DUCK LAKE WATERWAYS
AQUATIC PLANT MANAGEMENT PLAN

Final Report

July 1994

Prepared for :

City of Ocean Shores
PO Box 909
Ocean Shores, WA 98569

Prepared by:
Joy P. Michaud
Envirovision
1339 Quince St. NE
Olympia, WA 98506

In Association with:
Entranco Engineers Inc.
Resource Management Inc.

Produced and printed as always on Recycled Paper.

ACKNOWLEDGMENTS

Envirovision wishes to acknowledge the support of members of the steering committee for the Duck Lake Waterways Aquatic Plant Management Plan, especially Bill Miller (Project manager), Peter Jordan (Vice Pres. Fresh Waterways Corporation), Arne Kvist (Pres. Fresh Waterways Corporation), Mike Pence (City Manager), Dan Guy (WDFW) and Kathy Hamel (WDOE).

Scott Bonar (WDFW), David Wagner (Devils Lake Water Quality Improvement District), Dan Rawding (WDFW) and Pat Keough (Silver Lake Project) provided invaluable information and advice for producing the Grass carp stocking portion of this plan.

Last, the other members of the consultant team; David Morency and Jory Oppenheimer of Entranco Engineers Inc. and Terry McNabb and Steve Farone of Resource Management Inc. were instrumental in providing the support and extra work required to produce this plan within the constraints of a compressed timeline.

This project was funded in part by the Washington State Department of Ecology's Aquatic Weed Management Fund.

TABLE OF CONTENTS

TABLE OF CONTENTS i

LIST OF TABLES ii

LIST OF FIGURES ii

PROJECT OVERVIEW 1

LAKE AND WATERSHED CHARACTERISTICS 3

WATERSHED CHARACTERISTICS 3
LAKE CHARACTERISTICS 4
AQUATIC PLANT COMMUNITIES 4
WATER QUALITY 6
CHARACTERISTIC USE 9

PROBLEM STATEMENT FOR DUCK LAKE 11

AQUATIC PLANT MANAGEMENT GOALS 13

AQUATIC PLANT CONTROL PLAN 14

MECHANICAL PLANT REMOVAL 14
GRASS CARP STOCKING PROGRAM 15
MANUAL CONTROL ACTIVITIES 22
EXOTIC WEED PREVENTION 22

PUBLIC EDUCATION PROGRAM 25

EVALUATION PLAN 26

PLAN ELEMENTS, COSTS, AND FUNDING 29

SUMMARY AND CONCLUSIONS 31

REFERENCES 32

APPENDIX A. SUMMARY OF STEERING COMMITTEE MEETINGS
APPENDIX B. HARVESTING PLAN FOR THE DUCK LAKE WATERWAYS
APPENDIX C. INSTRUCTIONS FOR CREATING AN UNDERWATER VIEWING SCOPE

List of Tables

TABLE 1. PHYSICAL CHARACTERISTICS OF THE DUCK LAKE WATERWAYS. (REVISED FROM KCM, 1994).----4
TABLE 2. DUCK LAKE PLANT COMMUNITY AS OF 1994 DIVER SURVEY (ACRES).----6
TABLE 3. LIST OF BENEFICIAL USES FOR THE DUCK LAKE WATERWAYS----9
TABLE 4. PROBLEM LIST FOR THE DUCK LAKE WATERWAYS---- 11
TABLE 5. PLANT COMMUNITY COMPOSITION FOR EACH PORTION OF THE DUCK LAKE WATERWAY.---- 19
TABLE 6. GRASS CARP STOCKING RATE COMPARISONS.---- 20
TABLE 7. RECOMMENDED GRASS CARP STOCKING NUMBER FOR EACH OF THE IDENTIFIED OFFLOAD SITES (BASED ON A TOTAL STOCKING NUMBER OF 5500).---- 21
TABLE 8. ESTIMATED COSTS FOR IMPLEMENTATION OF THE DUCK LAKE AQUATIC PLANT CONTROL PLAN.---- 30

List of Figures

FIGURE 1. DUCK LAKE AQUATIC PLANT COMMUNITY----7
FIGURE 2. HARVESTING PLAN MAP FOR DUCK LAKE WATERWAYS---- 16

PROJECT OVERVIEW

The Duck Lake waterways located on Point Brown Peninsula in Ocean Shores, Washington, are a series of manmade lakes and canals that were constructed in the 1960's and 70's to allow development of the peninsula. In recent years the quality of the water in the waterways has deteriorated, and aquatic plants, including the non-native species Brazilian elodea (Egeria densa), have increased to the extent that traditional uses of the waterway are restricted. Due to the poor condition of the waterway, the City of Ocean Shores applied for and received a grant to complete a one-year study of the waterway system. The study occurred in 1992-93 and the results are contained in the report; "City of Ocean Shores, Duck Lake Phase I Restoration Study" (KCM, Inc. 1994).

A number of recommendations were made in the Phase I report. The most important recommendation, in terms of overall influence on lake water quality was to convert from on-site septic systems to a city sewer system. The City is currently trying to obtain funding for the beginning phases of the new system. The first phase would include sewering a large portion of the north end of the City and building a new wastewater treatment facility (John Gow, personal communication, 9 June 1994). It was also recommended that a biofiltration wetland be constructed at the mouth of Oyehut Creek and that "end of pipe" control of phosphorus occur on Clover Creek and the drainage from Ocean Shore drive.) At this time, funding has been received for design of the biofiltration wetland on Oyehut Creek and a loan application has been filed for construction of the facility (Bill Miller, personal communication, 6 June 1994.). A biofiltration wetland has also been proposed for Clover Creek, although no plans are currently underway for obtaining funding for this particular recommendation. The above engineering recommendations are aimed at controlling nutrient and other pollutant inputs to the system. Establishing stream and wetland buffer zones, stabilizing shorelines, public education programs, and implementation of best management practices (including revising City ordinances) were also recommended to decrease the overall quantity of pollutants that enter the watershed. Aeration of Bass Canal was also recommended as an in-lake restoration alternative.

In addition to water quality concerns, dense beds of aquatic plants also contribute to lake problems. Existing plant populations already cause problems with navigation and access, greatly diminishing recreational opportunities and decreasing available fish habitat. This problem is expected to become worse since much of the system is comprised of narrow channels and shallow water, and plants will continue to invade a greater portion of the waterway. During the Phase I study, discussion and review of available aquatic plant control options also occurred, and plant control alternatives were selected. These included stocking triploid (sterile) grass carp, mechanical removal (harvesting) of aquatic plants, and manual harvesting along private docks. The purpose of this plan is to develop an implementation strategy for grass carp stocking and harvesting that best meets the needs of the waterway and local residents. This plan was developed with the guidance of a steering committee of interested parties that included; city and county officials, members of the local Fresh Waterways Corporation, the State Department of Ecology (WDOE), the State Department of Fish and Wildlife (WDFW), and the consultant team. (A summary of the information presented and discussed at the steering committee meetings is included as Appendix A to this report.)

It is clear from the previous paragraphs that the City of Ocean Shores is taking an action-oriented approach to improving the condition of the waterways; even to the extent of implementing some very expensive recommendations. The aquatic plant control plan described in this report is an integral part of the overall plan for the lake and should be evaluated and implemented based on the need to provide a multi-task approach to saving and protecting the waterways.

LAKE AND WATERSHED CHARACTERISTICS

The following is largely summarized from the "Duck Lake Phase I Restoration Study Final Report." (KCM Inc., 1994). That document should be reviewed if more detailed information is needed.

Watershed Characteristics

The Duck Lake waterways is a system of lakes and interconnecting canals that occupies nearly all of Point Brown peninsula. The waterways were constructed between 1960 and 1973 to allow development of the peninsula. The nearly flat watershed (maximum elevation of 30 feet msl.), contains approximately 4,291 acres, 450 acres of which is contained by the waterway system. Surface water inflows to the waterway include three, small inlets; Oyehut Creek, a year-round source that enters the north end of Grand Canal, Clover Creek a year-round source that enters the south end of Grand Canal, and a seasonally flowing creek that enters the north end of Duck Lake. The only surface outflow is the outlet located at the southern end of Grand Canal. The outflow drains through a tide gate directly to North Bay and the Pacific Ocean. Generally, there is no flow from the lake during summer months.

The City of Ocean Shores represents the largest portion of land in the watershed (approximately 3,968 acres or 92% of the watershed). The majority of land (81%) in Ocean Shores is zoned for single family residential use, although most of this is undeveloped. It is estimated that there are about 12,000 lots in the City, only 25% of which have been developed (Miller, B., personal communication 4 May 1994). Commercial use (primarily associated with the tourist trade) represents 11% of land use, and private recreational property 8%.

There are two other communities in addition to the City of Ocean Shores, that are located in the watershed; Oyehut and Illahee. Both communities are approximately 15 acres in size (Miller, B., personal communication, 7 June 1994). Other notable land use features include; a 35 acre golf course located around the northern tip of Grand Canal, a wildlife refuge located on the southern tip of the peninsula, and the local high school located on Oyehut Creek. The remainder of the watershed (approximately 293 acres) is undeveloped and includes areas of dune, wetland, and forest. Currently, there are no industrial developments on the peninsula.

The almost flat peninsula is comprised primarily of sandy soils with areas of wetland and associated soils interspersed. The sandy soils form typical coastal dune ridges with sparse beach grass vegetation. The fine sand composing the dunes is deep and excessively drained, (i.e. they have very little water holding capacity). In terms of water quality problems; these soil characteristics indicate the soils would have little effectiveness as adsorption fields for septic effluents. Soils are either too wet as in the case of wetland soils, or in most cases, too sandy to allow treatment of effluents. As will be described later in this section, septic effluents and other pollution sources are suspected as being the major cause for water quality problems exhibited in the lake.

Lake Characteristics

Due to the presence of narrow restricting canals and different morphometric features, the waterways can be divided into five sections; Duck Lake, Grand Canal, Bass Canal, the Bell Canals, and Lake Minard (Figure 1). Duck Lake itself can be further divided into North- Mid- and South Duck Lake based on the narrow channels of water that separate these sections. In general, the waterways are long, narrow, and shallow and are connected by canals that are narrower yet. Table 1, summarizes the morphometric character of the waterways. These morphometric characteristics greatly influence the lake. First, the shallow, narrow nature of the system equates to a relatively small volume of water which means that pollutants entering the system are not diluted by large quantities of water. Second, the few small surface inflows in conjunction with the narrow channels means water is not mixed between portions of the lake, and that water is not quickly "flushed" through the system, but instead remains for a long period. Also, since the waterway system is almost entirely man-made, shoreline and banks are probably more susceptible to erosion and sloughing into the lake. And, last, the shallow nature of the waterways equates to a large quantity (or overall percentage of the waterways) of habitat available for aquatic plants.

Table 1. Physical Characteristics of the Duck Lake Waterways. (Revised from KCM, 1994).

	Length (feet)	Width (feet)	Area (acre)	Average Depth (ft)	Volume (acre-feet)
Duck Lake	Variable	Variable	252	9.2	2,555
Bass Canal	4,592	112	12	5.2	63
Grand Canal	22,960	184	98	8.9	863
Bell Canals	11,808	118	32	5.6	175
Lake Minard	7,216	341	56	16.4	920
TOTAL			450		4,576

Aquatic Plant Communities

During the Phase I study aquatic plants were mapped along 15 transects; 6 on Duck lake, 1 on Bass canal, 4 on Grand Canal, and 2 each on the Bell Canals and Lake Minard. The survey was conducted on August 5 and 6, 1993. This survey determined that "aquatic plants in Duck Lake and its canals occurred in patchy, mixed communities, that varied in overall species composition and density." The following plant community descriptions were summarized from Appendix B of the Phase I study (KCM,1994).

In Duck Lake proper, aquatic plants occupied the littoral zone to a depth of 2.7 meters (10 feet). In the southern or main portion of Duck Lake, the submersed aquatic plant community was comprised of mixed stands of Brazilian elodea (Egeria densa), a non-native species, a few species of pondweed (Potamogeton spp.), Common elodea (Elodea canadensis) and a type of macroscopic algae (Nitella spp.). Plant biomass was dominated by Brazilian elodea; and in the portion of the lake that contained this plant (the mid portion of the main body of Duck Lake) total plant biomass was higher, than in the southern portion where common elodea and nitella dominated the plant

community. Coontail (Ceratophyllum demersum), a rootless, floating species was also noted in one of the Duck Lake transects, and aquatic lilies (Nuphar sp.) occupied the near shore area in places. The Phase I study noted that emergents such as burreeds (Sparganium sp.), smartweed (Polygonum sp.) and Iris (Iris spp.) were present in dense stands around most of the lakeshore. Although not noted in the Phase I study, Cattails (Typha sp.) also occur along the shoreline. They are especially dense in the narrow channels that connect the different portions of Duck Lake and in the canal connecting Duck Lake to the Grand canal.

In North- and Mid-Duck Lake, where the water is generally deeper and more colored (tea colored) than in the main body of the lake, the submersed macrophyte community was described as sparse to very sparse and consisted of pondweeds, common elodea, and lilies. No Brazilian elodea was noted in this portion of Duck Lake.

Bass Canal had a sparse aquatic plant community. Although Brazilian elodea was apparently the only species found in the transect; isolated patches of pondweed, common elodea, and lilies were also observed. The sparse and unhealthy looking nature of the plants in this canal was attributed to the brownish, milky color of the water.

