Lake Fenwick and Lake Meridian Integrated Aquatic Plant Management Plan (IAPMP)

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The City of Kent, Washington

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EXECUTIVE SUMMARY

Brazilian Elodea (*Egeria densa*) (BE) and Eurasian watermilfoil (*Myriophyllum spicatum*) (EWM) are non-native, invasive plants that have become established in Lake Fenwick and Lake Meridian, respectively. The establishment of these exotic plants in Kent is having a negative impact on lake recreation, aesthetics, and fish and wildlife habitat. The presence and continued growth of these plants threatens to degrade the use and enjoyment of the lakes by residents of the City of Kent and other lake patrons.

The purpose of this IAPMP is to provide guidelines for implementing and monitoring control measures for the growth and spread of non-native aquatic plants, specifically the growth of BE in Lake Fenwick and EWM in Lake Meridian. It is the goal of the people of Kent to use this IAPMP to protect beneficial uses of each lake, to preserve ecological function, to educate lake visitors about invasive species, and to achieve these goals at reasonable costs.

Several methods of treatment for nuisance aquatic plant populations are available, including chemical, mechanical, biological, and physical controls. The appropriate method of control depends on the characteristics of the plant being targeted and the management goals for the lake. Brazilian Elodea and Eurasian watermilfoil are classified as State Class B Noxious Weed species, which requires aggressive control when possible, aimed at destroying the entire plant including the root system.

Evaluation of the available alternatives led to the selection of 3 treatment scenarios for BE in Lake Fenwick and 2 for EWM in Lake Meridian. Alternatives were eliminated if known outcomes were not compatible with project objectives and management goals. Due to limitations of use, several alternatives were considered infeasible and were eliminated. Feasible alternatives are provided in the Table ES-1 below.

Table ES-1. Treatment Scenarios for Lakes Fenwick and Meridian

Treatment Scenario	Lake	Cost	Duration of Control	Labor Necessary
No Action	Fenwick/Meridian	$0	0	None
Grass Carp	Fenwick	$52,220	5+ years	Minimum
Bottom Barriers	Meridian	$114,200	6+ years	Moderate

The treatment scenarios were selected based on several criteria including 1) ability to provide the lakes with the level of invasive weed control necessary, 2) minimization of costs, 3) minimization of labor, and 4) appropriateness for location and environment. These strategies differ in scale of control, intensity of control, duration of control, and in costs.

INTRODUCTION

Aquatic plants are an integral part of a lake ecosystem. Native aquatic plants provide food and habitat for waterfowl and fish. However, when aquatic plants grow too densely, they can have adverse impacts on lakes. Under certain environmental circumstances, native plants can cause nuisance conditions, making it difficult to boat or swim without becoming entangled in plants. Such conditions occur when ample supplies of nutrients and light are available for the plants to grow. Non-native, invasive plants cause significant problems in lakes around the world. The shallow character of a lake is changed when non-native plants invade the shoreline and littoral regions. Non-native plants often provide little if any benefit to the existing ecosystem and have a tendency to out-compete the native, more beneficial plants. In most cases, non-native plants are introduced to a body of water by human action, often via boats and boat trailers transporting plant fragments to the water body from another.

Brazilian Elodea (BE) and Eurasian watermilfoil (EWM) are non-native, invasive plants that have become established in Lake Fenwick and Lake Meridian, respectively. The City of Kent, Washington (in support of the local lake communities represented by the Friends of Lake Fenwick and Lake Meridian Homeowner's Association) prepared this integrated aquatic plant management plan (IAPMP) to address the problem of managing the non-native, invasive aquatic plants in both Lake Fenwick and Lake Meridian.

It is not known when Brazilian elodea became established in Lake Fenwick. The URS (1985) restoration report did not include reference to BE or other aquatic plants. It is assumed that due to the high turbidity and algal production in the lake that the aquatic plant community was not considered a problem at the time of that investigation. However, BE was observed as a well established plant in 1989 by Gibbons (unpublished data). Its presence is having a negative impact on beneficial uses of the lake. It is the hope of the City of Kent to provide users of the lake an increased opportunity for recreational activities in defined areas with the implementation of the IAPMP. Implementation would also enhance diversity in the littoral habitat and result in an increased habitat value.

Lake Meridian has had EWM well before the 1978 Metro study of the lake, which noted that EWM covered most of the lake perimeter between the depths of 3 to 5 meters. The plant is a non-native, noxious weed and, due to its invasive nature, is having adverse economic and ecological impacts on the lake. The City of Kent and the Lake Meridian Homeowner's Association hope to gain limited control over EWM and provide lake users increased recreational use and habitat.

In September of 2000, lake surveys were conducted to determine the extent of BE in Lake Fenwick and EWM in Lake Meridian. Data collected during that survey was used to prepare this aquatic plant management plan. This IAPMP describes the potential actions that can be used to manage BE in Lake Fenwick and EWM in Lake Meridian.

PROBLEM STATEMENT

Lake Fenwick

The establishment of Brazilian Elodea (*Egeria densa*) in Lake Fenwick is having a negative impact on lake recreation, aesthetics, and habitat. Over 90% of the lake's 15-acre littoral zone is covered with this non-native, invasive species. The presence and continued growth of BE threatens to degrade the use and enjoyment of this lake for residents of the City of Kent and other lake patrons. Furthermore, the BE population in Lake Fenwick can be a source from which BE could spread to other nearby lakes.

Brazilian elodea is a robust plant that was once sold in Washington as an aquarium plant. It was likely introduced into the region's lakes by thoughtless disposal of aquarium contents into the lakes. It has become well established in coastal lakes in both Washington and Oregon. Further spread of BE via boats, trailers, and fishing gear has aided its advancing coverage of Washington lakes. BE has no effective natural control vector in North America, so it is extremely difficult to control.

When introduced into a lake, BE forms dense beds that outcompete native aquatic plants. These thick plant mats interfere with swimming, boating, fishing, and water skiing and create poor habitat for fish. In lakes where BE has become established, it may out compete even Eurasian watermilfoil. Specifically in Lake Fenwick, BE's environmental benefits (providing fisheries habitat structure and attached algae substrate) are counter balanced by its adverse impacts. Adverse impacts are directly related to BE's high density of coverage. The dense coverage creates poor fish habitat by limiting movement and forage areas well as limiting the ability to see and hence catch prey species. Its density is also reducing water quality. During non photosynthetic periods, the BE community, including the microbial population utilizing the plants as substrate, will consume dissolved oxygen to meet its metabolic requirements faster that re-aeration will replace dissolved oxygen in the water column, resulting in the lowering of dissolved oxygen levels. At times, the level of dissolved oxygen may drop below thresholds needed to support fish. Dissolved oxygen levels could be lowered sufficiently near the sediment water interface to result in the release of nutrients from the sediments into the overlying water. These nutrients in turn would increase the growth of algae in the lake. Water quality impacts have been somewhat offset by the operation of the hypolimnetic aerator in the lake. This system provides oxygen to the bottom waters to in part meet the oxygen demand of the water and sediments.

Based on discussions with lake users during field surveys there was a concern that the BE in Lake Fenwick has diminished fish habitat and certainly adversely impacts fishing access, limits swimming opportunities, and reduces the overall aesthetic of the lake and surrounding park.

Lake Meridian

The establishment of Eurasian watermilfoil (*Myriophyllum spicatum*) in Lake Meridian is having a negative impact on lake recreation, aesthetics, and habitat. It has been estimated that EWM covers 82% of the lake's 43-acre littoral zone. The presence and continued expansion of this plant within Lake Meridian threatens to degrade the use and enjoyment of the lake for residents of the City of Kent. The EWM population was well established prior to the 1977 restoration study of the lake (Metro, 1978), and has served as a source for introduction to other lakes since that time.

EWM is an invasive, non-native, aquatic plant that grows rapidly into dense beds in depths of up to 18 feet. EWM spreads primarily through vegetative fragmentation. Waves, wind, and boats may disturb plants and sever small fragments. Each fragment has the potential to take root and start a new infestation. EWM is hardy and can take root in a variety of physical, pH, salinity, and temperature conditions. These factors allow EWM to easily outcompete native aquatic plants, drastically altering the ecological balance of the lake.

Recreational value and aesthetics of Lake Meridian are affected as well. Although Lake Meridian Park is extremely popular, their concern has been over swimming interference by EWM at the park and by shoreline residents. In general, people tend to avoid lakes and ponds that are congested with aquatic plants, preferring to boat, swim, or water-ski in other locales. EWM community at Lake Meridian may in fact be limiting the popular use of the lake, but it still remains a very popular recreational spot, warranting a full time police unit (boat and crew) assigned to the lake to enforce safety regulations. Also, of concern is the fact that fragments of EWM from Lake Meridian can become lodged in boats, boat trailers, anchors, and fishing gear, and transported to nearby lakes that are not yet infested.

LAKE/WATERSHED FEATURES

Lake Fenwick

Lake Fenwick is located within the City of Kent, Washington. Its watershed is sub-basin within the large Green-Duwamish Watershed (Figure 1). The lake is popular recreation lake with direct public access via Lake Fenwick Park. Lake Fenwick has a small residential watershed of just under one square mile (Figure 2). The park and other open space within the Lake Fenwick watershed cover approximately 20 percent of the area. The remaining portion of the watershed is developed as urban residential. The Lake Fenwick Park has trails and open space areas in addition to public non-motorized boat launch facilities. The park is owned and operated by the City. It occupies the majority of the shoreline except for approximately 8 residences on the southern shoreline of the lake.

Nonpoint runoff from the residential areas is the major source of nutrients to the lake. Lake Fenwick has had a long history of water quality problems and the City of Kent has aggressively pursued actions to improve the lake's water quality. Since the late 1970's, the City has employed Best Management Practices (BMP's) to manage stormwater runoff from residential watersheds (Gibbons & Funk 1983). This included diversion of the main inlet stream from entering the lake at the mid northern-eastern area to a treatment pond and wetland to the north of the lake (URS, 1985). In the mid 1990's, the City installed a hypolimnetic aeration system into the lake to address internal loading of phosphorus and low dissolved oxygen levels. This system is still in operation. In addition, stormwater flows were routed through a constructed wetland to reduce nutrient inflows. With watershed BMP's implemented and the operation of the hypolimnetic aerator Lake Fenwick is a meso-eutrophic lake (relatively rich in nutrients and aquatic productivity). There are limited recent data on lake water quality and it can be assumed that there have been changes in both the hydrologic and continued reduction in nutrient loading since the URS 1985 restoration report. These changes are due to increased watershed development and runoff management steps taken by the City of Kent in addition to the hypolimnetic aeration system operated to control internal phosphorus loading. That study reported total phosphorus loading of 5,378 kilograms per year in 1981. The lake still experiences periodic blue-green bacteria blooms (cyanobacteria) with chlorophyll *a* concentrations observed as high as 30 micrograms per liter. A typical blue-green observed in recent years has been *Aphanizomenon flos-aquae* (Gibbons, 2001 unpublished data).

