table 4. A fish screen on the seasonal outlet prevents trout from migrating out of the lake.

Table 4. Annual stocking estimates by species, year, and size class (revised from WDFW 2003b).

	1997	1998	1999	2000	2001	2002	2003
Rainbow	23k L	363 L	96k F	-	20k F	290 L	20k L, 35k F
Brown	25k F	25k F	20k F	6k F	-	-	-
Cutthroat	-	-	602 L, 15k F	250 L, 9k F	250 L, 9k F	9k F	375 L, 11k F

Note: k=thousand, F=fry or fingerlings, L= at or above legal size limit

These stocking efforts are conducted through the joint operation of a netpen program by the Lake Lawrence LMD and WDFW. In a typical year, trout fingerlings are introduced to the netpen in the fall by the WDFW and volunteers from the LMD. The volunteers then care and feed the fish over the winter. These fish (mostly rainbow trout) are then released in the spring in time for fishing season. Brown trout were introduced into the lake from 1997 – 2000 primarily to control nonnative species (e.g. sunfish and yellow perch) that would otherwise compete for food needed by the rainbow trout. The trout fishery at Lake Lawrence is one of the best in Thurston County and survival rate of trout fry is relatively high compared to other area lakes (Phillips, L. Pers. Comm.). The netpen program is considered to be very successful by both lake residents and WDFW and is a key component of their lake management activities. Working with the WDFW to continue this program is an important goal of the LMD.

The following table lists the most common birds and mammals that are found in or near Lake Lawrence. Bald eagles and great blue herons are listed species that are discussed in more detail in the Threatened or Endangered Plants and Animals Section.

Table 5. List of birds (mainly waterfowl) and mammals found in the vicinity of Lake Lawrence.

Birds	
American Coot	*Fulica Americana*
American Crow	*Corvus brachyrhynchos*
Bald Eagle	*Haliaeetus leucocephalus*
Bufflehead	*Bucephala albeola*
California gull	*Larus californicus*
California Quail	*Callipepla californifa*
Canada Goose	*Branta Canadensis*
Common Merganser	*Mergus merganser*
Common Raven	*Corvus corax*
Great Blue Heron	*Ardea herodias*
Killdeer	*Charadrius vociferus*
Lesser Scaup	*Aythya affinis*
Mallard	*Anas platyrhynchos*
Pied-billed Grebe	*Podilymbus podiceps*
Redhead	*Aythya americana*
Ringneck Duck	*Aythya collaris*
Steller's Jay	*Cyanocitta stelleri*
Wood Duck	*Aix sponsa*
Mammals	
Beaver	*Castor canadensis*
Common Muskrat	*Ondatra zibethicus*
Common Raccoon	*Procyon lotor*
Coyote	*Canis latrans*
Gray Fox	*Urocyon cinereoargenteus*
Mink	*Mustela vison*
Mule Deer	*Ododcoileus hemionus*
Porcupine	*Erethizon dorsatum*
River Otter	*Lutra canadensis*
Striped Skunk	*Mephitis mephitis*
Virginia Opossum	*Didelphis Virginia*

AQUATIC PLANT COMMUNITY

Plant Survey

The aquatic plant community was surveyed by Thurston County staff on July 17 and July 21, 2003 to document plant coverage (Thurston County 2004a). Global positioning satellite (GPS)

equipment was used to log sampling locations. A small boat was used to conduct a surface survey of the entire littoral zone of the lake. In deeper areas where plants were not visible from the surface a weighted rake with a rope attached was used to bring up plant samples for identification. Detailed notes on plant species, density, and coverage were recorded with GPS equipment and on a hardcopy map. A complete list of aquatic plants found during the survey and their relative density and abundance is shown in Table 6.

Table 6. Aquatic plant survey results for Lake Lawrence, 2003. Source: Thurston County (2004b)

Scientific Name	Common Name	Type	Distribution/Density(1)
Potamogeton zosteriformis	Flat-stemmed pondweed	Submerged	2
Potamogeton amplifolius	Bigleaf pondweed	Submerged	4
Potamogeton crispus	Curlyleaf pondweed	Submerged	2
Potamogeton gramineus	Grass-leaved pondweed	Submerged	1
Potamogeton natans	Float.-leaved pondweed	Submerged	2
Potamogeton pectinatus	Sago pondweed	Submerged	1
Potamogeton praelongus	White-stem. pondweed	Submerged	4
Potamogeton pusillus	Slender pondweed	Submerged	4
Vallisneria americana	Water celery	Submerged	4
Elodea canadensis.	American waterweed	Submerged	2-3
Naja spp.	Naja spp.	Submerged	2
Ceratophyllum demersum	Coontail	Submerged	1
Utricularia vulgaris	Common bladderwort	Submerged	2
Alisma triviale	American water plantain	Emergent	2
Eleocharis spp.	Spikerush	Emergent	2
Equisetum spp.	Water horsetail	Emergent	2
Lilaeopsis occidentalus	Western lilaeopsis	Emergent	1
Ludwigia palustris	Water purslane	Emergent	1
Phalaris arundinacea	Reed Canary Grass	Emergent	4
Pontentilla palustris	Marsh cinquefoil	Emergent	2
Sparganium augustifolium	Narrow leaf bur-reed	Emergent	1
Scirpus acutus	Hardstem bulrush	Emergent	3
Scirpus/Juncus spp.	unidentified rushes	Emergent	3
Typha latifolia	Cattail	Emergent	3
Iris pseudacorus	Yellow flag	Emergent	2
Spirea douglasii	Douglas spirea	Emergent	2
Lemna minor	Lesser duckweed	Free-floating	1
Brasenia scherberi	Watershield	Floating-leaf	2-3
Nuphar polysepala	Spatterdock	Floating-leaf	2
Nymphaea odorata	Fragrant waterlily	Floating-leaf	2-3
Chara spp.	Chara or Muskgrass	Algae	4
Nitella spp.	Nitella	Algae	2

(1): Ecology distribution value definitions as follows: 1 = few plants in only one or a few locations, 2 = few plants, but with a wide patchy distribution, 3 = plants growing in large patches and co-dominant with other plants, 4 = plants in nearly mono-specific patches and dominant, 5 = thick growth covering the substrate at the exclusion of other species

Plant Characterization

The plant growth distribution in Lake Lawrence is illustrated in Figure 2. Roughly 40 percent of the total surface area (130 acres out of 330) of Lake Lawrence is covered with plant growth. Most of this area is colonized by submerged aquatic plants, with only 5-7 acres covered with floating-leaved plants. Submerged aquatic plants are found throughout the littoral zone to a water depth of approximately 15 feet. The floating-leaved plants are found closer to shore in shallower (< 10 feet) waters. The emergent plants identified in the plant survey were primarily located in the shallow (< 5 feet) lacustrine littoral zones along the southern and western shores of the East basin.

The shallow grade along the northeastern, western, and southern shores of the East basin provides an expansive shallow region to support plant growth. The eastern shore of the East basin is more steeply sloped with a littoral zone limited to a narrower band extending out from the shoreline. The northern portion of this eastern shoreline is currently developed while the area to the south is mostly forested and zoned for agriculture or is part of a large wetland (Langan, R. Pers. Comm.). The West basin has up to 50% of its surface acreage colonized by aquatic plants.