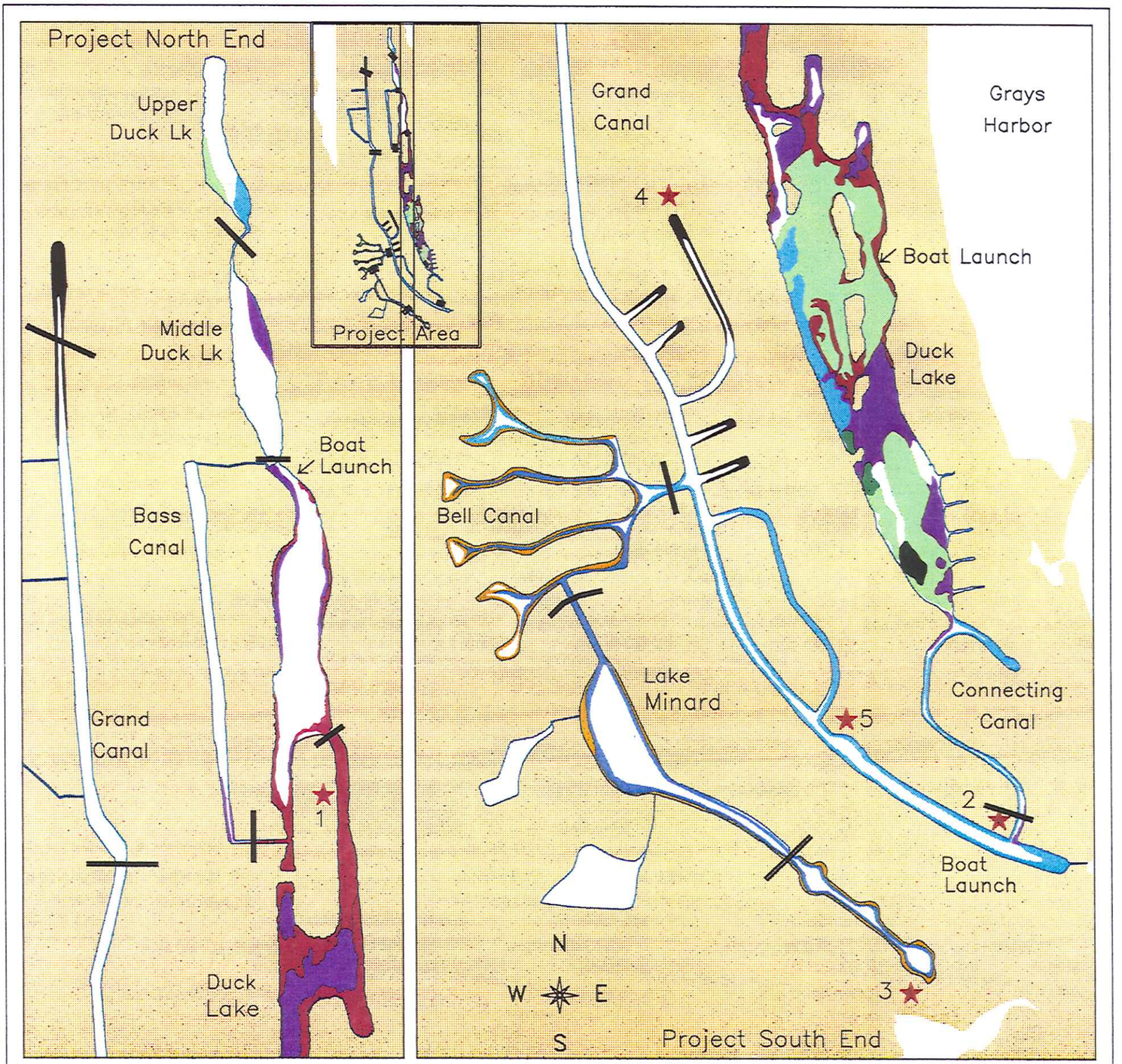
Plant species dominance and density changed between the upper and lower portions of Grand canal. In the upper portion of the canal, the native milfoil (Myriophyllum sibiricum) and coontail dominated the community, while in the mid to lower portion common elodea dominated. Measured plant densities were higher in the upper portion of the canal.

In the Bell Canals, where again the water is more tea-colored, the plant community was comprised of low to moderate densities of native milfoil, common elodea, and pondweeds. One notable exception was a dense growth of coontail in one of the embayments. It was noted that water clarity was visibly better in this embayment than elsewhere in the canal system.

The plant community in Lake Minard was at a low to moderate density and biomass that was dominated by common elodea. Native milfoil and pondweeds were also noted in transects. In Lake Minard, the lake bottom steepens sharply after about an 8 foot depth (2.4 meters), consequently plant growth is somewhat restricted to the littoral shelf.

Although aquatic plants are not yet dense throughout the system, they are dense in critical places and cause severe restrictions for navigation and access, as well as other limits to beneficial uses as will be described in the Problem Statement developed for the waterway. Furthermore the plant community can be expected to continue to invade new area and grow to increased densities. The results of the Phase I survey indicated that aquatic plants have essentially colonized the waterways to a depth of just under 3 meters, and that the current Maximum Colonization Depth (MDC), or the depth at which light becomes a limiting factor for growth, is 3.1 meters. This suggests that if water clarity improves (and light levels increase) plants will be able to inhabit a greater portion of the lake.

Additional aquatic plant mapping was performed as part of this project, to complete digitization of the shoreline and plant community begun during the Phase I study. On May 12, 1994, a digital map of the entire shoreline of the waterways was created in a geographic information system (GIS) file.



SCALE = 1:16,000 *Feet*

0 1000 2000 3000 4000 5000 6000 7000 8000

Figure 1.

Macrophytes, 5/31/94

Legend

- Myriophyllum spicatum (patchy)
- Egeria densa (dense)
- Elodea canadensis (dense)
- Elodea canadensis (sparse)
- Egeria & Elodea (variable density)
- Nitella sp. (dense)
- Nitella sp. (sparse)
- Potamogeton & Ceratophyllum spp.
- Bridge
- Potential Harvester Access Sites 1–5

On May 31, 1994, following digitization of the shoreline, underwater inspections were used to map the plant community and determine the dominant species present. This information was also mapped in digital form. Mapping results are displayed in Figure 1. Table 2, provides quantitative estimates of the plant community as calculated from the digitized information.

Table 2. Duck Lake Plant Community as of 1994 Diver Survey (Acres).

	N. Duck	Mid Duck	S. Duck	Bass Canal	Bell Canal	Lake Minard	Grand Canal	Total
Native milfoil					14.1	7.5		21.6
Brazilian elodea			53.8	0.3				54.2
Common elodea (dense)		0.2			7.1	11.2		18.5
Common elodea (sparse)	1.5		9.2		3.6		21.7	36.0
Mixed elodea (dense)		2.2	47.8	0.6			0.7	51.2
Macroalgae (dense)			3.9					3.9
Macroalgae (sparse)	1.7		59.9					61.6
Coontail							8.4	8.4
Total	3.2	2.4	174.6	0.9	24.7	18.7	30.8	255.4

Acreage shown for each community represents the entire mapped zone where these plants dominate. Within the milfoil, elodea-sparse, and Macroalgae-sparse zones, the plant distribution was patchy to sparse.

Note: Potamogeton (primarily narrow leafed varieties) was present in many shoreline areas, often with common elodea, but was only mapped where dominant over large areas (usually with Ceratophyllum).

Water Quality

The most significant water quality characteristics of the waterway were the extremely high nutrient (phosphorus and nitrogen) and iron concentrations measured in the lake. During the Phase I study, Total Phosphorus (TP) concentrations throughout the waterway ranged from 16 ug/L to 3,210 ug/L. TP concentrations measured in Duck Lake, though high, were within the "normal" range measured in surface waters, ranging from 16 to 155 ug/L, with mean summertime concentrations of 23-36 ug/L. At the extreme end of the scale, mean summertime TP concentrations measured in Bell canal were 1,949 ug/L, with an annual average of 1,958 ug/L. These are extremely high TP concentrations, not at all typical of surface water concentrations even in hypereutrophic (very nutrient rich) lakes. Grand Canal and Lake Minard also exhibited very high TP concentrations; concentrations were consistently greater than 500 ug/L. Soluble Reactive Phosphorus (SRP), the portion of the TP that is available for algae to use, accounted for greater than 70% of the TP in Grand Canal and Lake Minard, and 79% of the TP in Bell Canal. As stated in the Phase I study, "The high SRP concentrations measured in the waterways are not typically found in natural surface

waters and suggest that continual input of SRP was occurring to maintain the concentrations, such as from septic leachate."

Total iron concentrations in the waterways ranged from 83 ug/L to 37,800 ug/L. The highest concentrations were measured in Bass Canal and Duck Lake, where mean annual concentrations of 18,281 and 8,062 ug/L, respectively, were measured. This is the reverse of the trend measured for phosphorus in the different portions of the waterway. Similar to the phosphorus results, the iron concentrations are well above the normal range measured in surface waters. A typical range for surface waters is 50 to 200 ug/L (Wetzel, 1983). The extremely high iron concentrations were attributed to water flow through soil deposits with high iron content. (Near surface groundwater is the largest source of flow to the lake.)

Sources of water to the waterway include; surface inflows (streams and stormwater), precipitation, near-surface groundwater, and the deeper groundwater. A water budget was completed during the Phase I study to compare the magnitude of contribution from each of these sources. The study determined that the largest contributor or most significant source of water was the near-surface groundwater (39% of the total inflow), while surface inflow was estimated to contribute 27%, and precipitation and deep groundwater to contribute 18 and 17%, respectively. Outflow or loss of water from the lake occurs through the outlet (92%), as evaporation (4%), and through groundwater recharge (7%).

Water budget results and nutrient concentrations measured in each of the components were used to calculate phosphorus and nitrogen budgets for the lake. The near-surface groundwater system was estimated to contribute 61% and 46% of phosphorus and nitrogen to the lake, respectively. The next largest contributor was the deep groundwater system which contributed 16% and 35%, of phosphorus and nitrogen, respectively. Internal loading sources (14% and 7%), precipitation (6% and 9%) and the Duck Lake Inlet (3% and 3%) contributed the least amounts of phosphorus and nitrogen.

The water and nutrient budget information emphasize the importance of the near-surface groundwater to the ultimate quality of the lake water. The concentration of nutrients is very high in this source. (Concentrations ranged from an average of 460 ug/L to 770 ug/L during dry and wet weather, respectively in Duck Lake.) These high concentrations in combination with the fact that it contributes the largest share of water to the lake, indicates that lake water quality will not improve until nutrient sources to this supply (primarily septic leachate) are controlled.

Chlorophyll a measurements were also indicative of eutrophic conditions. The total range in concentrations measured throughout the waterway was from 1.1 to 87 ug/L. Peak concentrations in the range of 50-70 ug/L occurred in Lake Minard in May and June, a similar size peak occurred in North Grand in mid to late July, and the largest peak (87 ug/L) occurred in South Duck Lake in mid to late August. Phytoplankton abundance ranged from very low (3 cells/mL in Bass Canal in September) to extremely high (almost 500,000 cells/mL in Lake Minard in November). The highest numbers were measured in Lake Minard and Bell Canal and the peaks were primarily comprised of blue-green algae. With the exception of one or two sampling dates, blue-greens represented nearly 90% of the population in Lake Minard throughout the sampling period. In the Bell Canals they represented over 90% of the population from October through June. Blue-greens

were also the dominant phytoplankton on North Duck and the South Grand Canal Stations. The North Grand Canal station exhibited a fairly diverse community year-round. The Bass Canal station had a comparatively diverse community when compared to Lake Minard and Bell Canals, however, euglenoids rather than blue-greens dominated the population during much of the year.

Characteristic Use

In addition to the plant community and water quality descriptions, lake characterization would not be complete without a description of how the lake is used by area residents; people and wildlife. One of the first tasks for the steering committee was to develop a list of beneficial uses the lake provides and identify where those uses occur. This task was somewhat confused by the fact that the existing location of many of the beneficial uses identified, is a reflection of the current aquatic plant problem. That is, traditional use areas may have been different, or different use areas would develop if the plants were controlled. An important example is the area used for fish spawning. Spawning currently occurs most in the main body of Duck Lake, but spawning habitat (shoreline edges) exists throughout the waterway. Traditionally, the canals (Bass, Bell, and Grand) were the most important spawning areas (Jordan, P., personal communication, 17 May 1994). It is believed that poor water quality (low dissolved oxygen caused by dense plant canopies) is likely limiting spawning areas. Consequently, much of the waterway could become important fish habitat if plants were controlled. Table 3, contains a list of the beneficial uses identified by the steering committee and notations on the current use area.

Table 3. List of Beneficial Uses for the Duck Lake Waterways

Beneficial Use	Location
Swimming	Around homes (little park activity)
Non-motorized Boats	Grand Canal primarily & near private homes
Water-skiing	Duck Lake (South)
Fishing	South Duck Lake (Mid and North were previously popular fishing places)
Jet Skiing	Near Boat launches (Duck Lake)
Sailing	Near private homes
Waterfowl Habitat	Throughout the System
Birdwatching	Throughout the system
Power Boating	Duck Lake
Boat Parade	Duck Lake and Grand Canal
Irrigation	Golf Course (Grand Canal) and Limited Use throughout waterway by private homeowners
Fish Habitat	Shoreline area throughout the system

The results of a 1993 survey by Ocean Shores Fresh Waterways Inc. provided further evidence on how local residents use the lake and the importance they place on maintaining the quality of the waterways. Boating (77% of respondents), fishing (68%), and Birdwatching (65%) were the top three identified uses, followed by swimming (30%), picnics (26%), water-skiing (16%), jetskiing

(13%) and windsurfing (6%). When asked what type of restoration activities they would support, 86% supported pollution control, 70% supported canal restoration, and 66% erosion control. (Only 9% of those surveyed did not think the waterways should be restored.)

PROBLEM STATEMENT FOR DUCK LAKE

One of the first steps necessary to development of an aquatic plant control plan is to clearly describe existing problems that can be attributed to the plant population. To aid with development of a problem statement for Duck Lake, the steering committee began by creating a list of the problems experienced in the lake. After the list was developed the degree of impact or importance was noted (high, moderate, or low) for each portion of the waterway. The results of this task are shown in the matrix below.

Table 4. Problem List for the Duck Lake Waterways

	Duck Lake	Grand Canal	Bell Canals	L. Minard	Bass Canal
Boating	H	H	H	H	H
Boat Parade	Y	Y			
Fishing	M+	H	H	M-	H
Swimming	M	H	H	M	H
Aesthetics	H	H	H	H	H
Water Qual	M	H	H	M	H
Property Values	M	M	M	M	H+
Water Depth Loss	M	H+	H+	M	H+
Non-Native Vegetation	Y				Y

H (High Impact), M (Moderate Impact), L (Low Impact)

"Y" for yes is used to note where a problem occurs when it is not appropriate to assign a magnitude to the impact.

The matrix information and discussions with the steering committee were used to develop the following problem statement:

> *Aquatic plants, including the non-native species Egeria densa, in the Duck Lake Waterways have increased to the extent that boat access to all finger canals and interconnecting canals between the different waterbodies is restricted, and lakefront property owners are having increased difficulty accessing the open water area, due to the dense plant growth along the shoreline. The plant beds and associated localized increases in sedimentation, are causing water depth to decrease and therefore also contributing to access and navigation problems. Available area for recreational activities such as fishing, swimming, jetskiing, sailing, canoeing, and rowing has been greatly decreased due to the problems associated with navigating through the plants. These activities are for the most part limited to Mid- and South Duck Lake and part of Grand Canal; the remainder of the waterway has been almost eliminated as a recreational resource. Participation in holiday boat parades has decreased from 25 to 5 boats due to weed infestations and boat owner concerns about becoming stranded or*

burning out boat engines in the dense weed beds. The Duck Lake waterway has traditionally been an excellent bass and panfish fishery, and has been the site of many semi-professional bass tournaments. The number of tournaments and participation has greatly decreased over the past several years due to poor fishing quality. Property values along the canalways are being affected; Bass Canal residents are seeking lower tax rates due to the especially poor quality of this portion of the waterway.