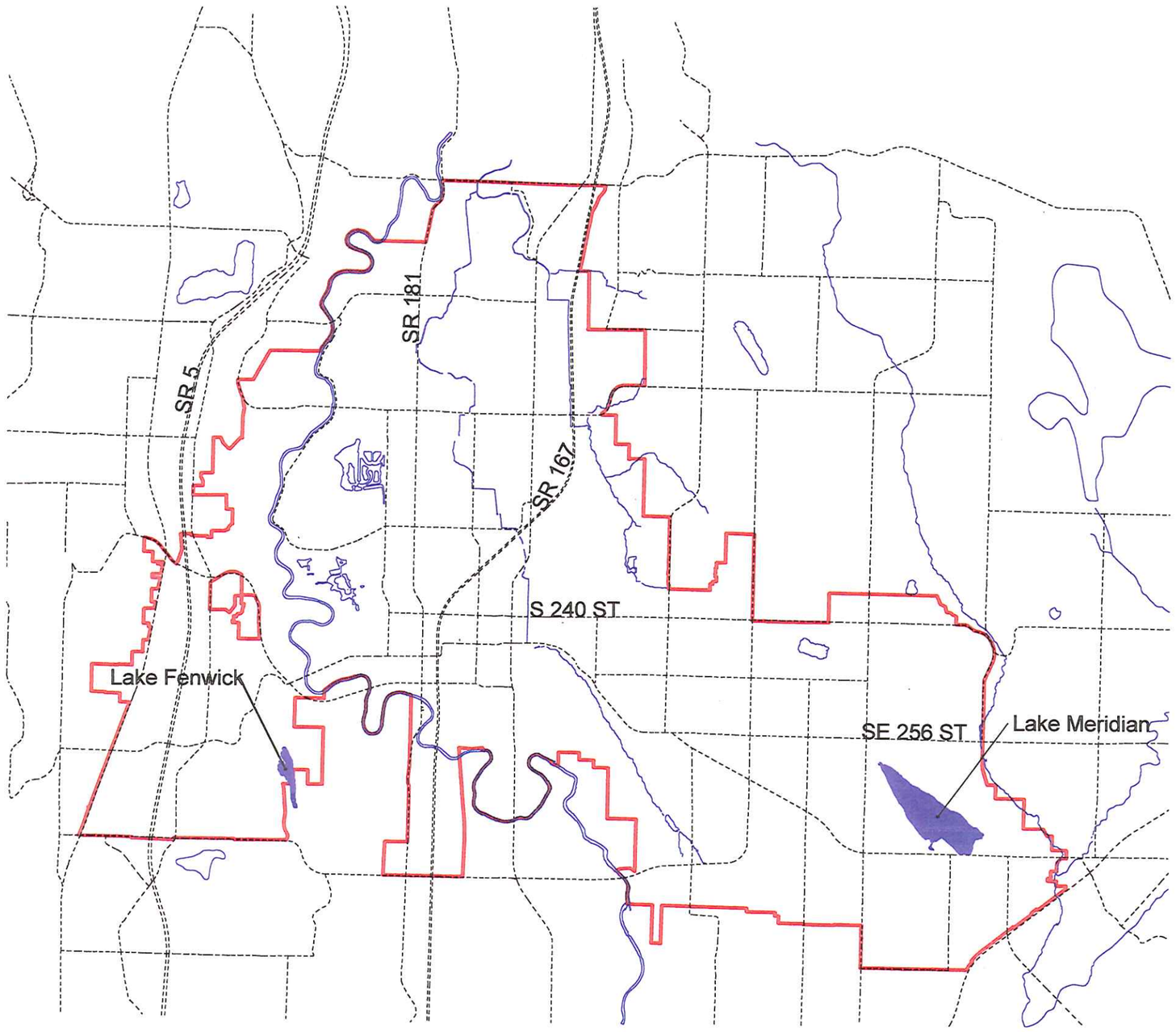
Lake Fenwick has an approximate lake volume of 300 acre-ft covering 24 acres and water depth is relatively shallow. The maximum depth is 28 ft and average depth is only 13 ft. The littoral zone is approximately 15 acres. There is a small outlet flow from the south end of the lake. The outflow from the lake is intermittent in the summer depending on the time and quantity of precipitation during the spring and summer.

Lake Meridian

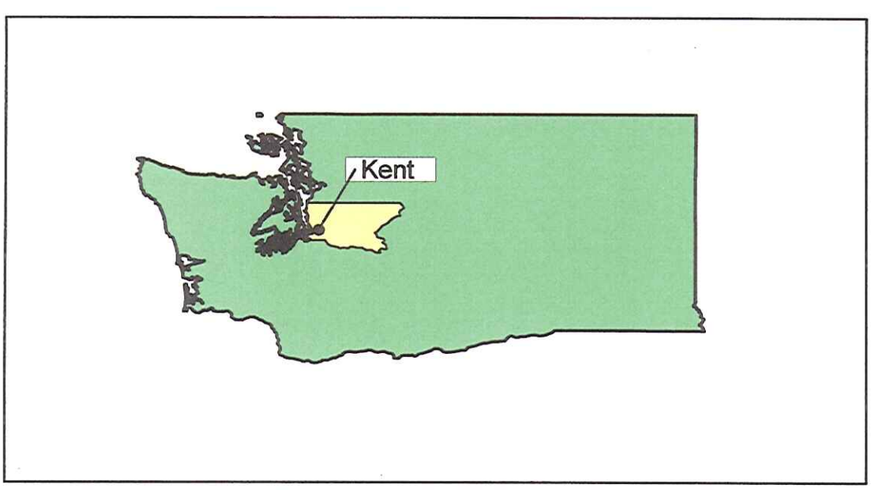
Lake Meridian is located within the City of Kent, Washington. Its watershed is a sub-basin within the large Green-Duwamish Watershed (Figure 1). Lake Meridian has an urban watershed that encompasses just over one square mile (Figure 3). Most of the watershed has been developed as suburban and urban residential. Over 82 percent of the shoreline is residentially developed with near shore homes (nearly 200). Only on the southwest end of the lake where the Lake Meridian Park is located is the lake's shoreline not developed. There is a small riparian wetland adjoining the park at the southern end of the lake near the park. The wetland does have reed canary grass, but loosestrife is actively removed from the lake's shoreline and was not observed in the wetlands during the boat survey. The intermittent inlet stream drains approximately 30 percent of the watershed. Residence report that there are numerous springs that flow into the lake below the lake surface. The outlet has been moved and the channel modified recently to enhance potential fish habitat within the Big Soos Creek system. Outlet flows are potentially intermittent depending on annual precipitation cycle.

The lake is very popular recreation lake with direct public access via Lake Meridian Park. This park has trails, picnic facilities, area open space areas, swimming beach, boat docks, in addition to public boat launch facilities. The park and lake support large numbers of daily visitors. No current estimates are available on day use, but historical popularity of the lake has resulted in the full time patrol of the City police to assist with safety and enforce City regulations. The park has reported concern over EWM within the swimming area relative to reducing recreational opportunities and swimming safety, especially near the deeper swim area.

Lake Meridian has a lake volume of 6,100 acre-feet with a 150 acre surface area. The maximum depth is 90 ft and the average depth is 41 ft. The lake's littoral zone covers approximately 15 acres. Lake Meridian is a mesotrophic lake (moderately abundant nutrients and algal production) according to the Metro 1978 study. This is in contrast to the 1998 citizen's monitoring report (King Co, 1998), which has classified Lake Meridian as oligotrophic relative to TSI units. Note that although several indicators, such as secchi disk transparency, have historically been in the oligotrophic range that other parameters have indicated that it is mesotrophic, phytoplakton density/community structure and oxygen deficit rate. The lake strongly stratifies. The sources of non-point pollution are from urban runoff, most of the agricultural lands in the basin have been converted to residential. The City has taken steps to restore fisheries habitat in the outlet channel of the lake, hence any action taken to control aquatic plants within the lake must take into account potential downstream impacts on fisheries survival in and utilization of the outlet channel.



