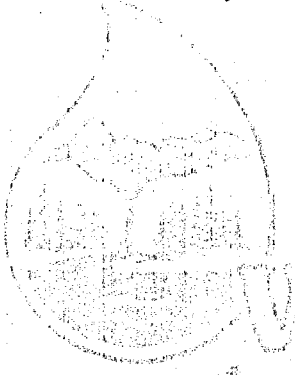
cc all Bd Members
3-9-91

LAKE LIMERICK AQUATIC PLANT MANAGEMENT STUDY



WATER
environmental
services, inc.

MARCH 1991

WATER Environmental Services, Inc.

LAKE LIMERICK AQUATIC PLANT MANAGEMENT STUDY

INTRODUCTION

Lake Limerick is a 130 acre manmade lake located approximately 5 miles from Shelton, Washington in Mason County. A shallow lake, it has a mean depth of 9 ft and maximum depth of 24 ft (Bortleson et al., 1976). The lake was created over twenty years ago by constructing a dam on Cranberry Creek in the southern end of the lake. The major tributary is Cranberry Creek at the western end that drains nearby Cranberry Lake. Other points of inflow (evident during Feb. 24, 1991 survey) include that from adjacent Lake Leprechaun (a small lake within the confines of the Estates), a stream emptying into the northernmost embayment, and a large diameter inverted squash culvert flowing in at the extreme eastern end ("bird sanctuary" embayment). There were also several other drainage influents up to 12 inches in diameter along the shoreline.

Lake Limerick and adjacent Lake Leprechaun provides its residents with many beneficial uses, such as recreation activities, aesthetic enjoyment and wildlife habitat, and also functions as one source of irrigation water for grounds use. However, over the years, the lake has shown signs of increasing eutrophication (high productivity of organic matter), manifested in dense aquatic weed growth and thick mats of filamentous algae (Dick Lombard, Lake Limerick, pers. comm.). Anecdotal information supplied by Allied Aquatics (Appendix A) noted approximately 67 acres of macrophytes inhabited the lake in June, 1990. Dominant macrophyte species affecting the lake were the submergents, Potamogeton amplifolius (big-leaved pondweed), Egeria

densa (Brazilian Elodea), and Elodea canadensis (American Elodea), with a variety of subdominants also observed.

For years, the association has attempted to mechanically control nuisance aquatic weed growth through use of a small Aquamarine harvester with little effect (Dick Lombard, Lake Limerick, pers. comm.). In fact, aquatic weed growth has expanded considerably since the last USGS survey of the lake in 1974, which documented <1% surface area coverage by macrophytes (Bortleson et al., 1976). The lake community has become increasing concerned over detriments to aesthetic and recreational enjoyment of the lake as well as increased safety risks associated with excessive weed and algal growth. As a result, the association is in search of a more effective means of combating the current weed problem and restoring and maintaining beneficial uses of the lake.

At this point, it is important to note that macrophytes are naturally a significant component of any aquatic ecosystem, offering a source of food, refuge, nesting sites and bank stabilization. But, excessive and persistent aquatic weed growth is often symptomatic of a larger water quality problem affecting the lake. Rapid and progressive development of nuisance weed growth signals that a system imbalance may exist as a result of overenrichment from nutrient sources within and/or outside the lake itself. Often, it is more cost-effective to rectify the problem if the underlying cause of the problem can be determined.

Thus, the Board and the lake community are faced with two matters affecting the lake. One is short-term and involves deciding on a

course of action to deal with the immediate, physical problem of too many weeds currently present in the lake; the other is that of developing a comprehensive, long-term lake management plan that would include an ongoing aquatic plant control component, as well as possible watershed management practices to reduce influence of any identified non-point source contamination of the lake on aquatic weed and algal growth.

Project Purpose and Scope

The purpose of this investigation was to conduct a preliminary scoping of Lake Limerick, particularly with regard to the aquatic plant problem, and perform a needs assessment relative to the management goals of the lake community. This phase is the first of a three-phase program for the lake proposed by WATER, with subsequent phases possibly providing for more intensive investigation/planning, as well as an implementation phase.

This investigation was concerned with scoping out the current status of the lake and was accomplished by (1), meeting with some lake representatives to get a sense of the community's perceptions on lake quality and management goals, (2), conducting a site visitation to examine lake and shoreline conditions firsthand and collect a few water samples to document ambient conditions in the lake at that point in time, and (3), gather additional written or verbal information available on the lake as well as possible macrophyte control techniques that may be applicable to Lake Limerick's specific situation. The preliminary information generated from the above actions was compiled and reviewed with the following objectives:

- defining lake status, particularly regarding nuisance macrophytes,
- identifying immediate actions that could be implemented, and
- recommending further courses of action needed to develop and refine a lake management plan specific to Lake Limerick.

Results of this investigation are presented below.

Lake Limerick Site Visitation

An important element of this investigation involved a one day visit of Lake Limerick and vicinity to provide firsthand observation of existing conditions in the lake and along its shoreline, and to gather water/weed samples for additional background data. A cursory boat survey was performed by WATER on February 24, 1991. The entire lake shoreline was traversed by small boat, including all embayments. In addition, Lake Leprechaun, a tiny lake also within confines of the Estates, was checked from shore, as were the Cranberry Creek inflow and the influent stream from Lake Leprechaun.

Although February is still very early in the typical growth season, we did find a variety of submerged weeds growing throughout the lake in varying densities. Pondweeds (mostly Potamogeton amplifolius) were in evidence along most of the lake shoreline, growing alone or intermixed with other plants. However, the most striking weed growth (for this time of year) was the occurrence of Brazilian Elodea (Egeria densa), particularly along the southern and western portions of the lake. Plants of this species were already found to be within one-two feet of the water surface in 5-10 feet of water. In addition, cottony surface

mats of filamentous green algae (Mougeotia sp., Spirogyra sp., and Zygnema sp.) were observed in a few areas around the shoreline; these species have been found to flourish in waters of high organic content.