AQUATIC PLANT MANAGEMENT GOALS

Before a plan could be developed for controlling aquatic plants in the waterway, program goals were needed to provide a method of determining success. The list of beneficial uses and problem statement for the Duck Lake Waterways was used to develop a list of goals for managing the lake plant problem. This list was developed with the aid of the steering committee. (These goals were used to develop the criteria against which the success of the program will be evaluated. The evaluation plan is described later in this document.) After the goals were listed, committee members were asked to select their top three goals. This resulted in a ranking of the three top priorities for plant control. In the list provided below, the first three listed are in order of rank, the remainder were not prioritized.

Goals Selected

#1 Control 70% of submerged vegetation ("softweeds"). Retain 30% for fish and wildlife habitat

#2 Improve fish habitat and fishability of the lake

#3 Create and maintain boat lanes

Unranked Goals

- Retain lilies. Reduce reeds and cattails to within 5-10' of shoreline in narrow channels where access becomes a problem.
- Do not increase the incidence or magnitude of erosion (e.g. through cattail removal).
- Improve water quality (It is acknowledged that although improvements in water quality are an important goal for the overall management plan for the waterways, plant control should only result in indirect improvements to water quality primarily as an improvement in dissolved oxygen concentrations in and near existing plant beds.)

AQUATIC PLANT CONTROL PLAN

The initial discussion and review of available plant control options occurred during the Phase I study. As a consequence, the main elements of the control plan were selected previous to the development of this plan, allowing this plan to focus on implementation of the selected alternatives.

The aquatic plant control plan for the Duck Lake Waterways consists of four parts; mechanical harvesting of aquatic plants to provide short-term relief to lake residents and allow access to all portions of the lake, stocking grass carp as a long-term measure to control the aquatic plants, manual control activities, and an exotic weed prevention program. Each of these programs is described separately below.

Mechanical Plant Removal

The following is a summary of the harvesting plan produced for the Duck Lake Waterways. The complete plan is included as Appendix B to this report.

The purpose of the aquatic plant harvesting effort is to permit recreational use of the waterway, until the proposed grass carp control program becomes fully effective. Therefore, proposed harvesting areas were selected and prioritized based on; 1) allowing access to all portions of the lake and canal system, and 2) those areas that receive the most boating use.

Harvesting recommendations were made with the aid of the steering committee. The harvesting area includes 17 acres on the main body of Duck Lake and 16 acres in the canal system. The harvest area in Duck Lake is in the vicinity of the peninsula at Overlake Street NE and along the western shoreline south of the peninsula, as shown in Figure 2. Harvesting in the canals will occur as a 20 foot wide cut down the center of; all of Grand Canal south of Ocean Lake Way including the lateral canals, the Bell Canals, and the canals at either end of Lake Minard. (The 20 foot wide swath will allow boat traffic to pass in both directions.) No harvesting will occur in the main body of Lake Minard, Mid or North Duck Lake, or Bass Canal. With the exception of the Grand Canal north of the last lateral canal, all harvest areas will be cut twice during the summer growing period; July and August. The north end of the Grand Canal (4 acres) was selected for only one cut due to the lower use of this portion of the waterway. A map depicting harvest areas is included as Figure 2. It is estimated that harvesting will take from 40 to 60 calendar days. (This is based on harvesting 29 acres twice during the season, plus an additional 4 acres that will be harvested once, for a total annual harvest of 62 acres.)

Two options were considered for implementing the harvesting plan; 1) using a contract service, or 2) purchasing the equipment and hiring personnel to do the harvesting. Companies that provide weed harvesting services have provided cost estimates ranging from $500 to $870 per acre. This would result in a total annual cost of $31,000 to $53,940 for the 62 acres. This cost would include harvesting, offloading cut plants at the shoreline, and transporting plants to the City compost facility at the sewage treatment plant.

Also, they are a more "natural" alternative than addition of pesticides or other chemical additive. 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 affects on fish communities. (Indirect affects are more difficult to ascertain and more varied.) 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.

There are also a few advantages specific to the Duck Lake Waterways. The most important advantage is that Eurasian Watermilfoil has not been found in the lake. This non-native, highly invasive species is low on the species preference list for what Grass carp will consume. Therefore, it is possible that by stocking grass carp in a lake with Eurasian watermilfoil, as they eliminate other plant species they will provide the means for milfoil to invade a greater portion of the lake. The main species of concern in the Duck Lake Waterways is Brazilian elodea (also a non-native), a species that is listed as a preferred species for Grass carp (WDFW,1990). The second most important plant species in terms of biomass are the pondweeds; these are primarily the narrow-leafed varieties that are also a preferred species. (It should be noted that information on preferred species is variable. The preferred species list used by WDFW was developed through research done by the University of Washington. However, local projects (e.g. Devils Lake, Oregon) have shown contradictory results.) A last advantage is that although only sterile Grass carp are allowed to be used in Washington State, there continues to be a concern about the potential for the carp to invade other water bodies and cause unplanned environmental damage. The Duck Lake Waterways represent very little potential for impact to other systems. The outlet discharges to the ocean where the fish are not likely to survive, and the inflowing streams do not lead to upstream waterbodies. (Screening of inlets and outlets will still be required to both protect the inlets and to ensure carp are retained within the Waterways for maximum effectiveness.)

Some of the potential problems associated with the introduction of Grass carp to the Waterways 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) the plant habitat (shallow water over enriched sediments) would still remain leaving an for milfoil (or another invasive species) to take over, 3) Loss of the plant community may cause increased algae growth, 4) Uneven distribution of affects (either based on plant palatability or habitat) may alter plant community diversity, resulting in a community consisting primarily of one or two nuisance species. (This last disadvantage is 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.)

Given the importance of selecting an appropriate stocking rate for the lake, a review of similar projects is warranted to aid in making a stocking rate recommendation for the Duck Lake Waterways. Results from two lakes in the region (Pacific Northwest, west side of Cascade range) that have been planted with grass carp are summarized in the following paragraphs.

Devils Lake, an Oregon coastal lake, was first stocked with grass carp in 1986-87. At that time the 680 acre lake had approximately 375 acres of plants primarily comprised of Eurasian Watermilfoil and Coontail (42%) and Brazilian elodea (33%) (D. Wagner. Devils Lake Water Quality Improvement District, personal communication, 24 May 1994 and 21 July 1994). The fish were stocked at a rate of about 72 per vegetated acre (7 per metric ton); 27090 fish were planted. (The stocking rate selected was the most conservative of three rates proposed by University of Washington researchers.) Within the first year the plant community changed and became almost entirely dominated by Brazilian elodea (71%) and coontail, also the biomass increased (probably as a result of specific plant characteristics). However, the overall trend was decreasing plant growth and better lake conditions. (The plants apparently did not reach the surface and recreational access was greatly improved.) In mid-July of 1993, 5000 additional carp were stocked to replace those lost through mortality. By mid-August when a plant survey was completed, the plant community was greatly decreased; remaining plants were apparently maintained at a short height above the sediment surface. Currently, (spring 1994) there are almost no plants remaining in the lake (D. Wagner. personal communication, 6 June 1994). It is unknown to what extent the loss of the plants can be attributed to the carp and what was caused by the colder, wetter summer of 1993 being less conducive to plant growth. Although data have yet to be evaluated, it appears that the warmwater fishery has suffered. A spring 1994 survey showed no perch (previously these over-populated the lake), no crappies, no bass recruits, and few bluegills (Wagner, D. personal communication, 6 June 1994).

Silver Lake, located in Cowlitz County Washington was stocked with grass carp in early summer of 1992. There were approximately 1630 vegetated acres in Silver Lake; 83000 fish were stocked resulting in a rate of 50 fish per vegetated acre. By 1993 it was estimated there was a 50% reduction in plants (P. Keough, personal communication, 6 June 1994). Again, it is unknown to what extent the decrease can be attributed to the cold, wet conditions the occurred during the summer of 1993. It is too early in the case of the Silver Lake project to predict what the ultimate effectiveness of the effort will be, but at this point it seems as though overstocking may have occurred. At the very least, the two existing projects suggest that stocking rates should be based on the years of lowest plant biomass to allow for climactic affects.

These two examples and many others indicate that it is difficult to predict the affects of a given stocking rate. Grass carp stocking rates in Washington State are based on a model developed by the University of Washington. The model was based on results from stocking experiments performed in lakes and ponds on both the East and West side of Washington State. Their research also included an evaluation of stocking results from all over the United States and Europe. The WDFW has used the University's model to develop stocking rates that are appropriate for different regions. The model can provide a stocking rate based either on the number of acres of vegetation, or the number of tons of vegetation present.

Stocking rates for Duck Lake were first calculated based on the number of acres of submersed vegetation. The recommended rate to attain plant "control" is dependent upon the number of acres of submerged vegetation and whether the existing plants are "preferred" or "less preferred" by the carp. As shown in Table 5, the majority of the Waterway is composed of plants that are "preferred" by Grass carp. (In some cases, notably part of Grand Canal and Bell Canal, there were transects in which non-preferred species dominated. However, visual accounts of these parts of the

waterway indicate that preferred species are typically dominant and that stocking rates should be based on preferred species abundance.) Assuming the stocking rate for Ocean Shores is the one that applies to Aberdeen and Hoquiam, the rate recommended by the model would be 100-120 fish per vegetated acre. A total of from approximately 26,000 - 31,000 fish were recommended based on this model.

Table 5. Plant Community Composition for each portion of the Duck Lake Waterway.

Lake	# Transects	# Acres of Submerged Plants**	% Preferred Plants	% Less Preferred
N. Duck	1	3.2	88 %	12 %
Mid Duck	1	2.4	100 %	
S. Duck	4	174.6	100 %	
Grand Canal	4	30.8	4*-100 %	0-96 %
Bass Canal	1	0.9	100 %	
Bell Canal	2	24.7	0-98 %	1-100 %
Lk Minard	2	18.7	68-100 %	0-32 %
Total		255.3		

* Two of the four transects had a large population of either native milfoil or coontail.

**The species distribution or % preferred species information was based on the aquatic plant transects performed during the 1993 Phase I study (KCM, 1994). The information on acres of submerged plants was based on the 1994 survey information (RMI, 1994).

Since plant biomass levels in Duck Lake were not measured or observed at the densities experienced in other lakes, there would appear to be a high potential for overstocking if total acres of vegetation are used as the basis for stocking. Consequently, a stocking estimate based on the number of tons of vegetation was also calculated. For the Duck Lake region, the recommended stocking rate is 9.8-10.2 fish per metric ton of vegetation. If the maximum plant density estimate measured in the 1993 study (KCM, 1994) is assumed for the entirety of the vegetated acres (530 g/m2, dry wt.), and assuming dry weight is approximately 10% of the wet weight of the plant biomass, then using the 255.4 acres measured in 1994 (RMI, 1994), a total of 548 metric tons of plants are contained in the lake. This results in a stocking estimate of 5,369 to 5,588 fish, or 21 to 22 fish per vegetated acre.

The difference between the two estimates provided by the model is quite large. According to one of the model authors (S. Bonar. personal communication 6 June 1994), the model is much less appropriate for regions such as the one Duck Lake is located in, that are at the extreme end of the predictive scale. It was suggested that for these areas, estimates based on the metric ton of vegetation would be more reliable. It was also suggested that the rate used for Devils Lake may be most appropriate, since this rate was calculated based on grass carp studies from lakes in Europe and elsewhere with similar climates. Using the Devil's Lake rate of 7 fish per metric ton of vegetation would result in a total of 3,836 fish being stocked in Duck Lake. Since evidence now suggests that Devil's Lake was overstocked, and since original plant density in that lake was higher than Duck Lake, an even lower rate would seem appropriate. Table 6, provides a comparison of

stocking rates for the two existing projects and different calculated estimates for the Duck Lake waterways.

Table 6. Grass Carp Stocking Rate Comparisons.

Lake	# Stocked	# per Vegetated Acre	Year Stocked	Summary/ Comments
Silver Lake	83,000	50	1992	50% reduction (est.) in first year
Devils Lake	27090	72 (7 per metric ton)	1986	1st 5 years satisfactory control; improved recreation etc. Year 6 few plants, Year 7 none seen w/lower fish pops.
Duck Lake	26,-31,000	110-120		Based on the States model and vegetated acres
	5,369-5,588	22		Based on the States model and metric tons of vegetation
	18,389	72		Based on Devils Lake rate for #/acre
	3836	15		Based on Devils Lake rate for #/ metric ton

Another confounding factor in the Duck Lake plan is that grass carp stocking will occur in conjunction with harvesting to provide more immediate relief to property owners for the first few years of the project. The harvesting program may accelerate the time required for grass carp to control the vegetation, since large amounts of biomass will be removed through harvesting and the new shoots may be more palatable to the young carp. After reviewing information on the variation in success of grass carp stocking programs, and in recognition of the vital importance of the submerged plants for maintaining the quality of the fishery and waterfowl populations, the steering committee agreed that a conservative approach was best. During production of the draft plan a stocking rate of 37 fish per vegetated acre or 9500 fish will originally agreed upon and recommended. However, that recommendation was formulated by comparisons of stocking rates based on the total number of vegetated acres. Subsequent information that allowed comparison between stocking rates based on biomass raised concerns about the potential for overstocking. Based on the new information a total of 3800 (using the #/metric ton rate utilized for Devils Lake) to 5,500 (using the State model) fish should be stocked in Duck Lake. (Note: WDFW will make the final determination on stocking rates and numbers after a permit for stocking has been filed and approved.) The rates calculated here are submitted for guidance.

A thorough evaluation program was also recommended to allow early assessments of the impact of the stocking program. Evaluations are recommended to occur at two year intervals for the first six years of the project. The evaluation after the first two years will primarily focus on signs of over-stocking, since it would be far too soon at that point to assess whether there are too few fish in the lake. (If the appropriate stocking rate is used, control ought to occur gradually over the first six years of the program. Since the rate of control may be on an exponential scale based on the

increasing size of the fish, this suggests that during the first few years, control will be only moderate.)