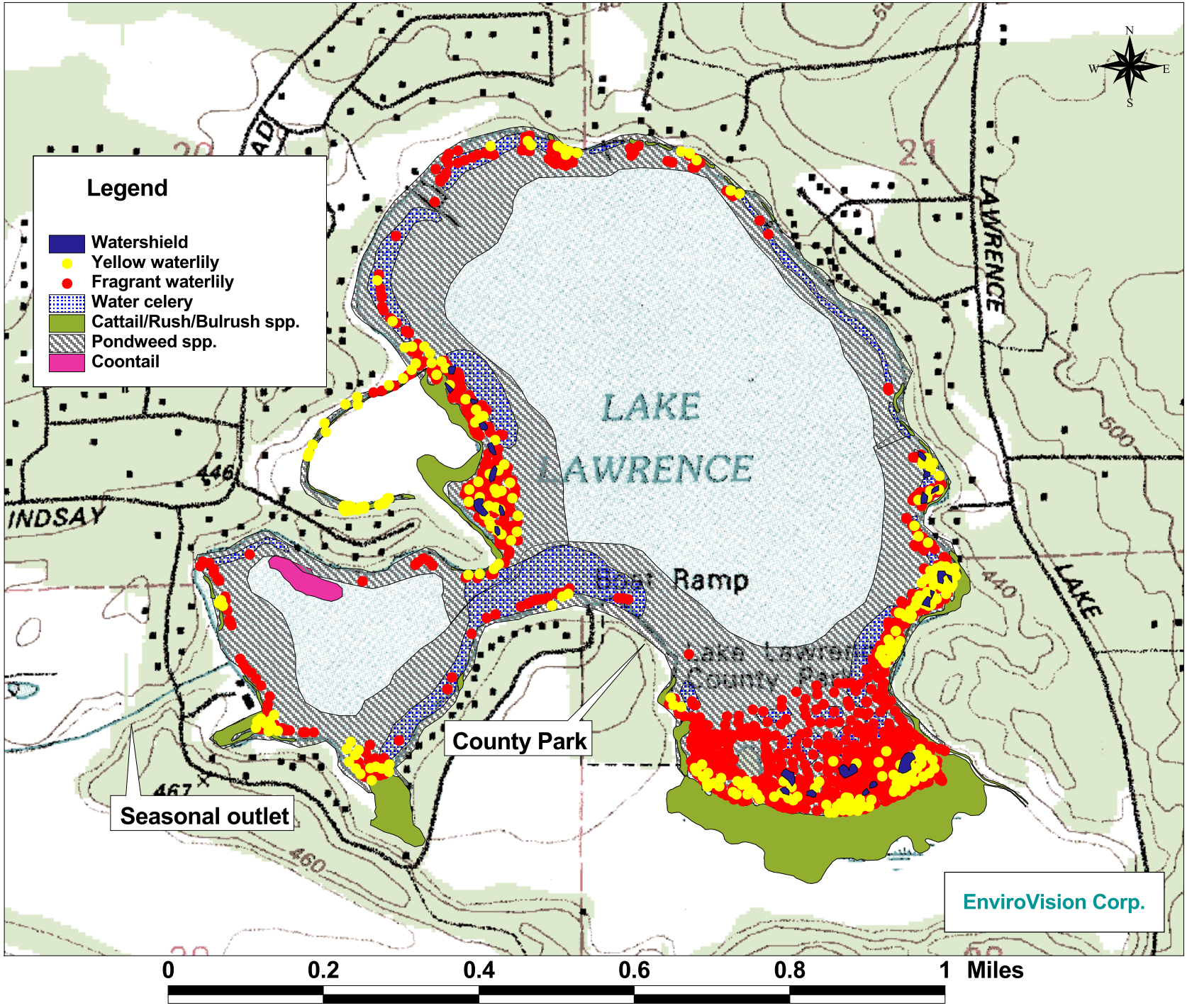
A quantitative aquatic plant survey was conducted in 1989 (Thomas et al. 1990) as part of a grass carp feasibility study. *Potamogeton praelongus*, *Elodea canadensis, Vallisneria americana,* and *Nymphaea odorata* were noted as the dominant plants in the lake. Maximum plant biomass during the 1989 survey was 1,010 g/m^2, and plants were found growing in 38% of the total surface area of the lake.

Since 1989, qualitative plant surveys have been conducted annually to support plant management activities on the lake (Langan, R. Pers. Comm.). The 2003 survey results indicate that a healthy variety of native plants inhabit the lake. All of the native aquatic plants found in 1989 were documented in the 2003 survey, along with several other plant species (Table 6). Two invasive noxious weeds were documented in the 2003 survey; fragrant water lily and yellow flag.

Fragrant (white) waterlilies, an invasive noxious plant, have been documented in the lake since at least 1989. By 1996 they covered almost 80 surface acres of the lake but were nearly eradicated with an herbicide (glyphosate) application. Since that time the amount of fragrant waterlilies has slowly increased, and approximately 2 acres of these plants were again treated in 2003. Figure 2 shows the pretreatment distribution of fragrant waterlilies.

Yellow flag is also present in low density in scattered locations. The exact locations of yellow flag are not shown in Figure 2 due to overall low abundance. It is a goal of the LMD to eradicate fragrant waterlilies and yellow flag, and control efforts will continue into the future.

Figure 2. Lake Lawrence 2003 aquatic plant community prior to fragrant waterlily herbicide treatment.



THREATENED OR ENDANGERED PLANTS AND ANIMALS

Information on rare, threatened or endangered plant species was obtained from the Natural Heritage Program at the Washington Department of Natural Resources (WDNR). At present it appears that there are no rare, threatened or endangered plant species in or in the vicinity of Lake Lawrence. A search of the WDNR Natural Heritage Program data base was conducted in 1991 as part of the Phase 1 Restoration study (KCM 1991). In that search *Carex comosa* (bearded sedge), a State Sensitive Plant, was identified as occurring in the nearshore areas of Lake Lawrence. That plant was listed as a historical occurrence and was not found during the 2003 aquatic plant survey. *Carex comosa* was last identified in the vicinity of Lake Lawrence in 1945 and has not been seen since (Swope-Moody, S. Pers. Comm.) However, during the aquatic plant survey a High Quality Native Plant Community (red alder-Douglas fir) was identified in a small area just south of the WDFW public boat launch. This is consistent with findings from the Phase 1 Restoration Study (KCM 1991) and the Natural Heritage Program database.

Information on rare, threatened or endangered animal species was obtained from the Priority Habitats and Species Program of the WDFW. There were two bird species listed in the Priority Habitats and Species Report: bald eagle and great blue heron. Each documented occurrence was listed as a "breeding occurrence". A bald eagle roosting site was documented at the Lake Lawrence County Park area in the Phase 1 Lake Restoration Study (KCM 1991). This specific site was not identified in Priority Habitat and Species Report but areas to the south and east of Lake Lawrence were identified as bald eagle territories. A great blue heron nesting site located on the south side of the East basin was documented in 1990. The Priority Habitats and Species Report did state that the nesting site was not found during a more recent field survey in 1996. However, great blue herons are seen at the lake every year (Langan, R. Pers. Comm.). All of Lake Lawrence including the large wetland in the southern end of the East basin has been documented with “regular large occurrences” of waterfowl and serve as breeding areas.

The only priority fish species listed was cutthroat (anadromous and resident) trout, which are resident to the unnamed creek that serves as the outflow to the lake. As stated earlier, the outflow only flows seasonally (January – June) in a typical year (KCM 1991). During times of stream discharge fish are prevented from entering or leaving the lake by a fish screen.

CHARACTERISTIC USE

During development of this plan the lake residents, LMD steering committee, and natural resource managers were asked to develop a list of beneficial uses the lake provides and identify where those uses occur. Beneficial uses identified included; swimming, boating, fishing, wildlife viewing, and fish and wildlife habitat. WDFW owns and maintains a boat launch just north of the County Park (Figures 3 and 4). The County Park is a heavily utilized recreation area. There are three residential developments (Lake Lawrence West, Scenic Shores, and Wildaire Estates, west to east) on the north shore of the East basin that have picnic facilities and private boat launches for lake residents. There is also a picnic area and private boat launch on the northwestern corner of the West Basin for residents living in the Edwards Lake Lawrence development. Most of the swimming in the lake takes place at the private boat launches