The site visitation also revealed evidence of possible non-point source inputs of nutrients entering the lake from developed shoreline and upland areas. Of note was occurrence of areas of submerged leaf litter (alder) on the lake bottom resulting either from direct leaf drop or carried into the lake by wind or surface water flow. Decomposition of this organic material can pose as a source of nutrient enrichment to the lake. Apparently the lake community is aware of this matter and will be implementing leaf cleanup measures as needed (Dick Lombard, Lake Limerick, pers. comm.), which is highly encouraged. Other potential sources of nonpoint enrichment can result from maintenance of well-fertilized lakeshore turf with minimal or no shoreline vegetative buffer to intercept flow of sediments and nutrients into the lake, impervious or semi-impervious surface areas that act as direct avenues for movement of contaminants to the lake, leaking septic systems (especially suspect given the age of the development.), and direct drainage from the upper watershed.

Certainly, the point of this discussion was only to illustrate the possibility for additional inputs of nutrients and sediments to the lake can occur from many sources that can oftentimes be easily identified and rectified. The Lake Limerick community should be aware that it can minimize nonpoint source loading of nutrients to the lake, that only act to further stimulate nuisance plant growth. The potential for nonpoint inputs from the watershed suggest that

luxuriant growth of aquatic weeds in Lake Limerick may be stimulated not only by internal nutrient sources (ie.lake sediments), but also by external inputs from shoreline and upland activities. It is highly recommended that sources and factors contributing to nutrient enrichment of the lake be further investigated in a more comprehensive study (see below).

Background Data on Lake Limerick

Water qualtiy data on Lake Limerick is wanting. A review of published literature revealed a single limnological survey was performed by the USGS on August 16, 1974 (Bortleson et al., 1976) during which two depths were sampled for selected physical/chemical/bacteriological parameters (Appendix B). While it is difficult to accurately characterize a lake by a single sample data set, the data on this date 17 years ago indicated generally good water quality, with low to moderate nutrient content, high relative water transparency for mid summer, and low occurrence of emersed and submersed aquatic vegetation.

In the last seventeen years, though, the lake's water quality has apparently deteriorated as illustrated by increased areal coverage and density of macrophytes to nuisance proportions and occurrence of algal blooms. The Board currently estimates weed coverage of about 67 acres, which is over half the lake surface area.

As part of the site visit on February 24, WATER did do some limited chemical and biological water sampling (Tables 1, 2). Review of the biological data show the algal community at this time was

predominantly made up of Chrysophyte species, both diatoms and golden-brown algae, which are fairly typical late winter/spring-time forms in regional lakes. Of note, though is the presence in moderate numbers of the golden-brown species Synura, which is a species that can cause taste and odor problems in high densities. The zooplankton (micro-invertebrate) community was fairly diverse for this time of year, and was numerically dominated by small-bodied herbivorous rotifers and nauplii (immature rotifers), which consume small particulates such as algae, bacteria and detritus (decayed matter). The presence of larger crustacean zooplankters (Daphnia sp. and Cyclops sp.) as well as the phantom midge larvae, Chaoborus sp., suggest that suitable food sources are most likely present in the lake to support planktivorous fish (eg.trout and juvenile spiny-rays); the lake apparently supports these types of fish (Dick Lombard, Lake Limerick, pers. comm.). A nutrient sample was collected and sent to an outside chem lab for analysis of nitrogen and phosphorus concentrations (important nutrients for algal/plant growth). At the time of this writing, results were still pending and will be forwarded to the Board with interpretation as soon as received by WATER.

Again, the above data represents only a single sample date and does not really provide enough information to define the water quality of the lake. A more comprehensive limnological investigation is highly recommended to truly understand and characterize chemical/physical/ and biological processes affecting the lake water quality, and to design a comprehensive integrated plant management program.

RECOMMENDATIONS

Immediate (Short-term) Goals

Results of this preliminary scoping investigation reveal that in the last decade or so, growth and proliferation of aquatic weeds (namely Brazilian Elodea, American Elodea and Big-leaved pondweed) have resulted in a major infestation of nuisance proportions in Lake Limerick. Firsthand observations and information provided by lake residents confirm the presence of these weeds throughout the lake, causing obvious aesthetic, recreational and water quality problems. Of particular concern to the lake residents is the increased safety risks associated with dense weed growth.

WATER therefore concurs with the Board that a critical macrophyte problem exists in Lake Limerrick that warrants prompt, specific management action targeting the nuisance species. If NO ACTION is taken to control growth of these problematic plants, the weeds can be expected to expand their coverage of the lake, which is shallow, and will eventually occupy all available littoral area (75%-95%).

The question arises as to what management actions would be most appropriate to deal with the current weed problem. As described earlier, several weed species apparently grow to nuisance proportions in Lake Limerick. Thus, any management action(s) must effectively target these principal weed species and minimize impacts to desirable plants and aquatic organisms. It is important to note that there is no ideal management alternative that is altogether 100% effective, completely free of environmental impacts and cost-effective. With

this in mind, the choice becomes one of balancing all these factors with specific regard to environmental, social, political and site constraints.