For maximum affect the first year, Grass carp should be planted in early spring just as the plants are beginning to grow. To obtain better dispersal of the fish and to reach the distribution numbers recommended, they should be offloaded in a number of places in the system. There are five recommended offloading sites; two on Duck Lake (from the bridge that separates Mid- from North Duck Lake and at the junction of Duck Lake canal and the Grand Canal), one near the middle of the Grand Canal (@ Oceanlake Way) and at the bridge over the Bell Canals (Pt. Brown Avenue) and the Tonquin Avenue bridge on Lake Minard. The carp are anesthetized just previous to stocking to decrease mortality from handling shock. However, the longer they remain in the water that contains the anesthetic the larger the mortality from anesthetizing. Therefore, although it might be advantageous to stock at additional places (e.g. the extreme ends of the Bell Canals) the above plan represents a tradeoff between causing increased fish mortality and obtaining maximum dispersal.

Table 7, depicts the number of fish that should be stocked at each of the identified offload sites. The numbers are based on stocking a total of 5500 grass carp and the percent of the vegetated acreage found in different sections of the waterway.

Table 7. Recommended grass carp stocking number for each of the identified offload sites (based on a total stocking number of 5500).

Lake	# Vegetated Acres	% of Veg. Acres	# Fish Stocked
Mid &North Duck&Bass Canal	6.5	3	165
South Duck L.	174.6	68	3740
Grand Canal	30.8	12	660
Bell Canals	24.7	9.7	533
Lake Minard	18.7	7.3	402
Total	255.3	100	5500

Screening of the inlets and outlets is necessary before the carp are stocked, both to ensure the fish do not reach untargeted water bodies and to keep them in the lake where they can efficiently reduce vegetation levels. In the case of the Duck Lake waterways, two of the three inflowing streams do not lead to upstream water sources; water enters as a seep or spring. These do not require screening. The third, Oyehut Creek, can be screened at an upstream culvert located where the creek passes beneath Damon Road. (Eventually the lower portion of Oyehut Creek will be developed into a biofiltration wetland, at that time a screen may be needed to keep the fish from entering the wetland. This will be addressed in the wetland design plans.) A simple, horizontal grid that lies over the entire top of the U-shaped outlet weir should retain the carp while also eliminating concern associated with young ducklings getting stranded on the wrong side of the weir. The WDFW recommends screens for grass carp control be no greater that 1-1/4" mesh. Cost for building and

installing screens has been estimated at $15,000 for the outlet screen, and $1,500 for Oyehut Creek. There will also be an additional yearly O&M cost of $3,600 associated with screening (J. Gow, personal communication, 15 June 1994).

The base cost for Grass carp is approximately $3.50 per 8-11" fish to $4.00 per 10-14" fish (Freeze, M., personal communication, 2 May 1994). (These costs may be reduced by using a bidding process if more than 5000 fish are required.) Assuming a maximum of 5500 fish (@t $4.00 each with 8% sales tax), the cost would be approximately $23,760.00 for the fish. A delivery charge may also be collected depending upon the number of fish required and whether a bid process is followed. For the purpose of this plan a cost of $24,000 is estimated for the fish and shipping costs.

An additional cost associated with the grass carp stocking program is the cost to replace carp lost to natural mortality. It has been assumed for the purpose of this project, that carp would be replaced once during every 5 year cycle and that approximately 1/3 of the fish would be replaced, or in this case approximately 1000 fish. Clearly, this estimate will need to be refined at the time of stock replacement and will be greatly affected by lake conditions that exist at that time. The additional cost at year 5 is estimated at $4,500.00.

To stock grass carp in Duck Lake a number of permits and documents are required. A fish planting permit must be approved by the WDFW. This permit must include a State Environmental Policy Act (SEPA) environmental checklist. An Hydraulic Project Approval permit may also be required for screening of the inflow and outflow. There is a $24.00 application fee associated with these permits, and a six to eight week processing time.

Manual Control Activities

As described in the Phase I study (KCM, 1994) there are additional control activities recommended for use by lake residents. These include hand-pulling or raking of plants near shoreline and dock areas, and placement of bottom barriers. It is recommended that the residents concentrate on emergent vegetation (cattails and reeds) in the next few years, since the grass carp should eventually control the submergent vegetation. In order to reduce the potential for increased shoreline erosion from resident manual removal activities, the importance of maintaining a 10-15 foot vegetation border should be stressed through the public education program. There are no public costs associated with these activities.

Exotic Weed Prevention

An important concern associated with many of the aquatic plant control techniques, including grass carp stocking, is that only the plants have been removed, not the habitat. This is similar to preparing a plant bed in a garden but not bothering to plant anything in it. Chances are it will be dandelions and not roses that take over the new ground. The same is true for aquatic plants. There are certain plants, including native species, that by their nature are invasive and quickly colonize disturbed or newly exposed habitat. The grass carp should control these plants to some extent (depending upon the plant), but it will continue to be important that new colonies of these plants are identified as early as possible and removed from the system.

The primary plant species of concern are; Eurasian Watermilfoil (Myriophyllum spicatum), Parrotfeather (Myriophyllum aquaticum), Hydrilla (Hydrilla verticillata), Fanwort (Cabomba caroliniana), and Water Hyacinth (Eichhornia crassipes) and Brazilian Elodea (Elodea densa). The last of these already exists in the waterway and the main concern is ensuring that it is not transported to other waterways. Eurasian Watermilfoil, Parrotfeather, and to a limited extent Fanwort, already occur in waters in Washington State and therefore the potential for invasion is very high.

"Hydrilla is probably the most troublesome submersed aquatic plant in North America." This is because of its ability to grow in many different habitats (flowing and non-flowing systems, low to high light levels, and from one inch to 50 feet of water) (Gibbons, M. et al., 1994). Although the plant has yet to be discovered in Washington State waters, it appears to be migrating in this direction. Early detection is critical if this plant is to be controlled.

A prevention program is needed for all lakes, but may be especially critical for those where new habitat is being exposed, as previously described. The exotic plant prevention program for Duck Lake consists of two parts; a citizen education and "patrol" program to aid in early detection of troublesome species, and a program to ensure the existing exotic is not inadvertently transported to other lakes.

Citizen education requires a yearly mailing to all residents in Ocean Shores that includes a description of the program and its importance and a description and sketch of each of the plants of concern. (This information is currently provided in the "Citizen's Manual for Developing Integrated Aquatic Vegetation Management Plans" (Water Environmental Services, 1994), so there would be no cost for development of the materials.) The local Fresh Waterways Corporation may be the best organization for taking the lead on this and ensuring the yearly mailings and reminders are sent.

At least 10 local residents should be trained in aquatic plant identification and assigned specific sections of the waterways to patrol. Patrols of the waterways should be made at least three times during the summer; when plants first begin to grow, during mid-summer, and late in the growing season. Patrol would entail slowly moving along the edge of the plant bed and making periodic (every 500 feet) transects from the plant bed edge to the shoreline area looking for the plants. A rake or anchor could be used for pulling up questionable plants if identification is difficult. A viewing scope can be used to help patrollers "see into" the water better. (Appendix C provides an example of how to make a scope out of common household materials.) The Aquatic Plant Program at the Department of Ecology will provide expert identification of questionable plants, if necessary.

A public campaign to prevent movement of invasive plants between this waterway and others should include posting signs at all boat ramps describing the invasive species prevention program and the need to thoroughly wash all boat and trailer parts before transporting between water bodies. (If a pump and hose were provided at each boat ramp, it would facilitate this effort.) Again, a mailing to all residents describing the need to be careful and concerns about introducing Brazilian elodea to other lakes as well as the need to prevent introduction of additional species to Duck Lake should also be sent out yearly to all residents.

The cost for the prevention program includes costs for two mailings each year to residents, providing signage at the boat ramps, and a plant identification training workshop. Total cost is estimated at $7,100.00. (Note: Currently, plant identification workshops are offered for free to members of the Washington Lake Protection Association (WALPA). If these workshops continue to be offered, the workshop cost in this plan could be eliminated.)

PUBLIC EDUCATION PROGRAM

A public education program for the Duck Lake Waterways has been described in the Phase I study (KCM, 1994). The program is primarily aimed at controlling sources of pollution to the system and includes recommendations for landscaping, household, and construction practices as well as other elements. There are also public education elements associated more directly to the aquatic plant control program. The exotic weed prevention program is one of those elements. A brochure describing erosional concerns associated with removal of cattails and reeds should also be developed and circulated.

Probably the most important public education element associated with this plan is the initial presentation of the plan to residents, followed by annual reviews for the first four years to update residents on the plan effectiveness, and provide them with an opportunity to voice their comments and concerns. Since a conservative stocking rate has purposely been selected and the carp may take a number of years to control the plants, there is a high potential for residents to be dissatisfied with the program in the early stages. Public forums and discussions will help by educating and preparing residents and gaining their support from the start. These public meeting could best be run through the local Fresh Waterways Corporation, a group that already has the support of many residents. If this is the case, there would be no additional cost associated with this portion of the public education program.

EVALUATION PLAN

The results of the aquatic plant control program must be evaluated against the goals set for the lake. In short, the program will have been a success if; 70% of the submerged vegetation is removed and 30% remains, fish habitat and fishability improve, boat lanes are maintained, lily beds are retained and cattails are reduced, plants do not deter navigation into the different portions of the waterway, and water quality is improved. The following is a description of each of the monitoring or evaluation techniques that are recommended to track program success.

Goal #1: 70% removal of submerged plants/ 30% retained

Aquatic plant mapping similar to what was done during the 1994 study should be performed once a year for the first four years after carp stocking, and then every two years unless plant community changes indicate rapid or detrimental change is occurring. To deter costs, Duck Lake and the Grand Canal should be the focus of these surveys. These surveys will allow comparison of changes in the extent of the plant bed, substantial changes in the community composition, and direct calculation of the number of acres of plants remaining. Transects and density estimates, following the method used in the 1993 study, should be performed on the second, fourth, and sixth years to provide density comparisons. These too should be limited to Duck Lake and the Grand Canal to optimize program costs.

A detailed evaluation report should be scheduled for the spring of the second year that carp inhabit the lake. The primary purpose of this first report should be to address whether over-stocking may have occurred, and to make recommendations for removal if necessary. (Fisheries information described under Goal #2 should be used to provide additional evidence of possible negative or positive impacts on the fish populations.)

It is extremely difficult to predict what amount of change would constitute the type of gradual plant control that would indicate that a proper stocking rate was selected. Some guidelines are suggested for evaluation here, they are based on an assumption of what would constitute a gradual decrease and that peak grass carp biomass would occur near year six. Roughly, by the end of the second season of stocking, plants should have decreased by 20% to no more than 35%. By the spring of the fourth year, at least a 60% reduction in plant biomass should be measured, but no more than 70% should have been removed. If this is not the case, committee members should review the stocking density selected and stock additional fish or develop a program for removal if necessary.

Cost:	Aquatic Plant Mapping	$2000.00/yr (each year for 6 years)
	Plant Density Estimates	$1650.00/yr (years 2,4, &6)

Goal #2: Improve fish habitat and fishability

Improvements in fish habitat should be measured both directly and indirectly. Direct changes should be measured as changes in; plant community distribution (healthy lily beds and decreased

quantities of submerged plants) and water quality indicators (adequate dissolved oxygen). These would be assessed through other portions of the evaluation plan. Age class distributions and abundance of different fish species should be monitored as indirect indicators of changes in fish habitat and fishery quality. Bi-annual electroshocking surveys of fish populations should be used to provide this information. (As the plant populations decrease, the quantity of prey species and young-of-the-year Bass should be the focus of these studies.) Also annual creel surveys (done by volunteers) should be utilized to estimate fishing success and fishermen's satisfaction with lake conditions.

Although not directly related to project goals, the weight and condition of the stocked grass carp should be estimated each year to allow rough estimates of the biomass of carp present each year. This will allow eventual comparison to plant biomass decreases to aid in early evaluation of over stocking.

Cost: Electroshocking Survey and report $2000.00 (@ 2,4, and 6 years)
Creel Surveys (Volunteers) $0.00 (annual survey)

Goal #3: Create and maintain boat lanes

For the first few years of the program, mechanical harvesting will be relied upon to maintain the boat lanes. Success in this case will be dependent upon whether the harvesting frequency selected and extent of coverage is sufficient to meet users desires. An annual survey of residents and users is recommended to track peoples concerns about this and other aspects of the project.

Cost: Volunteer collected information $0.00

Unranked Goal: Retain lilies/Reduce Cattails and Reeds to within 10-15 feet of the shoreline in narrow channels important for navigation and access.

This should be evaluated as part of the plant community evaluations, described under goal #1. (The annual residents survey described under Goal #3 should include a question about whether erosion or other problems have occurred as a result of any of the control activities, since increased erosion was identified as one of the concerns associated with removal of the cattail/reed beds.)

Cost: No additional costs

Unranked Goal: Improve water quality

In terms of aquatic plant control water quality changes may occur in dissolved oxygen concentrations and phytoplankton populations. A continuing water quality monitoring effort should be instituted for Duck Lake to monitor the impacts of the many changes that will be occurring in the lake and watershed as a result of implementation of this and other plans. The costs for the water quality monitoring is more appropriately associated with implementation of the sewering plans. However, it is recommended that volunteers collect chlorophyll samples in Duck Lake and the Grand Canal in the intervening years until a more comprehensive monitoring plan

exists. This will allow some assessment of whether changes in the plant community are affecting algal populations. Samples should be collected twice a month from May through September (10 times) from the station in South Duck Lake and South Grand Canal.

Cost: Analytical Expense $500.00/yr

Evaluation Report

It is too often the case that projects such as these are implemented, but no succinct evaluation is ever made. A year end evaluation report should be prepared that summarizes the results of each of the surveys (volunteers and others) and assesses the success of the program against project goals for each year. Without this step, the information will remain in separate pieces and it will become increasingly difficult through time to discern the ultimate success of the program and therefore to make decisions to about future needs.

Cost: $1500.00

The total cost to evaluate the success of the aquatic plant control program is estimated to be $32,450.00 over a 6 year period, which represents 12 percent of the total cost for implementation of this plan over the same timeframe. Unfortunately, there is a strong tendency to minimize evaluation programs for projects such as these, because the evaluation itself does not result in any "real" change being made. However, the need for adequate evaluation can not be over-emphasized. Poor evaluation will result in uncertainty about the success of the program, and therefore increased difficulties if trying to win support for future efforts. In the case of using grass carp, a new, relatively untried plant control technique, evaluation is critical to determining future stocking rates.

PLAN ELEMENTS, COSTS, AND FUNDING

Table 8, provides a summary of each element identified in this plan and the associated costs. Total cost for the plan over a six year period is estimated at $262,350, for an average of about $44,000 per year. The majority of the cost occurs during the first year when both grass carp are stocked and harvesting occurs. The estimated cost assumes that harvesting will only be required for the first three years. (It is also possible that harvesting will only be necessary for the first year or two, depending upon the effectiveness of the carp stocking program in the first few years.)