City of Kent, Washington



N

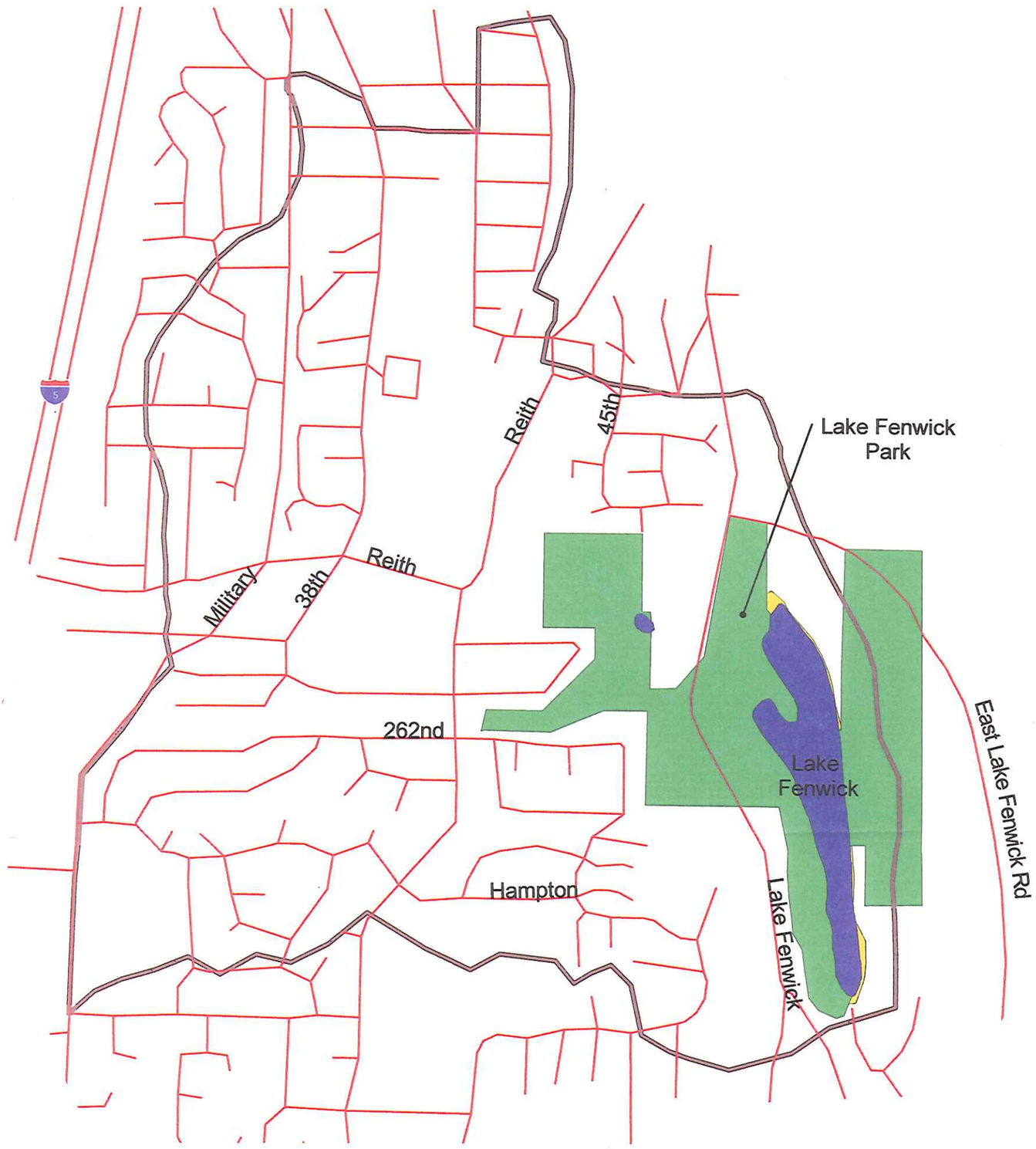
Legend

- Lakes
- Rivers
- Roads
- Kent City Limits

NOT TO SCALE

Lake Fenwick and Lake Meridian
Location Map
July 2000
Kent, Washington

Figure 1
Location Map



Legend

- Street
- Watershed Boundary
- Waterbody
- Park
- Wetland

*NOT TO SCALE

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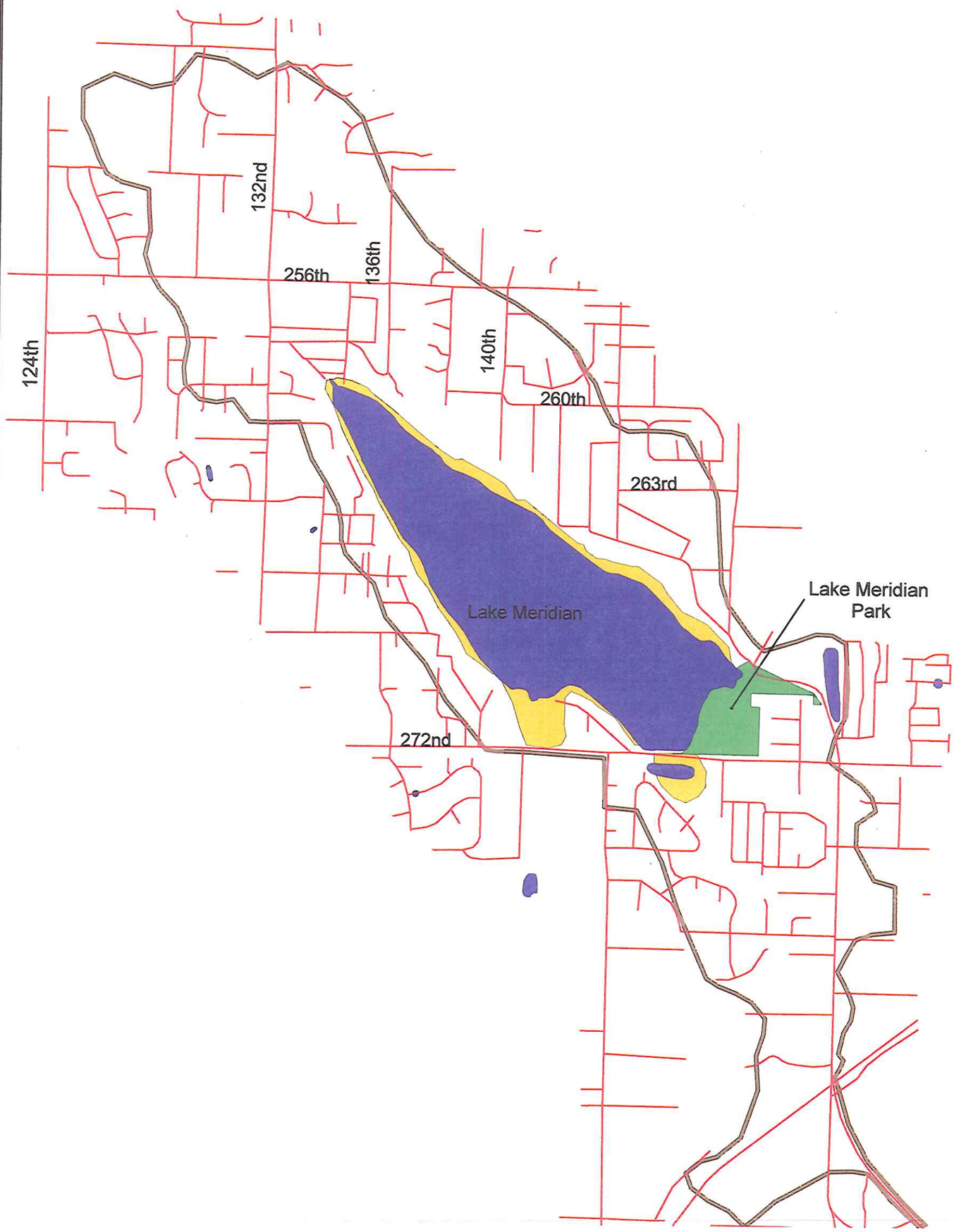
Lake Fenwick Watershed
Boundary Map
July 2000
Kent, Washington

Figure 2



Legend

- Street
- Watershed Boundary
- Waterbody
- Park
- Wetland

*NOT TO SCALE

N

Lake Meridian Watershed
Boundary Map
July 2000
Kent, Washington

Figure 3

BENEFICIAL USES

Lake Fenwick and Lake Meridian are multi-use resources that support a variety of beneficial uses for both humans and wildlife. Beneficial uses can be affected by and need to be protected from invasive plants such as BE or EWM.

Human

Recreational use is the most visible benefit of both Lake Fenwick and Lake Meridian. In both lakes, primary contact recreation includes swimming and wading, and water skiing in Lake Meridian only. Lake Fenwick Park and Boat Launch offers year-round access to boaters and anglers. The park is also used for picnicking and social events. Lake Meridian Park and Boat Launch also offers year-round access to boaters, water skiers, personal watercraft users (jet skis), picnickers, and anglers. During the summer months, lifeguards are stationed at the southeast shore of Lake Meridian, allowing high use of the swimming area.

Additional beneficial human uses for both lakes include residential living, water supply for irrigation, and aesthetics. Intakes are for private use only, and the lake provides no public water supply. No water withdrawals from the lakes are formally covered by water-rights. The southern perimeter of Lake Fenwick has experienced limited development for single-family homes. Almost the entire perimeter of Lake Meridian has been developed for single-family homes except for the park area, providing high-value real estate sites for residential use. Aesthetically, the people of Kent may enjoy the peacefulness and beauty of both lakes, and may observe wildlife using the lake habitat. See Figures 4 and 5 for beneficial use mapping.

Aquatic Plants and Phytoplankton

The previous URS study conducted on Lake Fenwick does not reference aquatic plants. This is probably because the overriding environmental problem was turbidity and sediment loading to the lake as well as excessive phosphorus loading (URS, 1985). Brazilian elodea was observed as a well established plant in 1989 by Gibbons (unpublished data). Blue-green bacteria blooms were reported to occur as a consequence of stormwater diversion in the 1981 (Gibbons, et al. 1983) and blue-greens continue to dominate the phytoplankton (Gibbons, unpublished data, 2001). However the Lake Fenwick Restoration Study by Entranco, December 1991 does contain a wealth of information about Lake Fenwick including aquatic plant survey data. These data show that Brazilian elodea was present, but not dominant in 1990. More aquatic plants species were recorded in the 1990 survey than the 2000 survey conducted by Tetra Tech. Species recorded in 1990, but not in 2000 include: underwater moss (*Fossodems ventricosus*), bigleaf pondweed (*Potamogeton amplifolius*), sago pondweed (*P. pectinatus*), watershield (*Brasenia schreberi*) and common bladderwort (*Utricularia vulgaris*) (Entranco, 1991). The Tetra Tech survey did find one species in 2000 that was not noted in the 1990 survey fernleaf pondweed (*P. robbinsii*). In 1990 the dominant macrophyte

was elodea (*Elodea canadensis*) while the subdominant species included flat stem pondweed (*P. zosteriformis*), coontail (*Ceratophyllum demersum*), and water lily (*Nuphar polysepalum*). The introduction of invasive species like Brazilian elodea most likely has contributed to the decrease in species diversity within Lake Fenwick. It is interesting to note that the plants that were dominant or subdominant in 1991 are still present in the lake ten years later.

The aquatic plant survey conducted as part of the Metro 1978 study of Lake Meridian indicated the EWM occupied a continuous band around the lake littoral between the depths of 3 to 5 meters. Other plants that were noted were *Nuphar* sp., *Nymphaea* sp., *Brassenia* sp., *Potamogeton* sp., *Elodea* sp., *Najas* sp., and the macro-algae *Chara* sp. and *Nitella* sp. As in the previous study the phytoplankton community is dominated by greens and other flagellated species, such as *Volvox* sp. and *Dinobryon* sp. (Gibbons, unpublished data, 2001)

Wildlife and Fisheries

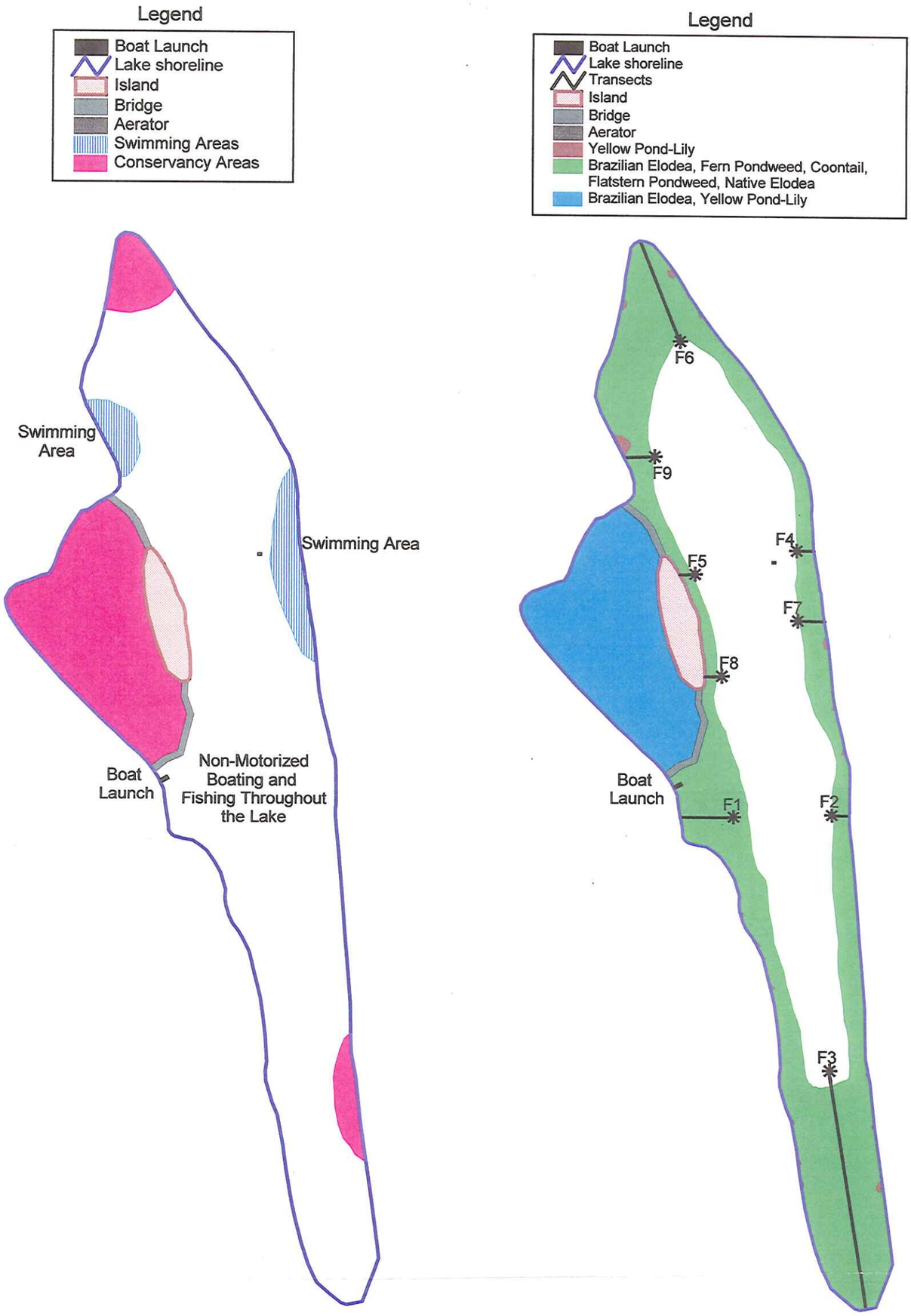
Lakes Fenwick and Meridian are home to a variety of wildlife. Fish known to be present in both lakes include rainbow trout, smallmouth bass, and largemouth bass, all of which are considered species of concern from a management perspective for King County (WDFW, 2000). There are also several species of spiny rays and catfish in each lake. Lake Fenwick is stocked with approximately 4000 rainbow trout each year and Lake Meridian is stocked with approximately 8000 rainbow trout (WDFW, 2000). Stocking is conducted in the spring and stocked fish are of catchable size. The outflow from Lake Fenwick and the outlet channel have fish passage obstructions, so anadromous fish are not likely to be present (WDFW, 2000). Lake Meridian does have an outflow that is hydraulically connected to the Green River, and anadromous fish utilize the outlet channel. Chinook salmon, *Oncorhynchus tshawytsha*, is listed as a threatened species in the Green River drainage. Both lakes provide nesting, forage, and cover to a number of resident or migrating bird species. Reported bird species using Lake Fenwick include wood ducks, pied-billed grebe, black-headed grosbeak, pileated woodpecker, rudy-crowned kinglet, golden-crowned kinglet and other woodland birds (Rainier Audubon Society webpage, 2001). It is assumed that many species of song birds and ducks also utilize the lake Meridian area, however because there is less open space and treecover around and near the lake that there is less opportunity for use in Lake Meridian than Lake Fenwick. According to the regional biologist (WDFW, 2000) however, no systematic surveys of fish or wildlife species have been conducted for Lakes Fenwick or Meridian and the surrounding areas in recent years.

A review of the Washington Department of Fish and Wildlife Priority Habitats and Species database revealed that several species of concern occur in King County and may be impacted by the IAPMP (Table 1). Typically, any of these species could be present during all or part of the year in any King County lacustrine system. The Washington Natural Heritage Program letter (see Appendix A) states that there are no data on significant high quality ecosystems or rare plants in the vicinity of the lakes. Also, habitat conditions at both lakes are unsuitable for the western pond turtle and they are unlikely to be present. No resident bird species were considered species of concern. Amphibian

presence is undocumented, but they may be present at Lake Fenwick. Impacts to these species will be minimized as much as possible in the event they are observed at the lake.