Of particular concern is the problem occurrence of Brazilian Elodea (Egeria densa) in Lake Limerick. This weed is an introduced submersed plant from South America that is a widespread, popular aquarium plant in the United States. While heavy infestations of this plant have plagued the southeastern U.S. (Tarver et. al., 1979), the occurrence and establishment of Egeria densa isn't as prevalent in the Pacific Northwest, being somewhat sporadic West of the Cascades (Warrington, 1980; Peter Newroth, B.C. Min. of Envir., pers. comm.; Kathey Hamel, WA Dept. Ecol, pers. comm.). The growth habit of this plant is such that it can grow rooted to the bottom or floating (unanchored) in mats near the surface, and propagates mainly by fragmentation (Warrington, 1980). The smaller, closely related Elodea canadensis has a similar growth habit. In contrast, Potamogeton amplifolius is a submerged plant characterized by perennial rhizomes (underground horizontal stems with nodes, buds and roots) and also produces seeds.

If the management goal is concurrent control of all three major species, then growth habits, ecology and susceptibility to control must be considered for all. Because of the ability of Elodea and Egeria to effectively reproduce by fragmentation of vegetative stems, mechanical control such as harvesting and even rotovation would not be recommended at this time. A further constraint against using rotovation in Lake Limerick is the presence of many submerged tree stumps along the lake bottom (Dick Lombard, Lake Limerick, pers.

comm.) that can interfere with and reduce efficiency of mechanical operation.

Physical control methods such as placement of bottom barrier material can effect localized control in the area of placement, and is most useful for spot treatment around docks and the nearshore. However, it is a relatively expensive control technique, and its potential use in Lake Limerick would be limited to small areas were no weed growth may be tolerated. In Long Lake (Kitsap County), lake drawdown was attempted in 1979 as a means of controlling dense growths of Egeria densa, but full macrophyte recovery occurred after only one year of depressed growth (Jacoby et al., 1983.) Thus, physical drawdown does not appear to be a viable option for use in Lake Limerick.

While the use of biological control agents is still in its infancy, researchers and lake managers have made great advances in identifying and, in some cases, testing their effects on biological systems. In particular, since introduction of a foreign organism to a given habitat can be potentially disruptive to the ecosystem and its movements difficult to control, great care is being given to developing environmentally safe and efficient controls. It is important to note that the realistic objective of biological control of aquatic vegetation is not the eradication, but the reduction of the target species to lower, more acceptable levels through introduction of grazing or pathogenic organisms or manipulations of the aquatic environment (Cooke et al., 1986).

There has been some interest in the use of a particular biocontrol agent, the grass carp, as a result of a recent ruling by the State of

Washington permitting regulated use of sterile grass carp in inland waters (See State Quidelines, Appendix C) and several test plantings that are being monitored in Oregon (Devils Lake) and Washington (Chambers Lake). Laboratory and field studies have indicated that the grass carp can control growth of some types of nuisance aquatic plants, but do show some preferential feeding behavior (Pauley and Thomas, 1987). To date, the full impacts of grass carp introductions on control effectiveness and ecology of aquatic systems in the Northwest are still being determined. Specific data on effectiveness against Egeria densa, in particular, is necessary before considering this alternative for use in Lake Limerick. In addition, certain baseline data requirements must be met as part of the permit application process (See Appendix C, eg. Lake Restoration Feasibility Requirements).

A final option is that of chemical control. The major species of nuisance plants inhabiting Lake Limerick show varying susceptibility to a number of aquatic herbicides (Westerdahl and Getsinger, 1988; Appendix D). Of the three main herbicides listed in this manual: Endothol, Fluridone and Diquat, Fluridone is currently approved and available for use in the State of Washington with the least permitting requirements. Approval and/or permitting procedures for the other two contact herbicides are unclear at this time, so their use is not recommended.

Fluridone (marketed as SONAR, Elanco Products) is a systemic herbicide that is absorbed by plant roots/shoots and demonstrated "good" control of Egeria densa, Elodea canadensis and Potamogeton spp. (Westerdahl

and Getsinger, 1988). Through careful timing, dosage and placement of this herbicide, detrimental impacts to non-target plants and organisms can be minimized. In addition, it has a low order of toxicity to aquatic organisms at the recommended dosage, and EPA determined after exhaustive research that proper use of the product does not pose a threat to human health; this was recently reaffirmed for the case of Long Lake by Thurston County Public Health (WATER, 1990). There is no water use restriction.

Based on the above information, use of fluridone (SONAR) is the recommended option for immediate control of these weed species in Lake Limerick for 1991. Because of its potential for substantial drift outside the treatment perimeter, a block-type treatment is highly recommended. However, in order to optimize placement of the herbicide blocks to maximize target contact and minimize non-target plant impacts, it is highly recommended that a pre-treatment aquatic plant survey (boat survey) be performed to map distribution of the weed species and also provide quantitative plant density and biomass data to be used for future effectiveness monitoring (and also a requirement for grass carp planting). Accurate description and location of problem plants to be treated would help in meeting Washington Department of Wildlife goals of preserving 25% of the aquatic vegetation. To monitor effectiveness of treatment, a post-treatment survey should be performed. Aerial surveying techniques are a rapid, accurate means of tracking areal plant distribution; an aerial imaging mission could be flown prior to and following herbicide application, utilizing the boat survey quantitative data for imagery calibration. Also, some limited water quality sampling for nutrients and biota is

recommended following herbicide treatment (eg. once a month) to make sure short-term goals are being met (ie. reduction in nuisance algae growth).

To recap recommendations for immediate action to control problem plants in Lake Limerick in 1991:

- o perform aquatic plant survey to map distribution, and to obtain plant biomass and density data by quantitative sampling for immediate effectiveness tracking and as a base for future needs,
- o conduct SONAR treatment as main element of a short-term plant management treatment, using small blocks collectively applied to about 30-35 acres (algicides and/or other specific herbicides to be applied as needed, eg. Rodeo for lily control),
- o conduct aerial survey before and after treatment to monitor effectiveness (can use results from boat survey to calibrate imagery),
- o perform limited water quality sampling (ie. algae, zooplankton nutrient sampling) to determine that short-term herbicide application is meeting immediate goals and not having detrimental effects.