Currently, funding for lake restoration activities has been obtained through grants and by a line item in the City of Ocean Shores budget. The City and the Freshwaterways Corporation recognize that long-term funding will be necessary to implement this plan and other recommendations made during the Phase I study. The mayor has appointed an ad hoc committee to research all funding sources, to choose the most cost-effective method of implementing recommended measures. The funding sources that will be addressed include; creation of an LID, GO bonds, revenue bonds, Department of Community Development, Public Works Trust Fund, FHA, the City general fund, and environmental grant making foundations.

Table 8. Estimated Costs for Implementation of the Duck Lake Aquatic Plant Control Plan.

Element	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	6 Year Total
Mechanical Control (Contract Service)							
Harvesting	$42,500	$42,500	$42,500				$127,500.00
Cattail Removal	$10,000						$10,000.00
Access Site Prep.	$15,600						$15,600.00
Grass Carp Stocking							
Initial Stocking	$24,000						$24,000.00
Screening	$16,500	$3,600	$3,600	$3,600	$3,600	$3,600	$34,500
Replacement					$4500		$4500.00
Public Involvement and Education							
Invasive Plant Workshop	$600.00		$600.00		$600.00		$1800.00
Mailings/Postage	$3000.00		$3000.00		$3000.00		$9000.00
Volunteer Plant Surveys	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Signage	$500.00						$500.00
Public Meetings	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Evaluation Program							
Aquatic Plant Mapping	$2000.00	$2000.00	$2000.00	$2000.00	$2000.00	$2000.00	$12,000.00
Plant Density Estimates		$1,650.00		$1,650.00		$1,650.00	$4,950.00
Fishery Surveys		$2,000.00		$2,000.00		$2,000.00	$6000.00
Annual Creek Survey	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Annual Residents Survey	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Analytical (Chlorophyll a)	$500.00	$500.00	$500.00	$500.00	$500.00	$500.00	$3000.00
Evaluation Report	$1,500.00	$1,500.00	$1,500.00	$1,500.00	$1,500.00	$1,500.00	$9000.00
Total	$130,700	$50,150	$50,100	$7,650	$10,600	$7,650	$262,350

SUMMARY AND CONCLUSIONS

Although the density and total acreage of the aquatic plant community in the Duck Lake Waterways is not yet at the levels measured in other heavily infested lakes, recreational use and probably fish habitat have already been adversely affected. Given the overall shallow nature of the waterways, the potential for invasion of more area at greater densities is very high. This report details a plan for controlling the plants. The plan includes a short-term control strategy to bring immediate relief to residents (mechanical harvesting) and a strategy that should bring long-term control (grass carp stocking). The plan also includes an exotic weed prevention program and a plan for evaluating the success of these efforts.

It is always difficult to predict how a lake will ultimately respond to different management and restoration efforts. In the Duck Lake Waterways this may especially be the case, simply due to the magnitude of change that can be expected from eventual sewering in combination with aquatic plant control. Although overall an improvement is expected in lake conditions, there will still be plenty of nutrients available for algae growth and nutrient dynamics can be expected to change dramatically. There will also be changes in the biological populations that will impact the eventual character of the lake.

Clearly some steps are necessary to restore the Duck Lake Waterways. And, those recommended in the Phase I study and detailed further in this report appear to be the appropriate steps. However, by taking these steps gross manipulations are being made to a system that is only partially understood. Therefore, it is not possible to entirely predict the changes that will occur. The lake at this point will become a managed system; it will require continued monitoring and evaluation and will likely require additional "tweaking" in the future to adjust new lake conditions.

REFERENCES

Bonar, Scott. 6 June 1994. Personal Communication (telephone communication with Joy P. Michaud, Envirovision, Olympia, WA) Washington State Department of Fish and Wildlife, Olympia, WA.

Freeze, Michael. 2 May 1994. Personal Communication (telephone communication with Joy P. Michaud, Envirovision, Olympia, WA) Keo Fish Farms, Inc. Keo, Arkansas.

Gibbons, Maribeth., Gibbons, H. and Sytsma, Mark. 1994. A Citizen's Manual for Developing Integrated Aquatic Vegetation Management Plans. First Edition. Prepared for: Washington State Department of Ecology. January 1994. #93-93.

Gow, John. 9 June 1994. Personal Communication (telephone communication with Joy P. Michaud, Envirovision, Olympia, WA) City Engineer, Ocean Shores, WA.

Jordan, Peter. 17 May 1994. Personal Communication (May 17, 1994 Steering Committee meeting) Vice-President Fresh Waterways Inc. Ocean Shores, WA.

KCM, Inc. February 1994. City of Ocean Shores Duck Lake Phase I Restoration Study, Final Report. KCM, Inc. Seattle, WA.

Keough, Pat. 6 June 1994. Personal Communication (telephone communication with Joy P. Michaud, Envirovision, Olympia, WA) Project Coordinator, Silver Lake.

Miller, Bill. 4 May 1994. Personal Communication (telephone communication with Joy P. Michaud, Envirovision, Olympia, WA) Project Manager, Duck Lake Aquatic Plant Management Plan, Ocean Shores, WA.

Miller, Bill. 6 June 1994. Personal Communication (telephone communication with Joy P. Michaud, Envirovision, Olympia, WA) Project Manager, Duck Lake Aquatic Plant Management Plan, Ocean Shores, WA

Miller, Bill. 7 June 1994. Personal Communication (telephone communication with Joy P. Michaud, Envirovision, Olympia, WA) Project Manager, Duck Lake Aquatic Plant Management Plan, Ocean Shores, WA

RMI, 6 June 1994. Personal Communication (fax communication with Joy P. Michaud, Envirovision, Olympia, WA) Subconsultant to Duck Lake Aquatic Plant Management Plan, Tumwater, WA.

Wagner, David. 24 May 1994. Personal Communication (telephone communication with Joy P. Michaud, Envirovision, Olympia, WA) Devils Lake Water Quality Improvement District, Lincoln County, OR.

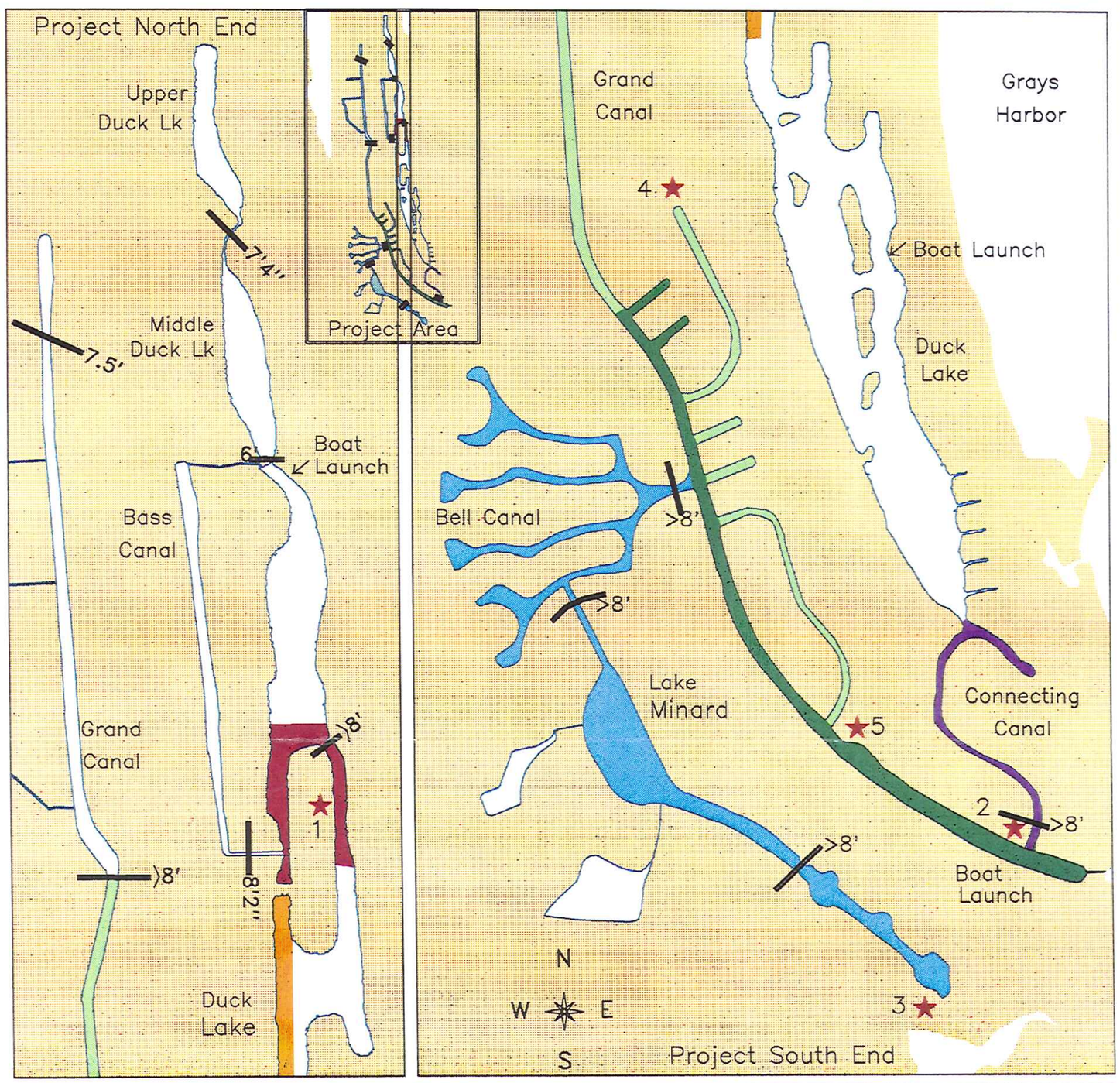
Wagner, David. 6 June 1994. Personal Communication (telephone communication with Joy P. Michaud, Envirovision, Olympia, WA) Devils Lake Water Quality Improvement District, Lincoln County, OR.

WATER Environmental Science. October 1993 (Appendix B to KCM, 1994). 1993 Duck Lake Aquatic Plant Survey. October 1993. Bainbridge Island, WA.

Washington Department of Wildlife. 1990. Grass Carp use in Washington. WDW Fisheries Management Division. F.M. No. 90-4. March 1990.

APPENDIX A

Summary of Steering Committee Meetings



SCALE = 1:16,000

Feet

0 1000 2000 3000 4000 5000 6000 7000 8000

Figure 2.

Harvesting Areas

Legend

- Harvesting Zone 1
- Harvesting Zone 2
- Harvesting Zone 3
- Harvesting Zone 4
- Harvesting Zone 5
- Harvesting Zone 6
- Bridge
- Potential Harvester Access Sites 1–5

Conversely, to purchase a machine with an adequate capacity to handle the 62 acres would cost approximately $70,000 to $90,000, not including tax and shipping. The cost of operating the equipment locally using City employees would be about $350/acre or $21,700 per year, and includes use of a transport truck to haul weeds to the disposal site. (This is based on experience in Thurston and Skagit Counties.) This cost could be decreased if volunteers were used, although maintenance, training, and hauling costs would still be incurred.

Due to the high cost associated with purchasing, operating, and maintaining harvesting equipment, and because harvesting operations are expected to be phased out after about three years of operation, it was recommended that a contract service be used to perform the harvesting.

An additional cost associated with harvesting is development of shoreline access sites. Trailer ramps are needed at a number of access sites to load and unload the harvester and to unload the plants. These access sites are needed to reduce overall transport time and should promote lower contract bids. Currently, there are only two public access sites that could be used for harvester operations. Both of these are located on Duck Lake. Four additional sites are proposed for development as offload areas. At a cost of $3,900 per site, access improvements would require an additional $15,600. Proposed sites are identified in Figure 2. Since these sites are located on private property, easement agreements will be needed for each site and various permits may be needed to conduct the work.

Costs for developing access sites could be eliminated if the harvest contractor was allowed to offload plants onto private properties adjacent to the location of cutting. This option would preclude the need for access improvements and would eliminate the cost of transporting cut plants to a disposal site, but could create some inconvenience to property owners. Property owners could compost plants on site, or take them to the City compost facility. Since there is a substantial amount of undeveloped private property along the waterway, this option may be feasible without greatly inconveniencing lake residents, if these properties could be utilized.

Finally, the harvest plan includes removal of approximately 0.5 acres of cattails that are clogging the boat lane between the north and middle basin of Duck Lake, in the vicinity of the constriction at Chance A La Mer St. This work could be performed from shore using a dragline, backhoe, or similar equipment. The estimated cost for removal of this material and opening the channel is $10,000, and would require a number of permits; a 404 permit from the Army Corps of Engineers, a shoreline permit (WDOE), and Hydraulic Project Approval (HPA) permit (WDFW), and a Temporary Modification of Water Quality Standards permit (WDOE). Due to erosion and sideslope problems, additional costs would be associated with "design" of the channel to ensure bank stability. These design costs have not been included in this report.

Grass Carp Stocking Program

There were a number of reasons that Grass Carp stocking was selected as a feasible alternative for controlling aquatic macrophyte populations in the waterways. Generally, Grass carp provide some advantages over other plant control alternatives. First, they are inexpensive both in terms of initial costs and long-term operation and maintenance (O&M) costs (restocking every 4 to 10 years).

select their top three goals. This resulted in a ranking of the three top priorities for weed control. In the list provided below, the first three listed are in order of rank, the remainder were not prioritized.

Goals Selected

#1 Control 80% of submerged vegetation ("softweeds"). Retain 20% for fish and wildlife habitat
#2 Improve fish habitat and fishability of the lake
#3 Create and maintain boat lanes

Unranked Goals

- Retain lilies. Reduce reeds and cattails to within 5-10' of shoreline near developed sites and in narrow channel areas
- Do not increase the incidence or magnitude of erosion (e.g. through cattail removal)
- Improve water quality (It is acknowledged that although improvements in water quality are an important goal for the overall management plan for the waterways, plant control will result in indirect improvements to water quality primarily as an improvement in dissolved oxygen concentrations in and near existing plant beds.)

The last discussion was aimed at prioritizing lake areas for control. This is primarily aimed at developing a harvesting plan. The number of acres to harvest, their location, and frequency of control needed will be used to determine number and type of harvesters required. This task too was somewhat confused by the grass carp issue. Grass carp stocking is the primary recommendation for control of the plants, if the stocking program is successful, carp should remove many of the plants that are prioritized for harvest. Consequently, the purpose and need for harvesting will likely change with time. In the near term, the objective may be to bring more immediate relief to lake users while waiting for the Grass Carp to grow large enough ton control the plant populations, and in the long term, harvesting may be needed to control plants in areas that the carp do not control either due to low palatability of the plant or due to the carp not avoiding certain lake areas (carp are thought to avoid narrow channel areas and areas where there is a lot of activity). Therefore, the harvesting plan will need to be re-evaluated after grass carp have been stocked to focus resources, if it is still necessary, in places where carp are not being effective.