Figure 3. Lake Lawrence 2003 harvesting areas and residential development

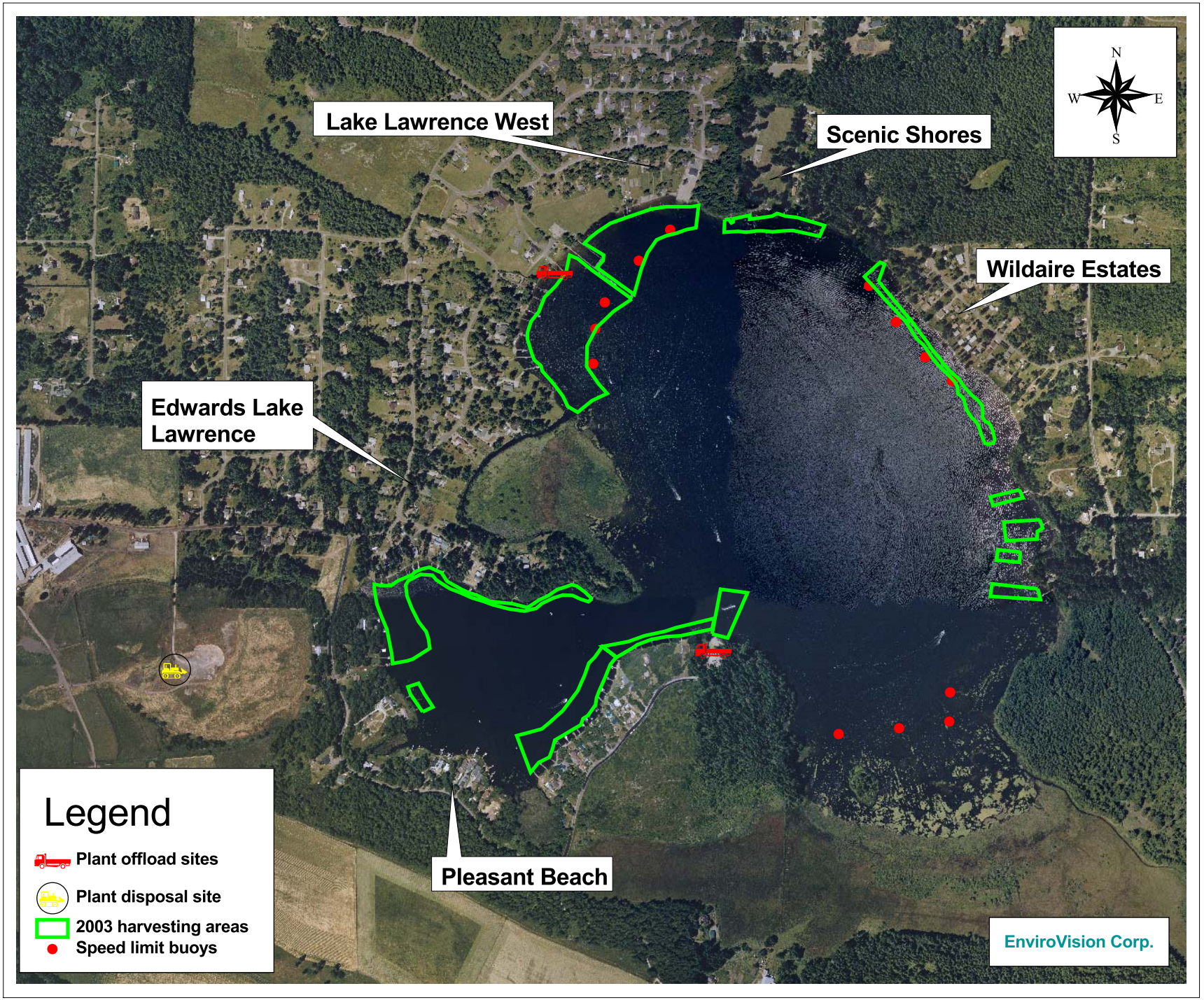
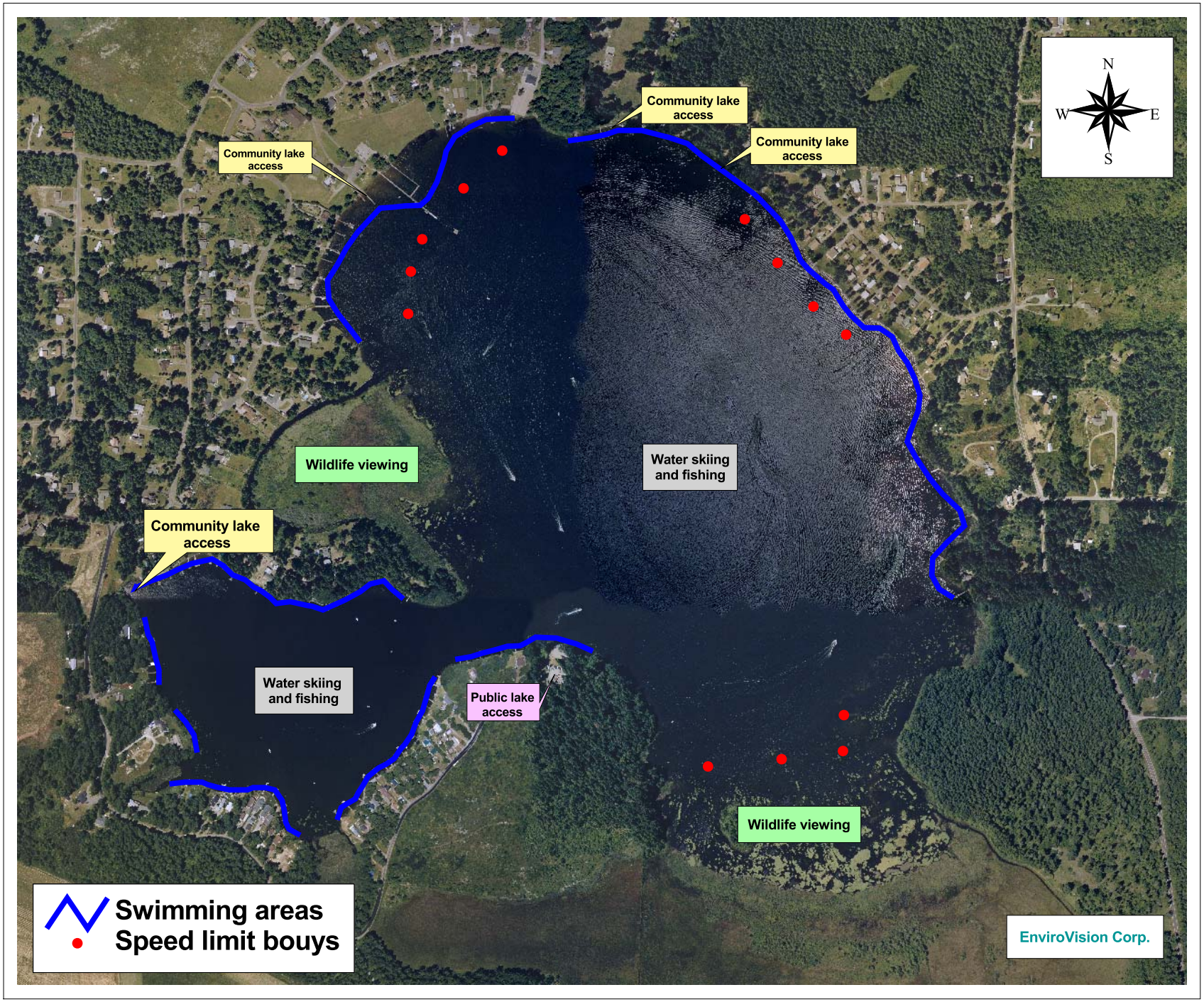


Figure 4. Waterbody use map for Lake Lawrence



associated with the residential developments. Some swimming also takes place near the WDFW boat ramp. Swimming also occurs near single residential homes but some of these areas have been impacted by dense plant growth.