Long-Term Goals

More importantly, WATER encourages the Lake Limerick Board of Trustees and residents to consider developing a long-term, comprehensive lake management plan for the community that incorporates an aquatic plant management element that can be modified as needed. Initially, this would involve more intensive investigation of the general water

quality of the lakes and shoreline watershed characteristics as they may affect the occurrence of nuisance aquatic plant growth. As stated earlier, problematic macrophytes are often symptomatic of an imbalance in the aquatic system, and thus of larger problem. In many cases, specific aquatic plant management controls to deal with the immediate physical problem of nuisance growth can be combined with prudent watershed management practices to help limit additional flow of nutrients into the system that may stimulate overproduction in the lake. The goal of the long-term program would be to eventually diminish the role of herbicidal usage in the lake and encourage proactive measures, supplemented by reactive controls as needed.

One way to achieve this (ie. to define a comprehensive lake management program) is to perform a diagnostic study of the lake and watershed. Objectives of such an investigation would include:

- characterize existing water quality of Lakes Limerick and Leprechaun,
- identify factors contributing to decline of lake water quality and causing aquatic weed and algae growth,
- define approaches that will reduce aquatic plant growth problem and algae problem,
- formulate lake management plan to restore and protect Lakes Limerick and Leprechaun water quality and resource uses.

Certainly the scope and intensity of such an investigation would be dictated by certain local constraints (eg. budgetary limitations, safety and liability considerations), as well as by project objectives (eg. consideration of grass carp use requires a minimum level water quality study). There are various funding avenues that the Lake Limerick community could pursue to help minimize direct financial burden of undertaking such a study. Washington State Department of Ecology currently administers a Centennial Fund that provides state

matching funds for such diagnostic studies (termed Phase I studies) to public entities in the state. The Board may consider making application for such a grant itself, if it qualifies, or approach another public entity such as Mason County through which to apply for the grant. Realistically, a Phase I Study could run between $150,000 to $250,000 for a lake system like Lake Limerick. However, alternatives to Phase I studies are also possible by adjusting the scale and scope of a diagnostic study to meet the minimum needs of the project.

To sum up, development of a long-term lake management plan for Lake Limerick (and Lake Leprechaun), including an integrated aquatic plant management component, would require a comprehensive investigation of:

- historical/watershed background data
- water quality assessment
  - -aquatic plant survey (distribution/biomass)
  - -nutrient budget, limitation
  - -hydraulic budget
  - -biological interrelationships
  - -lake response
- lake restoration feasibility
- public involvement (public meetings)

Conducting such an investigation would also provide the base data nedded in designing a truly effective integrated aquatic plant management program.

BOARD OF TRUSTEES
AGENDA

FEBRUARY 16, 1991

ROLL CALL

MINUTES JANUARY 19, 1991

FINANCIAL REPORT NAN STRICKLIN

COMMITTEE REPORTS:

GREENS	CARL NIELSEN
WATER	DAVE BEST
25TH ANNIVERSARY	CHRISTLE LALLE
LAKE/DAM	PHIL LALLE
ARCHITECTURAL	JOHN STRICKLIN
INN	VICKI MYERS
MAINTENANCE	BUD PEARSON
LONG RANGE PLAN	BOB KING
LL COMMUNITY SUPPORT	SHARON HAYWORTH
EXECUTIVE	DICK LOMBARD

COMMENTS FROM MEMBERSHIP:

OLD BUSINESS:

NEW BUSINESS:

Appointments - Lake Limerick Days Coordinator
Elections Supervisor

CORRESPONDENCE:

ADJOURN

WATER ENVIRONMENTAL SVCS., INC.
9515 Windsong Loop NE
Bainbridge Is., WA 98110

(206) 842-9382

DATE 2/14/91

SUBJECT Resume

TO:

Rob Wilson-Hoss
236 W. Birch
Shelton, WA 98584

Hoss and Wilson-Hoss
FEB 15 1991
RECEIVED

Dear Rob:

Enclosed is a business profile for WATER Environmental Services, Inc. and resume on myself. I'm putting together a miniproposal for scoping work on Lake Limerick which I'll fax to you tomorrow, as we discussed.

Looking forward to talking to you more about the Lake.

Sincerely,

Maribeth Gibbons

WATER Environmental Services, Inc.
9515 Windsong Loop NE
Bainbridge Island, WA 98110
(206) 842-9382

BACKGROUND

WATER Environmental Services, Inc. (WATER) is a certified Women's Business Enterprise (WBE) that has been providing professional environmental consulting services since 1984. WATER offers a broad range of limnological services, specializing in water quality analysis and assessment, aquatic plant management, aquatic plant and wetland community characterization, and lake, reservoir and river restoration. The business is committed to providing highest quality environmental services through comprehensive environmental assessment/management.

The corporate office is located on Bainbridge Island along with a small scientific laboratory with multi-microcomputer facilities to support the company's technical work. Environmental field sampling capabilities are demonstrated by water quality and aquatic biological sampling equipment, including 10 ft and 19 ft sampling boats.

PRESENT ACTIVITIES

WATER has a proven reputation in lake and stream management and restoration, having conducted numerous projects involving water quality monitoring and assessment, aquatic macrophyte control, and environmental assessment. WATER's clients include state and local public agencies, private businesses, and engineering/environmental consulting firms requiring aquatic investigation support.