It was suggested that a contractual service may better meet our needs for the first few years of the project, until we can identify specific problem areas that exist after the carp introduction. Further, RMI staff reported that cattail seem to be on the increase and are already inhibiting boat access (this statement was supported by committee members). Neither harvesting or grass carp are expected to affect these emergent plants, and some other equipment (e.g. an "aquamog") would be necessary to control these species.

STEERING COMMITTEE MEETING SUMMARIES FOR DEVELOPMENT OF THE DUCK LAKE AQUATIC PLANT CONTROL PLAN

The Aquatic Plant Management Plan for the Duck Lake Waterways was developed with the aid of a steering committee. To a large extent the committee was comprised of the many of the same members that assisted with development of the Phase I study. Invited members included; Bill Miller (Project Coordinator), Arne Kvist (Pres. Fresh Waterways Inc.), Peter Jordan (Vice Pres. Fresh Waterways Inc.) Mike Pence (City Manager) Bruce Wolgemuth (Mayor), Bob Paylor (Grays Harbor County), Kathy Hamel (WDOE), Dan Guy (WDFW), David Morency (EEI), Jory Oppenheimer (EEI), and Joy P. Michaud (Envirovision--Project Lead).

The first meeting of the steering committee occurred on May 17, 1994. An agenda was mailed out before the meeting along with copies of Chapters 3, 4, and 7 from the "Citizen's Manual for Developing Integrated Aquatic Vegetation Management Plans". Members were asked to review the information before the meeting. A copy of the agenda for the first meeting and a list of participants is included with this summary. The primary tasks which were completed included; creating a problem statement, listing and locating beneficial uses, defining goals and objectives, and control zones. A map of the shoreline had been produced by RMI in preparation for the meeting, and this map was used to identify key areas. Committee members were also provided with a flow diagram depicting project schedule elements, and a hand-out that summarized some of the issues related to grass carp stocking and harvesting, as well as copies of Chapters 11 and 12 of the "Citizen's Manual" to review in preparation for the next meeting.

A summary of notes from the meeting, a map depicting potential access points, and a written Problem Statement was sent out to all committee members for review and approval. A copy of these is also attached.

The second meeting of the steering committee was held on June 7, 1994. At this meeting preliminary plans for harvesting and grass carp stocking were described and consensus was reached on harvesting areas and stocking rates. The evaluation plan and implementation costs were also described. A meeting agenda and participant list is attached. Although draft plans were handed out to meeting participants, these are not included in this appendix since the information is largely contained and more explicit within the main body of this report.

Attachments pertaining to the May 17th meeting.

Agenda
Participant List
Schedule/Flow Diagram
Issues Summary
Meeting Notes
Written Problem Statement
Marked Map

Agenda

Duck Lake Waterways IAPMP Steering Committee

05/17/94
1:00 PM to 4:00 PM
Convention Center
Conference Room #1

Meeting called by: Joy P. Michaud - Envirovision

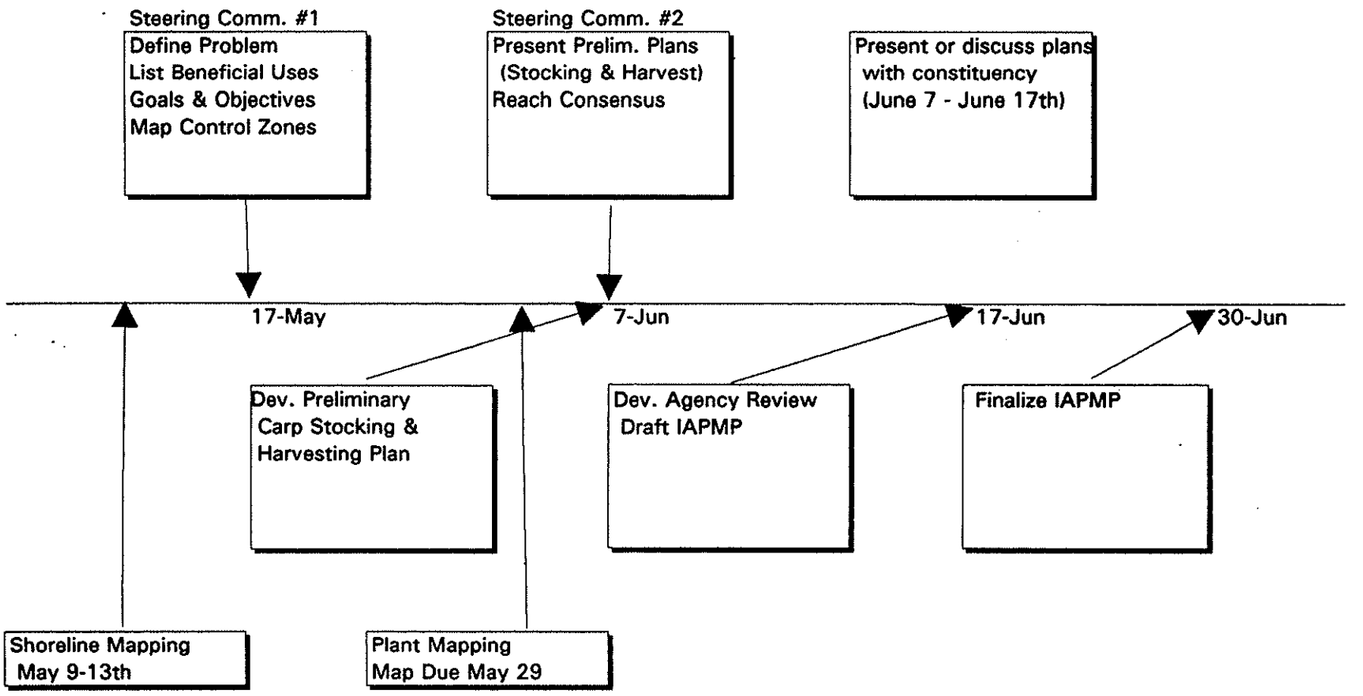
Members: Bill Miller (City of Ocean Shores), Arne Kvist (Freshwaterways Corp.), Peter Jordan (Freshwaterways Corp.), Kathey Hamel (Dept. of Ecology), Bob Paylor (Grays Harbor County), Mike Pence (City of Ocean Shores), Bill Freymond (Dept. of Wildlife), Bruce Wolgemuth (City of Ocean Shores), Joy Michaud (Envirovision), David Morency (Entranco)

Time	Agenda topics	Leader
1:00-1:05 PM	Project Update	Joy M.
1:05-1:10 PM	Discuss Meeting Format	Joy M.
1:10-1:40 PM	Define Problem Statement	Group
1:40-2:20 PM	List and Locate Beneficial Uses	Group
2:20-2:30 PM	Break	
2:30-3:15 PM	Define Goals and Objectives	Group
3:15-3:55 PM	Designate Control Intensities	Group
3:55-4:00 PM	Discuss Future Meetings	Joy M.

Special Note: The attached information was taken from "A Citizen's Manual for Developing Integrated Aquatic Vegetation Management Plans". It may be beneficial to review this information in preparation for the May 17th meeting.

Duck Lake IAPMP
May 17th Steering Comm. Mtg

NAME	AFFILIATION	PHONE
Jory Oppenheimer	Entranco	206 454-5600
Peter Jordan	OSFWC	206-289-2871
Arne Kvist	OSFWC	206-259-3636
David Morency	Entranco	206-454-5600 1-800-454-5601
Bill Miller	City of O.S.	206-289-0516 Home 206-289-2488 City office
Mike Pence	City of O.S.	206-289-2486 Work
Jessi Ellis	"	289-0966


Steering Comm. #1
Define Problem
List Beneficial Uses
Goals & Objectives
Map Control Zones
Steering Comm. #2
Present Prelim. Plans
(Stocking & Harvest)
Reach Consensus
Present or discuss plans
with constituency
(June 7 - June 17th)
17-May
7-Jun
17-Jun
30-Jun
Dev. Preliminary
Carp Stocking &
Harvesting Plan
Dev. Agency Review
Draft IAPMP
Finalize IAPMP
Shoreline Mapping
May 9-13th
Plant Mapping
Map Due May 29

Grass Carp Stocking Issues

Reasons for Stocking at Low Densities
- Easier to control affect (can always increase density)
- Duck Lake may not be representative of Region (Aberdeen & Hoquiam)
  air and water temperatures may both be warmer, this affects grazing efficiency
- Existing plant community is fairly diverse
- Concerns about plant/algae interactions

Reasons for Stocking at High Densities
- Quicker response time
- As water quality improves, clarity may increase, and weeds may then increase
  so want to stock carp at a rate to handle projected increase in clarity

Disadvantages for Stocking at Low Density
- May not achieve adequate response or may not control less desirable species
- Takes longer

Disadvantages for Stocking at High Density
- May greatly decrease or eradicate plant community, resulting in loss of fish and
  wildlife habitat and increases in algae populations
- Higher cost

Other Issues:

How to handle conservancy areas
How to maintain densities in areas with less palatable plants or less favorable conditions (canals)
Preventing movement/loss to saltwater
Should we consider designating a control area or stocking in only a portion of the waterway
Can we place screens to allow boat passage

Harvesting Issues

Using a contractual service vs. purchasing harvesters

Contractual service would allow harvest of "critical areas" (boating lanes and swimming beaches) while effectiveness of grass carp is being studied--after two or three years re-evaluate the need = no large capital expenditure

What is the acceptable level of control for different beneficial use areas

What priority system should be used in scheduling harvesting operations

Harvester equipment access sites (can parks be used? are there other sites?)

Disposal sites for plant matter (parks, airstrip, city composting facility, farms)

ENVIROVISION
Environmental Consulting Service

MEMORANDUM

TO: Duck Lake IAPMP Steering Committee
FROM: Joy P. Michaud
DATE: 20 May 1994
RE: Meeting Summary from May 17th Committee Meeting

Attached is a copy of the notes I have put together from the May 17th meeting, and a marked map indicating some of the points discussed. These are not intended as minutes from the meeting, but instead represent my interpretation of what was said or implied, or in some cases my thoughts on the subject. Consequently, it is important that these notes are reviewed carefully by steering committee members to ensure that points have not been misinterpreted and important considerations have not been missed. If you had a different impression or if in reading these notes more questions are raised, please call so we can discuss it. If you were not able to attend the meeting, you should review these notes to assess the focus of the discussions and ensure your concerns have not been missed or misrepresented. The list of goals for the project may be of special interest. These goals will be used to set the criteria against which the project will be evaluated, it is important that they accurately reflect participants needs.

I have also attached a written Problem Statement that I developed from the meeting notes and portions of the original grant application. Please review this to ensure it clearly describes the impact of the plant community on the lake and lake beneficial uses.

After I have reviewed and discussed comments on the meeting notes and problem statement, I will finalize the problem statement and if necessary prepare an addendum to the meeting notes to address concerns.

Thanks for your time and review.

cc.

Bill Miller
Arne Kvist
Peter Jordan
Bob Paylor
Dan Guy
Mike Pence
Bruce Wolgemuth
David Morency
Jory Oppenheimer

1339 Quince N.E. ▪ Olympia, WA 98506
(206) 754-1344 ▪ FAX (206) 943-4632

of the beneficial uses identified, is a result of the current weed problem. That is, traditional use areas may have been different, or different use areas would develop if weeds were controlled. Some examples-- jet skiers currently remain fairly close to the boat launch areas, but this is due to the problems they encounter if they try to run their machines through areas with dense plants. The entire waterway would be more accessible to jetskiers if the plants were controlled. Fish spawning currently occurs most in south Duck Lake, but spawning habitat (shoreline edges) exists throughout the waterway and traditionally the canals (Grand, Bass, and Bell) were the most important spawning areas. Poor water quality (low DO caused by dense plant canopies) are likely limiting spawning area. Consequently, much of the waterway (possibly excluding Lake Minard which may never have had a great deal of spawning) would become important fish habitat. Designation of a conservancy area was also discussed. One suggestion is to retain Lake Minard as a conservancy area by excluding carp from this portion of the waterway. Lake Minard would then act as a control site and would also continue to provide valuable waterfowl and fish habitat if grass carp were mistakenly overstocked and weed elimination became an issue. An accelerated weed harvesting program would then be needed for Lake Minard to compensate homeowners in this area. If the grass carp stocking program is successful, Lake Minard could then be opened up to stocking. There was little support for this idea.

The following is a list of beneficial uses identified and notations on the current use area.