AQUATIC PLANT MANAGEMENT GOALS

The following list of aquatic plant related problems was developed by the Lake Lawrence steering committee and lake residents:

- The lake has lost some of its aesthetic value; this has negatively impacted property values and there is a long-term public financial and recreational loss.
- The dense aquatic plants pose a safety hazard to swimmers and skiers who might get entangled in the vegetation.
- Aquatic plants restrict the portion of the lake where people can fish. It is no longer possible to troll through many areas of the lake. Plants foul fishing gear, motors, and oars.
- There are suspected water quality impacts from the plants, especially increased rates of sediment accumulation from decaying plants.
- The aquatic plants cause problems for the swimming areas associated with the community lake access locales at the private boat launches

The list of problems was used to create a problem statement for Lake Lawrence. The purpose of the problem statement is to describe as clearly as possible how the lake and its inhabitants are being negatively impacted by aquatic plants. The following problem statement was developed for the lake:

Lake Lawrence was once an aesthetic, pristine lake that provided important wildlife habitat, and offered many recreational opportunities, including; swimming, fishing, boating, and shoreline related activities. The lake also supports one of the most popular public parks in southern Thurston County. Beneficial uses of the lake have been severely impacted from dense, prolific growth of aquatic plants.

The shallow shoreline area provides an excellent habitat for aquatic plants. Over the past 10 years both physical and chemical control methods have been used to target the aggressive, non-native plant fragrant waterlily. Although this plant is now much less abundant as compared to past years, its rapid and dense growth pattern has caused an excessive deterioration in the quality of the lake and its value to the community. Another recently discovered noxious weed, yellow flag, may also negatively affect habitat, especially in the large wetland areas. Even before the introduction of noxious weeds, the lake was adversely affected by dense stands of native aquatic plants. Unfortunately these plants grow at their densest in the nearshore zone, which is also the portion of the lake that is valued and utilized most by lake residents and visitors. The lake community is concerned about the loss of recreational use of the lake, the long-term deterioration in water quality the plants will cause, the safety hazard the plants present to swimmers and boaters, and the commensurate loss in property values.

Before beginning development of a plant control plan management goals were defined against which the plan could be evaluated. Setting project goals is an important step because they are used to determine what control strategies will work, and will ultimately be used to evaluate whether plan implementation has been a success. The following list of management goals was developed by the steering committee and lake residents. A group rating process was used to rank the priority goals for plant control. The process resulted in the following priority goals.

- Eradicate all noxious aquatic plants from the lake and work to prevent future infestations.
- Significantly reduce the amount of aquatic plants in residential areas.
- Continue lake-wide aquatic plant control measures to maintain beneficial uses while protecting habitat for fish and wildlife.
- Conduct surveys on an annual basis to track the status of the aquatic plants in the lake and monitor for the introduction of new noxious weeds
- Continue an educational program that promotes lake and watershed stewardship and provides a greater awareness of the continual threat of noxious weeds and the importance of homeowner Best Management Practices (BMPs) for the long-term protection of Lake Lawrence.

AQUATIC PLANT MANAGEMENT OPTIONS

The residents of Lake Lawrence have managed aquatic plants since formation of the LMD in 1986. A summary of aquatic plant management efforts is shown in Table 7.

Table 7. Summary of aquatic plant control methods at Lake Lawrence

Year	Mechanical Harvesting Submerged Plants [1]	Fragrant Waterlily Control Method
1986	Yes	No
1987	Yes	No
1988	Yes	Bottom Barrier [2]
1989	Yes	Bottom Barrier [2]
1990	No	No
1991	No	No
1992	No	No
1993	No	No [3]
1994	Yes	Mechanical Removal [4]
1995	Yes	Mechanical Removal [4]
1996	Yes	Herbicide ~ 80 acres
1997	Yes	Herbicide [5]
1998	Yes	No
1999	Yes	No
2000	Yes	Herbicide ~ 10 acres
2001	Yes	No
2002	Yes	No
2003	Yes	Herbicide ~2 acres

(1) Typically consists of two 30-acre harvests
(2) Acres of Fragrant waterlily controlled is unknown
(3) A pilot study demonstrating rotovation took place at Long Lake, Thurston County in 1993. Long-term control of fragrant waterlily was not obtained. The technique appeared to be causing the spread of fragrant waterlily and increasing turbidity due to sediment disruption (Langan, R., Pers. Comm.).
(4) Using a County-owned backhoe mounted on a barge, thirteen lake residents provided over 500 hours of their time removing over 300 tons of lily tubers in 1994. These efforts continued in 1995. Long-term control of fragrant waterlily was not obtained. The technique appeared to be causing the spread of fragrant waterlilies and was very labor intensive for volunteers.
(5) Herbicide (glyphosate) was used to spot treat areas that were missed in 1996. Acres treated is unknown.

The primary plant control activity has been mechanical harvesting to control native submerged vegetation. In a typical year, two, 30-acre harvests are conducted; one just before the 4th of July and the other prior to Labor Day. These harvests are used to improve beneficial uses such as swimming, boating, skiing, and fishing. Although native submerged plants grow prolifically throughout the littoral zone of the lake, the harvests are conducted mainly in front of residential homes (Figure 3). Water celery, big leafed pondweed, and thin-leaved pondweeds comprise the bulk of aquatic plant biomass removed from the lake during harvesting.

Fragrant waterlily, a floating-leaved plant, has also been the target of control efforts. In 1994 lake residents attempted to control fragrant waterlilies by digging them up using a County-owned backhoe mounted on a barge. The extent of this effort is documented in the table above; over 500 hours of volunteer time was spent on this task. This method was deemed ineffective and may have caused a more widespread infestation in the lake. In 1996-1997 approximately 80 acres of fragrant waterlilies were treated with glyphosate. Spot treatments of fragrant waterlilies have taken place in 1998, 2000, and 2003 to keep them under control.

As described previously, there are two areas of concern associated with the aquatic plant community in Lake Lawrence; eradication of fragrant waterlily and yellow flag, and the long-term control of native submerged plants. All control alternatives described and approved by the WDOE (1994) (also see: http://www.ecy.wa.gov/programs/wq/plants/management/index.html) were initially considered for use in Lake Lawrence. These included the use of various herbicides, mechanical removal or harvesting, rotovation, sediment dredging, stocking grass carp, and other techniques. The process for selection of the preferred control option(s) began with presenting the entire range of control alternatives typically available to Washington State residents and describing the advantages and disadvantages of each and how each might best be utilized on the lake. Appendix B provides information on the aquatic plant control methods that were presented at a public meeting and through a newsletter. (Appendix C provides information on permitting requirements for the different aquatic plant control methods.)

The next step was to combine these control alternatives to form different strategies that met some or all aquatic plant management goals. Two control methods for eradication of fragrant waterlily and yellow iris (floating-leaved and emergent plants, respectively) were presented at the final public meeting for consideration in selecting a recommended action plan. These control methods included:

- Repeated annual applications of the systemic herbicide (Rodeo®) until eradication is achieved
- Use of annual handpulling efforts until eradication is achieved

Three control strategies for native submerged plants were presented at the final public meeting for consideration in selecting a recommended action plan. These were:

- Continuation of the existing mechanical harvesting program
- Continuation of the existing mechanical harvesting program as a short-term (3-5 year) control measure, and stocking grass carp for long-term control
- Annual use of contact herbicides (Reward® or Aquathol®)

Initially there was some concern expressed about the use of chemicals in an aquatic environment. Discussions of the toxicity of the selected herbicides and the herbicide approval process helped to alleviate some of these concerns. The following summary of the herbicide approval process is provided for clarification.

To be approved for use in aquatic environments, an herbicide must pass stringent toxicity testing by the federal government. These tests are designed to assess impacts to the target population

(plants) as well as non-target populations such as fish, aquatic insects, and other organisms. The tests also examine what happens to the chemical over the long-term to insure the chemical quickly breaks down into a non-toxic form and that, for example, it does not accumulate in sediments or fish tissue. Herbicides approved for use in Washington State undergo an additional review process called a risk assessment. Many of the aquatic herbicides approved for use in the United States have been approved for use in Washington, although a few are not allowed under the State's more stringent standards. The relatively low toxicity of the herbicides (glyphosate, diquat, and endothall) considered for use in this plan warranted their acceptance as three aquatic herbicides allowed for use in Washington State. However, Thurston County has adopted a Pest and Vegetation Management Policy (Thurston County 2004b) with additional standards that must be met prior to the use of herbicides to control vegetation.