RECENT EXPERIENCE

WATER's experience and technical capabilities demonstrate use of an integrated approach to problem solving in such areas as lake and river restoration/management, water quality assessment and management, and aquatic macrophyte control. The firm is well-versed in acquiring and interpreting scientific data, while applying the results to successful and innovative solutions.

WATER can provide the following services:

- o field sampling and ambient data collection, monitoring
- o water quality investigations and management planning
- o data compilation and evaluation
- o lab analyses of algae, zooplankton, macroinvertebrates, and aquatic plant communities
- o technical report preparation/semi-technical publications
- o water pollution/toxicity assessment
- o watershed pollution source assessment
- o wetland assessments

A brief description of recent projects is provided below.

LONG LAKE MILFOIL ERADICATION/CONTROL FEASIBILITY STUDY, 1990
Thurston County Public Works
Contact: Mr. Tom Clingman

WATER performed a feasibility study for eradication or control of Eurasian Watermilfoil in Long Lake, Thurston County. Project elements involved assessment of habitat and recreation impacts from milfoil infestation, if no action taken; assessing feasibility and effectiveness of viable milfoil control options for possible use in Long Lake, including environmental impacts and costs, and compatibility with County aquatic vegetation management policies; identification of options to control milfoil pioneer colony growth; production of a series of technical memos addressing each of these elements; and participation in the County's Public Awareness Program. A final report was produced utilizing the tech memos and input from public and interagency meetings held regarding this issue.

PHANTOM LAKE MONITORING PHASE IIb, 1990--
Kramer, Chin & Mayo, Inc. (City of Bellevue)
Contact: Dr. Harry Gibbons

As part of this twelve month monitoring investigation, WATER is responsible for performing scheduled sample collection for physical, chemical and biological parameters, as well as phytoplankton and zooplankton sample analyses (identification, enumeration, biomass). WATER also designed and conducted a whole lake aquatic macrophyte survey to map distribution of aquatic macrophytes in the lake, including quantification through biomass sampling and analyses.

LAWRENCE LAKE PHASE I RESTORATION ANALYSIS, 1990
Kramer, Chin & Mayo, Inc. (Thurston County)
Contact: Dr. Harry Gibbons

WATER is conducting zooplankton and phytoplankton sampling of Lawrence Lake, determining plankton species identification, enumeration and biomass of samples, as well as analyzing the bio-data in terms of longterm trends as part of the larger comprehensive analyses.

MARTHA LAKE RESTORATION PHASE I, 1990
Entranco Engineers, Inc. (Snohomish County)
Contact: Mr. Ralph Nelson

Responsibilities on this Phase I project include designing and performing an aquatic macrophyte survey of lake to characterize plant distribution, including plant biomass determinations on collected samples. In addition, the relationship between lake zooplankton, phytoplankton and nutrients will also be assessed.

LAKE CHAPLAIN BIOANALYSIS, 1989--
City of Everett Public Works, Water Plant
Contact: Mr. Mark Zempel

WATER is analyzing water samples taken from the intake and PUD line of the City water supply (Lake Chaplain) for specific algal content, including enumeration and biovolume.

PEND OREILLE RIVER MACROPHYTE BIOMASS ANALYSIS, 1989
WA Department of Ecology, Environ. Investigations
Contact: Ms. Barbara Carey

Aquatic plant and ash-free dry weight analyses were performed on macrophyte samples taken from weed beds in the Pend Oreille River. The biomass data were used by the agency as part of a larger investigation to characterize water quality and fishery habitat within and outside weed beds and evaluate changes in both resulting from weed management techniques in the River.

LAKE BALLINGER WATERSHED STORM DRAIN INVENTORY, 1989
City of Mountlake Terrace
Contact: Mr. Carl Rautenberg

A comprehensive inventory on selected sections of the underground stormwater conveyance system in the Lake Ballinger Watershed was conducted during January-February, 1989.

LAKE BALLINGER AQUATIC PLANT SURVEY, 1989 and 1988
City of Mountlake Terrace
Contact: Mr. Carl Rautenberg

During summer of 1989 and 1988, WATER performed a coordinated boat and aerial survey of aquatic plants in Lake Ballinger to identify and document distribution of macrophytes in the lake. Computer-enhanced color imagery obtained from the aerial survey calibrated with ground-truthed plant data was used together to construct an areal distribution map of macrophytes in this lake.

LAKE ROESIGER PHASE I RESTORATION ANALYSIS, 1988
Kramer, Chin & Mayo, Inc., (Snohomish County)
Contact: Dr. Harry Gibbons

WATER conducted an aquatic plant survey and the biological sampling and analysis (algae, zooplankton, and benthos) portions of this Phase I Lake Roesiger investigation. The data collected by WATER was used in nutrient source assessment and lake water quality characterization.

PHANTOM/LARSEN LAKES PHASE IIa RESTORATION, 1988--
Kramer, Chin & Mayo, Inc. (City of Bellevue)
Contact: Dr. Harry Gibbons

Aquatic bio-analyses (ID, enumeration, biovolume) is being conducted on zooplankton and phytoplankton water samples collected from Larsen Lake. The data collected by WATER will be used in monitoring biological impacts of the restoration effort on the lake.

AQUATIC PLANTS IN SELECTED WATERS OF KING COUNTY, A 1988 UPDATE
Municipality of Metropolitan Seattle
Contact: Ms. Judy Bevington

An aquatic plant survey was conducted during the summer, 1988 in selected areas of Lake Washington, Lake Sammamish and Portage Bay as part of Metro's area-wide Milfoil Control Program. Areal distribution and density of milfoil and other macrophytes were measured at 10 sites in these waters. In addition to providing areal maps and discussion of plant distribution, WATER assessed post-treatment effectiveness on milfoil control of rotovation treatment conducted in three of these sites during fall-winter, 1987.