Beneficial Use	Location
	Around homes (little park activity)
	Grand Canal primarily & near private homes
	Duck Lake (South)
	South Duck Lake (Mid and North were previously popular fishing places)
	Near Boat launches (Duck Lake)
	Near private homes
	Throughout the system
	Duck Lake
	Duck Lake and Grand Canal
	Golf Course (Grand Canal) and Limited
	Use throughout waterway by private homeowners
	Shoreline area throughout the system

A list of Goals for managing the lake plant problem was created. It was pointed out that these goals would be used to develop the criteria for evaluating the success of the program and they should be specific to lake plant problems. If these goals are met, the program will have been a success. After the goals were listed, committee members were asked to

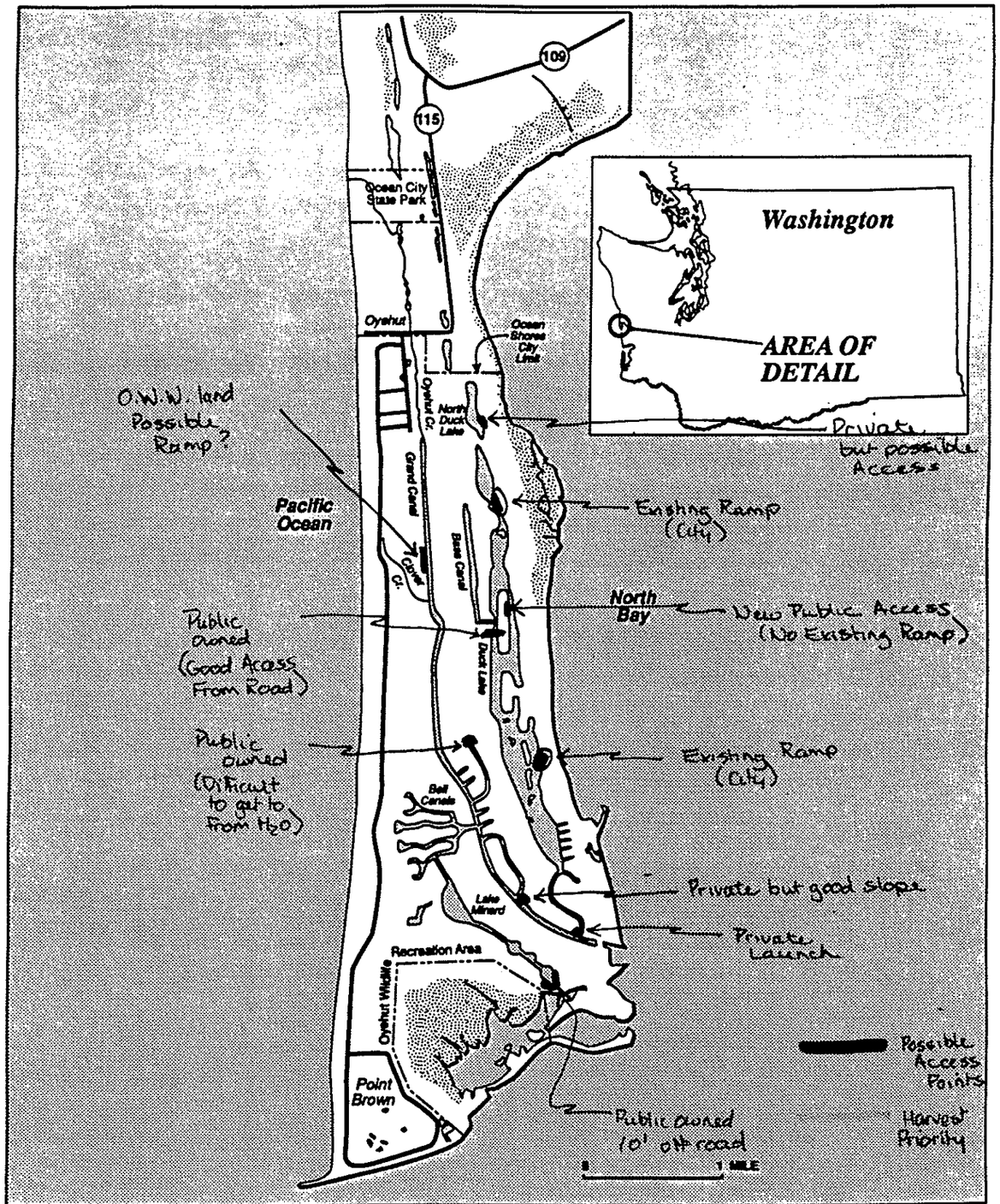
Committee members agreed that there were many issues associated with harvesting plans and directed the consultant team to plan for the use of grass carp and whatever other options will bring control of the plants, not necessarily limiting or including harvesting. Peter Jordan suggested we develop a "matrix", comparing these.

Harvesting areas that were described as priority were; near developed properties (although this priority was not specifically listed, it was implied in other portions of the meeting), in a swath through the center of each of the canals, and around the northern perimeter of the peninsula located in the northern portion of south Duck Lake.

Next meeting scheduled for June 7, to present preliminary plans.

PROBLEM STATEMENT FOR DUCK LAKE

Aquatic plants, including the non-native species Egeria densa, in the Duck Lake Waterways have increased to the extent that boat access to all finger canals and interconnecting canals between the different waterbodies is restricted, and lakefront property owners are having increased difficulty accessing the open water area, due to the dense plant growth along the shoreline. The plant beds and associated localized increases in sedimentation, are causing water depth to decrease and therefore also contributing to access and navigation problems. Available area for recreational activities such as fishing, swimming, jetskiing, sailing, canoeing, and rowing has been greatly decreased due to the problems associated with navigating through the plants. These activities are for the most part limited to South Duck Lake and part of Grand Canal; the remainder of the waterway has been almost eliminated as a recreational resource. Participation in holiday boat parades has decreased from 25 to 5 boats due to weed infestations and boat owner concerns about becoming stranded or burning out boat engines in the dense weed beds. The Duck Lake waterway has traditionally been an excellent bass and panfish fishery, and has been the site of many semi-professional bass tournaments. The number of tournaments and participation has greatly decreased over the past several years due to poor fishing quality. Property values along the canalways are being affected; Bass Canal residents are seeking lower tax rates due to the especially poor quality of this portion of the waterway.



KCM *1917 First Avenue* *Seattle, Wash. 98101*	City of Ocean Shores DUCK LAKE PHASE I RESTORATION STUDY	Figure 1-1. LOCATION MAP

Meeting Notes - May 17th Steering Committee Meeting

The recently completed digitized map of the shoreline recently completed by RMI was displayed and we discussed possible access points for harvesting equipment. RMI had identified 2 public boat launches (both on South Duck Lake) and one apparently privately owned launch at the extreme end of south Duck Lake. There are not enough "currently developed" launch sites to efficiently offload weeds. Another problem noted by RMI was that the bridge between south and mid Duck Lake was too short to get equipment under. Peter Jordan commented that the water depth too, would limit access beneath this bridge, and access beneath the bridge that divides mid Duck from North Duck (a narrow cattail filled channel). A separate access site will be needed if this portion of the lake is to be harvested. Additional potential access properties were identified--see attached map. We also briefly discussed disposal sites for harvested weeds. The airstrip and some other City-owned property were mentioned. It was suggested that John Gow (Ocean Shores, Public Works) be contacted to discuss disposal options.

To help with development of the Problem Statement for the Duck Lake waterways we began by creating a list of the problems experienced. Bill Miller commented that many of these problems are described in the original grant application and it should be used to help with development of the Problem Statement. After the list was developed the degree of impact or importance was noted (high, moderate, or low) for each portion of the waterway. The results of this task are shown in the matrix below.

	Duck Lake	Grand Canal	Bell Canals	L. Minard	Bass Canal
	H	H	H	H	H
	Y	Y			
	M+	H	H	M-	H
	M	H	H	M	H
	H	H	H	H	H
	M	H	H	M	H
	M	M	M	M	H+
	M	H+	H+	M	H+
	Y				Y

H (High Impact), M (Moderate Impact), L (Low Impact)
NOTE: "Y" for yes is used to note where a problem occurs when it is not appropriate to assign a magnitude of the impact.

Next beneficial uses were listed and a discussion of where these beneficial uses occurred followed. This task was somewhat confused by the fact that the existing location of many

Attachments pertaining to the June 7 meeting.

Agenda
Participant List
Copies of Overheads

Agenda

Duck Lake Waterways IAPMP Steering Committee

06/07/94
1:00 PM to 4:00 PM
Convention Center
Conference Room #1

Meeting called by: Joy P. Michaud - Envirovision

Members: Bill Miller (City of Ocean Shores), Arne Kvist (Freshwaterways Corp.), Peter Jordan (Freshwaterways Corp.), Kathey Hamel (Dept. of Ecology), Bob Paylor (Grays Harbor County), Mike Pence (City of Ocean Shores), Bill Freymond (Dept. of Wildlife), Bruce Wolgemuth (City of Ocean Shores), Joy Michaud (Envirovision), David Morency (Entranco)

Time	Agenda topics	Leader
1:00-1:05 PM	Project Update	Joy M.
1:05-1:10 PM	Comments on Meeting Notes from May 17th	Joy M.
1:10-1:30 PM	Harvesting Plan/Discussion	Joy M./Group
1:30-2:00 PM	Stocking Plan/ Open Discussion	Joy M./Group
2:00-2:15 PM	Break	
2:15-2:30 PM	Evaluation Plan	Joy M.
2:30-2:45 PM	Implementation Costs	Joy M.
2:45-3:30 PM	Open Discussion/Consensus on Approach	Group

PRELIMINARY HARVESTING PLAN FOR DUCK LAKE

Harvested Areas:

20 foot swath down all canals (except Bass and N. end of Grand)
Duck Lake Peninsula
No harvesting in Lake Minard (just end channels)

Frequency:

2 cuts per summer season (50-70 days)
No winter (christmas parade) cut

Harvest Priority:

1) Boat lane @ eastern side of peninsula
2) Duck/Grand Connecting Canal
3) North along Grand
4) Grand lateral canals
5) Bell/Lake Minard
6) Western shoreline of Duck lake (conservancy area?)

Cattail Removal

Channel between north and middle basins of Duck Lake (0.5 acres)

Costs for Contract Service:

@$500-800/acre for 70 acres = $35,-56,000.00/yr
Cattails = $35,000 (???) once every 5 years

Costs for Own/Operate:

#1 200 cu.ft. capacity harvester = $70,-90,000.00
Employee Cost = $24,500
Volunteers = $0
(These do not include O&M costs, and assume a county/city dump truck could be used.)

* Additional costs are also associated with development of offloading sites

Stocking Rate Comparisons Appropriate for Duck Lake

Lake	# Stocked	# per Veg. Acre	Year Stocked	Summary
Silver	83000	50	1992	50% reduction in first year
Devil's	27090	72	1986	1st 5 years satisfactory control;improved recreastion etc. Year 6, few plants. Year 7 none seen w/lower fish pops.
Duck L.				
	26,-31000	110-120		Based on # veg. acres
	5,478	22		Based on tons of plants
	18,389	72		Based on Devils Lake rate

APPENDIX B

Harvesting Plan for the Duck Lake Waterways

Prepared by: Entranco Engineers Inc.
10900 NE 8th St. Suite 300
Bellevue, WA 98004

DUCK LAKE INTEGRATED AQUATIC VEGETATION MANAGEMENT PLAN

HARVESTING PROGRAM ELEMENT

Prepared for
ENVIROVISION
and the
CITY OF OCEAN SHORES

by ENTRANCO

July 25, 1994

SUMMARY

The following harvesting plan was developed in cooperation with the Duck Lake Waterways Integrated Aquatic Plant Management Plan (IAPMP) Steering Committee and Envirovision.

The proposed plan will involve two cuts per summer, over 33 acres, for a period of 1-3 years. This will include 17 acres on Duck Lake and 16 acres of canal harvesting (12 acres with two cuts per season and 4 acres with one cut per season) on the Grand Canal, Bell Canal, and other portions of the canal system. Total length of canal harvesting is estimated at 6.7 miles. Canal harvesting will involve cutting a 20 foot wide path down the middle of each canal, while lake harvesting will involve channel and open water clearing operations. The purpose of the harvesting effort is to maintain boating and recreational access on a provisional basis until the proposed grass carp control program becomes fully effective.

Because harvesting operations are expected to be phased out after 1-3 years, the Steering Committee decided that it would be most appropriate to have harvesting performed as a contracted service rather than by purchasing and operating their own harvesting equipment.

Companies that provide weed harvesting services have provided cost estimates ranging from $500 to $870 per acre. This means that total annual costs for harvesting will be in the range of $31,000 to $53,940 given the total harvest area of 62 acres per year (two cuts on 29 acres and one cut on 4 acres). This cost will include harvesting, unloading cut plants at the shoreline, and transporting plants to the City compost facility at the sewage treatment plant.

An additional $15,600 will be required to make shoreline access improvements at four sites. Trailer ramps are needed at each of these sites to load and unload the harvester and to unload aquatic plants. These improvements are needed to reduce overall transport time (from harvest site to off-load site) and should promote lower contract bids. Easement agreements will be needed for each site and various permits may be needed to conduct this work.

An option to making the access improvements would be to have the harvest contractor off-load cut plants on private properties adjacent to the location of cutting. This option would preclude the need for access improvements and would eliminate the cost of weed transport to a disposal site, but could create some inconvenience for shoreline property owners. Property owners could compost the cut plants on-site or take them to the City compost facility at the Sewage Treatment Plant.

Finally, the harvest plan will include $10,000 to remove about 0.5 acre of cattails that are clogging the boat lane between the north and middle basin of Duck Lake, in the vicinity of the constriction at Chance A La Mer NE. This work will be performed using a dragline, backhoe, or similar equipment from the shore.

CONTENTS

PAGE

SUMMARY..... 2

INTRODUCTION..... 4

AQUATIC WEED CONTROL GOALS..... 4

DESCRIPTION OF HARVESTING OPERATIONS..... 5

DUCK LAKE HARVEST AREAS..... 5

FREQUENCY/DURATION/TIMING..... 6

HARVEST SEQUENCE..... 6

COST ESTIMATES FOR CONTRACT SERVICES..... 6

SHORELINE ACCESS IMPROVEMENTS.....7

DISPOSAL OPTIONS..... 7

PURCHASE OPTION..... 8

BIDDING AND CONTRACTING..... 9

INTRODUCTION

Duck Lake is located in the City of Ocean Shores on the Pacific Coast of Western Washington. The lake covers 280 acres and has an extensive canal system totalling more than 11 miles in length **(see Figure 2 in main text)**. Other small lakes, including Lake Minard, are part of the fresh waterway system. The lake and canal system were created by dredging between 1960 and 1973. The lake is highly eutrophic and has an average depth of only 11 feet. Average canal depths range from 5 to 9 feet depending on location. Canal widths range from 112 to 184 feet.

A recent plant survey conducted on May 31, 1994, by Resource Management, Inc. for Envirovision, indicates that 255 acres are infested by aquatic plant growth. This includes 180 acres in Duck Lake and 75 acres in the canal system. The survey indicates that about 157 acres are heavily infested and that the remaining 98 acres are only sparsely covered by aquatic plants. Plant species include native milfoil *(Myriophyllum)*, Brazilian waterweed *(Egeria densa)*, native waterweed *(Elodea canadensis), Nitella,* and small areas of pondweed *(Potamogeton sp)*, coontail *(Ceratophyllum demersum)*, and pond lily *(Nymphaea sp and Nuphar sp)*. Some shorelines of the lake are also heavily vegetated by cattails *(Typha sp)*.

The Steering Committee intends to stock the lake and canal system with grass carp as the primary means of controlling undesirable aquatic plant growth. Since it is expected that full grass carp control will take 1-3 years, mechanical plant harvesting will be implemented as an interim means of maintaining boating and recreational access. Although the option of equipment purchase was considered, the Steering Committee determined that harvesting should be performed as a contract service due to the temporary nature of the work.

AQUATIC WEED CONTROL GOALS

The Steering Committee has established the following weed control goals:

1. Control 80 percent of submerged weeds and retain 20 percent for fish and wildlife habitat.
2. Improve fish habitat and fishability of the lake.
3. Maintain and improve boat access for fishing, water skiing and related recreational uses.

The proposed harvesting operations will assist in achieving all three goals over a 1-3 year period. Once grass carp has become fully effective, it is anticipated that mechanical harvesting will no longer be necessary. The need for mechanical harvesting will be re-assessed by the Steering Committee at the end of each harvesting season.