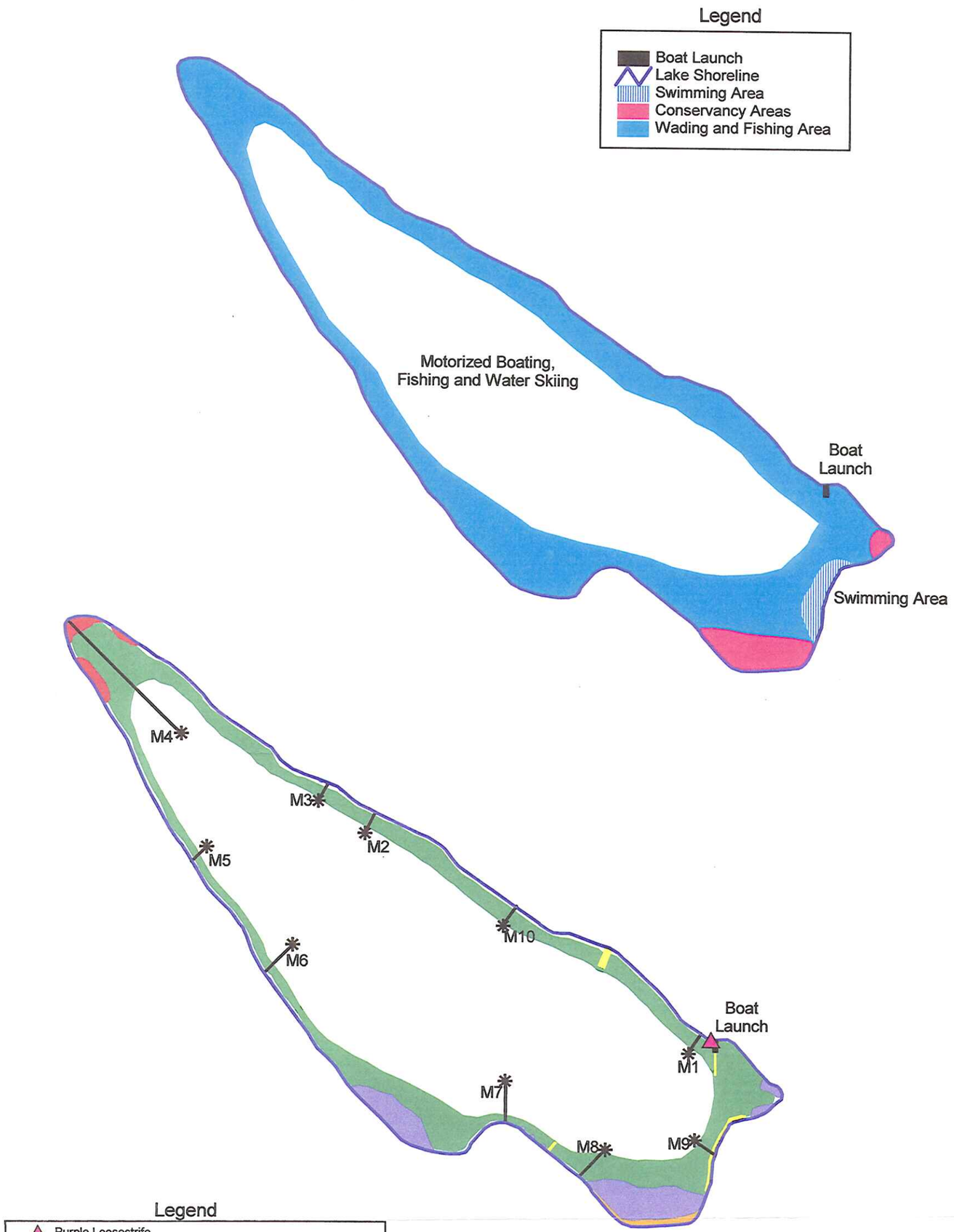
Plants

The Washington Department of Natural Resources Natural Heritage Program maintains a database of rare plants around the state. A search of this database revealed that Swamp Sandwort and Golden Indian Paintbrush are listed as federally threatened or endangered species that occur in King County. However, there is no record of their presence in or near Lake Fenwick or Lake Meridian. All endangered, threatened and sensitive rare plants in King County are listed in Table 2. In the event that any listed species is discovered during the implementation of this IAPMP, the City of Kent will take all necessary measures to keep impacts to those plants at a minimum.



Lake Fenwick Beneficial Uses and Aquatic Weed Maps
July 2000
Kent, Washington

Figure 4



Lake Meridian Beneficial Uses
and Aquatic Weed Maps
July 2000
Kent, Washington

Figure 5

Table 1. Priority Species Occurring in King County, Washington

Common Name	Scientific Name	State Status	Federal Status
Fishes			
Largemouth Bass	*Micropterus salmoides*		
Rainbow Trout	*Salmo gairdneri*		
Smallmouth Bass	*Micropterus dolomieui*		
Reptiles			
Western Pond Turtle	*Clemmys mormorata*	E	SC
Amphibians			
Larch Mountain Salamander	*Plethodon larselli*	S	SC
Spotted Frog	*Rana pretiosa*	E	C
Western Toad	*Bufo boreas*	C	SC
Birds (Non-Breeding Populations)			
Bufflehead	*Bucephala albeola*		
Goldeneye	*Bucephala spp.*		
Pied-billed Grebes	*Podilymbus podiceps*		
Snow Goose	*Chen caerulescens*		
Trumpeter Swam	*Cygnus buccinator*		
Tundra Swam	*Cygnus columbianas*		

E=endangered, SC=species of concern, S=sensitive, C=candidate species

Table 2. Threatened, Endangered, and Sensitive Rare Plants Occurring in King County, Washington

Scientific Name	Common Name	State Status	Federal Status*
Arenaria paludicola	Swamp sandwort	PE	LE
Aster curtus	White-top aster	S	SC
Botrychium lanceolatum	Lance-leaved grape-fern	S	
Botrychium lunaria	Moonwort	S	
Botrychium minganens	Victorin's grape-fern	R	
Botrychium pedunculosum	Stalked moonwort	S	SC
Botrychium pinnatum	St. John's moonwort	S	
Campanula lasiocarpa	Alaska harebell	S	
Carex buxbaumii	Buxbaum's sedge	S	
Carex comosa	Bristly sedge	S	
Carex pauciflora	Few-flowered sedge	S	
Carex saxatilis var major	Russet sedge	S	
Carex stylosa	Long-styled sedge	S	
Cassiope lycopodioides	Clubmoss cassiope	S	
Castilleja levisecta	Golden paintbrush	E	LT
Cimicifuga elata	Tall bugbane	T	SC
Cyperus bipartitus	Shining flatsedge	S	
Fritillaria camschatcensis	Black lily	S	
Galium kamtschaticum	Boreal bedstraw	S	
Hydrocotyle ranunculoides	Floating water pennywort	R	
Hypericum majus	Canadian St. John's wort	S	
Lobelia dortmanna	Water lobelia	T	
Lycopodiella inundata	Bog clubmoss	S	
Lycopodium dendroideum	Treelike clubmoss	S	
Platanthera chorisiana	Choris' bog-orchid	T	
Platanthera obtusata	Small northern bog-orchid	S	
Utricularia intermedia	Flat-leaved bladderwort	S	

LE=listed endangered, LT=listed threatened, SC=species of concern, S=sensitive, T=threatened, E=endangered, R=under review, PE=possibly extirpated

AQUATIC PLANT COMMUNITIES

Lake Fenwick

Divers surveyed plant communities on September 19, 2000. A total of 5 submerged species were observed, including Brazilian Elodea (see Table 3). A single emergent species, Yellow Pond-Lily, occurred in various lakeshore areas.

Table 3. Aquatic Plants Observed at Lake Fenwick

Common Name	Scientific Name
Fern Pondweed	*Potamogeton robbinsii*
Brazilian Elodea	*Egeria densa*
Coontail	*Ceratophyllum demersum*
Flatstem Pondweed	*Potamogeton zosteriformis*
Native Elodea	*Elodea canadensis*
Yellow Pond-Lily	*Nuphar polysepala*

A total of 9 transects were swamby divers, and BE was observed along all transects (Figure 4). In addition to the transects from the shoreline to a depth where aquatic plants were no longer present (approximately 20 feet of water depth), the boat crew observed the aquatic plant community in between each transect to verify the uniformity of the community structure. Data from the diver transects and the surface circumnavigation of the lake demonstrated that Brazilian elodea was present from 0-18 ft deep and was present in 77% of the littoral area surveyed. Variation in BE density occurred with water depth. High densities occurred from 0-8 ft, medium densities at 8-13 ft, and densities became low from 13-18 ft (see Figure 6). No detectable variation in density existed across the lake. The average density of BE throughout Lake Fenwick was approximately 3-10 plants/square foot, or medium density. Table 4 lists the areas covered by the plant communities at the lake. The littoral area is impacted to some degree by BE on 14 of 15 acres. Figure 4 includes an aquatic plant map for coverage reference.

The lake sediments were highly organic and contain plant material in varying degrees of decay. It was also noted by the divers that a significant portion of the lake bottom was covered by woody debris of all sizes and species. The divers also noted the fish observed during the survey were associated with the woody debris and not dense aquatic weed stands.

Brazilian elodea is a native of South America and is found in lakes, ponds, sloughs, and streams in the coast lowlands lowlands of Washington and Oregon. The plant does not sexually reproduce in the Northwest. Propagation occurs when the stem of male plants fragment and the nodes form new plants. The plant can produce dormant shoots that can over-winter in the sediments.

Table 4. Lake Fenwick Aquatic Plant Approximate Coverage (acres)

Aquatic Plant	Coverage (acres)
Yellow Pond-Lily	0.09
Brazilian Elodea, Fern Pondweed, Coontail, Flatstem Pondweed, Native Elodea	10
Brazilian Elodea, Yellow Pond-Lily	4

Lake Meridian

Divers surveyed plant communities on September 18, 2000. A total of 8 submerged species were observed, including EWM (see Table 5). Two emergent species were observed, including White Water Lily and Yellow Lily. Eleven transects were swam and mapped using a Garmin 48 Personal Navigator.

Table 5. Aquatic Plants Observed at Lake Meridian

Common Name	Scientific Name
Coontail	*Ceratophyllum demersum*
Native Elodea	*Elodea canadensis*
Eurasian Watermilfoil	*Myriophyllum spicatum*
Nitella	*Nitella sp.*
Slender Pondweed	*Potomogeton pusillus*
Whitestem Pondweed	*P. praelongus*
Yellow Pond-Lily	*Nuphar luteum*
White Water Lily	*Nymphaea odorata*
Redhead Grass	*P. richardsonii*
Flatstem Pondweed	*P. zosteriformis*

EWM was observed along all 9 transects (figure 5). EWM beds grew from depths of 2 ft to 15 ft all the way around the lake, and were at their greatest density at depths of 6 to 14 ft (see Figure 7). Transects with the greatest density of EWM were near the boat launch and at the northwest end of the lake. However, the plant is moderately dense throughout the lake as observed during the circumnavigation of the lake by the boat crew. Table 6 lists the areas covered by plant communities at the lake. The littoral area is impacted to some degree by EWM on 35 of the 42 acres of littoral area. Figure 5 includes an aquatic plant map of Lake Meridian. EWM occurs in Lake Meridian alongside several other submerged plant species. Throughout the survey, it was noted that EWM plants and other species were growing in a mosaic pattern. Even very dense EWM stands were interspersed with other native and non-noxious weeds.

Table 6. Lake Meridian Aquatic Plant Approximate Coverage (acres)

Aquatic Plant	Coverage (acres)
Eurasian Watermilfoil, Coontail, Native Elodea, Pondweeds, Nitella	35
Cattails, Iris, other emergents	0.8
White Water-Lily	1
White Water-Lily, Yellow Pond-Lily	6

Eurasian watermilfoil is native to Eurasia and northern Africa, but is a non-native invader in the Northwest. This plant rarely reproduces from seeds in the northwest. It normally propagates from plant fragments and rhizomes. This plant tolerates a wide range of water as sediment conditions. Lake Meridian sediment varies from sandy to silt mixed with organic mud within the littoral zone, EWM did not show a preference between the substrate but rather its density was correlated to water depth. This is in response to light or nutrients from shallow groundwater inflow through the sediments.

Figure 6. Average density at depth of Brazilian Elodea in Lake Fenwick.
Density = Low (0-3 plants) =1, Medium (4-9 plants) =2, High (10+ plants) =3.