AQUATIC PLANTS IN SELECTED WATERS OF KING COUNTY, A 1987 UPDATE
Municipality of Metropolitan Seattle
Contact: Ms. Judy Bevington

An aquatic plant survey was conducted as part of Metro's area-wide Milfoil Control Program with the purpose of monitoring and updating growth trends in Eurasian watermilfoil and other aquatic plants in selected regional waters. Areal distribution and density of milfoil and other macrophytes were measured at eight sites in Lake Washington, Lake Sammamish and Portage Bay during the summer of 1987. Report included 1987 survey results as well as discussion of plant distribution trends in these sites over the last 10 years.

LITERATURE REVIEW: EFFECTIVENESS OF MECHANICAL HARVESTING AND THREE HERBICIDES AND STATUS OF OTHER CONTROL METHODS FOR EURASIAN WATERMILFOIL
Municipality of Metropolitan Seattle, 1986
Contact: Ms. Joanne Davis

WATER conducted a comprehensive literature review of various technologies for the control of Eurasian watermilfoil emphasizing potential usefulness for Metro's aquatic plant management program. In particular, mechanical harvesting, the aquatic herbicides 2,4-D, Endothall and Fluridone, and status of other promising control methods were compared and analyzed in terms of control effectiveness, costs, limitations and advantages.

LAKE OSOYOOS EURASIAN WATER MILFOIL CONTROL PROGRAM
Washington Department of Ecology
--Rotovator Demonstration Project, 1986
Contact: Mr. Allen Moore

The 1986 study involved evaluation of environmental impacts and control effectiveness of a new method of mechanical control (rotovation) used in a demonstration project for containment of Eurasian water milfoil in Lake Osoyoos. Specific objectives were pre- and post-treatment monitoring of selected water quality parameters, sediment core analysis, benthic invertebrate population analysis, EPA priority pollutant monitoring and toxicity assessment, as well as determining efficacy of macrophyte control attained in the lake.

--Carryover Control of Eurasian Watermilfoil, 1985
Contact: Mr. Allen Moore

In July, 1985, WATER began a monitoring study to determine carryover effects of a 2,4-D DMA application made in the summer, 1984 for the control of Eurasian water milfoil in Lake Osoyoos. The intensive macrophyte sampling routine included plant biomass determinations, enumeration and quantification of macrophyte species and mapping of plant populations in the treatment areas. The thrust of the project was to evaluate control effectiveness of herbicide application on Eurasian water milfoil by analyzing plant population density and species changes one year after treatment.

PEND OREILLE RIVER EURASIAN WATER MILFOIL CONTROL PROGRAM, 1984-1990
Pend Oreille County (WA Department of Ecology)
Contact: Mr. Paul Wilson (Ms. Kathy Hamel--DOE)

WATER has been involved since 1984 in monitoring studies and the design and implementation of an integrated program for the control of Eurasian watermilfoil in the Pend Oreille River in Eastern Washington. The 1984 and 1985 studies included water quality monitoring during 2,4-D DMA herbicide applications in the river to document possible downstream contamination. Intensive macrophyte sampling was conducted on treated plots in the river to assess immediate kill effectiveness of 2,4-D on Eurasian water milfoil. In addition, quantitative analysis of plant populations in previously treated areas in the river was performed to determine carryover control of the herbicide on Eurasian watermilfoil.

The 1986 effort consisted of implementing and monitoring a greatly expanded management plan designed by WATER that involved integration of newly-developed mechanical and biological control techniques with herbicide applications in the river. Specifically, WATER's participation in the 1986 program consisted of evaluation of mechanical rotovation of 36 acres of river sediments, establishment of shoreline beds of dwarf spikerush and assessment of competitive success of this species, evaluation of effectiveness of an application of the aquatic herbicide SONAR on treatment of Eurasian watermilfoil and design of the 1987 program. In addition, coordinated boat and

aerial surveys were conducted by WATER during the summer, 1986 to document distribution of macrophytes in the upper reach of the Pend Oreille River (37 rivermiles). WATER also produced a series of semi-technical newsletters describing Eurasian watermilfoil control efforts taking place in the Pend Oreille River.

WATER's involvement in the 1987 program consisted of monitoring carryover effectiveness on Eurasian watermilfoil growth of the previous year's rotovation treatment and pilot SONAR application, as well as evaluating reproductive success of the spikerush plantings. Ground and aerial plant surveys were also performed to update macrophyte growth trends. Newsletters were again published as a continuation of the effort to inform the public about milfoil control in the river.

WATER's participation in the 1988 Milfoil Control Program in the Pend Oreille River included assessment of one-year carryover effectiveness of selected 1987 rotovation treatment sites in the river, intensive rotovator machine performance evaluations, and extended mapping of milfoil and other aquatic plants along 50 miles of the river by coordinated aerial and boat survey.

During 1989, WATER was contracted by Pend Oreille County to evaluate one-year and two-year carryover effectiveness of rotovation performed at various sites along the river for milfoil control. A survey was also conducted to locate the upstream boundary of Eurasian watermilfoil growth in the Pend Oreille River (Washington).

For the 1990 Program, WATER continued to evaluate carryover effectiveness of rotovation at selected sites in the Pend Oreille River. In addition, a survey was performed both upstream to document upstream boundary of milfoil growth and downstream to the Canadian border to determine evidence of downstream movement of milfoil infestation.