DESCRIPTION OF HARVESTING OPERATIONS

Aquatic plant harvesting involves the use of three pieces of mechanical equipment: (1) an aquatic plant harvester, (2) an off-shore conveyor, and (3) a disposal truck. Plant harvesters come in a range of sizes, but most contractors use small-to-medium sized machines for ease of transport and on/off loading. The several contract companies that were contacted about the Duck Lake project indicated that they typically use a machine with a 200 cubic foot plant storage capacity.

Harvesters are floating machines and are usually propelled by paddle wheels. They have one horizontal and two vertical cutter bars mounted on a hydraulically operated cutter/conveyor on the front end of the harvester. The cutter/conveyor is lowered into the water and, as the plant material is cut, the conveyor lifts the plants onto the storage deck of the harvester. Cutting width is typically 5 to 8 feet and cutting depth is typically 4 to 6 feet. Once the harvester is full of cut plants, it must make a trip to the shore to unload the plants. The distance to off-loading sites affects travel time and overall harvest operating costs. Thus, a reasonable number of strategically located off-loading sites is necessary for optimal harvest efficiency. The number and location of off loading sites is addressed in a subsequent section of this report.

A portable off-shore conveyor is used to move cut plants from the harvester to a waiting truck for transport. Typically, a dump truck is used for transporting weeds to a final disposal site. Disposal operations are discussed in more detail later in this report.

At the disposal site, plants are usually arranged in wind rows to dewater. This process significantly reduces the weight and volume of the plants, since the water content of the plants is quite high (around 90 percent). After drying, the plants can be composted or used for mulch.

DUCK LAKE HARVEST AREAS

The Steering Committee decided that approximately 6.7 miles of canals would be harvested as shown on **Figure 2** in the main text. Bass Canal and the northern end of Grand Canal, where wetland construction is proposed, will not be harvested. Also, no harvesting is proposed for Lake Minard, but is proposed for the canals on either end of the lake. *Total canal* harvesting, based on a 20 foot wide cut, with two cuts per summer on 12 acres, and one cut per summer on 4 acres, is estimated at 28 acres.

Additional harvesting is proposed in Duck Lake in the vicinity of the peninsula at Overlake Street NE and along the western shoreline south of Overlake Street SE. Estimated *total lake* harvest will be 34 acres, with two cuts per season on 17 acres. *Total lake and canal* acres will be approximately 62 acres.

FREQUENCY, DURATION, TIMING

The plan is based on two cuts per season. Some other lake groups in Washington perform three cuts per season, but this is usually done where pond lilies are a dominant plant, since lilies have a relatively rapid re-growth rate. The plants in the Duck Lake system are expected to be controlled with two cuts per season; however, the Steering Committee has the option of increasing or decreasing the number of cuts based on observations that will be made during the first year of operation.

Discussions with companies who perform contract services indicates that harvesting will take about 40 to 60 calendar days. We have assumed that it would be best to do the work during the months of July and August. This is typically the period of greatest weed growth. Following the first year of harvesting, the Steering Committee can also assess the adequacy of this schedule and make any desired adjustments. For example, they may find that it would be desirable to perform three cuts in the canals, or they may want to split the harvest operation (June and August) or extend the duration of harvest operations. Any such adjustments would add to the cost of the operation.

HARVEST SEQUENCE

Harvesting will begin by cutting a 20 foot wide boating lane through the narrow passage that separates the eastern shoreline of Duck Lake and the peninsula at Overlake Street NE. This will provide boating access for all property owners along the shorelines of Duck Lake for the entire length of the lake. Next, harvesting operations will proceed to the canal connecting Duck Lake and Grand Canal, then northward along Grand Canal, then into the Bell Canal/Lake Manard system, and finally, the lateral canals connecting with the Grand Canal. This will progressively provide access to Duck Lake to all properties fronting the canal system. Work will then proceed northward to the northern limit of harvesting on the Grand Canal. The last phase of harvesting will be to cut the open water zone in Duck Lake. This would complete the first harvest cycle, and then the operation would be repeated for the second cut.

COST ESTIMATES FOR CONTRACT SERVICES

Based on information provided by several contractors, cost per acre could vary between $500 and $870. Thus, the cost for cutting 62 acres would be $31,000 to $53,940. This range of cost will include transportation and disposal. However, these costs do not include the cost of access improvements necessary for the contractor to get equipment in and out of the lake.

The cost estimates provided above assume that the harvester operation would cut plants and return to one of five on/off load sites to unload the plants and truck them to a disposal site (see **Figure 2** in the main text). Since only one of these sites is equipped with a trailer ramp, the other four sites would require improvements to allow for loading and unloading of the

harvester and off-loading of cut plants.

An additional $10,000 is estimated for the removal of 0.5 acre of cattails in the vicinity of Chance A La Mer NE **(see disclaimer on page 10)**. This will be performed using dragline, backhoe or similar equipment.
See the following section for discussion of permitting.

SHORELINE ACCESS IMPROVEMENTS

Based on trailer dimensions of 36-38 feet in length, and 2.5 feet of vertical ground clearance, a trailer ramp into the lake or canal should have a slope of about 15 percent. Assuming the existing canal bank has a slope of about 3:1, that the end of the ramp should extend about four feet below the water line, and that the width of the ramp would be 16 feet, total excavation for a typical ramp was estimated at about 150 cubic yards. Since the harvesting program will be a temporary operation, it is assumed that excavated material will be stockpiled on site and restored at the completion of harvesting operations. Restoration work will double the earthwork to 300 cubic yards per site.

At $8 per cubic yard, the total cost of excavation would be $2,400 per site **(see disclaimer on page 10)**. Each ramp will be topped with 3 inches of large gravel. This equates to about 15 cubic yards or 35 tons and would cost $700 per site at $20 per ton. Total cost per site would be $3,100 for cut and fill. Another 25 percent ($800) for mobilization, contingencies, etc., will be added for a total cost per site of $3,900 or $15,600 for four sites.

Since the estimate presented above is based on "typical" site conditions and not actual site conditions, the City Engineer should be contacted to perform site investigations and provide the drawings necessary to bid the work. The City Engineer can also provide the basic site survey and staking work needed to locate the excavation work in the field.

This work may require Shoreline, HPA, NPDES, Water Quality Modification and 404 permits. The State of Washington Departments of Ecology and Fish and Wildlife, and the US Army Corps of Engineers should be contacted. Permits may also be needed for the cattail removal operation.

Also, the propose access sites are all on private property, except for one existing public access site on Duck Lake. Therefore, easement agreements will be required.

DISPOSAL OPTIONS

It is estimated that 620 to 930 cubic yards of plant material will be removed from the lake/canal system over the course of a summer harvest (62 acres at 10-15 cubic yards per acre (Entranco Engineers, Inc. 1987. Pattison and Long Lakes Restoration Project - Final Report.). Daily removal will be about 20 to 30 cubic yards of wet material. This material

about three miles south of the south end of Duck Lake. According to the City Engineer, John Gow (personal communication), the facility will have no problem handling this volume of material, and there will be no charge for compost disposal.

An option to this approach would be to have the harvester operator unload the weeds on private lots adjacent to the site of cutting. This would require residents to dispose of the plants. If spread to dry, the weight and volume would decrease significantly. Then the material could be used for compost or garden mulch or mulched into the lawn for those with mulching lawn mowers. This approach might provide significant reductions in travel time and harvester operational costs because it would preclude the need for trucking and off-site disposal. It would also preclude the need for additional access improvements, for permitting, and for acquisition of easement agreements.

PURCHASE OPTION

A machine with a 200 cubic foot capacity should be adequate for the 62 acre harvest proposed. If the Steering Committee wanted to purchase such equipment, it would probably cost about $70,000 to $90,000, not including tax, shipping, etc. The cost of operating the equipment locally, based on experience in Thurston and Skagit counties, using county employees would be about $350 per acre, or $21,700 per year applied to the 62 acres on the Duck Lake/canal system. This cost could be lower if volunteers were used as they are now on some lakes in Thurston and Skagit counties. These costs would include lease of a dump truck from the City for transport of weeds to the compost disposal site.

The difference between purchase and contract options suggests that it would be advantageous to for the City or the Ocean Shores Fresh Waterways Corporation to purchase and operate their own equipment if they wanted to make harvesting a long-range plant management program. However, under the present plan, harvesting will only be employed for 1-3 years until the grass carp control program gets underway. Therefore, the Steering Committee has decided that contract services be used for mechanical control.

It should be noted that the purchase option is not always considered the best approach in the long run because of all the coordination and management issues attendant with this option. For example, after about eight years of ownership/operation, Thurston County is now going to a contract service on one of the lakes on which they provide weed control services. This is due to problems with both equipment and personnel management. Some equipment purchased by the County has been difficult to maintain and it has worn out sooner than expected. Based on Thurston County experience, it is also difficult to keep good employees when only seasonal work is available. This means that re-hiring and re-training is an on-going process.

BIDDING AND CONTRACTING

Based on discussions with Mark Swartout of Thurston County (personal communication), it will probably be advantageous for the Ocean Shores Fresh Waterways Corporation (OSFWC) to be the contracting entity rather than the City of Ocean Shores. This is because (1) local governments must pay the prevailing wage, while private corporations are not required to do so, and (2) local governments must require the contractor to post a performance bond. In the case of Thurston County, the bond was set at the full price of the annual harvest operation.

Although the OSFWC might still want to require a performance bond, it could be set at a lower amount. Thurston County is also retaining 20 percent of the billing to the end of the contract to cover possible damage claims and related concerns.

Method of payment to the contractor should be based on a map showing numbered harvest areas, with the number of acres of each area shown on the map and provided to the contractor. Also, each area should be marked off with buoys in the field, although this may not be necessary in the canals where it should be easy to visually determine if the 20 foot wide cut has been made. The City or OSFWC should appoint a contract officer who will visit the site at the time of invoicing to verify the number of acres cut. The contractor should be paid when a given harvest area is completely cut, so that the contract officer does not have to try to estimate partial area completion as a basis for payment. The payment clause should include verification of cut by the contract officer - in other words, the work should be performed to the satisfaction of the contract officer.

The City or OSFWC may wish to include an additive optional hourly rate in the bid document so that they have the option of requesting additional work above and beyond the acreage cutting. The main harvesting operation should not involve any work around docks or in narrow canals. This makes the work more efficient and therefore, less expensive. The hourly rate portion of the contract may be exercised if supplemental work is desired.

Suggestions for bidding the harvest contract services include the following:

1. Provide a copy of the harvesting plan with the bid documents given to the prospective contractors.
2. Obtain a list of potential contractors from the States of Washington, Oregon, and California, to ensure that several bids are obtained.
3. Obtain sample contract and bid packages from other local government organizations to assist in bid package and contract preparation. Call representatives of these organizations to determine what special provisions to put in the contract.
4. Conduct a bidders conference in Ocean Shores so that bidders will have the opportunity to see the lake/canal system, access sites and disposal site prior to bid preparation.
5. Request a list of 5 references from each bidder and contact the references to see if others are satisfied with the contractor's performance.
6. Indicate in the bid that selection will be based on bid price, references, level of service

provided, ability to meet schedule and related factors. This will give the City or OSFWC the ability to choose a contractor on factors other than low bid, if such factors are deemed to outweigh price considerations.
7. Consider bidding access improvement and cattail work as an option to the harvest work or as a separate contract, since providers of weed harvest services may not do this kind of work routinely.

Disclaimer

All cost provided in this report are estimates only and Entranco makes no warranty, expressed or implied, as to the accuracy of such estimates compared to bid or actual cost. Actual cost of contract harvest services may vary depending on market forces outside the control of Entranco. Also, cost estimates of access improvements are based on a conceptual, planning-level approach and it is recommended that site surveys and engineering plants be prepared by a registered engineer prior to preparation of refined cost estimates.

APPENDIX C

Instructions for Creating an Underwater Viewing Scope

Selected from: TVA's Water Quality Series Booklet 2
Homemade Sampling Equipment

MATERIALS:

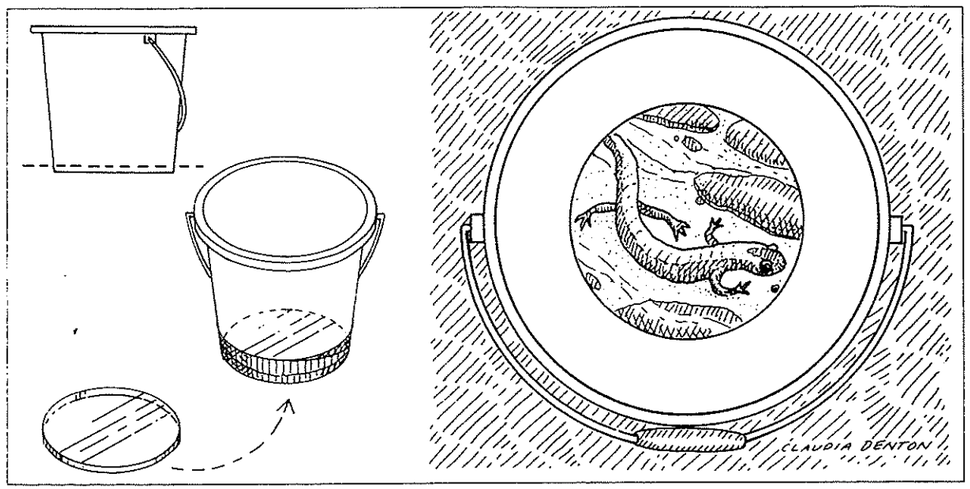
6, 8, or 10 foot long by 3- 4 foot wide fiberglass window screening or 1/4-inch netting
two 4-inch wide strips of canvas (6, 8, or 10 feet long)
two 4-inch wide strips of canvas (3 - 4 feet long)
2 broom handles or wooden dowels (4- 6 feet, both need to be same size)
thread
sewing machine

DIRECTIONS:

1. Sew 6, 8, or 10 foot long (depending on your net size) strips of canvas to top and bottom of the net.
2. Make two 1-inch casings at either end of net with the 3 or 4 foot strips of canvas making sure to sew bottom end of casings shut as shown.
3. Insert broom handles orwooden dowel.

UNDERWATER VIEWER

For viewing aquatic organisms



MATERIALS:

any size plastic, metal, or wooden bucket
1/4-inch thick plexiglass piece (size to fit bottom of bucket)
saber saw
hand saw or tin snips
silicone sealant or duct tape

DIRECTIONS:

1. Use saber saw to cut plexiglass into a circle to fit diameter of bucket.
2. Use regular saw or tin snips to cut off bottom of bucket.
3. Use silicone sealant or duct tape to attach plexiglass to bottom of bucket.

SAMPLING SUPPLIES

SAMPLING PANS

For sorting and counting aquatic invertebrates

MATERIALS:

opaque plastic bottles or milk jugs
scissors or sharp knife

OR

aluminum pie pans
white enamel spray paint
newspaper