Thurston County is involved with operations and provides advice related to vegetation management for the Lake Lawrence LMD. Thus, aquatic plant control activities at Lake Lawrence must comply with guidelines set forth in the Thurston County Pest and Vegetation Management Policy. According to this policy "*It is the intent of the county to set an example in implementing integrated pest and vegetation management programs that minimize the use of pesticides*". Lake Lawrence is designated as a Sensitive Area under this policy. Any proposal to apply pesticides (including herbicides) to the lake must undergo public review and be approved by the Thurston County Board of Health and Thurston County Board of Commissioners.

Only pesticides permitted for use by the Thurston County Environmental Health Division or specifically allowed by the Thurston County Board of Health can be used in Long Lake as part of the LMD-sponsored IAVMP. Glyphosate (Rodeo®) is an herbicide that is currently approved for use by Thurston County. The herbicide Reward® considered in this plan contains the active ingredient diquat dibromide. Diquat dibromide failed a pesticide review in 1991 (Thurston County 2004b). Some Thurston County's concerns associated with diquat dibromide included:

- *Yellow perch suffer significant respiratory stress when herbicide concentration in water is similar to what is normally present during aquatic vegetation control.*
- *Diquat also contains ethylene dibromide as an inert ingredient, which is considered to be an animal positive carcinogen.*
- *Persists in the soil for years with little degradation even though not biologically or chemically active.*
- *EPA requested additional testing for possible adverse effects in gene mutation and DNA damage.*
- *There were some effects to male reproductive capacity in mice.*
- *Cows were especially sensitive to treated waters.*
- *Respiratory equipment was recommended for applicators.*

Aquathol® (active ingredient endothall) also failed a pesticide review conducted in 2000 (Thurston County 2004b). Some of the County's concerns associated with Aquathol® included:

- *Salmonid smoltification and gill injury are significant.*
- *Potential dermal and eye irritation, and 24-hour swimming restrictions after treatment.*
- *High mobility, and may persist in low oxygen environments.*

RECOMMENDED AQUATIC PLANT CONTROL PLAN

It should be stressed that the residents of Lake Lawrence are not dissatisfied about the natural environment at the lake but are concerned about how historical uses (e.g. sawmills and reservoir) may be contributing to current aquatic plant problems. The residents recognize that native aquatic plants, when present at low to moderate levels, are beneficial to the lake ecosystem. Since formation of the LMD in 1986, lake residents have followed the County IPM guidelines and have only used herbicides as one part of the aquatic plant control prescription. To date, native submerged plants have been managed lake wide through mechanical harvesting, and on a smaller scale by individual homeowners in front of their property. Biological or chemical control methods have not been used on native submerged plants.

Several physical control methods (mechanical harvesting, modified rotovation, bottom barriers, and hand-removal) have been used to control fragrant waterlilies with little to no success. An IPM prescription for control of fragrant waterlilies at Lake Lawrence was adopted in 1995 and is included as an attachment to this plan. This IPM called for the use of an herbicide (glyphosate) in residential or recreational shoreline areas to control fragrant waterlilies. The IPM also called for physical removal of lilies from these areas while leaving fragrant waterlilies in other areas. It should be noted that since the fragrant waterlily IPM was adopted in 1995, the overall amount of fragrant waterlilies has been reduced from 80 acres to less than 2 acres. This reduction in fragrant waterlilies can be solely attributed to the use of glyphosate. Lake residents and managers have attempted to augment the use of herbicides by physically removing waterlilies. However, lake residents and managers have since come to the conclusion that physical removal of lilies is extremely difficult and not cost-effective. Additionally, the County no longer owns the barge-mounted backhoe that was used for fragrant waterlily control in 1994-1995. Therefore, physical removal of fragrant waterlilies on a large-scale using volunteers and County equipment is no longer a viable option

The following sections contain a detailed description of the strategy that was selected for control (or eradication) by plant community type.

FLOATING-LEAVED (FRAGRANT WATERLILY) PLANT CONTROL

The control objective for the non-native fragrant waterlilies is eradication. While fragrant waterlilies are the dominant floating-leaved plant in the lake they co-exist with others such as yellow water lilies and watershield. It is desirable to retain these other plants because of their

habitat and recreational value. To meet these needs targeted applications of an herbicide with the active ingredient glyphosate (e.g. Rodeo®) is recommended.

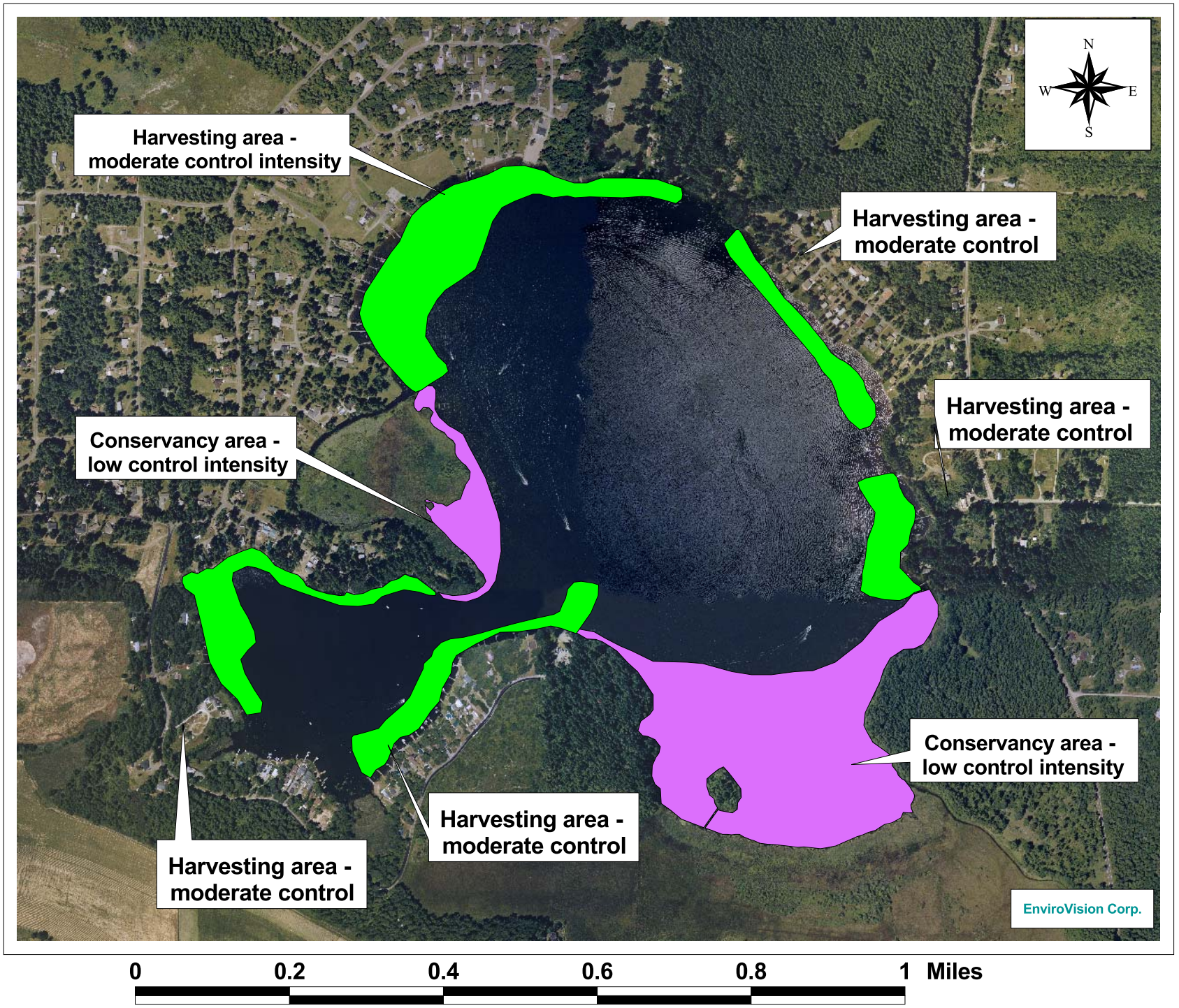
Glyphosate was selected for the herbicide treatment because of effectiveness, duration, low cost, and negligible environmental impact. Glyphosate is a systemic herbicide that is absorbed by foliage and passed throughout the plant. Since it kills the rhizomes, it results in long-term control of the plant community. This herbicide has low toxicity to bottom-dwelling organisms, fish, birds, and other mammals and dissipates quickly; therefore it is considered to have a low environmental impact. Toxicity information is included in Appendix C.