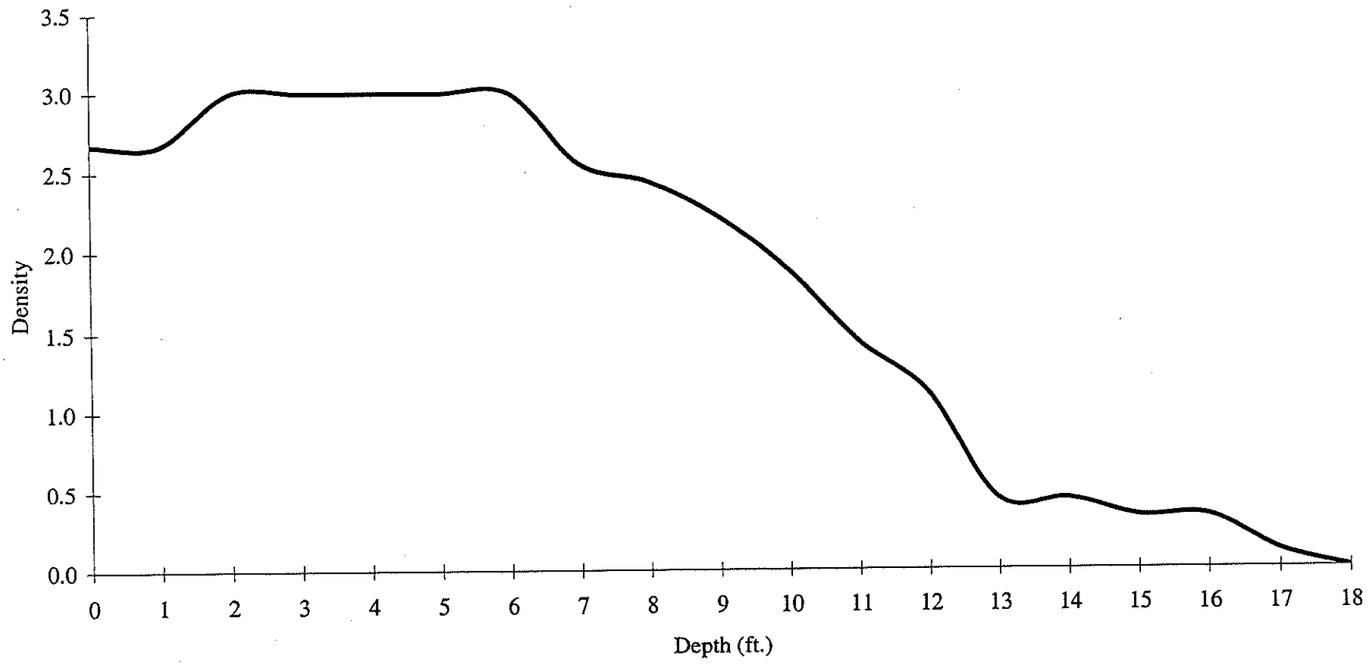
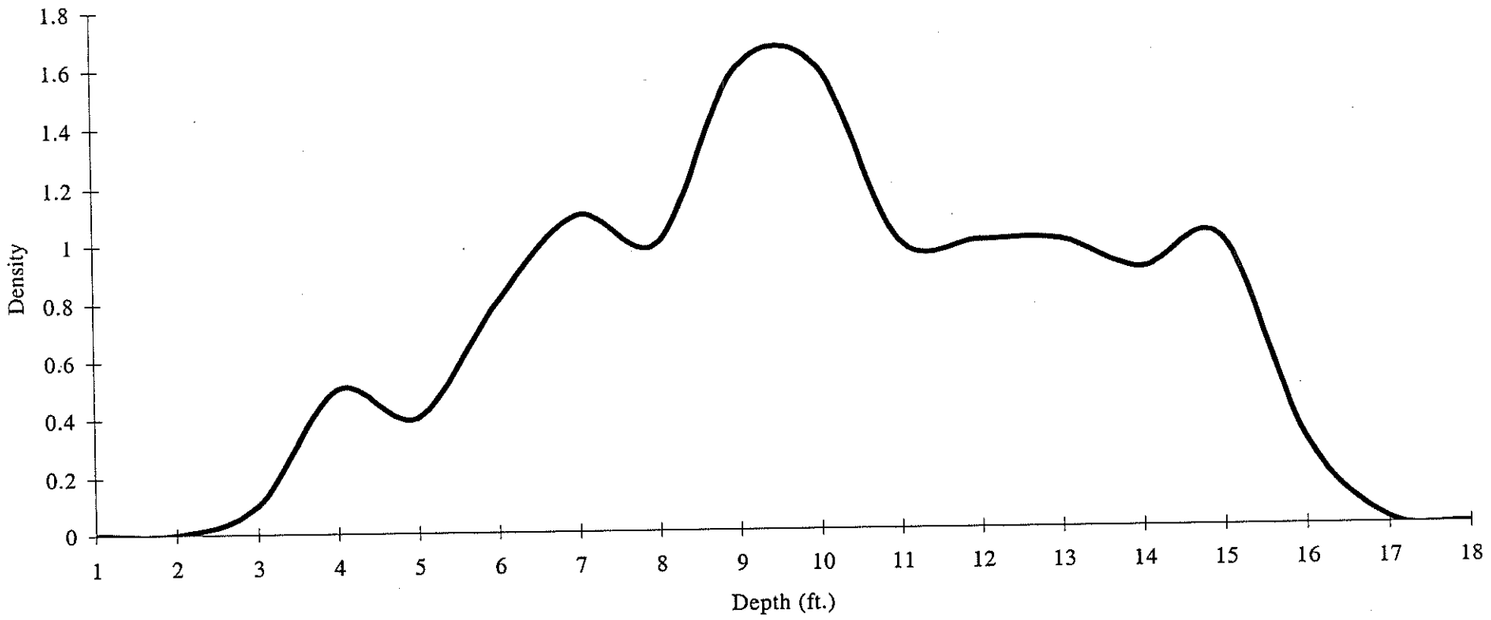


Figure 7. Average Density at Depth of Eurasian watermilfoil in Lake Meridian.
Density = Low (0-3 plants) =1, Medium (4-9 plants) =2, High (10+ plants) =3



PLAN FORMULATION AND SELECTION

Management Goals

The purpose of the Lake Fenwick and Lake Meridian IAPMP is to provide guidelines for implementing and monitoring management measures for non-native aquatic plants, specifically the growth of Brazilian Elodea in Lake Fenwick and Eurasian Watermilfoil in Lake Meridian. It is the goal of the people of Kent to use this IAPMP as a guide to protect beneficial uses of each lake, to preserve ecological function of the lakes, to educate lake users about invasive species, and to achieve these goals at reasonable costs.

The specific management goals proposed in this IAPMP are to:

- Suppress growth of existing BE beds to provide enhanced environmental habitats and recreational opportunities
- Prevent the spread of BE to nearby lakes
- Provide specific management of EWM in high use areas
- Provide hands-on plant management actions for citizens
- Educate residents of Kent and visitors of Lake Fenwick and Meridian about exotic species dangers and controls
- Build community stewardship by involving residents of Kent and visitors of Lake Fenwick and Meridian in the planning and implementation process
- Keep management program costs affordable

Control Intensity

The level of control needed to maintain or restore beneficial uses in Lakes Fenwick and Meridian is plant species and community dependent. There is a possibility to eradicate BE from Lake Fenwick, however that level of control may lead to an increase the algal growth in the lake. The aquatic plant management program for Lake Meridian will be one of specific control rather than eradication. Eradication of EWM is not economically or politically attainable at this time in Lake Meridian.

Aquatic Control Alternatives Available

Several methods of treatment of nuisance aquatic plant populations are available, including chemical, mechanical, biological, and physical controls. The appropriate method of control depends on the characteristics of the plant being targeted and the management goals for the lake. BE and EWM are classified as State Class B Noxious Weed species. As such, an aggressive control system aimed at destroying the entire plant, including the root system is recommended.

Chemical Methods

The City of Kent, as a significant stakeholder in the integrated planning process for both lakes and with an active City wide integrated pest management program, has set as a practical constraint on the planning process that herbicide use only be considered as last alternative and only if all concerns relative to herbicide use are addressed with guarantee of no adverse environmental risk. With that as a formulation constraint the following information presented on chemical control is for information and future reference.

Application of all aquatic herbicides require a National Pollutant Discharge Elimination System (NPDES) permit from the Washington Department of Ecology and must be applied by a licensed aquatic herbicide applicator (applicators are licensed by Washington State Department of Agriculture). The Washington Department of Agriculture has agreed to become the permit holder of the NPDES permit for noxious weed control activities. Coverage under this permit can be obtained for free by contacting the Department of Agriculture. Permit conditions including reporting and monitoring requirements must be complied with.

Fluridone:
This is a slow acting systemic herbicide (capable of killing the entire plant) control method for large-scale infestations of EWM and BE and well as other submersed plants. Carry-over control effectiveness can last for many years or more depending on lake and plant conditions. For planning purposes, it can produce effective control (80 to 90 plus percent, although greater control has been attained in some situations for both BE and EWM) carry-over reduction in plants where there is little water movement and where herbicide concentration can be maintained for an extended period of time (approximately eight weeks). (Contact time is essential to the success of the project.) Fluridone may affect other plant species that have not been targeted. As in all chemical applications, it is possible that fluridone may travel out of the application area. In some cases, the application of fluridone will alter nutrient levels (increased concentration) and dissolved oxygen (decreased concentrations) in the lake. However because fluridone is very slow acting, dissolved oxygen conditions measured during several whole lake herbicide treatments in Washington lakes have not been depressed. Fluridone costs approximately $1300 to $1800/acre to apply.

This treatment is an alternative that would offer control and may have the potential to achieve eradication of both BE and EWM in both lakes if used in combination with other management alternatives as a follow-up. In addition, fluridone does not have a label restricted for swimming and fishing. However, potential impacts (real or perceived) on fisheries resources downstream of the lakes (Chinook salmon, *Oncorhynchus tshawytsha*, is listed under EPA, Endangered Species Act, as an threatened species in the Green River drainage of which Lake Meridian and its outlet stream are part) severely limit its potential use in either Lake Fenwick or Meridian. ESA issues, potential challenges to a untested

NPDES permit process, tribe concerns, and public opinion may result in permitting difficulties for the use of this or any other herbicide at this location at this time. Therefore, fluridone is not recommended as a control agent in this IAPMP.

Glyphosate:
Glyphosate is intended for use on emergent plants only, and is not appropriate for use on BE or EWM. For this reason, it is unsuitable for use in Lake Fenwick or Lake Meridian.

Endothall:
Endothall is a fast acting, non-selective, contact aquatic herbicide. The herbicide acts by destroying the vegetative parts of the plant but does not kill the roots. Thus, the controlled plants will grow back, either the following season, or if treated in the spring, the treated plant may re-grow by the end of that growth season. Endothall requires a short contact time and can be used in small as well as large area applications. Although generally considered a non-selective herbicide, EWM has in some cases been selectively controlled by low doses of endothall. The drift of the herbicide out of the target area is low and it will dissipate from the water column fairly quickly. Endothall is not an appropriate herbicide for control of BE because of its lack of consistent control of the plant. There are label restrictions fish consumption and irrigation when it is in use. Costs range from $500 to $700/acre. Since the short control duration is undesirable and the use restrictions potentially problematic because of ESA issues downstream, endothall is not appropriate for use in control of BE at Lake Fenwick or EWM in Lake Meridian.

Copper Compounds:
Copper is a fast acting, non-selective herbicide or algaecide. This method offers large-scale, moderate to high intensity control that may last weeks or months. There are no use restrictions for swimming or fishing and a short contact time is necessary. However, Copper chelates have potential toxic effects to fish and wildlife since it persists in the environment. The cost of using Copper chelates ranges from $120 to $340/acre. In Washington State, copper compounds may be used only for algae control in non-salmonid-bearing waters. Because of the short length of control and restriction on its use it is not appropriate for control of BE or EWM in Lake Fenwick and Meridian and is not recommended in this IAPMP.

Triclopyr:
Although triclopyr is not yet registered for use by the U.S. Environmental Protection Agency, it is anticipated that it will receive registration by EPA upon the completion of their review. This herbicide is selective and systemic (kills plant including roots). This fast acting herbicide has proven to be effective against purple loosestrife and in spot treatments of EWM. The label (when registered) may contain restrictions for fishing within the treated area. Costs are estimated to be in excess of $1,600 per acre. Upon receiving its full label, triclopyr may be considered to control Eurasian watermilfoil in Lake Meridian, but until that time, it is not included in this IAPMP. As a selective

herbicide triclopyr is not effective against BE and is therefore not applicable for Lake Fenwick. In addition, downstream fishery issues would still have to be addressed relative to ESA concerns before this herbicide can be included in the integrated management program for the lakes.