OTHER WORK PROJECTS

WATER has provided technical water quality analyses services in monitoring water supplies for cities and also in a support capacity on lake restoration projects for municipalities and environmental/engineering consulting businesses in Washington State. These services include freshwater nutrient, algae, zooplankton, macrophyte, and benthic invertebrate determinations and data interpretation.

WATER ENVIRONMENTAL SERVICES, INC.
BIOGRAPHICAL SKETCH

Maribeth V. Gibbons,
President

Position: Limnologist, Environmental Engineer/Scientist

Education:

M.S. 1984, Environmental Engineering, Washington State University
M.S. 1980, Environmental Science, Washington State University
B.A. 1977, Mathematics, Washington State University

Maribeth Gibbons has 11 years of applied research and technical experience in the areas of lake and stream restoration, water quality assessment/management, aquatic macrophyte surveys and control evaluations, and non-point source assessment. Ms. Gibbons has conducted limnological work involving monitoring studies and the design and implementation of restoration measures and/or management plans on several water bodies in Washington State such as Osoyoos, Badger, Bead, and Liberty Lakes as well as Pend Oreille, Columbia, Snake, and Spokane Rivers. Her skills include field sampling, laboratory analysis of physical, chemical, and biological parameters, nutrient and water budget determination, water quality data interpretation, and technical report writing. She is particularly qualified in taxonomic classification of freshwater zooplankton, algae, and macrophytes. Maribeth's areas of published expertise include aquatic macrophyte control, internal nutrient cycling, microinvertebrate ecology, primary productivity, and lake modelling.

As principal of WATER, Ms. Gibbons has managed eleven significant Eurasian water milfoil projects in the form of a control feasibility study on Long Lake (Thurston County), control evaluation and management planning at Lake Osoyoos and the Pend Oreille River, macrophyte surveys, as well as aquatic plant surveys on Lake Ballinger for City of Mountlake Terrace and, for Seattle Metro, surveys on Lake Washington, Lake Sammamish, and Portage Bay and a macrophyte control literature review. She has provided technical biological assessment services for municipalities and engineering/environmental consulting firms on Lakes Ballinger, Roesiger, Stevens, Chaplain, Larsen, Phantom, Erie, Campbell, Long, Pattison, Lawrence and Snake. Prior to the establishment of WATER, Ms. Gibbons completed all coursework for a Ph.D. degree in Engineering Science while working as a Laboratory Technician and Research Assistant in the Department of Civil and Environmental Engineering at Washington State University.

Ms. Gibbons is currently active in several professional societies, particularly North American Lake Management Society for which she chairs the Scholarship Committee, Washington State Lake Protection Association, Aquatic Plant Management Society, and Western Region Aquatic Plant Management Society, and belongs to various honorary scientific organizations, such as Sigma Xi, Phi Kappa Phi, and Tau Beta Pi. She is registered as an Engineer in Training (Washington).

PRINCIPAL PUBLICATIONS

Pend Oreille River Eurasian Watermilfoil Control Program, 1990. 1990. Project Completion Report prepared for Pend Oreille County, WA. WATER, Bainbridge Island, WA.

Eurasian Watermilfoil Eradication/Control Feasibility Study. 1990. Project Completion Report prepared for Thurston County Public Works, Olympia, WA. WATER, Bainbridge Island, WA.

Pend Oreille River Eurasian Watermilfoil Control Program, 1989. 1989. Project Completion Report prepared for Pend Oreille County, WA. WATER, Bainbridge Island, WA.

Efficacy of Rotovation in Controlling Eurasian Watermilfoil in the Pend Oreille River, Washington. 1988. 1st Author. In, Lake Reserv. Manage. 4(1), North Amer. Lake Manage. Soc., pp.153-160.

Pend Oreille River Eurasian Watermilfoil Control Program, 1988. 1988. Project Completion Report prepared for Pend Oreille County, WA. WATER, Bainbridge Island, WA.

Aquatic Plants in Selected Waters of King County: 1988 Update. 1988. Technical Report prepared for Municipality of Metropolitan Seattle, Seattle, WA.

Aquatic Plants in Selected Waters of King County: 1987 Update. 1987. Technical Report prepared for Municipality of Metropolitan Seattle, Seattle, WA.

Pend Oreille River Eurasian Watermilfoil Control Program 1987. 1987. Project Completion Report prepared for Pend Oreille County, WA. WATER, Bainbridge Island, WA.

A Literature Review on the Effectiveness of Mechanical Harvesting and Three Herbicides, and Status of Other Control Methods for Eurasian Watermilfoil. 1986. Technical Report prepared for Municipality of Metropolitan Seattle, Seattle, WA.

Pend Oreille River Eurasian Watermilfoil Control Program, 1986. Project Completion Report prepared for Pend Oreille County, WA. 1986. WATER, Bainbridge Island, WA.

Lake Osoyoos Rotavator Demonstration Project. 1986. Project Completion Report prepared for Washington Department of Ecology, WATER, Bainbridge Island, WA.

Control and Management of Eurasian Water Milfoil in the Pend Oreille River, Washington. 1986. Co-author, 1st H.L. Gibbons. In Proceedings of the First International Symposium on Eurasian Water Milfoil (Myriophyllum spicatum) and Related Haloragaceae Species, July 23-24, 1985, Vancouver, B.C., Canada. APMS pp. 116-125.

Eurasian Water Milfoil Control Program for the Pend Oreille River: Water Quality and Aquatic Plant Evaluation. Project Completion Report for Winchester Creek Company. 1985. WATER, Bainbridge Island, WA.

Carryover Effectiveness of 2,4-D DMA on Eurasian Water Milfoil in Lake Osoyoos, Washington. Project Completion Report for State of Washington Department of Ecology. 1985. WATER, Bainbridge Island, WA.