This herbicide was used to treat all the fragrant waterlilies (approximately 2 acres) in the lake in 2003. Glyphosate was sprayed onto the fragrant waterlilies while avoiding other floating-leaved plants. It is likely some will have either survived this treatment or were not detected and therefore were not treated. It is reasonable to estimate that 1-2 acres (single plants up to larger patches) will have to be treated in 2004. Because only a few acres of waterlilies are present at the lake, overall control intensity for this noxious weed is low (Figure 5). The amount of fragrant waterlilies will steadily decrease through continued annual treatments until eradication is achieved. It is estimated that fragrant waterlilies will eradicated or at undetectable levels after four consecutive years of treatment.

It is assumed that two applications of the herbicide will be required in any treatment year to ensure application success. Prior to treatment a detailed aquatic plant survey and GPS mapping effort would be conducted to identify all the fragrant waterlilies (individual plants and patches of plants) in the lake. Glyphosate would then be applied to these patches and single plants where they occur. The first treatment should take place no earlier than mid-summer to ensure that all fragrant waterlilies have reached the surface of the lake. It is relatively common for some plants to survive this initial treatment as they are either not identified by the applicator or herbicide is washed off by waves. Thus a second treatment conducted a few weeks after the first would result in improved control. Care should be taken by the applicators to avoid collateral damage to the native yellow waterlilies and watershield. The herbicide would be re-applied annually until fragrant waterlilies are eradicated.

Costs for herbicide treatments are commonly based on a per-acre cost. The cost of using glyphosate typically ranges from $250 - $350 per acre treated. However, this per acre cost becomes more accurate as the number of acres to be treated increases (e.g. > 10 acres). Most applicators charge a minimum fee per treatment and include other costs such as public notification and plant surveys. For example, approximately 2 acres of fragrant waterlilies were treated in 2003. The treatments took place on two separate occasions, included public notification and a survey, and cost approximately $4,000. Based on this cost in 2003, to treat a maximum of 2 acres of floating-leaved plants twice per season, it is estimated to cost $3,500 per treatment year. This cost estimate for 2004 is slightly less than 2003 as it likely there will fewer plants to treat. By controlling fragrant waterlilies in this manner they should be eradicated after a few seasons. Although annual costs may change slightly as the plants near eradication, over the 10-year period of this plan glyphosate treatment has been estimated to cost $14,000.

Figure 5. Aquatic plant control intensity for harvesting and fragrant waterlily eradication



By implementing this eradication strategy for fragrant waterlilies, it is possible that eventually only a few (single plants) fragrant water lilies will be found during the annual plant survey. If that is the case it may not be cost-effective to hire an applicator to spray only a few plants. Although difficult, alternative methods such as hand-pulling or diver hand-removal could be used to control low numbers of these plants. Lakeside residents can also help to eradicate fragrant waterlilies by handpulling, installing bottom barriers, or other physical methods. Although this requires time and energy on the part of the residents it also compliments the lake-wide eradication effort.

EMERGENT PLANT CONTROL

Yellow flag is another noxious aquatic plant that is targeted for eradication from the lake. This emergent plant inhabits the shoreline of the lake and often exists in locations above the waterline. It is a fast-growing plant that can quickly spread throughout shoreline and wetland areas, displacing native vegetation. This plant is not susceptible to herbivory by vertebrates and invertebrates, and may even cause gastroenteritis if eaten by cattle (Sutherland 1990). Because yellow flag mainly propagates through rhizomes, it is very difficult to control through physical methods on a large scale.

As with fragrant waterlilies, all yellow flag will be identified and mapped during the annual plant survey. Overall abundance of this plant is still relatively low, and glyphosate will be used to treat it at the same time that fragrant waterlilies are sprayed. Eradicating this plant while it is at a low density and before it becomes a (more expensive) problem is a priority. Lake residents are strongly urged to contact the County if they have yellow flag on their property, and if possible permission to treat these plants should be obtained from homeowners. The cost to spot treat the lake edge with glyphosate to kill these plants is included in the cost estimate for spraying fragrant waterlilies.

Because this is a shoreline plant that may be considered attractive by homeowners an ongoing education program that emphasizes the negative aspects of noxious weeds should be implemented. An annual event where lake residents hand-pull small plants or dig up or cover mature plants should occur if yellow flag populations decrease to the point at which herbicide treatments are no longer cost effective. The use of herbicides should be reinstated if at any time the population appears to be increasing or if physical control is not deemed effective.

NATIVE SUBMERGED PLANT CONTROL

The selected strategy for controlling native submerged plants is to continue the mechanical harvesting program in the short-term and stock the lake with triploid (sterile) grass carp as a long-term plant control method. However, if in the future a State-approved herbicide is approved for use by Thurston County that is effective for controlling the plants in Lake Lawrence, it is recommended for consideration under this plan.

Short-Term Control Strategy - Mechanical Harvesting
Mechanical harvesting is a way to remove plants in order to provide open areas of water for recreational activities and navigation. A detailed discussion of this plant control method is provided in Appendix B. Permitting requirements for mechanical harvesting are provided in

Appendix C. Mechanical harvesting is the current submerged plant control strategy at Lake Lawrence. Harvesters have been used to control submerged plants at the lake since 1986. Two separate 30-acre harvests take place; each just before the July 4th and Labor Day holidays. The harvesters remove the upper portion of the aquatic plants in approximately 30% of the littoral zone. This leaves a substantial amount of plant material in the lake both in the harvested and unharvested areas. The areas harvested in 2003 are shown in Figures 3 and 5

Mechanical harvesting was identified as the most effective and feasible method to control submerged vegetation in the lake before grass carp become established. The control intensity in areas to be harvested is categorized as moderate (Figure 5). Under the current harvesting program, members of the Lake Lawrence steering committee coordinate with Thurston County staff to conduct an annual inspection of the areas designated for harvest. These areas are reviewed and approved annually by the steering committee. The LMD budget, level of plant growth, and areas to be maintained as conservation areas are some of the factors weighed when the steering committee members choose harvesting areas. Because the process to initiate annual mechanical harvesting is lengthy (e.g. months not weeks), assumptions about harvesting needs often are based on the plant survey from the preceding year. Since the onset of mechanical harvesting in 1986, there has never been an instance where mechanical harvesting services were contracted based on the preceding year's plant growth but were not required due to lack of plants in the current year.

This harvesting program would continue until grass carp begin to perceptibly reduce submerged aquatic plants in the lake. Assuming the grass carp are initially stocked at a rate sufficient to control vegetation, it is estimated that annual harvesting would have to continue for up to four years after initial stocking. Plant biomass surveys will be conducted to determine how effectively the grass carp reduce plant growth and is discussed later in this plan.

Although mechanical harvesting does not remove all the plants where it is used and plants generally tend to grow back in the same season, the residents are generally satisfied with the current harvesting program. This can be directly attributed to reliable communication among the harvester operators, lake residents, and Thurston County staff. Residents are informed of the harvesting schedule through newsletters and by members of the steering committee.

Long-Term Control Strategy – Stocking Grass Carp

Although lake residents are reasonably pleased with the mechanical harvesting program (method), they are frustrated with harvesting effectiveness and duration of control. There is a general sense that there has been no long-term reduction in the overall abundance or density of submerged aquatic plants. Lake residents have expressed interest in a more permanent and less expensive solution to nuisance levels of submerged aquatic plants. Therefore, grass carp stocking was chosen as a long-term method to control submerged plants.