2,4-Dichlorophenoxyacetic acid:
This systemic herbicide, 2,4-dichlorophenoxyacetic acid known as 2,4-D, is available for use on infestations of EWM. It is relatively selective and suitable for treating EWM at a dose rate of 100 pounds per acre. It is not effective against BE. Application costs are estimated to be $300 to $450 per acre. Navigate, a granular form of 2,4-D, may reduce the drift of 2,4-D from target areas as compared to liquid formulations. However, EWM most likely will not be eradicated by the use of 2,4-D in Lake Meridian. As with other 2,4-D applications to control established populations of EWM, this herbicide may slow its expansion but rarely prevents its dispersion within the lake (Smith and Barko, 1990). In addition, the carry-over effectiveness of 2,4-D is such that some EWM will remain and continue to grow (Goldsby et al., 1978). There are many factors that can reduce the exposure of EWM to 2,4-D herbicide including water depth, and water movement due to winds, waves and currents (Adams, 1983; Smith et al.1995). Given the current condition of the plant communities and downstream ESA issues, 2,4-D is not recommended in this IAPMP.

Biological Methods

Grass Carp:
The use of a herbaceous fish (white amur, *Ctenopharyngodon idella*) to control aquatic plants, including EWM and BE, has been used in other lakes in the state with varying success (Gibbons et al., 1998). Grass carp are originally from Asia and are a different species from the common carp (Brady 1982). Grass carp are one of the largest members of the minnow family Cypriniae. They may weigh up to 110 pounds but rarely exceed 35 pounds when stocked in ponds. Their life span is about 12 to 15 years but experience has shown that most ponds must be restocked after 7-8 years to provide continued control of aquatic plants. Small grass carp are highly vulnerable to predation from both fish and birds and easily eliminated from ponds. Stock grass carp at least 8 to 12 inches long to ensure their survival. The use of this biological agent for BE and EWM control may provide long term, large-scale, high-intensity control for relatively low costs ($50 to $400/acre depending on stocking density). The fish offer a low maintenance alternative, can cover a large area, and will not reproduce due to sterility.

Only sterile triploid fish may be introduced into the waters of the state with a specific permit issued by the Washington Department of Fish and Wildlife. However, it is difficult to determine the correct number of fish per acre to introduce into a water body to provide a definable effect on the aquatic plant community. The planting of grass carp into a lake usually results in either removal of all plants or limited impact on the observed standing crop of plants. Thus, either over-stocking or under-stocking of grass carp is the normal outcome of this fish's introduction. Eradication of both BE and EWM can be

achieved with grass carp if overstocked. Non-target ecological impacts are under debate, and several unpredictable elements (e.g., predation, angler harvest, escapement, etc.) may render the control ineffective. If carp are stocked in the lakes it is likely that they will feed on the native plants before or as they feed extensively on the non-native plants. Grass carp may provide BE and EWM control in Lake Fenwick and Lake Meridian, but observable decreases in the plant density may not occur for 3-5 years, and would likely result in a decrease in native plant densities as well as non-native plant densities.

The Silver Lake experience (Gibbons et al., 1998) demonstrated that BE and EWM can be eradicated from the lake by grass carp, if the introduced population of fish is in excess of the aquatic vegetation production. However, the drawback to this approach is that all submersed aquatic plants will be removed at the same time. At Lake Fenwick there is a significant amount of habitat structure for fisheries in the form of underwater trees and branches that have fallen into the lake. The total loss of aquatic plants from the lake may not adversely impact the fisheries, in fact, the change in structure would allow for an improved overall habitat in that movement and food gathering may become easier for the fish in the lake with less plant density.

This situation does not exist in Lake Meridian, and 100 percent removal of submersed aquatic plants would significantly reduce habitat structure for fisheries in that lake. The potential inability to control the movement of grass carp out of Lake Meridian into the downstream channel might make obtaining a permit to introduce the fish into the lake difficult or impossible due to ESA issues. Hence, grass carp are not a recommended part of this IAPMP for Lake Meridian.

However, if eradication of BE in Lake Fenwick is a primary management goal, the use of grass carp for Lake Fenwick is a possibility. An outlet control structure could be established that would prevent any grass carp from leaving Lake Fenwick. The application of grass carp to eradicate BE from the lake may result in an increase in algal production or bio-turbidity, as well as the loss of all submersed plants in the lake until the grass carp are removed or decrease in number. It is estimated that it will take 3 to 5 years after introduction to achieve eradication. To counter the increase in algal densities, the hypolimnetic aerator may have to operate to provide more oxygen to the lake and an alum treatment may have to be applied to control phosphorus and bio-turbidity generated by the feeding of the carp on plants and sediment detritus. When the population of grass carp decline or are removed native aquatic plants will re-establish communities in the lake.

Milfoil Weevil:
The milfoil weevil, *Euhrychiopsis lecontei*, has been associated with declines of EWM (Creed and Sheldon, 1995). In eastern Washington, the milfoil weevil is found on both Eurasian watermilfoil and native northern watermilfoil, *Myriophyllum sibericum*, (Tamayo et al., 1999). There have been no reported declines in EWM in Washington State attributed to the milfoil weevil. In addition, as with most biological controls, eradication is usually not achieved by a single bio-control agent. Another concern is that the present commercial supply of weevils comes from the Mid-west and there is a risk of

introducing zebra mussels or other nonindigenous animals to Washington State waters with the introduction of weevils. Given the uncertainty associated with this technique, it is not a recommendation of this IAPMP. However, if future information demonstrates that the milfoil does in fact significantly control EWM in the Pacific Northwest, then its use could be re-visited. (Natural populations of these weevils are in fact present in Lake Meridian, but have not been observed in the densities that are apparently needed to bring about a decline in milfoil.)

Mechanical Methods

Harvesting:
Mechanical harvesting is a short-term technique to temporarily remove plants from a water body. Harvesting involves cutting plants below the water surface, with or without collection of cut fragments for onshore disposal. Harvesting provides limited control for less than one season, and at times requires 3 to 4 cuttings per year. Harvesting immediately removes the plant to cutting depth (usually 5 feet). It may reduce internal loading of nutrients related to plant decomposition if harvested plants are removed from the waterbody. Collected plant materials may be composted instead of more costly disposal methods. Drawbacks of harvesting include 1) the production of fragments that can re-root later and encourage spread into new areas (not a problem in Lake Meridian or Fenwick because they have long established populations of the exotic species), 2) limitations on extent of (depth) control, 3) impacts of machinery on fish and invertebrate species, 4) plant disposal considerations if composting is not an option, 5) it is not species specific, and 6) the high initial capital costs associated with purchase or rental of harvesting equipment, plus high operational costs associated with access points. Furthermore, operation may require a specialist and inclement weather may delay schedules. Harvesting aquatic plants require a Hydraulic Project Approval permit from Washington Fish and Wildlife. Costs vary depending on transportation and equipment and are estimated to range from $600/acre to $1,400/acre. Because fragmentation is the primary means of reproduction for BE and EWM, use of this mechanical option as a major, large-scale control element is not recommended for this IAPMP for Lake Fenwick because it is too small and has too many bottom obstructions to harvest successfully. Harvesting can be considered for Lake Meridian if drawbacks in regard to funding and sustaining operational costs can be over come.

Rotovation/Cultivation:
Rotovation or cultivation is the process of physically removing the roots of plants from the lake sediments. This control measure can provide 2 to 3 years of perennial plant control through removal of plants and root disruption. Winter treatment minimizes impacts to summer season recreation. In some cases, diversity may increase with treatment. This control method is not species specific; native plants will be removed along with target species. This method would have impacts on fish and invertebrate species through bottom disturbance, increased turbidity, and loss of native submersed plant habitat. Any obstructions on the lake bottom would impair machinery. In addition,

the physical disturbance of the sediment would result in increased nutrient availability to the algae in the lake. Rotovating aquatic plants require a Hydraulic Project Approval permit from Washington Fish and Wildlife. Alone, rotovation can be expensive ($1,800 per acre plus a capital cost of $150,000 to $200,000), time-consuming, and its impacts to the aquatic environment outweigh the short-term control offered. Rotovation is not recommended in this IAPMP.

Diver-operated Dredge:
Unlike most other methods, a diver-operated dredge offers only small-scale control. It is species specific, site specific, can be done at any depth, and can be used near obstructions. Bottom disturbance and increased turbidity are only temporary impacts. However, with certain sediments the generation of turbidity reduces visibility and slows plant removal and reduces removal efficiency. Drawbacks include labor intensive, time to cover area, potential fragment production, and a high cost of $2400 to $4200/day depending on density and coverage of plant beds. A diver-operated dredge may be useful in removing small, isolated patches and EWM, but its applicability to dense community of BE is limited. Furthermore, it's effectiveness on removing BE are not well documented. Diver-operated dredge requires an HPA (Hydraulic Project Approval) from Washington Department of Fish and Wildlife. It may also require a section 404 permit from the U.S. Army Corps of Engineers. The small-scale control offered by this method relative to cost is insufficient for use in this IAPMP.

Physical Methods

Hand-Digging:
This alternative involves digging out each individual plant by hand, or with the aid of a spade or long knife, from the root system to ensure removal of the entire plant. This technique is labor intensive and most suitable in low plant density areas that cover less than 5,000 square feet. In waters less than 3 ft deep, no special gear is required. However, beyond 3 ft, divers may be contracted to complete removal. Costs depend on size and extent of target plant beds and the need for contract divers. While volunteer labor can be obtained free, contract divers can charge up to $3,200/day. Environmental impact is typically short-term and due to turbidity increases that result from removal activities. Hand digging of plant stems and roots could be used for small-scale, intensive removal of BE and EWM around private dock areas and short shoreline segments. If roots systems are completely removed, this technique provides a more long-term control (compared to hand-cutting described below). However, lake infestation at both lakes is too wide-spread to be addressed by hand removal alone. It is a useful technique that individual homeowners can use to control EWM around their docks and beach areas. Hand-pulling used in conjunction with other control methods would offer greater success.

Hand Cutting:
This technique employs a hand removal system that leaves the aquatic plant root system intact. This method is less intensive than hand-digging, and is accomplished by pulling scythes, rakes, smaller individual hand cutters or other specialized devices through the plant bed from a boat or by a group of people. Cut plants must be removed from the water. Effectiveness of hand cutting is usually short-term since BE or EWM may resprout from remaining, intact root systems. Costs depend on the cutting implement purchased or rented, and labor. Hand cutting would, like mechanical harvesting, create stem fragments and fail to provide long-term, high-intensity control and is not recommended for use with this IAPMP except for individual control in small areas.

Bottom Barriers:
Placement of a barrier over plant beds provides small-scale, high intensity control for up to 3 years. A number of materials can be applied to the lake bottom, including sand-gravel, polyethylene, polypropylene, synthetic rubber, burlap, fiberglass screens, woven polyester, and nylon film. The effectiveness of bottom barriers depends on materials used, application techniques, and sediment composition. Bottom barriers are best suited for plant growth control in localized areas where exclusion of all plants is desired. Costs depend on materials used, size of area covered, and labor. Materials costs may range from $0.15 to $0.75/square foot and installation from $0.25 to $0.50/square foot. More expensive materials may be more effective in control, and less costly materials may require replacement. Periodic maintenance is necessary to remove silt and rooting fragment accumulations on barrier materials. There is a possibility of suspension of barrier materials due to water movement or gas accumulation beneath the material. Bottom barrier application requires an HPA (Hydraulic Project Approval) from Washington Department of Fish and Wildlife. However, individuals can place bottom barriers without a formal HPA if they follow the procedure outlined in Aquatic Plants and Fish pamphlet. Bottom barriers are a useful method of spot treatments of BE in Lake Fenwick and EWM in Lake Meridian. Although barriers can be expensive, the use of burlap with sandbags or rocks as anchors is relatively inexpensive.