Internal Nutrient Loading in Lakes, 1984, pp. 80-91. Co-author, 1st H.L. Gibbons. In Understanding Watershed and Lake Management. Metropolitan Council of the Twin Cities Area, Pub. No. 10-84-040.

Effects of Multiphase Restoration, Particularly Aluminum Sulfate Application, on the Zooplankton Community of a Eutrophic Lake in Eastern Washington. 1984. J. Freshwater Ecol. 2: 393-404.

Phosphorus Cycling in a Shallow, Eutrophic Lake, Masters Thesis, 1984, Washington State University, Pullman, WA.

Enhancement of Internal Cycling of Phosphorus by Aquatic Macrophytes; with Implications for Lake Management, 1984. Co-author, 1st B.C. Moore. In Lake and Reservoir Management, EPA 440/5/84-001, pp. 113-117.

Refinement of Control and Management Methodology for Eurasian Water Milfoil in the Pend Oreille River, Washington, 1983. Co-author, 1st H.L. Gibbons, Jr. State of Washington Water Research Center, Report No. 56, Washington State University, Pullman, WA.

Preliminary Assessment of Multiphase Restoration Efforts at Liberty Lake, Washington, 1982. Co-author, 1st W.H. Funk. State of Washington Water Research Center, Report No. 43, Washington State University, Pullman, WA.

Seasonal Patterns in the Zooplankton Community of a Eutrophic Lake in Eastern Washington Prior to Multiphased Restoration. 1982. J. Freshwater Ecol. 1: 615-628.

An Investigation of the Zooplankton Community of Liberty Lake, Washington, With Special Regard to Seasonal Succession, Masters Thesis, 1980, Washington State University, Pullman, WA.

PAPERS PRESENTED

"Nonpoint Source Detection in Three Western Washington Lakes Using Remote Sensing Approach-ASA", Pacific Northwest Pollution Control Federation Annual Conference, Bellevue, Wash., Oct 29-31, 1990.

"Controlling Aquatic Weeds: A Northwest Perspective". Pacific Northwest Regional Workshop on Lake and Reservoir Management, sponsored by North American Lake Managment Society/Washington Lake Protection Association, Seattle, Wash., Sept. 15-16, 1989.

"Harvesting, Rotovation." Washington State Lake Protection Association Second Annual Conference, Spokane, Wash., Oct. 1, 1988.

"Efficacy of Rotovation in Controlling Eurasian Watermilfoil in the Pend Oreille River, Washington." North American Lake Management Society Seventh Annual Symposium, Orlando, Florida, Nov. 3-7, 1987.

"Effectiveness and Impacts of Rotavation on Control of Eurasian Watermilfoil in Eastern Washington", Western Aquatic Plant Management Society Sixth Annual Meeting, Boise, Idaho, March 12-13, 1987.

M E M O R A N D U M

TO: Rob Wilson-Hoss, Limerick Lake, Board Member
FROM: Maribeth V. Gibbons, WATER Environmental Services, Inc.
SUBJECT: Limerick Lake Management Study
DATE: February 15, 1991

Proposal to Develop a Lake Management Plan for Limerick Lake

This is in response to your conversation with me yesterday regarding the lake community's concern over the current macrophyte problem and deteriorating condition of Limerick Lake. With a view to finding solutions specific to your lake, I propose a three-phase program to examine the present condition of the lake and immediate watershed and develop a management plan addressing the goals of the lake community, particularly with respect to the aquatic weed problem. The three-phase program would consist of a scoping phase, a planning and investigation phase, and an implementation phase. The elements of these phases are briefly discussed below.

Phase 1. Scoping/Needs Assessment Phase

This phase is concerned with scoping out the current status of the lake, gathering available background data and information on the lake and surrounding shoreline, and performing a needs assessment relative to management goals of the lake community. The phase consists of meeting with lake residents to determine immediate and longterm management goals, including a site visitation to examine lake conditions firsthand and collect several water samples (nutrient, algae, zooplankton, macrophytes) to aid in this preliminary assessment. Available background data on the lake as well as data generated from the collected samples will be compiled and reviewed to get a handle on lake status, to identify immediate actions that could be implemented, and to determine if and what additional data and investigative measures may be needed. The results of this assessment will be produced in a short technical memo and presented/discussed in another meeting with lake representatives, as a precursor to the next phase.

Phase 2. Investigation/Planning Phase

Based on results and recommendations of the Scoping Phase, this phase consists of more intensive investigation and planning specific to the lake community's management goals. It may be necessary to gather more data on the lake to support development of a long-term lake management strategy. The plan will be developed in cooperation with the lake community to realistically meet its objectives, including proposed activities that are feasible and within budgetary and other constraints. The comprehensive lake management plan will include an integrated aquatic plant management program.

Phase 3. Implementation of a Long-term Lake Management Program

This phase consists of implementation of those activities/measures recommended in the Management Plan resulting from Phase 2. WATER staff will be available to provide consulting services on an on-call basis to advise the lake community on carrying out recommended measures and/or assessing effectiveness of activities, with a goal of refining the program over time as needed.

ESTIMATE OF COST OF SERVICES
LIMERICK LAKE MANAGMENT STUDY

TASK 1. Scoping/Needs Assessment Phase

LABOR & OVHD 28 hours @ $54/hr	= $1512
DIRECT COSTS	
Analytical costs-sample analysis(chem/biol)	= $ 500
Travel	= $ 80
Misc. direct costs	= $ 158
TOTAL	= $2250

TASK 2. Investigation/Planning Phase
To be determined, pending recommendations from Phase 1.

TASK 3. Implementation Phase
To be determined, pending recommendations from Phase 2.