Grass Carp are a plant-consuming fish native to China and Siberia. They are raised commercially in the southeast U.S. for use in lake and pond plant control projects. These fish do not compete with other fish species for either food or spawning habitat and in that sense are a good biological control agent. A detailed discussion of this plant control method is provided in

Appendix B. Several permits need to be completed and approved prior to stocking grass carp in the lake. Permitting requirement for stocking grass carp are provided in Appendix C.

Grass carp were considered as a submerged plant control method for Lake Lawrence in the past. A feasibility study of stocking grass carp was conducted by WDFW in the late 1980's (Thomas et al. 1990). The researchers assessed the status of aquatic plants, warm water fish, and water quality, and predicted possible impacts on those communities and parameters by stocking grass carp. The researchers recommended that grass carp be stocked in the lake only if complete removal of submerged aquatic plants was acceptable. They also stated that the lowest stocking rate (approximately 72 grass carp per vegetated acre) be used, with additional stocking at the four year point if desired plant control results were not achieved.

One of the WDFW requirements for allowing grass carp use is to screen inlets and outlets of the waterbody in which they are stocked. In Lake Lawrence's case, there is no inlet, thus eliminating inlet-screening concerns. The outlet flows only seasonally, and is already screened to retain trout stocked in the lake. The fact that there are no salmon utilizing the lake also reduces screening concerns.

WDFW would likely require some long-term monitoring of the plant populations (and potentially fish and waterfowl) to allow documentation of the impact of the grass carp on other biological communities. This information would also be critical in determining the need for additional stocking to control plants. More detailed information on monitoring is included later in the Implementation, Evaluation and Monitoring Section of this Plan. Depending upon what is required, this could cost as much as $5,000 on a given monitoring year. An allowance for this additional cost has been included in final plan implementation costs.

Overview of Grass Carp Considerations

There were a number of reasons that grass carp stocking was selected as a long-term submerged plant control alternative. Generally, grass carp provide some advantages over other plant control alternatives. First, the grass carp themselves are inexpensive both in terms of initial costs and long-term operation and maintenance costs (restocking every 4 to 10 years). (In lakes that require expensive screening projects the cost advantage is less significant.)

Grass carp are also generally considered a more acceptable alternative than continual applications of herbicides. As a biological manipulation tool they have the advantage of not competing with native fish for food or spawning habitat, so there are no direct effects on fish communities. Although also described as a disadvantage of using grass carp, the fact that it will take a number of years before the full effect of the carp is attained may be an advantage. Immediate, large shifts in the ecosystem (such as from use of a herbicide) do not occur, and the more gradual change may allow biological communities to react in a natural way.

Some of the potential problems associated with the introduction of grass carp to Lake Lawrence are: 1) Overstocking would cause removal of too many plants or total eradication and cause loss of fish and wildlife habitat as well as other negative environmental change; 2) Loss of the plant community may result in increased algae growth; 3) Uneven distribution of effects (either based on plant palatability or habitat) may alter plant community diversity, resulting in a community

consisting primarily of one or two nuisance species; and 4) Potentially little to no impact on submerged aquatic plants. These last two disadvantages are primarily a concern associated with understocking the fish. If the fish are adequately stocked or overstocked there may be changes to the aquatic plant community, but eventually the community would be controlled at a low level or eradicated, so that the alteration is less important. However, if the lake is understocked, the fish may not adequately control the less palatable plant species. In the case of Lake Lawrence, all submerged aquatic plants that are currently known to occur are highly to moderately palatable to grass carp (Pauley and Bonar 1995).

If the worse case scenario is assumed and the grass carp are overstocked, total eradication of the submersed plant community can be expected. The carp will continue to maintain eradication conditions until enough fish have died to allow the plants to regain a foothold. In theory, the carp should then continue to hold the plant population back for a few more years as the number and size of carp reaches an equilibrium with the plant population. If carp are not replaced, they will all eventually die and the plants will quickly recolonize their former habitat.

To summarize, some of the advantages of stocking grass carp include:

- Inexpensive compared to most other control methods
- Offer long-term control (assumes re-stocking at regular intervals)
- Are a biological alternative to aquatic plant control, which conforms to Thurston County IPM policy by minimizing the use of herbicides
- Generally a high satisfaction by lake residents where grass carp are stocked regardless of level of plant control

Some of the disadvantages of stocking grass carp include:

- It may take several years to achieve plant control
- If the waterbody is overstocked, all submersed aquatic plants may be eliminated, if it is understocked no impact may be observed
- The type of plants grass carp prefer might also be those most important for habitat and for waterfowl food
- Removing excess fish is difficult and expensive
- All inlets and outlets to the lake must be screened (this requirement is already met for Lake Lawrence)

Experiments have shown that grass carp exhibit definite food preferences and some aquatic plant species will be consumed more readily than others (Pauley and Bonar 1995). However, it is important to note that grass carp did not remove plants in a preferred species-by-species sequence in multi-species plant communities. Instead they grazed simultaneously on palatable plants of similar preference before gradually switching to less preferred groups of plants. The relative preference of many plants was dependent upon what other plants were associated with them. The relative preference rank for the 20 aquatic plants tested was as follows: Potamogeton crispus (curly leaf pondweed) = P. pectinatus (sago pondweed) > P. zosteriformes (flat-stemmed pondweed) > Chara sp.(muskgrasses) = Elodea canadensis (American waterweed) = thin-leaved pondweeds Potamogton spp. > Egeria densa (Brazilian elodea) (large fish only) > P. praelongus

(white-stemmed pondweed) = Vallisneria americana (water celery) > Myriophyllum spicatum (Eurasian watermilfoil) > Ceratophyllum demersum (coontail) >Utricularia vulgaris (bladderwort) > Polygonium amphibium (water smartweed) > P. natans (floating leaved pondweed) > P. amplifolius (big leaf pondweed) > Brasenia schreberi (watershield) = Juncus sp.(rush) > Egeria densa (Brazilian elodea) (fingerling fish only) > Nyphaea sp. (fragrant waterlily) > Typha sp. (cattail) > Nuphar sp. (spatterdock).

There have been concerns expressed about the potential that stocking grass carp can increase algal blooms by increasing the amount of soluble phosphorus in the water via fish waste (i.e. excrement and urine) (Bonar et al. 2002). However, this does not appear to be the case in Washington (Bonar et al. 2002) as increases in turbidity have primarily been attributed to re-suspended sediments in cases where all plants are removed. Turbidity was not significantly higher in lakes where aquatic plant control was rated as moderate or where no plant control was observed.

Impacts to fish communities in the lake are also a concern. Pauley and Bonar (1995) studied fish communities for a six year period in three lakes before and after grass carp stocking. They concluded that while changes in fish populations did occur in the lakes, no consistent trend occurred after the introduction of grass carp. It should be noted that in two of the lakes, aquatic plants were not totally eliminated. The fact that Lake Lawrence has a substantial amount of undeveloped shoreline that contributes underwater structure (e.g. deadfalls) could help mitigate potential impacts on fish communities.

Although the stocking permit itself is not difficult to fill out and submit, the applicant should take a proactive approach and meet with WDFW staff to discuss the project. (Although WDFW staff were contacted during the development of this plan and were informed of the plan's direction, their policy is not to make a decision until an application is submitted). It is estimated that working with WDFW (grass carp stocking permit, negotiating a stocking rate [see below], and SEPA checklist) would cost approximately $5000. The following section describes a recommended plan for determining an appropriate stocking rate for the grass carp.

Stocking Recommendation

Probably the greatest problem in developing an appropriate stocking rate of grass carp in any lake is in trying to balance the growth rate, and therefore plant consumption rate, of the grass carp against the future plant population. The grass carp are planted at a relatively small size (10-14 inches), but grow quickly reaching a size of up to 40 pounds. They can eat as much as 1.5 times their weight in plant biomass each day. Therefore, the amount of vegetation they are able to consume increases substantially within just a few years. Meanwhile, lake plant populations can vary widely between years. For example, a cool wet summer or an infestation of an insect or disease that kills the plants can result in greatly reduced plant populations in some years.