Drawdown:
Lowering the lake's water level offers a large-scale, low-intensity control and may also allow for other improvements or maintenance. Control duration is only temporary however. Drawdown may encourage growth of beneficial wetland plant species that are attractive to waterfowl. Water level manipulation can be disadvantageous since it can affect beneficial plant species, cause a loss of recreation during implementation, decrease dissolved oxygen, and may impact benthic invertebrates and wetlands. Costs are variable; if an outlet structure is available, costs can be minimal. Drawdown has not proven effective in controlling many aquatic plants in Western Washington. Also, the low-intensity control is not useful in achieving management goals. Drawdown is not recommended for use in controlling BE and EWM at Lake Fenwick and Lake Meridian.

Watershed Controls:
This method involves using watershed best management practices (BMPs) to reduce the sources of external nutrient and sediment inputs, which support exotic plant invasions. BMPs are primarily carried out by homeowners and provide a small-scale, low intensity control alternative. Examples include 1) maintaining septic systems, 2) using prudent lawn and garden fertilizing practices, and 3) disposing of yard litter or shredding or composting well away from water's edge. BMPs are easy to implement, can be wide-ranging, and expenses are minimal, if any. However, BMPs will not result in immediate, substantial BE and EWM growth reduction since habitat has already been created that supports aquatic plant growth. While this treatment may not create a perceptible change in the density of BE and EWM, continued implementation of watershed BMPs in conjunction with the selected management alternative(s) can be included as part of an education program.

Water Column Dye:
This low intensity treatment requires dark colored dyes to be applied to the water, which suppress aquatic plant growth by shading out sunlight needed for photosynthesis. Aquashade (Applied Biochemists, Inc.) is the only dye registered as a herbicide. All others are sold strictly as pond dyes. Aquashade is a blue dye that is reported to be non-toxic to humans, livestock and aquatic organisms. It can be applied by pouring it into the water from shore or from a boat. The usefulness of dyes is limited to water bodies with no outflow and relatively small size and is used most effectively in lakes where the plants grow at least 2 ft. below the water surface. Expected duration of control can be up to a few months and may require repeated applications throughout the growing season. Aquashade costs approximately $50/gallon, which can be used to treat one acre of water at an average depth of 4 ft at the recommended dosage of 1 ppm (part per million). However, dyes have not been reviewed by Ecology's EIS and therefore are not available for use in Lake Fenwick and Lake Meridian.

Weed Rollers

A weed roller is a commercially available device used to remove aquatic plants from a well defined area and to keep the area free of aquatic plant growth. Weed rollers must be attached to a dock or post to work properly. A weed roller uses a low-voltage power unit that slowly drives an up-to-30-foot long roller (metal cylinder or pipe) set on the lake bottom through an adjustable arc of up to 270 degrees. A reversing action built into the drive automatically brings the roller back to complete the cycle. Fin-like projections on the rollers help detach plants from the sediment and remove roots. Detached plants should be removed from the water with a rake or gathered by hand. Once the plants are cleared from the area, the device can be used as little as one day per week or less to keep plants from recolonizing the area. When not in use, the equipment should be stored along side a dock or in a place where people will not step on the roller and accidentally injure themselves.

Little maintenance is required, but the unit must be removed from the water in winter in areas where lakes are expected to freeze. The life of the unit is predicted at a minimum of five years.

Advantages

- Rolling suppresses regrowth of plants in areas where it is regularly used.
- The treatment area can be modified by using up to three or more, ten foot roller tube sections, as well as by adjusting the roller tube travel arc.
- Weed rolling creates and maintains areas of open water adjacent to docks.
- Operating costs are low - about the same as using an ordinary light bulb.

Disadvantages

- Weed rolling will disturb some bottom dwelling animals and may interfere with fish spawning.
- If plants are present, weed rolling will cause plant fragmentation, which may increase the spread of some invasive weeds.
- Weed rolling can cause a depression to develop where the unit operates as the fine sediment is dispersed to other areas of the waterbody.
- When the cleared area is to be used for activities such as swimming or wading, the rollers should be unplugged from the power source, moved and stored under or along side a dock. People may injure themselves if they step on the roller tube.
- People should not be allowed in the water when the equipment is operating.

Permits

Installation of weed rolling devices in Washington requires hydraulic approval obtained free from the Washington Department of Fish and Wildlife. Check with your city or county to determine whether a shoreline permit is required.

Costs

Purchase cost is approximately $2,000. Installation is said to be simple and requires only a 110 volt ground fault interrupter and an outdoor extension cord in addition to the equipment package supplied by the manufacturer. Operating costs are reported to be analogous to the costs of using a 75 watt light bulb.

Weed rollers would be suitable for use in both lakes by individual homeowners or a group of homeowners that wanted to share a device. They are popular in the Midwest but haven't caught on here.

Alternatives Selection

Guidelines and recommendations for an integrated aquatic plant management program for Lake Fenwick and Lake Meridian are outlined below. This program identifies initial action control strategies that could be implemented along with regular review of implemented measures for evaluation of effectiveness. The lead agency to implement this program will be the City of Kent.

Evaluation of the available alternatives led to the selection of 3 scenarios for BE in Lake Fenwick and 2 for EWM in Lake Meridian. Alternatives were eliminated if their known outcomes were not compatible with project objectives and management goals. Several alternatives were considered infeasible, due to limitations of use, and were also eliminated.

Among the feasible alternatives remaining, the treatment scenarios presented below were selected based on several criteria, including 1) ability to provide the lakes with the level of invasive weed control necessary, 2) minimization of costs, 3) minimization of labor, and 4) appropriateness for location and environment and 5) management alternative not be dependent on the use of herbicides. These strategies differ in scale of control, intensity of control, duration of control, and in costs. Each treatment scenario provides an initial action that can be completed within one year and requires ongoing monitoring of up to 5 years.

It should be acknowledged that the benefits of any management alternative cannot be realized without some short-term adverse impacts. No ideal alternative is 100% effective against BE or EWM, species specific, environmentally safe, and also cost-effective. Selecting an appropriate treatment scenario involves weighing each factor and finding a balance between acceptable ecological and economical benefits and drawbacks.

Management Strategies

Scenario 1 – No Action:
As in all cases, it is an alternative to elect not to go forward with any of the proposed treatment scenarios. In the case of the no action alternative, it is expected that existing conditions will stay the same or worsen, leading to more severe environmental degradation and additional problems for the Lake Fenwick and Meridian communities. Even though, given the current coverage and densities of BE and EWM in Lakes Fenwick and Meridian, the probability of increased reduction in beneficial uses is not high, a no-action alternative is not considered acceptable for the nuisance plant condition in the lakes. It fails to meet project goals and, due to potential continued dominance of EWM and BE as well as, the potential expansion of non-native plant communities in the lakes that would likely lead to further decline in the lake environments.

Scenario 2 – Grass Carp:
In this alternative, grass carp would be stocked in Lake Fenwick at a maximum recommended density of 40 fish per submersed vegetative acre to ensure complete eradication of BE. Although this rate of grass carp is high it is less than the 50 fish per acre used in Silver Lake, which was over stocked and achieved eradication of all plants within three years. On the other hand, maximum rate of 40 fish per acre is considerably more than the 9 fish per acre used at Duck Lake, but that rate resulted in limited impact on BE coverage or density. Perhaps, grass carp can be planted in Lake Fenwick at a rate 20 fish per acre the first year and based on monitoring results restocked if needed in later years. However, for planning cost estimating the maximum stocking rate of 40 fish per acre will be used.

At a cost of $12/fish, grass carp stocking to eradicate BE would cost approximately $6,700 for the 14 littoral acres at 40 fish per acre. Lake Fenwick would need escapement protection constructed on its outlet. The outlet barrier would be needed to provide absolute blockage to fish escapement. This outlet barrier would be a bar screen structure with space between the bars of less than 1 inch. The outlet structure could designed so that the outflow is drawn from below the lake surface thus avoiding and reducing operation and maintenance problems. In addition, a HPA permit for the Washington Department of Fish and Wildlife is required for the outlet structure and a grass carp stocking permit is required for the introduction of the grass carp. This scenario provides a means of control (in this case eradication) that does not require the use of invasive procedures, such as mechanical or physical methods, or chemical use. However, it is the introduction of a non-native (however sterile) fish to control a non-native plant. The potential eradication of BE in Lake Fenwick could potentially result in increased nutrient availability for phytoplankton growth. However, with the continued efforts by the City for public education and implementation of BMP's as well as the operation of the hypolimnetic aerator, any increase in phytoplankton production would not be permanent.

Other management elements included in this scenario are permitting and administration of the program, monitoring, and public education. The administration of the IAPMP at Lake Fenwick would include the application and maintenance of a HPA for the construction of the outlet carp barrier and the application for a grass carp permit for the planting of the sterile grass carp into the lake. The monitoring program would collect data on the coverage and relative density of aquatic plants in the lake. This data would be compared to the plant maps presented in this plan. Based on that analysis, a determination of progress toward the management goal would be made. Public education would include signage and public announcements making users of the lake aware of non-native plant problems, what was being done to address current problems, and who to contact for additional information. (Fish and Wildlife staff will be installing signs at the boat launches declaring Lake Fenwick a lake infested with Brazilian elodea and Lake Meridian a lake infested with Eurasian watermilfoil. The signs are printed and now they are needing to gear up to get the signs posted).

Scenario 3 – Bottom Barriers:
Plant barriers placed on top of plant beds would provide localized control of BE in Lake Fenwick and EWM in Lake Meridian. It would require 300 sheets of burlap (105 inches by 25 feet each) to cover a total area of 1.5 acres. The recommended location of the bottom barriers are shown in Figure 5 for Lake Meridian. Relative location of bottom barriers for Lake Fenwick have not been determined at this time and because of the woody debris on the bottom of that lake site specific investigations would be need to provide recommended locations. Each burlap sheet would control 219 square feet of area. The sheets will be applied individually or in groups to control larger areas. Citizens, homeowners, and/or contractors can place the bottom barriers in the shallow edge of the BE or EWM plant beds (1-5 feet of water) and walk the barrier out to its 25-foot length. While spreading the burlap barrier down, sand bags (also made of burlap) can be placed on top of the barrier to keep it in place. Depths of up to 5 feet will be controlled using this approach. For deeper depths divers would have to be employed to place the bottom barriers. The cost of bottom barriers (burlap) would be approximately $22.50 (including shipping) per sheet, bags would cost $0.50 per bag at 2,000 bags per acre and sand or pea-gravel would be $20.00 per cubic yard. The cost per acre would be $5,700 for materials including sand and shipping costs. Labor for application is estimated at $2,200 per acre if contract out. Other material such as texel can be use for higher capital cost but would also require addition operation and maintenance. A HPA permit is required from the Washington Department of Fish and Wildlife. The ecological impact of bottom barriers is minimal in littoral area such as Fenwick and Meridian. Hand digging will be used in areas where isolated patches of BE or EWM grow, or where underwater obstructions prevent the use of bottom barriers.

Other management elements included in this scenario are permitting and administration of the program, monitoring, and public education. The administration of the IAPMP would include the application and maintenance of a HPA for the placement of bottom barriers into the lake. Administration of the program would also include the review of the monitoring data and implementation of the public education elements of this program. The monitoring program would collect data on the coverage and relative density of aquatic plants in the lake. This data would be compared to the plant maps presented in this plan. Based on that analysis, a determination of progress toward the management goal would be made. Public education would include signage and public announcements making users of the lake aware of non-native plant problems, what was being done to address current problems, and who to contact for additional information.

Table 5 presents the summary of costs for each scenario and lake.

Table 5. Treatment scenarios summary for both Lake Fenwick and Meridian

Alternative Treatment Scenarios	**Lake**	**Management Element**	**Cost**				
			Year 1	Year 2	Year 3	Year 4	Year 5
No Action	Fenwick	No Action	$0	$0	$0	$0	$0
	Meridian	No Action	$0	$0	$0	$0	$0
Grass Carp	Fenwick	Grass Carp	$6,720	$0	$0	$0	$0
		Outlet Barrier	$8,000	$0	$0	$0	$0
		Permitting & Administration	$5,000	$0	$0	$0	$0
		Monitoring	$3,500	$3,500	$3,500	$3,500	$3,500
		Contingency	$5,000	$0	$0	$0	$0
		Public Education	$3,000	$2,500	$1,500	$1,500	$1,500
	Scenario Totals		$31,220	$6,000	$5,000	$5,000	$5,000
	Total	$52,220					
Bottom Barriers	Fenwick	Bottom Barriers	$8,000	$4,000	$4,000	$4,000	$4,000
		Permitting & Administration	$5,000	$3,500	$3,500	$3,500	$3,500
		Monitoring	$2,500	$1,500	$1,500	$1,500	$1,500
		Contingency	$2,800	$1,400	$1,400	$1,400	$1,400
		Public Education	$3,000	$2,500	$1,500	$1,500	$1,500
	Scenario Totals		$21,300	$12,900	$11,900	$11,900	$11,900
	Total	$69,900					
	Meridian	Bottom Barriers	$16,000	$8,000	$8,000	$8,000	$4,000
		Permitting & Administration	$5,000	$3,500	$3,500	$3,500	$3,500
		Monitoring	$2,500	$1,500	$1,500	$1,500	$1,500
		Contingency	$5,600	$2,800	$2,800	$2,800	$1,400
		Public Education	$3,000	$2,500	$1,500	$1,500	$1,500
	Scenario Totals		$32,100	$18,300	$17,300	$17,300	$11,900
	Total	$114,200					

RECOMMENDED ACTION PLAN AND MONITORING

The recommended IAPMP for Lake Fenwick and Lake Meridian consists of two basic elements, one for each lake.