Research by WDFW has shown that a stocking rate of 22-24 fish per vegetated acre is the range most likely to result in control (Bonar, S. et al. 2002). Unfortunately, results varied largely in that study; areas with much fewer fish per acre resulted in total plant eradication, while areas with greater numbers resulted in no control. Biological factors such as increased mortality or predation are likely responsible for the large differences. Although WDFW ultimately determines grass carp stocking rates, an initial stocking rate of 20 grass carp per vegetated acre

and two re-stocking efforts in the next 10-year period is recommended. (Note: An initial stocking rate of approximately 72 grass carp per vegetated acre was recommended in the grass carp feasibility study in 1989 (Thomas et al. 1990). This was the most conservative stocking rate of four possible plant control scenarios using grass carp, and was based primarily on aquatic plant biomass and not plant coverage. An even more conservative initial stocking rate of 20 grass carp per vegetated acre is recommended in this plan based on more recent research (Bonar et al. 2002) and experience with obtaining permits for these activities.

Native Submerged Plant Control Cost Summary

The 10-year estimate for continuation of harvesting program is approximately $240,000. This assumes an annual cost of $60,000 for the first four years to harvest approximately 60 acres per year. If grass carp begin to perceptibly reduce aquatic vegetation a few years after they are stocked then annual harvesting will not be necessary. However, as explained below, the effectiveness (or control intensity) of grass carp stocking is often highly variable and mechanical harvesting should be maintained as an option to control submerged aquatic plants.

The total cost estimate for implementing a grass carp stocking program is approximately $56,300; this includes $30,000 for the initial stocking effort and technical support in the first year and $13,150 for restocking and technical support in both the fifth and ninth years of this Plan. An initial stocking rate of 20 fish per vegetated acre was used to generate this cost estimate (20 fish/vegetated acre x 125 acres x $10/fish). The grass carp re-stocking was assumed to be half (10 fish/vegetated acre) of the initial rate.

LOCAL SMALL-SCALE PLANT CONTROL

The current harvesting program only takes place beyond the end of residents' docks. Lake residents are responsible for managing submerged plants in the nearshore areas of their waterfront. Therefore, it is important to note that the strategies outlined above do not preclude lake residents from any small-scale physical control methods (e.g. raking or cutting) in areas of the lake adjacent to their properties. Additionally, representatives from the residential developments are not precluded from using these plant control methods (e.g. bottom barriers in swimming areas) to manage vegetation in front of their community access points. Information on these small-scale plant control methods and the necessary permits is presented in Appendix B and C, respectively.

INVASIVE PLANT PREVENTION AND DETECTION PROGRAM

There are a number of other non-native plants that are more destructive and difficult to control than the fragrant waterlily and yellow flag in Lake Lawrence. Other non-native, highly invasive plants of concern include; Eurasian watermilfoil (*Myriophyllum spicatum*), Parrotfeather (*Myriophyllum aquaticum*), Brazilian Elodea (*Egeria densa*), Hydrilla (*Hydrilla verticillata*), Fanwort (*Cabomba caroliniana*), and Water Hyacinth (*Eichhorinia crassipes*). These plants grow in the littoral zones of lakes, ponds, or rivers. A pro-active program to prevent their introduction or detect them before they become widespread is critical.

Shoreline (emergent) noxious plants are also destructive and difficult to control. Examples of these plants include Purple loosestrife (*Lythrum salicaria*) and Japanese knotweed (*Polygonum cuspidatum*). Thurston County has developed IPM prescriptions to control certain emergent noxious weeds. These IPM plans should be used at Lake Lawrence if any new noxious shoreline plants are discovered.

The use of herbicide treatments in Lake Lawrence will effectively eliminate fragrant waterlily and yellow flag. However, these plants could return to the lake through planting by an uninformed lake resident or introduction by boat activity or wildlife. It is also likely that a fraction of fragrant waterlily and yellow flag iris seeds could remain viable for many years and germinate after a period of dormancy. The focus of control efforts for non-native plants is a prevention and detection program. A contingency plan is also presented in case control of a large area is required.

To be effective this program should include both a source control component (prevention) and a detection program. The objective of source control is to prevent non-native aquatic plants from entering the lake. The objective of the detection program is to be able to quickly identify noxious plants in the lake before they become widespread and more costly to control.

The public boat launch represents an area where there is a high potential for introduction or re-introduction of invasive plants. The addition of a boat and trailer wash facility is sometimes recommended to enhance plant fragment removal. However, these can be expensive to install and they require continual oversight and maintenance. Furthermore, it is difficult to regulate their use and therefore their effectiveness is questionable. For these reason it is not recommended. At a minimum, existing signage at the boat launch warning about exotic plant introductions should be enhanced with specific instructions on how to clean boats and trailers.

Lake residents should also receive informative brochures on an annual basis reminding them of plant invasion problems and the importance of keeping their own equipment free of plants. It is also recommended that the lake community institute some public information campaign for opening day of the fishing season and a few other key weekends. Simply having volunteers hand out exotic plant identification cards for a few hours and help with boat and trailer checks will emphasize the importance of the effort and remind boaters of their responsibility to check equipment.

Early detection is the next step to protect against new infestations. While an infestation is still small there are options for control that are much less expensive than the whole lake treatment methods. Early detection, if done properly, requires both a trained group of lake volunteers who are responsible for occasional patrol of the lake, and periodic (bi-annual) diver surveys to assess the plant community. The main purpose of these surveys is to search for non-native aquatic plants. However, it will also provide a means for monitoring the native plant communities and determining where future control efforts should be focused. Volunteers would be trained each year in plant identification and survey techniques and each would be given the responsibility for surveying a certain section of shoreline once a month during the growing season. Their purpose would be to note any substantial changes in the plant community and to look for new invasions of nuisance species. Professional divers would perform a more complete survey every other

year. (While divers are surveying the lake they can determine whether new infestations can be handled by handpulling the plants or whether, for example, bottom barrier should be installed in a few places to ensure complete control.)

The primary advantage of controlling small infestations is that it reduces the chance that a large area would need to be controlled by a more intensive and expensive technique. Drawbacks of controlling small infestations are the high costs associated with diver surveys and hand pulling. (Costs for hand pulling by contract divers range from $500 to $2,500 per day depending upon plant type, acreage, and density.) Although the volunteer survey program should have no long-term cost, a training workshop would be necessary the first year. A volunteer training workshop cost of $1,500 has been included in plan implementation cost estimates.

The exotic plant control plan complements the plan for the eradication of fragrant waterlily and yellow flag. The surveys would be relied upon to detect new infestations of fragrant waterlily and yellow flag and allow immediate removal of the plants. If another exotic plant is found, immediate action should be taken and a survey should be planned for later in the same year to insure there were no surviving colonies. If the area infested is too large to control by handpulling, or if after two follow-up surveys the exotic plant is still found, bottom barriers would be placed in all areas where the plant was detected. Treatment with herbicide is recommended as a final resort if these efforts do not result in eradication of the exotic plant.

These additional surveys, bottom barrier installation, and herbicide treatments are contingency elements to the overall aquatic plant control plan for the lake. Since these costs would only accrue in the event of another infestation by fragrant waterlily, yellow flag, or another exotic plant, the costs could possibly be covered through an "early infestation grant" by the Department of Ecology. However, due to grant uncertainties, a contingency fund (10% annually) has been included as one of the plan cost elements, to insure protection of the lake.

PLANT CONTROL ADVISORY COMMITTEE

Proper implementation of this plan relies upon formation of a plant control advisory committee. This committee, which would be comprised of area residents, Thurston County staff, and other interested agencies, would have the following responsibilities:

- Review annual plant survey information and track potential problem areas.
- Insure permit requirements are met.
- Review exotic plant problems and determine the appropriate control strategy and urgency of control needed.
- Recruit and direct volunteers for annual surveys.
- Select and hire contractors when necessary for tasks such as training, hiring aquatic plant control contractors, monitoring, and etc.
- Provide information and newsletters to lake residents and act as spokespeople for answering questions on plant control problems and supporting long-term implementation of this plan.