Lake Fenwick

Eradication of BE in Lake Fenwick is possible with the introduction of the sterile grass carp. If successful, the use of grass carp to eliminate BE from the lake would be more cost effective than any other single or combination of techniques. In addition, grass carp represents the highest potential for long-term control of the BE in the lake.

Lake Meridian

For Lake Meridian, eradication EWM is not feasible under the environmental and potential regulatory constraints. Therefore, a management approach that provides control in high use beneficial areas is appropriate. Specifically, the use of bottom barriers as outlined in scenario three is the recommended program for Lake Meridian. Table 6 is a cost summary of the IAPMP for the two lakes.

Table 6. IAPMP Summary for Lake Fenwick and Lake Meridian.

Principle Action	Lake	Management Element	Cost Year 1	Cost Year 2	Cost Year 3	Cost Year 4	Cost Year 5
Grass Carp	Fenwick	Grass Carp	$6,720	$0	$0	$0	$0
		Outlet Barrier	$8,000	$0	$0	$0	$0
		Permitting & Administration	$5,000	$0	$0	$0	$0
		Monitoring	$3,500	$3,500	$3,500	$3,500	$3,500
		Contingency	$5,000	$0	$0	$0	$0
		Public Education	$3,000	$2,500	$1,500	$1,500	$1,500
	Annual Totals		$31,220	$6,000	$5,000	$5,000	$5,000
	Program Total	$52,220					
Bottom Barriers	Meridian	Bottom Barriers	$16,000	$8,000	$8,000	$8,000	$4,000
		Permitting & Administration	$5,000	$3,500	$3,500	$3,500	$3,500
		Monitoring	$2,500	$1,500	$1,500	$1,500	$1,500
		Contingency	$5,600	$2,800	$2,800	$2,800	$1,400
		Public Education	$3,000	$2,500	$1,500	$1,500	$1,500
	Annual Totals		$32,100	$18,300	$17,300	$17,300	$11,900
	Program Total	$114,200					

Lake Fenwick

During the first year of Lake Fenwick IAPMP implementation, a permit for introducing the grass carp and building the outlet carp barrier would have to be obtained; construction of the carp barrier would be completed; and introduction of 560 sterile grass carp into the lake will be completed. Monitoring would occur at the end of the plant growth season to determine if there was any indication of active feeding on the plants. Signs would be placed in Lake Fenwick Park informing citizen of the grass carp introduction to control BE and warning them not to remove the fish from the lake. Information will also be made available to inform the lake users about non-native plants and the City's program to management these invaders. Activity in years 2 through 5 includes annual monitoring to assess the level of BE control achieved by the grass carp and to continue to inform the public of the management efforts at the lake.

Lake Meridian

The implementation of the Lake Meridian IAPMP also includes administration and permitting. However, a new HPA may have to be secured each year in order to place new bottom barriers in the lake each year. The exact location of the bottom barrier placement will be determined at the time of permit application. The bottom barriers should be placed in high use areas such as swimming and dock facilities. The first site for bottom barrier use is at the swimming area in Lake Meridian Park. Additional barriers can be located where lakeside residents may offer both labor and financial support for the bottom barrier placement. Monitoring and public education elements are similar to those in Lake Fenwick.

Monitoring and Maintenance for Selected Alternatives

It will be necessary to monitor the selected action strategy to ensure that it is working as intended and to base management decisions. The following provides a schedule for such activity. Annual aquatic plant mapping should be conducted to map the plant community coverage and compare that data to the year 2000 baseline data. The aquatic plant survey should be conducted in a similar manner to the 2000 mapping using divers to define the plant communities by direct visual observation.

Grass Carp

Grass Carp themselves will require no maintenance. The on-going public education should establish the need to prevent removal of grass carp from the lake by anglers. The fish live for 8 to 12 years so they should live long enough to eliminate the plants. The outlet structure should be checked periodically to ensure that it is functioning correctly.

Bottom Barriers

Periodic inspection of bottom barrier materials is advised. Inspectors will determine whether the placement of the barrier is secure, remove any plants that have become rooted in the barrier material, and evaluate its effectiveness in suppressing EWM growth. Inspectors will also need to determine if untreated areas require bottom barrier treatment or if treated areas need to be re-treated. Monitoring should occur approximately one month after the initial implementation and be repeated every year thereafter. A member of the volunteer team can carry out inspection.

Schedule and Strategies for Implementing Plan

The following is a suggested schedule for the timing of implementation of treatment scenario components. Assuming the City will continue to provide the lead role during implementation, project managers may consider completion of the following components:

- Organization of the implementation volunteer group (Lake Meridian Homeowners Association and Friends of Lake Fenwick)
- Set number and dates for meetings of the implementation volunteer group
- Set dates for implementation of treatment scenarios
- Arrangements for implementation materials to be obtained and paid for
- Arrangements for materials to be delivered to the site on the day of implementation (barrier material, contractors, grass carp, etc.)
- Arrangements for additional mechanical equipment to be obtained and delivered to the site on the day of implementation (boats, hand tools, chest waders, etc.)

Table 7. Sample plan implementation schedule

Component	Responsible Party	Point of Contact	Deadline	Date Scheduled
Selection of Alternative	City of Kent	City of Kent employee (phone #)	April 30, 2001	April 30, 2001
Organization of Volunteer Group	City of Kent	City of Kent employee (phone #)	August 30, 2001	August 30, 2001
Grant Application	City of Kent	City of Kent employee (phone #)	October 30, 2001	October 30, 2001
1st Volunteer Group Meeting	Volunteer Group Leader	Volunteer Leader	August 30, 2001	
2nd Volunteer Group Meeting	Volunteer Group Leader	Volunteer Leader	September 30, 2001	
Set Date for Plan Implementation	Volunteer Group	Volunteer Group Leader (phone #)	January 30, 2002	April 30, 2002
Arrangement for grass carp and bottom barrier materials delivery	City of Kent	City of Kent	May 30, 2002	May 30, 2002

Strategies for Evaluation of Alternative Effectiveness and Need for Revision

Throughout the duration of the implementation and operation of the selected treatment scenario, it will be necessary to evaluate its effectiveness. Any conditions leading to the failure of the treatment need to be discovered and resolved quickly. A project manager and a member of the volunteer team will conduct evaluations of the selected treatment scenario. Annual evaluations will be prepared following selection of the preferred alternative as well as a protocol for revising any part of that treatment plan.

PUBLIC EDUCATION OPPORTUNITIES

Public Education Signs

Signs warning of the spread of BE and EWM via boat have been installed near the public boat launch. Public education signs addressing the purpose and method of BE and EWM control have not been erected. It is recommended that public education signs be installed at Lake Fenwick Park and Lake Meridian Park near the swimming hole and at the boat launch. These locations cover the greatest points of park visitation and will afford the greatest transfer of information to lake visitors.

Each public education sign should summarize the purpose, methods, and benefits of the lake IAPMP. Suggestions for, and explanations of BMPs should be included. Warnings of swimming and boating hazards associated with BE should also be included, particularly regarding any long-term suppression or eradication activities that may be implemented (i.e., bottom barriers or grass carp).

Best Management Practices (BMP)

BMPs should be made available to the visitors of Lakes Fenwick and Meridian and their community members. A brochure explaining the individual homeowner BMPs would be an appropriate method for ensuring that all lake users have access to the practices and procedures that will assist in eliminating the growth and spread of invasive species.

FUNDING

Future funding of the IAPMP or elements of the plan will require local funding base. This can be in the form of individual actions, but more effectively through community funding programs. Specifically, if the Lake Fenwick and Lake Meridian communities wish to proceed with implementation of the IAPMP funding districts will be needed to be formed within the City, since City funds are not currently available to support a sustain management program. Lake Management Districts or Special Improvement Districts can to formed to raise funds for the implementation of the IAPMP. These Districts could

with the City's support could seek an implementation grant from Ecology' Aquatic Plant Program for elements of the implementation program. However, the ongoing funding and execution for a long-term program will be the responsibility of the funding district formed (with City staff technical and administration support). It is recommended the citizen from both lake communities approach the City to form a Lake Management District to implement the IAPMP. This would ensure long-term management activities and local control of the lake environment.

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Appendix A. Natural Heritage Information System Letter

WASHINGTON STATE DEPARTMENT OF
Natural Resources

DOUG SUTHERLAND
Commissioner of Public Lands

February 20, 2001

Sara Townsend
Tetra Tech ISG
7080 SW Fir Loop
Portland OR 97223

SUBJECT: **Integrated Aquatic Plant Management Plan for 3 Lakes: Lake Fenwick & Lake Meridian in King County, and Long Lake in Spokane, Stevens, & Lincoln Counties**

We've searched the Natural Heritage Information System for information on rare plants and high quality ecosystems in the vicinity of your project areas. Currently, we have no information on significant natural features for either Lake Fenwick or Lake Meridian. A summary of information for Long Lake is enclosed. In your planning, please consider protection of these significant natural features. Please contact us for consultation on projects that may have an effect on these rare species or high-quality ecosystems.

The information provided by the Washington Natural Heritage Program is based solely on existing information in the database. In the absence of field inventories, we cannot state whether or not a given site contains high quality ecosystems or rare species; there may be significant natural features in your study area of which we are not aware. These data are being provided to you for informational and planning purposes only - the Natural Heritage Program has no regulatory authority.

We have begun to add to our database information on selected groups of animals of conservation concern, such as freshwater mussels, butterflies and bats. However, the authority for protection of animal species in Washington rests with the Department of Fish and Wildlife. To ensure that you receive information on all animal species of concern, please contact Priority Habitats and Species, Washington Department of Fish and Wildlife, 600 Capitol Way N, Olympia, WA 98501-1091, or by phone (360) 902-2543.

If you have the opportunity, visit our website at http:// www.wa.gov/dnr and click on *Conservation/Protection.* Please do not hesitate to call me at (360) 902-1667 if you have any questions, or by E-mail: sandra.moody@wadnr.gov.

Sincerely,

Sandy Swope Moody

Sandy Swope Moody, Environmental Coordinator
Washington Natural Heritage Program
PO Box 47014
Olympia WA 98504-7014

Appendix B. Public Involvement Summary

The City of Kent conducted a series of public meetings regarding the development of the Integrated Aquatic Plant Management Plan (IAPMP) for Lake Meridian and Lake Fenwick. Lake Meridian is surrounded by homes, however Lake Fenwick is relatively undeveloped and interest in the participation from residents near Lake Fenwick was very minimal.

Two meetings regarding the development of the plan took place at the City of Kent.

September 26, 2000

Sally McDonough, Lake Meridian Home Owners Association
Robyn Rauch, Lake Meridian Home Owners Association, President
Casey Gibbs, Lake Meridian Homeowner
Tom Brotherton, Kent City Council
Harry Gibbons, Tetra Tech ISG
Kelly Peterson, City of Kent

November 14, 2000

Robyn Rauch, Lake Meridian Home Owners Association, President
Bill Rausch, Lake Meridian Homeowner
Marilyn Gibbs, Lake Meridian Homeowner
Tom Brotherton, Kent City Council
Harry Gibbons, Tetra Tech ISG
Kelly Peterson, City of Kent

A Public Workshop was held on June 28, 2001, at the City of Kent Fire Station #75. Residents were offered the opportunity to discuss lake related issues, including the Aquatic Integrated Plant Management Plan with city staff and consultants.